TM 5-3805-380-24

TECHNICAL MANUAL

UNIT, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE FOR HIGH SPEED, SELF-PROPELLED, COMPACTOR

CATERPILLAR MODEL 815F
NSN 3805-01-431-8439
END ITEM CODE (EIC) E5E

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

HEADQUARTERS, DEPARTMENT OF THE ARMY

AUGUST 1999

Important Safety Information

⚠ WARNING

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety Is Involved.

The person servicing the product may be unfamiliar with many of the systems on the product. This makes it important to use caution when performing service work. A knowledge of the system and/or components is important before the removal or disassembly of any component.

Because of the size of some of the product components, the service person should check the weights noted in this manual. Use proper lifting procedures when removing any components.

Following is a list of basic precautions that should always be observed.

Safety Signs

Read and understand all Warning signs on the product before operating, lubricating or repairing this product. Replace any damaged, illegible or missing warning plates, signs or decals.

Protective Equipment

Always wear a hard hat, protective glasses, protective shoes and other protective equipment as required by job conditions when working around this product. In particular, wear protective glasses when pounding on any part of the product or its attachments with a hammer or sledge. Use welder's gloves, hood/goggles, apron and other protective clothing appropriate to the welding job being performed. Do not wear loose clothing or jewelry that can catch on parts of the product.

Pressurized Items

1. Relieve all pressure in air, oil or water systems before any lines, fittings or related items are disconnected or removed. Always make sure all raised components are blocked correctly and be alert for possible pressure when disconnecting any device from a system that utilizes pressure.
2. Lower the bucket, blade, ripper or other attachments to the ground before performing any work on the machine. If this cannot be done, make sure the bucket, blade, ripper or other attachment is blocked correctly to prevent it from dropping unexpectedly.
3. Loose or damaged fuel, lubricant and hydraulic lines, tubes and hoses can cause fires. Do not bend or strike high pressure lines or install ones which have been bent or damaged. Check lines, tubes and hoses carefully. Do not use your bare hand to check for leaks. Pin hole leaks can result in a high velocity fluid stream that will be invisible close to the hose, tube or line. This fluid can penetrate the skin and cause personal injury. Use a board or cardboard to check for leaks.

Mounting and Dismounting

Use steps and handholds when mounting or dismounting a machine. Clean any mud or debris from steps, walkways or work platforms before using. Always face machine when using steps, handholds and walkways. When it is not possible to use the designed access system, provide ladders, scaffolds, or work platforms to perform safe repair operations.

Hot Fluids and Parts

1. To avoid burns, be alert for hot parts on machines which have just been stopped and hot fluids in lines, tubes and compartments.
2. Be careful when removing fill caps, breathers and plugs on the machine. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure. The danger is even greater if the machine has just been stopped because fluids can be hot.

Lifting

Use a hoist when lifting components which weigh 23 kg (50 lb) or more, to avoid back injury. Make sure all chains, hooks, slings, etc., are in good condition and are in the correct capacity. Be sure hooks are positioned correctly. Lifting eyes are not to be side loaded during a lifting operation.

Repair

1. Disconnect battery and discharge any capacitors before starting to work on the product. Attach a "Do Not Operate" tag in the Operator's Compartment.
2. If possible, make all repairs with the machine parked on a level, hard surface. Block machine to prevent it from rolling while working on or under machine.

3. Do not work on any machine that is supported only by lift jacks or a hoist. Always use blocks or jack stands to support the machine before performing any service or disassembly.

4. Be careful when removing cover plates. Gradually back off the last two bolts or nuts located at opposite ends of the cover or device. Then, pry the cover loose to relieve any spring or other pressure, before removing the last two bolts or nuts completely.

5. Always use tools that are in good condition and be sure you understand how to use them before performing any service work.

6. Replace all fasteners with same part number. Do not use a lesser quality fastener if replacements are necessary.

7. Repairs which require welding should be performed only with the benefit of the appropriate reference information and by personnel adequately trained and knowledgeable in welding procedures. Make reference to "Techniques of Structural Repair Course", SEGV2549. Determine type of metal being welded and select correct welding procedure and electrodes, rods or wire to provide a weld metal strength equivalent at least to that of parent metal.

8. Do not damage wiring during removal operations. Reinstall the wiring so it is not damaged nor will it be damaged in operation by contacting sharp corners, or by rubbing against some object or hot surface. Do not connect wiring to a line containing fluid.

9. Be sure all protective devices including guards and shields are properly installed and functioning correctly before starting a repair. If a guard or shield must be removed to perform the repair work, use extra caution. Repair any loose or damaged fluid lines, tubes or hoses because leaks can cause fires.

10. Always use lift arm supports to keep lift arms raised. Keep the attachment tilted down when maintenance or repair work is performed which requires the lift arms in the raised position.

11. Tighten connections to the correct torque. Make sure that all heat shields, clamps and guards are installed correctly to avoid excessive heat, vibration or rubbing against other parts during operation. Shields that protect against oil spray onto hot exhaust components in event of a line, tube or seal failure must be installed correctly.

12. Do not operate a machine if any rotating part is damaged or contacts any other part during operation. Any high speed rotating component that has been damaged or altered should be checked for balance before reusing. Make sure all protective devices including guards and shields are properly installed and functioning correctly, before starting the engine or operating the machine.

13. On track-type machines, be careful when servicing or separating tracks. Chips can fly when removing or installing a track pin. Wear protective glasses. Track can unroll very quickly when separated. Keep away from front and rear of machine. The machine can move unexpectedly when both tracks are disengaged from the sprockets. Block the machine to prevent it from moving. Chips can fly also from bucket or ripper teeth or anywhere a pin is being removed or installed.

Asbestos Information

Caution should be used to avoid breathing dust that may be generated when handling components containing asbestos fibers. If this dust is inhaled, it can be hazardous to your health. Components in Caterpillar products that may contain asbestos fibers are brake pads, brake band and lining assemblies, clutch plates and some gaskets. The asbestos used in these components is usually bound in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust which contains asbestos is not generated.

If dust which can contain asbestos is present, there are several common sense guidelines that should be followed.

1. Never use compressed air for cleaning.

2. Avoid brushing or grinding of asbestos containing materials.

3. For clean up, use wet methods or a vacuum equipped with a high efficiency particulate air (HEPA) filter.

4. Use exhaust ventilation on permanent machining jobs.

5. Wear an approved respirator if there is no other way to control the dust.

6. Comply with applicable rules and regulations for the work place (for example in the U.S.A., OSHA requirements as set forth in 29 CFR 1910.1001).

7. Follow environmental rules and regulations for disposal of asbestos.

8. Avoid areas where asbestos particles may be in the air.

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INSERT LATEST UPDATED PAGES / WORK PACKAGES. DESTROY SUPERSEDED DATA

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Dates of issue for original and updated pages / work packages are:

Original .. 0 .. 15 June 88

Revision .. 0

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Technical Manual

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Washington D.C., 12 August 1999

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REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this publication. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Submit your DA Form 2028-2 (Recommended Changes to Equipment Technical Publications), through the Internet, on the Army Electronic Product Support (AEPS) website. The Internet address is http://aeps.ria.army.mil. If you need a password, scroll down and click on "ACCESS REQUEST FORM". The DA Form 2028 is located in the ONLINE FORMS PROCESSING section of the AEPS. Fill out the form and click on SUBMIT. Using this form on the AEPS will enable us to respond quicker to your comments and better manage the DA Form 2028 program. You may also mail, fax or email your letter, DA Form 2028, or DA Form 2028-2 direct to: Commander, U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-AC-NML, Rock Island, IL 61299-7630. The email address is amsta-ac-nml@ria.army.mil. The fax number is DSN 793-0726 or Commercial (309) 782-0726.

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B	Maintenance Allocation Chart (MAC).
C	Approved Fuels, Lubricants, Grease and Oil

HOW TO USE THIS MANUAL

This manual is designed to help service and repair the High-Speed Self-Propelled Compactor (NSN 3805-01-431-8439). Listed below are some special features that have been included to help locate and use the needed information.

A front table of contents is provided for quick reference to chapters and sections that will be used often.

Warning, Caution, and Note headings, subject headings, and certain other essential information are printed in bold type to make them easier to see.

The maintenance tasks describe what must be done to the compactor before starting the task and what must be done to return the compactor to operating condition after the task is finished.

The appendices are located at the end of the manual. They contain a reference guide to other manuals, and other material for maintaining the compactor.

This manual is directed at the unit, direct support and general support of the compactor. It covers the engine, power train, and operating systems. assembly/disassembly, test and adjusting, specifications, schematics and service instructions. The manual is also supplemented with appendixes covering Army peculiar service and maintenance information.

MAINTENANCE STRUCTURE:

The four levels of maintenance, unit, direct support, general support, and depot form the baseline for determining task assignments at each level. The maintenance allocation chart will be the primary tool for assigning tasks within the levels of the Army maintenance system.

- Read all WARNINGS and CAUTIONS before performing any procedure.
- The equipment conditions found in the maintenance procedure are of a general nature and the operator/crew may be able to perform only certain tasks within a procedure to accomplish the equipment condition.

Scope:
This manual contains service and repair instructions for the maintenance of the High-Speed Self-Propelled Compactor.

Description:
The compactor is a self-propelled; diesel powered tamping machine for high-speed embankment compaction. The compactor consists essentially of a multi-fuel engine, articulated steering, hydraulically controlled strike-off dozer blade, rear wheel oscillation, all wheel tamping feet with replaceable tamping tips and wheel cleaning bars.

Utility:
The high-Speed Self-Propelled Compactor will be used in construction applications to compact at high density a full range of soils, except clean sand, and perform limited dozing or "strike off" functions. The compactor will be used in the construction and repair, and/or maintenance of roads and airfields, logistical facilities, surfaces requiring extensive compaction of rock aggregates, preparation of asphalt/cement pavements, dams and embankments.

MOS Requirements:
Operator, MOS 62J, General Construction Machine Operator.
Unit Maintenance, MOS 62B20, Construction Equipment Repair.
Direct Support/General Support Maintenance, MOS 62B30, Construction Equipment Repair.

Logistics Assistance:
The U.S. Army Tank-automotive and Armaments Command (TACOM) Logistics Assistance Representatives (LARS), stationed at CONUS and OCONUS locations, are available to give on-site training and/or technical assistance.

Foreword

Literature Information

The operation and maintenance manual should be stored in the operator's compartment in the literature holder or seat back literature storage area.

The operation and maintenance manual contains safety, operation, transportation, lubrication and maintenance information.

Some photographs or illustrations in the operation and maintenance manual show details or attachments that can be different from your machine. Guards and covers might have been removed for illustrative purposes.

Continuing improvement and advancement of product design might have caused changes to your machine which are not included in the operation and maintenance manual. Read, study and keep the operation and maintenance manual with the machine.

Whenever a question arises regarding the machine, or the operation and maintenance manual, please consult any Caterpillar dealer for the latest available information.

Safety

The Safety Section lists basic safety precautions. In addition, this section identifies the text and locations of warning signs used on the machine.

Read and understand the basic precautions listed in the Safety Section before operating or performing lubrication, maintenance and repair on the machine.

Operation

The operation information is a reference for the new operator and a refresher for the experienced one. This information includes a discussion of gauges, switches, machine controls, attachment controls, transportation and towing information.

Photographs and illustrations guide the operator through correct procedures of checking, starting, operating and stopping the machine.

Operating techniques outlined in the operation and maintenance manual are basic. Skill and techniques develop as the operator gains knowledge of the machine and its capabilities.

Maintenance

The maintenance information is a guide to equipment care. The illustrated, step-by-step instructions are grouped by servicing intervals. Items without specific intervals are listed under When Required topics. Items in the Maintenance Interval Schedule are referenced to detailed instructions that follow.

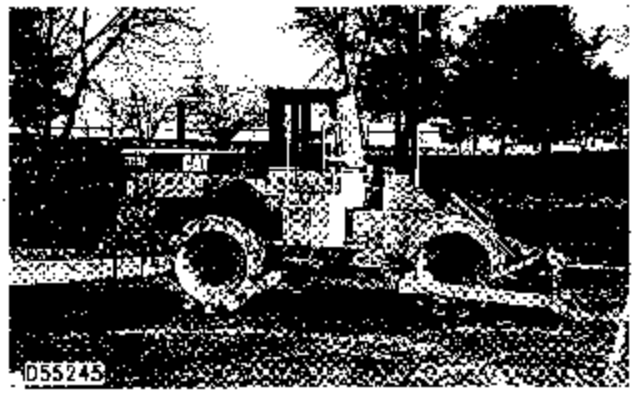
Maintenance Interval Schedule

Use the service hour meter to determine servicing intervals. Calendar intervals shown (daily, weekly, monthly, etc.) can be used instead of service hour meter intervals if they provide more convenient servicing schedules and approximate the indicated service hour meter reading. Recommended service should always be performed at the interval that occurs first.

Under extremely severe, dusty or wet operating conditions, more frequent lubrication than is specified in the Maintenance Intervals chart might be necessary.

Perform service on items at multiples of the original requirement. For example, at Every 500 Service Hours or 3 Months, also service those items listed under Every 250 Service Hours or Monthly and Every 10 Service Hours or Daily.

Machine Description



This machine is equipped with a 3306C diesel engine. It has a four-speed transmission and is designed primarily for moving material or compacting operations.

California

Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Safety

Warning Signs

There are several specific warning signs on this machine. Their exact location and description of the hazard are reviewed in this section. Please become familiarized with all warning signs.

Make sure all warning signs can be read. Clean or replace the warning signs if the words can not be read or the illustrations are not clear. When cleaning the warning signs, use a cloth, water and soap. Do not use solvent, gasoline, etc., to clean the safety signs. Solvents or gasoline, etc., could loosen the sign adhesive and allow the sign to fall off.

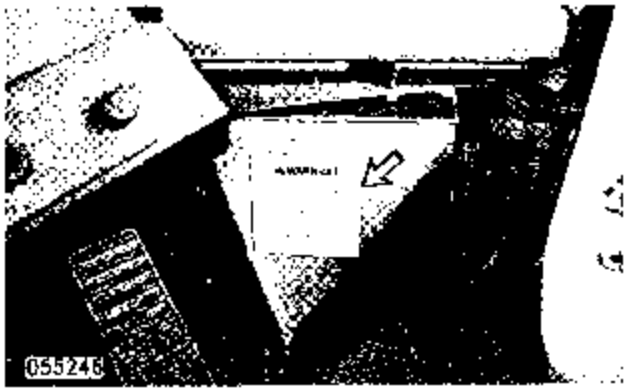
Replace any safety sign if it is damaged, missing or can not be read. If a safety sign is attached to a part that is replaced, make sure a new sign is installed on the replaced part. Contact any Caterpillar dealer for new safety signs.

⚠ WARNING

Do not operate or work on this machine unless you have read and understand the instructions and warnings in the Operation and Maintenance Manual.

Failure to follow the instructions or heed the warnings could result in injury or death.

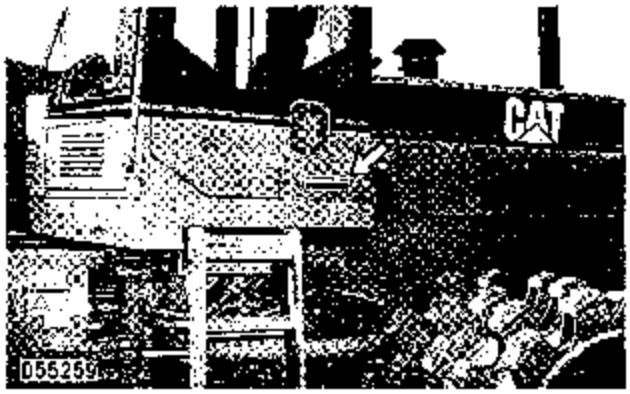
Contact any Caterpillar dealer for replacement manuals. Proper care is your responsibility.



Located in the operator's compartment

⚠ WARNING

Structural damage, an overturn, modification, alteration, or improper repair can impair this structure's protection capability thereby voiding this certification. Do not weld on or drill holes in the structure. Consult a Caterpillar dealer to determine this structure's limitations without voiding its certification.



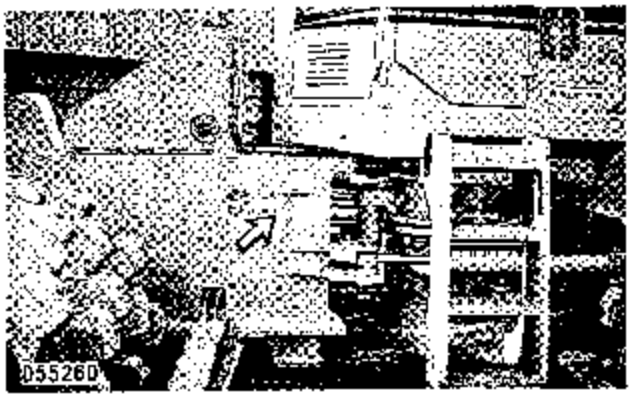
Located on the left side of the cab.

⚠ WARNING

No clearance for man in this area when machine turns; Severe injury or death from crushing could occur.

Connect steering frame lock link between front and rear frames before lifting machine, transporting machine on another vehicle, or performing service near center of machine.

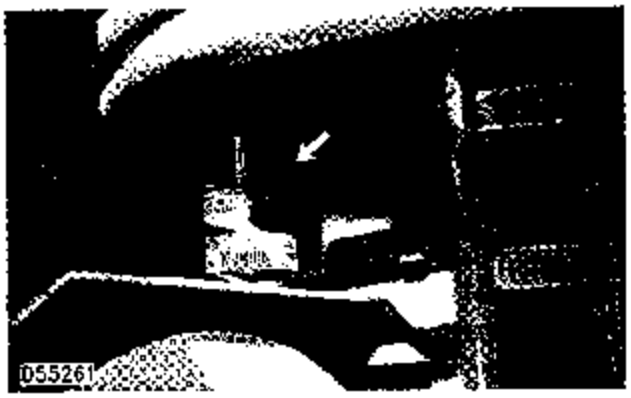
Disconnect steering frame lock link and secure to retaining plates before resuming operation or machine will not steer.



Located on the machine at the center pivot.

⚠ WARNING

(Highly compressed spring inside this housing can cause serious physical injury or death. Do not service until you read and understand the information in the service manual for servicing the parking/secondary brake actuator.)



Located on the parking/secondary brake actuator.

⚠ WARNING

Improper jumper cable connections can cause an explosion resulting in personal injury.

Batteries can be located in separate compartments. When using jump start cables always connect positive (+) cable to positive (+) terminal of battery connected to starter solenoid and negative (−) cable from external source to starter negative (−) terminal. (If machine is not equipped with starter negative terminal, connect to engine block.) Follow the procedure in the operation manual.

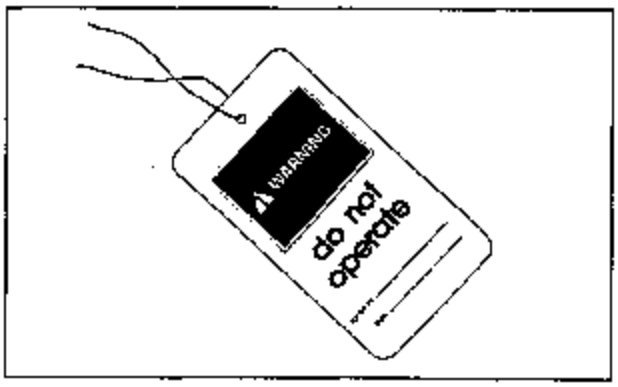
Located on the underside of the battery compartment cover.

⚠ WARNING

Do not step on the cleaner bar when machine is moving.

Located on each cleaner bar.

General Hazard Information



Attach a Do Not Operate, SEHS7332, or similar warning tag to start switch or controls before servicing or repairing the machine. This tag is available from your Caterpillar dealer.

Know the width of your attachments so proper clearance can be maintained when operating near fences, boundary obstacles, etc.

Wear a hard hat, protective glasses and other protective equipment as required by job conditions.

Do not wear loose clothing or jewelry that can catch on controls or other parts of the machine.

Make certain all protective guards and covers are secured in place on the machine.

Keep the machine, especially the deck, walkways and steps, free of foreign material, such as debris, oil, tools and other items which are not part of the machine.

Secure all loose items such as lunch boxes, tools and other items which are not part of the machine.

Know the appropriate work site hand signals and who gives them. Accept signals from one person only.

Inhaling air conditioner refrigerant gas through a lit cigarette or other smoking method or inhaling fumes released from a flame contacting air conditioner refrigerant gas, can cause bodily harm or death. Do not smoke when servicing air conditioners or wherever refrigerant gas may be present.

Never put maintenance fluids into glass containers.

Drain all liquids into a suitable container. Dispose of all liquids according to local regulations.

Use all cleaning solutions with care.

Report all needed repairs

Do not allow unauthorized personnel on the machine.

Perform all maintenance unless otherwise specified as follows:

- The machine parked on level ground.
- The attachment controls in HOLD.
- The transmission control in NEUTRAL.
- The parking brake engaged.
- Lower the blade to the ground and apply slight down pressure.
- The engine stopped.
- The engine start switch key off and the key removed.
- The disconnect switch key off and the key removed.

Pressure Air

Pressure air can cause personal injury. When using pressure air for cleaning, wear a protective face shield, protective clothing and protective shoes.

The maximum air pressure must be below 205 kPa (30 psi) for cleaning purposes.

Fluid Penetration

Always use a board or cardboard when checking for a leak. Escaping fluid under pressure, even a pin-hole size leak, can penetrate body tissue, causing serious injury, and possible death. If fluid is injected into your skin, it must be treated by a doctor familiar with this type of injury immediately.

Asbestos Information

Caterpillar products and replacement parts shipped from Caterpillar are asbestos free. Caterpillar recommends the use of only genuine Caterpillar replacement parts. If any replacement parts containing asbestos are used, the following guidelines should be used in handling these parts and asbestos debris.

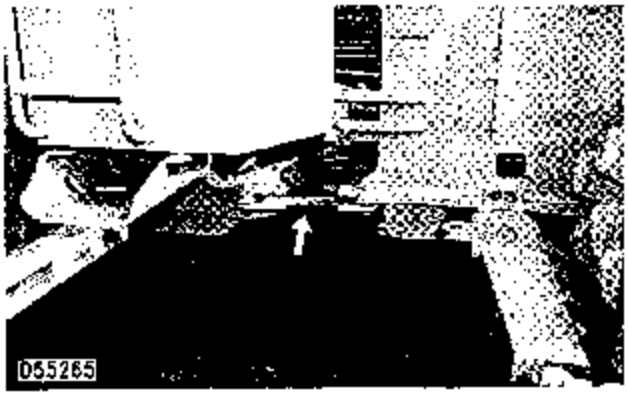
Caution should be used to avoid inhaling dust that might be generated when handling components containing asbestos fibers. If this dust is inhaled, it can be hazardous to your health. Components in products that might contain asbestos fibers are brake pads, brake band and lining assemblies, clutch plates and some gaskets. The asbestos used in these components is usually bound in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust which contains asbestos is not generated.

If dust which can contain asbestos is present, there are several common sense guidelines that should be followed.

- Never use compressed air for cleaning.
- Avoid brushing or grinding of asbestos containing materials.
- For clean up, use wet methods or a vacuum equipped with a high efficiency particulate air (HEPA) filter.
- Use exhaust ventilation on permanent machining jobs.

- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place (for example in the U.S.A., OSHA requirements as set forth in 29 CFR 1910.1001).
- Follow environmental rules and regulations for disposal of asbestos.
- Avoid areas where asbestos particles might be in the air.

Crushing or Cutting Prevention



Connect steering frame lock link between front and rear frames before lifting machine, transporting machine on another vehicle, or performing service near center of machine.

Support equipment and attachments properly when working beneath them. Do not depend on hydraulic cylinders to hold them up. An attachment can fall if a control is moved, or if a hydraulic line breaks.

Never attempt adjustments while the machine is moving or the engine is running unless otherwise specified.

Where there are attachment linkages, the clearance in the linkage area will increase or decrease with movement of the attachment.

Stay clear of all rotating and moving parts.

Keep objects away from moving fan blades. They will throw or cut any object or tool that falls or is pushed into them.

Do not use a kinked or frayed wire rope cable. Wear gloves when handling wire rope cable.

Retainer pins, when struck with force, can fly out and injure nearby persons. Make sure the area is clear of people when driving retainer pins.

Wear protective glasses when striking a retainer pin to avoid injury to your eyes.

Chips or other debris can fly off objects when struck. Make sure no one can be injured by flying debris before striking any object.

Rollover Protective Structure (ROPS) or Falling Objects Protective Structure (FOPS)

ROPS or FOPS is a guard located above the operator's compartment and secured to the machine.

To avoid possible weakening of the ROPS or FOPS, consult a Caterpillar dealer before altering, by adding weight to, welding on, or cutting or drilling holes into the structure.

Any alteration not specifically authorized by Caterpillar invalidates Caterpillar's ROPS and FOPS certification. The protection offered by this ROPS/FOPS will be impaired if it has been subjected to structural damage. Structural damage can be caused by an overturn accident, by falling objects, etc.

Do not mount any item such as fire extinguishers, first aid kits and lights by welding brackets to or drilling holes in any ROPS/FOPS structure. See your Caterpillar dealer for mounting guidelines.

Burn Prevention

Coolant

At operating temperature, the engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot coolant or steam. Any contact can cause severe burns.

Steam can cause personal injury.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to remove with your bare hand.

Remove the cooling system filler cap slowly to relieve pressure.

Cooling system additive contains alkali that can cause personal injury. Avoid contact with the skin, eyes and mouth.

Allow cooling system components to cool before draining.

Oils

Hot oil and components can cause personal injury. Do not allow hot oil or components to contact the skin.

At operating temperature, the hydraulic tank is hot and can be under pressure.

Remove the hydraulic tank filler cap only after the engine has been stopped and the filler cap is cool enough to remove with your bare hand.

Remove the hydraulic tank filler cap slowly to relieve pressure.

Relieve all pressure in air, oil, fuel or cooling systems before any lines, fittings or related items are disconnected or removed.

Batteries

Batteries give off flammable fumes which can explode.

Do not smoke when observing the battery electrolyte levels.

Electrolyte is an acid and can cause personal injury if it contacts skin or eyes.

Always wear protective glasses when working with batteries.

Fire or Explosion Prevention

All fuels, most lubricants and some coolant mixtures are flammable.

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

Do not smoke while refueling or in a refueling area.

Do not smoke in areas where batteries are charged, or where flammable materials are stored.

Batteries can be located in separate compartments. When using jump start cables always connect positive (+) cable to positive (+) terminal of battery connected to starter solenoid and negative (–) cable from external source to starter negative (–) terminal. (If not equipped with starter negative (–) terminal, connect to engine block.)

See the Operation Section of this manual for specific starting instructions.

Clean and tighten all electrical connections. Check daily for loose or frayed electrical wires. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the machine.

Keep all fuels and lubricants stored in properly marked containers and away from all unauthorized persons.

Store all oily rags or other flammable material in a protective container.

Do not weld or flame cut on pipes or tubes that contain flammable fluids. Clean them thoroughly with nonflammable solvent before welding or flame cutting on them

Remove all flammable materials such as fuel, oil and other debris before they accumulate on the machine.

Do not expose the machine to flames, burning brush, etc., if at all possible.

Shields, which protect hot exhaust components from oil or fuel spray in the event of a line, tube or seal failure, must be installed correctly.

Fire Extinguisher

Have a fire extinguisher available and know how to use it. Inspect and have it serviced as recommended on its instruction plate.

The recommended place to mount a fire extinguisher is on the radiator guard portion of the tilt hood at the rear of the machine. Do not weld on or drill holes in the ROPS structure to mount the fire extinguisher on the ROPS.

A fire extinguisher can be mounted to the ROPS legs, by strapping the mounting plate to the leg. Keep the fire extinguisher over 4.5 kg (10 lb) size, as low as possible on one leg. But, never mount it in the top one-third length of the leg.

Ether

Ether is poisonous and flammable.

Inhaling ether vapors or repeated contact of ether with skin can cause personal injury.

Use ether only in well-ventilated areas.

Do not smoke while changing ether cylinders.

Use ether with care to avoid fires.

Do not store replacement ether cylinders in living areas or in the operator's compartment.

Do not store ether cylinders in direct sunlight or at temperatures above 40°C (102°F).

Discard cylinders in a protective place. Do not puncture or burn cylinders.

Keep ether cylinders out of the reach of unauthorized personnel.

Lines, Tubes and Hoses

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses.

Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Contact your Caterpillar dealer for repair or replacement.

Check lines, tubes and hoses carefully. Do not use your bare hand to check for leaks. Use a board or cardboard to check for leaks. See Fluid Penetration in the Safety Section for more details. Tighten all connections to the recommended torque. Replace if any of the following conditions are found.

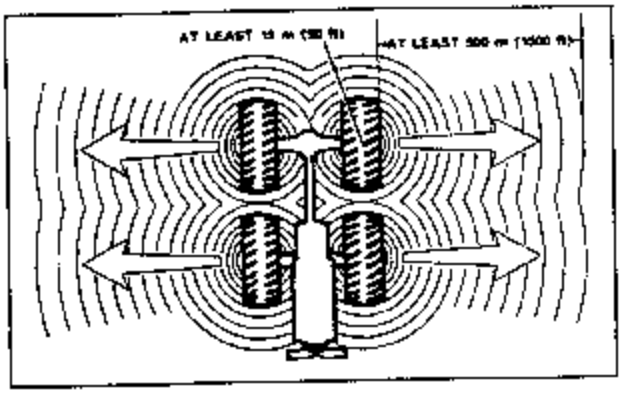
- End fittings damaged or leaking.
- Outer covering chafed or cut and wire reinforcing exposed.
- Outer covering ballooning locally.
- Evidence of kinking or crushing of the flexible part of hose.
- Armoring embedded in the outer cover.
- End fittings displaced.

Make sure that all clamps, guards and heat shields are installed correctly to prevent vibration, rubbing against other parts and excessive heat during operation.

Tire Information

Explosions of air inflated tires have resulted from heat-induced gas combustion inside the tires. The heat generated by welding or heating rim components, external fire, or excessive use of brakes can cause gaseous combustion.

A tire explosion is much more violent than a blowout. The explosion can propel the tire, rim and axle components as far as 500 m (1500 ft) or more from the machine. Both the force of the explosion and the flying debris can cause personal injury or death and property damage.



Do not approach a warm tire closer than the outside of the area represented by the shaded area in the illustration.

Dry nitrogen (N_2) gas is recommended for inflation of tires. If the tires were originally inflated with air, nitrogen is still preferred for adjusting the pressure. Nitrogen mixes properly with air.

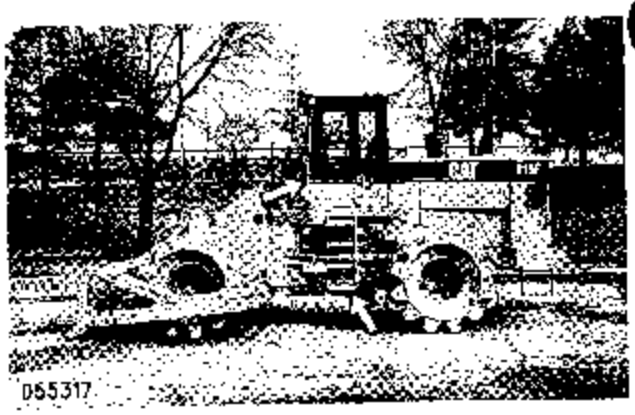
Nitrogen inflated tires reduce the potential of a tire explosion, because nitrogen does not support combustion. Also, nitrogen helps prevent oxidation and the resulting deterioration of rubber and corrosion of rim components.

Proper nitrogen inflation equipment and training in its use are necessary to avoid overinflation. A tire blowout or rim failure can result from improper or misused equipment.

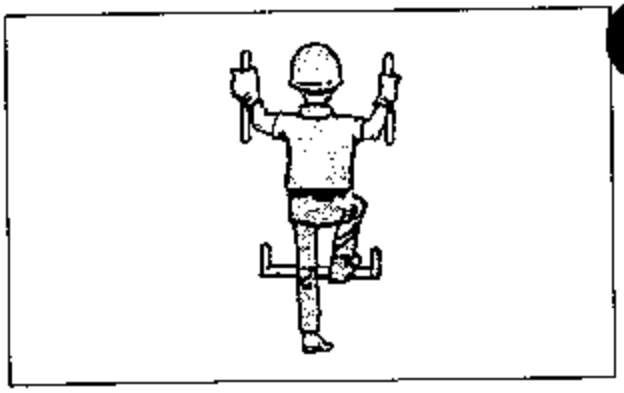
Stand behind the tread and use a self-attaching chuck when inflating a tire.

Servicing and changing tires and rims can be dangerous and should be done only by trained personnel using proper tools and procedures. If correct procedures are not followed while servicing tires and rims, the assemblies could burst with explosive force and cause serious personal injury or death. Follow carefully the specific information provided by your tire or rim servicing personnel or dealer.

Mounting and Dismounting



- Mount and dismount the machine only where steps and/or handholds are provided.
- Inspect, and when necessary, clean and have repairs made to steps and handholds before mounting and dismounting.

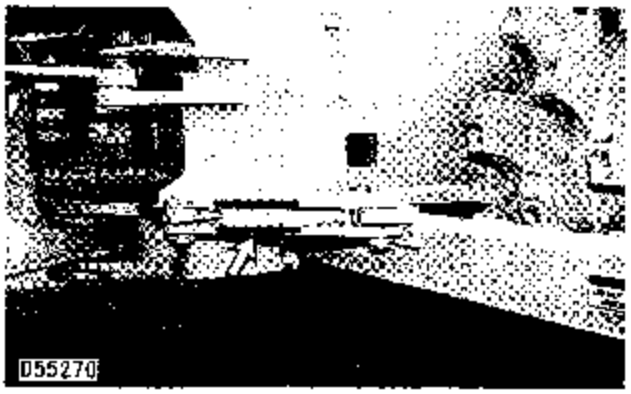


- Face the machine when mounting and dismounting.
- Maintain a three-point contact (two feet and one hand or one foot and two hands contact) with the steps and handholds.
- Never get on or off a moving machine.
- Never jump off the machine.
- Do not try to climb on or off the machine when carrying tools or supplies. Use a hand line to pull equipment up onto the platform.
- Do not use any controls as handholds when entering or leaving the operator's station.

Alternate Exit

Machines equipped with cabs are equipped with alternate exits. For additional alternate exit information, refer to topic Alternate Exit in the Monitoring Systems and Cab Features section of this manual.

Before Starting the Engine



Make sure the steering frame lock link is stored in the unlocked position as shown. The steering frame lock link must be removed to steer the machine.

Start the engine only from the operator's station. Never short across the starter terminals or across the batteries, as this could bypass the engine neutral-start system as well as damage the electrical system.

Inspect the condition of the seat belt and mounting hardware. Replace any damaged or worn parts. Replace the seat belt regardless of appearance, after three years of use. Do not use a seat belt extension or a retractable seat belt.

Adjust the seat so that full pedal travel can be obtained with the operator's back against the seat back.

Make sure the machine is equipped with a lighting system as required by conditions.

Make sure all lights are working properly.

Make sure no one is working on, underneath or close to the machine before starting the engine or beginning to move the machine. Make sure the area is free of personnel.

Engine Starting

Do not start the engine or move any of the controls if there is a Do Not Operate or similar warning tag attached to the start switch or controls.

Move all hydraulic controls to the HOLD position before starting the engine.

Move the transmission control lever to NEUTRAL.

Engage the parking brake

Diesel engine exhaust contains products of combustion which can be harmful to your health. Always start and operate the engine in a well-ventilated area. If in an enclosed area, vent the exhaust to the outside.

Before Operating the Machine

Clear all personnel from the machine and the area.

Clear all obstacles from the path of the machine. Beware of hazards such as wires, ditches, etc.

Be sure all windows are clean. Secure the doors and windows in either the open or shut position.

Adjust the rear view mirrors (if equipped) for best vision, especially close to the machine.

Make sure the machine horn, the backup alarm (if equipped) and all other warning devices are working properly.

Fasten the seat belt securely.

Machine Operation

Operate the machine only while seated and with the seat belt fastened.

Operate the controls only with the engine running.

Check for proper operation of all controls and protective devices while moving slowly in an open area.

The operator must be satisfied that no one will be endangered before moving the machine.

Do not allow riders on the machine unless additional seat, seat belt and Rollover Protective Structure (ROPS) are provided.

Report any needed repairs noted during operation.

Carry attachments close to the ground, approximately 40 cm (15 in) above ground level.

Stay an adequate distance from the edge of cliffs, overhangs and slide areas.

If the machine begins to sideslip on a grade, immediately dispose of the load and turn the machine downhill.

Be careful to avoid the condition which could lead to tipping when working on hills, banks or slopes, and when crossing ditches, ridges or other obstructions.

Work up and down slopes, rather than sideways, whenever possible.

Keep the machine under control and do not work it over its capacity.

Be sure hitch points and the towing device are adequate.

Connect trailing equipment to a drawbar or hitch only.

Never straddle a wire rope cable or similar device, nor allow others to do so.

No personnel should be between the machine and trailing equipment when maneuvering to connect them. Block the tongue or hitch of trailing equipment to align it with the drawbar or hitch.

Know the maximum height and reach of your machine.

Always keep the Rollover Protective Structure (ROPS) installed (if equipped) when operating the machine.

Machine Parking

Park on a level surface. If necessary to park on a grade, block the machine.

Apply the service brake to stop the machine.

Move the transmission control lever to NEUTRAL and the speed control to LOW IDLE.

Engage the parking brake.

Lower all attachments to the ground.

Stop the engine.

Turn the engine start switch key to OFF and remove.

Turn the battery disconnect switch key to OFF and remove the key when leaving the machine for an extended period of a month or longer. This will prevent battery drain by short circuits or current draw made by some of the components, or by vandalism.

Sound and Vibration Information

Sound Level for Enclosed Cab

The operator sound pressure level for this machine with a properly installed and maintained closed cab configuration is 75 dB (A).

Measurement is obtained on a static machine with the procedures and cab conditions as described in ISO 6394 or 86/662/EEC.

Vibration Level

Hands/Arms: The weighted root mean square acceleration to which the hands/arms are subjected, is less than 2.5 m/s^2.

Whole Body: The weighted root mean square acceleration to which the whole body is subjected is less than 0.85 m/s^2.

Measurements are obtained on a representative machine, using measuring procedures as set forth in the following standards: ISO 2631/1, ISO 5349, and SAE J1166.

CATERPILLAR®

SENR3130-04
December 1994

Specifications

Torque Specifications

Standard Torque For Metric Fasteners

NOTE: Take care to avoid mixing metric and inch dimensioned fasteners. Mismatched or incorrect fasteners can result in vehicle damage or malfunction, or possible injury. Exceptions to these torques are given in the Service Manual where needed.

NOTE: Prior to installation of any hardware, be sure components are in near new condition. Bolt and threads must not be worn or damaged. Hardware must be free of rust and corrosion. Clean hardware with a non-corrosive cleaner and apply engine oil to threads and bearing face. If thread lock or other compounds are to be applied, do not apply engine oil.

METRIC NUTS AND BOLTS		
Thread Size Metric	Standard Torque	
	N·m	lb ft
M6	12 ± 3	9 ± 2
M8	28 ± 7	20 ± 5
M10	55 ± 10	40 ± 7
M12	100 ± 20	75 ± 15
M14	160 ± 30	120 ± 22
M16	240 ± 40	175 ± 30
M20	460 ± 60	340 ± 45
M24	800 ± 100	600 ± 75
M30	1600 ± 200	1200 ± 150
M36	2700 ± 300	2000 ± 225

METRIC TAPERLOCK STUDS		
Thread Size Metric	Standard Torque	
	N·m	lb ft
M6	8 ± 3	6 ± 2
M8	17 ± 5	13 ± 4
M10	35 ± 5	26 ± 4
M12	65 ± 10	48 ± 7
M16	110 ± 20	80 ± 15
M20	170 ± 30	125 ± 22
M24	400 ± 60	300 ± 45
M30	750 ± 80	550 ± 60
M36	1200 ± 150	890 ± 110

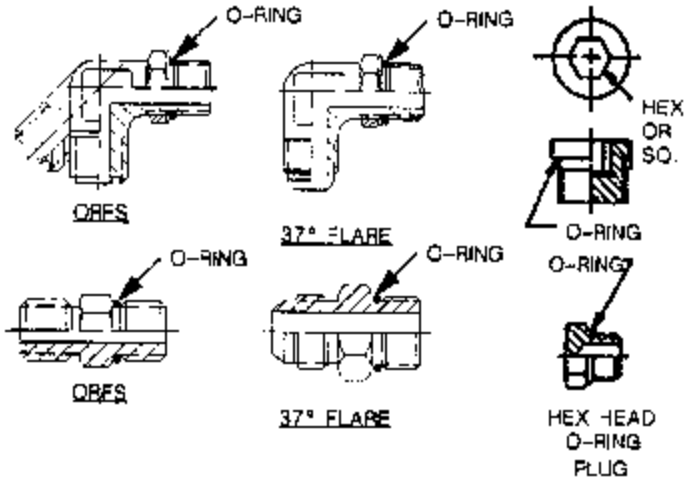
Standard Torque For Inch Fasteners

Exceptions to these torques are given in the Service Manual where needed.

INCH NUTS AND BOLTS		
Thread Size Inch	Standard Torque	
	N·m	lb ft
1/4	12 ± 3	9 ± 2
5/16	25 ± 6	18 ± 4.5
3/8	47 ± 9	35 ± 7
7/16	70 ± 15	50 ± 11
1/2	105 ± 20	75 ± 15
9/16	160 ± 30	120 ± 20
5/8	215 ± 40	160 ± 30
3/4	370 ± 50	275 ± 35
7/8	620 ± 80	460 ± 60
1	900 ± 100	660 ± 75
1 1/8	1300 ± 150	950 ± 100
1 1/4	1800 ± 200	1325 ± 150
1 3/8	2400 ± 300	1800 ± 225
1 1/2	3100 ± 350	2300 ± 250

INCH TAPERLOCK STUDS		
Thread Size Inch	Standard Torque	
	N·m	lb ft
1/4	8 ± 3	6 ± 2
5/16	17 ± 5	13 ± 4
3/8	35 ± 5	26 ± 4
7/16	45 ± 10	33 ± 7
1/2	65 ± 10	48 ± 7
5/8	110 ± 20	80 ± 15
3/4	170 ± 30	125 ± 22
7/8	260 ± 40	190 ± 30
1	400 ± 60	300 ± 45
1 1/8	525 ± 60	390 ± 45
1 1/4	750 ± 80	550 ± 60
1 3/8	950 ± 125	700 ± 92
1 1/2	1200 ± 150	890 ± 110

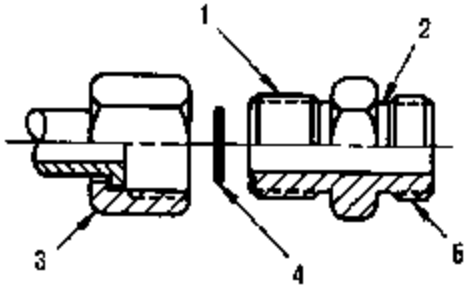
Standard Torque For O-Ring Face Seal Fittings And 37° Flared Fittings



FERROUS STRAIGHT THREAD O-RING PORT FITTING (TORQUES MATING WITH FERROUS MATERIALS)		
Nominal Tube O.D. mm (in)	Thread Size inch	Standard Torque N•m (lb ft)
3.18 (.125)	3/16 - 24	5.0 ± 1.5 (4 ± 1)
4.76 (.188)	3/8 - 24	12 ± 2 (9 ± 1)
6.35 (.250)	7/16 - 20	20 ± 2 (15 ± 1)
7.94 (.312)	1/2 - 20	25 ± 3 (18 ± 2)
9.52 (.375)	9/16 - 18	35 ± 3 (26 ± 2)
9.52 (.375)	5/8 - 18	50 ± 5 (37 ± 4)
12.70 (.500)	3/4 - 16	75 ± 7 (55 ± 5)
15.88 (.625)	7/8 - 14	105 ± 10 (75 ± 7)
19.05 (.750)	1 1/16 - 12	175 ± 15 (130 ± 11)
22.22 (.875)	1 3/16 - 12	230 ± 20 (170 ± 15)
25.40 (1.000)	1 5/16 - 12	285 ± 30 (210 ± 22)
31.75 (1.250)	1 5/8 - 12	330 ± 30 (240 ± 22)
38.10 (1.500)	1 7/8 - 12	430 ± 40 (320 ± 30)
50.80 (2.000)	2 1/2 - 12	450 ± 45 (330 ± 33)

NOTE: Use 50 percent of the above torque values when either the fitting or port material is non-ferrous.

O-Ring Face Seal Fittings



O-Ring Face Seal Fittings
1. O-ring face seal fitting. 2. O-ring groove. 3. O-ring face seal nut. 4. O-ring. 5. Straight thread O-ring port end fitting.

O-RING FACE SEAL FITTING NUT		
Thread Size inch	Standard Torque	
	N•m	lb ft
9/16 - 18	15 ± 2	11 ± 1.5
11/16 - 16	25 ± 2	18 ± 1.5
13/16 - 16	45 ± 4	33 ± 3
1 - 14	65 ± 6	48 ± 4.5
1 3/16 - 12	90 ± 9	65 ± 7
1 7/16 - 12	130 ± 15	95 ± 11
1 11/16 - 12	180 ± 20	135 ± 15
2 - 12	210 ± 20	155 ± 15

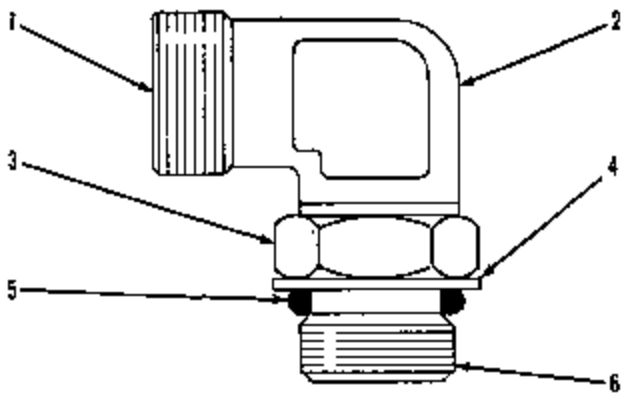
Fitting Installation

Hydraulic Line Installation

1. For a metal tube to hose installation, install the tube and tighten all bolts finger tight.
2. Tighten the bolts at the rigid end.
3. Install the hose and tighten all bolts finger tight.
4. Put the hose in a position so that it does not make contact with the machine or another hose.
5. Tighten the bolts on both connections.
6. Start the engine.
7. Move the implement control levers to all positions.
8. Look at the hose during movement of the implement. Make sure hose is not in contact with the machine or other hoses.
9. Shut off the engine.
10. If necessary, put the hose in a new position where it will not make contact when the implement is moved.

Assembly Of Fittings With Straight Threads And O-Ring Seals

This type of fitting is used in many applications. The tube end of the fitting will be different in design so that it can be used in many different applications. However, the installation procedure of the fitting is the same. If the tube end of the fitting body is the same as in the illustration (either an elbow or a straight body) it will be necessary to assemble the sleeve on the tube before connecting the tube to the end.



Elbow Body Assembly
1. End of fitting body (connects to tube). 2. Fitting body. 3. Locknut. 4. Backup washer. 5. O-ring seal. 6. End of fitting that goes into other part.

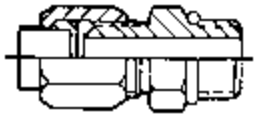
1. Put locknut (3), backup washer (4) and O-ring seal (5) as far back on fitting body (2) as possible. Hold these components in this position. Turn the fitting into the part it is used on until backup washer (4) just makes contact with the face of the part it is used on.
2. To put the fitting assembly in its correct position, turn the fitting body (2) out (counterclockwise) a maximum of 359 degrees. Tighten locknut (3) to the torque shown in the correct chart for the fitting used.

NOTE: If the fitting is a connector (straight fitting), the hex on the body takes the place of the locknut. To install this type fitting, tighten the hex against the face of the part it goes into.

Torques For Flared And O-Ring Fittings

The torques shown in the charts that follow are to be used on the nut part of 37 Degree Flared, 45 Degree Flared and Inverted Flared fittings (when used with steel tubing), O-Ring plugs, O-Ring fittings and swivel nuts when used in applications to 20 700 kPa (3000 psi).

37° Flared Fittings

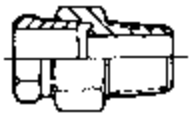


37° FLARED

SWIVEL NUTS

37° FLARED FITTING NUTS		
Nominal Tube O.D. mm (in)	Thread Size inch	Standard Torque N•m (lb ft)
3.18 (.125)	5/16	5.0 ± 1.5 (4 ± 1)
4.76 (.188)	3/8	11 ± 2 (8.0 ± 1.5)
6.35 (.250)	7/16	16 ± 4 (12 ± 3)
7.94 (.312)	1/2	20 ± 5 (15 ± 4)
9.52 (.375)	9/16	25 ± 5 (18 ± 4)
9.52 (.375)	5/8	35 ± 5 (26 ± 4)
12.70 (.500)	3/4	50 ± 7 (37 ± 5)
15.88 (.625)	7/8	65 ± 7 (48 ± 5)
19.05 (.750)	1 1/16	100 ± 10 (75 ± 7)
22.22 (.875)	1 3/16 - 12	120 ± 10 (90 ± 7)
25.40 (1.000)	1 5/16	135 ± 15 (100 ± 11)
31.75 (1.250)	1 5/8	180 ± 15 (135 ± 11)
38.10 (1.500)	1 7/8	225 ± 15 (165 ± 11)
50.80 (2.000)	2 1/2	320 ± 30 (240 ± 22)

45° Flared And 45° Inverted Flare Fittings

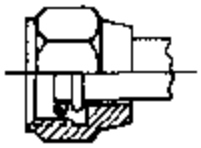


INVERTED 45° FLARED

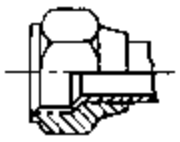
45° FLARED

45° FLARED AND 45° INVERTED FLARE FITTINGS		
Nominal Tube O.D. mm (in)	Thread Size inch	Standard Torque N•m (lb ft)
3.18 (.125)	5/16	5.0 ± 1.5 (4 ± 1)
4.76 (.188)	3/8	8.0 ± 1.5 (6 ± 1)
6.35 (.250)	7/16	11 ± 2 (8.0 ± 1.5)
7.94 (.312)	1/2	17 ± 3 (13 ± 2)
9.52 (.375)	5/8	30 ± 3 (22 ± 2)
11.11 (.438)	11/16	30 ± 3 (22 ± 2)
12.70 (.500)	3/4	38 ± 4 (28 ± 3)
15.88 (.625)	7/8	50 ± 5 (37 ± 4)
19.05 (.750)	1 1/16	90 ± 8 (65 ± 6)
22.22 (.875)	1 1/4	100 ± 10 (75 ± 7)

Air Conditioning Fittings



O-RING



45° FLARE

AIR CONDITIONING FITTINGS			
O-Ring Fitting End		45° Flare Fitting End	
Thread Size inch	Standard Torque N•m (lb ft)	Steel Tubes Standard Torque N•m (lb ft)	Aluminum Tubes Standard Torque N•m (lb ft)
5/8 - 18	14 ± 4 (10 ± 3)	30 ± 3 (22 ± 2)	23 ± 3 (17 ± 2)
3/4 - 16	27 ± 4 (20 ± 3)	52 ± 5 (38 ± 4)	33 ± 4 (24 ± 3)
7/8 - 14	40 ± 4 (30 ± 3)	60 ± 7 (44 ± 5)	38 ± 4 (28 ± 3)
1 1/16 - 14	45 ± 5 (33 ± 4)	75 ± 8 (55 ± 6)	50 ± 5 (37 ± 4)

Tapered Pipe Thread Fittings

TAPERED PIPE THREAD FITTINGS		
Pipe Thread Size inch	Standard Torque	
	Threads with 1E2200E Sealant	Threads without Sealant
	N•m (lb ft)	N•m (lb ft)
1/16 - 27	15 (11)	20 (15)
1/8 - 27	20 (15)	25 (18)
1/4 - 18	25 (18)	35 (26)
3/8 - 18	35 (26)	45 (33)
1/2 - 14	45 (33)	60 (45)
3/4 - 14	60 (45)	75 (55)
1 - 11 1/2	75 (55)	90 (65)
1 1/4 - 11 1/2	95 (70)	110 (80)
1 1/2 - 11 1/2	110 (80)	130 (95)
2 - 11 1/2	130 (95)	160 (120)

Tightening Other Fittings

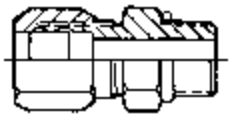
Hi Duty (Shear Sleeve) Tube Fittings

After tube has been put through the nut and makes contact against the tube shoulder in the fitting body, turn the nut with a wrench until a small decrease in torque is felt. This is an indication that the sleeve has been broken off the nut. Hold the tube to prevent turning and tighten the nut 1½ turns.

Hi Seal Fittings

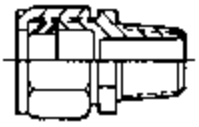
Put nut and sleeve over the tubing with the short heavy end of the sleeve facing the end of tubing. Put the tube end against the counterbore in the body of the fitting and tighten until nut is over the last thread on the body. The remainder of space is used whenever the fitting is removed and installed again.

Ermeto Tube Fittings



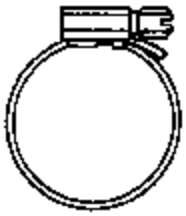
Put nut and sleeve over the tube with head or shoulder end of sleeve next to nut. Push tube into counterbore of fitting body as far as possible. Turn nut clockwise until sleeve holds tube and prevents movement. Tighten the nut 1¼ turns more to seat sleeve and give a locking action. When necessary to assemble again, put sleeve over tube and tighten nut until a sudden increase in torque is felt. Then tighten ⅙ to ⅓ turn more to seat the sleeve.

Flex Fittings



Put nut and sleeve over the tubing and push tube into counterbore of fitting body as far as possible. Tighten the nut until it is against the hex part of the fitting body.

Torque for Standard Hose Clamps – Worm Drive Band Type



HOSE CLAMP – BAND TYPE		
Clamp Width	Torque On New Hose	Retightening Torque
7.9 mm (.312 in)	0.9 ± 0.2 N•m (8 ± 2 lb in)	0.7 ± 0.2 N•m (6 ± 2 lb in)
13.5 mm (.531 in)	4.5 ± 0.5 N•m (40 ± 5 lb in)	3.0 ± 0.5 N•m (25 ± 5 lb in)
15.9 mm (.625 in)	7.5 ± 0.5 N•m (65 ± 5 lb in)	4.5 ± 0.5 N•m (40 ± 5 lb in)

Torque for Constant Torque Hose Clamps

A constant torque hose clamp can be used in place of any standard hose clamp. Make sure the constant torque hose clamp is the same size as the standard clamp. Due to extreme temperature changes, hose will heat set. Heat setti causes hose clamps to loosen. Loose hose clamps can res in leaks. There have been reports of component failures caused by hose clamps loosening. The new, constant torqu hose clamp will help prevent these failures.

Each installation application can be different depending on the type of hose, fitting material and anticipated expansion contraction of the hose and fittings. A torque wrench shoul be used for proper installation of the new, constant torque hose clamps. Constant torque hose clamps should be installed as follows:

- To allow for maximum expansion, install clamps at 5.7 N•r (50 lb in).
- To allow for equal expansion and contraction, instal clamp at 10.2 N•m (90 lb in).
- To allow for maximum contraction, install clamps at 14.1 N•m (125 lb in).

CATERPILLAR®

SENR5593
September 1995

Specifications

3306B Engine
For Caterpillar Built Machines

8Z82840-UP
10Z29500-UP
13Z32475-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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Introduction

When the words "use again" are in the description, the specification given can be used to determine if a part can be used again. If the part is equal to or within the specification given, use the part again.

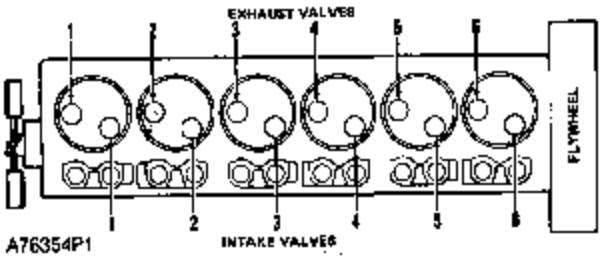
When the word "permissible" is in the description, the specification given is the "maximum or minimum" tolerance permitted before adjustment, repair and/or new parts are needed.

A comparison can be made between the measurements of a worn part and the specifications of a new part to find the amount of wear. A part that is worn can be safe to use if an estimate of the remainder of its service life is good. If a short service life is expected, replace the part.

REFERENCE: See 3306B Engine, SENR5594.

Specifications

Engine Design



Cylinder And Valve Location

Bore ..... 120.7 mm (4.75 in)

Stroke ..... 152.4 mm (6.00 in)

Number of Cylinders 6

Cylinder Arrangement ..... in line

Valves per Cylinder 2

Combustion ..... Direct Injection

Firing Order (Injection Sequence) 1, 5, 3, 6, 2, 4

Rotation of Crankshaft (when seen from flywheel end) ..... counterclockwise

NOTE: The No. 1 cylinder is opposite the flywheel end.

Fuel Injection

Firing order (injection sequence) 1,5,3,6,2,4

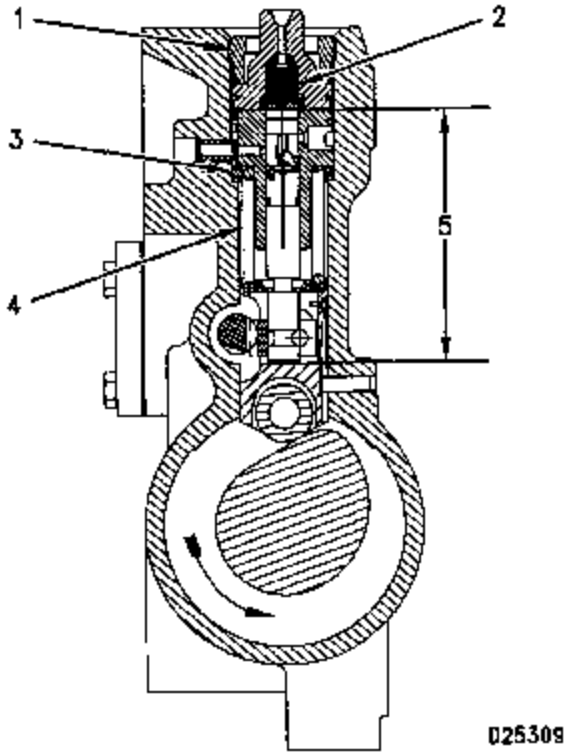
Injection Timing Before TC (Top Center)

Fuel Injection Pump Group:

- 7C2605 ..... 18 degrees
- 6I2830 ..... 12 degrees
- 6I2831 ..... 14 degrees
- 6I2832 ..... 18 degrees
- 6I2834 ..... 21 degrees
- 6I2837 ..... 27 degrees
- 7W5932 ..... 14 degrees
- 106-7684 ..... 16.5 degrees
- 111-3769 ..... 10 degrees
- 115-9595 ..... 11 degrees
- 120-9296 ..... 8 degrees
- 120-9931 ..... 12 degrees

For information on additional fuel injection pump groups refer to TMI (Technical Marketing Information)

Fuel Injection Pump



Torque for the nuts that hold the fuel lines (use 5P144 Fuel Line Socket) ..... 40 ± 7 N•m (30 ± 5 lb ft)

(1) Torque for bushing ..... 163 ± 14 N•m (120 ± 10 lb ft)

(2) 8N1415 Spring (reverse flow check):
- Length under test force ..... 8.69 mm (.342 in)
- Test force ..... 111.21 ± 6.5 N (25 ± 1 lb)
- Free length after test ..... 12.12 mm (.477 in)
- Outside diameter ..... 9.78 mm (.385 in)

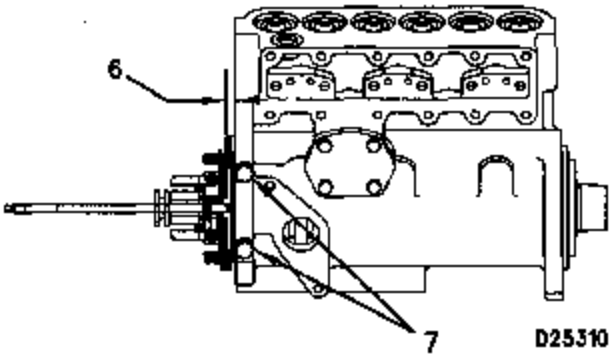
(3) Thickness of 4W6669 Spacer ..... 5.049 − 0.005 mm (.1988 ± .0002 in)

(4) 7N1067 Spring:
- Length under test force ..... 43.52 mm (1.713 in)
- Test force ..... 116.5 ± 5.8 N (26.18 ± 1.30 lb)
- Free length after test ..... 48.73 mm (1.918 in)
- Outside diameter ..... 25.9 mm (1.02 in)

(4) 4P9831 Spring:
- Length under test force ..... 44.60 mm (1.756 in)
- Test force ..... 74.5 ± 3.7 N (16.74 ± .83 lb)
- Free length after test ..... 47.85 mm (1.884 in)
- Outside diameter ..... 25.9 mm (1.02 in)

(5) Length of pump plunger (new) ..... 73.886 ± 0.013 mm (2.9089 ± .0005 in)

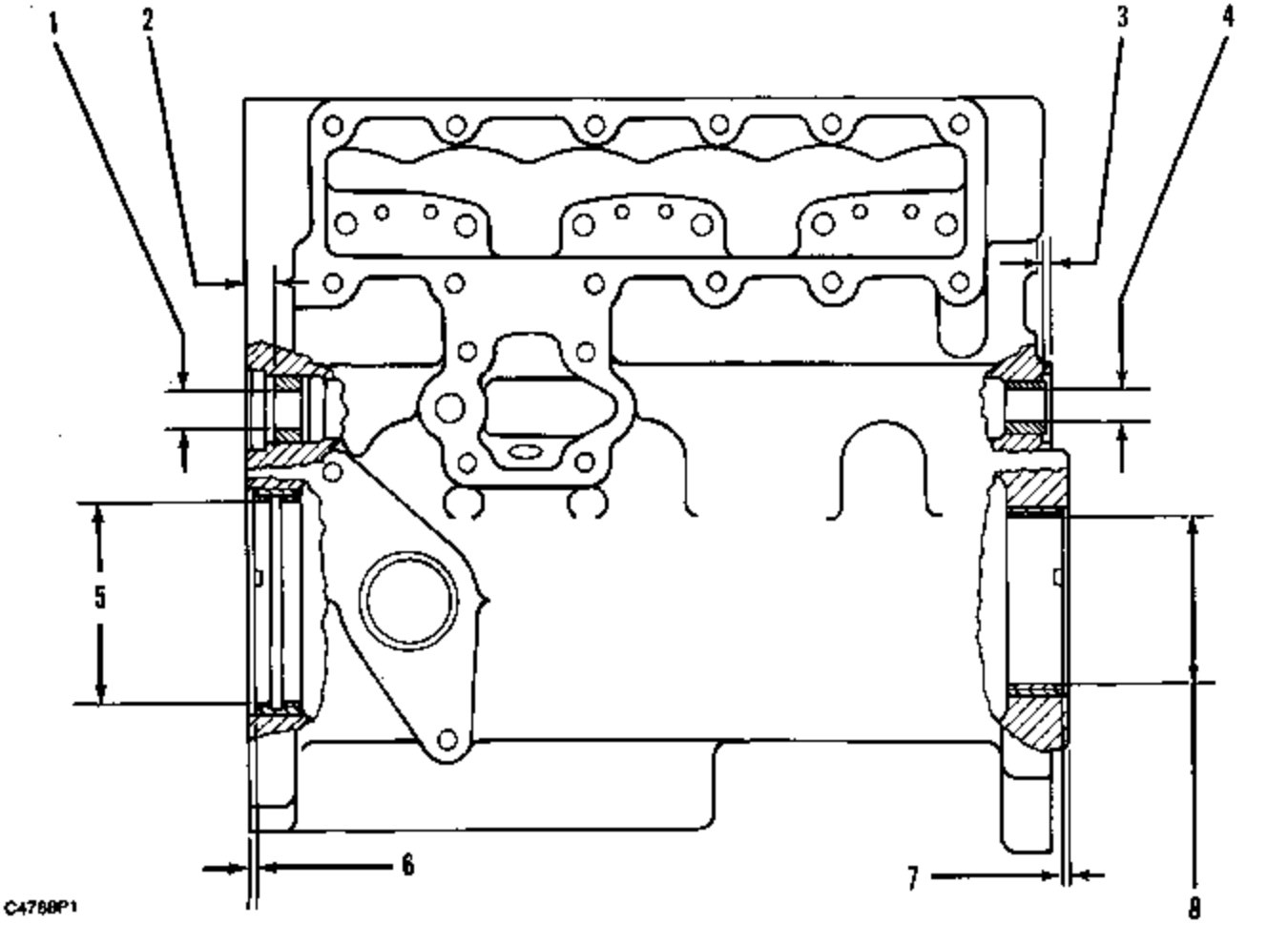
Minimum permissible length (worn) ..... 73.873 mm (2.9084 in)



(6) Distance from housing to end of rack when rack and gears are engaged at center of fourth tooth position ..... 7.24 ± 0.08 mm (.285 ± .003 in)

(7) Torque for plugs ..... 5 ± 1 N•m (44 ± 9 lb in)

Fuel Injection Pump Housing



(1) Diameter of the rack bearing in the governor end after assembly .... 12.746 ± 0.045 mm (.5018 ± .0018 in)
Diameter of fuel rack .... 12.662 ± 0.005 mm (.4985 ± .0002 in)

(2) Distance from the governor end of the pump housing to the end of the rack bearing ..... 7.16 ± 0.13 mm (.282 ± .005 in)

(3) Distance from the drive end of the pump housing to the end of the rack bearing .... 0.25 ± 0.25 mm (.010 ± .010 in)

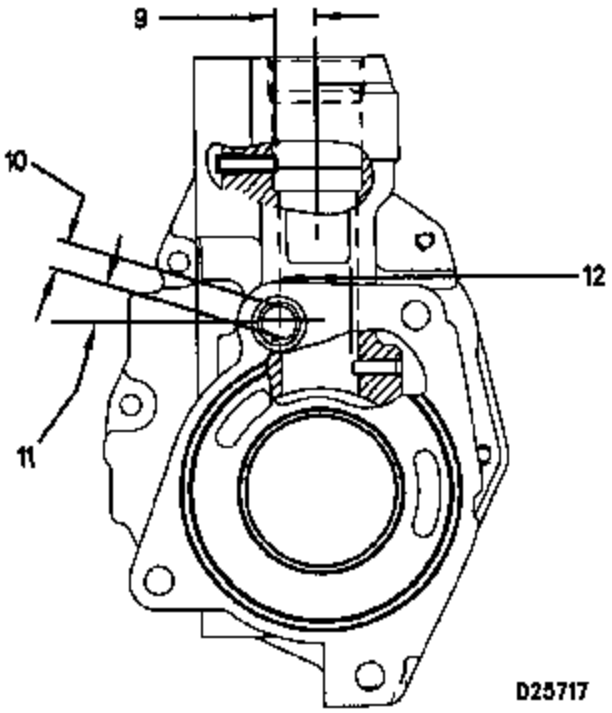
(4) Diameter of the rack bearing in the drive end after assembly ..... 12.767 ± 0.058 mm (.5026 ± .0023 in)

(5) Inside diameter of the camshaft bearing in the governor end of the pump housing after assembly .... 68.339 ± 0.039 mm (2.6905 ± .0015 in)
Diameter of the camshaft bearing journal .... 68.250 ± 0.013 mm (2.6870 ± .0005 in)
Install the camshaft bearing in the pump housing with the bearing joint at the top of the vertical centerline.

(6) Distance from the governor end of the pump housing to the end of the camshaft bearing .... 0.25 ± 0.20 mm (.010 ± .008 in)

(7) Distance from the drive end of the pump housing to the end of the camshaft bearing ..... 1.00 ± 0.25 mm (.039 ± .010 in)

(8) Inside diameter of the camshaft bearing in the drive end of the pump housing .... 55.090 ± 0.039 mm (2.1689 ± .0015 in)
Diameter of the camshaft bearing journal ..... 55.000 ± 0.013 mm (2.1654 ± .0005 in)
Install the camshaft bearing in the pump housing with the bearing joint at the top of the vertical centerline.



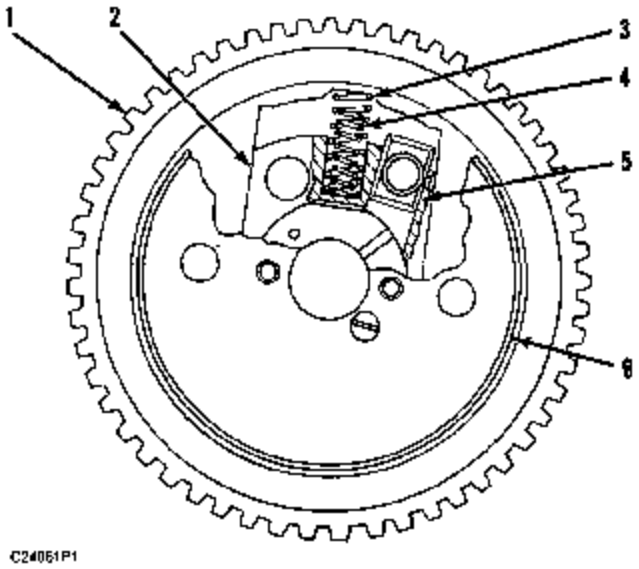
(9) Distance from the centerline of the pump bore to the end of the dowel ..... 15.03 ± 0.25 mm (.592 ± .010 in)

(10) Distance from flat surface of the rack bearing to the opposite wall of the bore after assembly ..... 11.178 ± 0.050 mm (.4401 ± .0020 in)

(11) Install the rack bearing with the flat surface (as shown) to an angle of ..... 15 degrees

(12) Distance from the end of the dowel to the opposite wall of the bore ..... 26.492 ± 0.100 mm (1.0430 ± .0040 in)

Automatic Timing Advance



(1) Fuel pump drive gear.

(2) Weight assembly.

(3) 1W5879 Outer Spring:

Length under test force	44.2 mm (1.74 in)
Test force	40 ± 2 N (9.0 ± .3 lb)
Free length after test	54.6 mm (2.15 in)
Outside diameter	15.4 mm (.61 in)

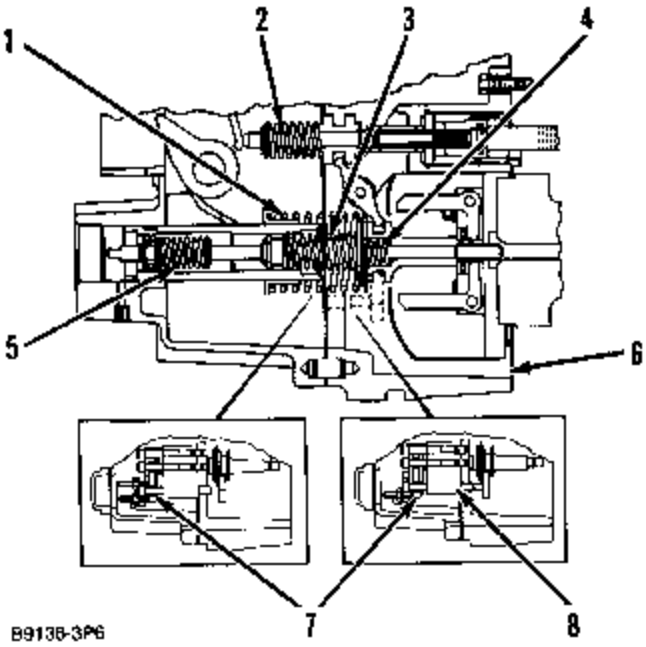
(4) 1W5878 Inner Spring:

Length under test force	35.7 mm (1.41 in)
Test force	none
Free length after test	35.7 mm (1.41 in)
Outside diameter	11.1 mm (.44 in)

(5) Slide.

(6) Plate.

Governor



(1) Governor spring. See the Governor Spring Chart.

(2) Broken link spring. See the Miscellaneous Spring Chart.

(3) Dashpot spring. See the Miscellaneous Spring Chart.

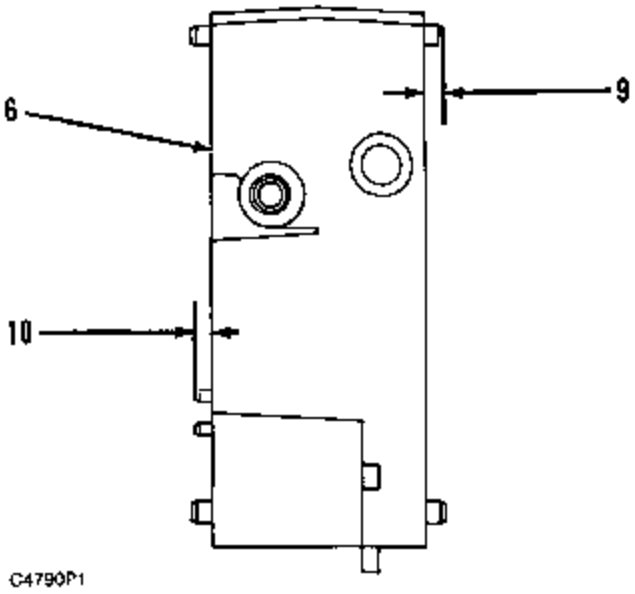
(4) Overfueling spring. See the Miscellaneous Spring Chart.

(5) Centering spring. See the Miscellaneous Spring Chart.

(6) Governor housing assembly.

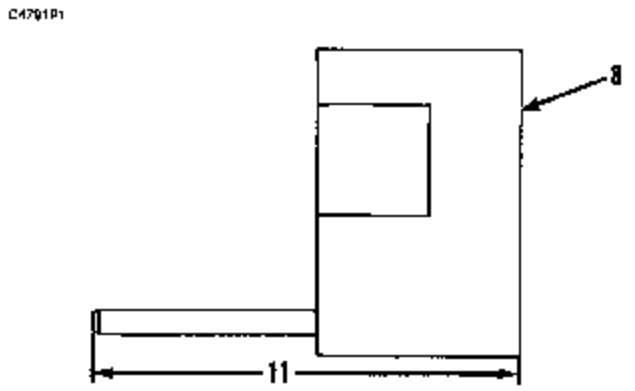
(7) Bumper spring. See the Miscellaneous Spring Chart.

(8) Full load stop block.

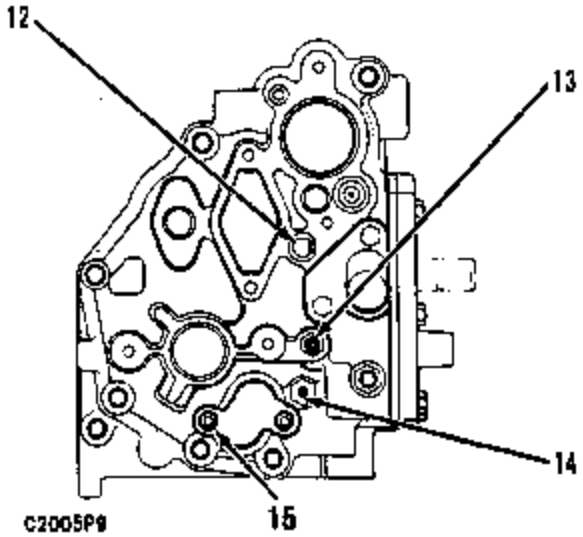


(9) Distance four dowels extend above the surface of governor housing (6) ..... 6.0 ± 0.5 mm (.24 ± .02 in)

(10) Distance two dowels extend above the surface of the governor housing ..... 3.0 ± 0.5 mm (.12 ± .02 in)



(11) Distance from the surface of block (8) to the end of the dowel ..... 62.00 ± 0.75 mm (2.44 ± .03 in)

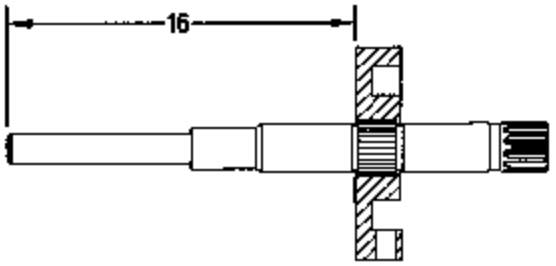


(12) Tighten the plug to a torque of ..... 14 ± 2 N•m (10 ± 1 lb ft)

(13) Tighten the body to a torque of .... 6.25 ± 1.35 N•m (4.6 ± 1.0 lb ft)

(14) Tighten the insulator to a torque of .... 3.4 ± 0.5 N•m (31 ± 4 lb in)

(15) Tighten bolts to a torque of ..... 3.5 ± 0.4 N•m (31 ± 4 lb in)



(16) Throttle shaft assembly. Be sure collar is installed to a length of .. .. 105.2 ± 0.5 mm (4.14 ± .02 in)

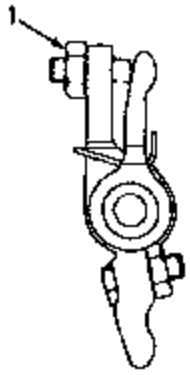
NOTE: This dimension is required to properly reassemble the governor to insure engine shutdown or prevent internal governor damage from the lever assembly.

GOVERNOR SPRING CHART (1)				
Spring Part No.	**7L4958**	**7L8058**	**8L9790**	**8M9140**
Color Code And No. Of Stripes:	two white	two yellow	one end pink	one green
Put a force on spring of:	13.4 N (3.00 lb)	35.6 N (8.00 lb)	17.8 N (4.00 lb)	17.8 N (4.00 lb)
Then add more force to make spring shorter by:	22.86 mm (.900 in)	20.32 mm (.800 in)	22.86 mm (.900 in)	22.86 mm (.900 in)
Total test force	47.8 ± 1.5 N (10.74 ± .34 lb)	41.5 ± 1.1 N (9.32 ± .24 lb)	59.9 ± 1.2 N (13.45 ± .27 lb)	73.9 ± 1.4 N (16.6 ± .32 lb)
Free length after test	59.4 ± 1.0 mm (2.34 ± .04 in)	59.4 ± 1.0 mm (2.34 ± .04 in)	59.4 ± 1.0 mm (2.34 ± .04 in)	59.4 ± 1.0 mm (2.34 ± .04 in)
Outside diameter	34.57 ± 0.38 mm (1.361 ± .015 in)	34.57 ± 0.38 mm (1.361 ± .015 in)	34.98 ± 0.38 mm (1.377 ± .015 in)	34.93 ± .38 mm (1.375 ± 0.015 in)

GOVERNOR SPRING CHART (1)			
Spring Part No.	**8M9141**	**2N2675**	**8N8594**
Color Code And No. Of Stripes:	one purple	one brown	two lt. blue
Put a force on spring of:	17.8 N (4.00 lb)	28.9 N (6.50 lb)	22.2 N (5.00 lb)
Then add more force to make spring shorter by:	65.9 ± 2.2 N (14.80 ± .50 lb)	46.7 ± 0.4 N (10.50 ± .10 lb)	53.7 ± 0.9 N (12.07 ± .20 lb)
Total test force	65.9 ± 2.2 N (14.80 ± .50 lb)	46.7 ± 0.44 N (10.50 ± .10 lb)	53.7 ± 0.94 N (12.10 ± .21 lb)
Free length after test	59.4 ± 1.0 mm (2.34 ± .04 in)	59.4 ± 1.0 mm (2.34 ± .04 in)	59.4 ± 1.0 mm (2.34 ± .04 in)
Outside diameter	34.82 ± 0.38 mm (1.371 ± .015 in)	33.99 ± 0.38 mm (1.338 ± .015 in)	34.89 ± 0.38 mm (1.373 ± .015 in)

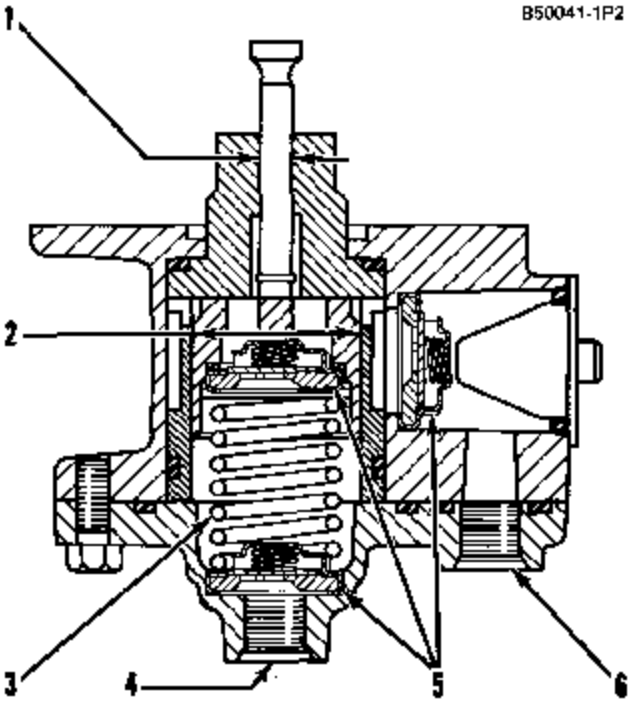
MISCELLANEOUS SPRING CHART					
Spring Type	**(2) Broken Link**	**(3) Dashpot**	**(4) Overfueling**	**(5) Centering**	**(7) Bumper**
Part No.	**2W2216**	**4N6410**	**7N7267**	**3K5733**	**1W4243**
Length under test force	26.23 mm (1.033 in)	26.16 mm (1.030 in)	10.75 mm (.423 in)	19.3 mm (.76 in)	26.3 mm (1.04 in)
Test force	13.34 ± 0.66 N (3.002 ± .149 lb)	4.45 ± 0.36 N (1.00 ± .08 lb)	2.22 ± 0.11 N (.50 ± .02 lb)	61 ± 5 N (13.7 ± 1.1 lb)	0.194 N (.0437 lb)
Free length after test	58.74 mm (2.31 in)	31.24 mm (1.230 in)	32.95 mm (1.297 in)	31 ± 2 mm (1.22 ± .08 in)	32 mm (1.3 in)
Outside diameter	11.32 mm (.45 in)	14.8 mm (.58 in)	11.0 mm (.433 in)	14.35 mm (.565 in)	8.3 mm (.33 in)
Color Code (stripes)	none	one pink	none	none	one yellow

Shutoff Pivot Lever



(1) Tighten locknut to a torque of .... 1.70 ± 0.25 N•m (15 ± 2 lb in)

Fuel Transfer Pump



(1) Clearance between guide and tappet .... 0.0025 to 0.0101 mm (.0001 to .0004 in)

NOTE: The guide and tappet are a matched set. If one part is worn, a new guide and tappet assembly must be installed.

(2) Bore in sleeve for the piston .. .. 34.000 ± 0.015 mm (1.3386 ± .0006 in)

Diameter of piston ..... 33.972 ± 0.008 mm (1.3375 ± .0003 in)

(3) 7W0134 Spring:

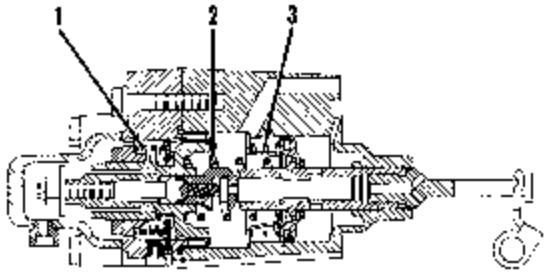
Length under test force ..... 33.67 mm (1.326 in)
Test force ..... 221 ± 11 N (49.7 ± 2.5 lb)
Free length after test .... 56.1 mm (2.21 in)
Outside diameter ..... 27.36 mm (1.08 in)

(4) Fuel inlet port.

(5) Check valves.

(6) Fuel outlet port.

Fuel Ratio Control



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(1) 7W2826 Spring:

Length under test force ..... 13.59 mm (.535 in)
Test force .... 77.4 ± 2.32 N (17.4 ± .52 lb)
Free length after test ... . 32.56 mm (1.281 in)
Outside diameter .... 35.12 mm (1.383 in)

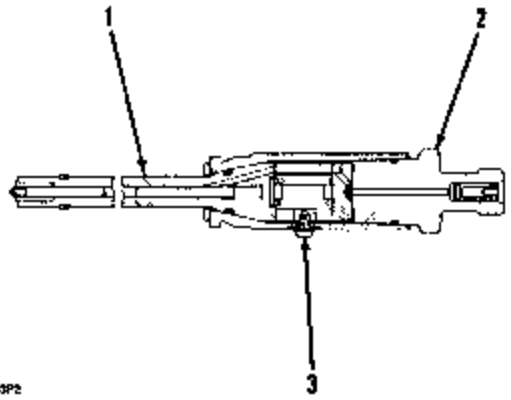
(2) 7W2828 Spring:

Put a load on spring of .... 77.4 N (17.4 lb)
Then make spring shorter by .... 3.68 mm (.145 in)
Total test force ..... 107.69 ± 1.51 N (24.20 ± .34 lb)
Free length after test .... 46.4 mm (1.83 in)
Outside diameter .... 24.45 mm (.963 in)

(3) 8N5765 Spring:

Length under test force .... 24.0 mm (.945 in)
Test force .... 22.25 ± 4 N (5.0 ± .9 lb)
Free length after test .... 80.5 mm (3.17 in)
Outside diameter . ... 35.57 mm (1.400 in)

Fuel Injection Nozzle



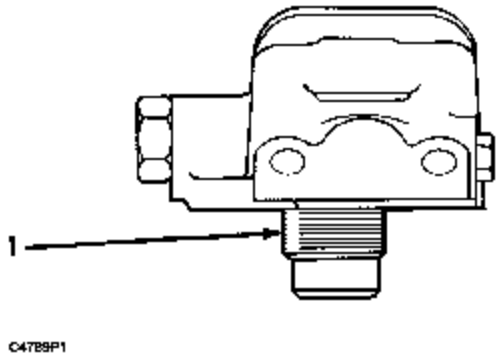
(1) Body assembly.

(2) Adapter assembly. Tighten to ... 72 ± 7 N•m (53 ± 5 lb ft)

(3) Bleed screw. Tighten to ..... 2.7 ± 0.8 N•m (25 ± 7 lb in)

The fuel injection nozzle cannot be disassembled and no adjustments can be made.

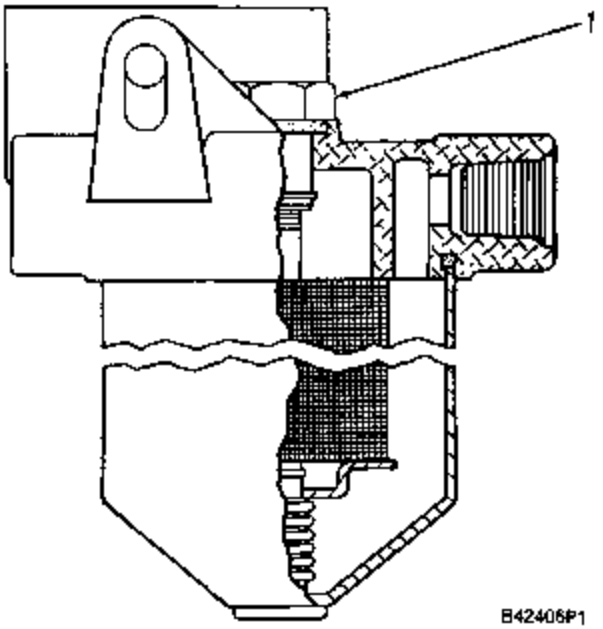
Fuel Filter Base



(1) Stud. Put 9S3265 Retaining Compound on the tapered end of the stud to a distance of .... 7.6 ± 1.5 mm (.30 ± .06 in)

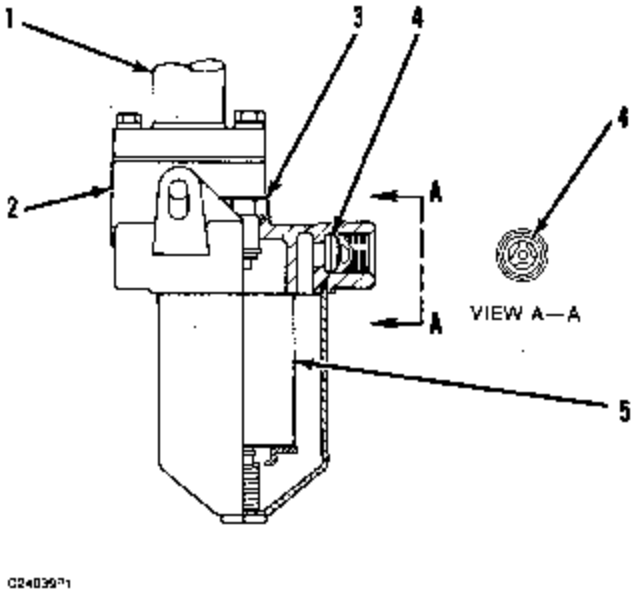
Tighten the stud to a torque of .... 68 ± 14 N•m (50 ± 10 lb ft)

Primary Fuel Filter



(1) Torque for fuel filter nut ..... . 24 ± 4 N•m (20 ± 3 lb ft)

Fuel Priming Pump And Primary Fuel Filter



(1) Fuel priming pump.

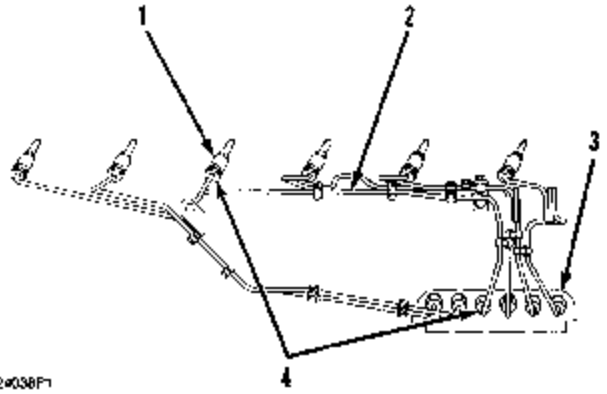
(2) Primary fuel filter base.

(3) Nut. Tighten to .... 24 ± 4 N•m (20 ± 3 lb ft)

(4) Check valve. Stake three places.

(5) Primary filter element.

Fuel Injection Lines



(1) Nozzle assembly.

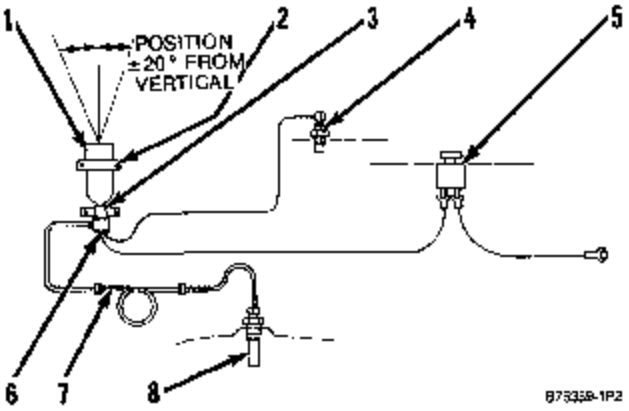
(2) Fuel injection lines.

(3) Fuel injection pump.

(4) Torque for nuts that hold the fuel injection line to the injection pump and nozzle ..... 41 ± 7 N•m (30 ± 5 lb ft)

NOTE: Nozzle assembly (1) must be supported with a wrench while tightening the fuel line nut.

Ether Starting Aid



Typical example

(1) Ether cylinder assembly.

(2) Clamp assembly.

(3) Ether valve assembly. Do not mount in a location that subjects valve assembly and cylinder assembly (1) to temperatures greater than 93°C (200°F).

Install valve assembly so cylinder assembly (1) can be installed in a vertical position as shown.

(4) Temperature switch. The temperature switch will not allow starting fluid to reach the atomizer if the engine temperature is above 38°C (100°F).

(5) Starting aid switch. Install switch close to operator's starting station.

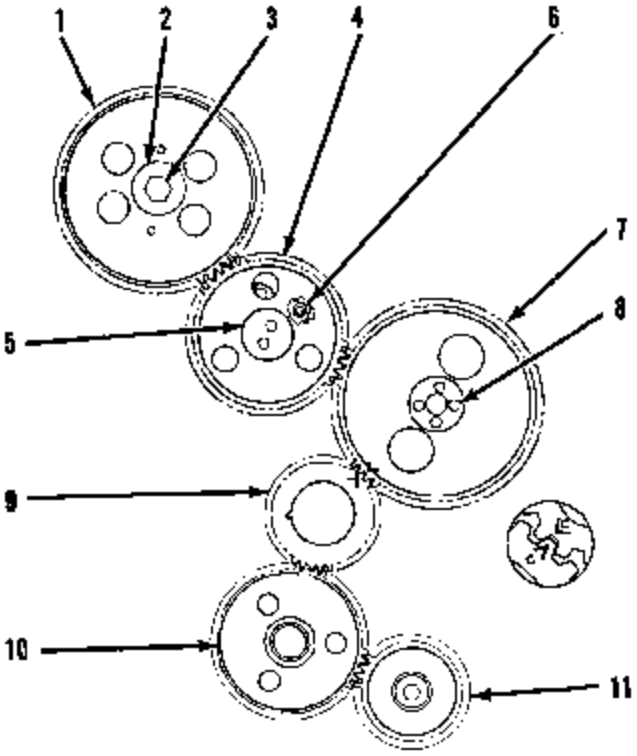
(6) Ether valve connector.

(7) Steel tube. Assemble 3.16 mm (.125 in) O.D. steel tubing between valve assembly and atomizer assembly. No electric wires are to be clamped to the ether line.

(8) Atomizer assembly. Install atomizer with orifices pointed toward each end of the engine.

NOTE: Since orifices are not visible when installed, a dash mark (in same position as orifices) is stamped on the flats of the hex nut.

Timing Gears



77261-4P2

(1) Fuel pump drive gear.

(2) Washer. Assemble with large diameter away from gear.

(3) Bolt. With the timing pin and timing bolt correctly installed, put a clockwise force of 70 N•m (50 lb ft) on the drive gear for the fuel pump and tighten bolt to ..... 270 ± 25 N•m (200 ± 20 lb ft)

(4) Fuel pump idler gear.
Endplay for the idler gear (new) ..... 0.10 to 0.41 mm (.004 to .016 in)
Maximum permissible endplay (worn) ..... 0.86 mm (.034 in)
Bore in bearing for the idler gear (new) ..... 35.004 ± 0.048 mm (1.3781 ± .0019 in)
Diameter of shaft for idler gear (new) ..... 34.902 ± 0.020 mm (1.3741 ± .0008 in)
Clearance between shaft and bearing (new) ..... 0.033 to 0.168 mm (.0013 to .0066 in)
Maximum permissible clearance between shaft and bearing (worn) ..... 0.23 mm (.009 in)

(5) Plate. Assemble machined side of plate adjacent to the shaft.

(6) Bolt. Tighten to ..... 25 ± 7 N•m (18 ± 5 lb ft)

(7) Camshaft gear

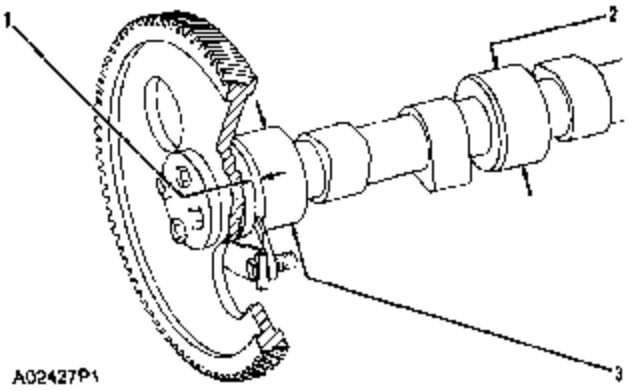
(8) Bolts. Tighten to ..... 55 ± 7 N•m (40 ± 7 lb ft)

(9) Crankshaft gear.
Maximum temperature of the gear for installation on the crankshaft ..... 316°C (600°F)

(10) Idler gear for oil pump.

(11) Drive gear for oil pump.

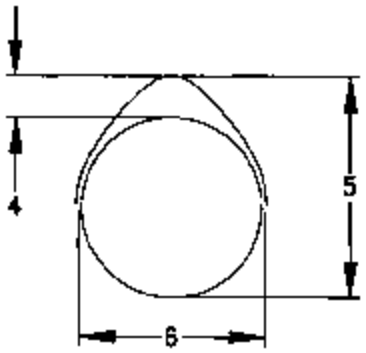
Camshaft



(1) Width of groove in camshaft for thrust washer (new) ..... 4.83 ± 0.05 mm (.190 ± .002 in)
Thickness of thrust washer (new) ..... 4.65 ± 0.03 mm (.183 ± .001 in)
Endplay of the camshaft (new) ..... 0.18 ± 0.08 mm (.007 ± .003 in)
Maximum permissible endplay (worn) ..... 0.64 mm (.025 in)

(2) Diameter of camshaft bearing surface (journal) (new) ..... 58.699 ± 0.013 mm (2.3110 ± .0005 in)

(3) Bore in bearing for camshaft (new) ..... 58.80 ± 0.06 mm (2.315 ± .002 in)
Clearance between bearing and bearing surface (journal) (new) ..... 0.03 to 0.17 mm (.001 to .007 in)
Maximum permissible clearance between bearing and bearing surface (journal) (worn) ..... 0.20 mm (.008 in)



(5) Height of camshaft lobes.

To find lobe lift use the following procedure:

A. Measure camshaft lobe height (5).

B. Measure base circle (6).

C. Subtract base circle (STEP B) from lobe height (STEP A). The difference is actual lobe lift (4).

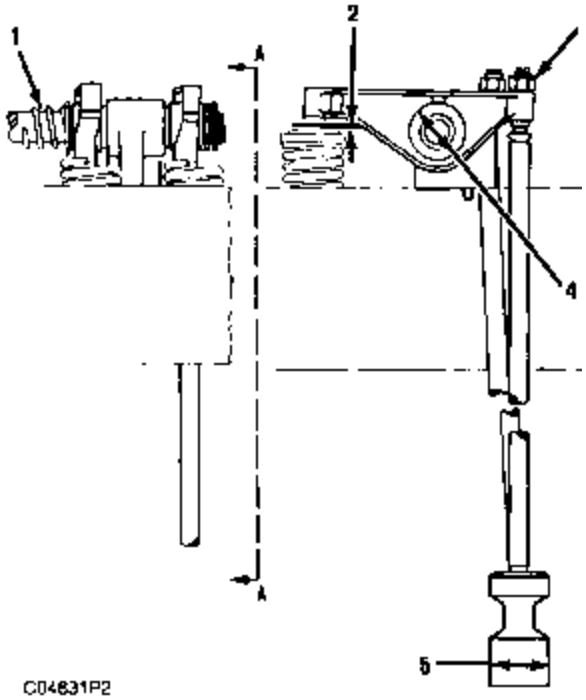
D. Specified camshaft lobe lift (4) is:

a. Exhaust lobe ..... 8.382 mm (.3300 in)

b. Intake lobe ..... 8.382 mm (.3300 in)

Maximum permissible difference between actual lobe lift (STEP C) and specified lobe lift (STEP D) is ..... 0.25 mm (.010 in)

Valve Rocker Arms And Lifters



(1) 4B4910 Spring (new):

Length under test force ..... 69.85 mm (2.750 i

Test force ..... 62.3 to 71.2 N (14 to 16 l

Free length after test ..... 101.6 mm (4.00 l

Outside diameter ..... 24.6 mm (.97 i

(2) Valve Lash.

Intake valves ..... 0.38 ± 0.08 mm (.015 ± .003 i

Exhaust valves ..... 0.64 ± 0.08 mm (.025 ± .003 i

(3) Tighten locknut on intake and exhaust valve adjustment screw to a torque of ..... 29 ± 7 N•m (22 ± 5 lb

(4) Bore in bearing for shaft (new) ..... 18.448 ± 0.013 m (.7263 ± .0005 i

Diameter of shaft (new) ..... 18.402 ± 0.013 m (.7245 ± .0005 i

Maximum permissible clearance between bearing and shaft (worn) ..... 0.20 mm (.008 i

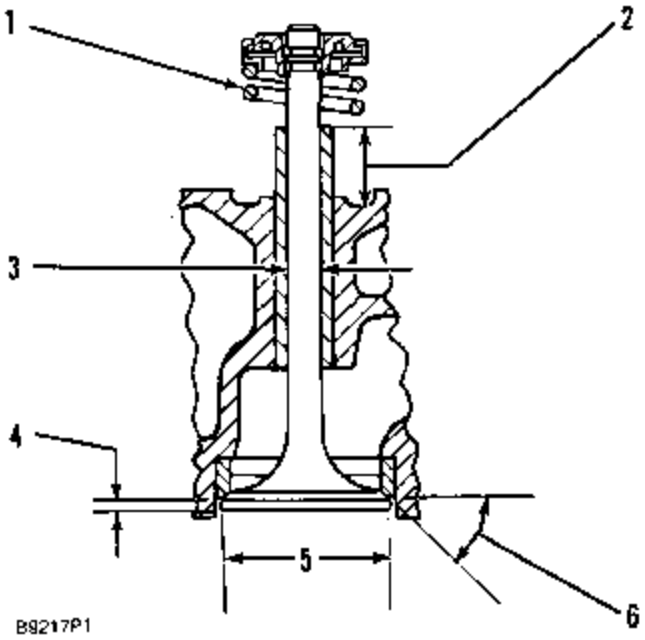
(5) Diameter of valve lifter (new) ..... 33.287 ± 0.013 m (1.3105 ± .0005 i

Bore in block for valve lifter (new) .... 33.388 ± 0.050 m (1.3145 ± .0020 i

Maximum permissible clearance between lifter and bore for valve lifter worn) ..... 0.30 mm (.012 i

Valves

NOTE: Guideline For Reusable Parts; Valves And Valve Springs. SEBF8002 and SEBF8034 have the procedures and specifications necessary for checking used valves and valve springs.



(1) 7S7144 Spring for valves (new):
Length under test force ..... 44.86 mm (1.766 in)
Test force ..... 257 ± 25 N (57.7 ± 4.5 lb)
Use again minimum load at length under test force ..... 217 N (48.83 lb)
Length of spring at valve open position ..... 32.28 mm (1.271 in)
Use again minimum load at valve open position .... 656 N (148.5 lb)
Free length after test ..... 52.07 mm (2.05 in)
Outside diameter ..... 35.21 mm (1.386 in)
Spring must not be bent more than ..... 1.82 mm (.072 in)

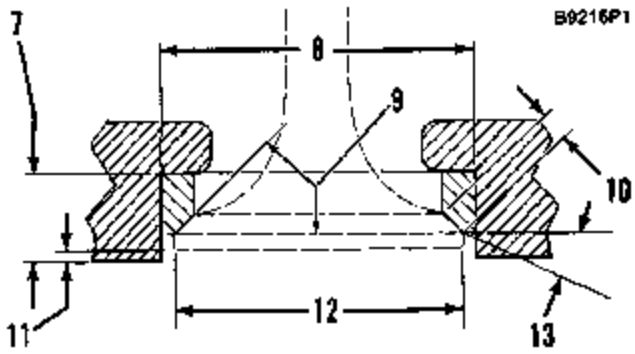
(2) Height to top of valve guide ..... 22.23 ± 0.25 mm (.875 ± .010 in)

(3) Diameter of valve stem (new) ..... 9.441 ± 0.008 mm (.3717 ± .0003 in)
Use again minimum diameter ..... 9.408 mm (.3704 in)
Bore in valve guide with guide installed in the head.
Minimum permissible (new) ..... 9.456 mm (.3723 in)
Maximum permissible (worn) ..... 9.581 mm (.3772 in)

(4) Valve lip thickness:
6N9916 Exhaust Valve
Use again minimum ..... 2.69 mm (.106 in)
7N0753 Exhaust Valve
Use again minimum ..... 2.44 mm (.096 in)
2W2620 Intake Valve
Use again minimum...2.69 mm (.106 in)
6N9915 Intake Valve
Use again minimum ..... 2.44 mm (.096 in)

(5) Diameter of valve head:
Exhaust valve ..... 48.16 ± 0.13 mm (1.896 ± .005 in)
Intake valve ..... 51.31 ± 0.13 mm (2.020 ± .005 in)

(6) Angle of valve face ..... 29 ¼ ± ¼ degrees



(7) Depth of bore in head for valve seat insert ..... 12.28 ± 0.13 mm (.483 ± .005 in)

(8) Diameter of valve seat insert for exhaust valve ..... 50.889 ± 0.013 mm (2.0035 ± .0005 in)
Bore in head for valve seat insert for exhaust valve ..... 50.813 ± 0.030 mm (2.0005 ± .0012 in)
Diameter of valve seat insert for intake valve ..... 52.032 ± 0.013 mm (2.0485 ± .0005 in)
Bore in head for valve seat insert for intake valve ..... 51.956 ± 0.030 mm (2.0455 ± .0012 in)

(9) Angle of face of valve seat insert ..... 30 ± 1 degrees

(10) Maximum permissible width of valve seat (intake and exhaust) ..... 1.93 mm (.076 in)
Minimum permissible width of valve seat (intake and exhaust) ..... 1.14 mm (.045 in)

(11) Dimension from top of closed valve to face of head:
Minimum permissible dimension for 6N9916 or 7N0753 Exhaust Valve ..... 0.66 mm (.026 in)
Minimum permissible dimension for 6N9915 or 2W2620 Intake Valve ..... 0.15 mm (.006 in)

(12) Outside diameter of the face of the valve seat insert:
Exhaust seat ..... 46.02 mm (1.812 in)
Maximum permissible, exhaust seat ..... 47.29 mm (1.862 in)
Intake seat ..... 49.28 mm (1.940 in)
Maximum permissible, intake seat ... 50.55 mm (1.990 in)

(13) Angle to grind seat face of the insert to get a reduction of maximum seat diameter ..... 15 degrees

Cylinder Head

77084P1

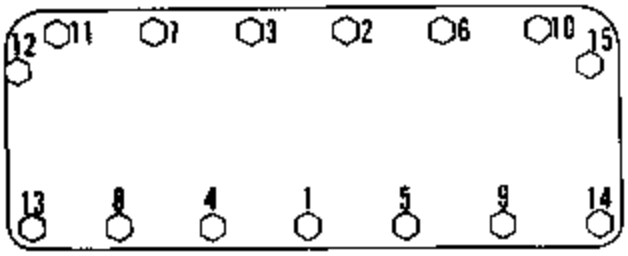
View From Right Side Of Engine

Thickness of cylinder head (new) ..... 100.03 ± 0.76 mm (3.936 ± .030 in)

Put 2P2506 Thread Lubricant on the threads of all bolts except bolt (25). Tighten all bolts in the sequence that follows:

Step 1. Tighten all bolts in number sequence to ..... 155 N•m (115 lb ft)
Step 2. Again tighten all bolts in number sequence to ..... 250 ± 17 N•m (185 ± 13 lb ft)
Step 3. Again tighten all bolts in number sequence (hand torque only) to ..... 250 ± 17 N•m (185 ± 13 lb ft)
Step 4. Tighten all bolts in letter sequence (hand torque only) to ..... 43 ± 7 N•m (32 ± 5 lb ft)

Valve Cover



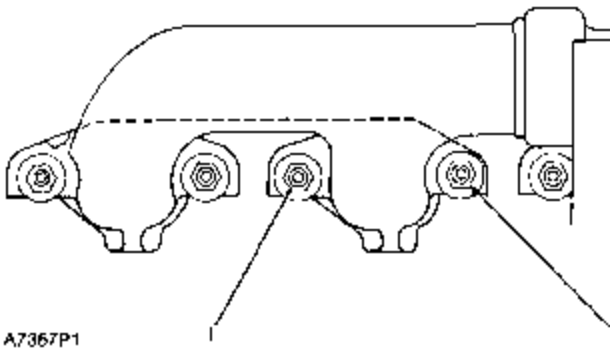
77083P1

View From Right Side Of Engine

Put 5H2471 Cement on the face of valve cover and top side of gasket.

Tighten bolts by number sequence shown to ..... 11 ± 3 N•m (96 ± 27 lb in)

Exhaust Manifold



A7367P1

Typical Example

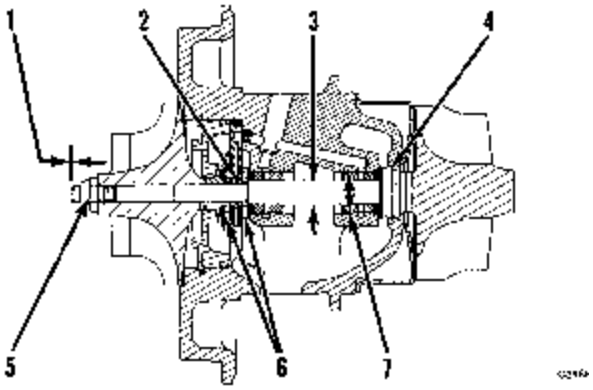
Put 5P3931 Anti-Seize Compound on all threads.

(1) Torque for studs ..... 27 ± 4 N•m (20 ± 3 lb ft)

(2) Torque for nuts holding exhaust manifold .... 45 ± 7 N•m (33 ± 5 lb ft)

Turbochargers

S3B



(1) Endplay for shaft (new) ..... 0.102 ± 0.025 mm (.004 ± .001)

Maximum permissible endplay (worn) ..... 0.20 mm (.008)

(2) Thickness of thrust bearing (where thrust rings contact bearing) ..... 5.36 ± 0.03 mm (.211 ± .001 in)

(3) Diameter of shaft (new) ..... 12.697 to 12.706 mm (.4999 to .5002 in)

Bore in the bearing (new) ..... 12.741 to 12.748 mm (.5016 to .5019 in)

Maximum permissible clearance between bearing and shaft (worn) ..... 0.05 mm (.002 in)

(4) Maximum permissible gap of oil seal ring, measured in bore of housing ..... 0.25 mm (.010 in)

NOTICE

The impeller shaft nut is a left hand thread (CCW).

(5) Install the compressor wheel (at room temperature) as follows:

a. Put compressor wheel on the shaft.
b. Put a small amount of clean engine oil on the threads.
c. Tighten the nut (CCW) to 14 to 17 N•m (125 to 150 lb in).
d. Loosen the nut and tighten again to 9 N•m (80 lb in) plus an additional 60 degrees (⅙ turn).

NOTICE

Do not bend or add stress to the shaft when the nut is loosened or tightened.

(6) Thickness of each thrust ring ..... 2.553 ± 0.013 mm (.1005 ± .0005 in)

(7) Bore in housing (new) ..... 20.744 to 20.757 mm (.8167 to .8172 in)

Outside diameter of the bearing (new) ..... 20.630 to 20.643 mm (.8122 to .8127 in)

Maximum permissible clearance between bearing and bore in housing (worn) ..... 0.15 mm (.006 in)

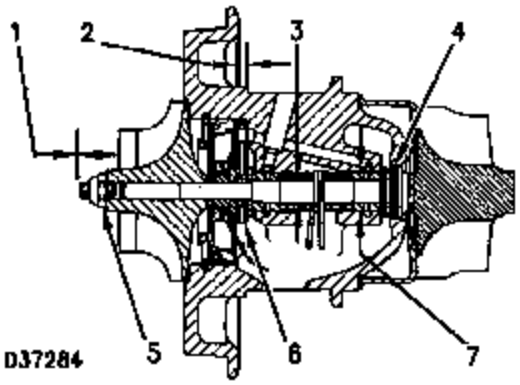
Torque for four nuts (put 5P3931 Anti-Seize Compound on threads) and bolts that hold turbocharger to exhaust manifold ..... 55 ± 5 N•m (40 ± 4 lb ft)

Install the band clamps to hold the cartridge to the compressor housing as follows:

a. Tighten clamps to ..... 14 ± 1 N•m (125 ± 10 lb in)
b. Tap (nit) clamp lightly all around.
c. Tighten again to ..... 14 ± 1 N•m (125 ± 10 lb in)

NOTE: Put clean engine oil in the oil inlet of the turbocharger after assembly or before installation to provide start up lubrication and/or storage protection.

S3A



(1) Endplay for shaft (new) ..... 0.100 ± 0.018 mm (.0039 ± .0007 in)

Maximum permissible endplay (worn) ..... 0.02 mm (.008 in)

(2) Thickness of thrust bearing (where thrust rings contact bearing) ..... 5.372 ± 0.013 mm (.2115 ± .0005 in)

(3) Diameter of shaft (new) ..... 11.570 to 11.577 mm (.4555 to .4558 in)

Bore in bearing(new) ..... 11.608 to 11.618 mm (.4570 to .4574 in)

Maximum permissible clearance between bearing and shaft(worn) ..... 0.05 mm (.002 in)

(4) Maximum permissible gap of oil seal ring, measured in bore of housing ..... 0.25 mm (.010 in)

(5) Install the compressor wheel (at room temperature) as follows:

a. Put compressor wheel on the shaft

NOTICE

Do not bend or add stress to the shaft when nut is loosened or tightened.

b. Remove nut from shaft and apply 6V1541 Quick Cure Primer on the threads of the shaft and nut followed by application of 9S3265 Retaining Compound.
c. Tighten nut to 14.4 ± 0.5 N•m (125 ± 4 lb in)

(6) Thickness of each thrust ring ..... 2.5463 ± 0.0064 mm (.10025 ± .00025 in)

(7) Bore in housing (new) ..... 19.050 to 19.075 mm (.7500 to .7510 in)

Outside diameter of the bearing (new) ... . 18.936 to 18.948 mm (.7455 to .7460 in)
Maximum permissible clearance between bearing and bore in housing (worn) ..... 0.15 mm (.006 in)
Torque for four nuts (put 5P3931 Anti-Seize Compound on threads) and bolts that hold turbocharger to exhaust manifold ..... 70 ± 15 N•m (50 ± 11 lb ft)

Tighten both band clamps with procedure that follows:

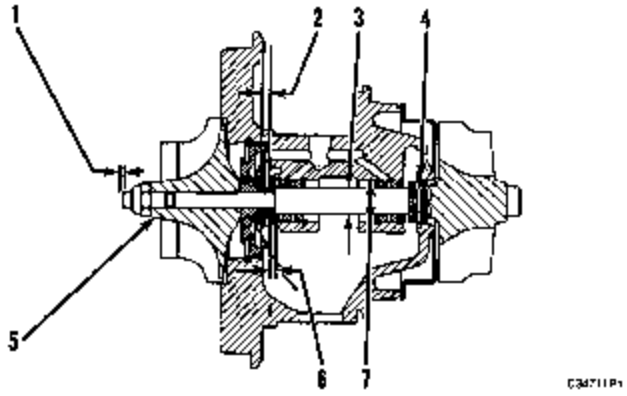
a. Tighten to ..... 14 ± 1 N•m (125 ± 10 lb in)
b. Tap (hit) clamp lightly all around.
c. Tighten again to ..... 14 ± 1 N•m (125 ± 10 lb in)

NOTICE

Do not overtighten the clamps.

NOTE: Put clean engine oil in the oil inlet of the turbocharger after assembly or before installation to provide start up lubrication and/or storage protection.

S4D



(1) Endplay for shaft (new) . ... 0.114 ± 0.038 mm (.0045 ± .0015 in)

Maximum permissible endplay (worn) ..... 0.20 mm (.008 in)

(2) Thickness of thrust bearing (where thrust rings contact bearing) . ... 5.36 ± 0.03 mm (.211 ± .001 in)

(3) Diameter of shaft (new) ... . 15.997 to 16.005 mm (.6298 to .6301 in)

Bore in the bearing (new) .... 16.035 to 16.043 mm (.6313 to .6316 in)

Maximum permissible clearance between bearing and shaft (worn) .... 0.05 mm (.002 in)

(4) Maximum permissible gap of oil seal ring, measured in bore of housing .... 0.25 mm (.010 in)

(5) Install the compressor wheel (at room temperature) as follows

a. Put compressor wheel on the shaft.
b. Put a small amount of clean engine oil on the threads.
c. Tighten the nut to a torque of . ..... 14 to 17 N•m (125 to 150 lb in).

NOTICE

Do not bend or add stress to the shaft when nut is loosened or tightened.

d. Remove nut from shaft and apply 6V1541 Quick Cure Primer on the threads of the shaft and nut followed by application of 9S3263 Retaining Compound.
e. Tighten nut to a torque of .... 4 N•m (30 lb in).
f. Tighten nut more 90 degree rotation.

(6) Thickness of each thrust ring .... 2.553 ± 0.013 mm (.1005 ± .0005 in)

(7) Bore in housing (new) ..... 24.994 to 25.006 mm (.9840 to .9845 in)

Outside diameter of the bearing (new) .... 24.882 to 24.892 mm (.9796 to .9800 in)
Maximum permissible clearance between bearing and bore in housing (worn) ..... 0.15 mm (.006 in)

Tighten both band clamps (that hold the compressor and turbine housings to the cartridge group) with procedure that follows:

a. Tighten to .... 14 ± 1 N•m (125 ± 10 lb in)
b. Tap (hit) clamp lightly all around.
c. Tighten again to ..... 14 ± 1 N•m (125 ± 10 lb in)

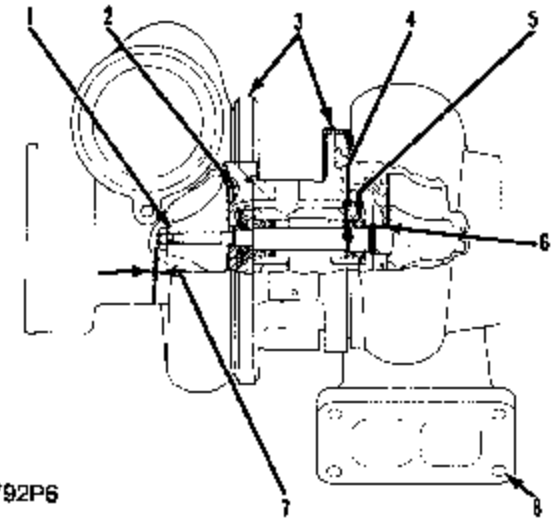
NOTICE

Do not overtighten the clamps.

Torque for four nuts (put 5P3931 Anti-Seize Compound on threads) and bolts that hold turbocharger to exhaust manifold .... 55 ± 5 N•m (40 ± 4 lb ft)

NOTE: Put clean engine oil in the oil inlet of the turbocharger after assembly or before installation to provide start up lubrication and/or storage protection.

TV61



A34792P6

Make reference to Analyzing Turbocharger Failure, Form No. FEG45138.

(1) Turbocharger impeller installation:
   a. Put impeller on shaft.
   b. Put a small amount of clean engine oil on the threads and impeller face that will be under the nut.
   c. Tighten the nut to ..... 17 N•m (13 lb ft)

NOTICE

Do not bend or add stress the shaft when the nut is loosened or tightened.

   d. Loosen the nut on the shaft.
   e. Tighten nut to ..... 3.5 N•m (30 lb in)
   f. Tighten the nut an additional ..... 120 degrees
   g. Remove the nut from the shaft.
   h. Use 6V1541 Quick Cure Primer on the threads of the shaft and nut
   i. Put 9S3265 Retaining Compound on the threads of the shaft and nut.
   j. Again tighten the nut to ..... 3.5 N•m (30 lb in)
   k. Again tighten the nut and additional ..... 120 degrees

(2) Torque for the bolts that hold back plate ..... 10 ± 1 N•m (90 ± 10 lb in)

(3) Torque for the clamp bolts ..... 14 ± 1 N•m (125 ± 10 lb in)

(4) Bore in the bearings ..... 15.921 to 15.931 mm (.6268 to .6272 in)

Diameter of the surface on the shaft for the bearings ..... 15.875 to 15.885 mm (.6250 to .6254 in)

(5) Bore in the housing ..... 24.961 to 24.973 mm (.9827 to .9832 in)

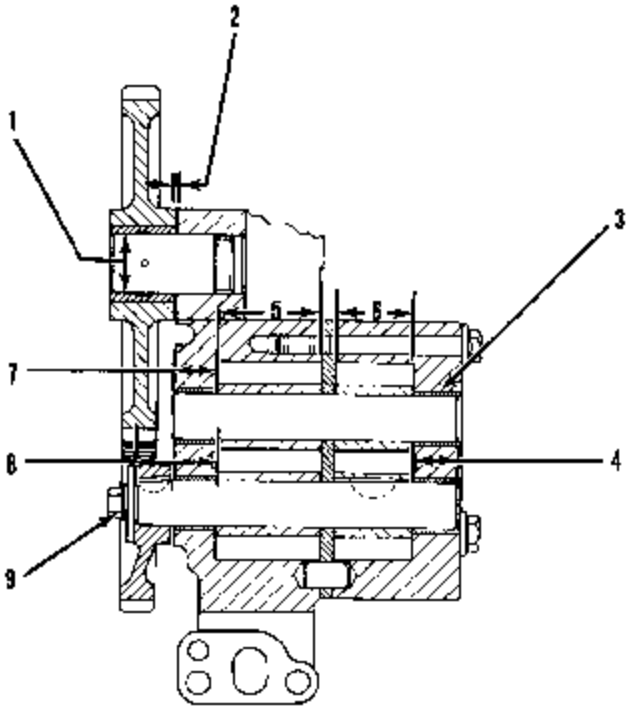
Outside diameter of the bearing ..... 24.846 to 24.859 mm (.9782 to .9787 in)

(6) Clearance between the ends of the oil seal ring ..... 0.20 to 0.38 mm (.008 to .015 in)

(7) Endplay for the shaft ..... 0.08 to 0.25 mm (.003 to .010 in)

(8) Put 5P3931 Anti-Seize Compound on the threads and tighten the bolts that hold the turbocharger to the manifold to a torque of ..... 54 ± 5 N•m (40 ± 4 lb ft)

Oil Pump



6S310P6

(1) Bore in bearing of idler gear ..... 28.600 ± 0.048 mm (1.1260 ± .0019 in)

Diameter of shaft for the idler gear ... 28.512 ± 0.013 mm (1.1225 ± .0005 in)

Clearance between bearing and shaft ..... 0.028 to 0.150 mm (.0011 to .0059 in)

(2) Clearance between gear and body of pump ..... 0.05 to 0.66 mm (.002 to .026 in)

(3) Diameter of shafts for pump ..... 22.217 ± 0.005 mm (.8747 ± .0002 in)

Bore in bearings for shafts ..... 22.286 ± 0.051 mm (.8774 ± .0020 in)

Clearance between shafts and bearings ..... 0.013 to 0.125 mm (.0005 to .0049 in)

(4) Depth that bearings are installed in pump bodies ..... 1.52 ± 0.25 mm (.060 ± .010 in)

(5) Gear. Length of gears ..... 50.808 ± 0.025 mm (2.0003 ± .0010 in)

Depth of bore in pump body for gears ..... 50.935 ± 0.020 mm (2.0053 ± .0008 in)
Clearance between end of gears and pump body ..... 0.081 to 0.173 mm (.0032 to .0068 in)

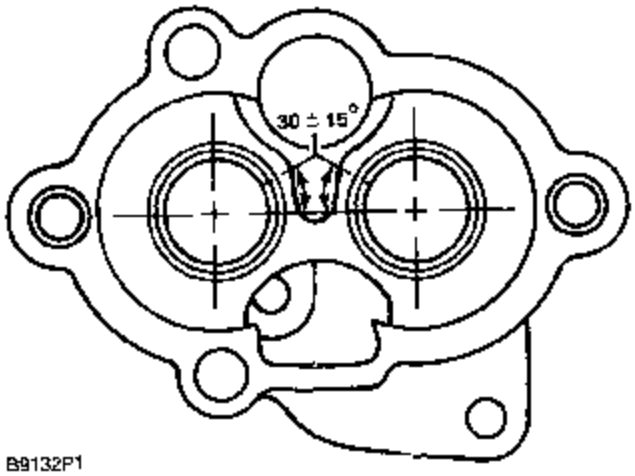
(6) Length of gears ..... 38.070 ± 0.025 mm (1.4988 ± .0010 in)

Depth of bore in pump body for gears ..... 38.197 ± 0.020 mm (1.5038 ± .0008 in)
Clearance between end of gears and pump body ..... 0.081 to 0.173 mm (.0032 to .0068 in)

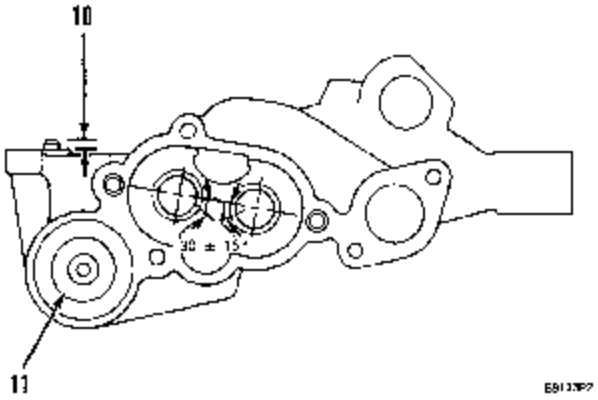
(7) Distance from the end of the idler shafts to gear faces ..... 21.03 ± 0.13 mm (.828 ± .005 in)
Maximum temperature of gear when shrinking in place ..... 400°C (750°F)

(8) Distance from the end of the drive shaft to gear face ..... 38.23 ± 0.13 mm (1.505 ± .005 in)
Maximum temperature of gear when shrinking in place ..... 400°C (750°F)

(9) Torque for bolt holding drive gear to drive shaft ..... 47 ± 9 N•m (35 ± 7 lb ft)



B9132P1



B9133P2

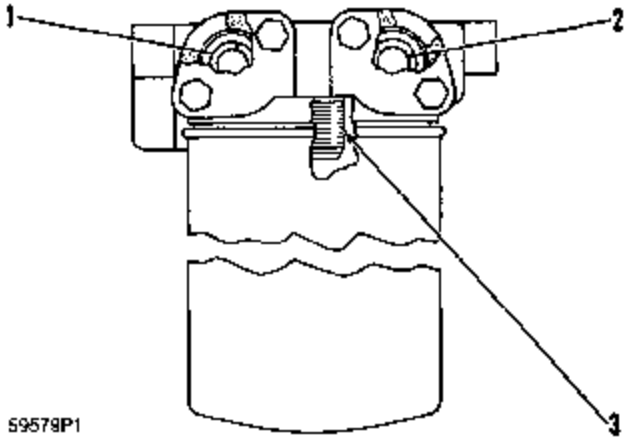
NOTE: Install the bearings in the cover and body (Positions A and B) for the oil pump so the bearing junctions (joints) are in the position shown (30 ± 15 degrees from centerline).

(10) Distance dowel extends from body ..... 4.1 ± 0.5 mm (.16 ± .02 in)

(11) Shaft assembly. Distance shaft assembly extends from body ..... 30.50 ± 0.25 mm (1.200 ± .010 in)

NOTE: Before running, lubricate pump with oil. Pump must rotate freely by hand.

Oil Filter



S9579P1

Oil cooler bypass valve and oil filter bypass valve must open at a pressure difference of ..... 172 ± 21 kPa (24.9 ± 3.0 psi)

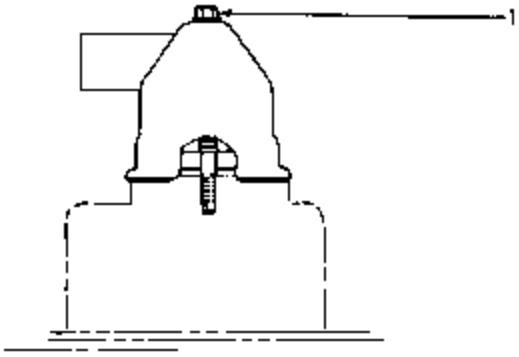
(1),(2) BM3182 Spring for bypass valves:

Length under test force ..... 63.5 mm (2.5 in)
Test force ..... 40 N (8.92 lb)
Free length after test ..... 91.7 mm (3.61 in)
Outside diameter ..... 20.6 mm (.81 in)

(3) Torque for stud:

Put 9S3263 Thread Lock Compound on threads to 7.6 ± 1.5 mm (.30 ± .06 in) from the taperlock end of the stud. Tighten the stud to a torque of ..... 68 ± 7 N•m (50 ± 5 lb ft)

Oil Breather Cap



A22037P1

(1) Torque for bolt that holds breather cap ..... 14 ± 3 N•m (10 ± 2 lb ft)

Engine Oil Pressure

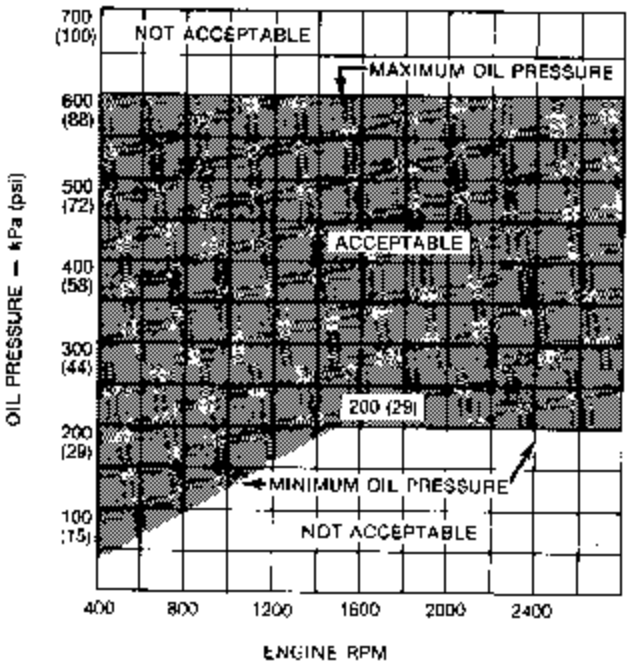
All steps of this procedure must be followed for the pressure findings to be usable.

1. Be sure that the engine is filled to the correct level with SAE 10W-30 oil. If any other viscosity of oil is used, the information in the Engine Oil Pressure Graph does not apply.
2. Remove the oil pressure switch and connect the 1U5470 Engine Pressure Group to the main oil manifold at the location from which the oil pressure switch was removed.
3. Run the engine to get the engine oil temperature at 99°C (210°F).

NOTE: A 3°C (5°F) increase in temperature gives approximately 7 kPa (1 psi) decrease in engine oil pressure.

NOTE: Make sure engine oil temperature does not go above 115°C (239°F).

4. Keep the engine oil temperature constant with the engine at its rated rpm and read the pressure gauge.
5. On the Engine Oil Pressure Graph, find the point that the lines for engine rpm and oil pressure intersect (connect).

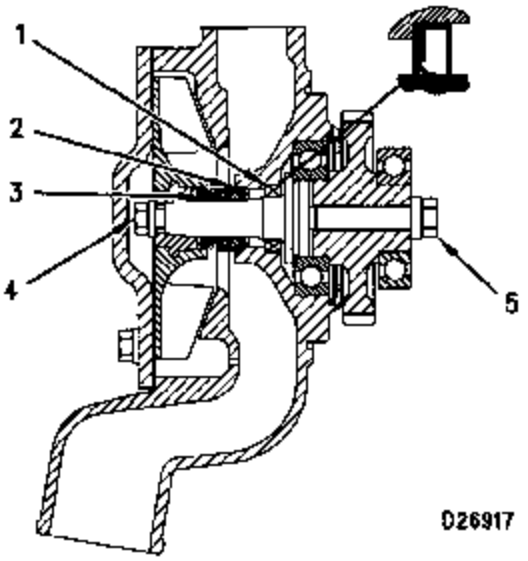


C27341P1

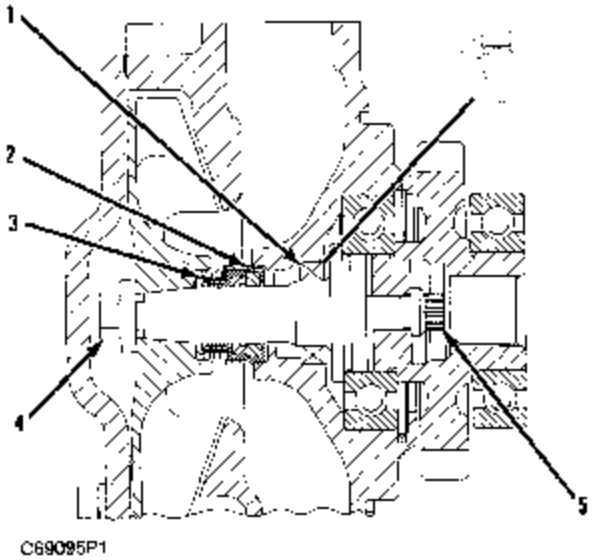
6. If the results do not fall within the "ACCEPTABLE" pressure range given in the graph, find the cause and correct it. Engine failure or a reduction in engine life can be the result if engine operation is continued with oil manifold pressure outside this range.

NOTE: A record of engine oil pressure, kept at regular intervals, can be used as an indication of possible engine problems or damage. If there is a sudden increase or decrease of 70 kPa (10 psi) in oil pressure, even though the pressure is in the "ACCEPTABLE" range on the graph, the engine should be inspected and the problem corrected.

Water Pump



Typical Example



Typical Example

(1) Oil seal. Do not lubricate the seal lip. Assemble with the lip toward the water pump drive.

(2) Water seal and ring:
   a. Put distilled water on the seal.
   b. Use the 125-9622 Seal Installation Tool to install the seal and ring together in the housing bore, with the shiny face of the ceramic ring toward the carbon seal.

(3) Seal assembly:
   a. Remove the spring from the seal.
   b. Put clean distilled water inside the seal assembly.
   c. Use the 125-9622 Seal Installation Tool and hand pressure to install the seal assembly on the shaft until the carbon face makes light contact with the shiny face of ceramic ring.
   d. Install the spring.

(4) Torque for bolt that holds the impeller ..... 38 ± 1.5 N•m (28 ± 1 lb ft)

(5) Torque for bolt that holds the gear .... 97 ± 7 N•m (72 ± 5 lb ft)

BELT TENSION CHART								
BELT SIZE	WIDTH BELT TOP		GAUGE READING				BORROUGHS GAUGE NUMBERS	
			BELT TENSION "INITIAL"*		BELT TENSION "USED"**		OLD GAUGE NUMBER	NEW GAUGE NUMBER
	MM	IN	N	LB	N	LB		
3/8	10.72	0.422	445 ± 22	100 ± 5	400 ± 22	90 ± 10	BT-33-95	BT-33-97
1/2	13.89	0.547	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-95	BT-33-97
5V	15.88	0.626	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72	BT-33-72C
11/16	17.48	0.688	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72	BT-33-72C
3/4	19.05	0.750	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72	BT-33-72C
15/16	23.83	0.963	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72	BT-33-77
8K	27.92	1.099	800 ± 22	180 ± 5	489 ± 44	110 ± 10	--------	BT-33-109
6PK	20.94	0.824	667 ± 22	150 ± 5	467 ± 44	105 ± 10	--------	BT-33-109
MEASURE TENSION OF BELT FARTHEST FROM ENGINE								

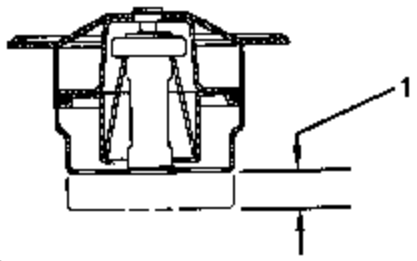
* BELT TENSION "INITIAL" is for a new belt.

** BELT TENSION "USED" is for a belt with over 30 minutes of operation at rated speed.

D01599

Water Temperature Regulator

111-8010 Regulator:

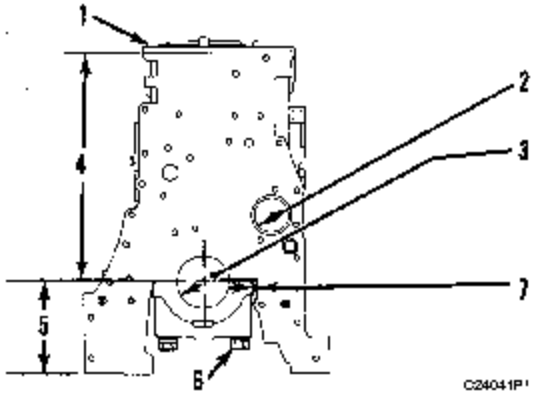


D26791

Temperature when completely open ..... 91°C (196°F)

Minimum completely open distance ..... 9.50 mm (.374 in)

Cylinder Block



(1) Thickness of spacer plate .... 9.970 ± 0.025 mm (.3925 ± .0010 in)

Thickness of spacer plate gasket ..... 0.196 ± 0.025 mm (.0077 ± .0010 in)

NOTE: For height of liner over top of spacer plate make reference to Cylinder Liner Projection.

(2) Camshaft bearing bore (installed) ..... 58.80 ± 0.06 mm (2.315 ± .002 in)

Bore in block for camshaft bearings ..... 65.100 ± 0.025 mm (2.5630 ± .0010 in)

(3) Bore in block for main bearings (standard size) ..... 96.926 ± 0.013 mm (3.8160 ± .0005 in)

Bore in block for main bearings 0.51 mm (.020 in) oversize ..... 97.436 ± 0.013 mm (3.8361 ± .0005 in)

(4) Dimension from center of main bearing bore to top of cylinder block (new) ..... 383.515 ± 0.165 mm (15.099 ± .0064 in)

(5) Dimension from center of main bearing bore to bottom of cylinder block (new) ..... 153.99 ± 0.10 mm (6.063 ± .004 in)

(6) Torque for bolts holding bearing caps for main bearings.

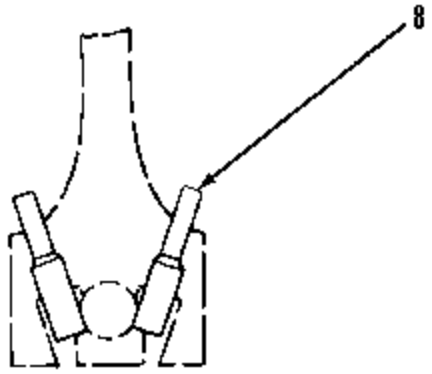
a. Put 2P2506 Thread Lubricant on threads and washer face.
b. Tighten all bolts to ..... 41 ± 4 N•m (30 ± 3 lb ft)
c. Put a mark on each bolt and cap.
d. Tighten all bolts from mark ..... 90 ± 5 degrees

NOTE: Install bearing caps with the part number toward the front of the engine. Be sure that the mark (number) on the bearing cap next to the bolt hole is in agreement with the mark in the cylinder block.

(7) Clearance between main bearing cap and cylinder block ..... 0.033 mm (.0013 in) tight to 0.043 mm (.0017 in) loose

Main bearing cap width ..... 165.095 ± 0.020 mm (6.4998 ± .0008 in)

Width of cylinder block for main bearing cap ..... 165.100 ± 0.018 mm (6.5000 ± .0007 in)

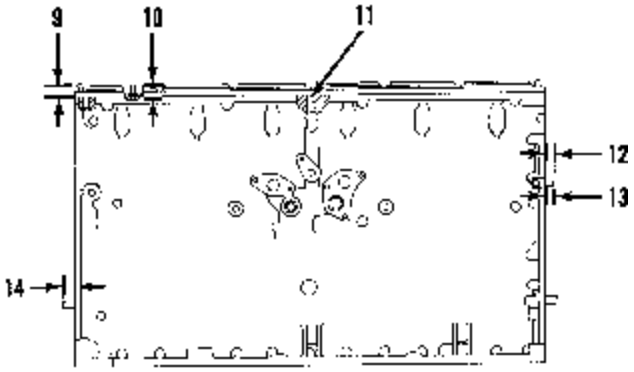


C24040P1

(8) Piston cooling orifice.

NOTICE

There are holes in the bores for the main bearings, between the cylinders for piston cooling orifices. These holes must have orifices (8) installed.



C24042P1

(9) Distance two dowels extend from the surface of the cylinder block ..... 19.8 ± 0.5 mm (.78 ± .02 in)

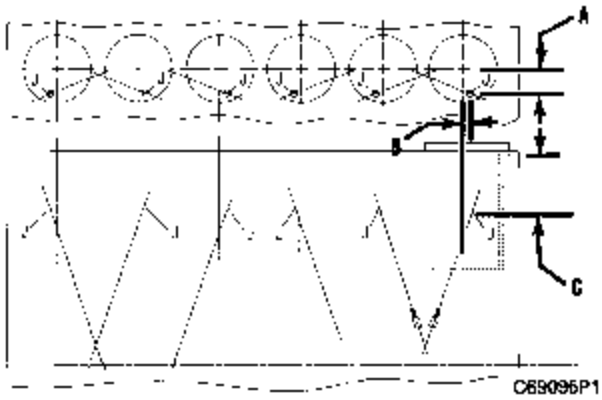
(10) Distance hollow dowel extends from the surface of the cylinder block ..... 16.0 ± 0.5 mm (.63 ± .02 in)

(11) Depth to install two dowels below the surface of the cylinder block (apply loctite #11358) ..... 1.0 ± 0.5 mm (.04 ± .02 in)

(12) Distance dowels extend from the front face of the cylinder block ..... 22.4 ± 0.5 mm (.88 ± .02 in)

(13) Distance stud extends from the front face of the cylinder block ..... 15.7 ± 0.5 mm (.62 ± .02 in)

(14) Distance two dowels extend from the rear face of the cylinder block ..... 12.7 ± 0.5 mm (.50 ± .02 in)



C69096P1

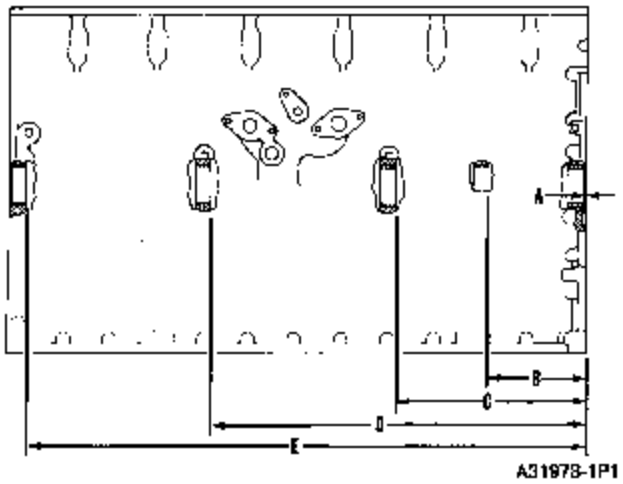
Check piston cooling jets by passing a 2.29 mm (.090 in) diameter drill rod through jet and a 12.7 mm (.50 in) circle located at J. Dimensions for location J are:

(A) 49.8 mm (1.96 in)

(B) 12.7 mm (.50 in)

(C) 108.0 mm (4.25 in)

Camshaft Bearings



Depth to install camshaft bearings.

Dimension A ..... 0.5 ± 0.5 mm (.02 ± .02 in)

Dimension B ..... 154.0 ± 0.5 mm (6.06 ± .02 in)

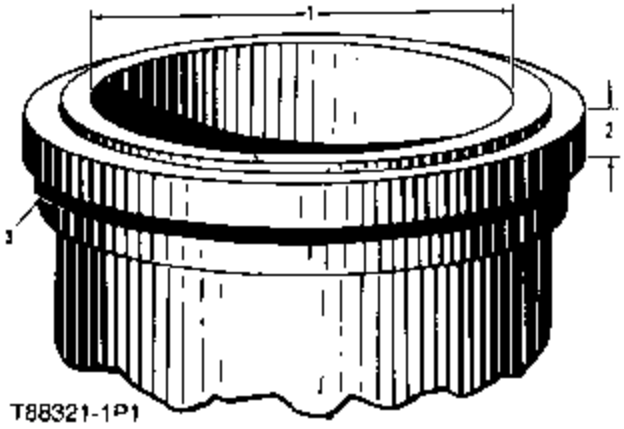
Dimension C ..... 303.2 ± 0.5 mm (11.94 ± .02 in)

Dimension D ..... 601.7 ± 0.5 mm (23.69 ± .02 in)

Dimension E ..... 903.4 ± 0.5 mm (35.57 ± .02 in)

NOTE: The camshaft bearing at the front of the block must be installed with oil holes in a horizontal position and joint at top within ± 15 degrees from vertical.

Cylinder Liner



NOTE: Make reference to Guideline for Reusable Parts; Pistons and Cylinder Liners, Form No. SEBF8049 and SEBF8068.

(1) Bore in liner (new) ..... 120.675 ± 0.025 mm (4.7509 ± .0010 in)

Use again maximum bore when measured near upper end of the wear surface of the cylinder liner ..... 120.78 mm (4.755 in)

(2) Thickness of flange on liner ..... 10.282 ± 0.020 mm (.4048 ± .0006 in)

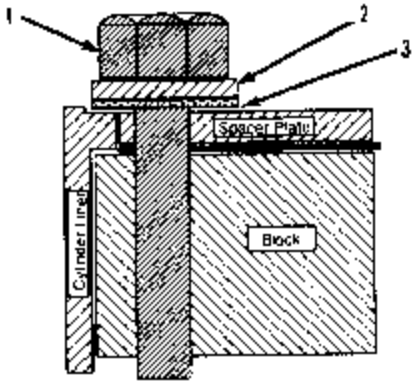
(3) Filler band.

Cylinder Liner Installation

Put liquid soap on bottom liner bore in block, on grooves in lower liner, and on O rings. Install O-rings on liner. Put filler band (3) in engine oil for a moment and install on liner. Immediately install liner in cylinder block (before expansion of filler band).

Cylinder Liner Projection

Tools Needed		
8T0455	Liner Projection Tool Group	1
1P2403	Dial Indicator	1
1P5512	Contact Point, 22.4 mm (.88 in) long	1
1P2402	Gauge Body	1
1P5507	Gauge	1



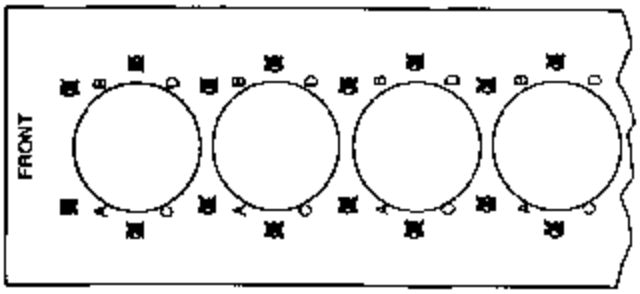
C54149P1

(1) Bolt. (2) Washer. (3) Washer.

COMPONENTS NEEDED			
Item	Part No	Description	Quantity For One Cylinder
1	051589	Bolt	6
2	8F1484	Washer	6
3	7K1977[1]	Washer	6

[1] These are plastic washers, an expendable item, therefore you may wish to order more than the amount indicated.

1. Install clean liners or cylinder packs (without the filler band or the rubber seals), spacer plate gasket and clean spacer plate



C63970P1

2. Install bolts and washers, as indicated previously, in the holes indicated with an X. Install all bolts or the six bolts around the liner. Tighten the bolts to a torque of .. 95 N•m (70 lb ft).

NOTE: Install the plastic washer next to the spacer plate.

3. Use the 8T0455 Liner Projection Tool Group to measure liner projection at positions indicated with and A,B,C and D. Record measurements for each cylinder. Add the four readings for each cylinder and divide by four to find the average

4. The cylinder liner specifications are as follows:
   Liner projection ..... 0.033 to 0.175 mm (0.0013 to 0.0069 in)
   Maximum variation in each cylinder ... 0.051 mm (.002 in)
   Maximum average variation between adjacent cylinders ..... 0.051 mm (.002 in)
   Maximum variation between all cylinders ..... 0.102 mm (.004 in)

5. If the liner projections are out of specification, try rotating the liner or install the liner in another bore to see if the measurements improve.

NOTE: Do not exceed the maximum liner projection of 0.152 mm (.006 in). Excessive liner projection will contribute to liner flange cracking.

6. With the proper liner projection, mark the liners in the proper position and set them aside.

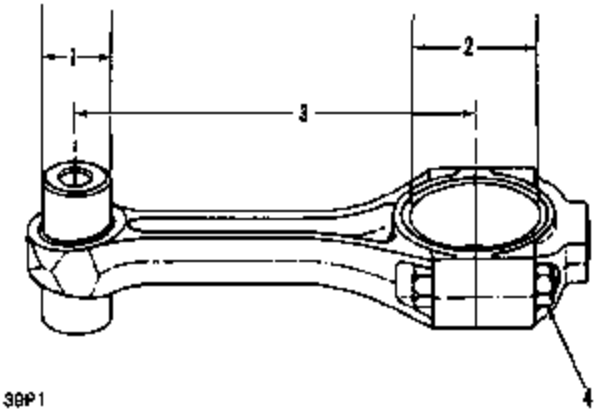
7. When the engine is ready for final assembly, the O-ring seals, cylinder block and upper filler band must be lubricated before installation.

If the lower O-rings are black in color, apply liquid soap on the lower O-ring seals and the cylinder block. Use clean engine oil on the upper filler band.

If the lower O-rings are brown in color, apply engine oil on the lower O-ring seals, the cylinder block and the upper filler band

NOTE: Apply liquid soap and/or clean engine oil immediately before assembly. If applied too early, the filler bands may swell and be pinched under the liners during installation.

Connecting Rod



(1) Bore in bearing for piston pin (new) ..... 43.2105 ± 0.0076 mm (1.70120 ± .0003 in)
Diameter of piston pin (new) ..... 43.175 ± 0.005 mm (1.6998 ± .0002 in)
Maximum permissible clearance between bearing and piston pin (worn) ..... 0.08 mm (.003 in)

(2) Bore in connecting rod for bearing ... 82.550 ± 0.013 mm (3.2500 ± .0005 in)

(3) Distance between center of piston pin and center of crankshaft bearing (new) ..... 243.71 ± 0.03 mm (9.595 ± .001 in)

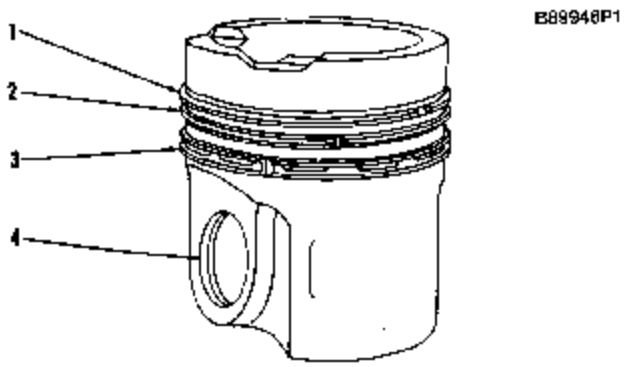
(4) Torque on nut for connecting rod:
a. Put 2P2506 Thread Lubricant on threads and nut seat
b. Tighten both nuts to ..... 41 ± 4 N•m (30 ± 3 lb ft)
c. Mark each nut and end of bolt.
d. Tighten both nuts (from mark) ... . 90 ± 5 degrees

Install the connecting rod in the piston with the slot for the bearing tab on the same side as the "V" mark on the piston.

Make reference to Special Instructions, Form No. GMG02394 and SMHS7366 for information about checking and reconditioning connecting rods. Also see Guideline For Reusable Parts; Salvage of Non Serrated Connecting Rods, Form No. SEBF8064.

Pistons And Rings

Make reference to Guideline For Reusable Parts; Pistons, Form No. SEBF8049; Cylinder Liners, Form No. SEBF8068; and Piston Pins And Retaining Rings, Form No. SEBF8051.



(1) Top piston ring. See the Piston And Piston Rings charts

(2) Intermediate piston ring. See the Piston And Piston Rings charts.

(3) Oil control ring. See the Piston And Piston Rings charts.

(4) Bore in piston for pin ..... 43.195 ± 0.008 mm (1.7006 ± .0003 in)
Clearance between pin and bore in piston ..... 0.008 to 0.033 mm (.0003 to .0013 in)
Maximum permissible clearance (worn) ..... 0.05 mm (.002 in)
Pin diameter ..... 43.175 ± 0.005 mm (1.6998 ± .0002 in)

NOTE: When installed in the engine, the "V" mark on top of the piston must be in alignment with the "V" mark on the cylinder block.

PISTON AND PISTON RINGS			
	(1) TOP RING	(2) INTERMEDIATE RING	(3) OIL CONTROL RING
Part No.	**2W1707**[1]	**2W1708**[1]	**7E6047**[2]
Width of groove in piston for piston ring (new).	[3]	[3]	3.188 ± 0.013 mm (.1255 ± .0005 in)
Thickness of piston ring (new).	[3]	[3]	3.137 ± 0.013 mm (.1235 ± .0005 in)
Clearance between groove and piston ring (new).	[3]	[3]	0.051 ± 0.025 mm (.0020 ± .0010 in)
Maximum permissible clearance (worn).	[3]	[3]	0.15 mm (.006 in)
Clearance between ends of piston ring when installed in a cylinder liner with a bore size of 120.650 mm (4.7500 in).	0.622 ± 0.191 mm (.0245 ± .0075 in)	0.622 ± 0.191 mm (.0245 ± .0075 in)	0.57 ± 0.19 mm (.022 ± .007 in)
Increase in clearance between ends of piston ring for each 0.03 mm (.001 in) increase in cylinder liner bore size.	0.08 mm (.003 in)		

[1] Install piston ring with "UP" side toward the top of the piston. The 2W1707 Top Piston Ring has the mark "UP-1". The 2W1708 Intermediate Piston Ring has the mark "UP-2".
[2] Install the 7E6047 Oil Control Ring with the gap in the spring 180 degrees away from the gap in the ring.
[3] "Keystone" style piston rings and grooves in the piston. The 1U6431 Keystone Piston Ring Groove Gauge is necessary for measuring these grooves. For correct use of the gauge group, see the instruction card that is supplied with the gauge group.

PISTON AND PISTON RINGS			
	(1) TOP RING	(2) INTERMEDIATE RING	(3) OIL CONTROL RING
Part No.	**9S3029**[1]	**5S6750**[1]	**7E6047**[2]
Width of groove in piston for piston ring (new).	3.233 ± 0.013 mm (.1273 ± .0005 in)	2.446 ± 0.013 mm (.0963 ± .0005 in)	3.188 ± 0.013 mm (.1255 ± .0005 in)
Thickness of piston ring (new).	3.150 + 0.000 − 0.020 mm (.1240 + .0000 − .0008 in)	2.375 + 0.000 − 0.020 mm (.0935 + .0000 − .0008 in)	3.137 ± 0.013 mm (.1235 ± .0005 in)
Clearance between groove and piston ring (new).	0.071 to 0.117 mm (.0028 to .0046 in)	0.058 to 0.104 mm (.0023 to .0041 in)	0.051 ± 0.025 mm (.0020 ± .0010 in)
Maximum permissible clearance (worn).	0.15 mm (.006 in)		
Clearance between ends of piston ring when installed in a cylinder liner with a bore size of 120.650 mm (4.7500 in).	0.622 ± 0.191 mm (.0245 ± .0075 in)	0.622 ± 0.191 mm (.0245 ± .0075 in)	0.57 ± 0.19 mm (.022 ± .007 in)
Increase in clearance between ends of piston ring for each 0.03 mm (.001 in) increase in cylinder liner bore size.	0.08 mm (.003 in)		

[1] Install piston ring with "UP" side toward the top of the piston. The 9S3029 Top Piston Ring has the mark "UP-1". The 5S6750 Intermediate Piston Ring has the mark "UP-2". Use the 5P3519 Piston Ring Groove Gauge to check the top and intermediate ring grooves with straight sides.
[2] Install the 7E6047 Oil Control Ring with the gap in the spring 180 degrees away from the gap in the ring.

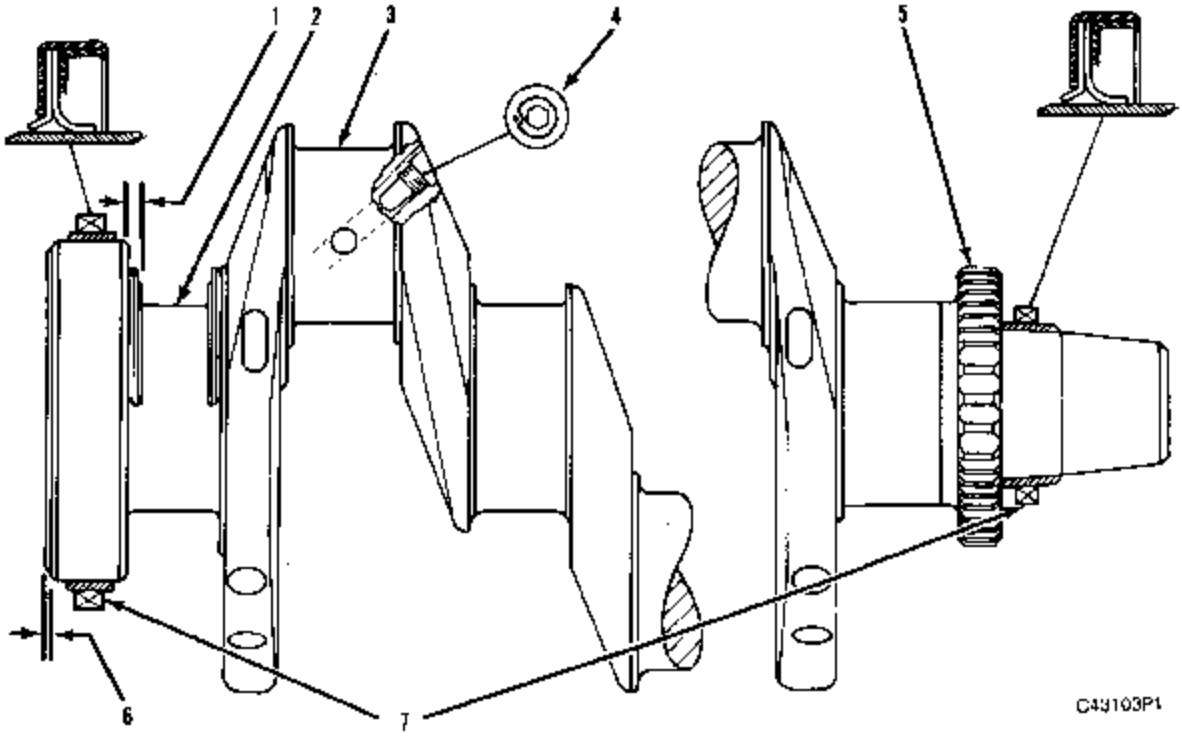
PISTON AND PISTON RINGS			
	(1) TOP RING	(2) INTERMEDIATE RING	(3) OIL CONTROL RING
Part No.	**2W1707**[1]	**5S6750**[1]	**7E6047**[2]
Width of groove in piston for piston ring (new).	[3]	2.446 ± 0.013 mm (.0963 ± .0005 in)	3.188 ± 0.013 mm (.1255 ± .0005 in)
Thickness of piston ring (new).	[3]	2.375 + 0.000 − 0.020 mm (.0935 + .0000 − .0008 in)	3.137 ± 0.013 mm (.1235 ± .0005 in)
Clearance between groove and piston ring (new).	[3]	0.058 to 0.104 mm (.0023 to .0041 in)	0.051 ± 0.025 mm (.0020 ± .0010 in)
Maximum permissible clearance (worn).	[3]	0.15 mm (.006 in)	0.15 mm (.006 in)
Clearance between ends of piston ring when installed in a cylinder liner with a bore size of 120.650 mm (4.7500 in).	0.622 ± 0.191 mm (.0245 ± .0075 in)	0.622 ± 0.191 mm (.0245 ± .0075 in)	0.57 ± 0.19 mm (.022 ± .007 in)
Increase in clearance between ends of piston ring for each 0.03 mm (.001 in) increase in cylinder liner bore size.	0.08 mm (.003 in)		

[1] Install piston ring with "UP" side toward the top of the piston. The 2W1707 Top Piston Ring has the mark "UP-1". The 5S6750 Intermediate Piston Ring has the mark "UP-2". Use the 5P3519 Piston Ring Groove Gauge to check the intermediate ring grooves with straight sides

[2] Install the 7E6047 Oil Control Ring with the gap in the spring 180 degrees away from the gap in the ring.

[3] "Keystone" style piston rings and grooves in the piston. The 1U6431 Keystone Piston Ring Groove Gauge is necessary for measuring these grooves. For correct use of the gauge group, see the instruction card that is supplied with the gauge group.

Crankshaft



(1) Thickness of thrust plates (new) ..... 5.461 ± 0.038 mm (.2150 ± .0015 in)

(2) Diameter of the main bearing journals (new) ..... 88.880 ± 0.020 mm (3.4992 ± .0008 in)

(3) Diameter of the connecting rod journals (new) ... . 76.180 ± 0.020 mm (2.9992 ± .0008 in)

(4) Tighten plugs to a torque of ..... 23 ± 4 N•m (17 ± 3 lb ft)
Then "stake" the crankshaft to hold plugs in place. "STAKE" use a center punch and a hammer to change the shape of the holes as shown.

(5) Crankshaft gear:
Do not heat gear to more than .... 316°C (600°F)

(6) Endplay for crankshaft (new) ..... 0.122 to 0.579 mm (.0048 to .0228 in)

(7) Wear sleeve and seal installation:

Remove front and rear seal groups as follows:

NOTE: Seals and wear sleeves cannot be used again after the seals and wear sleeves are separated.

a. Use the 1P3075 Puller Group to remove the seals
b. Use the 5P7318 Distorter Group to remove the wear sleeves.

Install front and rear seal groups as follows:

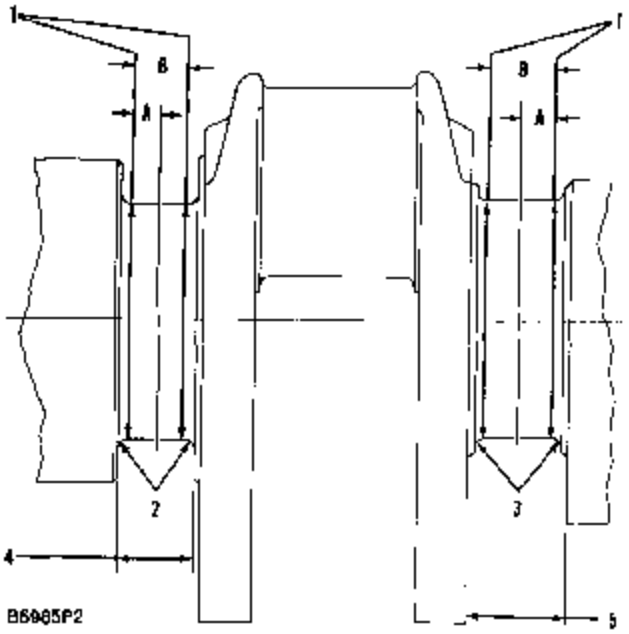
a. Clean the outer surface of the crankshaft with 6V1541 Quick Cure Primer.
b. Crankshaft seals must be installed with the lip of the seal toward the inside of the engine as shown. Make sure the correct seal is installed on each end of the crankshaft.

NOTE: No lubrication is needed to install wear sleeves and seals

c. Do not separate seals from sleeves. Install the seal groups as a unit on each end of the engine as shown with the correct tools.

NOTE: See Special Instruction SMHS7100 for front seal assembly installation and SMHS8508 for rear seal assembly installation procedures

Bearing Surface (Journal) For Main Bearings



(A) Distance from the centerline of the main bearing journal .... 14.262 mm (.5615 in)

(B) Dimension from line (A) ..... 28.524 mm (1.1230 in)

(1) Diameter of the main bearing journal at (A) and (B) (new) .... 88.880 ± 0.020 mm (3.4992 ± .0008 in)
Difference in the diameter at (A) and (B) must not be more than .... 0.015 mm (.0006 in)

(2) Radius-Rear journal ..... . 4.74 ± 0.20 mm (.187 ± .008 in)

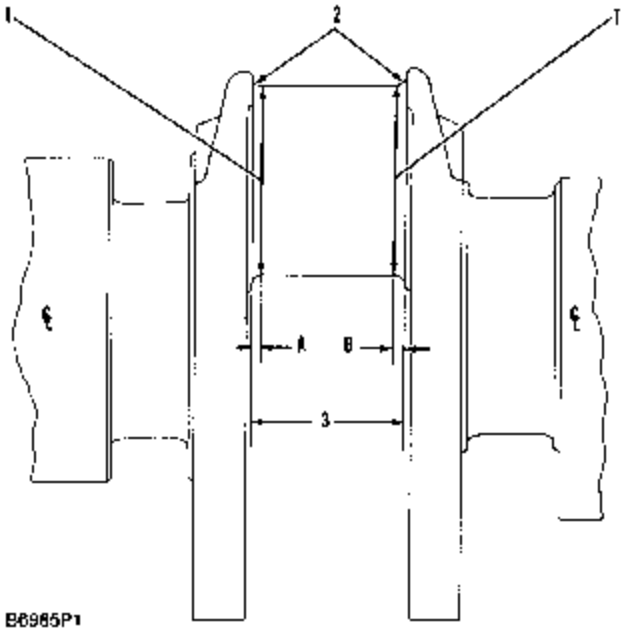
(3) Radius-All others (minimum) . ... 4.74 ± 0.20 mm (.187 ± .008 in)

NOTE: Radius must blend smoothly (have no sharp edges) with the machined surfaces of the journals.

(4) Width of rear journal ..... . 40.475 – 0.140 – 0.064 mm (1.594 + .006 – .003 in)

(5) Width of all journals except rear (maximum) ... 45.16 mm (1.78 in)

Bearing Surface (Journal) For Connecting Rods



(A) Measurement ..... 6.045 mm (.2380 in)

(B) Measurement ..... 6.045 mm (.2380 in)

(1) Diameter of the connecting rod journals (new) ..... 76.180 ± 0.020 mm (2.9992 ± .0008 in)
Difference in diameter at (A) and (B) must not be more than ..... 0.015 mm (.0006 in)

(2) Radius ..... 4.74 ± 0.20 mm (.187 ± .008 in)

NOTE: Radius must blend smoothly (have no sharp edges) with the machined surfaces of the journals.

(3) Width of journals ... 47.668 ± 0.140 mm (1.877 ± .006 in)

Connecting Rod and Main Bearings

Make reference to Guidelines for Reusable Parts; Main Bearings and Connecting Rods, Form No. SEBF8009, and Crankshaft Measurement, Form No. SEBF8041

Connecting Rod Bearings

Diameter of crankshaft journal (bearing surface) for connecting rod	
Original Size Journal	76.180 ± 0.020 mm (2.9992 ± .0008 in)
Undersize Journal 0.25 mm (.010 in)	75.926 ± 0.020 mm (2.9892 ± .0008 in)
Undersize Journal 0.51 mm (.020 in)	75.672 ± 0.020 mm (2.9792 ± .0008 in)
Undersize Journal 0.76 mm (.030 in)	75.418 ± 0.020 mm (2.9692 ± .0008 in)

Clearance between bearing and journal (new) ..... 0.076 to 0.168 mm (.0025 to .0066 in)

Maximum permissible clearance between bearing and journal ..... 0.25 mm (.010 in)

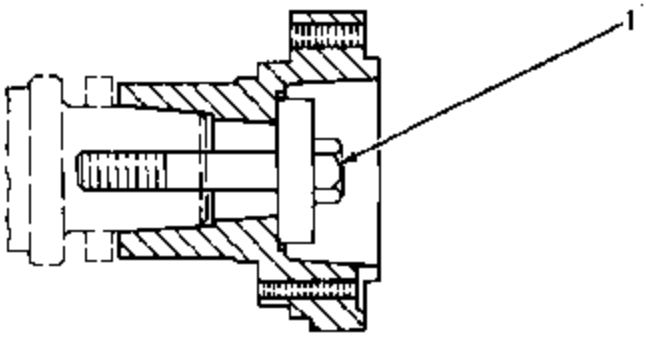
Main Bearings

Diameter of crankshaft journal (bearing surface) for main bearings	
Original Size Journal	88.880 ± 0.020 mm (3.4992 ± .0008 in)
Undersize Journal 0.25 mm (.010 in)	88.626 ± 0.020 mm (3.4892 ± .0008 in)
Undersize Journal 0.51 mm (.020 in)	88.372 ± 0.020 mm (3.4792 ± .0008 in)
Undersize Journal 0.76 mm (.030 in)	88.118 ± 0.020 mm (3.4692 ± .0008 in)

Clearance between bearing and journal (new) ..... 0.076 to 0.165 mm (.0030 to .0065 in)

Maximum permissible clearance between bearing and journal ..... 0.25 mm (.010 in)

Crankshaft Hub And Damper



A23401P1

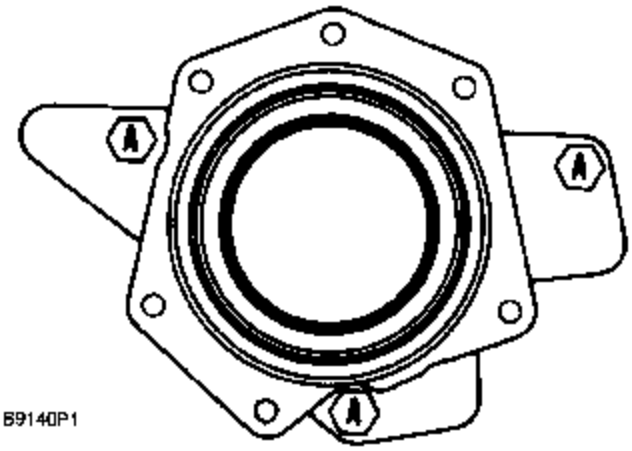
Typical Example

(1) Tighten bolt holding hub to crankshaft to ..... 312 ± 27 N•m (230 ± 20 lb ft)

Hit bolt with hammer and again tighten bolt to ..... 312 ± 27 N•m (230 ± 20 lb ft)

NOTE: Install washer with the maximum flat area next to the hub

Trunnion

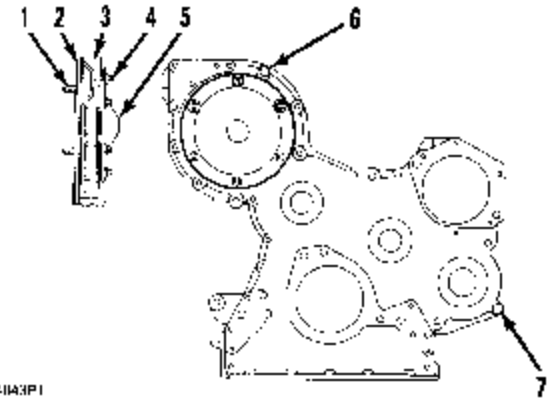


B9140P1

Typical Example

Tighten bolts (A) to ..... 135 ± 14 N•m (100 ± 10 lb ft)

Timing Gear Cover



C24143P1

(1) Stud. Apply 5P3413 Pipe Sealant. Distance studs extend from rear face of plate ... 26.2 ± 1.5 mm (1.031 ± .060 in)

(2) Plate assembly

(3) Front housing.

(4) Stud. Apply 5P3413 Pipe Sealant. Distance studs extend from front face of housing ..... 19.0 ± 0.8 mm (.748 ± .031 in)

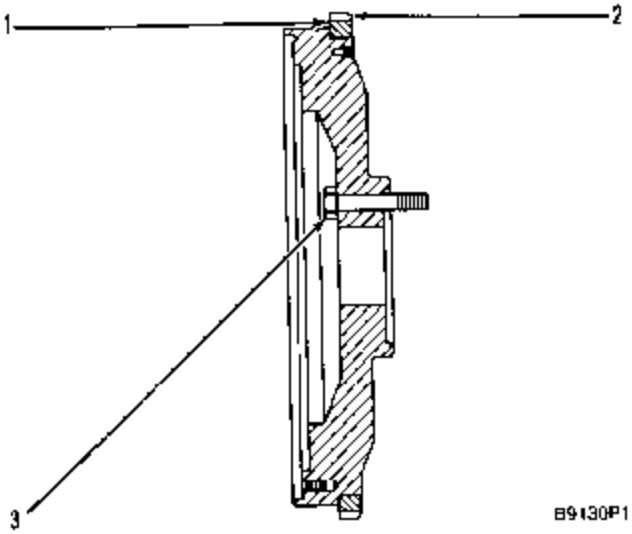
Torque for nuts holding cover for fuel pump drive gear ..... 25 ± 7 N•m (20 ± 5 lb ft)

(5) Cover.

(6) Bolt. Tighten to ..... 23 ± 4 N•m (17 ± 3 lb ft)

(7) Bolt. Tighten to ..... 23 ± 4 N•m (17 ± 3 lb ft)

Flywheel



Typical Example

(1) Ring gear.

(2) Chamfer side of ring gear (1).

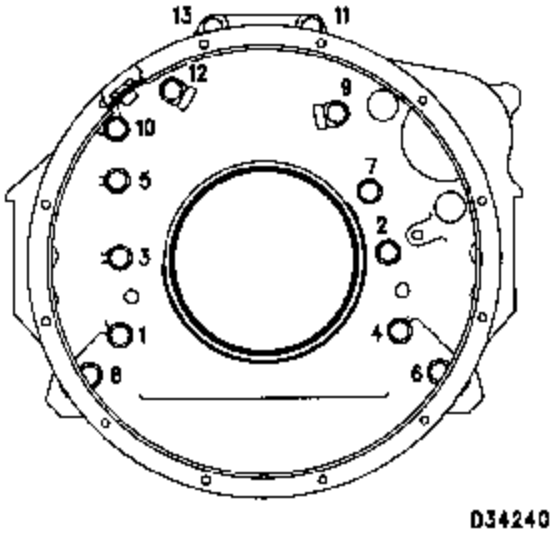
Install ring gear (1) on flywheel so that the chamfer side (2) of ring gear (1) is as shown.

NOTE: Do not heat ring gear to more than 320°C (608°F) before installing on the flywheel.

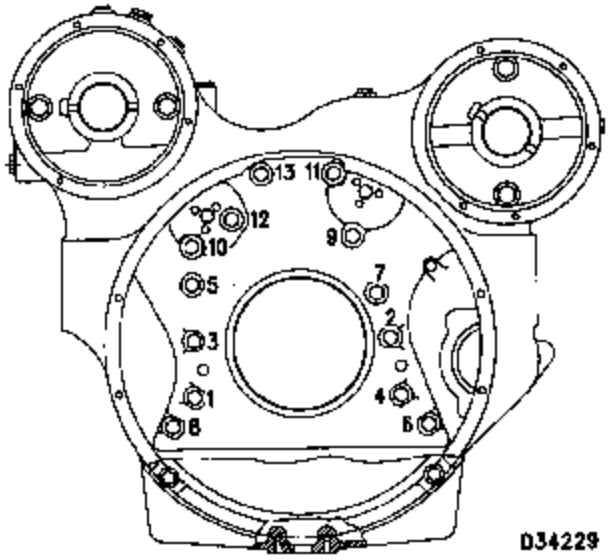
(3) Torque for flywheel bolts .. 215 ± 40 N•m (160 ± 30 lb ft)

Make reference to Flywheel Runout for the correct method of flywheel inspection.

Flywheel Housing

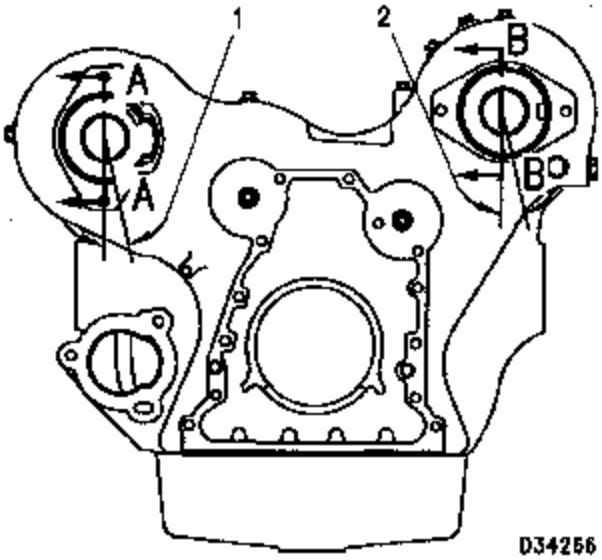


Typical Example

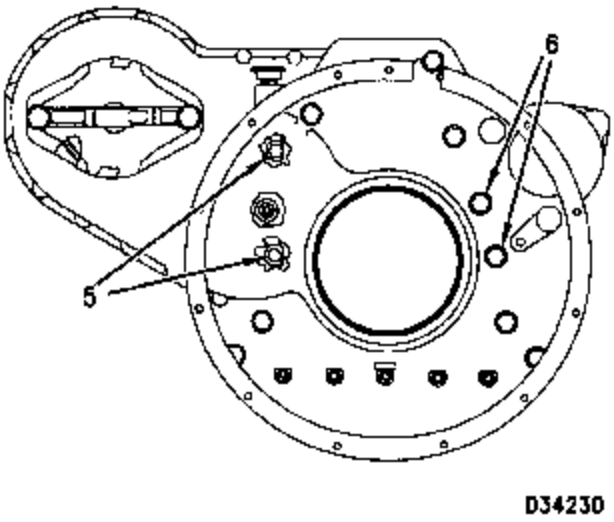


With Rear Accessory Drive Gears

Tighten flywheel housing bolts in number sequence to .... 100 ± 15 N•m (75 ± 11 lb ft)



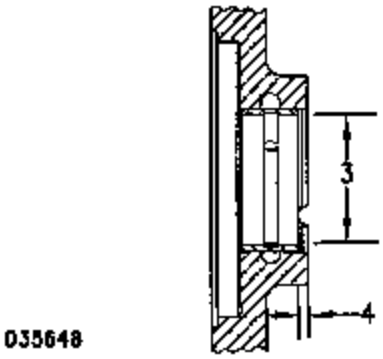
(1) and (2) Bearing joint location is 15 ± 1 degrees from vertical centerline as shown.



(5) Two bolts ..... 31.75 mm (1.250 in).

(6) Two bolts ..... 66.68 mm (2.625 in).

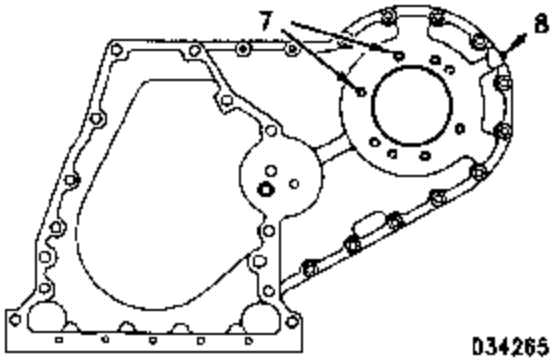
The remainder of the flywheel housing mounting bolts are ..... 69.85 mm (2.750 in)



Section View A-A And B-B

(3) Inside diameter of bearing in the flywheel housing ..... 63.525 ± 0.038 mm (2.5010 ± .0015 in)

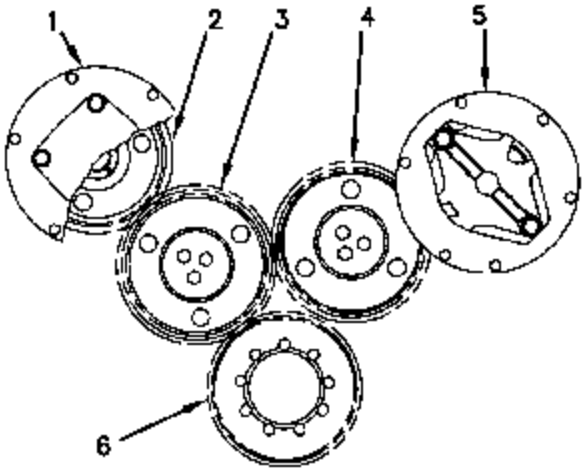
(4) Distance from the end of the flywheel housing to the bearing ..... 4.0 ± 0.5 mm (.136 ± .02 in)



(7) Studs. Put 5P3413 Thread Sealant on studs (eleven) and tighten to a torque of ..... 20 ± 3 N•m (15 ± 2 lb ft)

(8) Plug. Put 5P3413 Thread Sealant on plug before installation.

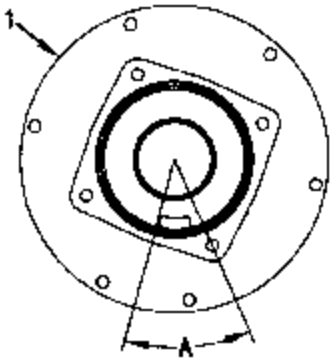
Rear Accessory Drive Gear



D34396

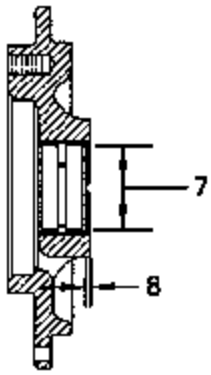
Typical Illustration

(1) Hydraulic pump adapter assembly.



D34401

(1) Hydraulic pump adapter assembly, bearing joint (A) installed at a 37.5 ± 1.0 degree location from the two bolt centerline of the adapter housing as shown.



D34400

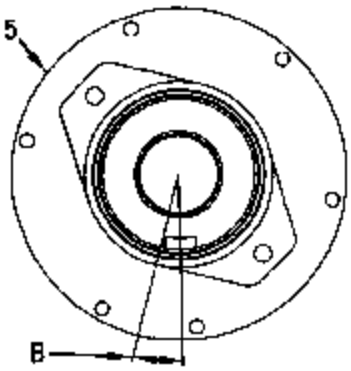
(7) Inside diameter of bearing in adaptor housing ..... 63.525 ± 0.038 mm (2.5010 ± .0015 in)

(8) Distance from the end of the bearing to the edge of the adapter housing ..... 3.5 ± 0.5 mm (.14 ± .02 in)

(2) Hydraulic pump drive gear.

(3) Idler gear

(4) Idler gear
Bore in bearing for the idler gears (3) and (4) ..... 82.527 ± 0.053 mm (3.2491 ± .0021 in)
Relief in bearing to line up with the relief in gears within two degrees.
Bearing must not extend beyond either face of gear.



D34399

(5) Hydraulic pump adapter assembly.

(B) Bearing joint installed at a 15 ± 1 degree location from the vertical centerline of the adapter housing as shown.

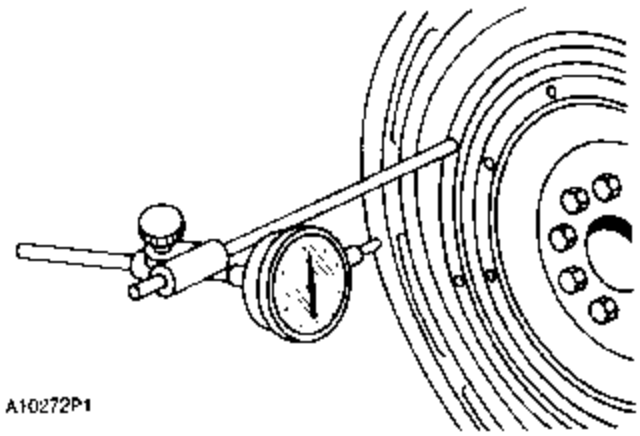
For adapter assembly bearing specifications see Steps (7) and (8).

(6) Crankshaft rear gear

Flywheel And Flywheel Housing

Tools Needed		
8T5096	Dial Indicator Group	1

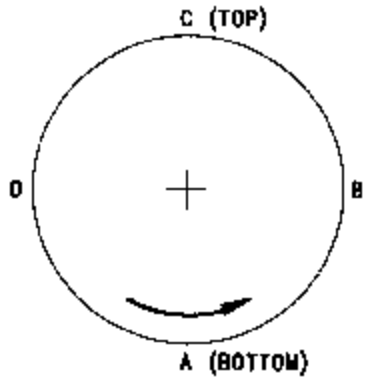
Face Run Out (Axial Eccentricity) Of The Flywheel Housing



8T5096 Dial Indicator Group Installed
(Typical Example)

If any method other than given here is used, always remember bearing clearance must be removed to get correct measurements.

1. Fasten a dial indicator to the flywheel so the anvil of the indicator will touch the face of the flywheel housing.
2. Put a force on the crankshaft toward the rear before the indicator is read at each point.

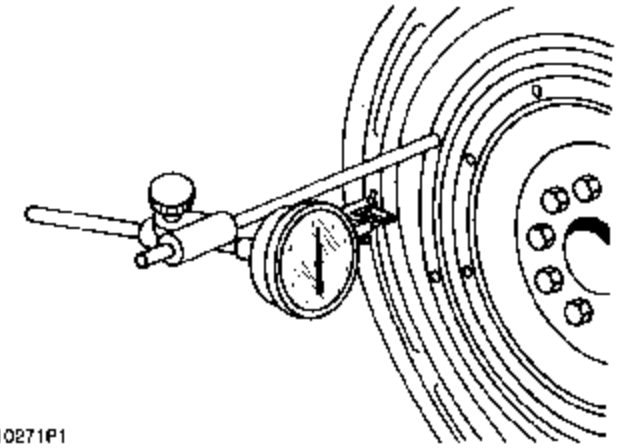


Checking Face Runout Of The Flywheel Housing

3. With dial indicator set at '0' (zero) at location (A), turn the flywheel and read the indicator at locations (B), (C) and (D).
4. The difference between lower and higher measurements taken at all four points must not be more than 0.38 mm (.015 in), which is the maximum permissible face run out (axial eccentricity) of the flywheel housing.

Bore Runout (Radial Eccentricity) Of The Flywheel Housing

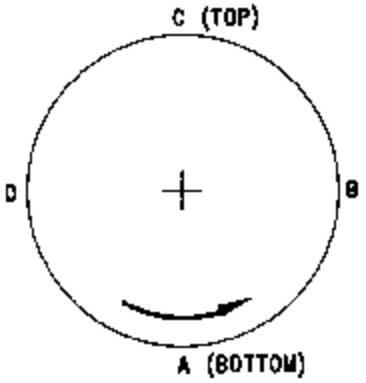
1. Fasten the dial indicator as shown so the anvil of the indicator will touch the bore of the flywheel housing.
2. With the dial indicator in position at (C), adjust the dial indicator to "0" (zero). Push the crankshaft up against the top of the bearing. Write the measurement for bearing clearance on line 1 in column (C) in the Chart For Dial Indicator Measurements.



8T5096 Dial Indicator Group Installed
(Typical Example)

NOTE: Write the dial indicator measurements with their positive (+) and negative (−) notation (signs). This notation is necessary for making the calculations in the chart correctly.

3. Divide the measurement from Step 2 by 2. Write this number on line 1 in columns (B) & (D).
4. Turn the flywheel to put the dial indicator at (A). Adjust the dial indicator to '0' (zero).
5. Turn the flywheel counterclockwise to put the dial indicator at (B). Write the measurements in the chart.



Checking Bore Runout Of The Flywheel Housing

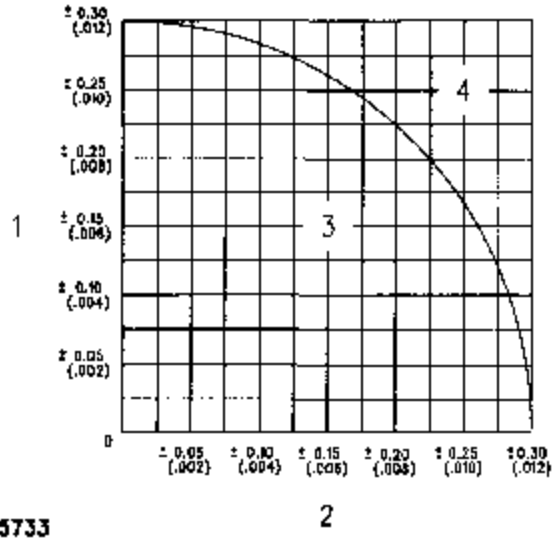
6. Turn the flywheel counterclockwise to put the dial indicator at (C). Write the measurement in the chart.
7. Turn the flywheel counterclockwise to put the dial indicator at (D). Write the measurement in the chart.

CHART FOR DIAL INDICATOR MEASUREMENTS					
		Position of dial indicator			
	Line No.	A	B	C	D
Correction for bearing clearance	I	0			
Dial Indicator Reading	II	0			
Total of Line 1 & 2	III	0	**	*	**

*Total vertical eccentricity (out of round).
**Subtract the smaller No. from the larger No. The difference is the total horizontal eccentricity.

D15721

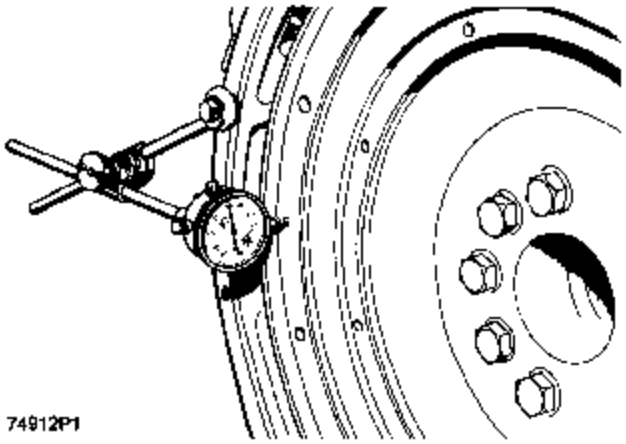
8. Add lines I & II by columns.
9. Subtract the smaller number from the larger number in line III in columns (B) & (D). The result is the horizontal eccentricity (out of round). Line III, column (C) is the vertical eccentricity.
10. On the graph for total eccentricity, find the point of intersection of the lines for vertical eccentricity and horizontal eccentricity.
11. If the point of intersection is in the range marked "Acceptable", the bore is in alignment. If the point of intersection is in the range marked "Not Acceptable", the flywheel housing must be changed.



Graph For Total Eccentricity
(1) Total Vertical Eccentricity [mm (in)]. (2) Total Horizontal Eccentricity [mm (in)]. (3) Acceptable. (4) Not Acceptable.

Face Runout (Axial Eccentricity) Of The Flywheel

1. Install the dial indicator as shown. Always put a force on the crankshaft in the same direction before the indicator is read so the crankshaft end clearance (movement) is always removed.

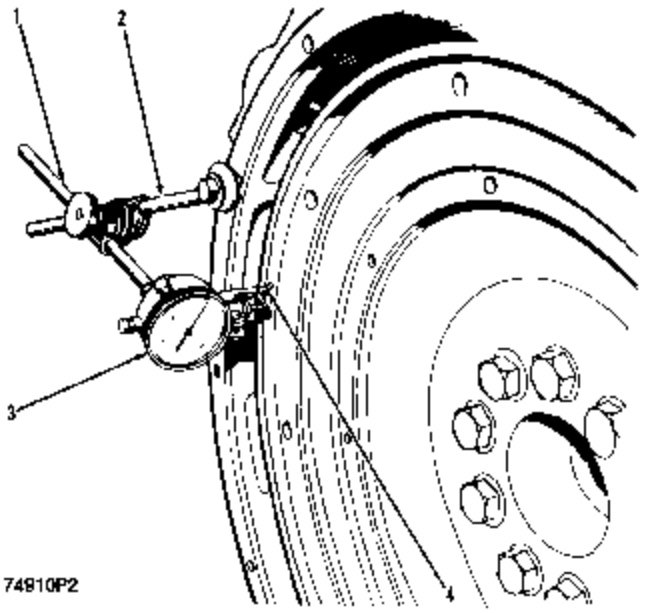


Checking Face Runout Of The Flywheel
(Typical Example)

2. Set the dial indicator to read "0" (zero).
3. Turn the flywheel and read the indicator every 90 degrees.

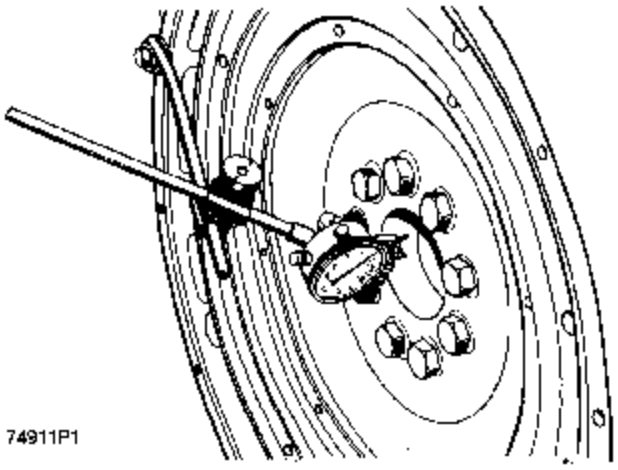
4. The difference between the lower and higher measurements taken at all four points must not be more than 0.15 mm (.006 in) which is the maximum permissible face runout (axial eccentricity) of the flywheel.

Bore Runout (Radial Eccentricity) Of The Flywheel



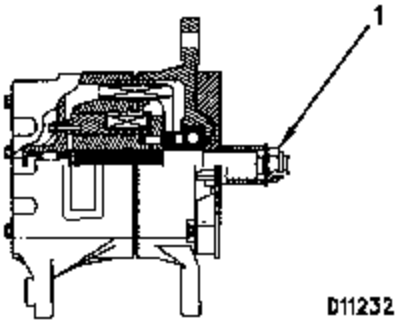
Checking Bore Runout Of The Flywheel (Typical Example)
(1) 7H1945 Holding Rod (2) 7H1645 Holding Rod (3) 7H1942 Indicator (4) 7H1940 Universal Attachment

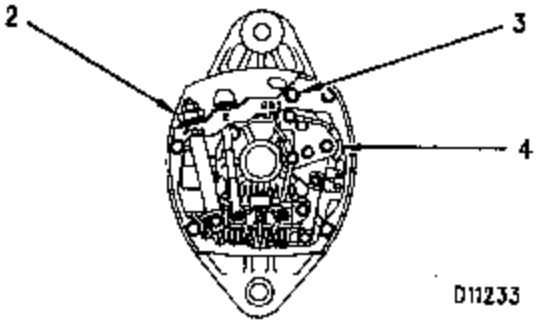
1. Install the dial indicator (3) and make an adjustment of the universal attachment (4) so it makes contact as shown.
2. Set the dial indicator to read '0' (zero).
3. Turn the flywheel and read the indicator every 90 degrees.
4. The difference between the lower and higher measurements taken at all four points must not be more than 0.15 mm (.006 in), which is the maximum permissible bore runout (radial eccentricity) of the flywheel
5. Runout (eccentricity) of the bore for the pilot bearing for the flywheel clutch, must not exceed 0.13 mm (.005 in).



Checking Flywheel Clutch Pilot Bearing Bore

Alternator And Regulator





6N9294 Alternator Group, 3T6352 Alternator 24V

NOTE: Load the battery with a carbon pile (4C4911 Battery Load Tester) to get the maximum alternator output.

Polarity ..... Negative Ground

Rotation ..... Either Direction

Speed for testing (rpm) 5000

Output voltage ..... 28 ± 1.0V

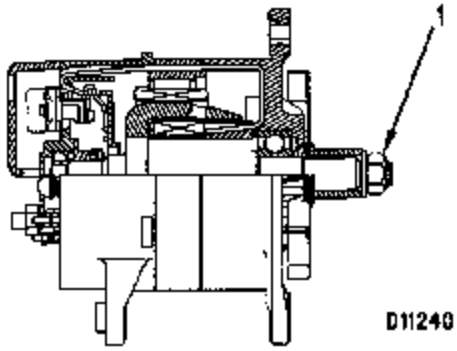
Output (hot) 35A

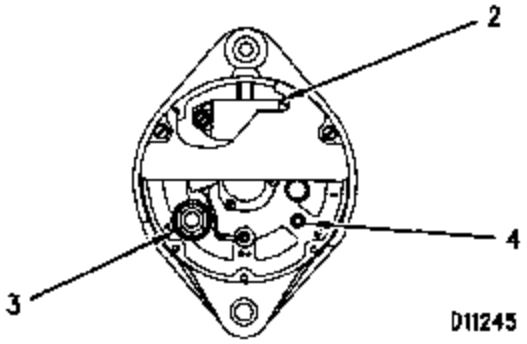
(1) Shaft nut torque ..... 102 ± 7 N•m (76 ± 5 lb ft)

(2) Torque for positive terminal nut ..... 5.2 ± 0.6 N•m (55 ± 5 lb in)

(3) Torque for ..... 2.25 ± 0.25 N•m (20 ± 2 lb in)

(4) Regulator.
Voltage setting ..... No adjustment
Permissible voltage range ..... 27 to 29V





6N9294 Alternator Group, 7N9720 Alternator 24V

NOTE: Load the battery with a carbon pile (4C4911 Battery Load Tester) to get the maximum alternator output.

Polarity ..... Negative Ground

Rotation ..... Either Direction

Speed for testing (rpm) 5000

Output voltage ..... 27.5 ± 1.0V

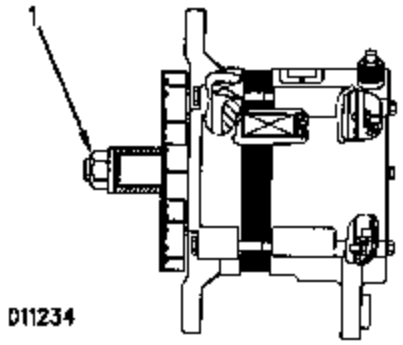
Output (hot) 35A

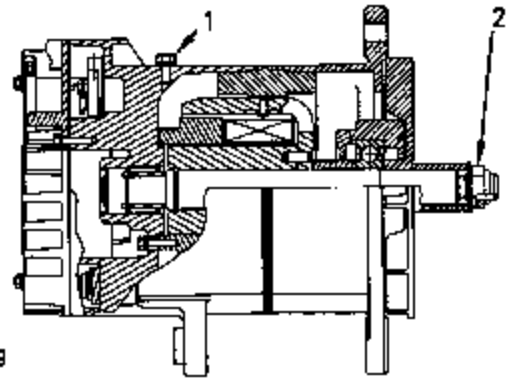
(1) Shaft nut torque ..... 102 ± 7 N•m (76 ± 5 lb ft)

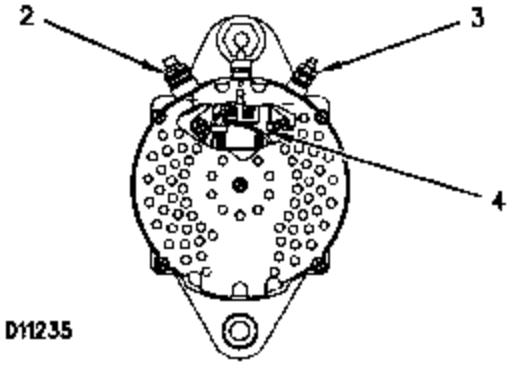
(2) Regulator.
Voltage setting ..... No adjustment
Permissible voltage range ..... 26.5 to 28.5V

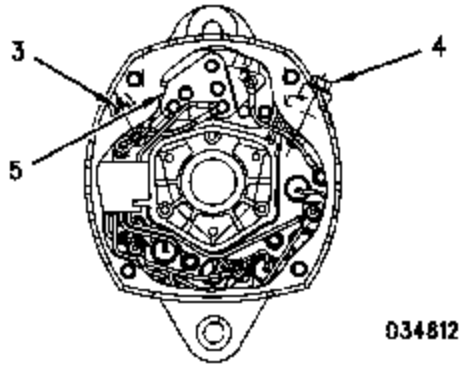
(3) Torque for positive terminal nut ..... 13.5 ± 1.3 N•m (119 ± 12 lb in)

(4) Torque for ground terminal nut ..... 2.1 to 2.8 N•m (19 to 25 lb in)









6N9294 Alternator Group, 9G4574 Alternator 24V

NOTE: Load the battery with a carbon pile (4C4911 Battery Load Tester) to get the maximum alternator output.

Polarity ..... Negative Ground

Rotation ..... Either Direction

Speed for testing (rpm) 5000

Output voltage ..... 28 ± 1.0V

Output (hot) 35.6A

(1) Shaft nut torque ..... 102 ± 7 N•m (76 ± 5 lb ft)

(2) Torque for positive terminal nut ..... 13.5 ± 1.3 N•m (119 ± 12 lb in)

(3) Torque for the ground terminal nut ..... 4.4 ± 1.0 N•m (39 ± 9 lb in)

Regulator.

Voltage setting ..... No adjustment

Permissible voltage range ..... 27 to 29V

100-5047 Alternator Group, 112-5041 Alternator 24V

NOTE: Load the battery with a carbon pile (4C4911 Battery Load Tester) to get the maximum alternator output.

Polarity ..... Negative Ground

Rotation ..... Either Direction

Speed for testing (rpm) 5000

Output voltage ..... 28 ± 1.0V

Output (hot) 47A

(1) Torque for the ground terminal nut ..... 6.2 ± 0.6 N•m (55 ± 5 lb in)

(2) Shaft nut torque ..... 102 ± 7 N•m (76 ± 5 lb ft)

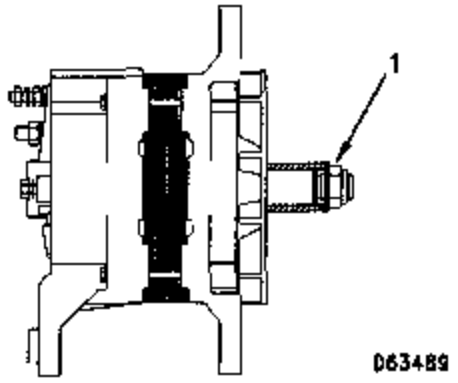
(3) B Terminal is the AC tap from stator

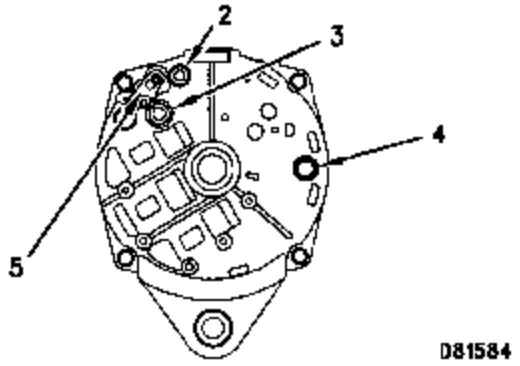
(4) Torque for positive terminal nut 13.5 ± 1.3 N•m (119 ± 12 lb in)

(5) Regulator.

Voltage setting ..... No adjustment

Permissible voltage range ..... 27 to 29V





107-7977 Alternator 24V

NOTE: Load the battery with a carbon pile (4C4911 Battery Load Tester) to get the maximum alternator output.

Polarity ..... Negative Ground

Rotation ..... Clockwise

Minimum full load current at 5000 rpm 68A

Minimum full load current at 2000 rpm 31A

Output voltage ..... 28 + 1.0V

(1) Shaft nut torque ..... 102 ± 7 N•m (75 ± 5 lb ft)

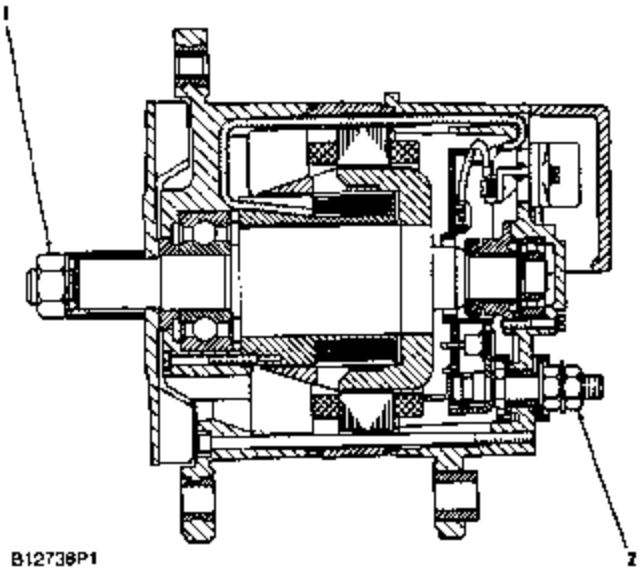
(2) Torque for warning light terminal ..... 2.26 + 0.57 N•m (20 ± 5 lb in)

(3) Torque for battery terminal ... 7.1 ± 0.9 N•m (63 ± 5 lb in)

(4) Torque for ground terminal .. 6.2 ± 0.6 N•m (55 ± 5 lb in)

(5) Regulator.
Voltage Setting ..... No Adjustment
Permissible Voltage Range ..... 27 to 29V

100-5047 Alternator Group, 100-5045 Alternator 24V



NOTE: Load the battery with a carbon pile (4C4911 Battery Load Tester) to get the maximum alternator output.

Polarity ..... Negative Ground

Rotation ..... Either Direction

Speed for testing (rpm) 5000

Output voltage ..... 28 ± 1.0V

Output (cold) 44.6A

Torque for the ground terminal nut ... 4 ± 1 N•m (35 ± 9 lb in)

(1) Torque for the pulley nut ..... 102 ± 7 N•m (76 ± 5 lb ft)

(2) Torque for the output terminal nut ..... 14 ± 1 N•m (20 ± 9 lb in)

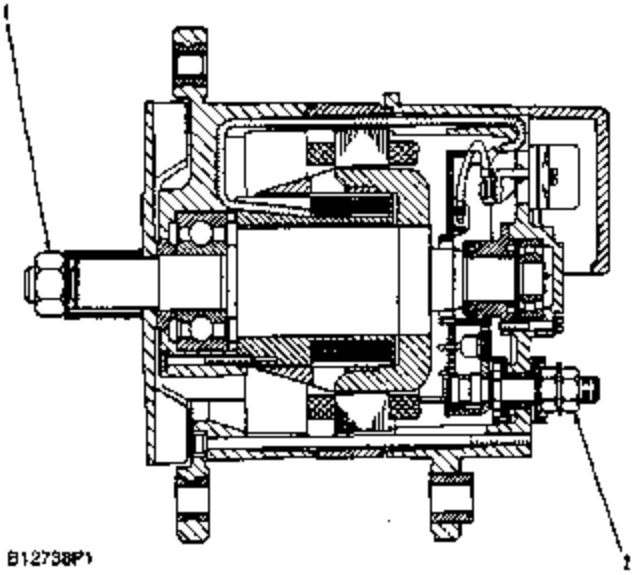
9G7567 Regulator (Under Alternator Cover). For use with the 100-5045 Alternator.

Voltage rating 28V

Polarity ..... Negative Ground

Voltage setting range ..... 27 to 29V

100-5047 Alternator Group, 100-5046 Alternator 24V



NOTE: Load the battery with a carbon pile (4C4911 Battery Load Tester) to get the maximum alternator output.

Polarity ..... Negative Ground

Rotation ..... Either Direction

Speed for testing (rpm) 5000

Output voltage ..... 27.5 ± 1.0V

Output (cold) 45A

Torque for the ground terminal nut ..... 2.3 ± .3 N•m (20 ± 2)

(1) Torque for the pulley nut ..... 102 ± 7 N•m (76 ± 5 lb ft)

(2) Torque for the output terminal nut ..... 14 ± 1 N•m (20 ± 9 lb in)

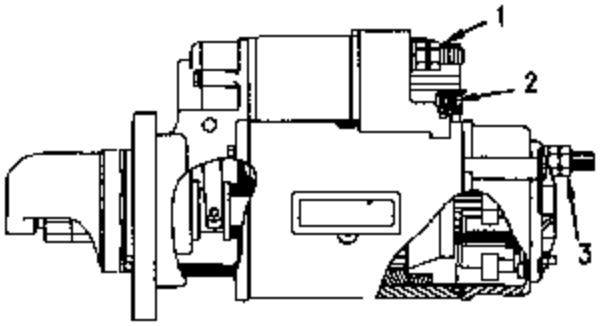
9G7567 Regulator (Under Alternator Cover) For use with the 100-5046 Alternator.

Voltage rating 28V

Polarity ..... Negative Ground

Voltage setting range ..... 26.5 to 28.5V

Electric Starter Motor



D03952

6V5226 And 6V5538

Rotation as seen from drive end ..... Clockwise

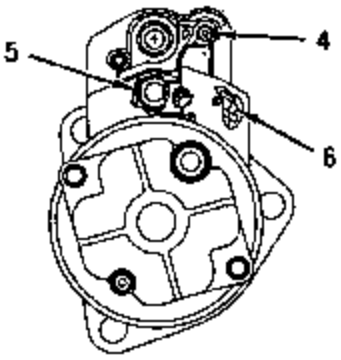
No load conditions

Speed (rpm) ..... 3300 Minimum
Current (amps) ..... 80 Maximum
Voltage 23.5V

(1) Battery terminal. Three cables or wire terminal maximum between nuts. Two cable terminals maximum with 0 AWG or larger. Tighten nut to a torque of ..... 30.5 ± 3.5 N•m (270 ± 31 lb in)

(2) Nut. Tighten nut to a torque of ..... 1.5 ± 0.5 N•m (13 ± 4 lb in)

(3) Ground terminal. Tighten nut to a torque of ..... 30.5 ± 3.5 N•m (270 ± 31 lb in)

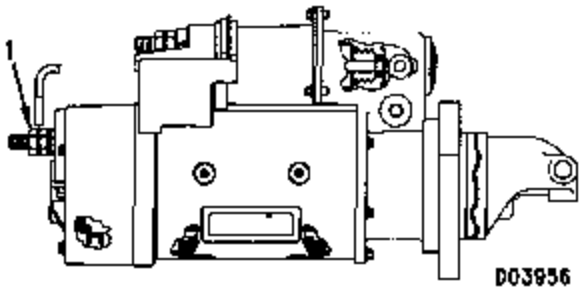


D03955

(4) Switch terminal. Tighten nut to a torque of ..... 2.25 ± 0.25 N•m (20 ± 2 lb in)

(5) Motor terminal. Tighten nut to a torque of ..... 30.5 ± 3.5 N•m (270 ± 31 lb in)

(6) Motor frame terminal. Tighten nut to a torque of ..... 17.5 ± 2.5 N•m (155 ± 22 lb in)



D03956

6V5207 And 6V5537

Rotation as seen from drive end ..... Clockwise

Minimum speed with no load ..... 5960 rpm

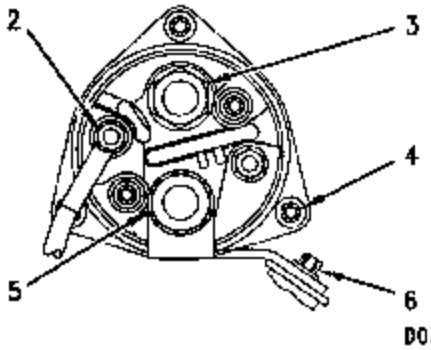
Maximum speed with no load ..... 9326 rpm

Current consumption (draw) at no load:

Minimum with solenoid at 23V 60A
Maximum with solenoid at 23V 75A

Clearing between pinion and housing (pinion clearance) ..... 8.3 to 9.9 mm (.33 to .39 in)

(1) Ground terminal. Tighten nut to a torque of ..... 30.5 ± 3.5 N•m (270 ± 31 lb in)



D03958

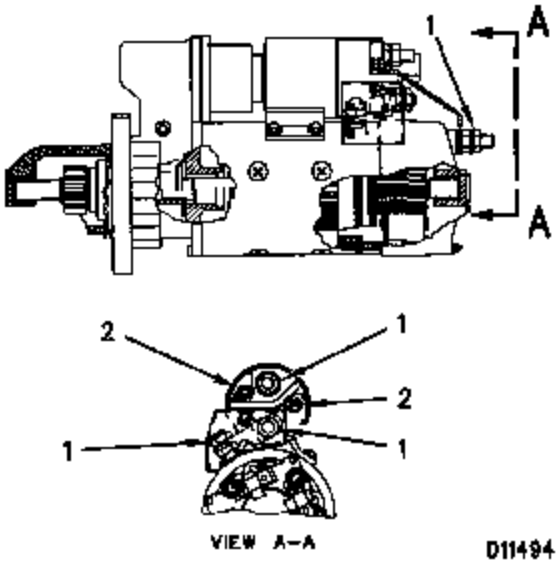
(2) Ground terminal. Tighten nut to a torque of ..... 2.25 ± 0.25 N•m (20 ± 2 lb in)

(3) Battery terminal. Three cables or wire terminal maximum between nuts. Two cable terminals maximum with 0 AWG or larger. Tighten nut to a torque of ..... 30.5 ± 3.5 N•m (270 ± 31 lb in)

(4) Switch terminal. Terminal for switch terminal must be insulated with heat shrinkable tubing. Tighten nut to a torque of ..... 2.25 ± 0.25 N•m (20 ± 2 lb in)

(5) Motor terminal. Tighten nut to a torque of ..... 30.5 ± 3.5 N•m (270 ± 31 lb in)

(6) Motor frame terminal. Tighten nut to a torque of 8 ± 3 N•m (71 ± 27 lb in)



6V5023 And 106-8552

Rotation as seen from the drive end ..... Clockwise

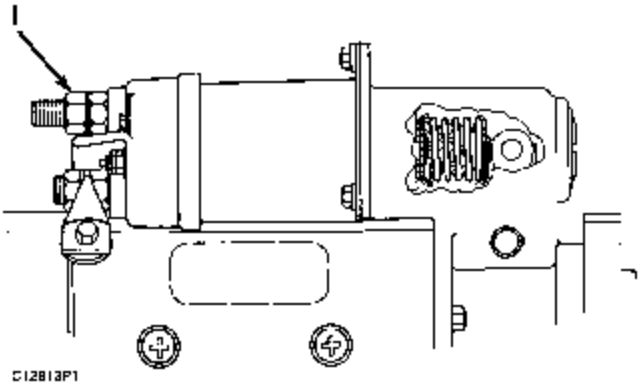
No load conditions:

Speed ..... 5500 rpm minimum
Current draw ..... 140A maximum
Voltage 24V

(1) Torque for the large terminal nuts ..... 27 to 33 N•m (20 to 24 lb ft)

(2) Torque for small terminal nuts ..... 2.0 to 2.5 N•m (18 to 22 lb in)

Starting Solenoid



(1) Torque for terminal nuts ..... 30 ± 3 N•m (22 ± 2 lb ft)

9X9511 24V (6V5207 And 6V5537 Starter)

Resistance of pull in windings ..... .50 to .59 ohms

Resistance of hold in windings ..... 1.3 to 1.8 ohms

Current consumption (draw):

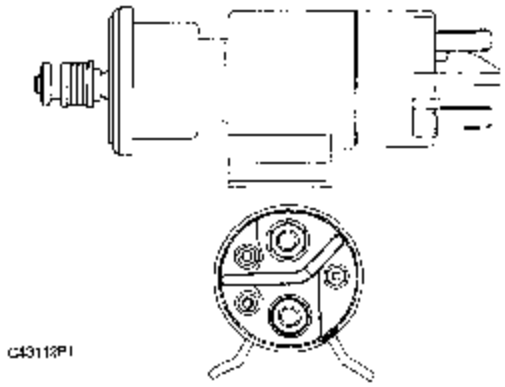
Pull in windings at 20V ..... 52 to 61A

Hold in windings at 20V 14.6A

3E0135 24V (6V5226 And 6V5538 Starter)

Current consumption (draw):

Pull in windings at 24V 103A
Hold in windings at 24V 19A



9X0332 24V (6V5023 And 106-8552 Starter)

Current consumption draw:

Pull in windings at 24V 51A
Hold in windings at 24V 7A

CATERPILLAR®

SENR5594
September 1995

Systems Operation Testing & Adjusting

3306B Engine
For Caterpillar Built Machines

8Z82840-UP
10Z29500-UP
13Z32475-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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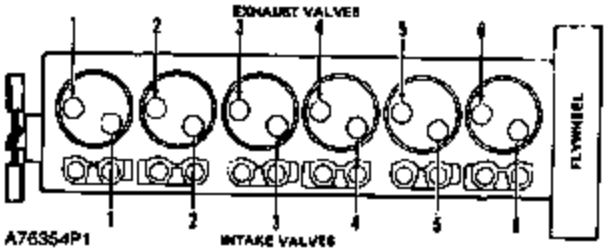
Specifications

NOTE: For Specifications with illustrations, make reference to Specifications for 3306B Engine SENR5593. If the specifications in SENR5593 are not the same as in the Systems Operation and the Testing and Adjusting, look at the printing date on the back cover of each book. Use the Specifications given in the book with the latest date.

Systems Operation

Engine Design



Cylinder And Valve Location

Bore ..... 120.7 mm (4.75 in)

Stroke ..... 152.4 mm (6.00 in)

Number of Cylinders 6

Cylinder Arrangement ..... in line

Valves per Cylinder 2

Combustion ..... Direct Injection

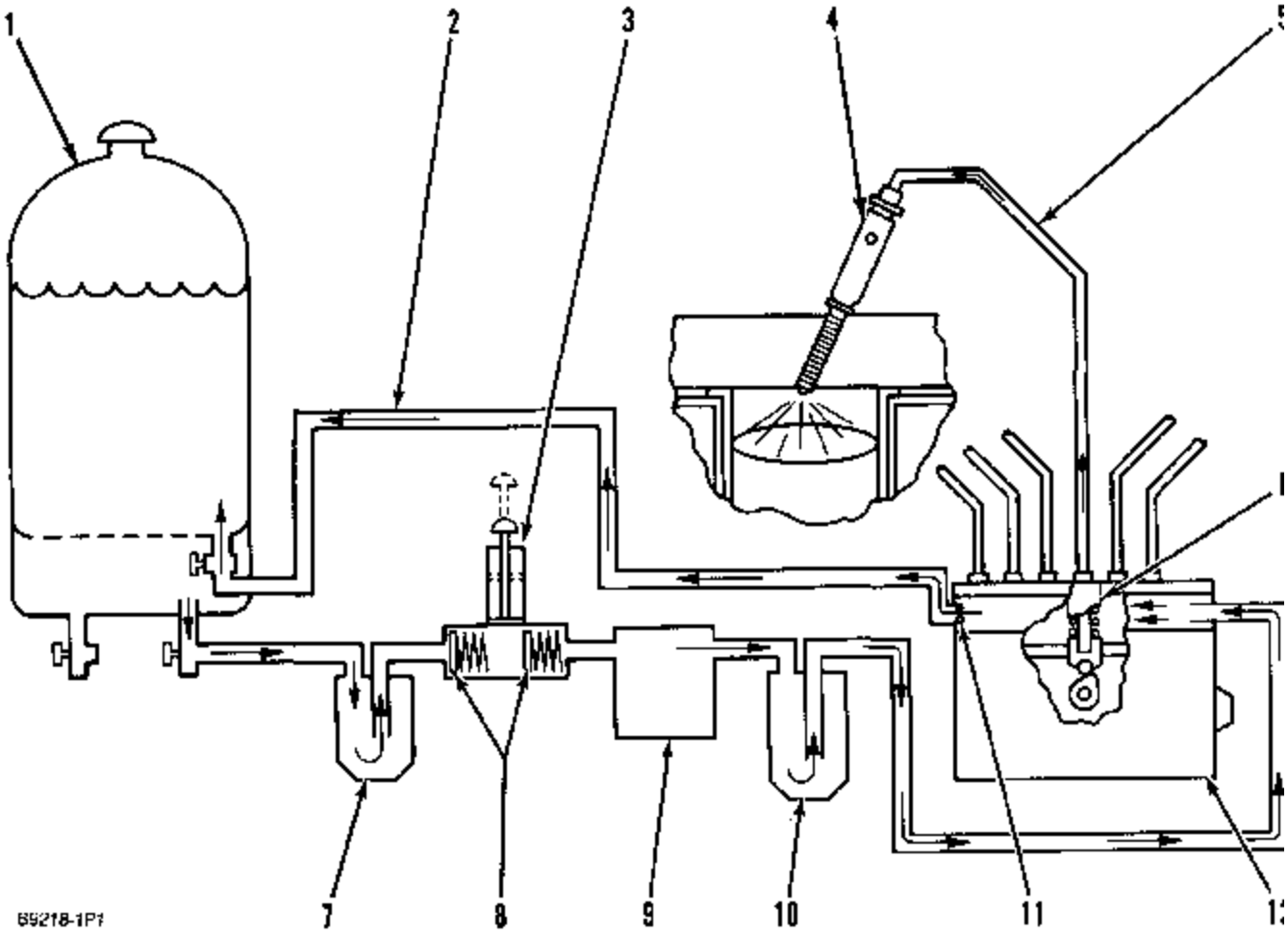
Firing Order (Injection Sequence) 1, 5, 3, 6, 2, 4

Rotation of Crankshaft (when seen from flywheel end) ..... counterclockwise

NOTE: The No. 1 cylinder is opposite the flywheel end.

Fuel System

Fuel Flow



Fuel System Schematic
(1) Fuel tank. (2) Fuel return line. (3) Priming pump. (4) Fuel injection nozzle. (5) Fuel injection line. (6) Fuel injection pump. (7) Primary fuel filter. (8) Check valve. (9) Fuel transfer pump. (10) Secondary fuel filter. (11) Constant bleed orifice. (12) Fuel injection pump housing.

Fuel is pulled from fuel tank (1) through primary fuel filter (7) and check valves (8) by fuel transfer pump (9). From the fuel transfer pump the fuel is pushed through secondary fuel filter (10) and to the fuel manifold in fuel injection pump housing (12). The pumping spring in the fuel transfer pump keeps the fuel pressure in the system at 170 to 290 kPa (25 to 42 psi). Constant bleed orifice (11) lets a constant flow of fuel go through fuel return line (2) back to fuel tank (1). This helps keep the fuel cool and free of air. Fuel injection pump (6) gets fuel from the fuel manifold and pushes fuel at very high pressure through fuel line (5) to fuel injection nozzle (4). The fuel injection nozzle has very small holes in the tip that change the flow of fuel to a very fine spray that gives good fuel combustion in the cylinder.

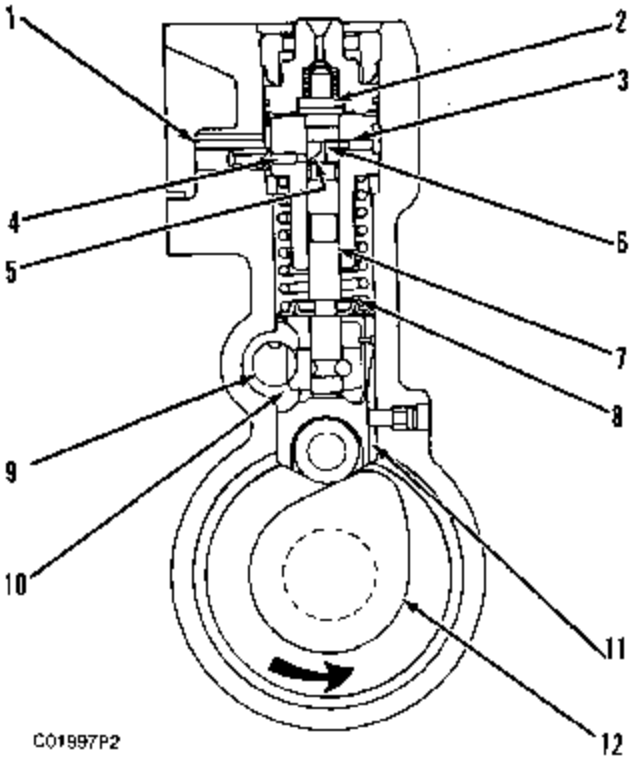
Fuel Injection Pump

The fuel injection pump increases the pressure of the fuel and sends an exact amount of fuel to the fuel injection nozzle. There is one fuel injection pump for each cylinder in the engine.

The fuel injection pump is moved by cam (12) of the fuel pump camshaft. When the camshaft turns, the cam raises lifter (11) and pump plunger (7) to the top of the stroke. The pump plunger always makes a full stroke. As the camshaft turns farther, spring (8) returns the pump plunger and lifter to the bottom of the stroke.

When the pump plunger is at the bottom of the stroke, fuel transfer pump pressure goes into inlet passage (1), around the pump barrel and to bypass closed port (3). Fuel fills the area above the pump plunger.

After the pump plunger begins the up stroke, fuel will be pushed out the bypass closed port until the top of the pump plunger closes the port. As the pump plunger travels farther up, the pressure of the fuel increases. At approximately 690 kPa (100 psi), check valve (2) opens and lets fuel flow into the fuel injection line to the fuel injection nozzle. When the pump plunger travels farther up, scroll (5) uncovers spill port (4). The fuel above the pump plunger goes through slot (6), along the edge of scroll (5) and out spill port (4) back to the fuel manifold. This is the end of the injection stroke. The pump plunger can have more travel up, but no more fuel will be sent to the fuel injection nozzle.



Fuel Injection Pump
(1) Inlet passage. (2) Check valve. (3) Bypass closed port. (4) Spill port. (5) Scroll. (6) Slot. (7) Pump plunger. (8) Spring. (9) Fuel rack. (10) Gear. (11) Lifter. (12) Cam.

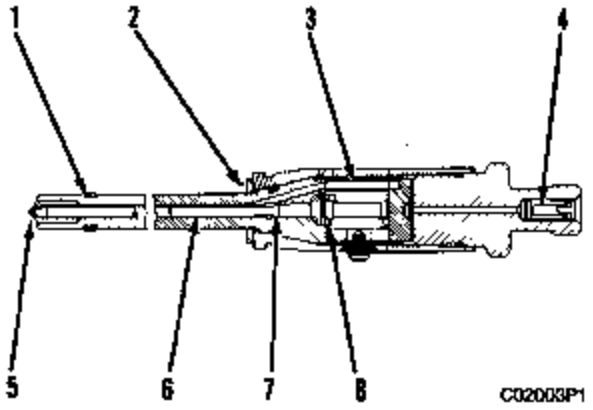
When the pump plunger travels down and uncovers bypass closed port (3), fuel begins to fill the area above the pump plunger again, and the pump is ready to begin another stroke.

The amount of fuel the injection pump sends to the injection nozzle is changed by the rotation of the pump plunger. Gear (10) is attached to the pump plunger and is in mesh with fuel rack (9). The governor moves the fuel rack according to the fuel needs of the engine. When the governor moves the fuel rack, and the fuel rack turns the pump plunger, scroll (5) changes the distance the pump plunger pushes fuel between bypass closed port (3) and spill port (4) opening. The longer the distance from the top of the pump plunger to the point where scroll (5) uncovers spill port (4), the more fuel will be injected.

To stop the engine, the pump plunger is rotated so that slot (6) on the pump plunger is in line with spill port (4). The fuel will now go out the spill port and not to the injection nozzle.

Fuel Injection Nozzle

The fuel injection nozzle goes through the cylinder head into the combustion chamber. The fuel injection pump sends fuel with high pressure to the fuel injection nozzle where the fuel is made into a fine spray for good combustion.



Fuel Injection Nozzle
(1) Carbon dam. (2) Seal. (3) Passage. (4) Filter screen. (5) Orifice. (6) Valve. (7) Diameter. (8) Spring.

Seal (2) goes against the cylinder head and prevents leakage of compression from the cylinder. Carbon dam (1) keeps carbon out of the bore in the cylinder head for the nozzle.

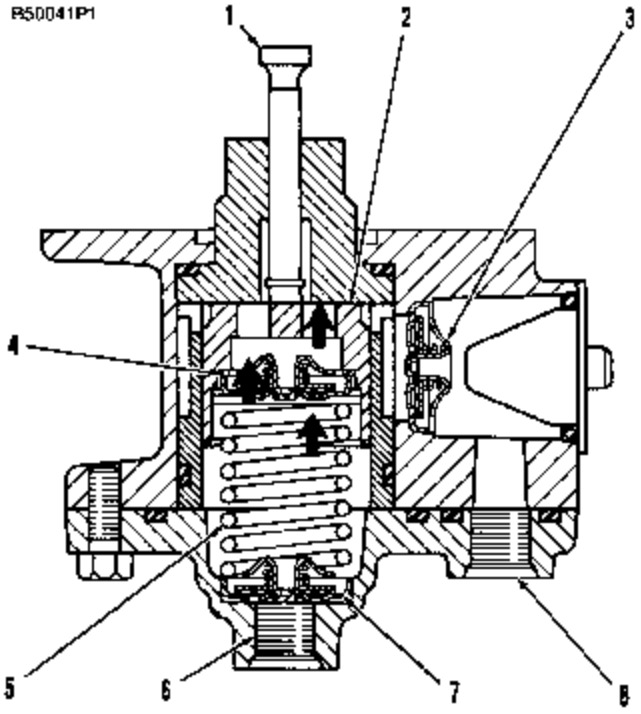
Fuel with high pressure from the fuel injection pump goes into the inlet passage. Fuel then goes through filter screen (4) and into passage (3) to the area below diameter (7) of valve (6). When the pressure of the fuel that pushes against diameter (7) becomes greater than the force of spring (8), valve (6) lifts up. This occurs when the fuel pressure goes above the Valve Opening Pressure of the fuel injection nozzle. When valve (6) lifts, the tip of the valve comes off the nozzle seat and the fuel will go through orifices (5) into the combustion chamber.

The injection of fuel continues until the pressure of fuel against diameter (7) becomes less than the force of spring (8). With less pressure against diameter (7), spring (8) pushes valve (6) against the nozzle seat and stops the flow of fuel to the combustion chamber.

The fuel injection nozzle can not be disassembled and no adjustments can be made.

Fuel Transfer Pump

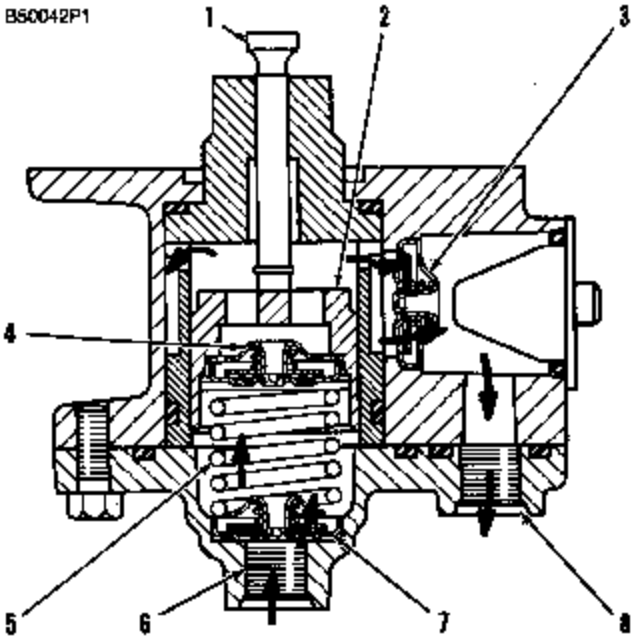
The fuel transfer pump is a piston pump that is moved by a cam (eccentric) on the camshaft for the fuel injection pump. The transfer pump is located on the bottom side of the fuel injection pump housing.



Fuel Transfer Pump (Start Of Down Stroke)
(Arrows Indicate Fuel Flow Direction)
(1) Push rod. (2) Piston. (3) Outlet check valve. (4) Pumping check valve. (5) Pumping spring. (6) Pump inlet port. (7) Inlet check valve. (8) Pump outlet port.

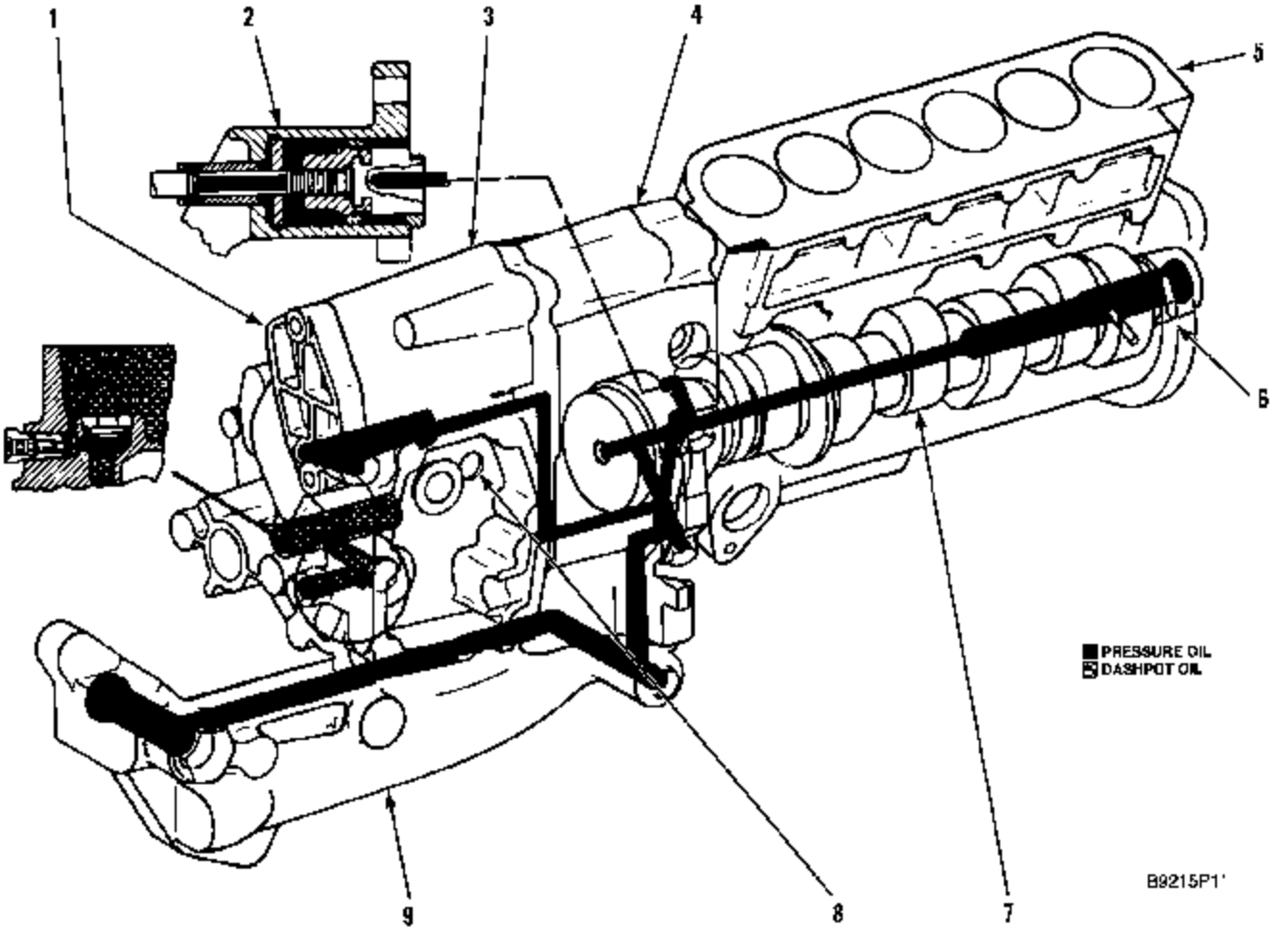
When the fuel injection pump camshaft turns, the cam moves push rod (1) and piston (2) down. As the piston moves down, inlet check valve (7) and outlet check valve (3) close. Pumping check valve (4) opens and allows the fuel below the piston to move into the area above the piston. Pumping spring (5) is compressed as the piston is pushed down by push rod (1).

As the fuel injection pump camshaft continues to turn, the cam no longer puts force on push rod (1). Pumping spring (5) now moves piston (2) up. This causes pumping check valve (4) to close. Inlet check valve (7) and outlet check valve (3) will open. As the piston moves up, the fuel in the area above the piston is pushed through the outlet check valve (3) and out pump outlet port (8). Fuel also moves through pump inlet port (6) and inlet check valve (7) to fill the area below piston (2). The pump is now ready to start a new cycle.

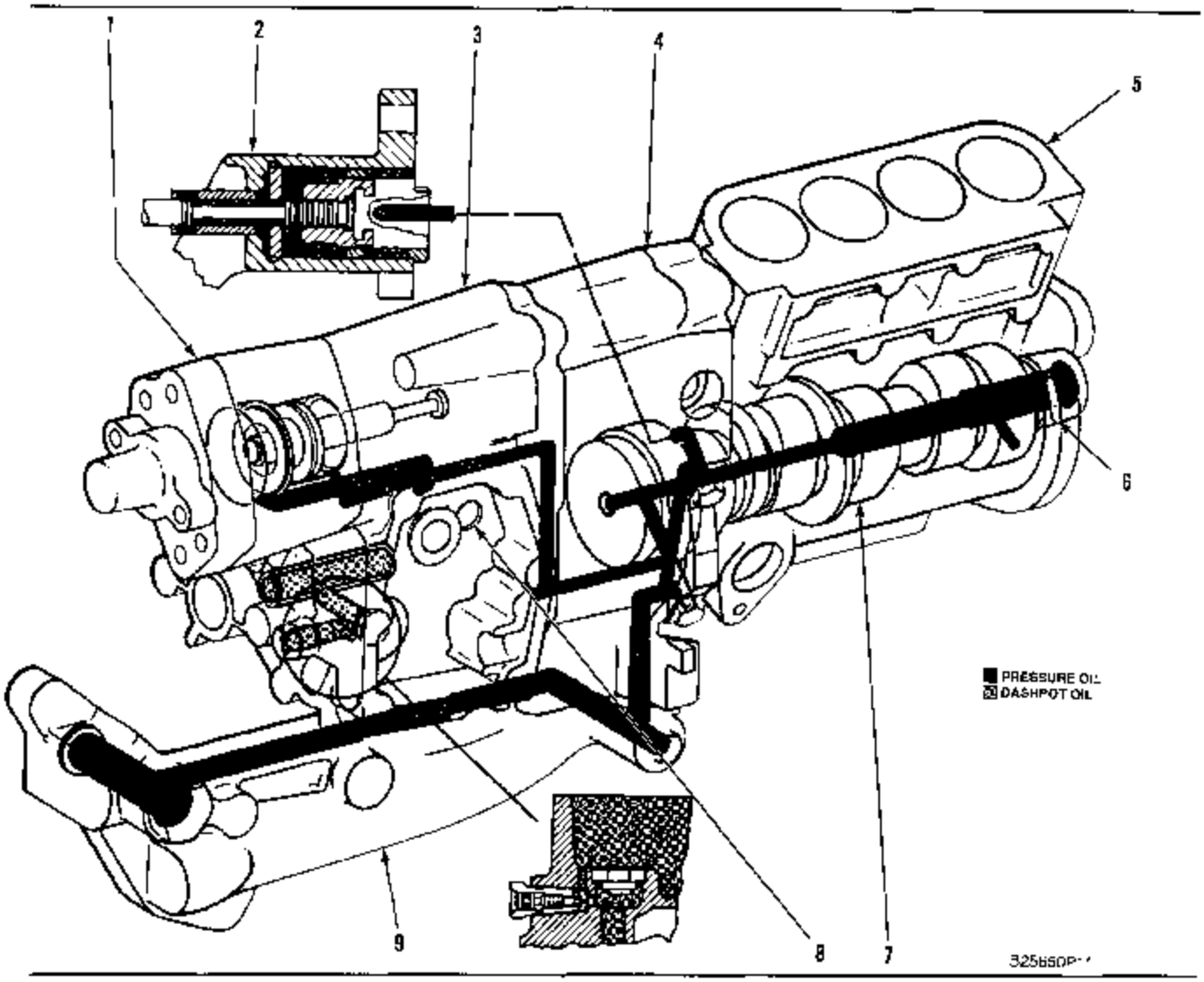


Fuel Transfer Pump (Start Of Up Stroke)
(Arrows Indicate Fuel Flow Direction)
(1) Push rod. (2) Piston. (3) Outlet check valve. (4) Pumping check valve. (5) Pumping spring. (6) Pump Inlet port. (7) Inlet check valve. (8) Pump outlet port.

Oil Flow For Fuel Pump And Governor



Fuel Pump And Governor
(1) Cover. (2) Servo. (3) Rear governor housing. (4) Front governor housing. (5) Fuel pump housing. (6) Drain hole. (7) Camshaft. (8) Drain hole. (9) Support.



Fuel Pump And Governor (With Fuel Ratio Control)
(1) Fuel ratio control. (2) Servo. (3) Rear governor housing. (4) Front governor housing. (5) Fuel pump housing. (6) Drain hole. (7) Camshaft. (8) Drain hole. (9) Support.

Oil from the side of the cylinder block goes to support (9) and into the bottom of front governor housing (4). The flow of oil now goes in three different directions.

A part of the oil goes to the rear camshaft bearing in fuel pump housing (5). The bearing has a groove around the inside diameter. Oil goes through the groove and into the oil passage in the bearing surface (journal) of camshaft (7). A drilled passage through the center of the camshaft gives oil to the front camshaft bearing and to the thrust face of the camshaft drive gear. Drain hole (6) in the front of fuel pump housing (5) keeps the level of the oil in the housing even with the center of the camshaft. The oil returns to the oil pan through the timing gear housing.

Oil also goes from the bottom of the front governor housing through a passage to the fuel pump housing and to governor servo (2). The governor servo gives hydraulic assistance to move the fuel rack.

Governor Without Fuel Ratio Control

The remainder of the oil goes through passages to the rear of rear governor housing (3), through cover (1) and back into another passage in the rear governor housing. Now the oil goes into the compartment for the governor controls. Drain hole (8) keeps the oil at the correct level. The oil in this compartment is used for lubrication of the governor control components and the oil is the supply for the dashpot.

Governor With Fuel Ratio Control

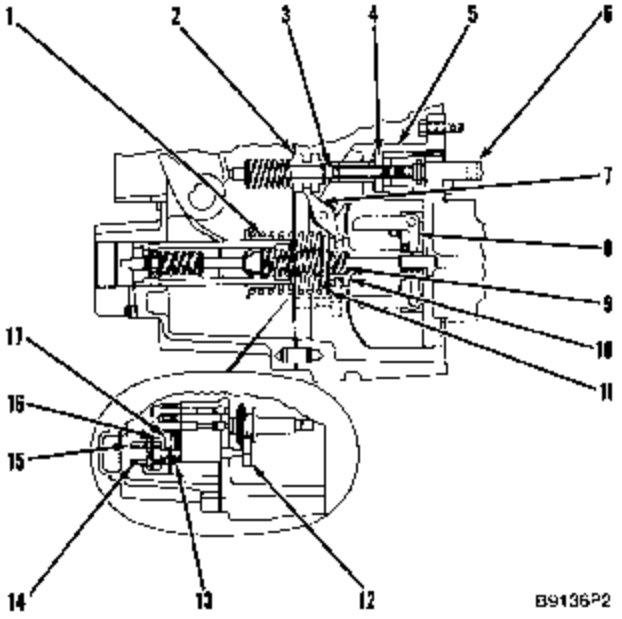
The remainder of the oil goes through passages to the rear of rear governor housing (3), through fuel ratio control (1) and back into another passage in the rear governor housing. Now the oil goes into the compartment for the governor controls. Drain hole (8) keeps the oil at the correct level. The oil in this compartment is used for lubrication of the governor control components and the oil is the supply for the dashpot.

The internal parts of the governor are lubricated by oil leakage from the servo and the oil is thrown by parts in rotation. The flyweight carrier thrust bearing gets oil from the passage at the rear of the camshaft.

Oil from the governor returns to the oil pan through a hole in the bottom of the front governor housing and through passages in the support and cylinder block.

Governor

The governor controls the amount of fuel needed by the engine to maintain a desired rpm.



Governor
(1) Governor spring. (2) Sleeve. (3) Valve. (4) Piston. (5) Governor servo. (6) Fuel rack. (7) Lever. (8) Flyweights. (9) Overfueling spring. (10) Riser. (11) Spring seat. (12) Stop bolt. (13) Torque spring. (14) Power setting screw. (15) Torque rise setting screw (16) Stop collar. (17) Stop bar.

The governor flyweights (8) are driven directly by the fuel pump camshaft. Riser (10) is moved by flyweights (8) and governor spring (1). Lever (7) connects the riser with sleeve (2) which is fastened to valve (3). Valve (3) is a part of governor servo (5) and moves piston (4) and fuel rack (6). The fuel rack moves toward the front of the fuel pump housing (to the right in the illustration) when moved in the FUEL OFF direction.

The force of governor spring (1) always pushes to give more fuel to the engine. The centrifugal (rotating) force of flyweights (8) always push to get a reduction of fuel to the engine. When these two forces are in balance (equal), the engine runs at a constant rpm.

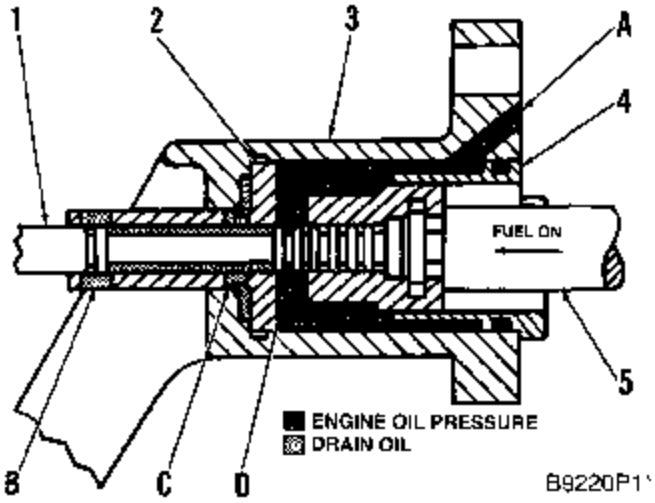
When the engine is started and the governor is at the low idle position, overfueling spring (9) moves the riser forward and gives an extra amount of fuel to the engine. When the engine has started and begins to run, the flyweight force becomes greater than the force of the overfueling spring. The riser moves to the rear and reduces the amount of fuel to the low idle requirement of the engine.

When the governor control lever is moved to the high idle position, governor spring (1) is put in compression and pushes riser (10) toward the flyweights. When the riser moves forward, lever (7) moves sleeve (2) and valve (3) toward the rear. Valve (3) stops oil flow through governor servo (5) and the oil pressure moves piston (4) and the fuel rack to the rear. This increases the amount of fuel to the engine. As engine speed increases, the flyweight force increases and moves the riser toward the governor spring. When the riser moves to the rear, lever (7) moves sleeve (2) and valve (3) forward. Valve (3) now directs oil pressure to the rear of piston (4) and moves the piston and fuel rack forward. This decreases the amount of fuel to the engine. When the flyweight force and the governor spring force become equal, the engine speed is constant and the engine runs at high idle rpm. High idle rpm is adjusted by the high idle adjustment screw. The adjustment screw limits the amount of compression of the governor spring.

With the engine at high idle, when the load is increased, engine speed will decrease. Flyweights (8) move in and governor spring (1) pushes riser (10) forward and increases the amount of fuel to the engine. As the load is increased more, governor spring (1) pushes riser (10) farther forward. Spring seat (11) pulls on stop bolt (12). Stop collar (16) on the opposite end has power setting screw (14) and torque rise setting screw (15) that control the maximum amount of fuel rack travel. The power setting screw moves forward and makes contact with torque spring (13). This is the full load balance point. If more load is added to the engine, engine speed will decrease and push riser (10) forward more. This will cause power setting screw (14) to bend (deflect) torque spring (13) until torque rise setting screw (15) makes contact with stop bar (17). This is the point of maximum fuel to the engine.

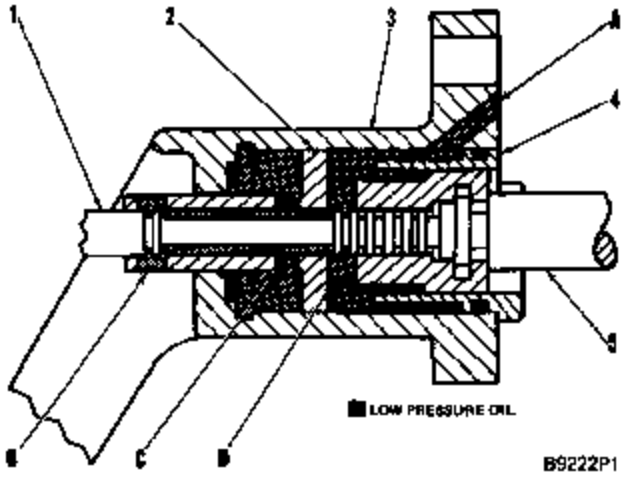
Governor Servo

The governor servo gives hydraulic assistance to the mechanical governor force to move the fuel rack. The governor servo has cylinder (3), cylinder sleeve (4), piston (2) and valve (1).



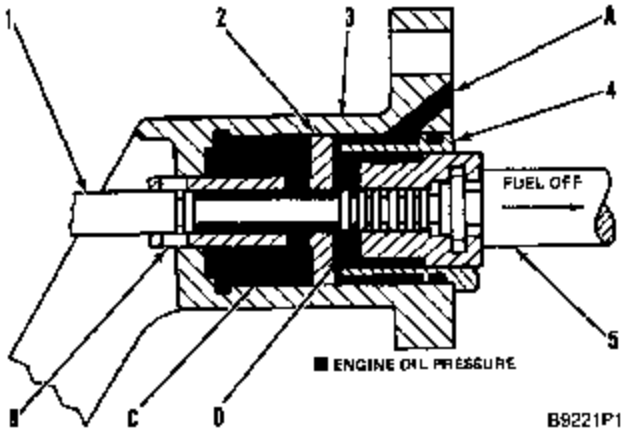
Governor Servo (Fuel On Position)
(1) Valve. (2) Piston. (3) Cylinder. (4) Cylinder sleeve. (5) Fuel rack. (A) Oil inlet. (B) Oil outlet. (C) Oil passage. (D) Oil passage.

When the governor moves in the FUEL ON direction, valve (1) moves to the left. The valve opens oil outlet (B) and closes oil passage (D). Pressure oil from oil inlet (A) pushes piston (2) and fuel rack (5) to the left. Oil behind the piston goes through oil passage (C), along valve (1) and out oil outlet (B).



Governor Servo (Balanced Position)
(1) Valve. (2) Piston. (3) Cylinder. (4) Cylinder sleeve. (5) Fuel rack. (A) Oil inlet. (B) Oil outlet. (C) Oil passage. (D) Oil passage.

When the governor spring and flyweight forces are balanced and the engine speed is constant, valve (1) stops moving. Pressure oil from oil inlet (A) pushes piston (2) until oil passages (C and D) are opened. Oil now flows through oil passage (D) along valve (1) and out through oil outlet (B). With no oil pressure on the piston, the piston and fuel rack (5) stop moving.

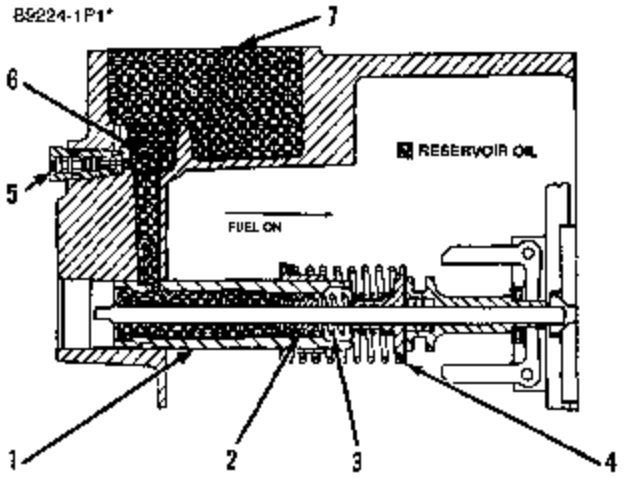


Governor Servo (Fuel Off Position)
(1) Valve. (2) Piston. (3) Cylinder. (4) Cylinder sleeve. (5) Fuel rack. (A) Oil inlet. (B) Oil outlet. (C) Oil passage. (D) Oil passage.

When the governor moves in the FUEL OFF direction, valve (1) moves to the right. The valve closes oil outlet (B) and opens oil passage (D). Pressure oil from oil inlet (A) is now on both sides of piston (2). The area of the piston is greater on the left side than on the right side of the piston. The force of the oil is also greater on the left side of the piston and moves the piston and fuel rack (5) to the right.

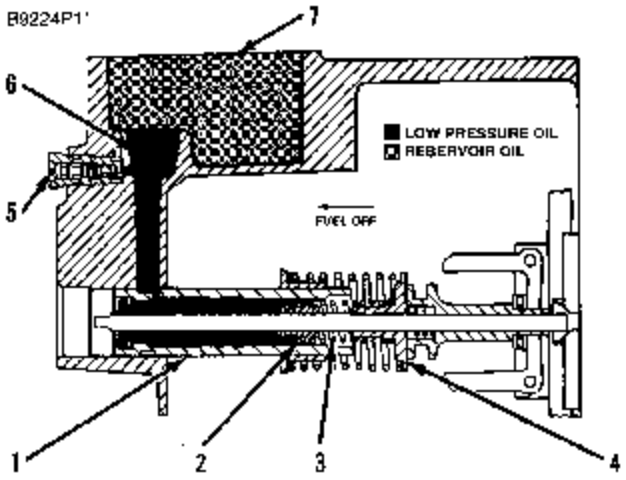
Dashpot

The dashpot helps give the governor better speed control when there are sudden speed and load changes. The dashpot has cylinder (1), piston (2), dashpot spring (3), needle valve (5) and check valve (6). Piston (2) and spring seat (4) are fastened to dashpot spring (3).



Dashpot (Governor Moving to Fuel On)
(1) Cylinder. (2) Piston. (3) Dashpot spring. (4) Spring seat. (5) Needle valve. (6) Check valve. (7) Oil reservoir.

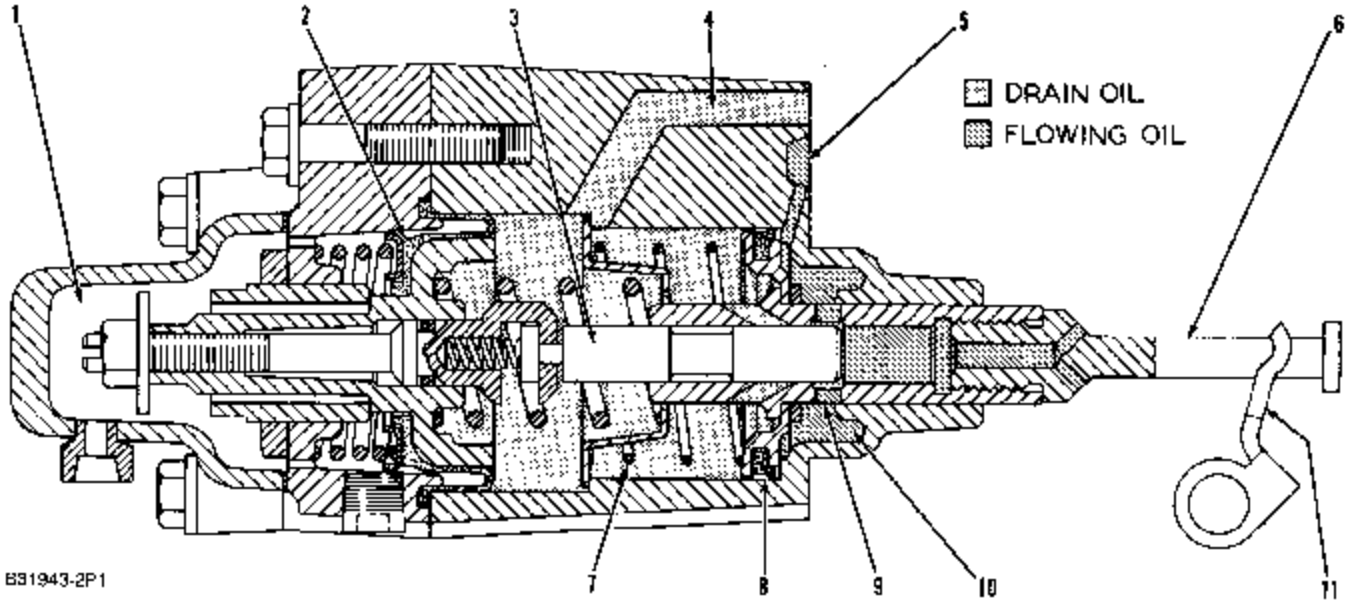
When the governor moves toward FUEL ON, spring seat (4) and piston (2) move to the right. This movement pulls oil from oil reservoir (7) through check valve (6) and into cylinder (1).



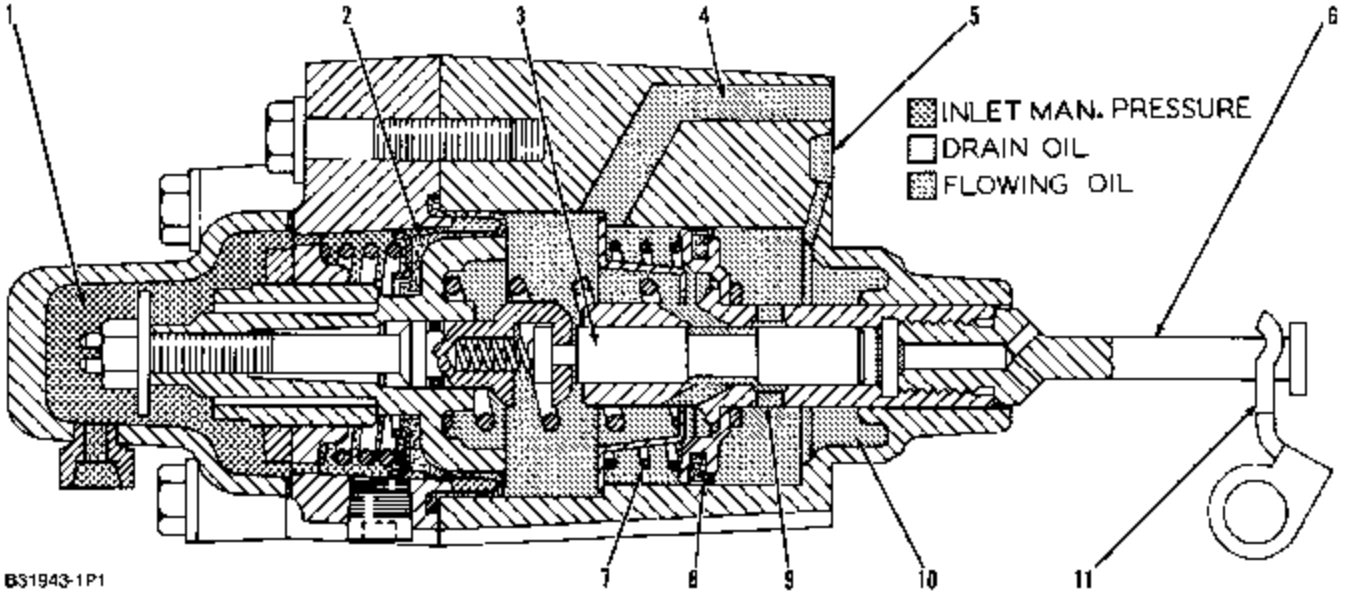
Dashpot (Governor Moving to Fuel Off)
(1) Cylinder. (2) Piston. (3) Dashpot spring. (4) Spring seat. (5) Needle valve. (6) Check valve. (7) Oil reservoir.

When the governor moves toward FUEL OFF, spring seat (4) and piston (2) move to the left. This movement pushes oil out of cylinder (1), through needle valve (5) and into oil reservoir (7).

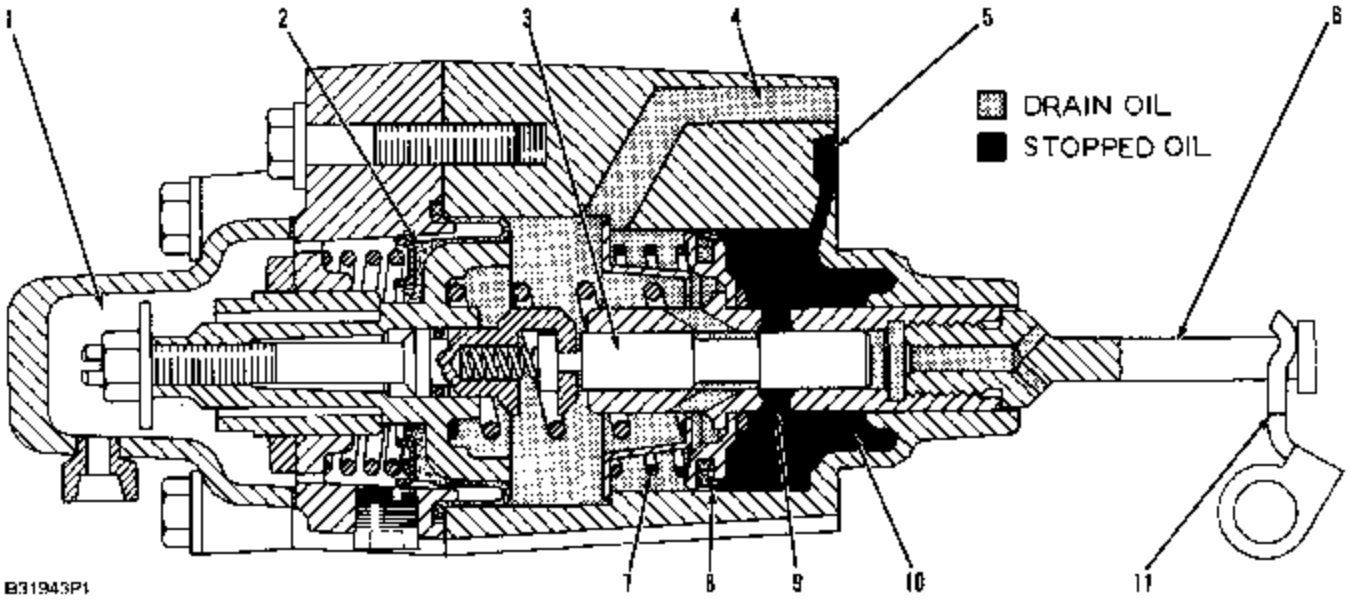
If the governor movement is slow, the oil gives no restriction to the movement of the piston and spring seat. If the governor movement is fast in the FUEL OFF direction, the needle valve gives a restriction to the oil and the piston and spring seat will move slowly.



Fuel Ratio Control (Engine Stopped)
(1) Inlet air chamber. (2) Diaphragm assembly. (3) Internal valve. (4) Oil drain passage. (5) Oil Inlet. (6) Stem. (7) Spring. (8) Piston. (9) Oil passage. (10) Oil Chamber. (11) Lever.



Fuel Ratio Control (Increase In Inlet Air Pressure)
(1) Inlet air chamber. (2) Diaphragm assembly. (3) Internal valve. (4) Oil drain passage. (5) Oil inlet. (6) Stem. (7) Spring. (8) Piston. (9) Oil passage. (10) Oil Chamber. (11) Lever.



Fuel Ratio Control (Ready for Operation)
(1) Inlet air chamber. (2) Diaphragm assembly. (3) Internal valve. (4) Oil drain passage. (5) Oil inlet. (6) Stem. (7) Spring. (8) Piston. (9) Oil passage. (10) Oil Chamber. (11) Lever.

The fuel ratio control limits the amount of fuel to the cylinders during an increase of engine speed (acceleration) to reduce exhaust smoke.

Stem (6) moves lever (11) which will restrict the movement of the fuel rack in the FUEL ON direction only.

With the engine stopped, stem (6) is in the fully extended position. The movement of the fuel rack and lever (11) is not restricted by stem (6). This gives maximum fuel to the engine for easier starts.

After the engine is started, engine oil flows through oil inlet (5) into pressure oil chamber (10). From oil chamber (10) oil flows through oil passage (9) into internal valve (3) and out oil drain passages in stem (6).

Stem (6) will not move until inlet manifold pressure increases enough to move internal valve (3). A line connects the inlet manifold with inlet air chamber (1) of the fuel ratio control.

When inlet manifold pressure increases, it causes diaphragm assembly (2) to move towards the right. This also causes internal valve (3) to move to the right. When internal valve (3) moves to the right, it closes oil passage (9).

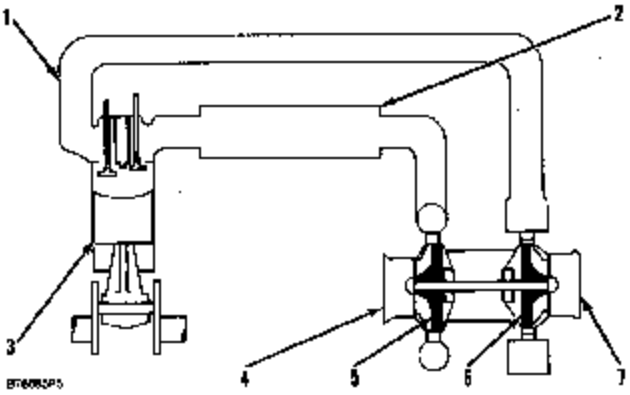
When oil passage (9) is closed, oil pressure increases in oil chamber (10). Oil pressure moves piston (8) and stem (6) to the left and into the operating position. The fuel ratio control will remain in the operating position until the engine is shut off.

When the governor control is moved to increase fuel to the engine, stem (6) limits the movement of lever (11) in the FUEL ON direction. The oil in oil chamber (10) acts as a restriction to the movement of stem (6) until inlet air pressure increases.

As the inlet air pressure increases, diaphragm assembly (2) and internal valve (3) move to the right. The internal valve opens oil passage (9), and oil in oil chamber (10) goes to oil drain passage (4). With the oil pressure reduced behind piston (8), spring (7) moves the piston and stem (6) to the right. Piston (8) and stem (6) will move until oil passage (9) is closed by internal valve (3). Lever (11) can now move to let the fuel rack go to the full fuel position. The fuel ratio control is designed to restrict the fuel until the air pressure in the inlet manifold is high enough for complete combustion. It prevents large amounts of exhaust smoke caused by an air-fuel mixture with too much fuel.

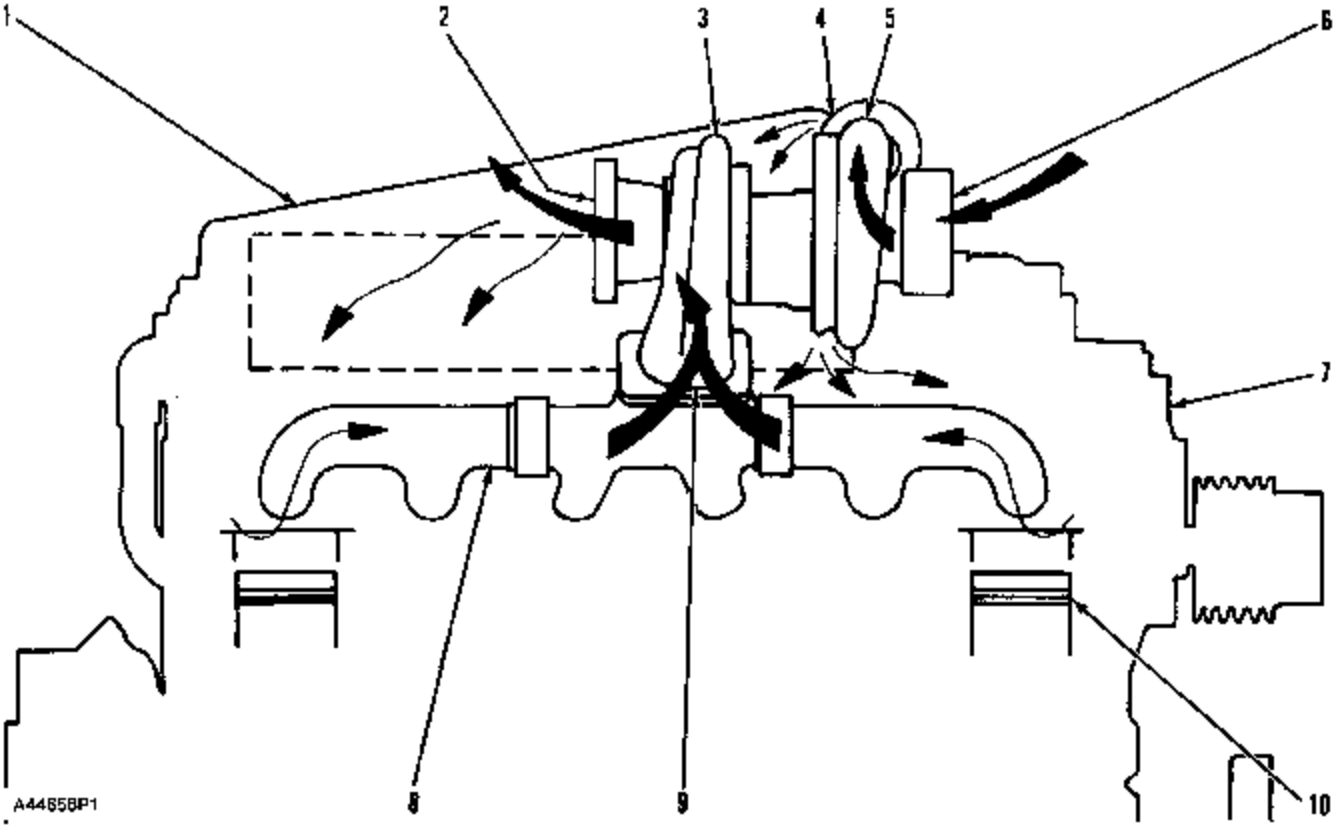
Air Inlet And Exhaust System

The air inlet and exhaust system components are: air cleaner, inlet manifold, cylinder head, valves and valve system components, exhaust manifold and turbocharger.

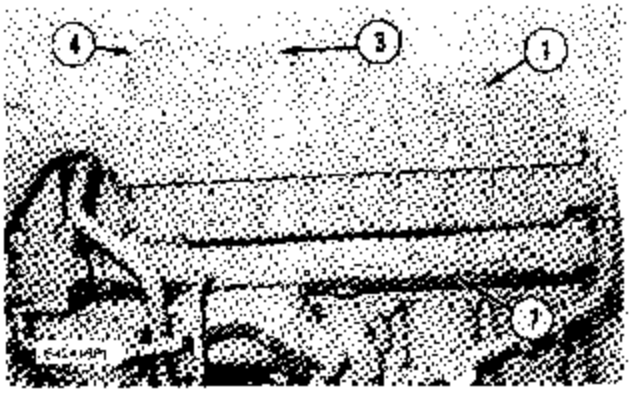


Air Inlet And Exhaust System
(1) Exhaust manifold. (2) Inlet manifold pipe. (3) Engine cylinders. (4) Air inlet. (5) Turbocharger compressor wheel. (6) Turbocharger turbine wheel. (7) Exhaust outlet.

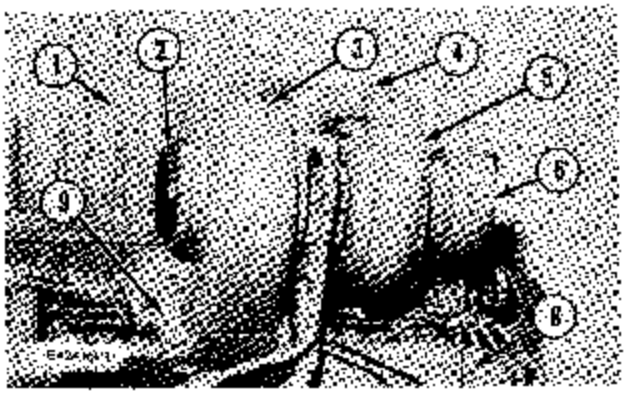
Clean inlet air from the air cleaner is pulled through the air inlet (4) of the turbocharger by the turning compressor wheel (5). The compressor wheel causes a compression of the air. The air then goes to the inlet manifold (2) of the engine. When the intake valves open, the air goes into the engine cylinder (3) and is mixed with the fuel for combustion. When the exhaust valves open, the exhaust gases go out of the engine cylinder and into the exhaust manifold (1). From the exhaust manifold, the exhaust gases go through the blades of the turbine wheel (6). This causes the turbine wheel and compressor wheel to turn. The exhaust gases then go out the exhaust outlet (7) of the turbocharger.



Turbocharger And Aftercooler Installed
(1) Aftercooler housing. (2) Exhaust outlet. (3) Turbine wheel housing. (4) Air outlet. (5) Compressor wheel housing. (6) Air inlet. (7) Cylinder head. (8) Exhaust manifold. (9) Exhaust inlet. (10) Cylinder bore.



Aftercooler
(1) Aftercooler housing. (3) Turbine wheel housing. (4) Air outlet. (7) Cylinder head.



Turbocharger
(1) Aftercooler housing. (2) Exhaust outlet. (3) Turbine wheel housing. (4) Air outlet. (5) Compressor wheel housing. (6) Air inlet. (8) Exhaust manifold. (9) Exhaust inlet.

The aftercooler cools the air coming out of the turbocharger before it goes into the inlet manifold. The purpose of this is to make the air going into the combustion chambers more dense. The more dense the air is, the more fuel the engine can burn efficiently. This gives the engine more power.

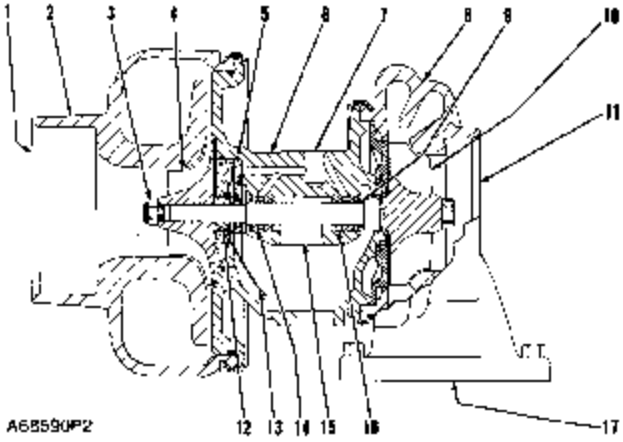
Turbocharger

The turbocharger is installed on the exhaust manifold. All the exhaust gases from the engine go through the turbocharger.

The exhaust gases enter the turbine housing (8) and go through the blades of turbine wheel (10), causing the turbine wheel and compressor wheel (4) to turn.

When the compressor wheel turns, it pulls filtered air from the air cleaners through the compressor housing air inlet. The air is put in compression by action of the compressor wheel and is pushed to the inlet manifold of the engine.

When engine load increases, more fuel is injected into the engine cylinders. The volume of exhaust gas increases which causes the turbocharger turbine wheel and compressor impeller to turn faster. The increased rpm of the impeller increases the quantity of inlet air. As the turbocharger provides additional inlet air, more fuel can be burned. This results in more horsepower from the engine.



Turbocharger (Typical Example)
(1) Air inlet. (2) Compressor housing. (3) Nut. (4) Compressor wheel. (5) Thrust bearing. (6) Center housing. (7) Lubrication inlet passage. (8) Turbine housing. (9) Sleeve. (10) Turbine wheel. (11) Exhaust outlet. (12) Sleeve. (13) Oil deflector. (14) Bearing. (15) Lubrication outlet passage. (16) Bearing. (17) Exhaust inlet.

Maximum rpm of the turbocharger is controlled by the rack setting, the high idle speed setting and the height above sea level at which the engine is operated.

NOTICE

If the high idle rpm or the fuel setting is higher than given in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche (for the height above sea level at and which the engine is operated), there can be damage to engine or turbocharger parts. Damage will result when increased heat and/or friction, due to the higher engine output, goes beyond the engine cooling and lubrication systems abilities.

The bearings for the turbocharger use engine oil for lubrication. The oil comes in through the lubrication inlet passage (7) and goes through passages in the center section for lubrication of the bearings. Oil from the turbocharger goes out through the lubrication outlet passage (15) in the bottom of the center section and goes back to the engine lubrication system.

Cylinder Head And Valves

There is one cylinder head for all cylinders. Each cylinder has one intake and one exhaust valve. Each intake and exhaust valve has a valve rotator. The valve rotator causes the valve to turn a small amount each time the valve opens and closes. This action helps keep carbon deposits off of the valve face and valve seat.

The cylinder head has valve seats installed and they can be replaced.

The valve guides can be replaced. There are threads on the inside diameter of the valve guides to hold oil that lubricates the valve stem.

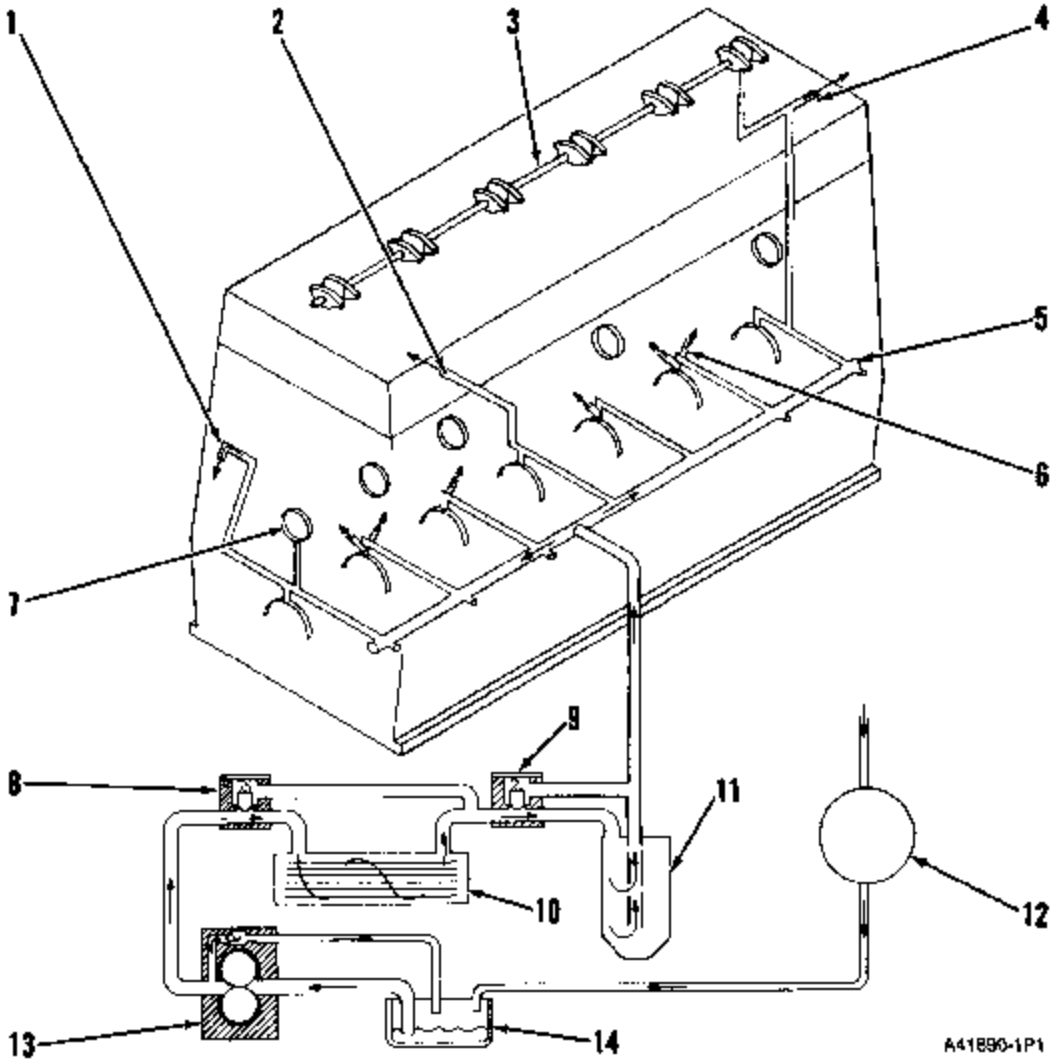
Valve Mechanism

The valve mechanism controls the flow of inlet air and exhaust gases in and out of the cylinders. The valve mechanism consists of rocker arms, push rods, valve lifters and camshaft.

The camshaft is driven by and timed to the crankshaft. When the camshaft turns, the camshaft lobes move the valve lifters up and down. The valve lifters move the push rods which move the rocker arms. Movement of the rocker arms make the intake and exhaust valves open according to the firing order (injection sequence) of the engine. A valve spring for each valve makes the valve go back to the closed position and holds it there.

Lubrication System

System Oil Flow

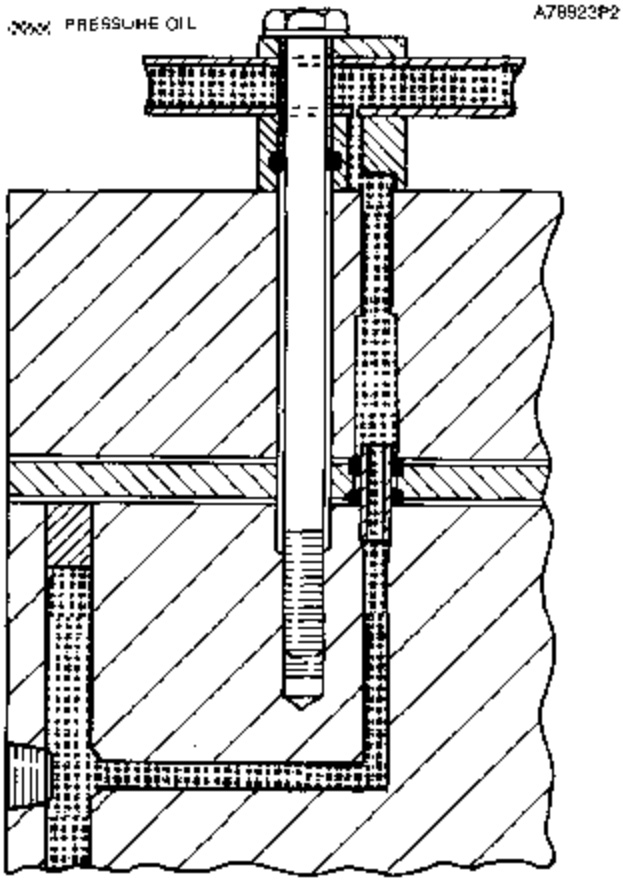


Lubrication System Schematic (Engine Warm)
(1) Oil passage (to front idler gear). (2) Oil passage (to turbocharger and fuel injection pump). (3) Rocker arm shaft. (4) Oil pressure connection. (5) Oil manifold. (6) Piston cooling orifices. (7) Camshaft bearing bore. (8) Oil cooler bypass valve. (9) Oil filter bypass valve. (10) Engine oil cooler. (11) Oil filter. (12) Turbocharger. (13) Oil pump. (14) Oil pan.

Oil pump (13) pulls oil from oil pan (14) and then pushes the oil to oil cooler (10). From the oil cooler the oil goes to oil filter (11) and then to oil manifold (5). From the oil manifold, oil goes to all main bearings, and piston cooling orifices (6). Oil passages in the crankshaft send oil to the connecting rod bearings. Oil from the front main bearing goes through oil passage (1) to the bearing for the fuel injection pump idler gear. Oil from the front main bearing also goes to camshaft bearing bore (7). The front camshaft bearing is the only bearing to get pressure lubrication.

Oil passage (2) from No. 4 main bearing sends oil to turbocharger (12) and the fuel injection pump housing on the right side of the engine.

An oil passage from the rear of the cylinder block goes below the head bolt hole and connects with a drilled passage that goes up next to the head bolt hole. A hollow dowel connects the vertical oil passage in the cylinder block to the oil passage in the head. The spacer plate has a hole with a counterbore on each side that the hollow dowel goes through. An O-ring is in each counterbore to prevent oil leakage around the hollow dowel. Oil flows through the hollow dowel into a vertical passage in the cylinder head to the rocker arm shaft bracket. The rocker arm shaft has an orifice to restrict the oil flow to the rocker arms. The rear rocker arm bracket also has an O-ring that seals against the head bolt. This seal prevents oil from going down around the head bolt and leaking past the head gasket or spacer plate gasket. The O-ring must be replaced each time the head bolt is removed from the rear rocker arm bracket.



Rocker Arm Oil Supply

Holes in the rocker arm shafts let the oil give lubrication to the valve system components in the cylinder head.

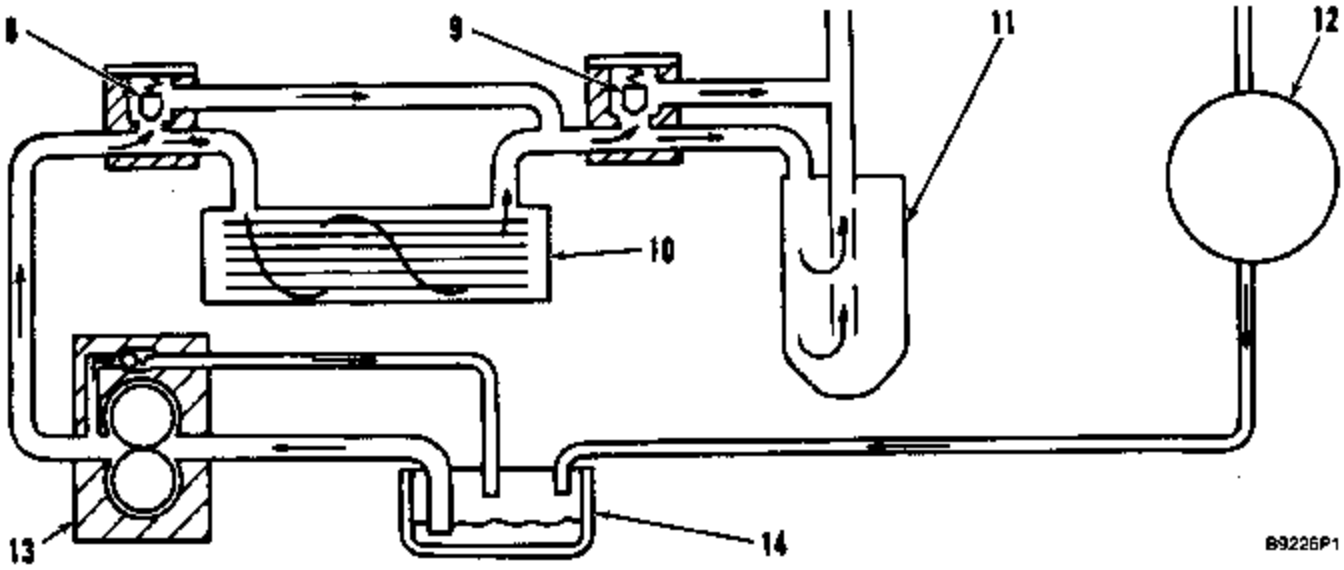
After the lubrication oil has done its work, it goes back to the engine oil pan.

There is a bypass valve in the oil pump. This bypass valve controls the pressure of the oil coming from the oil pump. The oil pump can put more oil into the system than is needed. When there is more oil than needed the oil pressure increases and the bypass valve will open. This allows the oil that is not needed to go back to the engine oil pan.

With the engine cold (starting conditions), bypass valves (8 and 9) will open and give immediate lubrication to all components when cold oil with high viscosity causes a restriction to the oil flow through oil cooler (10) and oil filter (11). Oil pump (13) sends the cold oil through the bypass valves around the oil cooler and oil filter to oil manifold (5) in the cylinder block.

When the oil gets warm, the pressure difference in the bypass valves decreases and the bypass valves close. Now there is a normal flow of oil through the oil cooler and oil filter.

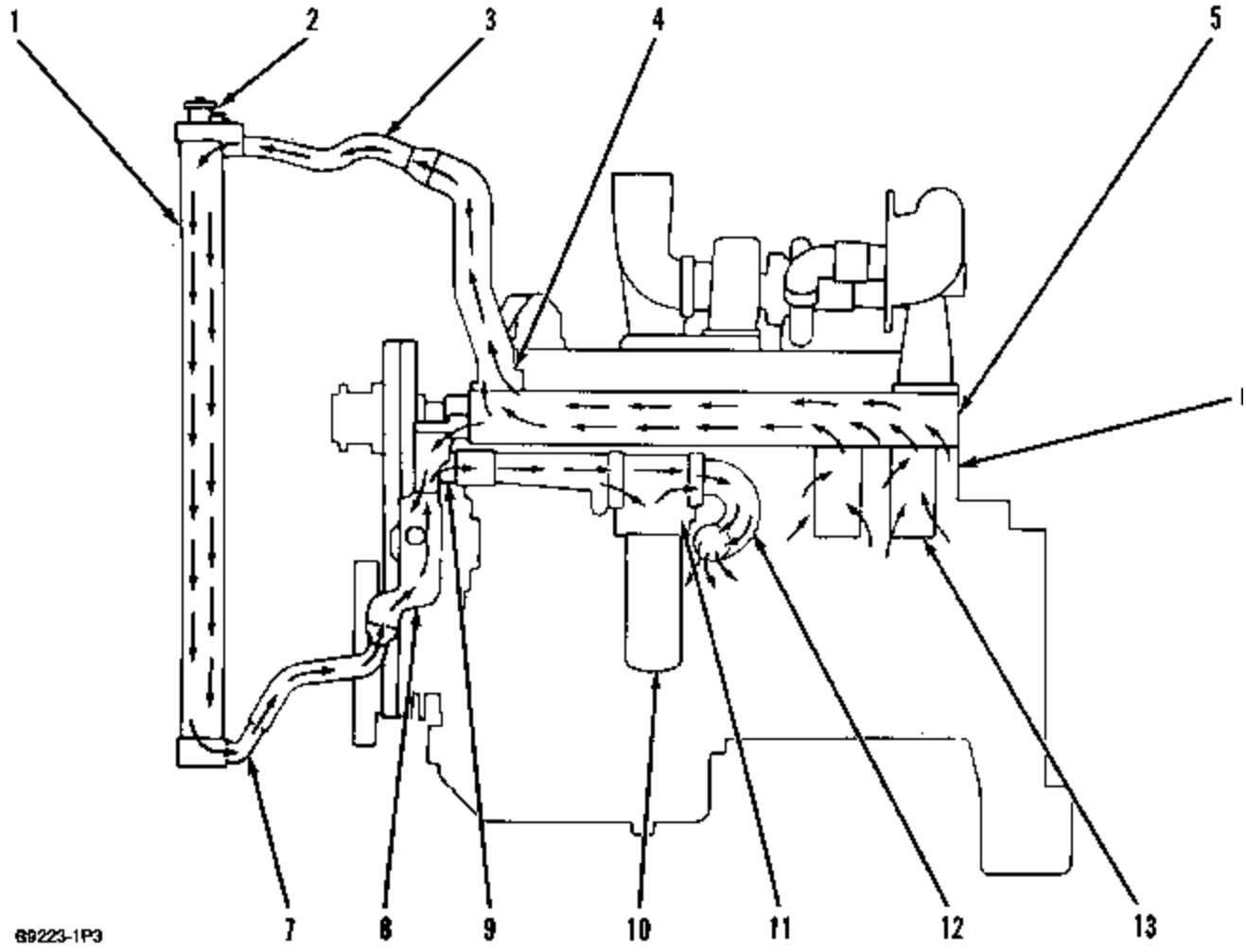
The bypass valves will also open when there is a restriction in the oil cooler or oil filter. This action does not let an oil cooler or oil filter with a restriction prevent lubrication of the engine.



Flow Of Oil (Engine Cold)
(8) Oil cooler bypass. (9) Oil filter bypass. (10) Engine oil cooler. (11) Oil filter. (12) Turbocharger. (13) Oil pump. (14) Oil pan.

Cooling System

Coolant Flow (Engine Without Aftercooler)



Coolant Flow (Engine Without Aftercooler)
(1) Radiator. (2) Pressure cap. (3) Inlet line to radiator. (4) Water temperature regulator. (5) Cylinder head. (6) Cylinder block. (7). Inlet line to water pump. (8) Water pump. (9) Internal bypass (shunt) line. (10) Engine oil filter. (11) Engine oil cooler. (12). Elbow. (13) Cylinder liner.

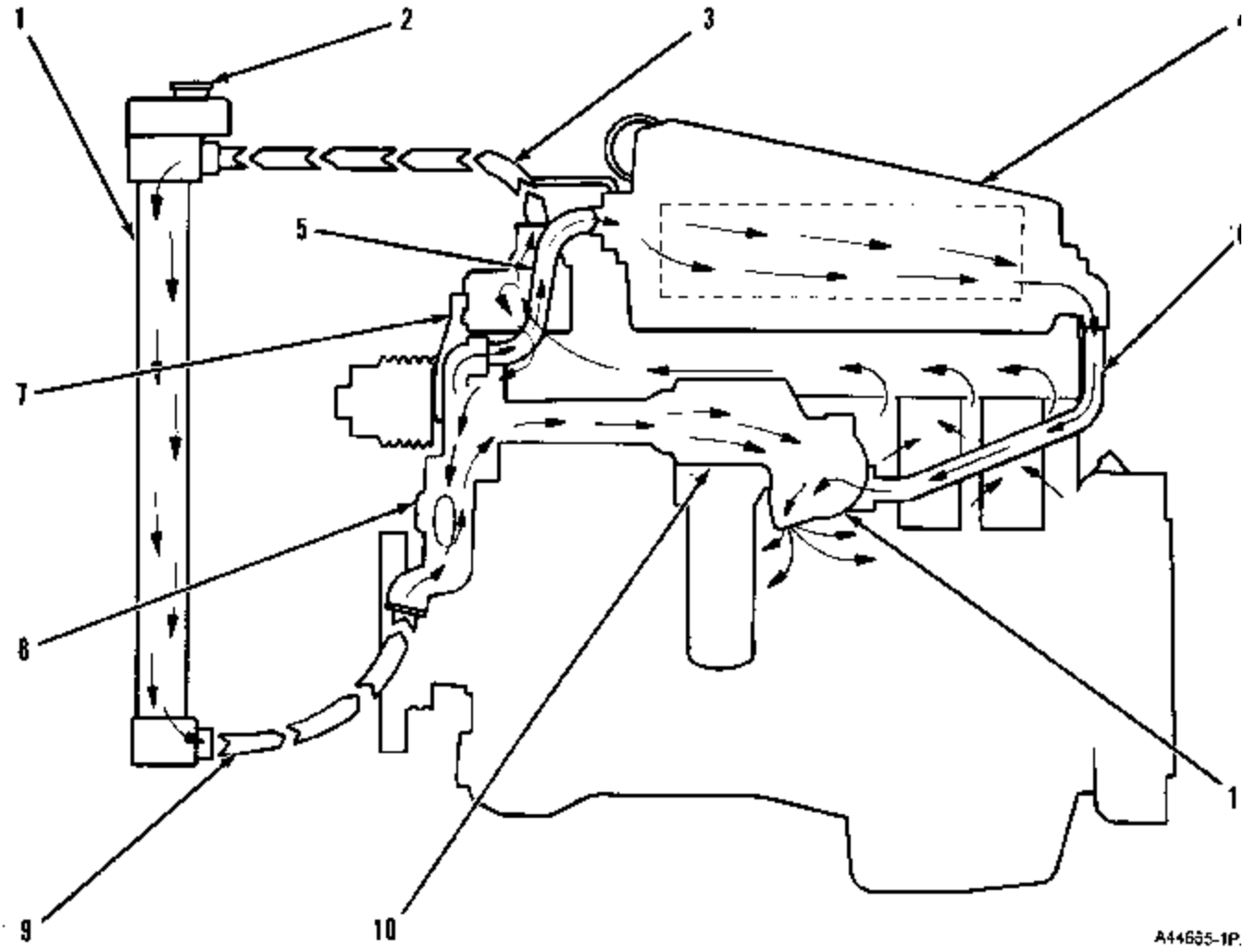
The water pump (8) is on the left front side of the engine. It is gear driven by the timing gears. Coolant from the bottom of the radiator (1) goes to the water pump inlet. The rotation of the impeller in the water pump (8) pushes the coolant through the system.

All of the coolant flow from the water pump (8), goes through the engine oil cooler (11). The elbow (12) on the outlet side of the engine oil cooler (11) connects to the side of the cylinder block (6).

On engines with an additional oil cooler a bonnet is mounted on the engine oil cooler (11). This bonnet sends the coolant flow through the other cooler which is for attachments, such as torque converters. The flow goes through one side on the way into the cooler. At the bottom of the cooler the flow turns and goes back up through the other side and into the bonnet again. Then the bonnet sends the coolant into the cylinder block (6).

The coolant enters the block and flows around cylinder liners (13) and up through the coolant directors into cylinder head (5). The coolant directors make the coolant flow around the valves and around the exhaust ports (passages) in the cylinder head. The coolant now goes to the front of the cylinder head. At the front of the cylinder head water temperature regulator (4) controls the direction of the coolant flow. If the coolant temperature is less than normal for engine operation, the water temperature regulator is closed. The coolant must go through internal bypass (9) to the water pump. When the coolant gets to the temperature of normal operation the water temperature regulator opens and most of the coolant flows through radiator inlet line (3) to the radiator. A part of the coolant still goes through internal bypass (9).

Coolant Flow (Engine With Aftercooler)



Coolant Flow (Engine With Aftercooler)
(1) Radiator. (2) Pressure cap. (3) Inlet line for radiator. (4) Aftercooler. (5) Aftercooler inlet line. (6) Return line from aftercooler. (7) Internal bypass (shunt) line. (8) Water pump. (9) Inlet line for water pump. (10) Engine oil cooler. (11) Bonnet.

Water pump (8) is on the left front side of the engine. It is gear driven by the timing gears. Coolant from the bottom of radiator (1) goes to the water pump inlet. The rotation of the impeller in water pump (8) pushes the coolant through the system.

The coolant flow from the water pump (8) is divided. Some goes through engine oil cooler (10). Bonnet (11) on the outlet side of engine oil cooler (10) connects to the side of the cylinder block.

On engines with an auxiliary oil cooler a different bonnet is on the engine oil cooler (10). This bonnet sends the coolant flow through the auxiliary cooler which is for attachments, such as torque converters

The flow goes through one side on the way into auxiliary oil cooler. At the bottom of auxiliary oil cooler, the flow turns and goes back up through the other side and into bonnet again. Then bonnet sends the coolant into the cylinder block.

The remainder of the coolant flow goes through aftercooler inlet line (5) into the core of aftercooler (4). The core of aftercooler (4) is a group of plates and fins. The coolant goes through the plates. The inlet air for the engine goes around the fins. This cools the inlet air The coolant comes out of the aftercooler (4) at the rear of the engine and goes through return line (6) to bonnet (11) on engine oil cooler (10). It mixes with the rest of the coolant from engine oil cooler (10) in bonnet (11) and goes into the cylinder block.

Cooling System Components

Water Pump

The centrifugal-type water pump has two seals, one prevents leakage of water and the other prevents leakage of lubricant.

An opening in the bottom of the pump housing allows any leakage at the water seal or the rear bearing oil seal to escape.

Fan

The fan is driven by two V-belts, from a pulley on the crankshaft. Belt tension is adjusted by moving the clamp assembly which includes the fan mounting and pulley.

Basic Block

Cylinder Block And Liners

A steel spacer plate is used between the cylinder head and the block to eliminate liner counterbore and to provide maximum liner flange support area (the liner flange sits directly on the cylinder block).

Engine coolant flows around the liners to cool them. Three O-ring seals at the bottom and a filler band at the top of each cylinder liner form a seal between the liner and the cylinder block.

Pistons, Rings And Connecting Rods

The piston has three rings; two compression and one oil ring. All rings are located above the piston pin bore. The two compression rings seat in an iron band which is cast into the piston. Pistons in some engines use compression rings with straight sides. Pistons in other engines use compression rings which are of the KEYSTONE type. KEYSTONE rings have a tapered shape and the movement of the rings in the piston groove (also of tapered shape) results in a constantly changing clearance (scrubbing action) between the ring and the groove. This action results in a reduction of carbon deposit and possible sticking of rings.

The oil ring is a standard (conventional) type and is spring loaded. Holes in the oil ring groove provide for the return of oil to the crankcase.

The piston pin bore in the piston is offset (moved away) from the center of the piston 0.76 mm (.030 in). The full floating piston pin is held in the piston by two snap rings which fit into grooves in the piston pin bore.

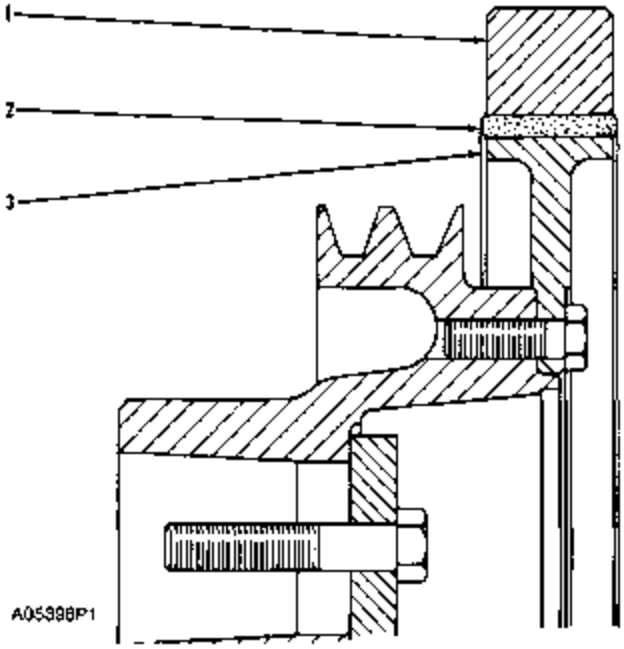
The piston pin end of the connecting rod is tapered to give more bearing surface at the area of highest load. The connecting rod is installed on the piston with the bearing tab slots on the same side as the "V" mark on the piston.

Crankshaft

The crankshaft changes the combustion forces in the cylinder into usable rotating torque which powers the machine. There is a gear at the front of the crankshaft that drives the timing gears and the engine oil pump. The connecting rod bearing surfaces get oil for lubrication through passages drilled in the crankshaft. A lip type seal and wear sleeve is used to control oil leakage in the front crankshaft seal. A hydrodynamic grooved seal assembly is used to control rear crankshaft oil leakage. The hydrodynamic grooves in the seal lip move lubrication oil back into the crankcase as the crankshaft turns.

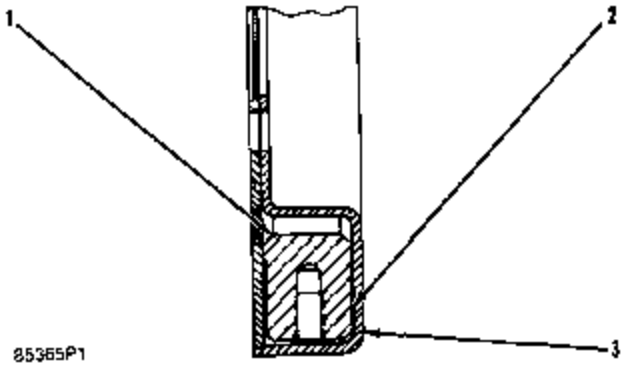
Vibration Damper

The twisting of the crankshaft, due to the regular power impacts along its length, is called twisting (torsional) vibration. The vibration damper is installed on the front end of the crankshaft. It is used for reduction of torsional vibrations and stops the vibration from building up to amounts that can cause damage.



Cross Section Of A Vibration Damper
(Typical Example)
(1) Flywheel ring. (2) Rubber ring. (3) Inner hub.

The damper is made of a flywheel ring (1) connected to an inner hub (3) by a rubber ring (2). The rubber makes a flexible coupling between the flywheel ring and the inner hub which reduces the vibrations of the crankshaft



Cross Section Of A Typical Viscous Vibration Damper
(1) Solid cast iron weight. (2) Space between weight and case. (3) Case.

The viscous damper is made of a weight (1) in a metal case (3). The small space (2) between the case and weight is filled with a thick fluid. The fluid permits the weight to move in the case to cause a reduction of vibrations of the crankshaft.

NOTICE

Inspect the viscous damper for signs of leakage or a dented (damaged) case (3). Either condition can cause weight (1) to make contact with the case and affec damper operation.

Electrical System

Reference

For the complete electrical system schematic, refer to Electrical System Schematic in the Service Manual.

Grounding Practices

Proper grounding for machine and engine electrical systems is necessary for proper machine performance and reliability. Improper grounding will result in uncontrolled and unreliable electrical circuit paths.

Uncontrolled engine electrical circuit paths can result in damage to main bearings, crankshaft journal surfaces, and aluminum components.

Uncontrolled electrical circuit paths can cause electrical noise which may degrade machine and radio performance.

To insure proper functioning of the machine and engine electrical systems, an engine-to-frame ground strap with a direct path to the battery must be used. This may be provided by way of a starter motor ground, a frame to starter motor ground, or a direct frame to engine ground

Ground wires/straps should be combined at ground studs dedicated for ground use only. All grounds should be tight and free of corrosion.

All ground paths must be capable of carrying any conceivable fault currents, and an awg #0 or larger wire is recommended for the cylinder head grounding strap.

The engine alternator should be battery (–) grounded with a wire size adequate to handle full alternator charging current.

NOTICE

When boost starting an engine, follow the instructions in "Engine Starting" in the "Operation Section" to properly start the engine.

This engine may be equipped with a 12 or 24 volt starting system. Use only equal voltage for boost starting.

This engine is tolerant to common external sources of electrical noise, but electro mechanical buzzers can cause disruptions in the power supply. If electro-mechanical buzzers are used anywhere on the machine, it is desirable to have the engine electronics powered directly from the battery system through a dedicated relay, and not through a common power bus with other key switch activated devices.

Engine Electrical System

The engine electrical system has three separate circuits: the charging circuit, the starting circuit and the low amperage circuit. Some of the electrical system components are used in more than one circuit. The battery (batteries), disconnect switch, circuit breaker, ammeter, cables and wires from the battery are all common in each of the circuits.

The charging circuit is in operation when the engine is running. An alternator makes electricity for the charging circuit. A voltage regulator in the circuit controls the electrical output to keep the battery at full charge.

NOTICE

The disconnect switch, if so equipped, must be in the ON position to let the electrical system function. There will be damage to some of the charging circuit components if the engine is running with the disconnect switch in the OFF position.

If the machine has a disconnect switch, the starting circuit can operate only after the disconnect switch is put in the ON position.

The starting circuit is in operation only when the start switch is activated.

The low amperage circuit and the charging circuit are both connected to the same side of the ammeter. The starting circuit connects to the opposite side of the ammeter.

Charging System Components

Alternator

This alternator is a three phase, self-rectifying charging unit, and the regulator is part of the alternator.

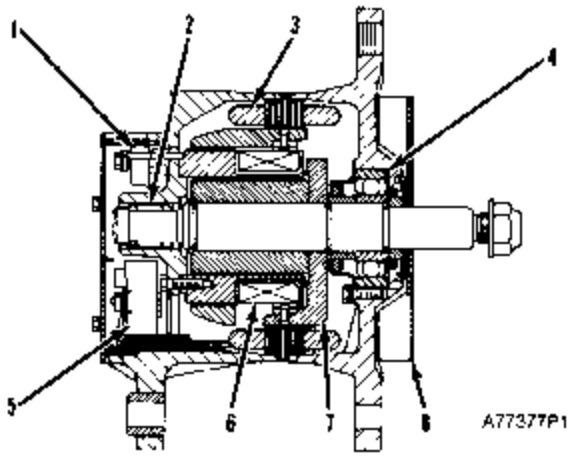
This alternator design has no need for slip rings or brushes, and the only part that has movement is the rotor assembly. All conductors that carry current are stationary. The conductors are: the field winding, stator windings, six rectifying diodes, and the regulator circuit components.

The rotor assembly has many magnetic poles like fingers with air space between each opposite pole. The poles have residual magnetism (like permanent magnets) that produce a small amount of magnet-like lines of force (magnetic field) between the poles. As the rotor assembly begins to turn between the field winding and the stator windings, a small amount of alternating current (AC) is produced in the stator windings from the small magnetic lines of force made by the residual magnetism of the poles. This AC current is changed to direct current (DC) when it passes through the diodes of the rectifier bridge. Most of this current goes to charge the battery and to supply the low amperage circuit, and the remainder is sent on to the field windings. The DC current flow through the field windings (wires around an iron core) now increases the strength of the magnetic lines of force. These stronger lines of force now increase the amount of AC current produced in the stator windings. The increased speed of the rotor assembly also increases the current and voltage output of the alternator.

The voltage regulator is a solid state (transistor, stationary parts) electronic switch. It feels the voltage in the system and switches on and off many times a second to control the field current (DC current to the field windings) for the alternator to make the needed voltage output.

NOTICE

Never operate the alternator without the battery in the circuit. Making or breaking an alternator connection with heavy load on the circuit can cause damage to the regulator.



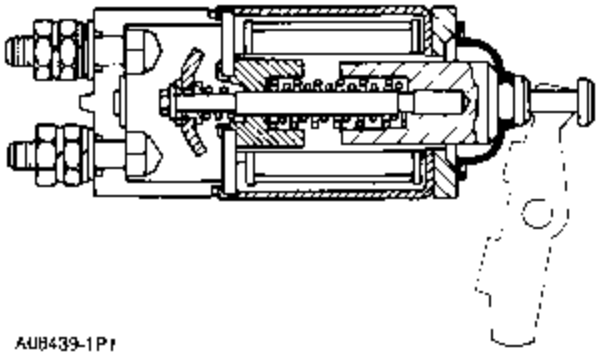
Typical Alternator Components
(1) Regulator. (2) Roller bearing. (3) Stator winding. (4) Ball bearing. (5) Rectifier bridge. (6) Field winding. (7) Rotor assembly. (8) Fan.

Starting System Components

Solenoid

A solenoid is a magnetic switch that does two basic operations.

a. Closes the high current starter motor circuit with a low current start switch circuit.
b. Engages the starter motor pinion with the ring gear.



Typical Solenoid Schematic

The solenoid switch is made of an electromagnet (one or two sets of windings) around a hollow cylinder. There is a plunger (core) with a spring load inside the cylinder that can move forward and backward. When the start switch is closed and electricity is sent through the windings, a magnetic field is made that pulls the plunger forward in the cylinder. This moves the shift lever (connected to the rear of the plunger) to engage the pinion drive gear with the ring gear. The front end of the plunger then makes contact across the battery and motor terminals of the solenoid, and the starter motor begins to turn the flywheel of the engine.

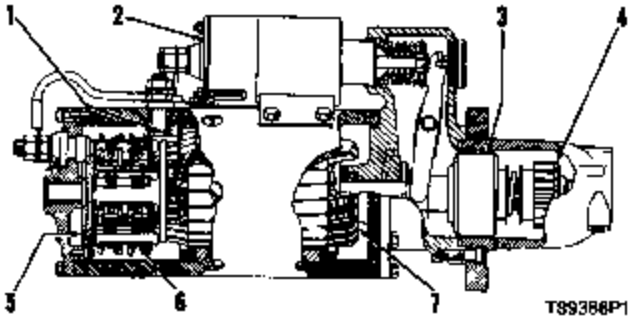
When the start switch is opened, current no longer flows through the windings. The spring now pushes the plunger back to the original position, and at the same time, moves the pinion gear away from the flywheel.

When two sets of windings in the solenoid are used, they are called the hold-in windings and the pull-in winding. Both have the same number of turns around the cylinder, but the pull-in winding uses a larger diameter wire to produce a greater magnetic field. When the start switch is closed, part of the current flows from the battery through the hold-in winding, and the rest flows through the pull-in windings to motor terminal, then through the motor to ground. When the solenoid is fully activated (connection across battery and motor terminal is complete), current is shut off through the pull-in windings. Now only the smaller hold in windings are in operation for the extended period of time it takes to start the engine. The solenoid will now take less current from the battery, and heat made by the solenoid will be kept at an acceptable level.

Starter Motor

The starter motor is used to turn the engine flywheel fast enough to get the engine to start running.

The starter motor has a solenoid. When the start switch is activated, the solenoid will move the starter pinion to engage it with the ring gear on the flywheel of the engine. The starter pinion will engage with the ring gear before the electric contacts in the solenoid close the circuit between the battery and the starter motor. When the circuit between the battery and the starter motor is complete, the pinion will turn the engine flywheel. A clutch gives protection for the starter motor so that the engine cannot turn the starter motor too fast. When the start switch is released, the starter pinion will move away from the ring gear.



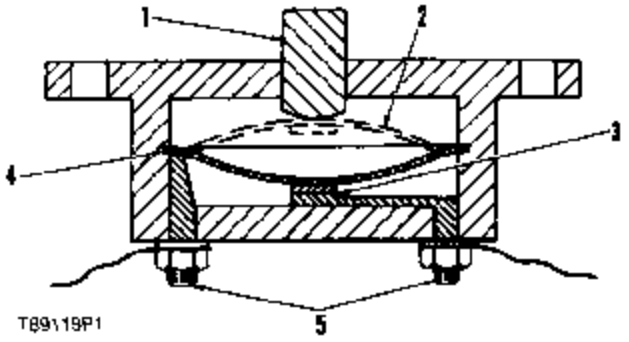
Starter Motor Cross Section
(1) Field. (2) Solenoid. (3) Clutch. (4) Pinion. (5) Commutator. (6) Brush assembly. (7) Armature.

Other Components

Circuit Breaker

The circuit breaker is a switch that opens the battery circuit if the current in the electrical system goes higher than the rating of the circuit breaker.

A heat activated metal disc with a contact point makes complete the electric circuit through the circuit breaker. If the current in the electrical system gets too high, it causes the metal disc to get hot. This heat causes a distortion of the metal disc which opens the contacts and breaks the circuit. A circuit breaker that is open can be reset (an adjustment to make the circuit complete again) after it becomes cool. Push the reset button to close the contacts and reset the circuit breaker.



Circuit Breaker Schematic
(1) Reset button. (2) Disc in open position. (3) Contacts. (4) Disc. (5) Battery circuit terminals.

Testing And Adjusting

Troubleshooting

Troubleshooting can be difficult. The Troubleshooting Index gives a list of possible problems. To make a repair to a problem, make reference to the cause and correction on the pages that follow.

This list of problems, causes and corrections will only give an indication of where a possible problem can be, and what repairs are needed. Normally, more or other repair work is needed beyond the recommendation in the list.

Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts. This list is only a guide and cannot give all possible problems and corrections. The serviceman must find the problem and its source, then make the necessary repairs.

Troubleshooting Index

1. Engine Will Not Turn When Start Switch Is On

2. Engine Will Not Start

3. Misfiring Or Running Rough

4. Stall At Low RPM

5. Sudden Changes In Engine Speed (RPM)

6. Not Enough Power

7. Too Much Vibration

8. Loud Combustion Noise (Knock)

9. Loud Noise (Clicking) From Valve Compartment

10. Oil In Cooling System

11. Mechanical Noise (Knock) In Engine

12. Fuel Consumption Too High

13. Loud Noise From Valves Or Valve Drive Components

14. Little Movement Of Rocker Arm And Too Much Valve Lash

15. Valve Rotocoil Or Spring Lock Is Free

16. Oil At The Exhaust

17. Little Or No Valve Lash

18. Engine Has Early Wear

19. Coolant In Lubrication Oil

20. Too Much Black Or Gray Smoke

21. Too Much White Smoke

22. Too Much Blue Smoke

23. Engine Has Low Oil Pressure

24. Engine Uses Too Much Lubrication Oil

25. Engine Overheating

26. Engine Overcooling

27. Coolant Leaks Outside Of Engine

28. Coolant Leaks At The Overflow Tube

29. Coolant Leaks Inside The Engine

30. Exhaust Temperature Too High

31. Starter Motor Does Not Turn

32. Alternator Gives No Charge

33. Alternator Charge Rate Is Low Or Not Regular

34. Alternator Charge Is Too High

35. Alternator Has Noise

Problem 1: Engine Will Not Turn When Start Switch Is On

Probable Cause:

1. Battery Has Low Output
   Make Reference to Problem 32.
2. Wires Or Switches Have Defect
   Make Reference to Problem 32.
3. Starter Motor Solenoid Has A Defect
   Make Reference to Problem 31.
4. Starter Motor Has A Defect
   Make Reference to Problem 31

5. Inside Problem Prevents Engine Crankshaft From Turning

If the crankshaft cannot be turned after the drive equipment is disconnected, remove the fuel injection nozzles and check for fluid in the cylinders while the crankshaft is turned. If fluid in the cylinders is not the problem, the engine must be disassembled to check for other inside problems. Some of these inside problems are bearing seizure, piston seizure, wrong pistons installed in the engine, and valves making contact with pistons.

Problem 2: Engine Will Not Start

Probable Cause:

1. Slow Cranking Speed

Make reference to Problem 32.

2. No Fuel In The Housing For The Fuel Injection Pumps

Fill the housing for the fuel injection pumps with fuel with the priming pump. Remove the air with the bleed valve

3. Dirty Fuel Filter

Install new fuel filter.

4. Dirty Or Broken Fuel Lines

Clean or install new fuel lines as necessary.

5. No Fuel To Cylinders

Put fuel in fuel tank. "Prime" (remove the air and/or low quality fuel from the fuel system).

6. Poor Quality Or Water In Fuel

Follow the recommendations given in SEBD0717, Diesel Fuels And Your Engine. Also, Special Instruction, SEHS6947 has fuel correction factors and tables.

7. Fuel Has "Cloud Point" Higher Than Atmospheric Temperature ("Cloud Point" = Temperature Which Makes Wax Form In Fuel)

Drain the fuel tank lines, and fuel injection pump housing. Change the fuel filter. Fill the tank with fuel which has the correct "cloud point" and remove the air from the system with the priming pump.

8. Wrong Fuel Injection Timing

Make adjustment to timing.

9. Overfueling Spring Not Installed

Install overfueling spring.

Problem 3: Misfiring Or Running Rough

Probable Cause:

1. Air In The Fuel System

Find air leak in the fuel system and correct. Remove air from fuel system. See Fuel System in Testing and Adjusting.

2. Fuel Pressure Is Low

Make sure there is fuel in the fuel tank. Look for leaks or bad bends in the fuel line between fuel tank and fuel transfer pump. Look for air in the fuel system. Check fuel pressure at the fuel injection pump housing. If fuel pressure at high idle is lower than 105 kPa (15 psi), install a new filter element. If fuel pressure is still low, check the pumping spring and the check valves in the fuel transfer pump.

3. Leak Or Break In Fuel Line Between Injection Pump And Fuel Injection Nozzle

Install a new fuel line.

4. Defect In Fuel Injection Nozzle(s) Or Injection Pump(s)

Run engine at rpm that gives maximum misfiring or rough running. Then loosen a fuel line nut on the injection nozzle for each cylinder, one at a time. Find the cylinder where loosening the fuel line nut does not change the way the engine runs. Test the injection pump and fuel injection nozzle for that cylinder. Install new parts where needed.

5. Fuel System Not Timed Correctly To Engine

Make adjustment to timing if necessary.

6. Wrong Valve Lash

Make adjustment. See the Subject Valve Lash in Testing and Adjusting

7. Bent Or Broken Push Rod

Replacement of push rod is necessary.

8. Worn Valve Seal Or Face Of Valve

Reconditioning of cylinder head is needed

Problem 4: Stall At Low RPM

Probable Cause:

1. Idle RPM Too Low

Make adjustments to governor so idle rpm is the same as given in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche.

2. Defect In Fuel Injection Nozzle(s) Or Fuel Injection Pump(s)

   Run engine at rpm that gives maximum misfiring or rough running. Then loosen a fuel line nut on the injection pump for each cylinder, one at a time. Find the cylinder where loosening the fuel line nut does not change the way the engine runs. Test the injection pump and fuel injection nozzle for that cylinder. Install new parts where needed.

Problem 5: Sudden Changes In Engine Speed (RPM)

Probable Cause:

1. Failure Of Governor Or Fuel Injection Pump

   Look for damaged or broken springs, linkage or other parts. Remove the governor. Check for free travel of the fuel rack. Be sure fuel injection pumps are installed correctly. Check for correct governor spring. Install new parts for those that have damage or defects.

Problem 6: Not Enough Power

Probable Cause:

1. Air In The Fuel System

   Find air leak in the fuel system and correct. Remove air from fuel system. See Fuel System in Testing and Adjusting.

2. Fuel Pressure Is Low

   Make sure there is fuel in the fuel tank. Look for leaks, or bad bends, in the fuel line between fuel tank and fuel transfer pump. Look for air in the fuel system. Check fuel pressure at the fuel injection pump housing. If fuel pressure at high idle is lower than 105 kPa (15 psi), install a new fuel filter element. If fuel pressure is still low, check the pumping spring and the check valves in the fuel transfer pump.

3. Poor Quality Or Water In Fuel

   Follow the recommendations given in SEBD0717, Diesel Fuels And Your Engine. Also, Special Instruction, SEHS6947 has fuel correction factors and tables.

4. Constant Bleed Valve Stays Open Or Closed

   Install new parts if needed.

5. Leaks In Air Inlet System

   Check the pressure in the air inlet manifold. Look for restrictions in the air cleaner.

6. Governor Linkage

   Make adjustment to get full travel of linkage. Install new parts for those that have damage or defects.

7. Wrong Valve Lash

   Make adjustment. See the Subject Valve Lash in Testing and Adjusting.

8. Defect In Fuel Injection Nozzle(s) Or Fuel Injection Pump(s)

   Run engine at rpm that gives maximum misfiring or rough running. Then loosen a fuel line nut on the injection pump for each cylinder, one at a time. Find the cylinder where loosening the fuel line nut does not change the way the engine runs. Test the injection pump and fuel injection nozzle for that cylinder. Install new parts where needed.

9. Wrong Fuel Injection Timing

   Make adjustment to timing.

10. Fuel Setting Too Low

    Make reference to the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche.

11. Turbocharger Has Carbon Deposits Or Other Causes Of Friction

    Make inspection and repair of turbocharger as necessary.

Problem 7: Too Much Vibration

Probable Cause:

1. Loose Bolt In Nut Holding Pulley Or Damper

   Tighten bolt or nut.

2. Pulley Or Damper Has A Defect

   Install a new pulley or damper.

3. Fan Blade Not In Balance

   Loosen or remove fan belts and operate engine for a short time at the rpm that the vibration was present. If vibration is not still present, make a replacement of the fan assembly.

4. Engine Supports Are Loose, Worn, Or Have A Defect

   Tighten all mounting bolts. Install new components if necessary.

5. Misfiring Or Running Rough

   Make reference to Problem 3.

Problem 8: Loud Combustion Noise (Knock)

Probable Cause:

1. Poor Quality Or Water In Fuel
   Follow the recommendations given in SEBD0717, Diesel Fuels And Your Engine. Also, Special Instruction, SEHS6947 has fuel correction factors and tables.

2. Defect In Fuel Injection Nozzle(s) Or Fuel Injection Pump(s)
   Run engine at rpm that gives maximum combustion noise. Then loosen a fuel line nut on the injection pump for each cylinder, one at a time. Find the cylinder where loosening the fuel line nut stops the combustion noise. Test the injection pump and fuel injection nozzle for that cylinder. Install new parts where needed.

3. Wrong Fuel Injection Timing
   Make adjustment to timing.

Problem 9: Loud Noise (Clicking) From Valve Compartment

Probable Cause:

1. Damage To Valve Spring(s) Or Locks
   Install new parts where necessary. Locks with defects can cause the valve to slide into the cylinder. This will cause much damage.

2. Not Enough Lubrication
   Check lubrication in valve compartment. There must be a strong flow of oil at engine high rpm, but only a small flow of oil at low rpm. Oil passages must be clean, especially those sending oil to the cylinder head.

3. Too Much Valve Lash
   Make adjustment. See the Subject Valve Lash in Testing and Adjusting.

4. Damage To Valves
   Make a replacement of the valve(s) and make an adjustment as necessary.

Problem 10: Oil In Cooling System

Probable Cause:

1. Defect In Core Of Oil Cooler
   Install a new core in the oil cooler.

2. Defect In Head Gasket
   Install a new head gasket.

Problem 11: Mechanical Noise (Knock) In Engine

Probable Cause:

1. Failure Of Bearing For Connecting Rod
   Inspect the bearing for the connecting rod and the bearing surface on the crankshaft. Install new parts when necessary.

2. Damage To Timing Gears
   Install new parts where necessary.

3. Damage To Crankshaft
   Make replacement of the crankshaft.

Problem 12: Fuel Consumption Too High

Probable Cause:

1. Poor Quality Or Water In Fuel
   Follow the recommendations given in SEBD0717, Diesel Fuels And Your Engine. Also, Special Instruction, SEHS6947 has fuel correction factors and tables.

2. Fuel System Leaks
   Large changes in fuel consumption may be the result. Inspect the fuel system for leaks and make repairs as necessary.

3. Fuel And Combustion Noise (Knock)
   Small increases in fuel consumption may be the result of fuel nozzles with defects, rough running, or factors causing loss of power. See Problem 3 and Problem 6.

4. Wrong Fuel Injection Timing
   Make an adjustment to fuel injection timing.

5. Excess Idle Time
   Shut off engine when not in use.

6. Brake Dragging
   Adjust or repair brakes.

Problem 13: Loud Noise From Valves Or Valve Drive Components

Probable Cause:

1. Damage To Valve Spring(s)
   Make replacement of parts with damage.

2. Damage To Camshaft
   Make replacement of parts with damage. Clean engine thoroughly.

3. Damage To Valve Lifter
   Clean engine thoroughly. Make a replacement of the camshaft and valve lifters. Look for valves that do not move freely. Make an adjustment to valve lash. See the Subject Valve Lash in Testing and Adjusting.

4. Damage To Valve(s)
   Make a replacement of the valve(s) and make an adjustment as necessary.

Problem 14: Little Movement Of Rocker Arm And Too Much Valve Lash

Probable Cause:

1. Too Much Valve Lash
   Make adjustment. See the Subject Valve Lash in Testing and Adjusting.

2. Not Enough Lubrication
   Check lubricant in valve compartment. There must be a strong flow of oil at engine high rpm, but only a small flow at low rpm. Oil passages must be clean, especially those sending oil to the cylinder head.

3. Rocker Arm Worn At Face That Makes Contact With Valve
   If there is too much wear, install new rocker arms. Make adjustment of valve lash, see the Subject Valve Lash in Testing and Adjusting.

4. End Of Valve Stem Worn
   If there is too much wear, install new valves. Make adjustment of valve lash, see the Subject Valve Lash in Testing and Adjusting

5. Worn Push Rods
   If there is too much wear, install new push rods Make adjustment of valve lash, see the Subject Valve Lash in Testing and Adjusting.

6. Valve Lifters Worn
   If there is too much wear, install new valve lifters. Make adjustment of valve lash, see the Subject Valve Lash in Testing and Adjusting.

7. Damage To Valve Lifters
   Install new valve lifters. Check camshaft for wear. Check for free movement of valves or bent valve stem. Clean engine thoroughly. Make adjustment of valve lash, see the Subject Valve Lash in Testing and Adjusting.

8. Worn Lobes On Camshaft
   Check valve lash. Check for free movement of valves or bent valve stems. Check for valve lifter wear. Install a new camshaft. Make adjustment of valve lash, see the Subject Valve Lash in Testing and Adjusting

Problem 15: Valve Rotocoil Or Spring Lock Is Free

Probable Cause:

1. Damage To Locks
   Locks with damage can cause the valve to fall into the cylinder. This will cause much damage.

2. Damage To Valve Spring(s)
   Install new valve spring(s).

Problem 16: Oil At The Exhaust

Probable Cause:

1. Too Much Oil In The Valve Compartment
   Look at both ends of the rocker arm shaft. Be sure that there is a plug in each end.

2. Worn Valve Guides
   Reconditioning of the cylinder head is needed.

3. Worn Piston Rings
   Inspect and install new parts as needed.

4. Running Engine Too Long At Low Idle
   Don't let the engine run for long periods of time at low idle.

Problem 17: Little Or No Valve Lash

Probable Cause:

1. Worn Valve Seal Or Face Of Valve
   Reconditioning of cylinder head is needed. Make adjustment of valve lash. See the Subject Valve Lash in Testing and Adjusting.

Problem 18: Engine Has Early Wear

Probable Cause:

1. Dirt In Lubrication Oil
   Remove dirty lubrication oil. Install a new oil filter element. Put clean oil in the engine.

2. Air Inlet Leaks
   Inspect all gaskets and connections. Make repairs if leaks are present

3. Fuel Leakage Into Lubrication Oil
This will cause high fuel consumption and low engine oil pressure. Make repairs if leaks are present. Install new parts where needed.

Problem 19: Coolant In Lubrication Oil

Probable Cause:

1. Failure Of Oil Cooler Core
Install a new core for the oil cooler.

2. Failure Of Cylinder Head Gasket
Install a new cylinder head gasket. Tighten the bolts that hold the cylinder head, according to Specifications.

3. Crack Or Defect In Cylinder Head
Install a new cylinder head.

4. Crack Or Defect In Cylinder Block
Install a new cylinder block.

5. Failure Of Seals For Cylinder Liners
Make a replacement of the seals.

Problem 20: Too Much Black Or Gray Smoke

Probable Cause:

1. Not Enough Air For Combustion
Check for a plugged air cleaner element or blockage in the air lines. Check inlet manifold pressure. Inspect turbocharger for correct operation.

2. Defective Fuel Injection Nozzle(s)
Test all nozzles. Install new nozzles if test shows replacement is needed.

3. Wrong Fuel Injection Timing
Make adjustment to timing.

Problem 21: Too Much White Smoke

Probable Cause:

1. Too Much Oil In Engine
Do not put too much oil in the crankcase. If the oil level in the crankcase goes up as the engine is used, check for fuel in the crankcase. Make repairs or replacement as necessary.

2. Misfiring Or Running Rough
Make Reference to Problem 3

3. Wrong Fuel Injection Timing
Make adjustment to timing.

4. Coolant In Combustion Chamber
Coolant in the combustion chamber can cause white smoke. A cracked cylinder head or liner, also a bad cylinder head gasket are possible causes for this condition.

Problem 22: Too Much Blue Smoke

Probable Cause:

1. Worn Valve Guides
See the Specification module for the maximum permissible wear of the valve guides

2. Worn Piston Rings
Worn piston rings and/or cylinder walls can be the cause of blue smoke and can cause a loss of compression. Make a visual inspection of the cylinder walls and piston rings. If necessary, measure the cylinder walls and piston rings. For the cylinder and piston ring specifications, see the Specifications module.

NOTE: High wear at low mileage is normally caused by dirt coming into the engine with the inlet air.

3. Failure Of Turbocharger Oil Seal
Check inlet manifold for oil. Make a repair or replacement of the turbocharger as necessary.

Problem 23: Engine Has Low Oil Pressure

Probable Cause:

1. Low Engine Oil Level
Check engine oil level and fill to proper level.

2. Oil Leaks
Check for loose oil filter or oil supply lines, etc.

3. Dirty Oil Filter Or Cooler Core
Check the operation of bypass valve for the filter. Install new oil filter elements if needed. Clean or install new oil cooler core. Remove dirty oil and fill the engine with clean oil to the correct level.

4. Diesel Fuel In Lubricating Oil
Find the place where diesel fuel gets into the lubrication oil. Make repairs as needed. Remove any oil that has diesel fuel in it. Install new oil filters and fill the engine with clean oil to the correct level.

5. Too Much Clearance Between Rocker Arm Shaft And Rocker Arms
Check for correct lubrication in valve train compartment. Install new parts as necessary.

6. Oil Pump Suction Pipe Has A Defect.
   Replacement of the pipe is needed.

7. Relief Valve For Oil Pump Does Not Operate Correctly
   Clean valve and housing. Install new parts as necessary.

8. Oil Pump Has A Defect
   Make a repair or replacement of the oil pump as needed.

9. Too Much Clearance Between Camshaft And Camshaft Bearings
   Install new camshaft and camshaft bearings if necessary.

10. Too Much Clearance Between Crankshaft And Crankshaft Bearings
    Inspect the bearings and crankshaft journals and make repairs and replacements as necessary.

11. Too Much Bearing Clearance For Idler Gear
    Inspect bearings and make replacements as necessary.

12. Piston Cooling Tubes Not Installed
    Install piston cooling tubes.

13. Defective Oil Pressure Gauge
    Replace oil pressure gauge

Problem 24: Engine Uses Too Much Lubrication Oil

Probable Cause:

1. Too Much Lubrication Oil In Engine
   Remove extra oil. Find where extra oil comes from. Put correct amount of oil in engine. Do not put too much oil in engine.

2. Oil Leaks
   Find all oil leaks. Make repairs as needed.

3. Oil Temperature Is Too High
   Check operation of oil cooler. Install new parts if necessary. Clean the core of the oil cooler.

4. Too Much Oil In Valve Compartment
   Make reference to Problem 16.

5. Worn Valve Guides
   Make reference to Problem 16.

6. Worn Piston Rings And Cylinder Liners
   Install new parts if necessary.

7. Failure Of Seal Rings In Turbocharger
   Check inlet manifold for oil and make repair to turbocharger if necessary.

Problem 25: Engine Overheating

Probable Cause:

1. Low Coolant Level
   If the coolant level is too low, not enough coolant will go through the engine and radiator. This lack of coolant will not take enough heat from the engine and there will not be enough flow of coolant through the radiator to release the heat into the cooling air. Low coolant level is caused by leaks or wrong filling of the radiator. With the engine cool, be sure the coolant can be seen at the low end of the fill neck on the radiator top tank.

2. Defective Temperature Gauge
   A temperature gauge which does not work correctly will not show the correct temperature. If the temperature gauge shows that the coolant temperature is too hot but other conditions are normal, either install a gauge you know is good or check the cooling system with the 4C6500 Digital Thermometer Group.

3. Dirty Radiator
   Check the radiator for debris between the fins of the radiator core which prevents free air flow through the radiator core. Check the radiator for debris, dirt, or deposits on the inside of the radiator core which prevents free flow of coolant through the radiator.

4. Loose Belt(s)
   Loose fan or gear driven water pump will cause a reduction in air or water flow. Tighten the belts according to the Belt Tension Chart that is shown in the Specifications Module.

5. Defective Hose(s)
   Defective hoses with leaks can normally be seen. Hoses that have no visual leaks can "collapse" (pull together) during operation and cause a restriction in the flow of coolant. Hoses become soft and/or get cracks after a period of time. See Operation & Maintenance Manual for the frequency to change hoses. The inside of the hose can become loose, and the loose particles of can cause a restriction in the flow of coolant.

6. Defective Water Temperature Regulator (thermostat)
   A regulator that does not open, or only opens part of the way, can cause above normal heating. See the Testing and Adjusting section for the procedure to test water temperature regulators.

7. Defective Water Pump

A water pump with a loose impeller does not pump enough coolant for correct engine cooling. A loose impeller can be found by removing the water pump, and by pushing the shaft back and pulling it forward. If the impeller has no damage, check the impeller clearance.

8. Air In Cooling System

Air can get into the cooling system in different ways. The most common causes are not filling the cooling system correctly, and combustion gas leaking into the system. Combustion gas can get into the system through inside cracks or bad cylinder head gaskets. Air in the cooling system causes a reduction in coolant flow and bubbles in the coolant. Air bubbles hold coolant away from engine parts, preventing heat flow.

Air in the cooling system can be found by the BOTTLE TEST. The equipment needed to make this test is a one pint bottle, a bucket of water, and a hose which will fit the end of the overflow pipe of the radiator.

Before testing make sure the cooling system is filled correctly. Use a wire to hold the relief valve in the radiator cap open. Install the radiator cap and tighten it. Put the hose over the end of the overflow pipe.

Start the engine and operate it at high idle rpm for a minimum of five minutes after the engine is at normal operating temperature. Use a cover on the radiator core to keep the engine at operating temperature. After five or more minutes at operating temperature, place the loose end of the hose in the bottle filled with water. Put the bottle in the bucket of water with the top down. If the water gets out of the bottle in less than forty seconds, there is too much exhaust gas leakage into the cooling system. Find the cause of the air or gas getting into the cooling system and correct as necessary.

9. Wrong Fan, Fan Or Shroud Not In Correct Position

A wrong fan, or a fan or shroud in a wrong position will cause a reduction or a loss of air flow through the radiator. The fan must be large enough to send air through most of the area of the radiator core. Make sure the fan size, fan shroud, and position of fan and shroud are according to the recommendations of the manufacturer.

10. Radiator Too Small

A radiator which is too small does not have enough area to release the heat to the cooling air. This will cause the engine to run at higher than normal temperatures. Make sure the radiator size is according to the recommendations of the manufacturer.

11. Not Enough Air Flow Through Radiator Because Of Restriction In Engine Compartment

The air flow through the radiator comes out of the engine compartment. Make sure the filters, air conditioners, and similar items are not installed in a way which prevents free flow of air into and out of the engine compartment.

12. High Outside Temperature

When outside temperatures are too high for the rating of the cooling system, there is not enough temperature difference between the outside air and coolant temperatures. To get better cooling, reduce engine load.

13. Operating At High Altitude

The cooling capacity of the cooling system goes down as the machine is used at higher altitudes. A system, under pressure, large enough to keep the coolant from boiling must be used.

14. Air Inlet Restriction

Restriction of the air coming into the engine causes high cylinder temperatures and more than normal amount of heat to pass to the cooling system. Check for a restriction with a water manometer or a vacuum gauge (which measures in inches of water). Connect the gauge to the engine air inlet between the air cleaner and the inlet to the turbocharger. With gauge installed, run engine at full load rpm and check the restriction. Maximum restriction of air inlet 635 kPa (25 inches of water). If the indication is higher than the maximum permissible restriction, remove the dirt from the filter element, or install a new filter element and check the restriction again. If the indication is still too high, there must be a restriction in the inlet piping.

15. Exhaust Restriction

Restriction in the exhaust system causes high cylinder temperatures and more than normal amount of heat to pass to the cooling system. To see if there is an exhaust restriction, make a visual inspection of the exhaust system. Check for damage to piping or for a bad muffler. If no damage is found, check the system for back pressure from the exhaust (pressure difference measurement between exhaust outlet and atmosphere). The back pressure must not be more than 1016 kPa (40 inches of water). You can also check the system by removing the exhaust pipes from the exhaust manifolds. With the exhaust pipes removed, start and run the engine to see if the problem is corrected.

16. Fuel Injection Timing Not Correct

Check and make necessary adjustments as given in the Testing and Adjusting section.

Problem 26: Engine Overcooling

Probable Cause:

1. Long Idle Periods
   When the engine is running with no load, only a small quantity of fuel is burnt and engine heat is removed too fast.

2. Very Light Load
   Very light loads can cause overcooling because of the low heat input of the engine.

3. Defective Water Temperature Regulator (thermostat)
   A regulator that is "stuck" open (will not move to the closed position) will cause overcooling. A thermostat that is stuck between the open and closed positions, or only opens part of the way, can cause overcooling when the engine has a light load. Also, coolant leaks around the thermostat, such as vent lines, can cause overcooling.

Problem 27: Coolant Leaks Outside Of Engine

Probable Cause:

1. Leaks In Hoses Or Connections
   Check all hoses and connections for visual signs of leakage. If no leaks are seen, look for damage to hoses or loose clamps.

2. Leaks In The Radiator And/Or Expansion Tank
   Put pressure to the radiator and/or expansion tank with the 9S8140 Cooling System Pressurizing Pump Group and check for leaks. Refer to Testing Radiator And Cooling System For Leaks in Testing And Adjusting Section.

3. Leaks In The Heater
   Put pressure to the cooling system with the 9S8140 Cooling System Pressurizing Pump Group and check the heater for leaks. Refer to Testing Radiator And Cooling System For Leaks in Testing And Adjusting Section.

4. Leaks In The Water Pump
   Check the water pump for leaks before starting the engine, then start the engine and look for leaks. If there are leaks at the water pump, repair or install a new water pump.

5. Cylinder Head Gasket Leakage
   Look for leaks along the surface of the cylinder head gasket. If you see leaks, install a new head gasket.

Problem 28: Coolant Leaks At The Overflow Tube

Probable Cause

1. Defective Pressure Cap Or Relief Valve
   Check the sealing surfaces of the pressure cap and the radiator to be sure the cap is sealing correctly. Check the opening pressure and sealing ability of the pressure cap or relief valve with the 9S8140 Cooling System Pressurizing Pump Group. Refer to Checking Pressure Cap in Testing And Adjusting Section.

2. Engine Runs Too Hot
   If coolant temperature is too high, pressure will be high enough to move the cap off of the sealing surface in the radiator and cause coolant loss through the overflow tube. See Problem 25: Engine Overheating.

3. Expansion Tank Too Small Or Installed Wrong
   The expansion tank can be either a part of the radiator or it can be installed separately from the radiator. The expansion tank must be large enough to hold the expansion of the coolant as it gets warm or has sudden changes in pressure. Make sure the expansion tank is installed correctly, and the size is according to the recommendations of the manufacturer.

4. Cylinder Head Gasket Leakage Or Crack(s) In Cylinder Head Or Cylinder Block
   Remove the radiator cap and, with the engine running, look for air bubbles in the coolant. Bubbles in the coolant are a sign of probable leakage at the head gasket. Remove the cylinder head from the engine. Check cylinder head, cylinder walls and head gasket surface of the cylinder block for cracks. When the head is installed, use a new head gasket, spacer plate gasket, water seals, and O-ring seals.

Problem 29: Coolant Leakage Inside Engine

Probable Cause:

1. Cylinder Head Gasket Leakage
   If the cylinder head gasket leaks between a water passage and an opening into the crankcase, coolant will get into the crankcase.

2. Crack(s) In Cylinder Head
   Crack(s) in the upper surface of the cylinder head, or an area between a water passage and an opening into the crankcase, can allow coolant to get into the crankcase.

3. Crack(s) In Cylinder Block
   Crack(s) in the cylinder block between a water passage and the crankcase will let coolant get into the crankcase.

Problem 30: Exhaust Temperature Is Too High

Probable Cause:

1. Air Inlet or Exhaust System Has A Restriction
   Remove restriction.

2. Wrong Fuel Injection Timing
   Make an adjustment to the timing.

Problem 31: Starter Motor Does Not Turn

Probable Cause:

1. Battery Has Low Output
   Check condition of battery. Charge battery or make replacement as necessary.

2. Wires or Switch Has Defect
   Make repairs or replacement as necessary.

3. Starter Motor Solenoid Has A Defect
   Install a new solenoid.

4. Starter Motor Has A Defect
   Make repair or replacement of starter motor.

Problem 32: Alternator Gives No Charge

Probable Cause:

1. Loose Drive Belt For Alternator
   Make an adjustment to put the correct tension on the drive belt.

2. Charging Or Ground Return Circuit Or Battery Connections Have A Defect
   Inspect all cables and connections. Clean and tighten all connections. Make replacement of parts with defects.

3. Brushes Have A Defect
   Install new brushes.

4. Rotor (Field Coil) Has A Defect
   Install a new rotor

Problem 33: Alternator Charge Rate Is Low Or Not Regular

Probable Cause:

1. Loose Drive Belt For Alternator
   Make an adjustment to put the correct tension on the drive belt.

2. Charging Or Ground Return Circuit Or Battery Connections Have A Defect
   Inspect all cables and connections. Clean and tighten all connections. Make replacement of parts with defects.

3. Alternator Regulator Has A Defect
   Install a new alternator regulator.

4. Alternator Brushes Have A Defect
   Install new brushes.

5. Rectifier Diodes Have A Defect
   Make replacement of rectifier diode that has a defect.

6. Rotor (Field Coil) Has A Defect
   Install a new rotor.

Problem 34: Alternator Charge Is Too High

Probable Cause:

1. Alternator Or Alternator Regulator Has Loose Connections
   Tighten all connections to alternator or alternator regulator.

2. Alternator Regulator Has A Defect
   Install a new alternator regulator.

Problem 35: Alternator Has Noise

Probable Cause:

1. Drive Belt For Alternator Is Worn Or Has A Defect
   Install a new drive belt for the alternator.

2. Loose Alternator Drive Pulley
   Check groove in pulley for key that holds pulley in place. If groove is worn, install a new pulley. Tighten pulley nut according to Specifications.

3. Drive Belt And Drive Pulley For Alternator Are Not In Alignment
   Make an adjustment to put drive belt and drive pulley in correct alignment.

4. Worn Alternator Bearings
   Install new bearings in the alternator.

5. Rotor Shaft Is Bent
   Make a replacement of the rotor shaft.

6. Rectifiers In The Alternator Are Shorted
   Make a replacement of the diode assembly.

Fuel System

Either too much fuel or not enough fuel for combustion can be the cause of a problem in the fuel system.

Many times work is done on the fuel system when the problem is really with some other part of the engine. The source of the problem is difficult to find, especially when smoke comes from the exhaust. Smoke that comes from the exhaust can be caused by a defective fuel injection nozzle, but it can also be caused by one or more of the reasons that follow:

a. Not enough air for good combustion.
b. An overload at high altitude.
c. Oil leakage into combustion chamber.
d. Not enough compression.
e. Fuel injection timing retarded.

Fuel System Inspection

To check for low fuel pressure, remove the ⅛ inch Pipe Plug from the fuel filter base. Connect a pressure gauge from the 1U5470 Engine Pressure Group to the hole where the plug was removed. Run the engine at high idle and check the fuel pressure reading. The fuel pressure must be at least 105 kPa (15 psi).

A problem with the components that send fuel to the engine can cause low fuel pressure. This can decrease engine performance.

1. Check the fuel level in the fuel tank. Look at the cap for the fuel tank to make sure the vent is not filled with dirt.

2. Check the fuel lines for fuel leakage. Be sure the fuel supply line does not have a restriction or a bad bend.

3. Install a new fuel filter. Clean the primary fuel filter.

4. Remove any air that may be in the fuel system. If there is air in the fuel system, use the priming pump and open the drain valve on the fuel injection pump housing until fuel without air comes from the drain line.

NOTICE

When fuel injection lines are loosened or tightened on the fuel injection nozzles, two wrenches must be used. The nozzle must be held with a wrench or damage to the nozzle can result.

To remove air from the fuel injection lines, loosen the fuel line nuts on the fuel injection nozzles ½ turn. Move the governor lever to the low idle position. Crank engine with the starter motor until fuel without air comes from the fuel line connections. Tighten the fuel line nuts.

NOTE: The fuel priming pump will not give enough pressure to push fuel through the reverse flow check valves in the fuel injection pumps.

Checking Engine Cylinders Separately

An easy check can be made to find the cylinder that runs rough (misfires) and causes black smoke to come out of the exhaust pipe.

Run the engine at the speed that is the roughest. Loosen the fuel line nut at a fuel injection pump. This will stop the flow of fuel to that cylinder. Do this for each cylinder until a loosened fuel line is found that makes no difference in engine performance. Be sure to tighten each fuel line nut after the test before the next fuel line nut is loosened. Check each cylinder by this method. When a cylinder is found where the loosened fuel line nut does not make a difference in engine performance, test the injection pump and fuel injection nozzle for that cylinder.

Temperature of an exhaust manifold port, when an engine runs at low idle speed, can also be an indication of the condition of a fuel injection nozzle. Low temperature at an exhaust manifold port is an indication of no fuel to the cylinder. This can possible be an indication of a nozzle with a defect. Extra high temperature at an exhaust manifold port can be an indication of too much fuel to the cylinder, also caused by a nozzle with a defect.

The most common defects found with the fuel injection nozzles are:

1. Carbon on tip of the nozzle or in the nozzle orifice.

2. Orifice wear.

3. Steel wire brushing of nozzle tip.

Testing Fuel Injection Nozzles

Testing of the fuel injection nozzles must be done off the engine. Perform the following tests using the 5P4150 Nozzle Testing Group to determine if nozzle performance is acceptable:

Valve Opening Pressure Test
Flush The Nozzle
Tip Leakage Test
Orifice Restriction Test
Bleed Screw Leakage Test

Refer to Special Instruction, SEHS7292, for operation of the 5P4150 Nozzle Testing Group.

Fuel Injection Lines

Fuel from the fuel injection pumps goes to the fuel injection nozzles through the fuel injection lines.

When fuel injection lines are disconnected or removed, always put caps or plugs on the ends to keep dirt out of the lines. When fuel injection lines are installed, be sure all clamps and dampers are installed in their original location.

The nuts that hold a fuel injection line to an injection nozzle and injection pump must be tightened to the correct torque. If the nut is loose, fuel will leak from the connection. If the nut is tightened too tight, the inside diameter of the line will become smaller and cause a restriction to the flow of fuel in the line. Use a torque wrench and a 5P0144 Fuel Line Socket to tighten the fuel injection line nuts to 40 ± 7 N•m (30 ± 5 lb ft).

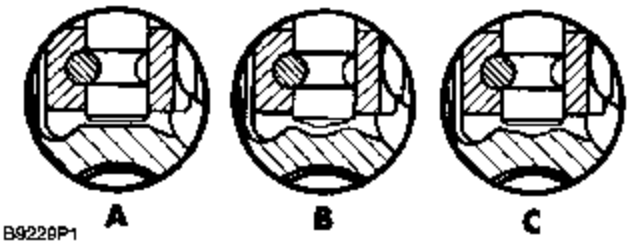
⚠ WARNING

Fuel injection lines which are bent, damaged or rubbing can leak and cause a fire. Replace any lines which have damage or leaks that cannot be corrected when tightened to the correct torque.

Checking The Plunger And Lifter Of An Injection Pump

NOTE: There are no different size spacers available to adjust the timing dimension of the fuel injection pumps. If the pump plunger or the *lifter is worn, they must* be replaced. Because there is no adjustment to the timing dimension possible, there is NO OFF ENGINE LIFTER SETTING PROCEDURE.

When there is too much wear on the fuel injection pump plunger, the lifter may also be worn and there will not be good contact between the two parts. To stop fast wear on the end of a new plunger, install new lifters in the place of the lifters that have wear.



Wear Between Lifter And Plunger
Fig. A. Illustrates the contact surfaces of a new pump plunger and a new lifter. In Fig. B the pump plunger and lifter have worn considerably. Fig. C shows how the flat end of a new plunger makes poor contact with a worn lifter, resulting in rapid wear to both parts.

An injection pump can have a good fuel flow coming from it but not be a good pump because of slow timing that is caused by wear on the bottom end of the plunger. When making a test on a pump that has been used for a long time, use a micrometer and measure the length of the plunger. If the length of the plunger is shorter than the minimum length (worn) dimension given in the chart, install a new pump.

FUEL PUMP PLUNGER
Length (new) ... 73.886 ± 0.013 mm (2.9089 ± .0005 in)
Minimum length (worn) ... 73.673 mm (2.9084 in)

Look for wear at the top part of the plunger. Check the operation of the plunger according to the instructions for the Fuel Injection Test Bench.

Removal And Installation Of Fuel Injection Pumps

Tools Needed		
BT5287	Wrench	1
BS2244	Extractor	1
BV4186	Timing Pin	1

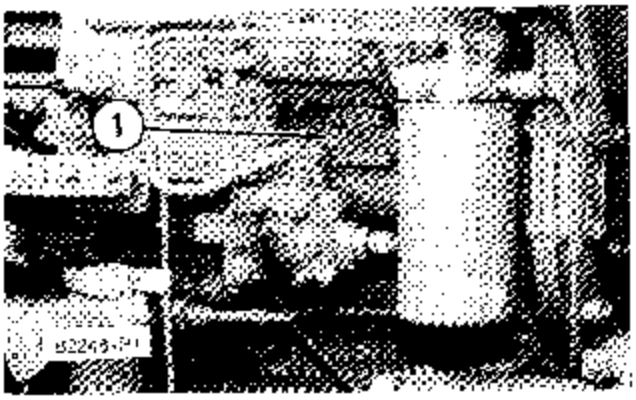
Removal of Fuel Injection Pumps

NOTICE

Before any parts are removed from the fuel injection pump housing, thoroughly clean all dirt from the housing. Dirt that gets inside the pump housing will cause much damage.

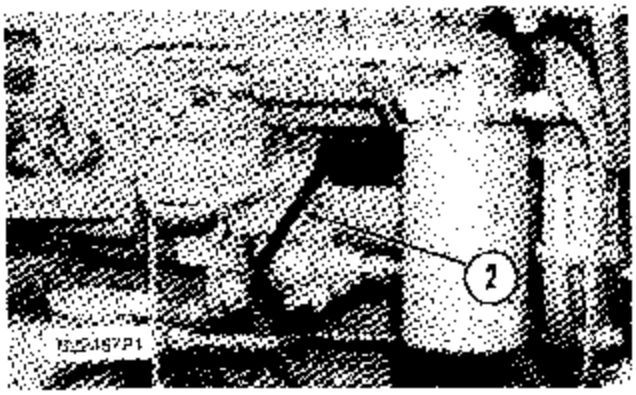
NOTE: The fuel rack must be in the center position before the fuel injection pumps can be removed.

1. Remove timing pin cover (1) from the side of the fuel injection pump housing.



Fuel Injection Pump Housing
(1) Timing pin cover.

2. Move the governor lever to the Fuel OFF position and install timing pin (2) in the rack centering hole as shown.



Timing Pin Installed
(2) Timing pin.

3. With the timing pin in position, move the governor lever to the high idle position. The fuel rack will move until the edge of the groove in the rack makes contact with the timing pin. The fuel rack is now in the center position. Fasten the governor lever in the HIGH IDLE position.

4. Remove the fuel injection line from the fuel injection pump.

5. Put the 8T5287 Wrench into spline of bushing that holds the fuel injection pump in the housing. Remove the bushing.

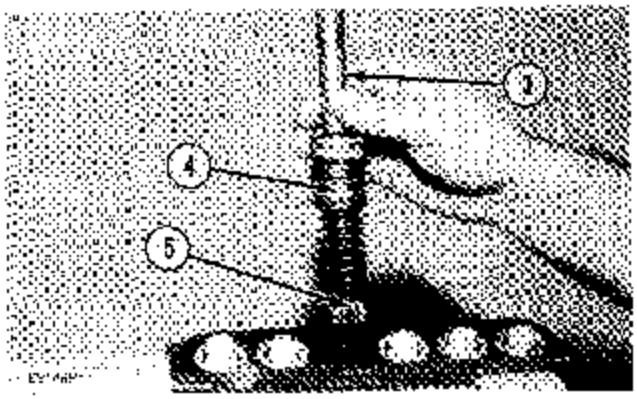
6. Install the 8S2244 Extractor on the threads of the injection pump. Carefully pull the pump straight up out of the bore.

Be careful when an injection pump is disassembled. Do not damage the surface on the plunger. The plunger and barrel are made as a set. Do not put the plunger of one pump in the barrel of another pump. If one part is worn, install a complete new pump assembly. Be careful when the plunger is put into the bore of the barrel. When injection pump and spacers are removed from the fuel injection pump housing, keep the parts together so they can be installed in the same location in the housing.

Installation of Fuel Injection Pumps

NOTICE

The fuel rack MUST BE IN THE CENTER POSITION before the correct installation of an injection pump is possible.



Fuel Pump Installation
(3) 8S2244 Extractor. (4) Groove of barrel. (5) Fourth tooth of gear segment.

1. Put the fuel rack in the center position. Make reference to Removal of Fuel Injection Pumps.

2. Put the 8S2244 Extractor on the threads of the fuel injection pump.

3. Make sure the lifter for the pump to be installed is at the bottom of its travel.

4. Put the groove of barrel (4) in alignment with the middle (fourth) tooth of gear segment (5).

5. Look into the bore for the fuel injection pump and locate both dowels. There is a dowel in the lifter and a dowel in the opposite side of the bore in the fuel injection pump housing. Put the groove in the pump barrel in alignment with the large dowel in the pump housing and put the slot (groove) on the opposite side of the gear teeth on the sector gear in alignment with the small dowel in the lifter. Install the fuel injection pump straight down into the bore.

6. Push down on extractor (3) (hand force only) and install O-ring and bushing that holds the injection pump in the pump housing. If the pump is in the correct position, the bushing will turn into the threads of the fuel injection housing with the fingers until it is even with the top of the housing. When the bushing is installed correctly, tighten the bushing to 163 ± 14 N•m (120 ± 10 lb ft).

NOTICE

The bushing must be tightened to the correct torque. Damage to the housing will be the result if the bushing is too tight. If the bushing is not tight enough, the pump will have leakage.

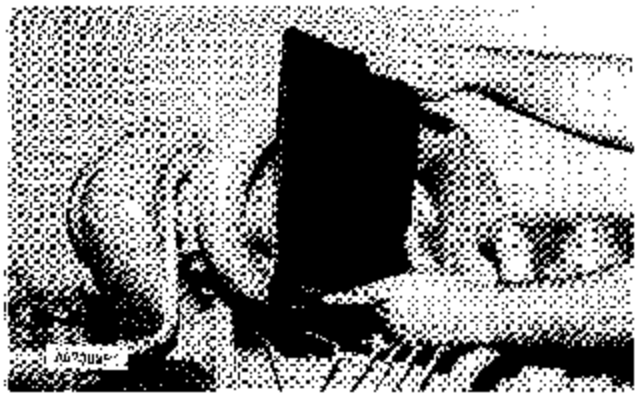
7. Install the fuel injection line to the pump and tighten to 41 ± 7 N•m (30 ± 5 lb ft).

8. Remove timing pin (4) and install timing pin cover (3).

NOTICE

If one or more of the fuel injection pumps have been installed wrong, it is possible for the engine to run out of control when started. When any of the fuel injection pumps have been removed and installed, take the precautions (steps) that follow to stop the engine if it starts to overspeed (run out of control).

a. Remove the air cleaner pipe from the turbocharger and leave the air inlet for the turbocharger open.
b. Set the governor at low idle.



Stopping The Engine (Typical Example)

⚠ WARNING

Be careful when plate is put against air inlet opening. Due to excessive suction, the plate can be pulled quickly against air inlet opening. To avoid crushed fingers, do not put fingers between plate and air inlet opening.

c. Start the engine, and if engine starts to overspeed (run out of control) put a steel plate over the air inlet to stop the engine.

Locating Top Center Compression Position For No. 1 Piston

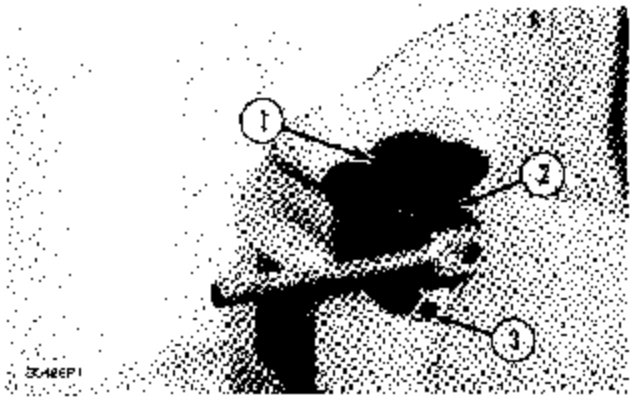
Tools Needed		
5P7307	Engine Turning Tool Group	1

No. 1 piston at top center (TC) on the compression stroke is the starting point for all timing procedures.

NOTE: The engine is seen from the flywheel end when direction of crankshaft rotation is given.

1. Remove starter motor.

2. Install the tools as shown.

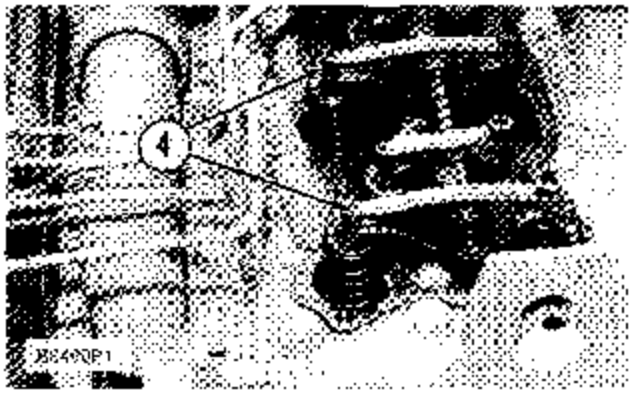


Engine Turning Tools Installed
(1) 5P7306 Housing. (2) 5P7305 Gear. (3) Timing bolt.

3. Remove the valve cover.

4. Rotate the crankshaft clockwise approximately 30 degrees. The reason for this step is to be sure the free play is removed from the timing gears when the engine is put on top center.

5. Remove the plug from the timing hole in the flywheel housing. Rotate the crankshaft until a ⅜-16 NC bolt, 50.8 mm (2.00 in) long, can be turned into the flywheel through the timing hole in the flywheel housing. No. 1 piston is now on top center.



Valve Cover Removed
(4) Rocker arms.

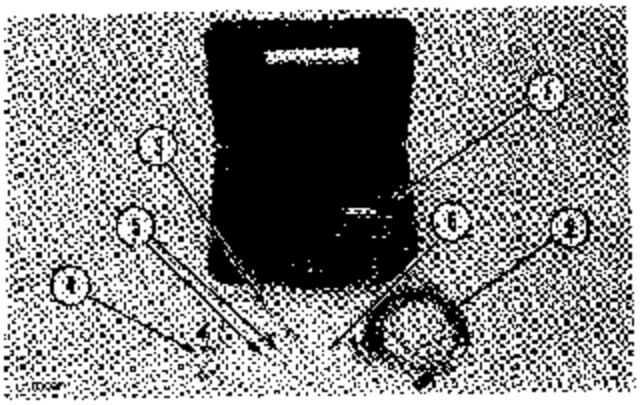
NOTE: If the crankshaft is turned beyond top center do Steps 4 and 5 again.

6. The intake and exhaust valves for No. 1 cylinder will be closed if No. 1 piston is on the compression stroke. You can move rocker arms (4) up and down with your hand.

7. If No. 1 piston is not on the compression stroke, remove the timing bolt and rotate the crankshaft counterclockwise 360 degrees. Install the timing bolt. The No. 1 piston is now at top center on the compression stroke.

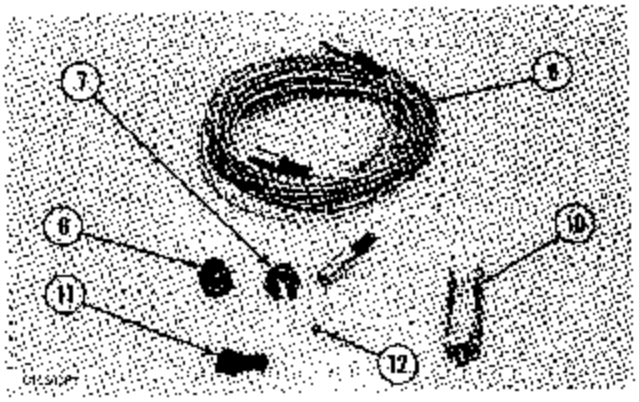
Checking Engine Timing With 8T5300 Timing Indicator Group And 8T5301 Diesel Timing Adapter Group

Tools Needed		
8T5300	Timing Indicator Group	1
8T5301	Diesel Timing Adapter Group	1



8T5300 Timing Indicator Group
(1) 8T5250 Engine Timing Indicator. (2) 5P7366 Cable Assembly. (3) 6V2197 Magnetic Transducer. (4) 5P7362 Cable. (5) 6V2199 and 6V3093 Transducer Adapters. (6) 8K4644 Fuse.

The 8T5300 Timing Indicator Group must be used with the 8T5301 Diesel Timing Adapter Group.



8T5301 Diesel Timing Adapter Group
(7) 5P7437 Adapter. (8) 6V2198 Cable. (9) 5P7436 Adapter. (10) 6V7910 Transducer. (11) 5P7435 Adapter. (12) 6V3016 Washer.

⚠ WARNING

A high pressure fuel line must be disconnected. To avoid personal injury or fire from fuel spray, the engine must be stopped before the fuel line is disconnected.

When checking the dynamic timing on an engine without a mechanical advance, Caterpillar recommends that the serviceman calculate and graph the dynamic timing on a worksheet like SEHS8140. These worksheets are available in pacs of 50 sheets. See Special Instruction, SEHS8580, for information required to calculate the timing curve.

After the timing values are calculated and plotted, the dynamic timing should be checked with the 8T5300 Engine Timing Indicator Group. To do this, the serviceman must operate the engine from 1000 rpm (base rpm) to high idle and from high idle to 1000 rpm (base rpm). Unstable readings are often obtained below 1000 rpm. He must record the dynamic timing at each 100 rpm and at the specified speeds during both acceleration and deceleration. Then he should plot the results on the worksheet.

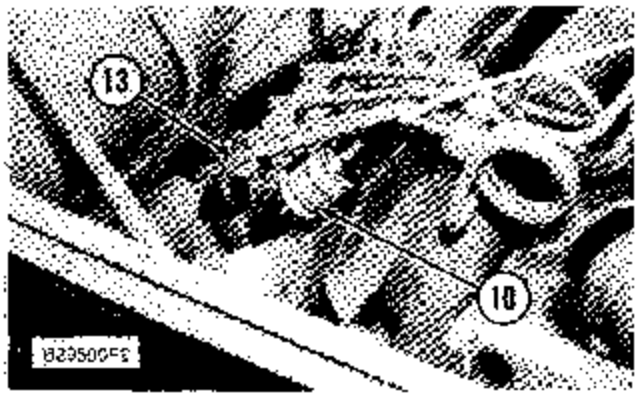
Inspection of the plotted value will show if the timing is within specifications. See Special Instruction, SEHS8580 for information required to calculate the timing.

1. See the Engine Information Plate for the performance specification number and make reference to the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche for the correct timing specifications to use.

2. Make reference to Operation Instructions inside the lid of the 8T5300 Timing Indicator (1) or Special Instruction, SEHS8580 for complete instructions and calibration.

⚠ WARNING

The engine must be stopped before the timing indicator group is installed. A high pressure fuel line must be disconnected and a probe must be installed against the flywheel.



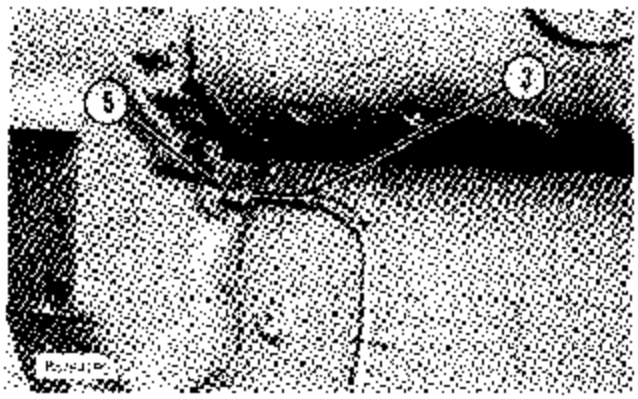
Transducer In Position
(10) Injection transducer, (13) Fuel injection line for No. 1 cylinder.

3. Loosen all fuel line clamps that hold No. 1 fuel injection line and disconnect fuel injection line (13) for No. 1 cylinder at the fuel injection pump. Slide the nut up and out of the way. Put 5P7436 Adapter (9) in its place and turn adapter (9) onto the fuel pump bonnet until the top of the bonnet threads are approximately even with the bottom of the "window" in adapter (9).

4. Put the 5P7435 Tee Adapter (11) on the injection transducer (10) and put the end of the 5P7435 Tee Adapter (11) in the "window" of the 5P7436 Adapter (9).

5. Put fuel injection line (13) on top of 5P7435 Tee Adapter (11). Install 5P7437 Adapter (7) and tighten to a torque of not more than 40 N•m (30 lb ft).

6. Remove the plug from the flywheel housing. Install transducer adapter (5) into the hole the plug was removed from. Tighten only a small amount.



Transducer In Position
(3) TC magnetic transducer. (5) Transducer adapter.

7. Push the TC magnetic transducer (3) into the transducer adapter (5) until it makes contact with the flywheel. Pull it back out 1.6 mm (.06 in) and lightly tighten the knurled locknut.

8. Connect the cables from the transducer to Engine Timing Indicator (1). Calibrate and make adjustments. For calibration procedure, make reference to Special Instruction, SEHS8580.

9. Start the engine and let it reach operating temperature. Then run the engine at approximately one half throttle for eight to ten minutes before measuring timing.

10. Run the engine at 100 rpm speed increments between 1000 rpm (base rpm) and high idle. (Smaller increments may be needed to find the point where timing advance starts and stops). Record and plot the engine timing indicator readings over the calculated timing graph.

11. If the readings are within ± 2.5 degrees of the calculated timing graph and the angle of change is approximately the same, the engine timing is set and operating correctly.

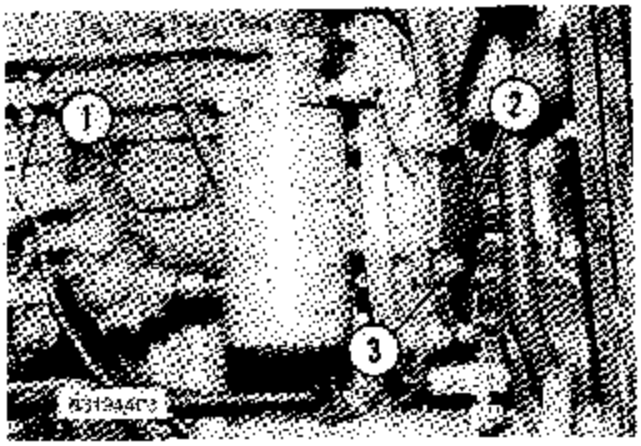
12. If the timing indicator readings are not within ± 2.5 degrees of the calculated graph and timing advance is not smooth through the speed range, an adjustment may be needed.

13. Make reference to Adjusting Engine Timing By Timing Pin Method for static adjustment of the fuel injection pump drive. Check engine timing again if the static engine timing was not correct. If the automatic timing advance is not correct, make a repair or replacement of the automatic advance unit. There is no adjustment to the unit.

Adjusting Engine Timing By Timing Pin Method

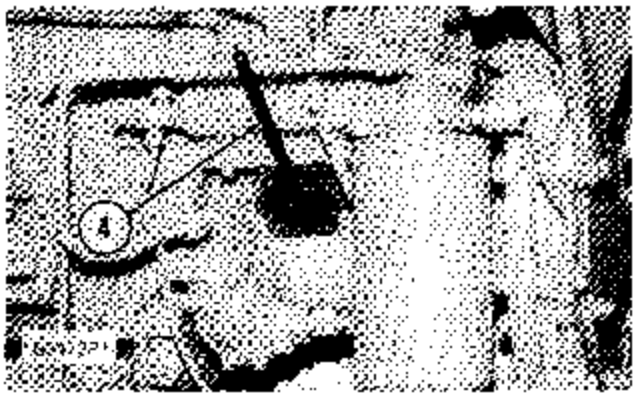
Tools Needed		
8S2264	Puller Group	1
1B3680	Bolt ⅜-24 NF, 95.3 mm (3.75 in) long.	2
4B5271	Washer	2
8B7560	Step Plate	1
6F7030	Bolt ⅜-24 NF, 25.4 mm (1.0 in) long.	2
6V4186	Timing Pin	1
6V6176	Adapter	1

1. Put No. 1 piston at top center on the compression stroke. Make reference to Locating Top Center Compression Position For No. 1 Piston. Remove the timing bolt and rotate the crankshaft clockwise 30 degrees.



Timing Pin Cover
(1) Timing pin cover. (2) Cover for timing gear. (3) Nut.

2. Remove timing pin cover (1) from the side of the fuel injection pump housing.



Timing Pin Installed
(4) 6V4186 Timing Pin.

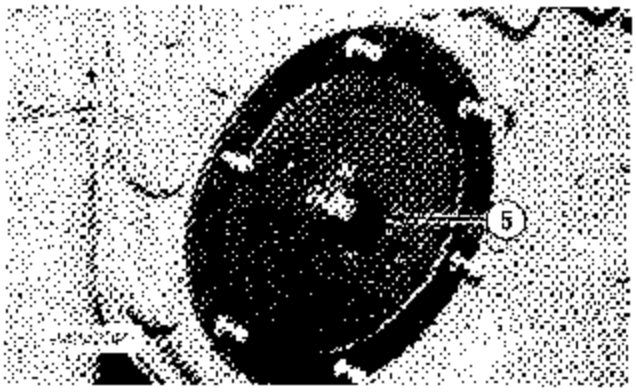
3. Install 6V4186 Timing Pin (4) in the fuel injection pump housing as shown. Slowly rotate the crankshaft counterclockwise until timing pin (4) goes into the slot in the fuel pump camshaft.

NOTICE

Too much pressure on the timing pin can damage the fuel injection pump camshaft or the timing pin.

4. Put the timing bolt in the timing hole in the flywheel housing. Slowly move the crankshaft counterclockwise (as seen from the flywheel end of the engine) until the fuel pump camshaft is tight against timing pin (4). This removes gear clearance from the drive train.

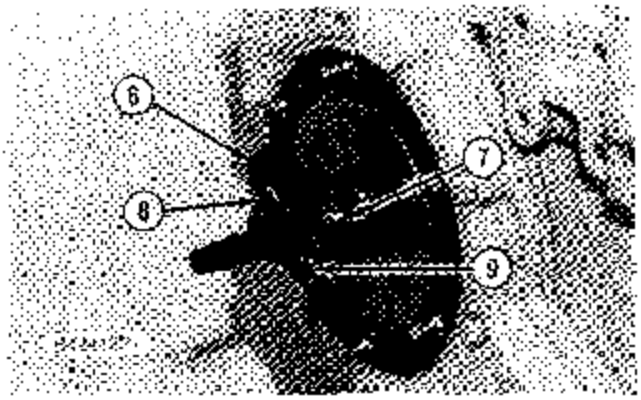
5. Remove nuts (3) and cover (2) from the timing gear housing.



Timing Gear For Fuel Injection Pump
(5) Bolt.

6. Loosen bolt (5) that holds the timing gear to the fuel pump camshaft. Turn bolt (5) out (counterclockwise) three turns.

7. Install 8S2264 Puller Group and loosen the timing gear from the fuel pump camshaft.



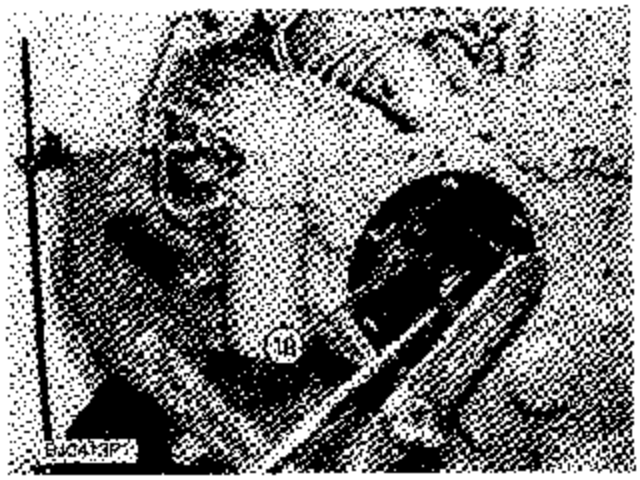
Puller Tools Installed
(6) 8S2264 Puller Group. (7) 8B7560 Step Plate. (8) 1B3680 Bolt 3/8-24 NF, 95.3 mm (3.75 in) long. (9) 4B5271 Washer

8. Rotate the flywheel clockwise 60 degrees before top center No. 1 piston.

9. Tighten retaining bolt (5) finger tight. Be sure timing pin (4) is in the groove in the fuel pump camshaft.

10. Slowly rotate the crankshaft counterclockwise until the timing bolt can be installed in the flywheel.

11. Install 4C9874 Spanner Wrench on the timing gear.



Adapter Installed On Timing Gear
(10) 4C9874 Spanner Wrench.

12. Hold a torque of 60 to 70 N•m (45 to 50 lb ft) on wrench (10) in a clockwise direction, and tighten bolt (5) that holds the timing gear to 270 ± 30 N•m (200 ± 20 lb ft).

13. Remove the timing bolt from the flywheel and timing pin (4) from the fuel pump camshaft.

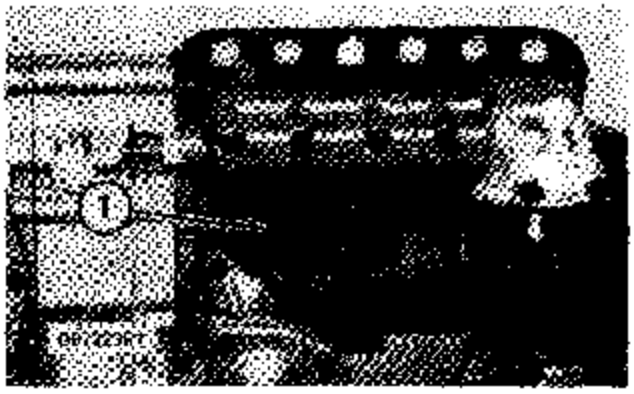
14. Use the 8T5300 Timing Indicator Group to verify the change to the timing.

Governor Adjustment For Fuel Ratio Control Linkage (If Equipped)

Tools Needed		
6V4186	Timing Pin.	1
6V2105	Rack Adjustment Tool Group.	1
6V2017	Governor Adjustment Tool Assembly.	1
0S1614	Bolt ¼-20. 12.7 mm (.5 in long).	2
9S0229	Contact Point. 9.7 mm (.38 in) long.	1
5P4814	Collet.	1
6V3075	Dial Indicator.	1
6V7941	Compressor, Over Fueling Spring.	1
6V2014	Bracket Assembly.	1

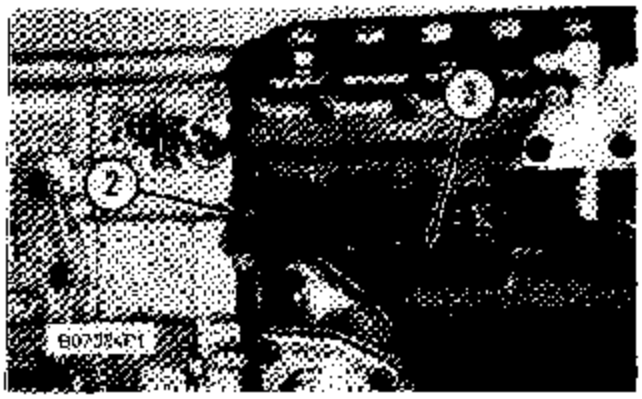
The governor adjustment for the fuel ratio control can be done with the fuel injection pump and governor on or off the engine.

NOTE: The fuel ratio control is set to specific dimensions at the factory. If the control is disassembled it must be set again on the 6V2029 Fixture Group before the governor adjustment is made. Make reference to Fuel Injection Test Bench SEHS7466 for instructions for the use of 6V2029 Fixture Group.

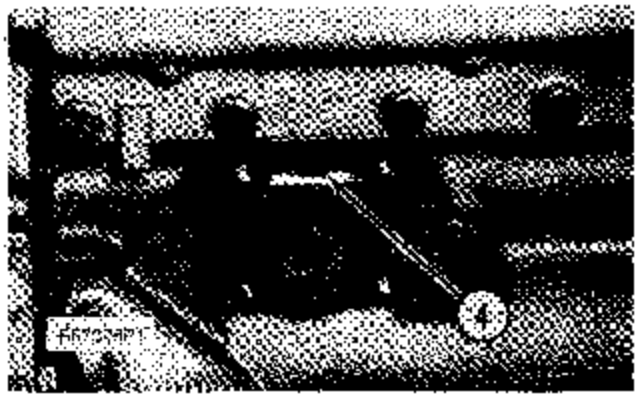


Fuel Injection Pump And Governor
(1) Cover.

1. Remove the fuel filter base and fuel line from the fuel injection pump housing and remove cover (1).
2. Install 5P4814 Collet (2) on 6V2014 Bracket Assembly (3).
3. Install the bracket assembly on the fuel pump housing. Lever (5) on the bracket assembly must be in slot (4) on the fuel rack. Push up on the bracket assembly while the bolts are tightened.

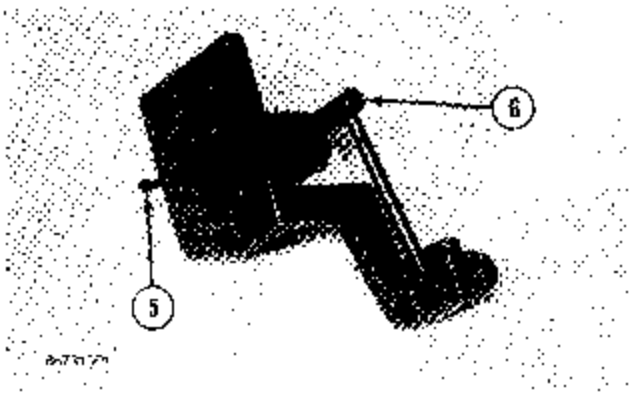


Bracket Assembly Installed
(2) 5P4814 Collet. (3) 6V2014 Bracket Assembly.

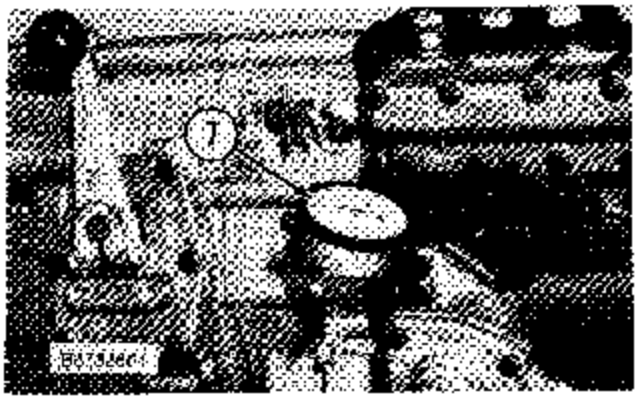


Cover Removed
(4) Slot on fuel rack.

NOTE: After the bracket assembly is tightened to the pump housing, shaft (6) must have axial (in and out) movement. If there is no axial movement of shaft (6), check to be sure lever (5) is in the slot on the fuel rack and that the bracket assembly is installed correctly. Check to make sure that lever (5) is not bent. Lever (5) must be perpendicular (at right angle) to the mounting face of the bracket assembly.

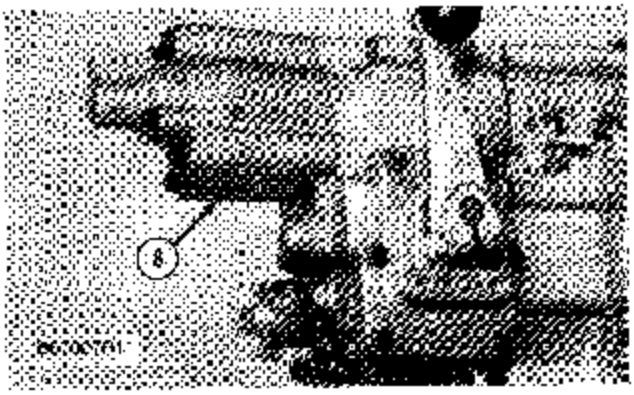


Bracket Assembly
(5) Lever. (6) Shaft.

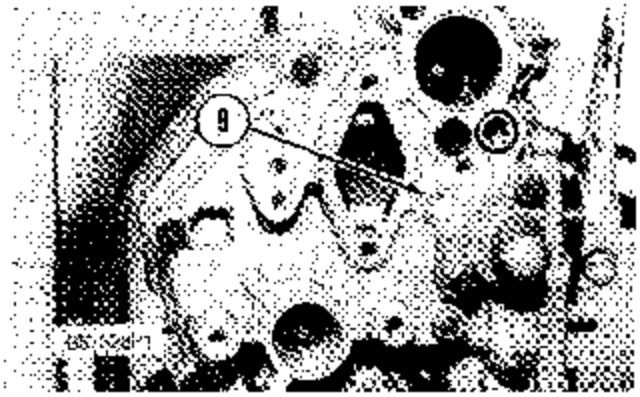


Dial Indicator Installed
(7) 6V3075 Dial Indicator.

4. Put 9S229 Contact Point, 9.7 mm (.38 in) long on 6V3075 Dial Indicator (7) and install dial indicator in collet (2).



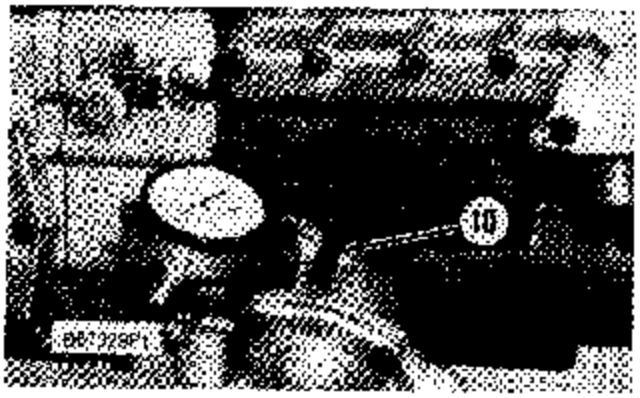
Governor
(8) Fuel Ratio Control.



Rear Of Governor Housing
(9) Plug.

6. Remove plug (9) from the rear of the governor housing.

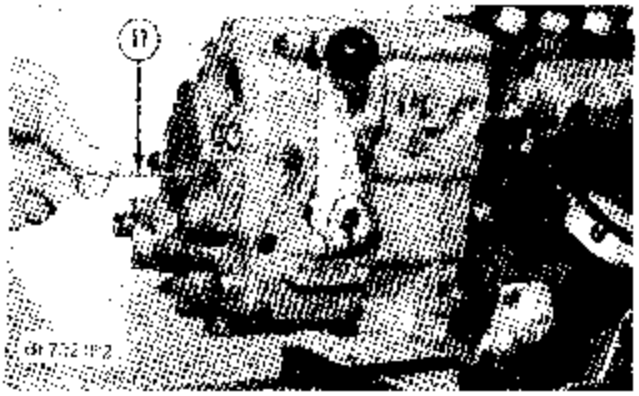
7. Move the governor control lever to the **fuel off** position (rotate governor shaft clockwise).



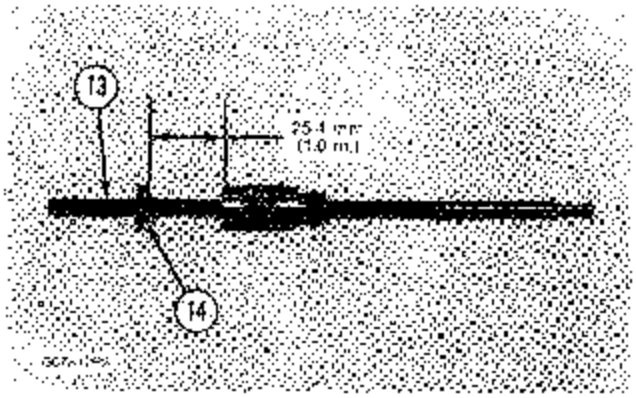
Timing Pin Installed
(10) 6V4186 Timing Pin.

8. Install 6V4186 Timing Pin (10) in the hole in the bracket assembly. Push timing pin in until contact is made with the fuel rack. Hold the timing pin gently against the fuel rack for Steps 9 and 10. If too much force is used to hold the timing pin, the fuel rack can stick and cause an incorrect zero reading.

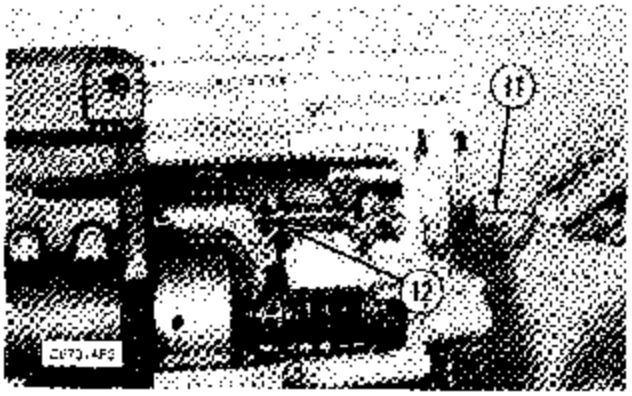
9. Hold the governor control lever in the **high idle** position (rotate governor shaft counterclockwise).



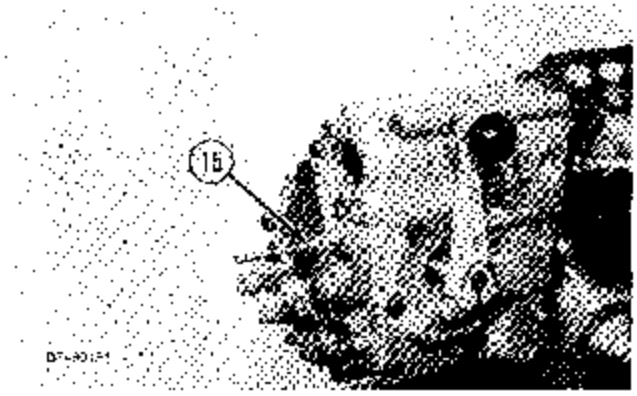
6V7942 Hook In Use
(11) 6V7942 Hook.



6V7941 Compressor Assembly
(13) Rod. (14) Knob.



Cutaway View Of Governor
(11) 6V7942 Hook. (12) Collar.



Compressor Assembly Installed
(15) 6V7941 Compressor Assembly.

10. Insert 6V7942 Hook (11) into the hole that plug (9) was removed from. Engage the end of hook (11) with collar (12) and pull toward the rear of the governor housing until the collar stops moving. This will make sure the fuel rack stops against the timing pin. This is the rack zero position.

11. With the hook still pulled toward the rear of the governor loosen collet (2) and adjust the revolution counter on the dial indicator to zero. Tighten the collet just enough to hold the indicator in this position. Move the dial of the indicator to get alignment of the pointer and zero.

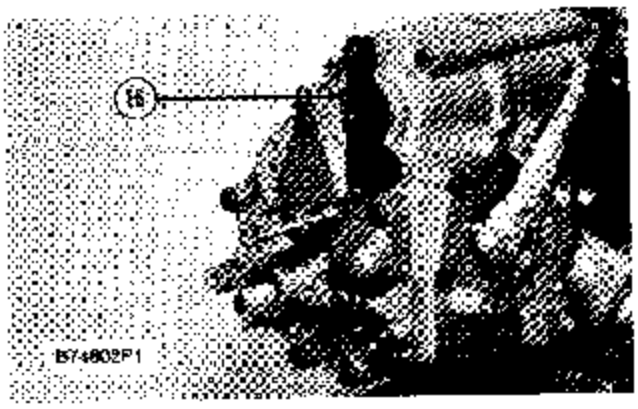
12. Remove timing pin (10) and hook (11), then release the governor control lever.

13. Turn rod (13) out of the 6V7941 Compressor Assembly (15) until knob (14) is 25.4 mm (1.0 in) from the compressor body. Install 6V7941 Compressor Assembly (15) in the hole plug (9) was removed from.

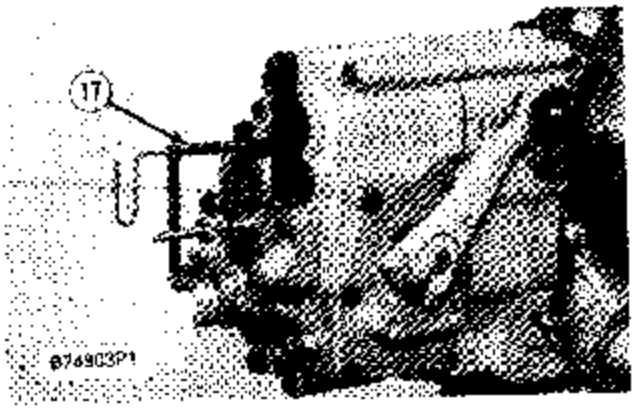
NOTE: The 6V7941 Compressor Assembly is used to compress the over fueling spring. The over fueling spring must be compressed to get an accurate fuel setting measurement.

14. Move the governor control lever to the **fuel off** position. Use two 0S1614 Bolts and install 6V2017 Governor Adjustment Tool (16). Be sure the end of the tool is behind the governor linkage, and that the flange is completely against the governor housing (the filter screen may have to be removed.

NOTE: If it is expected to be necessary to change the setting, install the outer part of 6V2105 Rack Adjusting Tool (17) along the left side of the 6V2017 Governor Adjustment Tool (16) when the 6V2017 Governor Adjustment Tool is installed.



Adjusting Tool Installed
(16) 6V2017 Governor Adjustment Tool.



Governor Linkage Adjustment
(17) 6V2105 Rack Adjustment Tool Group.

15. Move the governor control to the **full load** position and hold in this position.

16. Turn the over fueling spring compressor rod **in** (clockwise) until the indicator hands move approximately 1 mm.

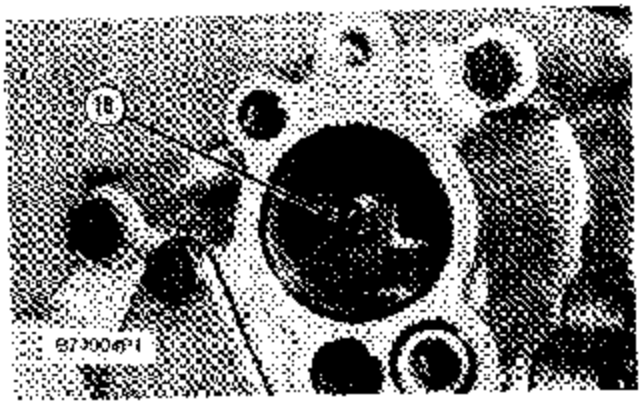
17. Slowly turn the rod **out** (counterclockwise) until the indicator hand stops moving. This is the **fuel ratio control setting**.

NOTE: There will be a small initial movement of the dial indicator hands, then, they will stop moving while the rod is turned out for another 1½ turns. Now the indicator hands will begin to move again and will follow the turning of the rod until the setting is reached. It is important that the rod be turned slowly so that the rack can follow the governor components.

18. Make reference to the TMI (Technical Marketing Information) or the Fuel Setting And Related Information Fiche for the correct fuel ratio setting and compare to the dial indicator reading.

19. If the fuel ratio control setting is not correct, use 6V2105 Rack Adjustment Tool (17) to loosen the locknut and turn the adjustment screw (18). Turn the screw clockwise to decrease the amount of fuel possible (less rack travel) at the limited position.

NOTE: One revolution of the adjustment screw will change the setting approximately 0.79 mm (.031 in).



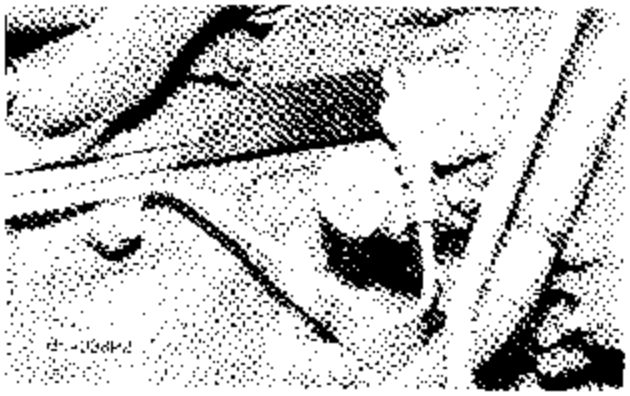
Adjustment Screw For Governor
(18) Adjustment screw.

NOTE: The dial indicator hands will not follow the turning of the adjustment screw. It will be necessary to repeat Steps 15 through 19 until setting is obtained.

Fuel Ratio Control And Governor Check

Tools Needed		
2W9161	Manual Shutoff Group	1
6V4186	Timing Pin	1
6V6070	Governor Adjusting Tool Group	1
FT1906	Air Test Kit	1
6V4060	Engine Set Point Indicator Group Or Circuit Testing Flashlight	1
8T1000	Electronic Position Indicator Group	1
4N5656	Cover	1

1. Remove the air line from the fuel ratio control and then remove the fuel ratio control.



Remove Air Line

2. Install the rack position indicator to measure fuel rack movement. See Steps 1 through 4 in the Fuel Setting Procedure for the correct installation of the tooling.

3. Turn the engine start key ON to activate the shutoff solenoid. Do not start the engine at this time.

4. Move the governor control linkage to the full FUEL ON position and hold or fasten it in this position.

5. Install the 6V4186 Timing Pin in the rack zeroing hole in the pump housing.

6. With the governor control lever in the full FUEL OFF position, use a 1N9354 lever and move the manual shutoff (if equipped) shaft slowly to the FUEL OFF position (counterclockwise). Watch and make sure the timing pin drops and engages with the slot in the fuel rack.

7. Release the manual shutoff shaft and zero 8T1000 position indicator (press the zero button).

8. Remove the 6V4186 Timing Pin and watch the indicator movement. The 8T1000 position indicator should show positive reading movement in the FUEL ON direction. If no movement occurs, repeat Steps 5, 6 and 7 to zero the indicator.

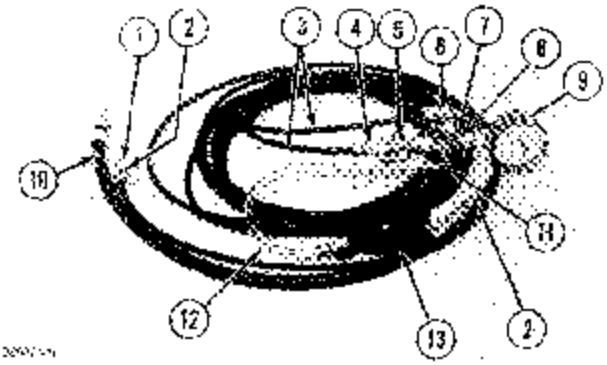
9. Release the governor control shaft and linkage.

10. Replace the fuel ratio control but do not reconnect the air line.

11. Start the engine and operate it for a minimum of five minutes to get the governor and engine up to normal operating temperatures.

⚠ WARNING

To help prevent an accident caused by parts in rotation, work carefully around an engine that has been started.



FT1906 Air Test Kit
(1) 8L6557 Connector. (2) 5P4405 Connector (two required). (3) 5P6011 Tube. (4) 5P4476 Connector. (5) 6K5741 Valve. (6) 5P4459 Elbow. (7) 7B192 Cross. (8) 3B6768 Bushing. (9) 6V7775 Gauge. (10) 6N3169 Hose Assembly. (11) 6V6757 Elbow. (12) 6.35 mm (.250 in) I.D. Flexible Tubing [1.2 m (4 ft) long]. (13) Air pressure bulb (Baumanometer No. 1890 or equivalent).

12. Check the leak down rate of the fuel ratio control (with the engine operating at low idle) as follows:
    a. Connect a pressure gauge, a shutoff valve, a pressure regulator and an air supply to the fitting from which the air line was removed.
    b. Apply 70 kPa (10 psi) air pressure to the fuel ratio control.
    c. Turn the shutoff valve OFF and check the leak down rate. Leakage of 20 kPa (3 psi) in 30 seconds is acceptable.
    d. If leakage is more than 20 kPa (3 psi) in 30 seconds, the fuel ratio control must be repaired before Steps 13 and 14 are done.
    e. Keep 70 kPa (10 psi) air pressure on the fuel ratio control for Step 13.

13. From low idle, rapidly move the governor control shaft to the full FUEL ON position and read the measurement on the 8T1000 position indicator. Press the "MAX" on the indicator to read the "dynamic fuel ratio control setting". Record the reading. Repeat three for four times.

NOTE: The fuel ratio control is activated and the maximum reading is the dynamic full torque setting of the engine. This setting is 0.5 mm (.02 in) greater than the static full torque setting. See the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche for the correct setting.

NOTE: On engines with the fuel ratio control out of adjustment, the fuel ratio control is active at startup. At this time the 8T1000 position indicator reading can be the dynamic fuel ratio control setting. Continue the checking procedure to find the dynamic full torque setting at Step 17.

14. Release all air pressure from the fuel ratio control. Start at low idle setting (in fuel setting specs) and rapidly move the governor control shaft to the full FUEL ON position and read the measurement on the 8T1000 position indicator. Press the "MAX" on the indicator to read the "dynamic fuel ratio control setting". Record the reading. Repeat three for four times.

15. If the dynamic fuel ratio setting is within ± 0.25 mm of the specifications in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche, an adjustment is not necessary.

16. For adjustment of the control see Fuel Ratio Control Adjustment.

17. Check boost pressure that gives full torque rack travel, as follows:
    a. Connect a pressure gauge, a pressure regulator and an air supply to the fitting from which the air line was removed.
    b. Apply 25 kPa (4 psi) air pressure to the fuel ratio control.
    c. Start at 900 rpm and rapidly move the governor control shaft to the full FUEL ON position and make a record of the maximum indicator reading.
    d. Repeat this procedure several times, each time increase the air pressure 5 kPa (.5 psi).
    e. Make a record of the first air pressure setting that gives full torque rack travel. Full torque rack travel was measured in Step 13.
    f. This is the boost pressure that moves the fuel ratio control out of the rack control position. This pressure gives dynamic full torque rack travel.

Fuel Ratio Control Adjustment

Tools Needed		
2W9161	Manual Shutoff Group	1
6V4186	Timing Pin	1
6V6070	Governor Adjusting Tool Group	1

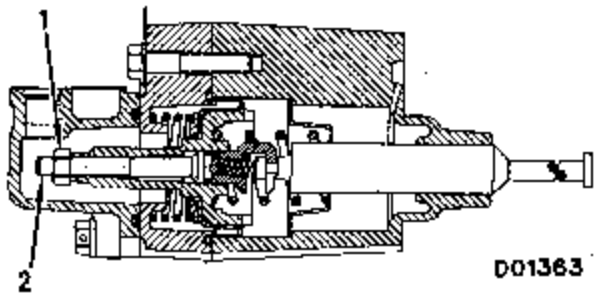
NOTE: Before the governor seals are cut or removed, see Fuel Ratio Control And Governor Check to make sure an adjustment is needed.

1. See the Engine Information Plate or the Fuel Setting And Related Information Fiche for the correct dynamic fuel ratio control setting specification before and adjustment is made.

2. Remove the air fuel ratio control.

3. Install and zero the rack position indicator group. See Fuel Ratio Control And Governor Check for this procedure.

4. Remove the cover from the fuel ratio control valve.



Fuel Ratio Control
(1) Nut. (2) Extension.

⚠ WARNING

To help prevent an accident caused by parts in rotation, work carefully around an engine that has been started.

5. Start the engine and operate it for a minimum of five minutes to get the governor and engine up to normal operating temperature.

6. Hold retainer (2) in position and loosen nut (1). This keeps the fuel ratio diaphragm from turning when nut (1) is loosened or tightened.

7. Turn valve extension (2) to get the correct setting. A clockwise direction will give a more positive setting. The counterclockwise direction will give a more negative setting. Several adjustments of valve extension (2) may be needed to get the correct dynamic fuel ratio control setting.

8. After each adjustment is made, check the dynamic fuel ratio control setting. Start at low idle setting (in fuel setting specs) and rapidly move the governor control shaft to the full FUEL ON position. Press the "MAX" on the indicator to read the "dynamic fuel ratio control setting". Record the reading. Repeat three for four times.

NOTE: If the correct dynamic fuel ratio control setting cannot be made with this adjustment, the internal governor linkage must be checked and adjusted or the fuel ratio control needs repair or replacement. See Check And Adjustment Of The Fuel Ratio Control Linkage for the governor linkage procedure.

9. After the correct adjustment has been made, tighten nut (1). Check the dynamic fuel ratio control setting again.

10. Install the O-ring and cover on the fuel ratio control. Tighten the bolts to a torque of 9 ± 3 N•m (7 ± 2 lb ft).

11. Apply 70 kPa (10 psi) air pressure to the fuel ratio control at the fitting. This will fully extend the fuel ratio control to get dynamic full torque.

12. Check the dynamic full torque setting. Start at low idle setting (in fuel setting specs) and rapidly move the governor control shaft to the full FUEL ON position and read the maximum measurement on the dial indicator.

NOTE: If the dynamic full torque setting cannot be reached a repair or replacement of the fuel ratio control is needed.

13. Stop the engine.

14. Install the wire and seal on the fuel ratio control

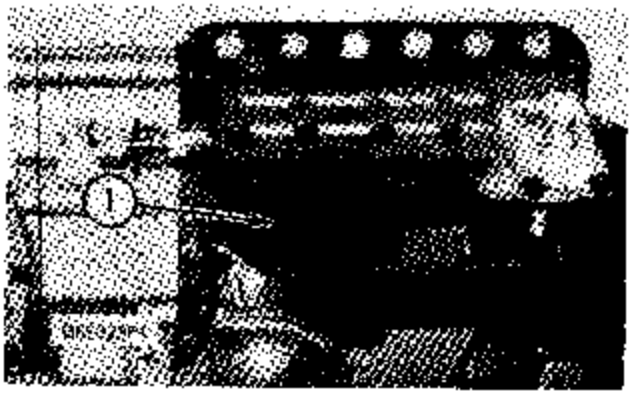
15. Install the air line on the engine.

16. Remove the rack position indicator tooling.

Fuel Setting Procedure

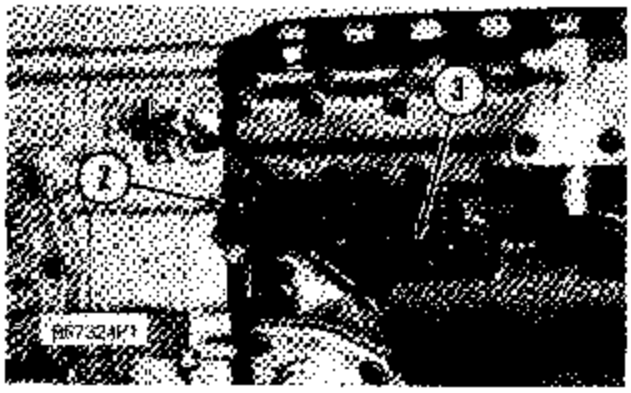
Tools Needed		
6V6070	Governor Adjusting Tool Group	1
8T0500	Circuit Tester	1

The static fuel setting can be done with the fuel injection pump and governor on or off the engine. For more information on the fuel setting procedure, see Special Instruction, SEHS8024.



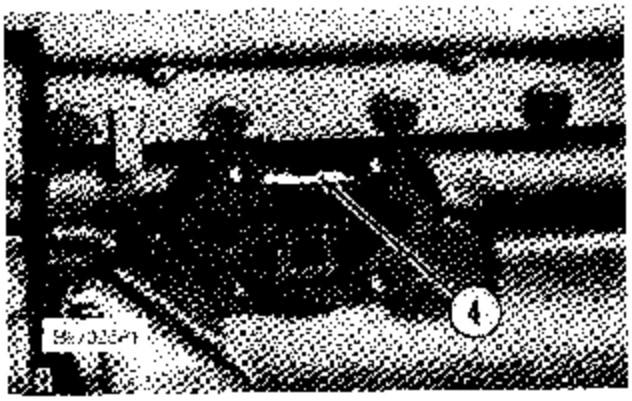
Fuel Injection Pump And Governor
(1) Cover.

1. Remove the fuel filter base and fuel line from the fuel injection pump housing and remove cover (1) from the side of the fuel injection pump housing.



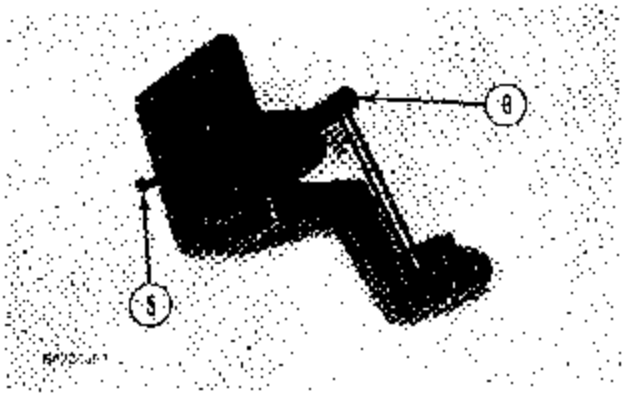
Bracket Assembly Installed
(2) 5P4814 Collet. (3) Bracket assembly.

2. Install 5P4814 Collet (2) on 6V2014 Bracket Assembly (3).



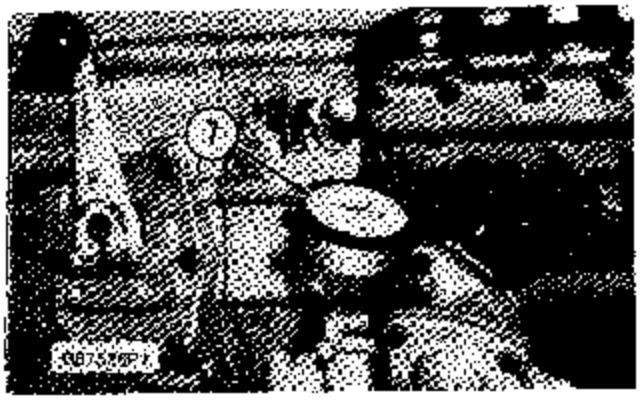
Cover Removed
(4) Slot on fuel rack.

3. Install the bracket assembly on the fuel pump housing. Lever (5) on the bracket assembly must be in slot (4) on the fuel rack. Push up on the bracket assembly while the bolts are tightened.



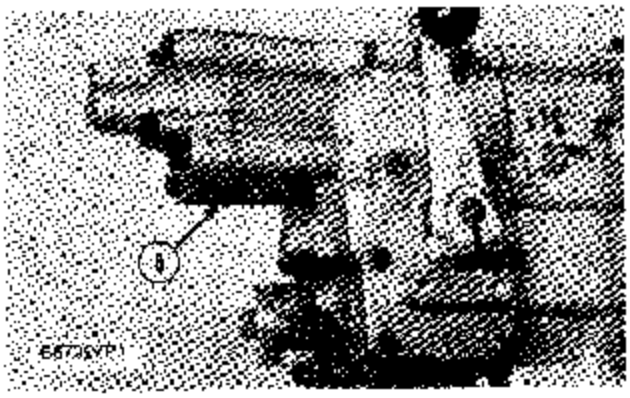
Bracket Assembly
(5) Lever (6) Shaft.

After the bracket assembly is tightened to the pump housing, shaft (6) must have axial (in and out) movement. If there is no axial movement of shaft (6), check to be sure lever (5) is in the slot on the fuel rack and that the bracket assembly is installed correctly. Check to make sure that lever (5) is not bent. Lever (5) must be perpendicular (at right angle) to the mounting face of the bracket assembly.



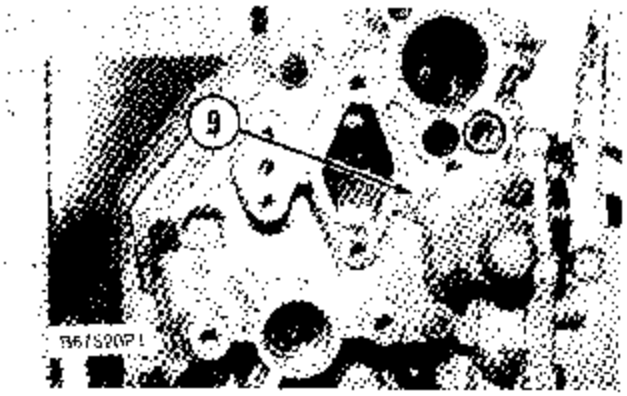
Dial Indicator Installed
(7) 6V3075 Dial Indicator.

4. Put 9S0229 Contact Point, 9.7 mm (.38 in) long on 6V3075 Dial Indicator (7) and install dial indicator in collet (2).



Governor .
(8) Fuel ratio control.

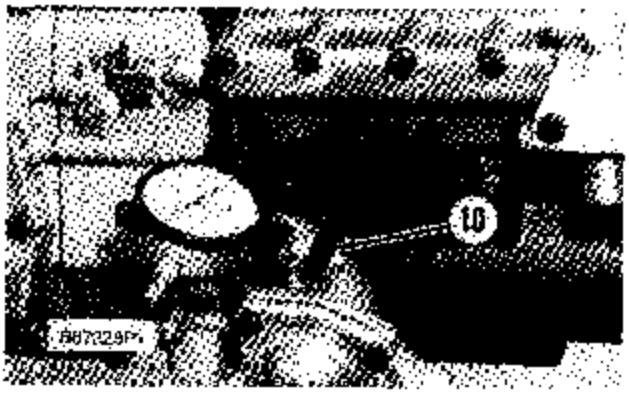
5. Remove fuel ratio control (8), (or cover), from the rear of the governor housing if equipped.



Rear Of Governor Housing
(9) Plug.

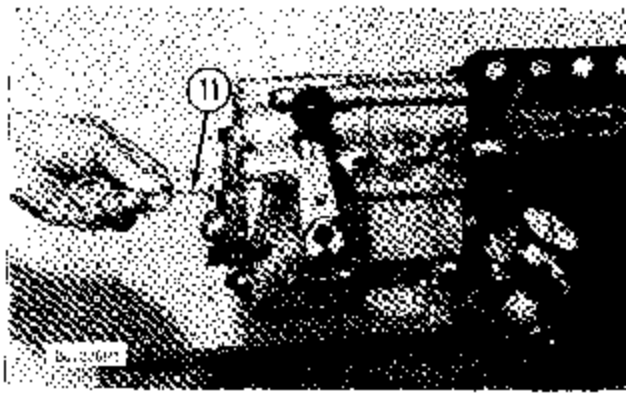
6. Remove plug (9) from the rear of the governor housing.

7. Move the governor control lever to the FUEL OFF position (rotate governor shaft clockwise).

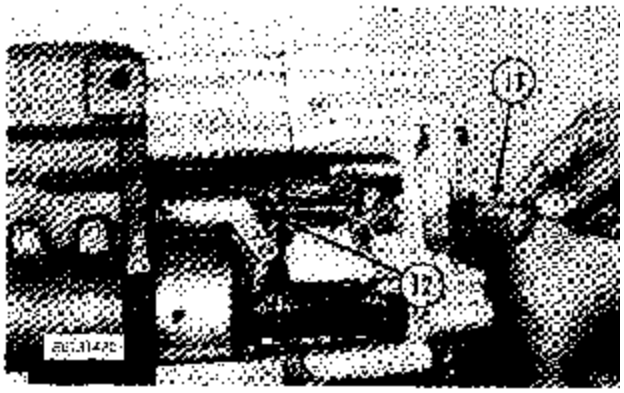


Timing Pin Installed
(10) 6V4186 Timing Pin.

8. Install 6V4186 Timing Pin (10) in the hole in the bracket assembly. Push timing pin in until contact is made with the fuel rack. Hold the timing pin gently against the fuel rack for Steps 9 and 10. If too much force is used to hold the timing pin, the fuel rack can stick and cause an incorrect zero reading.



6V7942 Hook In Use
(11) 6V7942 Hook.



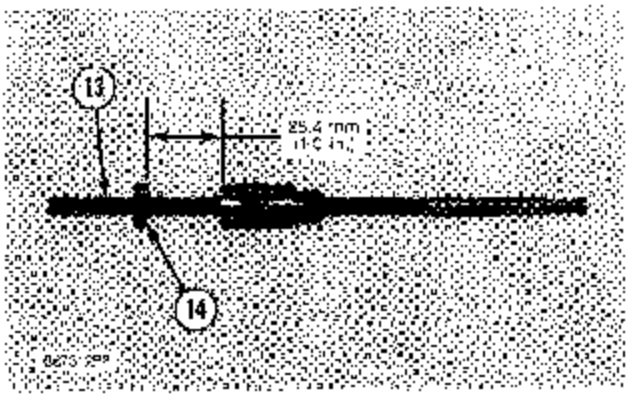
Cutaway View Of Governor
(11) 6V7942 Hook. (12) Collar.

9. Hold the governor control lever in the HIGH IDLE position (rotate governor shaft counterclockwise).

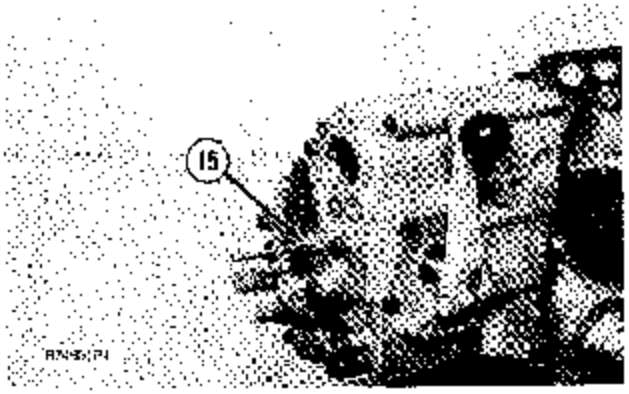
10. Insert 6V7942 Hook (11) into the hole that plug (9) was removed from. Engage the end of hook (11) with collar (12) and pull toward the rear of the governor housing until the collar stops moving. This will make sure the fuel rack stops against the timing pin. This is the rack zero position.

11. With the hook still pulled toward the rear of the governor, loosen collet (2) and adjust the revolution counter on the dial indicator to zero. Tighten the collet just enough to hold the indicator in this position. Move the dial of the indicator to get alignment of the pointer and zero.

12. Remove timing pin (10).



6V7941 Compressor Assembly
(13) Rod. (14) Knob.



Compressor Assembly Installed
(15) 6V7941 Compressor Assembly.

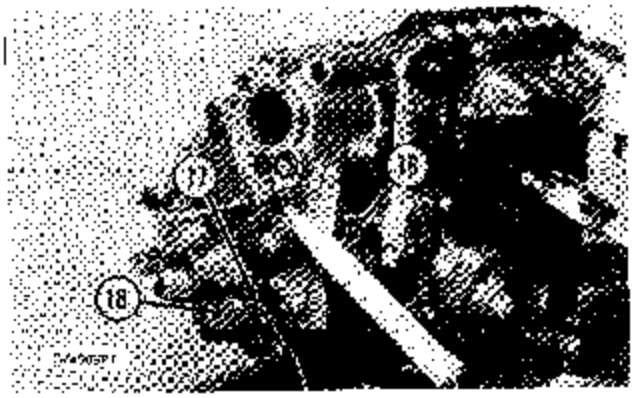
13. Turn rod (13) out of 6V7941 Compressor Assembly (15) until knob (14) is 25.4 mm (1.00 in) from the compressor body. Install 6V7941 Compressor Assembly (15) in the hole plug (9) was removed from.

NOTE: The 6V7941 Compressor Assembly is used to compress the over fueling spring. The over fueling spring must be compressed to get an accurate fuel setting measurement.

NOTE: Some fuel systems have a torque spring, and some do not. This difference in fuel systems makes it necessary to have a separate procedure for the fuel setting check and/or adjustment. Be sure to use the correct procedure (one of the two that follow) to check and/or adjust the fuel setting for your specific fuel system.

Fuel System WITHOUT a Torque Spring

14. Fasten the clip end of 8T0500 Circuit Tester (16) to rack contact screw (17) and put the other end to a good electrical ground.



Checking Static Fuel Setting
(16) 8T0500 Circuit Tester. (17) Rack contact screw.
(18) Adjustment screw cover.

15. Hold the governor control lever in the **FUEL ON** position (rotate lever fully counterclockwise).

16. Turn rod (13) of compressor assembly (15) **IN** (clockwise) until the light in circuit tester (16) goes off and the dial indicator hands move an additional 2 mm in the negative (−) direction after the light goes out.

NOTICE

DO NOT turn the rod any further in if the rod begins to tighten. Damage to the governor can occur if the rod is turned in further.

---

17. Slowly turn rod (13) **OUT** (counterclockwise) until the circuit tester light just comes on. This is the **STATIC FUEL SETTING**. See the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche for the correct static fuel setting.

NOTE: When the rod is turned **OUT**, there will be a small initial movement of the dial indicator hands, then, they will stop moving while the rod is turned **OUT** for approximately another 1½ turns. Now the indicator hands will begin to move again and will follow the turning of the rod until the setting is reached. It is important that the rod be turned slowly so that the rack can follow the governor components.

18. If the fuel setting is not correct, remove adjustment screw cover (18) from the rear of the governor housing.

Adjustment Screw Cover Removed
(20) Fuel setting screw.

19. Determine how much the setting will have to be changed (see example). Use the chart that follows to determine how far the adjusting screw must be turned.

ADJUSTMENT SCREW CHART	
Amount Of Change	**Turns Of Adjustment Screw**
3.0 mm (.118 in)	3¾
2.8 mm (.110 in)	3½
2.6 mm (.102 in)	3¼
2.4 mm (.094 in)	3
2.2 mm (.087 in)	2¾
2.0 mm (.079 in)	2½
1.8 mm (.071 in)	2¼
1.6 mm (.063 in)	2
1.4 mm (.055 in)	1¾
1.2 mm (.047 in)	1½
1.0 mm (.039 in)	1¼
0.8 mm (.031 in)	1
0.6 mm (.024 in)	¾
0.4 mm (.016 in)	½
0.2 mm (.008 in)	¼

Example #1

Actual Reading:	1.05 mm
Desired Setting:	1.25 mm
Difference:	0.20 mm

Since "desired setting" is higher than "actual reading," turn adjusting screw out (counterclockwise) approximately ¼ turn. Recheck the new setting and readjust if necessary.

Example #2

Actual Reading:	2.77 mm
Desired Setting:	1.85 mm
Difference:	0.92 mm

Since "desired setting" is lower than "actual reading," turn the adjusting screw in (clockwise) approximately 1⅛ turns. Recheck the new setting and readjust if necessary.

Example #3

Actual Reading:	−1.05 mm
Desired Setting:	−1.25 mm
Difference:	0.20 mm

Negative numbers work differently than positive numbers. If one number (−1.25) has a larger digital value than another one (−1.05), the first number (−1.25) is actually less than the other one. Therefore, in this example the "desired setting" is lower than the "actual reading." Turn the adjusting screw in (clockwise) approximately ¼ turn. Recheck the new setting and readjust if necessary.

Example #4

Actual Reading:	−2.77 mm
Desired Setting:	−1.85 mm
Difference:	0.92 mm

The "desired setting" is higher than the "actual reading." Turn the adjusting screw out (counterclockwise) approximately 1⅛ turns. Recheck the new setting and readjust if necessary.

Example #5

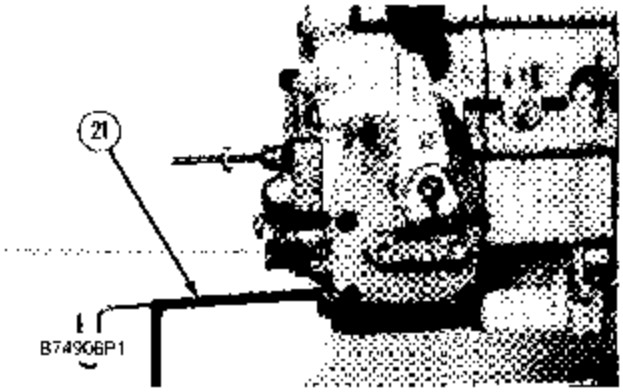
Actual Reading:	+1.05 mm
Desired Setting:	−1.25 mm
Difference:	2.30 mm

The "desired setting" is lower than the "actual reading." Turn the adjusting screw in approximately 2⅞ turns.

Example #6

Actual Reading:	−1.05 mm
Desired Setting:	+1.25 mm
Difference:	2.30 mm

The "desired setting" is higher than the "actual reading." Turn the adjusting screw out approximately 2⅞ turns.



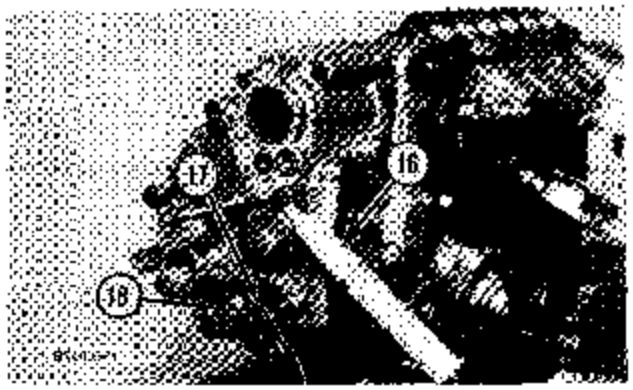
Adjusting Fuel Setting
(21) 6V2105 Rack Adjustment Tool Group

20. Use 6V2105 Rack Adjustment Tool Group (21) to loosen the locknut for adjustment screw and to turn the adjustment screw.

21. Adjust the fuel setting screw the number of turns determined in Step 19. Always recheck the setting after each adjustment and adjust again if needed.

Fuel System WITH a Torque Spring

14. Fasten the clip end of 8T0500 Circuit Tester (16) to rack contact screw (17) and put the other end to a good electrical ground.



Checking Static Fuel Setting
(16) 8T0500 Circuit Tester. (17) Rack contact screw
(18) Adjustment screw cover.

15. Hold the governor control lever in the **FUEL ON** position (rotate lever fully counterclockwise).

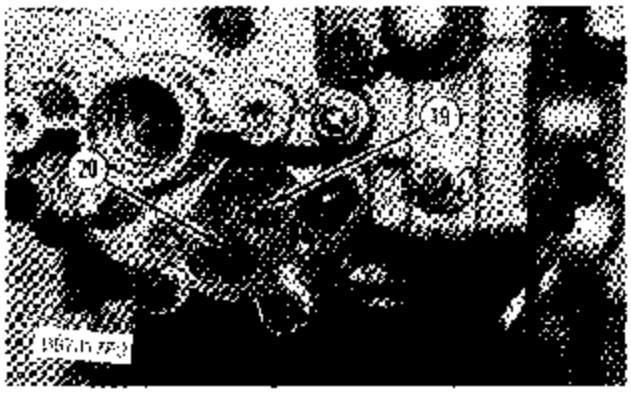
16. Turn rod (13) of compressor assembly (15) **IN** (clockwise) until the light in circuit tester (16) goes off and the dial indicator hands move an additional 2 mm in the negative (−) direction after the light goes out.

NOTICE

DO NOT turn the rod any further in if the rod begins to tighten. Damage to the governor can occur if the rod is turned in further.

17. Slowly turn rod (13) **OUT** (counterclockwise) until the circuit tester light just comes on. This is the **STATIC FUEL SETTING.** See the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche for the correct static fuel setting.

NOTE: When the rod is turned **out**, there will be a small initial movement of the dial indicator hands, then, they will stop moving while the rod is turned **out** for approximately another 1½ turns. Now the indicator hands will begin to move again and will follow the turning of the rod until the setting is reached. It is important that the rod be turned slowly so that the rack can follow the governor components.



Adjustment Screw Cover Removed
(19) Torque rise adjustment screw. (20) Fuel setting screw.

18. Slowly turn rod (13) **OUT** until the indicator hands stop moving, then turn the rod **OUT** an additional 1 to 2 turns.

19. Push in on rack stop collar. The new reading on the dial indicator is the **FULL TORQUE SETTING.** Refer to TMI (Technical Marketing Information) or Fuel Setting And Related Information fiche for the correct Full Torque Static Setting.

NOTE: On later engines, the dimension for the Full Torque Setting is given on the Engine Information Plate. The Full Torque Setting is a direct reading on the dial indicator.

Example #1

Static Fuel Setting:	2.18 mm
Static Full Torque Setting:	3.18 mm
Torque Rise Differential:	1.00 mm

20. If the fuel setting or the full torque setting is not correct, remove adjustment screw cover (18) from the rear of the governor housing.

21. Determine how much the settings will have to be changed (see example). Use the **ADJUSTMENT SCREW CHART** to determine how far the adjusting screws must be turned.

22. Use the 6V2105 Rack Adjustment Tool Group (21) to loosen the locknuts for adjustment screws and to turn the adjustment screws.

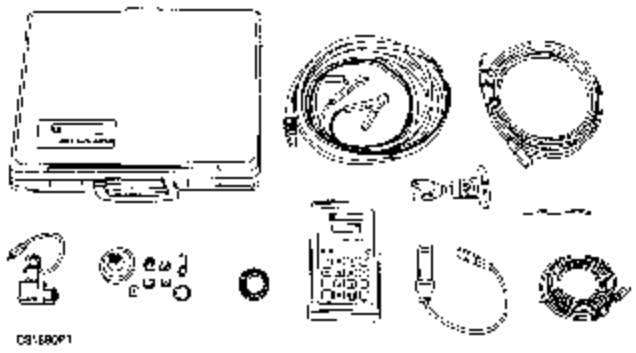
23. If both settings are to be increased, turn torque rise adjustment screw (19) out (counterclockwise) the same number of turns as fuel setting adjustment screw (20) is going to be changed. If the static fuel setting is going to be decreased, it is not necessary to change the torque rise setting at this time.

24. Adjust the fuel setting screw the number of turns determined in Step 21. Always recheck the setting after each adjustment and adjust again if needed.

25. After the static fuel setting is correct, adjust the torque rise adjustment screw the number of turns determined in Step 21. Always recheck the setting after each adjustment and adjust again if needed.

Engine Speed Measurement

Tools Needed		
6V3121	Multitach Group	1
	or	
6V4950	Injection Line Speed Pickup Group	1

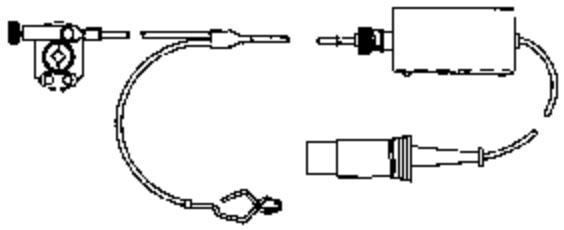


6V3121 Multitach Group

The 6V3121 Multitach Group can measure engine speed from a tachometer drive on the engine. It also has the ability to measure engine speed from visual engine parts in rotation.

Special Instruction, SEHS7807 is with the 6V3121 Multitach Group and gives instructions for the test procedure.

The 6V4950 Injection Line Speed Pickup Group is another diagnostic tool accessory that can be used with the 6V2100 Multitach. It can be used on all Caterpillar Diesel Engines equipped with 6 mm (.25 in) single wall fuel injection lines. With this pickup group, engine speed can be measured quickly, automatically, and with an accuracy of ± 1 rpm.



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6V4950 Injection Line Speed Pickup Group

Special Instruction, SEHS8029 is with the group and gives instructions for use of the 6V4950 Injection Line Speed Pickup Group.

Governor Adjustments

NOTICE
A mechanic with training in governor adjustments is the only one to make the adjustment to the set point rpm.

Engine rpm must be checked with an accurate tachometer. Make reference to Measuring Engine Speed.

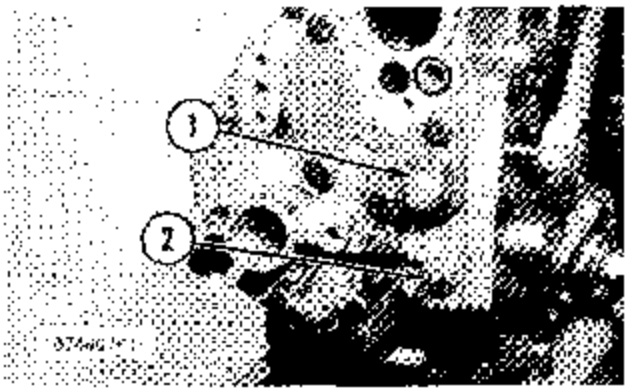
Low Idle Adjustment

NOTE: The correct LOW IDLE rpm is given in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche.

⚠ WARNING

To help prevent an accident caused by parts in rotation, work carefully around an engine that has been started.

Start the engine and run until the temperature of normal operation is reached. Check low idle rpm with no load on the engine. If an adjustment is necessary, use the procedure that follows:



Low Idle Adjustment
(1) Cover, (2) Low idle screw.

1. To adjust the LOW IDLE rpm, start the engine and run with the governor in the low idle position. Loosen the locknut for low idle screw (2). Turn the low idle screw to get the correct low idle rpm. Increase engine speed and return to low idle and check low idle speed again. Tighten the locknut.

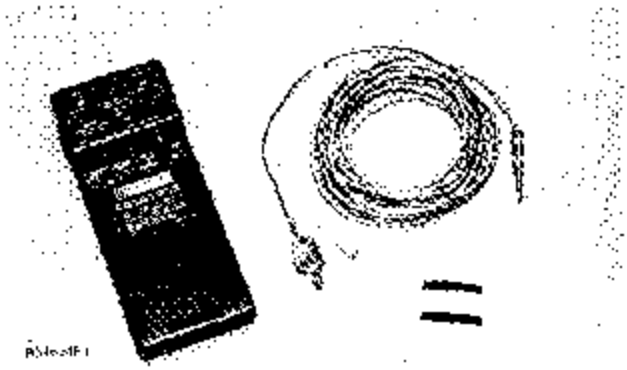
Checking Set Point (Balance Point)

Tools Needed		
6V4060	Engine Set Point Indicator Group	1

The engine set point is an adjusted specification and is important to the correct operation of the engine. High idle rpm is NOT an adjusted specification. Set point (formerly balance point) is full load rpm plus an additional 20 rpm. Set point is the rpm at which the fuel setting adjustment screw and stop or first torque spring just start to make contact. At this rpm, the fuel setting adjustment screw and stop or first torque spring still have movement between them. When additional load is put on the engine, the fuel setting adjustment screw and stop or first torque spring will become stable against each other. Set point is controlled by the fuel setting and the high idle adjustment screw.

There is a new and more accurate method for checking the "set point", formerly called the balance point, of the engine. If the tools for the new method are not available, there is an alternate method for checking the "set point".

The 6V4060 Engine Set Point Indicator Group with the 6V2100 Multitach can be used to check the set point. Special Instruction, SEHS7931 gives instructions for installation and use of this tool group.



6V4060 Engine Set Point Indicator Group

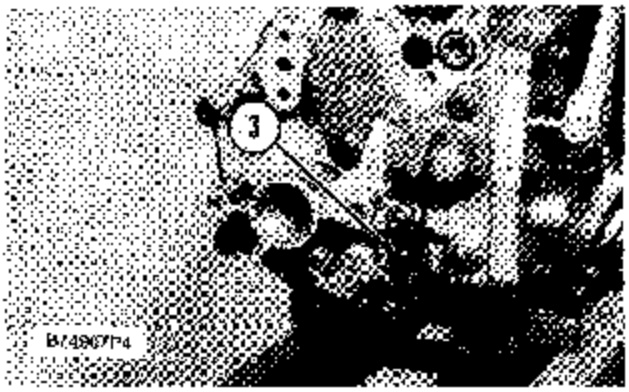
Alternate Method

Tools Needed		
8T0500	Circuit Tester	1
6V3121	Multitach Group	1

If the set point is correct and the high idle speed is within specifications, the fuel system operation of the engine is correct. The set point for the engine is:

A. At 20 rpm greater than full load speed.
B. The rpm where the fuel setting adjustment screw and stop or first torque spring just make contact.

Use the procedure that follows to check the set point. Make reference to Techniques For Loading Engines in Special Instruction, SEHS7050.



Terminal Location
(3) Brass terminal screw.

1. Connect a tachometer which has good accuracy to the tachometer drive.

2. Connect the clip end of the 8T0500 Circuit Tester to the brass terminal screw (3) on the governor housing. Connect the other end of the tester to a place on the fuel system which is a good ground connection.

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

3. Start the engine.

4. With the engine at normal conditions for operation, run the engine at high idle.

5. Make a record of the speed of the engine at high idle.

6. Add load on the engine slowly until the circuit tester light just comes on (minimum light output). This is the set point

7. Make a record of the speed (rpm) at the set point.

8. Repeat Step 6 several times to make sure that the reading is correct.

9. Stop the engine. Make a comparison of the records from Steps 5 and 7 with the information from the Engine Information Plate. If the Engine Information Plate is not available, see the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche.

The tolerance for the set point is ± 10 rpm. The tolerance for the high idle rpm is ± 30 rpm. If the readings from Steps 5 and 7 are within the tolerance, no adjustment is needed.

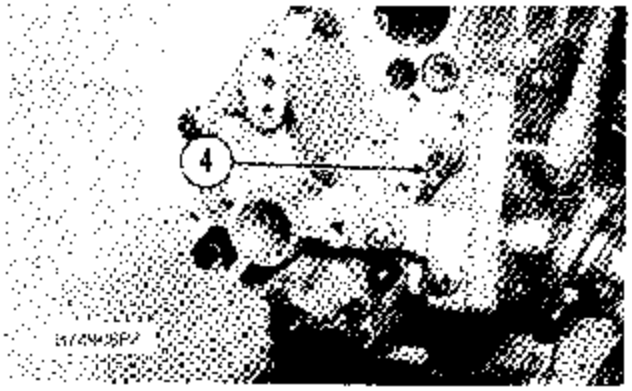
NOTE: It is possible in some applications that the high idle rpm will be less than the lower limit. This can be caused by high parasitic loads such as hydraulic pumps, compressors, etc.

Adjusting Set Point (Balance Point)

1. If the set point and the high idle rpm are within tolerance, no adjustment is to be made.

2. If the set point rpm is not correct, remove cover (1) and loosen locknut. Turn adjustment screw (4) to adjust the set point to the midpoint of the tolerance.

3. When the set point is correct, check the high idle rpm. The high idle rpm must not be more than the high limit of the tolerance.



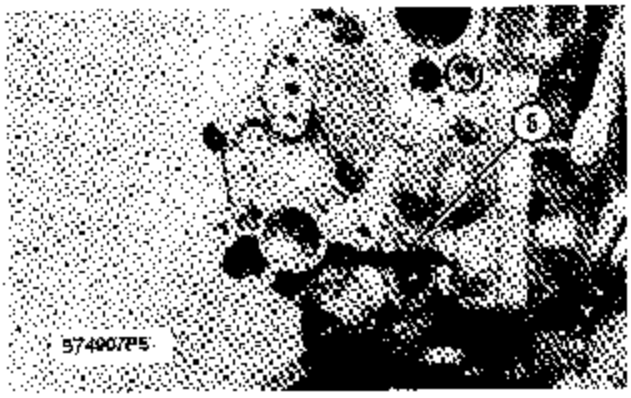
Set Point Adjustment
(4) Adjustment screw.

If the high idle rpm is more than the high limit of the tolerance, check the governor spring and flyweights. If the high idle rpm is less than the low limit of the tolerance, check for excess parasitic loads and then the governor spring and flyweights.

Dashpot Screw Adjustment

The dashpot adjustment screw does not normally need adjustment from the factory setting. If the engine is slow to change rpm with a change in load, it is possible that the dashpot adjustment screw is not adjusted correctly.

1. Turn dashpot adjustment screw (5) in (clockwise) until it stops.
2. Turn dashpot adjustment screw out (counterclockwise) ½ ± ¼ turn.



Dashpot Screw Adjustment
(5) Dashpot adjustment screw.

Air Inlet And Exhaust System

Restriction Of Air Inlet And Exhaust

There will be a reduction of horsepower and efficiency of the engine if there is a restriction in the air inlet or exhaust system.

Air flow through the air cleaner must not have a restriction of more than 762 kPa (30 inches of water) difference in pressure.

Back pressure from the exhaust (pressure difference measurement between exhaust outlet elbow and atmosphere) must not be more than 686 kPa (27 inches of water).

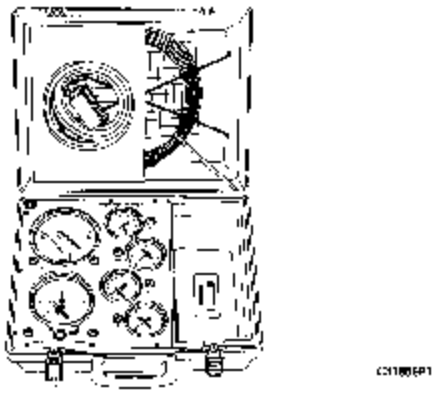
Measurement Of Pressure In Inlet Manifold

By checking the pressure in the inlet manifold the efficiency of an engine can be checked by making a comparison with the information given in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche. This test is used when there is a decrease of horsepower from the engine, yet there is no real sign of a problem with the engine.

The correct pressure for the inlet manifold is given in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche. Development of this information is done with these conditions: 746.7 mm (29.4 in) of mercury barometric pressure. 29°C (85°F) outside air temperature and 35 API rated fuel. Any change from these conditions can change the pressure in the inlet manifold. Outside air that has higher temperature and lower barometric pressure than given above will cause a lower horsepower and inlet manifold pressure measurement than given in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche. Outside air that has a lower temperature and higher barometric pressure will cause a higher horsepower and inlet manifold pressure measurement.

A difference in fuel rating will also change horsepower and the pressure in the inlet manifold. If the fuel is rated above 35 API, pressure in the inlet manifold can be less than given in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche. If the fuel is rated below 35 API, the pressure in the inlet manifold can be more than given in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche.

NOTE: Be sure that the air inlet and exhaust do not have a restriction when making a check of pressure in the inlet manifold.



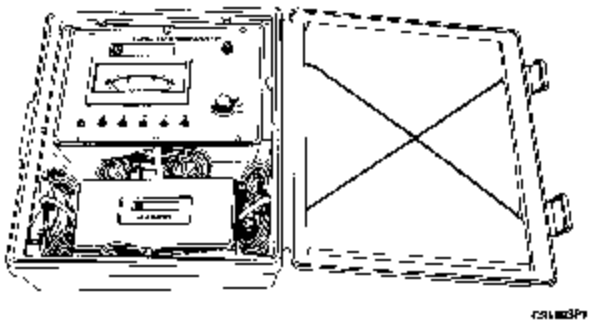
1U5470 Engine Pressure Group

Use the 1U5470 Engine Pressure Group to check the pressure in the inlet manifold.

This tool group has a gauge to read pressure in the inlet manifold. Special Instruction, SEHS8524 is with the tool group and gives information on the use of the group.

Location For Pressure Test
(1) Remove plug and install a tee for testing.

Checking Aftercooler Operation



4C6500 Digital Thermometer Group

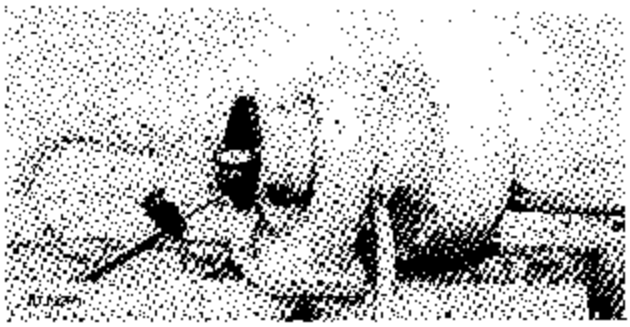
Use the 4C6500 Digital Thermometer to check the operation of the aftercooler. The testing procedure is in Operating Manual, NEHS0554.

Turbocharger

Every 7200 hours or if any unusual sound or vibration in the turbocharger is noticed, a quick check of bearing condition can be made without disassembling the turbocharger. This can be done by removing the piping from the turbocharger and inspecting the compressor impeller, turbine wheel and compressor cover. Rotate the compressor and turbine wheel assembly by hand and observe by feeling excess end play and radial clearance. The rotating assembly should rotate freely with no rubbing or binding. If there is any indication of the impeller rubbing the compressor cover or the turbine wheel rubbing the turbine housing, recondition the turbocharger or replace with a new or rebuilt one.

End clearance is best checked with a dial indicator. Attach a dial indicator with the indicator point on the end of the shaft. Move the shaft from end to end making note of the total indicator reading.

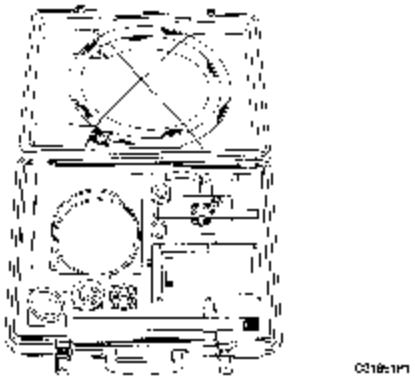
Refer to the Specifications for the correct end play dimensions. If end play is more than the maximum end play, rebuild or replace the turbocharger. End play less than the minimum end play could indicate carbon buildup on the turbine wheel and should be disassembled for cleaning and inspection.



Checking Turbocharger Rotating Assembly Endplay (Typical Example)

A more reliable check of bearing condition can be made only when the turbocharger is disassembled and the bearings, shaft journal and housing bore diameters can actually be measured.

Crankcase (Crankshaft Compartment) Pressure



8T2700 Indicator Group

Pistons or piston rings that have damage can be the cause of too much pressure in the crankcase. This condition will cause the engine to run rough. There will also be more than the normal amount of fumes coming from the crankcase breather. This crankcase pressure can also cause the element for the crankcase breather to have a restriction in a very short time. It can also be the cause of oil leakage at gaskets and seals that would not normally have leakage.

Normal crankcase pressure with a clean crankcase breather is 50.8 kPa (2 inches of water) or less.

Exhaust Temperature

Use the 123-6700 Infrared Thermometer to check exhaust temperature. The Operator's Manual, NEHS0630, for the 123-6700 Infrared Thermometer gives complete operating and maintenance instructions for this tool.

Compression

An engine that runs rough can have a leak at the valves, or have valves that need adjustment. Use the test that follows for a fast and easy method to find a cylinder that has low compression, or does not have good fuel combustion. Find the speed that the engine runs the roughest, and keep the engine at this rpm until the test is finished. Loosen a fuel line nut at fuel injection pump to stop the flow of fuel to that cylinder. Do this for each cylinder until a loosened fuel line is found that makes no difference in engine performance. Be sure to tighten each fuel line nut after the test before the next fuel line nut is loosened. This test can also be an indication that the fuel injection is wrong, so the cylinder will have to be checked thoroughly.

Cylinder Head

The cylinder head has valves, valve seat inserts, and valve guides that can be removed when they are worn or have damage. Replacement of these components can be made with the tools that follow.

Valves

Valve removal and installation is easier with use of the 5P1330 Valve Spring Compressor Assembly and 5S1322 Valve Keeper Inserter.

Valve Seat Inserts

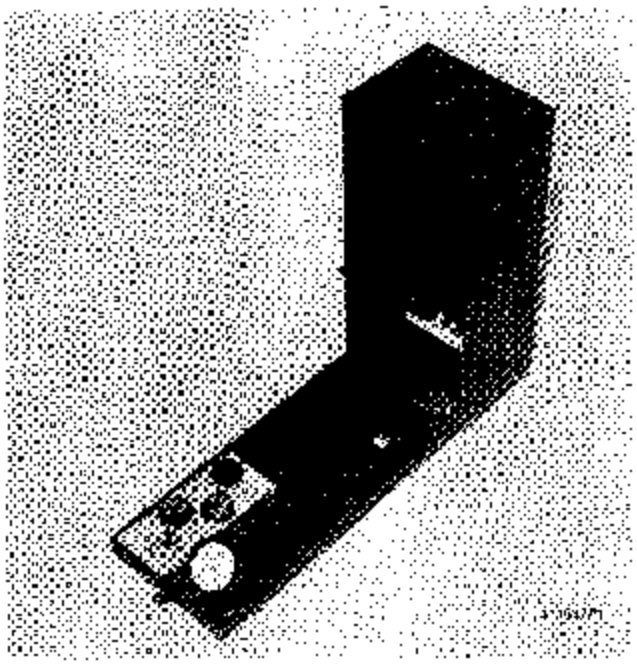
Tools needed to remove valve seat inserts are in the 6V4805 Valve Insert Puller Group. Special Instruction, SMHS7935 gives an explanation for this procedure. The insert can be more easily installed by lowering the temperature of the insert before installing it in the head.

Valve Guides

Tools needed to install valve guides are: 7S8858 Driver Bushing and 7S8859 Driver. The counterbore in the driver bushing installs the guide to the correct height. Use a 1P7450 Honing Arrangement to make a finished bore in the valve guide after installing the guide in the head. Special Instruction, SMHS7526 gives an explanation of this procedure. Grind the valves after installing new valve guides.

Checking Valve Guide Bore

Use the 5P3536 Valve Guide Gauge Group to check the bore of the valve guides. Special Instruction, GMG02562 gives complete and detailed instructions for use of the 5P3536 Valve Guide Gauge Group.



5P3536 Valve Guide Gauge Group

Valve Lash

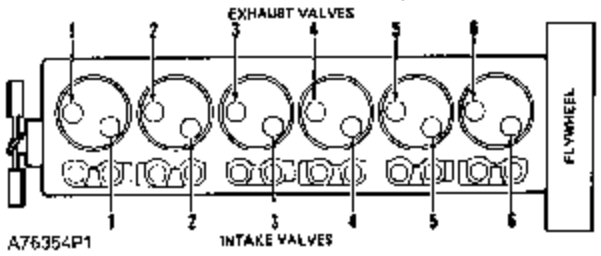
NOTE: Valve lash is measured between the rocker arm and the valves.

VALVE LASH CHECK: ENGINE STOPPED	
Exhaust . . .	0.56 to 0.71 mm (.022 to .028 in)
Intake	0.30 to 0.46 mm (.012 to .018 in)

NOTE: When the valve lash is checked, adjustment is NOT NECESSARY if the measurement is in the range given in the chart for Valve Lash Check: Engine Stopped. If the measurement is outside this range, adjustment is necessary. See the chart for Valve Lash Setting: Engine Stopped, and make the setting to the nominal (desired) specifications in this chart.

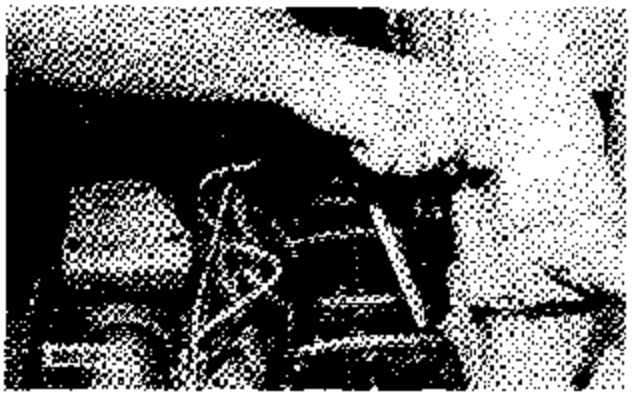
Valve Lash

VALVE LASH SETTING: ENGINE STOPPED
Exhaust ... 0.64 mm (.025 in) Intake ... 0.38 mm (.015 in)



Cylinder And Valve Identification

1. Put No. 1 piston at top center (TC) on the compression stroke. Make reference to Finding Top Center Compression Position For No. 1 Piston.
2. Make an adjustment to the valve lash on the intake valves for cylinders 1 and 2. Make an adjustment to the valve lash the exhaust valves for cylinders 1 and 3.
3. Turn the flywheel 360 degrees in the direction of engine rotation. This will put No. 4 piston at top center (TC) on the compression stroke.
4. Make an adjustment to the valve lash on the intake valves for cylinders 3 and 4. Make an adjustment to the valve lash on the exhaust valves for cylinders 2 and 4.
5. After valve adjustment is correct, tighten the nuts for the valve adjustment screws to 28 ± 4 N•m (22 ± 3 lb ft).



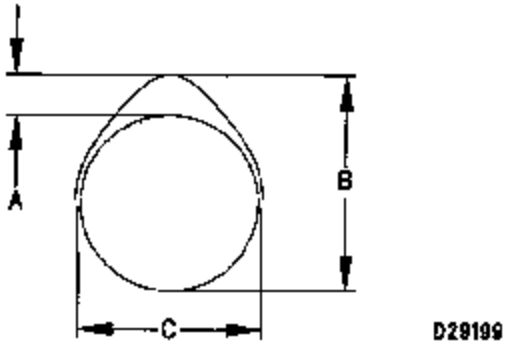
Valve Adjustment

Procedure For Measuring Camshaft Lobes

To find lobe lift, use the procedure that follows:

A. Measure camshaft lobe height (B) of one exhaust and one intake lobe.
B. Measure base circle (C) of one exhaust and one intake lobe.
C. Subtract base circle (STEP B) from lobe height (STEP A). The difference is actual lobe lift (A).
D. Specified camshaft lobe lift (A) is 8.382 mm (.3300 in).

Maximum permissible difference between actual lobe lift (STEP C) and specified lobe lift (STEP D) is 0.25 mm (.010 in).



Camshaft Lobe
(A) Lobe lift. (B) Lobe height. (C) Base circle.

Lubrication System

One of the problems in the list that follows will generally be an indication of a problem in the lubrication system for the engine.

Too Much Oil Consumption
Oil Pressure Is Low
Oil Pressure Is High
Too Much Bearing Wear
Increased Oil Temperature

Oil Leakage On Outside Of Engine

Check for leakage at the seals at each end of the crankshaft. Look for leakage at the oil pan gasket and all lubrication system connections. Check to see if oil comes out of the crankcase breather. This can be caused by combustion gas leakage around the pistons. A dirty crankcase breather will cause high pressure in the crankcase, and this will cause gasket and seal leakage.

Oil Leakage Into Combustion Area Of Cylinders

Oil leakage into the combustion area of the cylinders can be the cause of blue smoke. There are four possible ways for oil leakage into the combustion area of the cylinders:

1. Oil leakage between worn valve guides and valve stems.
2. Worn or damaged piston rings, or dirty oil return holes.
3. Compression ring and/or intermediate ring not installed correctly.
4. Oil leakage past the seal rings in the impeller end of the turbocharger shaft.

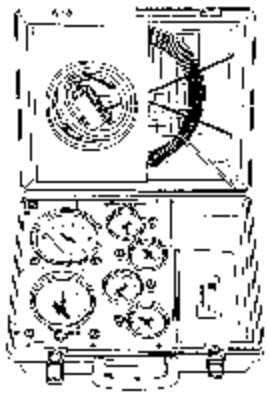
Too much oil consumption can also be the result if oil with the wrong viscosity is used. Oil with a thin viscosity can be caused by fuel leakage into the crankcase, or by increased engine temperature.

Measuring Engine Oil Pressure

Tools Needed		
1U5470	Engine Pressure Group	1

An oil pressure gauge that has a defect can give an indication of low oil pressure.

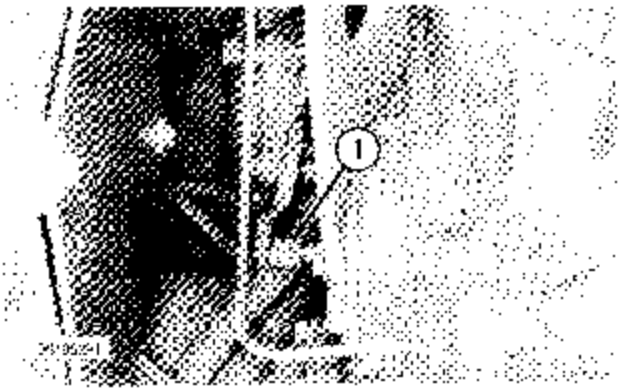
The 1U5470 Engine Pressure Group can be used to check engine oil pressure.



1U5470 Engine Pressure Group

This tool group has a gauge to read oil pressure in the engine. Special Instruction, SEHS8524 is with the tool group and gives instructions for the test procedure.

1. Be sure that the engine is filled to the correct level with SAE 10W-30 oil. If any other viscosity of oil is used, the information in the engine oil pressure chart does not apply.
2. Remove oil pressure switch (1) and connect the 1U5470 Engine Pressure Group to the main oil manifold at the location from which the oil pressure switch was removed.



Oil Pressure Switch Location
(1) Oil pressure switch.

⚠ WARNING

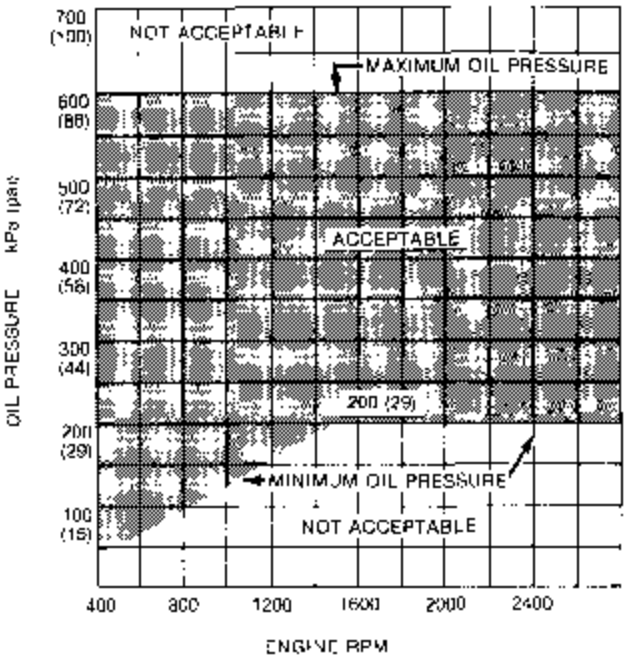
Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

3. Run the engine to get the engine oil temperature at 99°C (210°F).

NOTE: A 3°C (5°F) increase in temperature gives approximately 7 kPa (1 psi) decrease in engine oil pressure.

NOTE: Make sure engine oil temperature does not go above 115°C (239°F).

4. Keep the engine oil temperature constant with the engine at its rated rpm and read the pressure gauge. On the Engine Oil Pressure Graph, find the point that the lines for engine rpm and oil pressure intersect (connect).



C2734-P1

5. If the results do not fall within the "ACCEPTABLE" pressure range given in the graph, find the cause and correct it. Engine failure or a reduction in engine life can be the result if engine operation is continued with oil manifold pressure outside this range.

NOTE: A record of engine oil pressure, kept at regular intervals, can be used as an indication of possible engine problems or damage. If there is a sudden increase or decrease of 70 kPa (10 psi) in oil pressure, the engine should be inspected and the problem corrected

Oil Pressure Is Low

Crankcase Oil Level

Check the level of the oil in the crankcase. Add oil if needed. It is possible for the oil level to be too far below the oil pump supply tube. This will cause the oil pump to not have the ability to supply enough lubrication to the engine components.

Oil Pump Does Not Work Correctly

The inlet screen of the supply tube for the oil pump can have a restriction. This will cause cavitation (low pressure bubbles suddenly made in liquids by mechanical forces) and a loss of oil pressure. Air leakage in the supply side of the oil pump will also cause cavitation and loss of oil pressure. If the bypass valve for the oil pump is held in the open (unseated) position, the lubrication system cannot get to a maximum pressure. Oil pump gears that have too much wear will cause a reduction in oil pressure.

Oil Filter Bypass Valve

If the bypass valve for the oil filter is held in the open position (unseated) because the oil filter has a restriction, a reduction in oil pressure can result. To correct this problem, remove and clean the bypass valve and bypass valve bore. Install a new Caterpillar oil filter to be sure that no more debris makes the bypass valve stay open.

Too Much Clearance at Engine Bearings or Open Lubrication System (Broken or Disconnected Oil Line or Passage)

Components that are worn and have too much bearing clearance can cause oil pressure to be low. Low oil pressure can also be caused by an oil line or oil passage that is open, broken or disconnected.

Piston Cooling Tubes (Jets)

When engine is operated, cooling jets direct oil toward the bottom of the piston to lower piston and ring temperatures. If there is a failure of one of the jets, or it is bent in the wrong direction, seizure of the piston will be caused in a very short time.

Use the 5P8709 Piston Tool Group to check and adjust the alignment of piston cooling jets.

Oil Pressure Is High

Oil pressure will be high if the bypass valve for the oil pump cannot move from the closed position.

Too Much Bearing Wear

When some components of the engine show bearing wear in a short time, the cause can be a restriction in an oil passage. A broken oil passage can also be the cause.

If the gauge for oil pressure shows enough oil pressure, but a component is worn because it cannot get enough lubrication, look at the passage for oil supply to the component. A restriction in a supply passage will not let enough lubrication get to a component, and this will cause early wear.

Increased Oil Temperature

Look for a restriction in the oil passages of the oil cooler. If the oil cooler has a restriction, the oil temperature will be higher than normal when the engine is operated. The oil pressure of the engine will not get low just because the oil cooler has a restriction.

Also check the oil cooler bypass valve to see if it is held in the open position (unseated). This condition will let the oil through the valve instead of the oil cooler, and oil temperature will increase.

Cooling System

This engine has a pressure type cooling system. A pressure type cooling system gives two advantages. The first advantage is that the cooling system can have safe operation at a temperature that is higher than normal boiling (steam) point of water. The second advantage is that this type system prevents cavitation (low pressure bubbles suddenly made in liquids by mechanical forces) in the water pump. With this type system, it is more difficult for an air or steam pocket to be made in the cooling system.

The cause for increased engine temperature is generally because regular inspections of the cooling system were not made. Make a visual inspection of the cooling system before a test is made with test equipment.

Visual Inspection Of The Cooling System

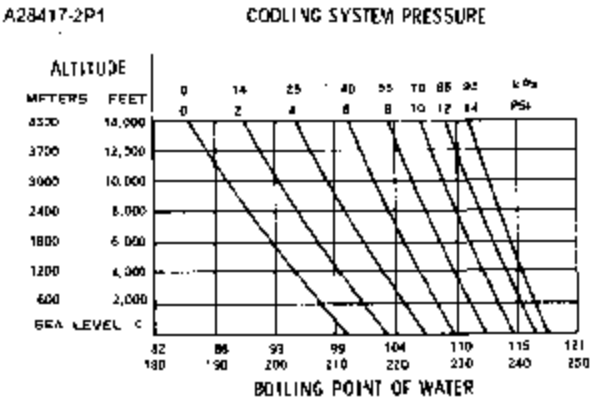
1. Check coolant level in the cooling system.
2. Look for leaks in the system.

NOTE: Water pump seals. A small amount of coolant leakage across the surface of the 'face-type' seals is normal, and required to provide lubrication for this type of seal. A hole is provided in the water pump housing to allow this coolant/seal lubricant to drain from the pump housing. Intermittent leakage of small amounts of coolant from this hole is not an indication of water pump seal failure. Replace the water pump seals only if a large amount of leakage, or a constant flow of coolant is observed draining from the water pump housing.

3. Look for bent radiator fins. Be sure that air flow through the radiator does not have a restriction.
4. Inspect the drive belts for the fan.
5. Check for damage to the fan blades.
6. Look for air or combustion gas in the cooling system.
7. Inspect the pressure cap and/or filler cap and the surface that seals the cap. This surface must be clean
8. Look for large amounts of dirt in the radiator core and on the engine.

Testing The Cooling System

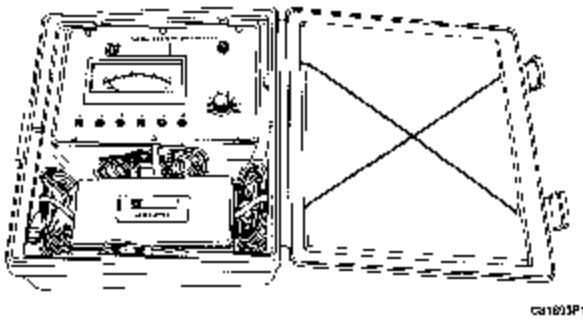
Remember that temperature and pressure work together. When a diagnosis is made of a cooling system problem, temperature and pressure must both be checked. Cooling system pressure will have an effect on cooling system temperatures. For an example, look at the chart to see the effect of pressure and height above sea level on the boiling (steam) point of water.



Boiling Point Of Water

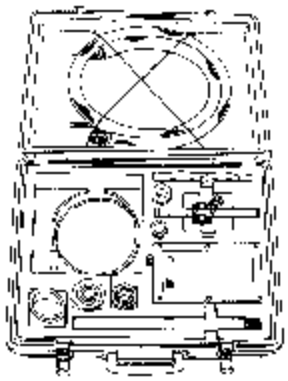
Test Tools For Cooling System

	Tools Needed	
4C6500	Digital Thermometer Group	1
8T2700	Indicator Group	1
6V3121	Multitach Group	1
9S8140	Cooling System Pressurizing Pump Group	1



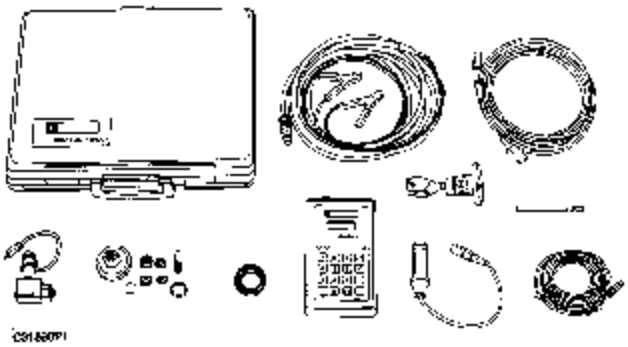
4C6500 Digital Thermometer Group

The 4C6500 Digital Thermometer Group is used in the diagnosis of overheating (engine hotter than normal) or overcooling (engine cooler than normal) problems. This group can be used to check temperatures in several different parts of the cooling system. The testing procedure is in Operating Manual, NEHS0554.



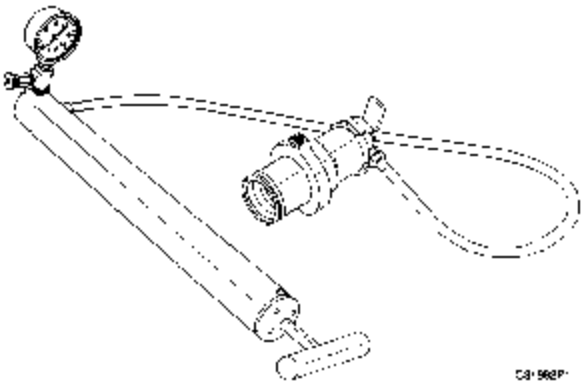
8T2700 Blowby/Air Flow Indicator Group

The 8T2700 Blowby/Air Flow Indicator Group is used to check the air flow through the radiator core. The test procedure is in Special Instruction, SEHS8712.



6V3121 Multitach Group

The 6V3121 Multitach Group is used to check the fan speed. The testing procedure is in Special Instruction, Form SEHS7807.



9S8140 Cooling System Pressurizing Pump Group

The 9S8140 Cooling System Pressurizing Pump Group is used to test pressure caps and to pressure check the cooling system for leaks.

⚠ WARNING

DO NOT loosen the filler or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

Make Proper Antifreeze Additions

Adding pure antifreeze as a makeup solution for cooling system top-off is an unacceptable practice. It increases the concentration of antifreeze in the cooling system which increases the concentration of dissolved solids and undissolved chemical inhibitors in the cooling system. Add antifreeze mixed with acceptable water to the same freeze protection as your cooling system. Use the chart as follows to assist in determining the concentration of antifreeze to use.

ANTIFREEZE CONCENTRATIONS	
Protection Temperature	**Concentration**
Protection to −15°C (5°F)	30% antifreeze and 70% water
Protection to −23°C (−10°F)	40% antifreeze and 60% water
Protection to −37°C (−34°F)	50% antifreeze and 50% water
Protection to −51°C (−60°F)	60% antifreeze and 40% water

Checking Pressure Cap

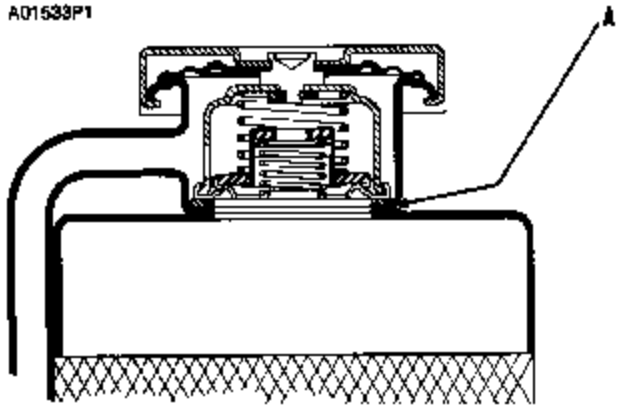
Tools Needed		
9S8140	Cooling System Pressurizing Pump Group	1

One cause for a pressure loss in the cooling system can be a defective seal on the radiator pressure cap.

⚠ WARNING

DO NOT loosen the filler or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

After the engine is cool, loosen the pressure cap and let the pressure out of the cooling system. Then remove the pressure cap.



Typical Schematic Of Pressure Cap
(A) Sealing surface of cap and radiator.

Inspect the pressure cap carefully. Look for damage to the seal or to the surface that seals. Any foreign material or deposits on the cap, seal or surface that seals, must be removed.

The 9S8140 Cooling System Pressurizing Pump Group is used to test pressure caps and to pressure check the cooling system for leaks.

⚠ WARNING

DO NOT loosen the filler or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

To check the pressure cap for the pressure that makes the pressure cap open, use the procedure that follows:

1. Remove the pressure cap from the radiator.
2. Put the pressure cap on the 9S8140 Cooling System Pressurizing Pump Group.
3. Look at the gauge for the exact pressure that makes the pressure cap open.
4. Make a comparison of the reading on the gauge with the correct pressure at which the pressure cap must open.

NOTE: The correct pressure that makes the pressure cap open is on the pressure cap and is also in the Specifications module.

5. If the pressure cap is defective, install a new pressure cap.

Testing Radiator And Cooling System For Leaks

Tools Needed		
9S8140	Cooling System Pressurizing Pump Group	1

To test the radiator and cooling system for leaks, use the procedure that follows:

⚠ WARNING

DO NOT loosen the filler or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

1. Remove the pressure cap from the radiator.
2. Make sure the coolant is over the top of the radiator core.
3. Put the 9S8140 Cooling System Pressurizing Pump Group on the radiator.
4. Operate the pump group and get a pressure reading on the gauge that is 20 kPa (3 psi) more than the pressure marked on the pressure cap.

5. Check the radiator for outside leakage.

6. Check all connections and hoses for the cooling system for outside leakage.

7. If you do not see any outside leakage and the pressure reading on the gauge is still the same after five minutes, the radiator and cooling system does not have leakage. If the reading on the gauge goes down and you do not see any outside leakage, there is leakage on the inside of the cooling system. Make repairs as necessary.

Water Temperature Regulator

1. Remove the regulator from the engine.

2. Heat water in a pan until the temperature is 90°C (195°F). This is the correct temperature for opening the regulator. Move the water around in the pan to make it all be the same temperature.

3. Hang the regulator in the pan of water. The regulator must be below the surface of the water and it must be away from the sides and bottom of the pan.

4. Keep the water at the correct temperature for ten minutes.

5. After ten minutes, remove the regulator and immediately measure the distance the regulator has opened. The distance must be a minimum of 9.53 mm (.375 in).

6. If the distance is less than 9.53 mm (.375 in), make a replacement of the regulator.

BELT TENSION CHART								
BELT SIZE	WIDTH BELT TOP		GAUGE READING				BORROUGHS GAUGE NUMBERS	
			BELT TENSION "INITIAL"*		BELT TENSION "USED"**		OLD GAUGE NUMBER	NEW GAUGE NUMBER
	MM	IN	N	LB	N	LB		
3/8	10.72	0.422	445 ± 22	100 ± 5	400 ± 22	90 ± 10	BT-33-95	BT-33-97
1/2	13.89	0.547	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-95	BT-33-97
5V	15.88	0.625	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72	BT-33-72C
11/16	17.48	0.688	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72	BT-33-72C
3/4	19.05	0.750	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72	BT-33-72C
15/16	23.83	0.983	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72	BT-33-77
8K	27.92	1.099	800 ± 22	180 ± 5	489 ± 44	110 ± 10	--------	BT-33-109
6PK	20.94	0.824	667 ± 22	150 ± 5	467 ± 44	105 ± 10	--------	BT-33-109
MEASURE TENSION OF BELT FARTHEST FROM ENGINE								

* BELT TENSION "INITIAL" is for a new belt.

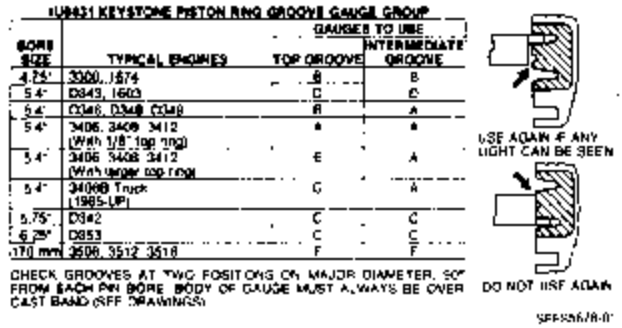
** BELT TENSION "USED" is for a belt with over 30 minutes of operation at rated speed.

D01599

Basic Block

Piston Rings

This engine has piston grooves and rings of the KEYSTONE (taper) design. The 1U6431 Keystone Piston Ring Groove Gauge Group is available to check the top two ring grooves in the piston. For correct use of the gauge group see the instruction card that is with the gauge group.



1U6431 KEYSTONE PISTON RING GROOVE GAUGE GROUP

BORE SIZE	TYPICAL ENGINES	GAUGES TO USE: TOP GROOVE	GAUGES TO USE: INTERMEDIATE GROOVE
4.75"	3300, 1674	B	B
5.4"	D343, 1603	C	C
5.4"	D346, D348, D349	B	A
5.4"	3406, 3408, 3412 (With 1/8" top ring)	A	A
5.4"	3406, 3408, 3412 (With larger top ring)	E	A
5.4"	3406B Truck (1985-UP)	G	A
5.75"	D342	C	C
6.25"	D353	C	C
170 mm	3508, 3512, 3516	F	F

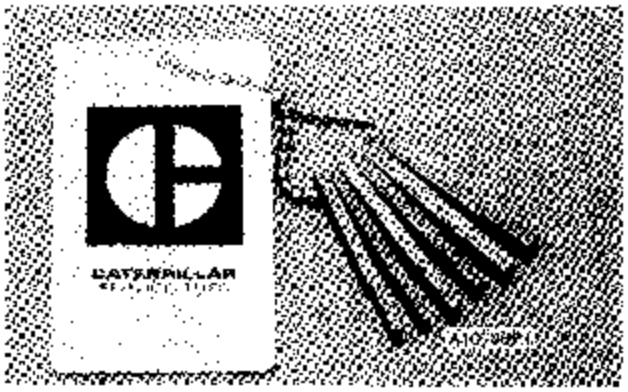
CHECK GROOVES AT TWO POSITIONS ON MAJOR DIAMETER, 90° FROM EACH PIN BORE. BODY OF GAUGE MUST ALWAYS BE OVER CAST BAND (SEE DRAWINGS)

C4802P1

Instructions For 1U6431 Keystone Piston Ring Groove Gauge Group

Pistons With Straight Sides in Ring Grooves

A 5P3519 Piston Ring Groove Gauge is available for checking ring grooves with straight sides. For instructions on the use of the gauge see the Guideline For Reusable Parts; Pistons, SEBF8049.



Piston Ring Groove Gauge

Connecting Rods And Pistons

Use the 7S9470 Piston Ring Expander to remove or install piston rings.

Use the 5P3525 Piston Ring Compressor to install pistons into cylinder block.

Tighten the connecting rod nuts in the step sequence that follows:

1. Put 2P2506 Thread Lubricant on threads.
2. Tighten both nuts to 40 ± 4 N•m (30 ± 3 lb ft).
3. Put a mark on each nut and cap.
4. Tighten each nut 90 degrees from the mark.

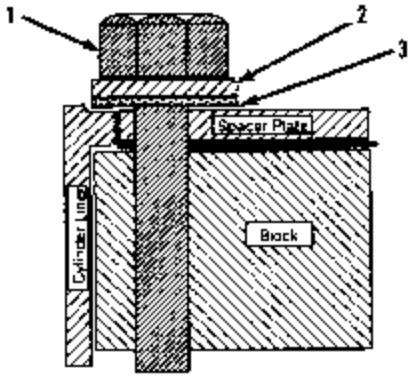
The connecting rod bearings must fit tightly in the bore in the rod. If bearing joints or backs are worn (fretted), check for bore size as this is an indication of wear because of looseness.

Connecting Rod And Main Bearings

Bearings are available with 0.25 mm (.010 in), 0.51 mm (.020 in) and 0.76 mm (.030 in) smaller inside diameter than the original size bearings. These bearings are for crankshafts that have been 'ground' (made smaller) than the original size.

Cylinder Liner Projection

Tools Needed		
8T0455	Liner Projection Tool Group	1
1P2403	Dial Indicator	1
1P5512	Contact Point, 22.4 mm (.88 in) long	1
1P2402	Gauge Body	1
1P5507	Gauge	1



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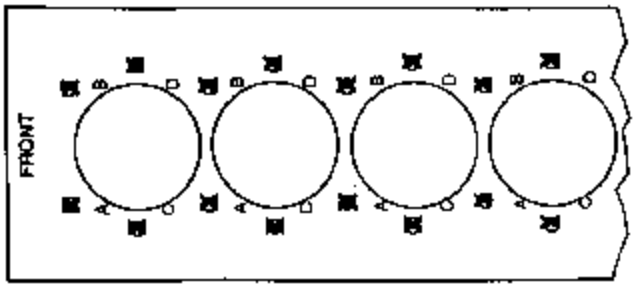
(1) Bolt. (2) Washer. (3) Washer.

COMPONENTS NEEDED			
Item	Part No	Description	Quantity For One Cylinder
1	0S1589	Bolt	6
2	8F1484	Washer	6
3	7K1977[1]	Washer	6

[1] These are plastic washers, an expendable item, therefore you may wish to order more than the amount indicated.

1. Install clean liners or cylinder packs (without the filler band or the rubber seals), spacer plate gasket and clean spacer plate.



C63970P1

2. Install bolts and washers, in the holes indicated with an X. Install all bolts or the six bolts around the liner. Tighten the bolts to a torque of .... 95 N•m (70 lb ft).

NOTE: Install the plastic washer next to the spacer plate.

3. Use the 8T0455 Liner Projection Tool Group to measure liner projection at positions indicated with and A,B,C and D. Record measurements for each cylinder. Add the four readings for each cylinder and divide by four to find the average.
4. The cylinder liner specifications are as follows:
   Liner projection ..... 0.033 to 0.175 mm (0.0013 to 0.0069 in)
   Maximum variation in each cylinder ..... 0.051 mm (.002 in)
   Maximum average variation between adjacent cylinders ..... 0.051 mm (.002 in)
   Maximum variation between all cylinders ..... 0.102 mm (.004 in)
5. If the liner projections are out of specification, try rotating the liner or install the liner in another bore to see if the measurements improve.

NOTE: Do not exceed the maximum liner projection of 0.152 mm (.006 in). Excessive liner projection will contribute to liner flange cracking.

6. With the proper liner projection, mark the liners in the proper position and set them aside.

7. When the engine is ready for final assembly, the O-ring seals, cylinder block and upper filler band must be lubricated before installation.

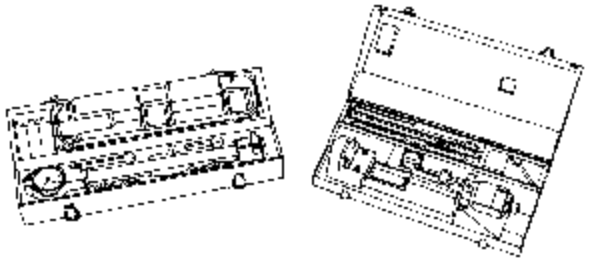
If the lower O-rings are black in color, apply liquid soap on the lower O-ring seals and the cylinder block. Use clean engine oil on the upper filler band.

If the lower O-rings are brown in color, apply engine oil on the lower O-ring seals, the cylinder block and the upper filler band.

NOTE: Apply liquid soap and/or clean engine oil immediately before assembly. If applied too early, the filler bands may swell and be pinched under the liners during installation.

Cylinder Block

The bore in the block for main bearings can be checked with the main bearing caps installed without bearings. Tighten the nuts holding the caps to the torque shown in the Specifications Section of this Service Manual. Alignment error in the bores must not be more than 0.08 mm (.003 in). Special Instruction, SMHS7606 gives instructions for checking alignment of the main bearing bores. 1P3537 Dial Bore Gauge Group can be used to check the size of the bores. Special Instruction, GMG00981 is with the group.



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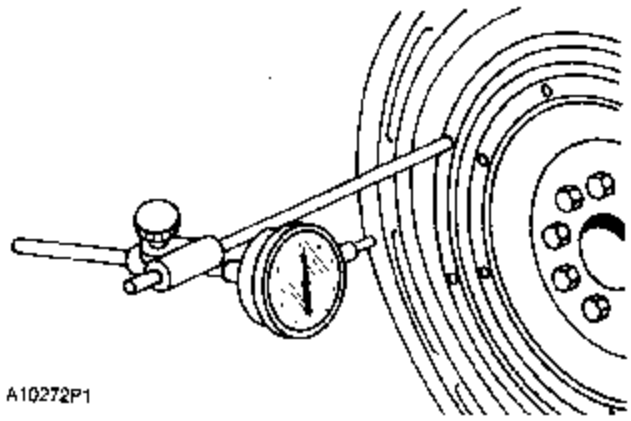
1P3537 Dial Bore Gauge Group

Flywheel And Flywheel Housing

Tools Needed		
8T5096	Dial Indicator Group	1

Face Run Out (Axial Eccentricity) Of The Flywheel Housing



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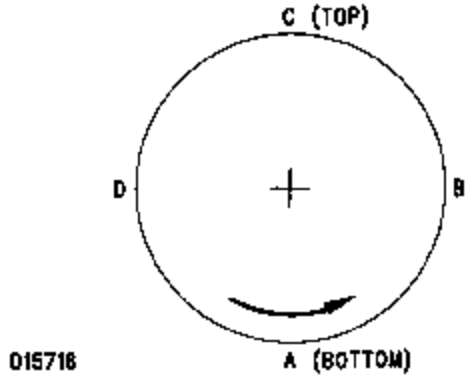
8T5096 Dial Indicator Group Installed
(Typical Example)

If any method other than given here is used, always remember bearing clearance must be removed to get correct measurements.

1. Fasten a dial indicator to the flywheel so the anvil of the indicator will touch the face of the flywheel housing.

2. Put a force on the crankshaft toward the rear before the indicator is read at each point.



Checking Face Runout Of The Flywheel Housing

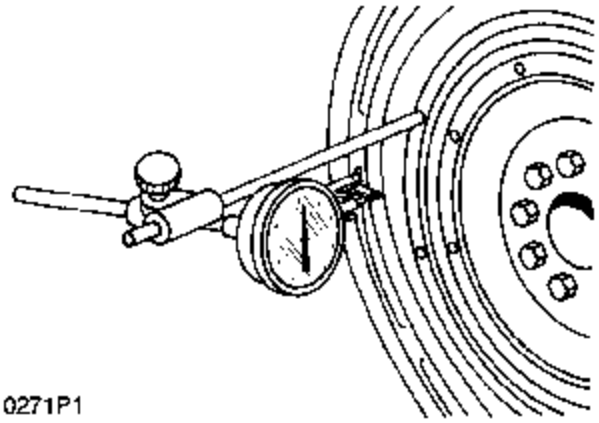
3. With dial indicator set at "0" (zero) at location (A), turn the flywheel and read the indicator at locations (B), (C) and (D).

4. The difference between lower and higher measurements taken at all four points must not be more than 0.38 mm (.015 in), which is the maximum permissible face run out (axial eccentricity) of the flywheel housing

Bore Runout (Radial Eccentricity) Of The Flywheel Housing

1. Fasten the dial indicator as shown so the anvil of the indicator will touch the bore of the flywheel housing.

2. With the dial indicator in position at (C), adjust the dial indicator to "0" (zero). Push the crankshaft up against the top of the bearing. Write the measurement for bearing clearance on line 1 in column (C) in the Chart For Dial Indicator Measurements.



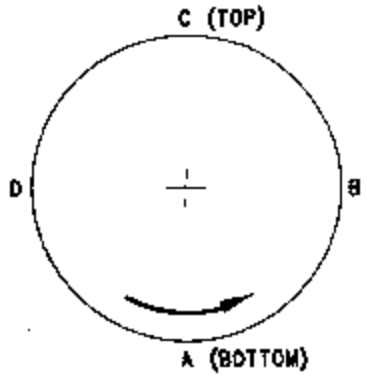
8T5096 Dial Indicator Group Installed
(Typical Example)

NOTE: Write the dial indicator measurements with their positive (+) and negative (−) notation (signs). This notation is necessary for making the calculations in the chart correctly.

3. Divide the measurement from Step 2 by 2. Write this number on line 1 in columns (B) & (D).

4. Turn the flywheel to put the dial indicator at (A). Adjust the dial indicator to "0" (zero).

5. Turn the flywheel counterclockwise to put the dial indicator at (B). Write the measurements in the chart.



Checking Bore Runout Of The Flywheel Housing

6. Turn the flywheel counterclockwise to put the dial indicator at (C). Write the measurement in the chart

7. Turn the flywheel counterclockwise to put the dial indicator at (D). Write the measurement in the chart

CHART FOR DIAL INDICATOR MEASUREMENTS					
	Position of dial indicator				
	Line No.	A	B	C	D
Correction for bearing clearance	I	0			
Dial Indicator Reading	II	0			
Total of Line 1 & 2	III	0	**	*	**

*Total Vertical eccentricity (out of round).
**Subtract the smaller No. from the larger No. The difference is the total horizontal eccentricity.

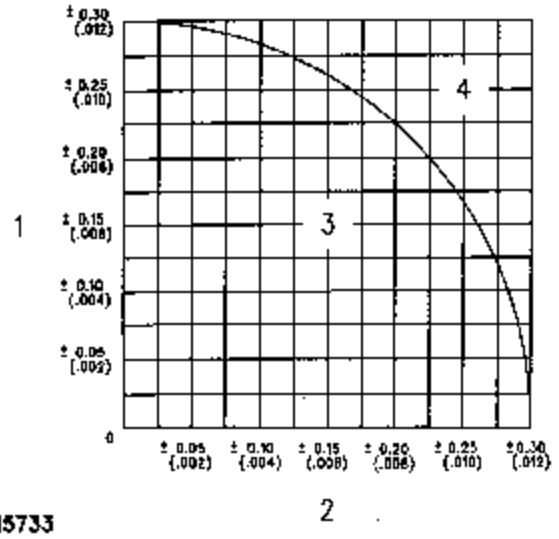
D15721

8. Add lines I & II by columns.

9. Subtract the smaller number from the larger number in line III in columns (B) & (D). The result is the horizontal eccentricity (out of round). Line III, column (C) is the vertical eccentricity.

10. On the graph for total eccentricity, find the point of intersection of the lines for vertical eccentricity and horizontal eccentricity.

11. If the point of intersection is in the range marked "Acceptable", the bore is in alignment. If the point of intersection is in the range marked "Not Acceptable", the flywheel housing must be changed.



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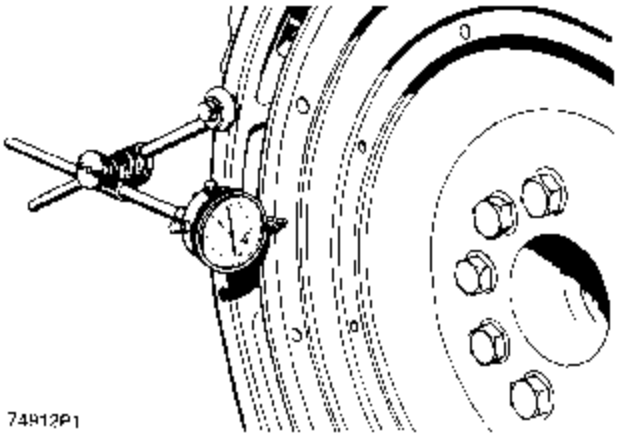
Graph For Total Eccentricity
(1) Total Vertical Eccentricity [mm (in)]. (2) Total Horizontal Eccentricity [mm (in)]. (3) Acceptable. (4) Not Acceptable.

Face Runout (Axial Eccentricity) Of The Flywheel

1. Install the dial indicator as shown. Always put a force on the crankshaft in the same direction before the indicator is read so the crankshaft end clearance (movement) is always removed.



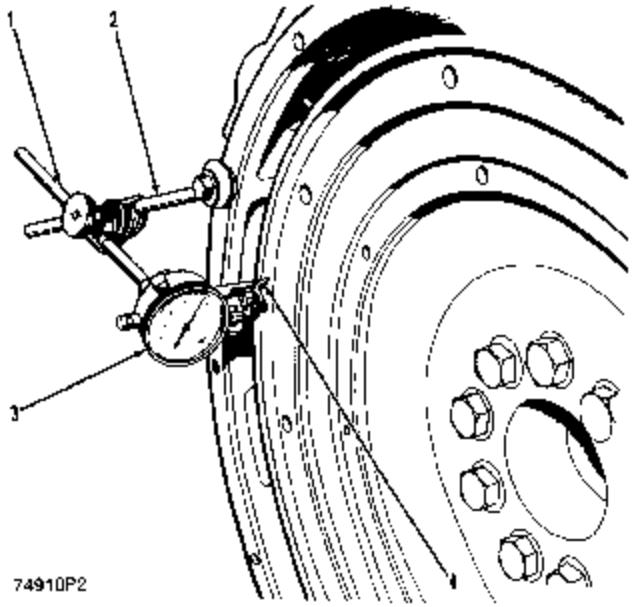
Checking Face Runout Of The Flywheel
(Typical Example)

2. Set the dial indicator to read "0" (zero).

3. Turn the flywheel and read the indicator every 90 degrees.

4. The difference between the lower and higher measurements taken at all four points must not be more than 0.15 mm (.006 in), which is the maximum permissible face runout (axial eccentricity) of the flywheel.

Bore Runout (Radial Eccentricity) Of The Flywheel



Checking Bore Runout Of The Flywheel (Typical Example)
(1) 7H1945 Holding Rod (2) 7H1645 Holding Rod (3) 7H1942 Indicator (4) 7H1940 Universal Attachment

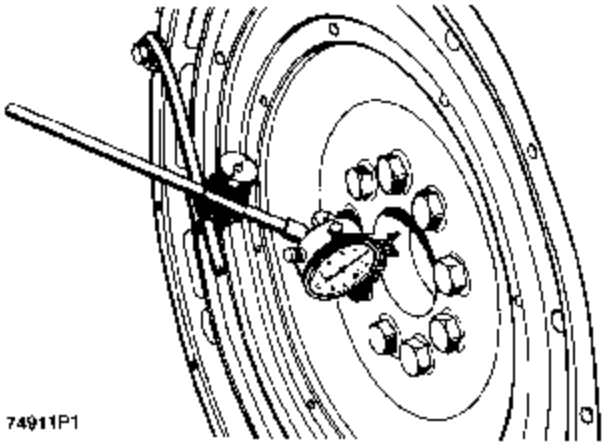
1. Install the dial indicator (3) and make an adjustment of the universal attachment (4) so it makes contact as shown.

2. Set the dial indicator to read "0" (zero).

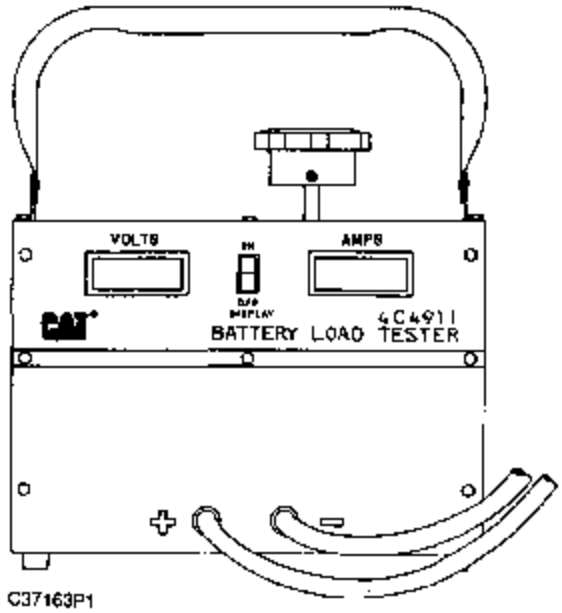
3. Turn the flywheel and read the indicator every 90 degrees.

4. The difference between the lower and higher measurements taken at all four points must not be more than 0.15 mm (.006 in), which is the maximum permissible bore runout (radial eccentricity) of the flywheel.

5. Runout (eccentricity) of the bore for the pilot bearing for the flywheel clutch, must not exceed 0.13 mm (.005 in).



Checking Flywheel Clutch Pilot Bearing Bore



Electrical System

Test Tools For Electrical System

Tools Needed		
4C4911	Battery Load Tester	1
8T0900	AC/DC Clamp-On Ammeter	1
6V7070	Heavy-Duty Digital Multimeter or	1
6V7800	Regular-Duty Digital Multimeter	1

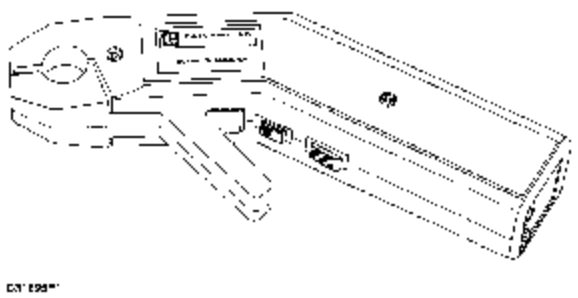
Most of the tests of the electrical system can be done on the engine. The wiring insulation must be in good condition, the wire and cable connections must be clean and tight, and the battery must be fully charged. If the on-engine test shows a defect in a component, remove the component for more testing.

The service manual Testing And Adjusting Electrical Components, REG00636 has complete specifications and procedures for the components of the starting circuit and the charging circuit.

The 4C4911 Battery Load Tester is a portable unit in a metal case for use under field conditions and high temperatures. It can be used to load test all 6, 8 and 12V batteries. This tester has two heavy-duty load cables that can easily be fastened to the battery terminals. A load adjustment knob on the top permits the current being drawn from the battery to be adjusted to a maximum of 1000 amperes. The tester is cooled by an internal fan that is automatically activated when a load is applied.

The tester has a built in LCD digital voltmeter and amperage meter. The digital voltmeter accurately measures the battery voltage at the battery through tracer wires buried inside the load cables. The digital amperage meter accurately displays the current being drawn from the battery under test.

NOTE: Make reference to Operating Manual, SEHS9249 for more complete information for use of the 4C4911 Battery Load Tester.

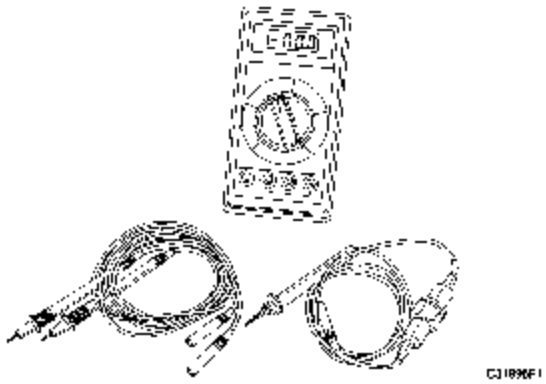


8T0900 AC/DC Clamp-On Ammeter

The 8T0900 AC/DC Clamp On Ammeter is a completely portable, self-contained instrument that allows electrical current measurements to be made without breaking the circuit or disturbing the insulation on conductors. A digital display is located on the ammeter for reading current directly in a range from 1 to 1200 amperes. If an optional 8V6014 Cable is connected between this ammeter and one of the digital multimeters, current readings of less than 1 ampere can then be read directly from the display of the multimeter.

A lever is used to open the jaws over the conductor [up to a diameter of 19 mm (.75 in)], and the spring loaded jaws are then closed around the conductor for current measurement. A trigger switch that can be locked in the ON or OFF position is used to turn on the ammeter. When the turn-on trigger is released, the last current reading is held on the display for five seconds. This allows accurate measurements to be taken in limited access areas where the digital display is not visible to the operator. A zero control is provided for DC operation, and power for the ammeter is supplied by batteries located inside the handle.

NOTE: Make reference to Special Instruction, SEHS9420 for more complete information for use of the 8T0900 Clamp-On Ammeter.



6V7070 Heavy-Duty Digital Multimeter

The 6V7070 Heavy-Duty Digital Multimeter is a completely portable, hand held instrument with a digital display. This multimeter is built with extra protection against damage in field applications, and is equipped with seven functions and 29 ranges. The 6V7070 Multimeter has an instant ohms indicator that permits continuity checks for fast circuit inspection. It also can be used for troubleshooting small value capacitors.

The 6V7800 Regular-Duty Digital Multimeter (a low cost option to the Heavy-Duty Multimeter) is also available, however, the 6V7800 Multimeter does not have the 10A range or the instant ohms feature of the 6V7070 Multimeter.

NOTE: Make reference to Special Instruction, SEHS7734 for more complete information for use of the 6V7070 and 6V7800 Multimeters

Battery

⚠ WARNING

Never disconnect any charging unit circuit or battery circuit cable from battery when the charging unit is operated. A spark can cause an explosion from the flammable vapor mixture of hydrogen and oxygen that is released from the electrolyte through the battery outlets. Injury to personnel can be the result.

The battery circuit is an electrical load on the charging unit. The load is variable because of the condition of the charge in the battery. Damage to the charging unit can result if the connections (either positive or negative) between the battery and charging unit are broken while the charging unit is in operation. This is because the battery load is lost and there is an increase in charging voltage. High voltage can damage, not only the charging unit, but also the regulator and other electrical components.

Use the 4C4911 Battery Load Tester, the 8T0900 Clamp-On Ammeter and the 6V7070 Multimeter to load test a battery that does not hold a charge when in use. See Special Instruction SEHS8268 for the correct procedure and specifications to use.

Charging System

The condition of charge in the battery at each regular inspection will show if the charging system operates correctly. An adjustment is necessary when the battery is constantly in a low condition of charge or a large amount of water is needed (more than one ounce of water per cell per week or per every 100 service hours).

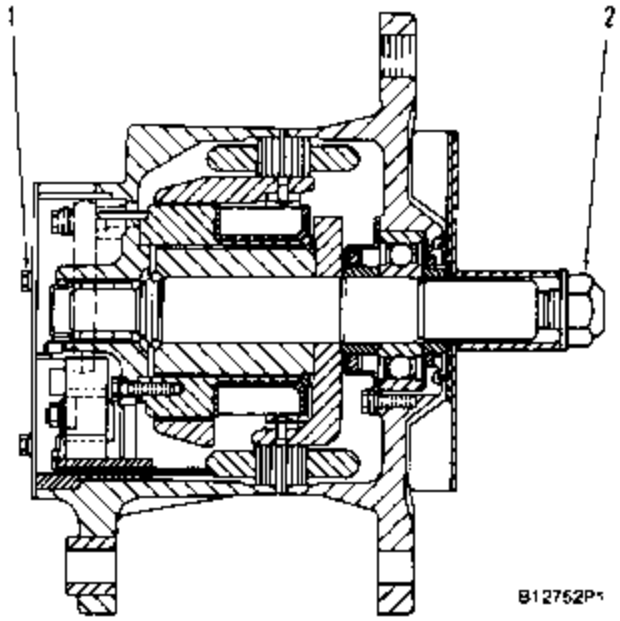
When it is possible, make a test of the charging unit and voltage regulator on the engine and use wiring and components that are a permanent part of the system. Off-engine (bench) testing will give a test of the charging unit and voltage regulator operation. This testing will give an indication of needed repair. After repairs are made, again make a test to give proof that the units are repaired to their original condition of operation.

Before the start of on-engine testing, the charging system and battery must be checked as shown in the Steps that follow.

1. Battery must be at least 75 percent (1.225 Sp.Gr.) fully charged and held tightly in place. The Battery holder must not put too much stress on the battery.
2. Cables between the battery, starter and engine ground must be the correct size. Wires and cables must be free of corrosion and have cable support clamps to prevent stress on battery connections (terminals).
3. Leads, junctions, switches, and panel instruments that have direct relation to the charging circuit must give correct circuit control.
4. Inspect the drive components for the charging unit to be sure they are free of grease and oil and have the ability to operate the charging unit.

Alternator Regulator

When an alternator is charging the battery too much or not enough, the charging rate of the alternator should be checked. Make reference to the Specifications module to find all testing specifications for the alternators and regulators.

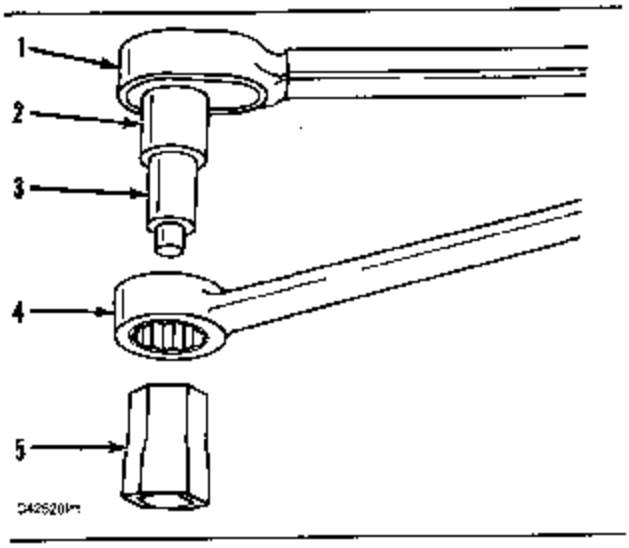


5N5692 Alternator
(1) Ground terminal. (2) Pulley nut.

No adjustment can be made to change the rate of charge on the alternator regulators. If rate of change is not correct, a replacement of the regulator is necessary.

Alternator Pulley Nut Tightening

Tighten nut that holds the pulley to a torque of 110 ± 10 N•m (80 ± 7 lb ft) with the tools shown.



Tools To Tighten Alternator Pulley Nut
(1) 8T9293 Torque Wrench. (2) 8S1588 Adapter (½ inch female to ⅜ inch male). (3) 2P8267 Socket Assembly. (4) 8H8517 Combination Wrench (1⅛ inch). (5) 8T5314 Socket.

Starting System

Use the multimeter in the DCV range to find starting system components which do not function.

Move the start control switch to activate the starter solenoid. Starter solenoid operation can be heard as the pinion of the starter motor is engaged with the ring gear on the engine flywheel.

If the solenoid for the starter motor will not operate, it is possible that the current from the battery did not get to the solenoid. Fasten one lead of the multimeter to the connection (terminal) for the battery cable on the solenoid. Put the other lead to a good ground. A zero reading is an indication that there is a broken circuit from the battery. More testing is necessary when there is a voltage reading on the multimeter.

The solenoid operation also closes the electric circuit to the motor. Connect one lead of the multimeter to the solenoid connection (terminal) that is fastened to the motor. Put the other lead to a good ground. Activate the starter solenoid and look at the multimeter. A reading of battery voltage shows the problem is in the motor. The motor must be removed for further testing. A zero reading on the multimeter shows that the solenoid contacts do not close. This is an indication of the need for repair to the solenoid or an adjustment to be made to the starter pinion clearance.

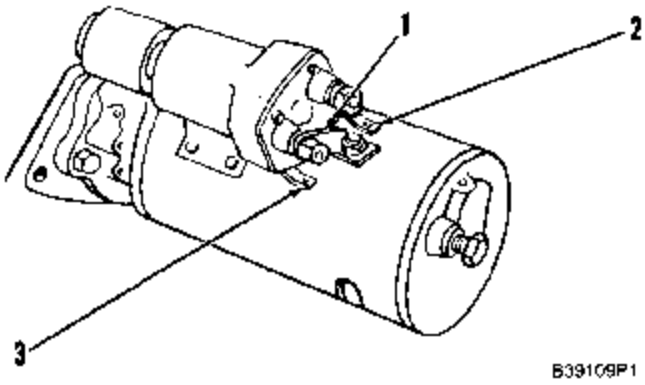
Make a test with one multimeter lead fastened to the connection (terminal) for the small wire at the solenoid and the other lead to the ground. Look at the multimeter and activate the starter solenoid. A voltage reading shows that the problem is in the solenoid. A zero reading is an indication that the problem is in the start switch or the wires for the start switch.

Fasten one multimeter lead to the start switch at the connection (terminal) for the wire from the battery. Fasten the other lead to a good ground. A zero reading indicates a broken circuit from the battery. Make a check of the circuit breaker and wiring. If there is a voltage reading, the problem is in the start switch or in the wires for the start switch.

A starter motor that operates too slow can have an overload because of too much friction in the engine being started. Slow operation of the starter motor can also be caused by a short circuit, loose connections and/or dirt in the motor.

Pinion Clearance Adjustment

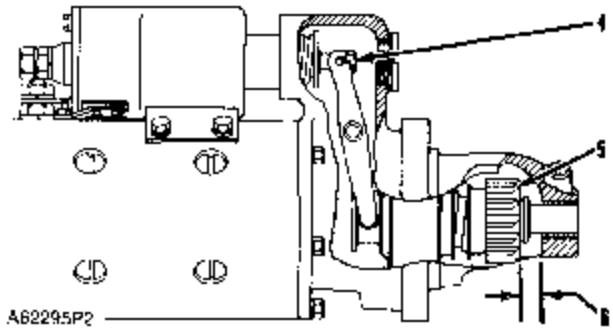
When the solenoid is installed, make an adjustment of the pinion clearance. The adjustment can be made with the starter motor removed.



Connection For Checking Pinion Clearance
(1) Connector (from MOTOR terminal on solenoid to motor). (2) SW terminal (3) Ground terminal.

1. With the solenoid installed on the starter motor, remove connector (1).
2. Connect a battery, of the same voltage as the solenoid, to the SW terminal (2).
3. Connect the other side of the battery to ground terminal (3).

4. Connect for a moment a wire from the solenoid connection (terminal) marked MOTOR to the ground connection (terminal). The pinion will shift to crank position and will stay there until the battery is disconnected.



Pinion Clearance Adjustment
(4) Nut. (5) Pinion. (6) Pinion clearance.

5. Push the pinion toward the commutator end to remove free movement

6. Pinion clearance (6) must be 8.3 to 9.9 mm (.33 to .39 in).

7. To adjust pinion clearance, remove plug and turn nut (4).

8. After the adjustment is completed, install the plug over nut (4) and install connector (1) between the MOTOR terminal on the solenoid and the starter motor.

CATERPILLAR®

SENR5598
October 1995

Disassembly & Assembly

3304B & 3306B Engines For Caterpillar Built Machines

3304B:	3306B:
9CB4600-UP	8Z82840-UP
7Z31600-UP	10Z29500-UP
9Z14100-UP	13Z32475-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operation that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warning in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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⚠ WARNING

Disconnect batteries before performance of any service work.

Disassembly & Assembly

Air Compressor

Remove & Install Air Compressor 1803-010

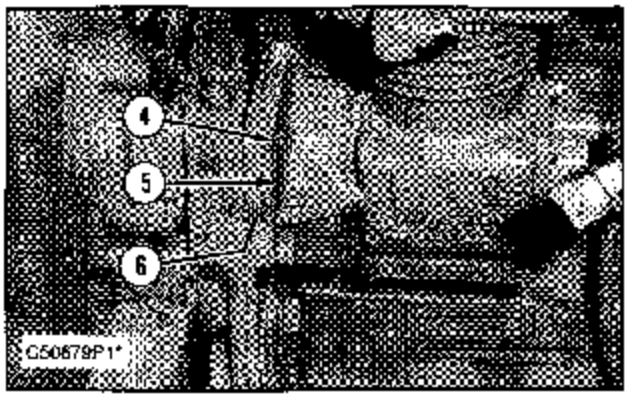
1. Drain the coolant from the radiator.

⚠ WARNING

To prevent possible personal injury, make sure all the pressure in the system has been released before any air lines are disconnected.

2. Open the drain valve on the air tank.

3. Disconnect line (1). Cap or plug immediately.
4. Disconnect line (2) (not shown). Cap or plug immediately.
5. Disconnect two hoses (3). Cap or plug immediately.



6. Remove five bolts (4).
7. Remove air compressor (5) and gasket (6) (not shown). Check gasket for wear or damage. Replace if necessary.

NOTE: When installing gasket, make sure all gasket surfaces are clean and free of dirt.

NOTE: For installation of the air compressor, reverse the removal steps.

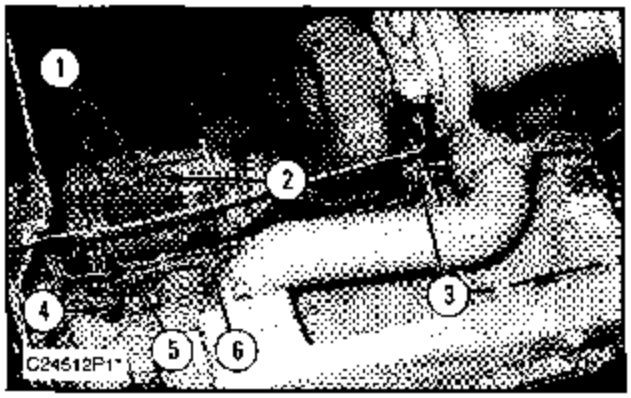
8. Fill the radiator with coolant to the correct level. See the Operation & Maintenance Manual.

Fuel Injection Lines

Remove & Install Fuel Injection Lines 1252-010

Tools Needed	A
5P0144 Socket	1

1. Thoroughly clean the area around each fuel injection line connection before removal of any fuel injection lines.



2. Remove bolts (3) and (5) that fasten the mounting brackets to the cylinder head.

3. Disconnect all fuel injection line nuts (2) at the fuel injection pump housing.

NOTICE

Do not let the tops of fuel injection nozzles (4) turn when fuel injection line nuts (6) are tightened. The nozzles will be damaged if the top of the nozzle turns in the body. The engine will be damaged if a defective fuel injection nozzle is used because the shape of fuel (spray pattern) that comes out of the nozzles will not be correct.

4. Use two wrenches, one to hold fuel injection nozzles (4) so they will not turn and one to disconnect fuel injection lines (1) from the nozzles.

5. Remove fuel injection lines (1) from the engine. Put caps and plugs on the nozzles, fuel injection lines and fuel injection pump housing to keep dirt from entering the fuel system.

NOTE: The following steps are for installation of the fuel injection lines.

6. Make sure the fuel injection lines are clean and dry.

7. Put fuel injection lines (1) in position. Install all fuel injection line nuts (2) and (6) until they are finger tight.

8. Use a torque wrench and Tool (A) to tighten all fuel injection line nuts (2) to a torque of **41 ± 7 N•m (30 ± 5 lb ft)**.

NOTICE

Do not let the tops of fuel injection nozzles (4) turn when the fuel injection lines are tightened. The nozzles will be damaged if the top of the nozzle turns in the body. The engine will be damaged if a defective fuel injection nozzle is used because the shape of fuel (spray pattern) that comes out of the nozzles will not be correct.

9. Use a wrench to hold fuel injection nozzles (4) so they will not turn. Use a torque wrench and Tool (A) to tighten all fuel injection line nuts (6) to a torque of **41 ± 7 N•m (30 ± 5 lb ft)**.

10. Install bolts (3) and (5) that fasten the mounting brackets to the cylinder head.

11. Remove (bleed) the air from the fuel system. See the Operation & Maintenance Manual.

Fuel Injection Nozzles

Remove Fuel Injection Nozzles 1254-011

Tools Needed		A	B
6V6980	Nozzle Puller*	1	
FT1533	Nozzle Adapter*		1
1P0074	Slide Hammer Puller		1

*Part of 6V7020 Nozzle Puller Group

Start By:

a. remove fuel injection lines

1. Remove bolt (1) and clamp (2) from the fuel injection nozzles to be removed.

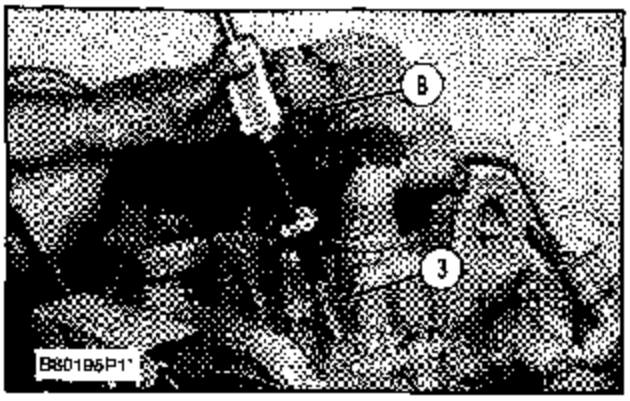
2. Install Tool (A) with the inside lip of the puller on the lower stepped diameter of the nozzle and the tip of the button in the threaded hole for bolt (1).

NOTICE

Do not exceed a torque of 17 N•m (150 lb in) on the screw of Tool (A) during removal of the nozzle. Added force can cause the stem of the nozzle to bend or break off.

3. Tighten the screw of Tool (A) to a maximum torque of **17 N•m (150 lb in)** to remove fuel injection nozzle (3).

4. If the fuel injection nozzle can not be removed with a maximum torque of **17 N•m (150 lb in)** on the screw of Tool (A), remove Tool (A).



Typical Example

5. Remove the protective cap from fuel injection nozzle (3), and install Tool (B) as shown.

NOTICE

Hold Tool (B) so the center line of the tool is in alignment with the centerline of fuel injection nozzle (3). This will prevent distortion of the nozzle which can cause it to bend or break off during removal.

6. Remove the fuel injection nozzle with Tool (B).

7. If Tool (B) was used to remove the fuel injection nozzle, replace the nozzle.

8. If Tool (A) was used to remove the fuel injection nozzle, remove the carbon dam seal on the end of the nozzle.

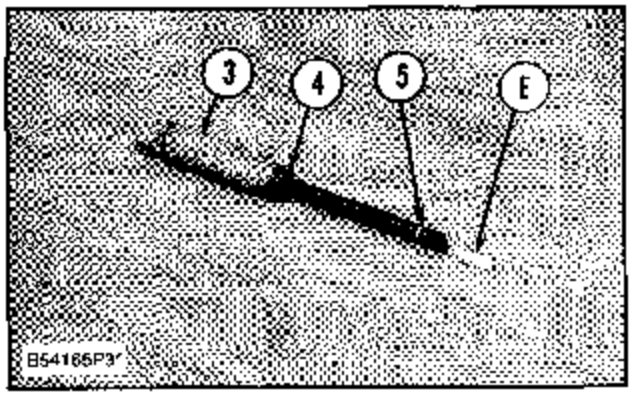
Install Fuel Injection Nozzle 1254-012

Tools Needed		C	D	E
6V4089	Reamer*	1		
BS2245	Cleaning Tool Group		1	
6V4979	Carbon Seal Tool			1

*Part of 6V7020 Nozzle Puller Gp.

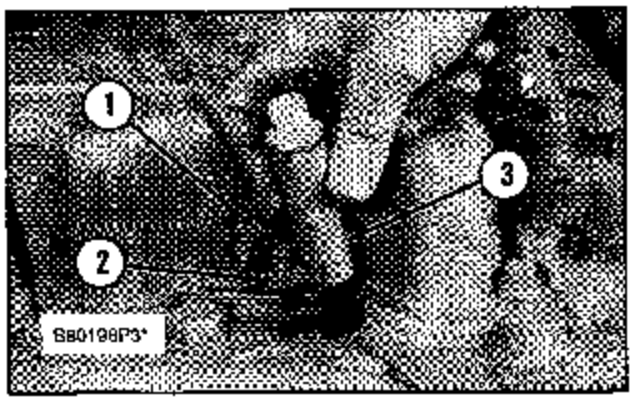
1. Use Tool (C) to clean the bore for the fuel injection nozzle. Use an open end wrench or tap driver to turn Tool (C).

2. Make reference to Special Instruction, Form No. SEHS7292, for the use of Tool (D). Clean the fuel injection nozzle with Tool (D).



3. Install a new seal (4) on fuel injection nozzle (3).

4. Put carbon dam seal (5) on the small end of Tool (E). Expand the carbon dam seal by sliding it to the large end. Put Tool (E) against the fuel injection nozzle. Slide carbon dam seal (5) off Tool (E) on to the nozzle. Slide the carbon dam seal into position in the groove on the nozzle as shown.



5. Put fuel injection nozzle (3) in position in the cylinder head. Install clamp (2) and bolt (1) to hold the nozzle in position.

End By:

a. Install fuel injection lines

Fuel Injection Pump Housing & Governor

Remove Fuel Injection Pump Housing & Governor 1286-011

Tools Needed		A
8S2264	Puller Group	1
8B7560	Step Plate	1
1A2116	Bolt [3/8" - 24 NF x 5 in. (127 mm) long]	2
5P1075	Washer	2

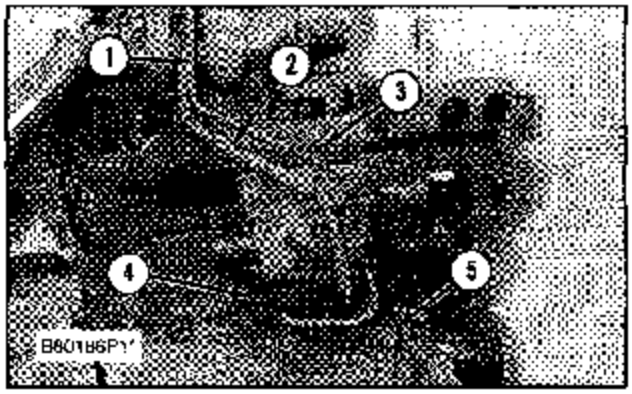
Start By:

a. remove fuel injection lines

b. remove fuel filter and base

c. remove fuel transfer pump

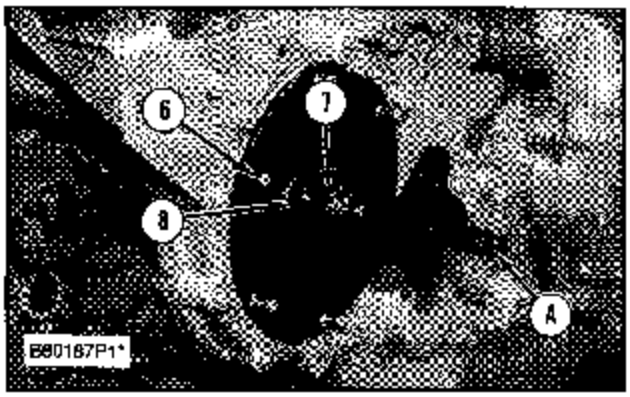
NOTE: The following illustrations are of a 3304B Engine.



1. Disconnect the governor control linkage from the governor.

2. On 3304B Engines only: remove oil supply line (1), oil drain line (2) and heat shield (3). Remove the O-ring seal from oil drain line (2) if it is damaged. Remove the gaskets and screen from the top of the turbocharger.

3. Disconnect fuel drain lines (4) and (5) from the fuel injection pump housing and governor.

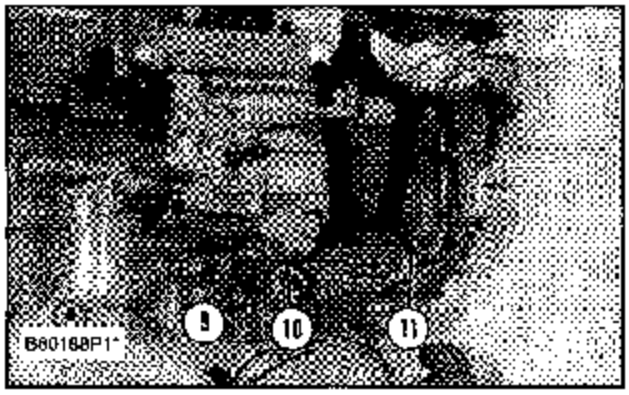


4. Remove the nuts, washers and cover from the timing gear housing. Remove studs (6) if they are damaged or loose.

5. Loosen bolt (7) enough to leave a gap of **3.18 mm (.125 in)** between washer (8) and the fuel pump drive gear.

6. Install Tool (A) as shown. Tighten the stud to pull the fuel pump drive gear loose from the taper on the fuel injection pump camshaft.

7. Remove Tool (A), bolt (7) and washer (8) from the engine.



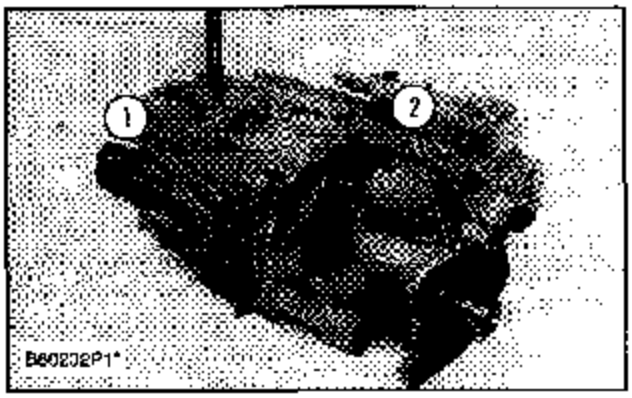
8. Fasten a nylon strap and hoist to the fuel injection pump housing and governor. The 3304B fuel injection pump housing and governor weighs **24 kg (53 lb)**. The 3306B fuel injection pump housing and governor weighs **29 kg (64 lb)**.

9. Remove bolt (9), bolt (10), three nuts (11) and the fuel injection pump housing and governor. Remove the two O-ring seals from the bottom and the two O-ring seals from the front of the fuel injection pump housing and governor.

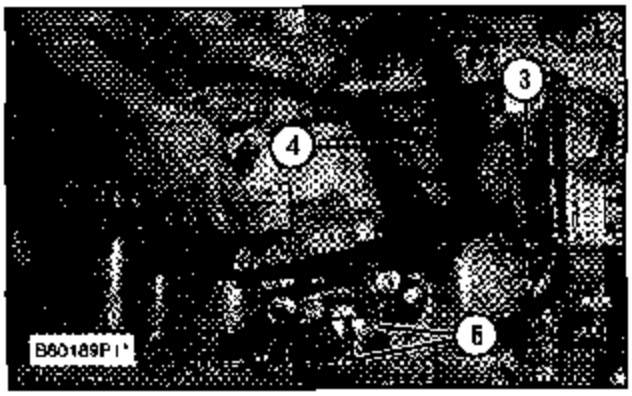
Install Fuel Injection Pump Housing & Governor 1286-012

Tools Needed		A	B
6V4186	Timing Pin	1	
5P7307	Engine Turning Tool Group		1

NOTE: The following illustrations are of a 3304B Engine.



1. Put clean engine oil on the O-ring seals. Install O-ring seals (1) in the bottom and O-ring seals (2) in the front of the fuel injection pump housing and governor.

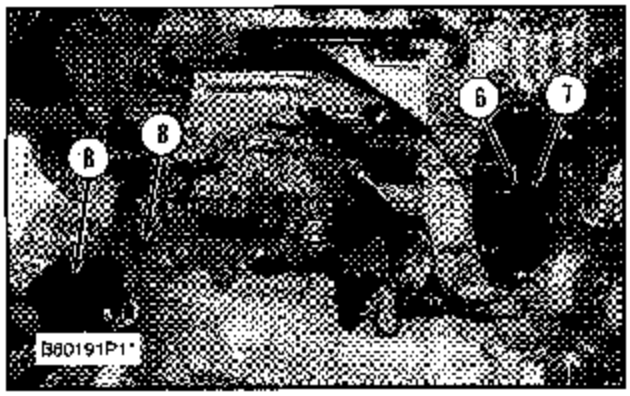


2. Make sure O-ring seals (1) and (2) stay in position in the fuel injection pump housing and governor. Fasten a hoist to the fuel injection pump housing and governor, and put it in position on the engine. Install the two bolts at location (5) and the three nuts on studs (3) to hold the fuel injection pump housing and governor in position.

3. Remove the bolts that hold cover (4) in position. Remove cover (4) and the gasket.

4. Put Tool (A) in position as shown. Install the bolt that holds the fuel pump drive gear to the fuel injection pump camshaft without the washer. This will allow the camshaft in the fuel system to be turned.

5. Put pressure on the end of Tool (A) and turn the camshaft slowly until the Tool drops into the groove (slot) in the camshaft. Leave Tool (A) in position in the groove (slot). Remove the bolt from the end of the camshaft.



6. Install washer (6) with the large diameter toward the front of the engine. Install bolt (7) and tighten it to a torque of **6.8 N•m (60 lb in)**.

7. Install Tool (B) as shown in the flywheel housing.

NOTE: Make sure bolt (7) does not loosen as the flywheel is turned.

8. Use Tool (B), and turn the flywheel in the direction of engine rotation until bolt (8) [3/8" - 16 NC x 4 in. (102 mm) long] can be installed in the flywheel.

NOTE: Do not turn the crankshaft counterclockwise to get bolt hole alignment.

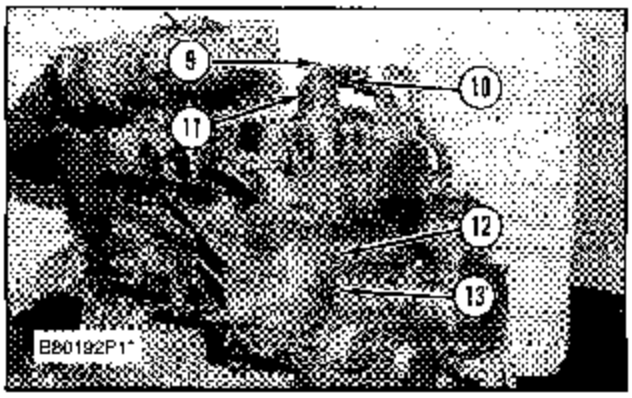
9. If you go past the bolt hole in the flywheel, turn the crankshaft counterclockwise opposite the direction of engine rotation (as seen from the front of the engine) approximately 30 degrees. This procedure will permit the (backlash) gear clearance to be removed from the timing gears when the crankshaft is turned in the direction of engine rotation (clockwise).

10. Loosen the clamp and bolt that hold the breather cap to the valve cover. Remove the breather cap and O-ring seal from the valve cover.

NOTE: The No. 1 piston is at top center on the compression stroke when the bolt can be put in the flywheel through the hole in the flywheel housing, and both rocker arms for the No. 1 piston can be moved by hand (have clearance with the valve stem).

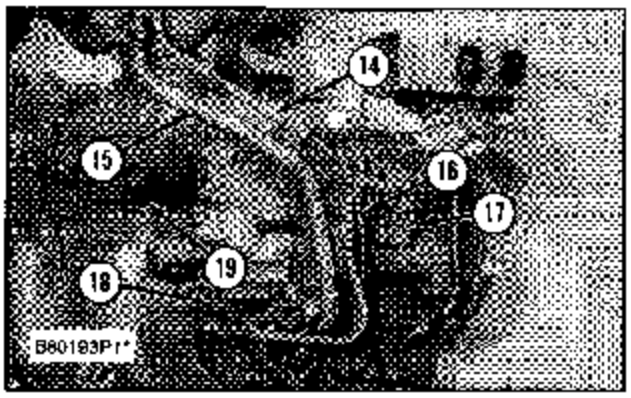
11. When both rocker arms are loose, tighten bolt (7) to a torque of **270 ± 25 N•m (199 ± 18 lb ft)**.

12. Remove Tool (A) and (B) and bolt (8) from the engine.



13. Put the O ring seal and breather cap (11) in position on the valve cover and the hose. Install hose clamp (10) and bolt (9). Tighten bolt (9) to a torque of **14 ± 3 N•m (10 ± 2 lb ft)**.

14. If studs (12) were removed, put **5P3413 Pipe Sealant** with Teflon on them, and install them in the timing gear cover. Put the gasket and cover (13) in position, and install the washers and nuts that hold them. Tighten the nuts to a torque of **27 ± 7 N•m (20 ± 5 lb ft)**.



15. Install the gasket, cover (17) and the bolts that hold it.

16. Connect fuel drain lines (16) and (18). Install heat shield (19).

17. On 3304B engines, install the strainer assembly in the turbocharger with the screen down. Install the gasket, oil inlet line and the bolts that hold them. Install the O-ring seal on oil drain line (15). Put clean engine oil on the O-ring seal and install the gasket, oil drain line and the bolts that hold them. Install the clamp that holds the oil lines together.

18. Connect the governor control linkage to the fuel injection pump housing and governor.

End By:

a. install fuel transfer pump

b. install fuel filter and base

c. install fuel injection lines

Governor

Disassemble Governor 1264-015

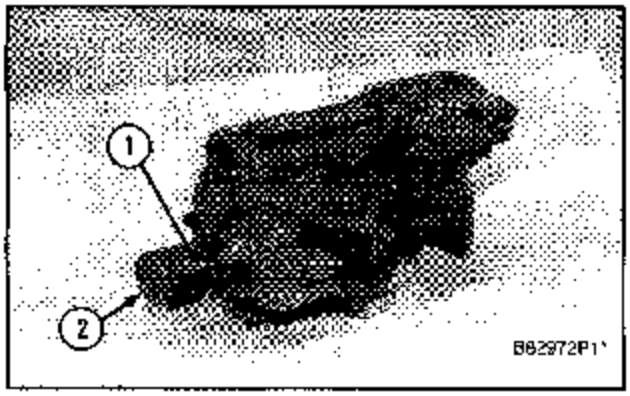
Tools Needed		A	B	C
1P0510	Driver Group	1		
1P1855	Pliers		1	
6V2163	Compressor Clamp*			1

* Part of 6V4095 Pump And Governor Reconditioning Tool Group

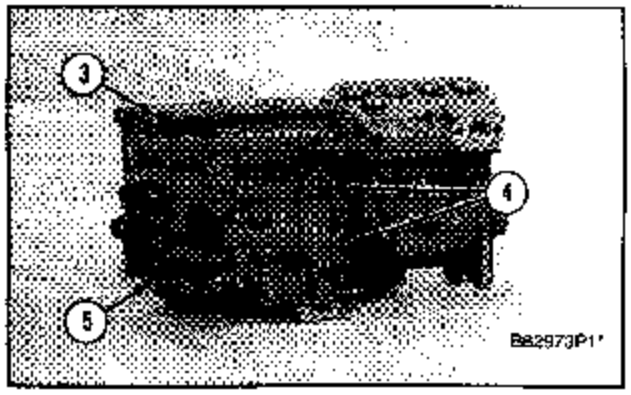
Start By:

a. remove fuel injection pump housing and governor

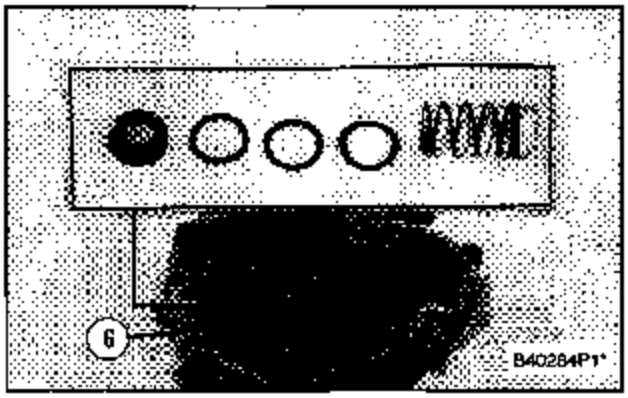
NOTE: If it is desired to remove only the governor so the fuel injection pump housing can be disassembled, do only Steps 1, 2, 15, 21, 25, 26, 27, 28, 31, 33, 34 and 37.



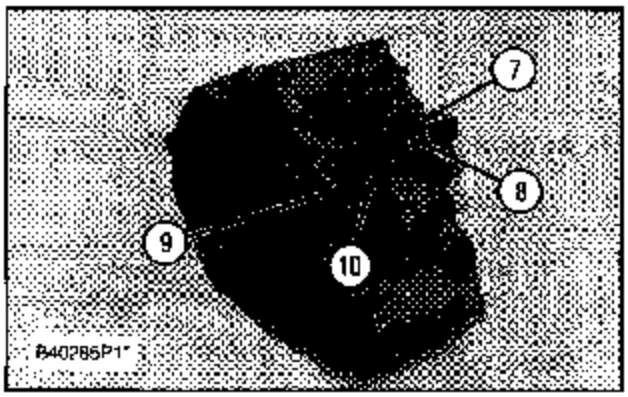
1. Remove bolts (1), the clamps and service motor (2) (if equipped).



2. Remove six bolts (3), two top bolts (4), housing (5) and the gasket.

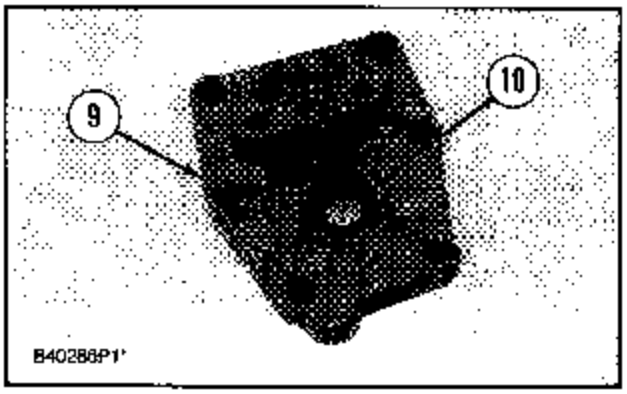


3. Remove governor spring (6), the two wave washers, one flatwasher and seat from the guide in the housing.

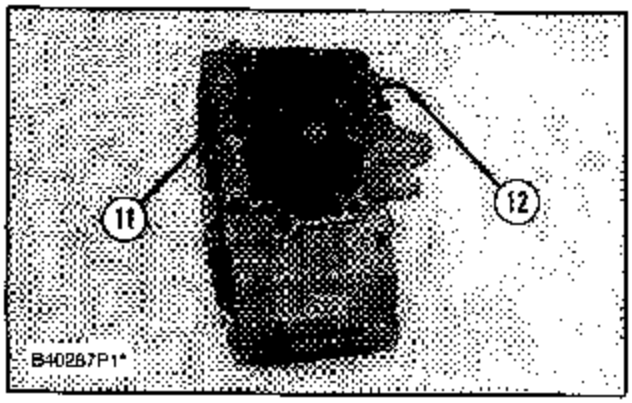


4. Mark the position of lever (7) on shaft (8). Loosen bolt (10). Use a chisel or screwdriver to expand lever (7) so it can be removed from shaft (8).

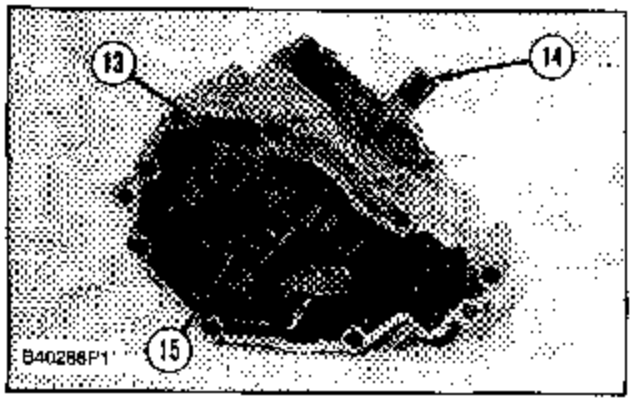
5. Remove cover assembly (9).



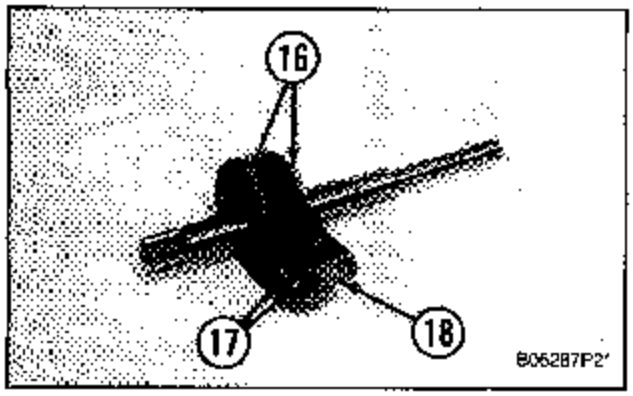
6. Use Tool (A) to remove seal (10) from cover (9).



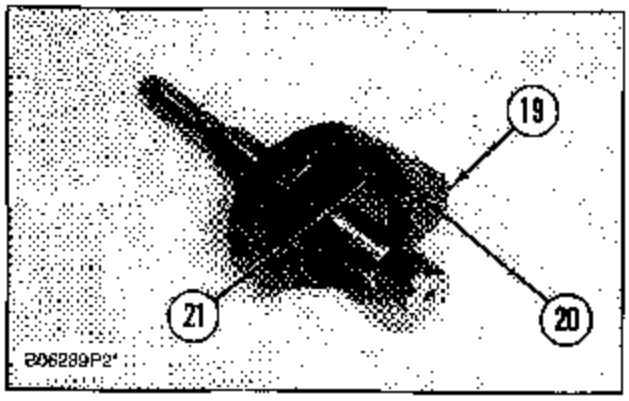
7. Remove low idle adjustment screw (12) and spring (11) from the housing.



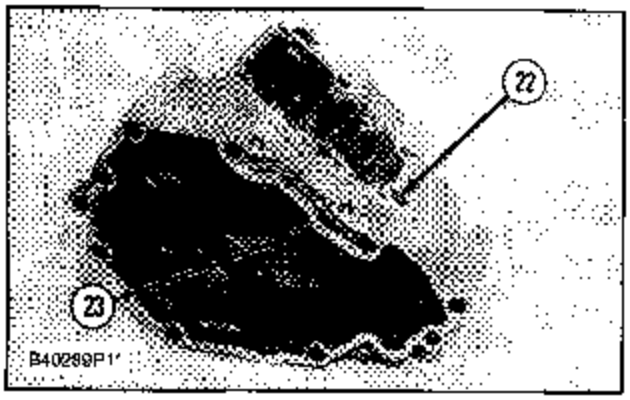
8. Remove shaft assembly (14), lever (13) and lever (15) from the housing.



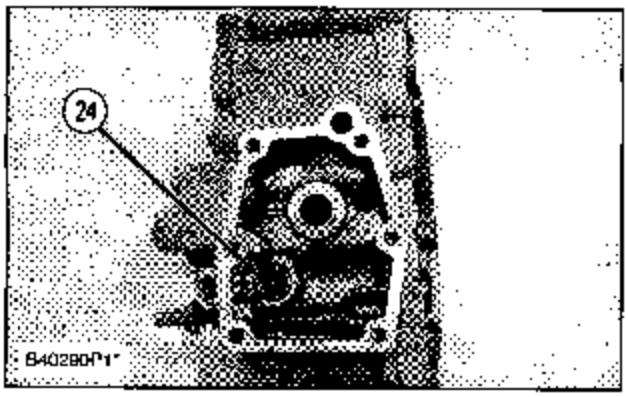
9. Remove two snap rings from pins (17), and remove pins (17). Remove plates (16) and stop (18) from the shaft assembly.



10. Remove pin (20), pin (19) and spring (21) from the shaft assembly.



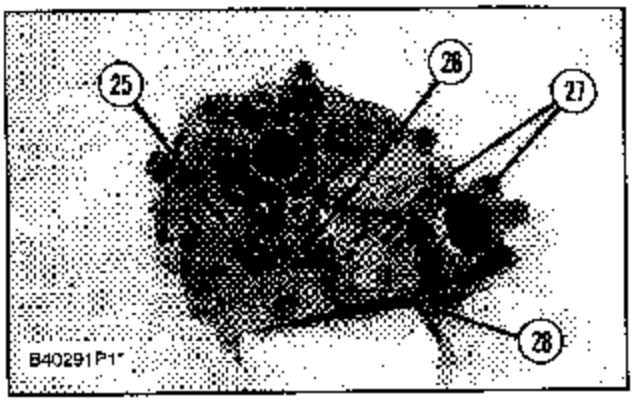
11. Remove shaft (22) and lever (23) from the housing.



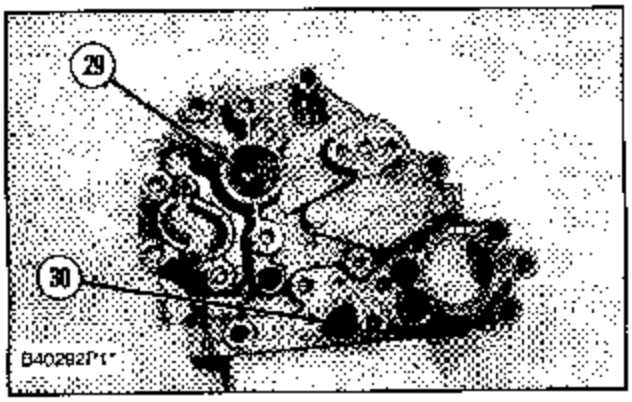
NOTICE

Remove check valve (24) only if a replacement is necessary because the check valve will be damaged during removal.

12. Remove check valve (24) if a replacement is necessary.

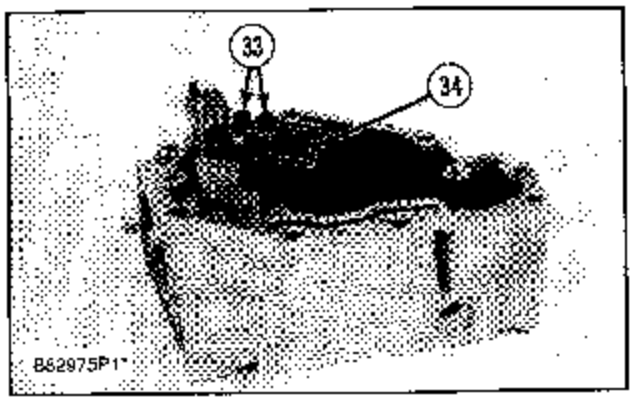


13. Remove contact (25) and body (26) for the governor dashpot adjustment screw from the housing. Remove bolts (27), cover (28) and the gasket from the housing.



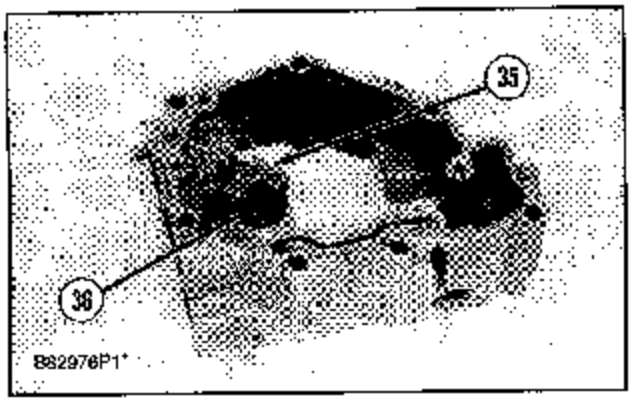
14. Remove seal (29) and adjustment screw (30) for high idle.

15. Remove two bolts (31), housing (32) and the gasket from the fuel injection pump housing.

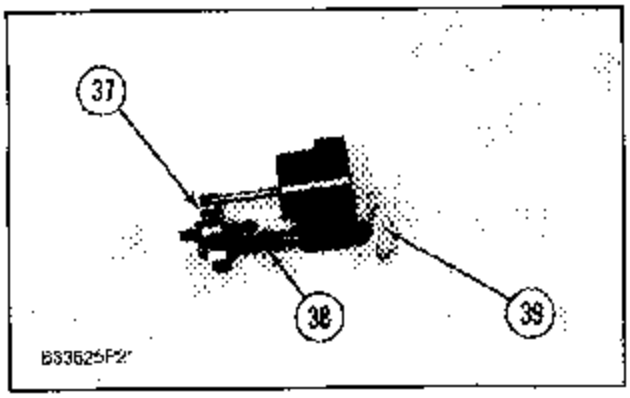


16. Remove bolts (33) and torque control group (34).

17. Disassemble the torque control group and inspect the spacer, spring and insulator for damage or wear.

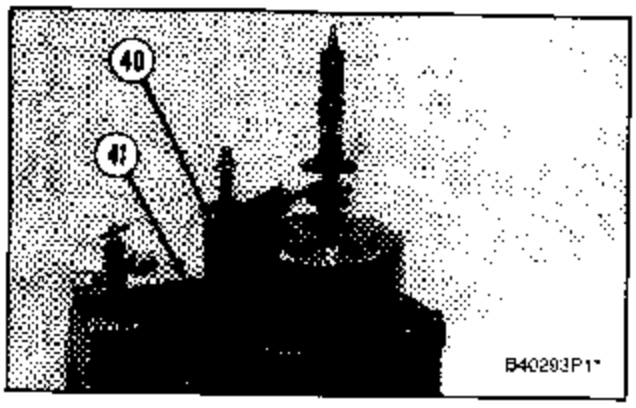


18. Remove bolts (36) and block (35) for the full load step from the housing.

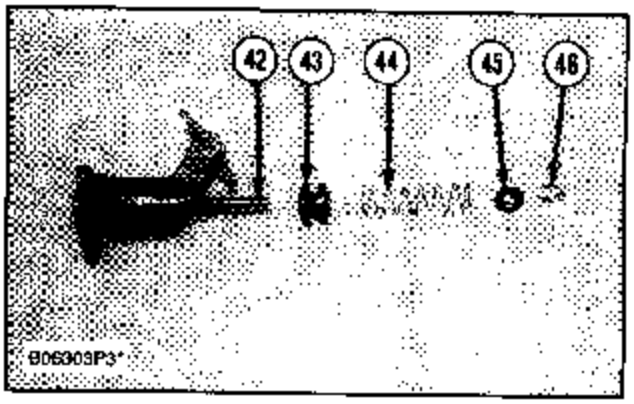


19. Remove the bolt that holds collar (37) to bolt (39). Remove collar (37) and spring (38) from bolt (39). Remove bolt (39) from the block.

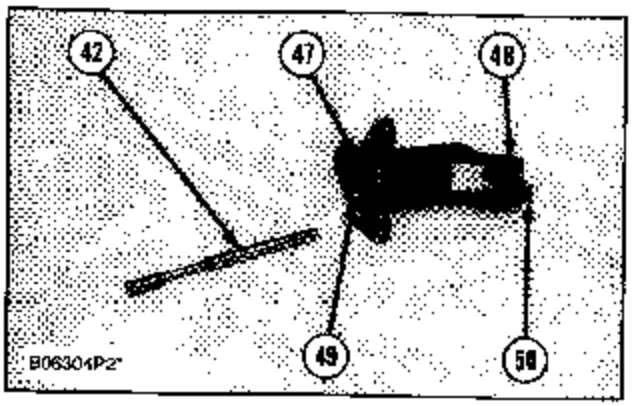
20. Remove the stop screw from collar (37) if a replacement is necessary.



21. Remove bolts (41) and governor servo (40) from the fuel injection pump.



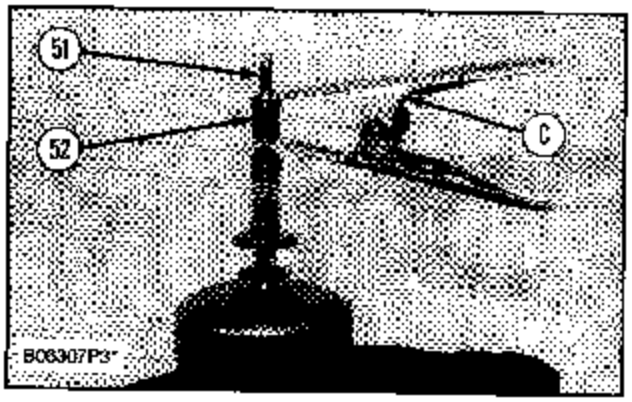
22. Remove lockring (46), seat (45), spring (broken link spring) (44) and sleeve (43) from valve (42). Remove the other lockring (46) from the groove in the center of valve (42).



NOTE: The groove in the bottom of valve (42) must be in alignment with the servo body to permit removal from the fuel rack.

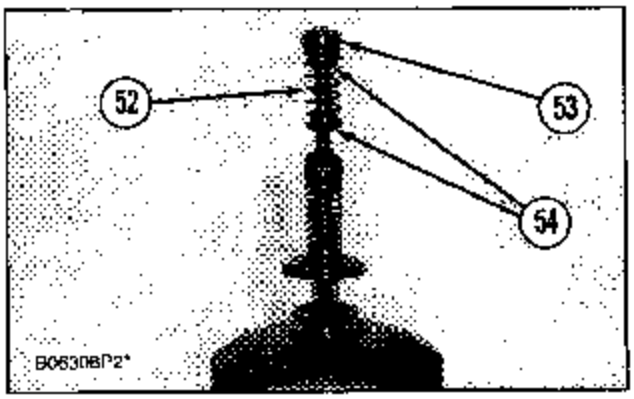
23. Remove valve (42), sleeve (47) and piston (49) from the governor servo. Remove the O-ring seal from sleeve (47).

24. Remove pin (48) and lever (50) from the governor servo.

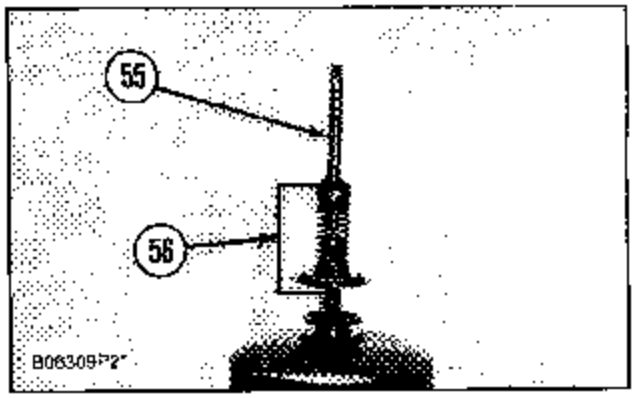


25. Use Tool (C) to hold spring (52) under compression so ring (51) can be removed. Spring (52) is used to put a preload on the thrust bearing for the camshaft in the fuel injection pump housing.

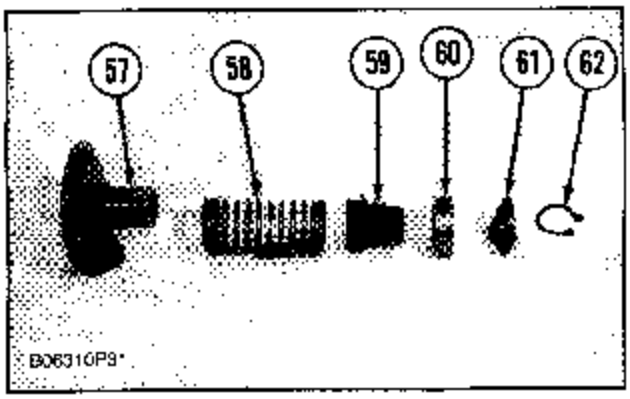
26. Remove ring (51). Remove Tool (C).



27. Remove bearing (53), sleeves (54) and spring (52) from the governor shaft.

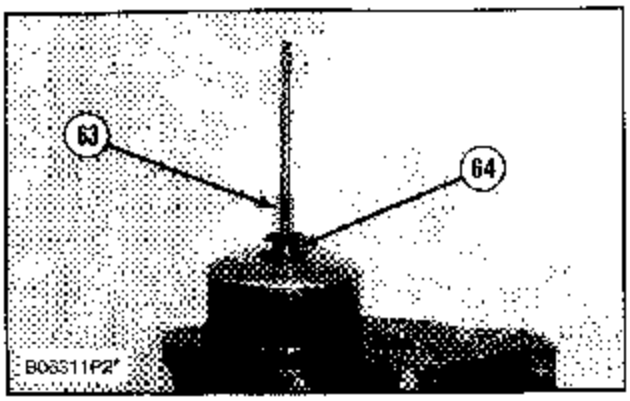


28. Remove ring (55) and dashpot assembly (56) from the governor shaft.

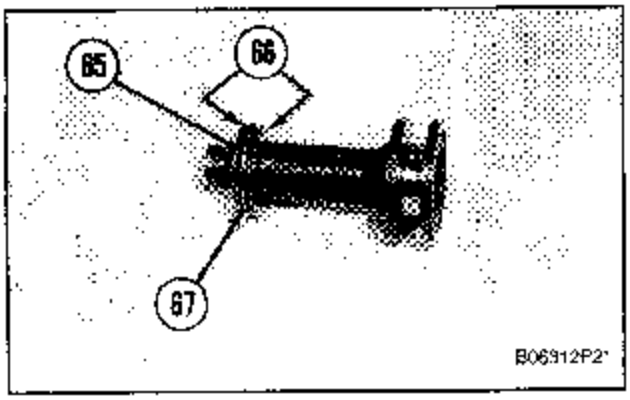


29. Use Tool (B) to remove snap ring (62) from seat (59). Remove ring (61) and spool (60) from seat (59).

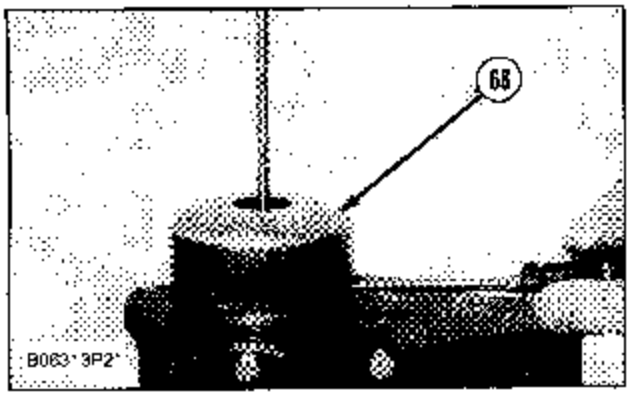
30. Remove seat (59) from spring (58), and remove spring (58) from seat (57).



31. Remove spring (overfueling spring) (63) and riser (64) from the governor shaft.



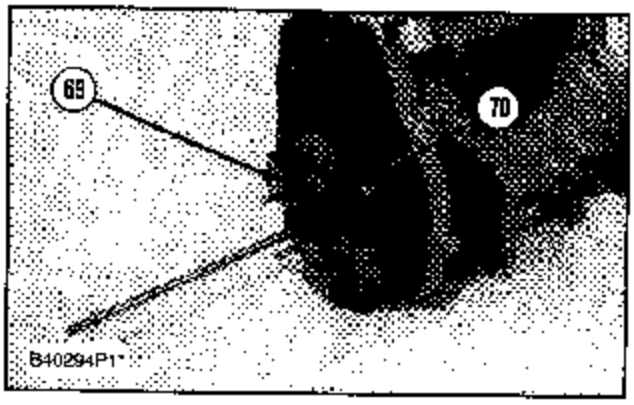
32. Remove ring (65), races (66) and bearing (67) from the riser.



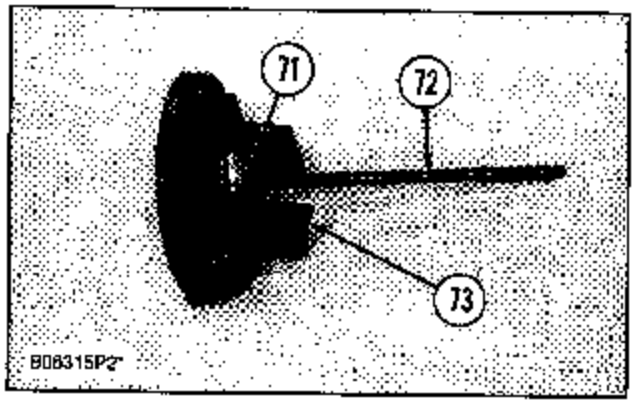
NOTICE

Make a replacement of shield (68) any time it is removed.

33. Use a screwdriver to remove shield (68) as shown.

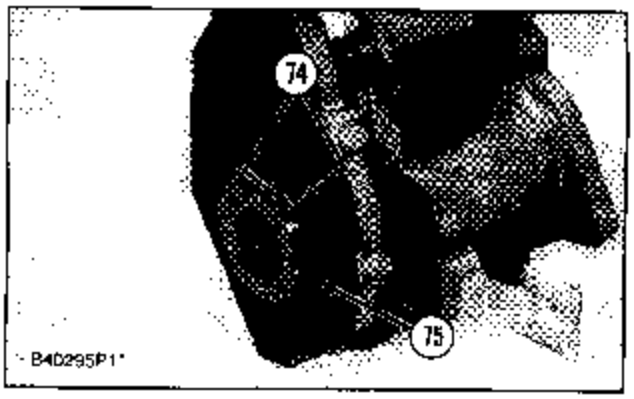


34. Remove bolts (69) and carrier (70) for the governor flyweights.



35. Remove dowels (71) and flyweights (73) from the carrier.

36. Remove shaft (72) from the carrier. Remove the dowel from shaft (72).



37. Remove races (74) and bearing (75) from the camshaft in the fuel injection pump housing.

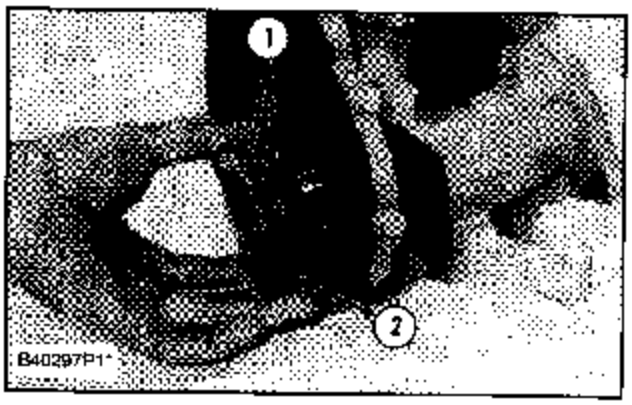
Assemble Governor 1264-016

	Tools Needed	A	B	C	D
6V2054	Shield Driver*	1			
1P1855	Pliers		1		
6V2163	Compressor Clamp			1	
1P0510	Driver Group				1

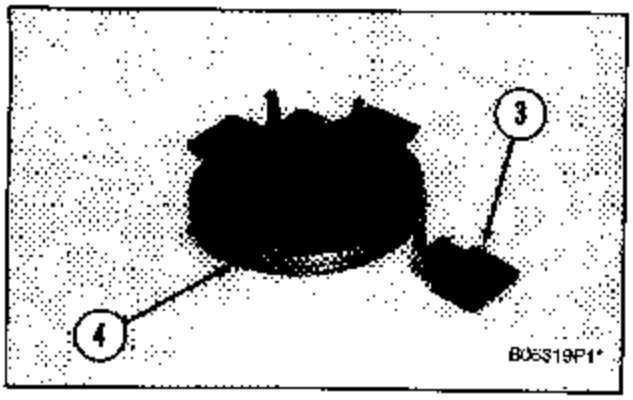
* Part of 6V4095 Pump And Governor Reconditioning Tool Group

NOTE: If the governor was removed only for repair of the fuel injection pump housing, do only Steps 1, 4, 5, 7, 9, 10, 11, 16, 22, 36, 39 and 40.

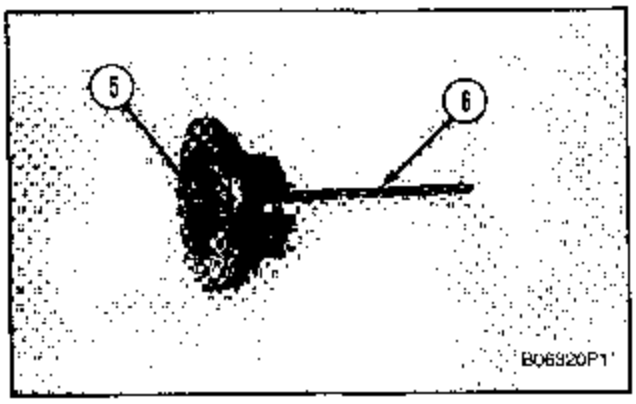
NOTE: Put clean engine oil on all parts before assembly. Be sure all oil passages are clean.



1. Install one race (1), bearing (2) and the other race (1) on the camshaft in the fuel injection pump housing as shown.

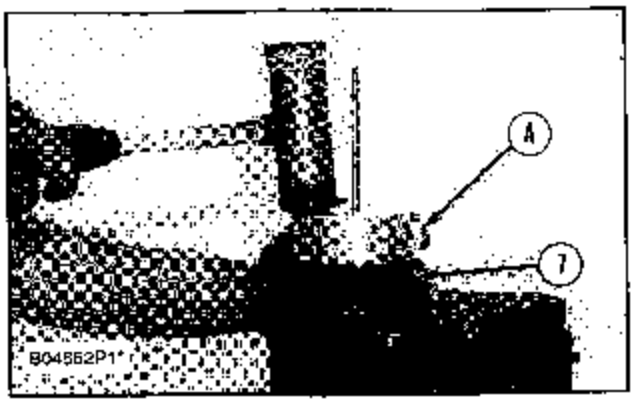


2. Put flyweights (3) in position on carrier (4), and install the dowels to hold the flyweights in place. The flyweights must move freely on the dowels and have **0.010 to 0.23 mm (0.0004 to 0.009 in)** end play.



3. Install dowel (5) in governor shaft (6). Install the governor shaft in the carrier as shown.

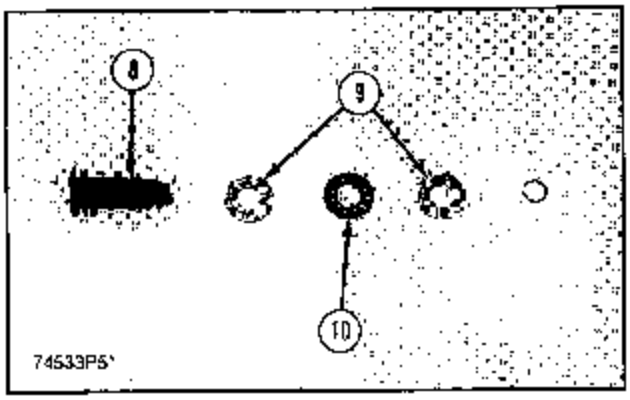
4. Put the carrier in position on the camshaft. Install the bolts that hold the carrier in place.



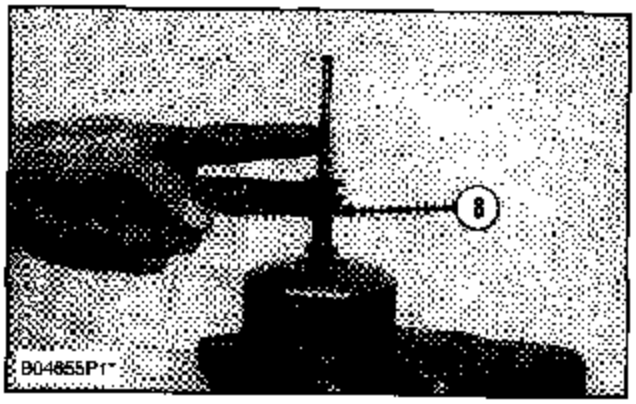
NOTICE

Replace shield (7) with a new part any time it is removed.

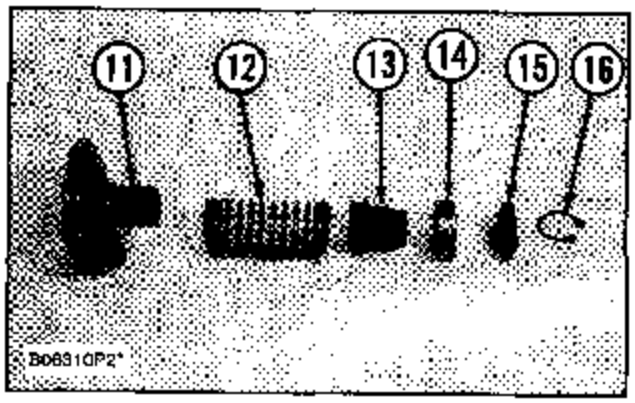
5. Install shield (7) on the carrier, and use Tool (A) to push the shield against its seat. Use a hammer and punch to stake the metal in two places on the side of the shield **180° ± 5°** apart next to the holes in the shield.



6. Install one race (9), bearing (10), the other race (9), and use Tool (B) to install the ring on riser (8) as shown.



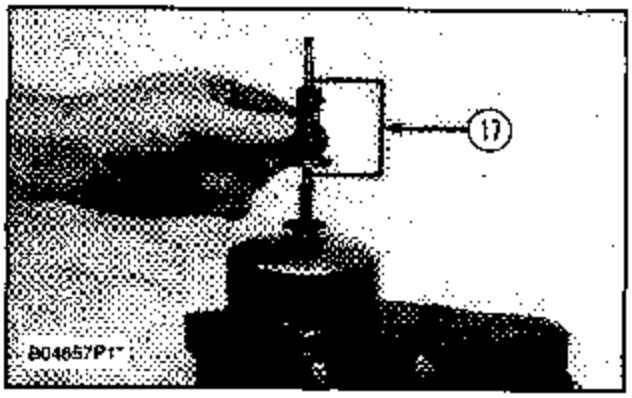
7. Install riser (8) and the spring (overfueling spring) on the governor shaft as shown.



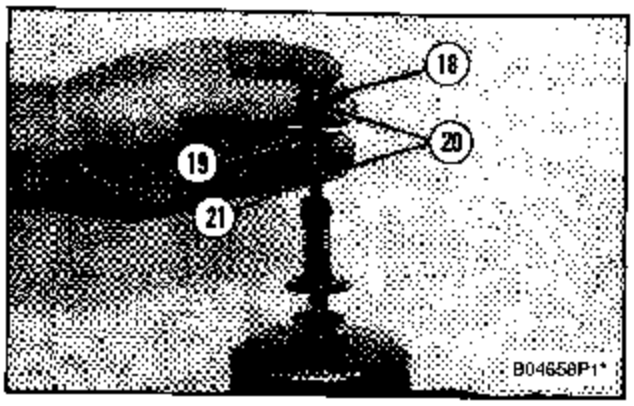
8. Assemble the dashpot as follows:

a. Install spring (12) on seat (11). Install seat (13) in spring (12).

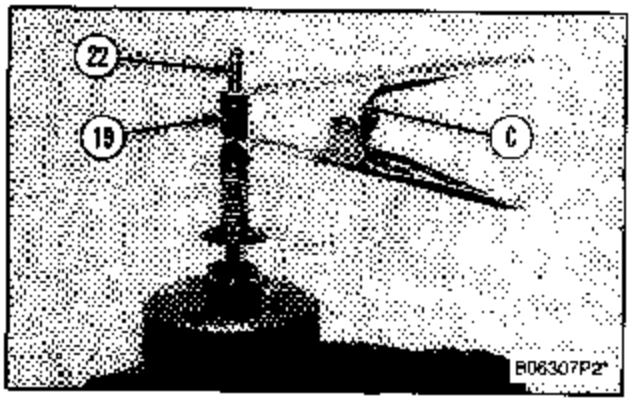
b. Put spool (14) and ring (15) in position on seat (13). Use Tool (B) to install snap ring (16) to hold them in place.



9. Install dashpot assembly (17) on the governor shaft as shown.

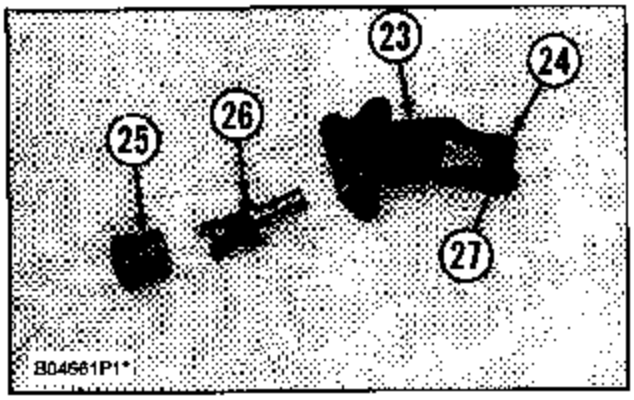


10. Install ring (21) in the lower groove in the governor shaft. Install one sleeve (20), spring (19) the other sleeve (20) and bearing (18) on the governor shaft as shown.



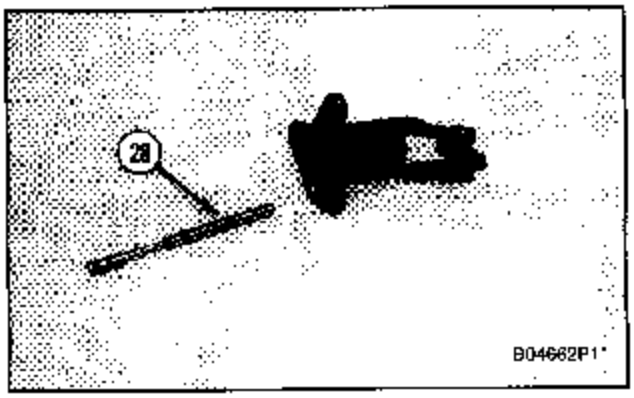
NOTE: Spring (19) is used to put a preload on the thrust bearing on the camshaft in the fuel injection pump housing.

11. Use Tool (C) to hold spring (19) under compression. Install ring (22) in the groove in the governor shaft. Remove Tool (C).

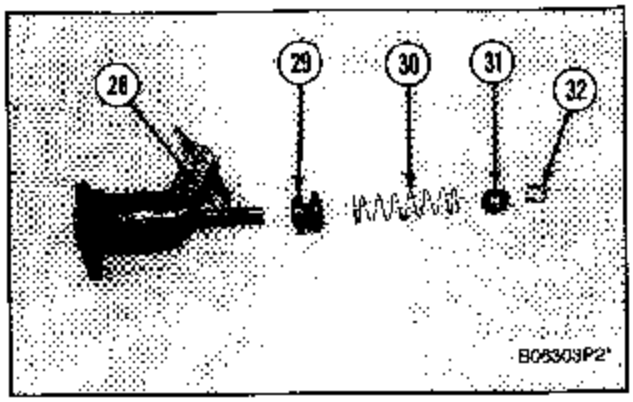


12. Put lever (27) in position on governor servo (23). Install pin (24) to hold the lever in place. Use a hammer and chisel to stake the metal four places **90°** apart on the outside surface on both legs of the governor servo to hold pin (24) in place.

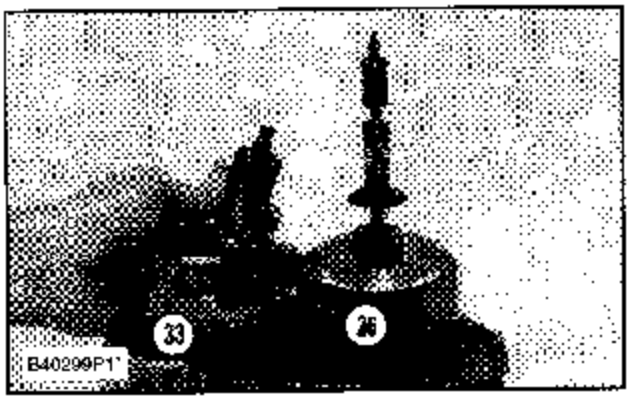
13. Install the O-ring seal on sleeve (25). Install piston (26) and sleeve (25) in the governor servo as shown.



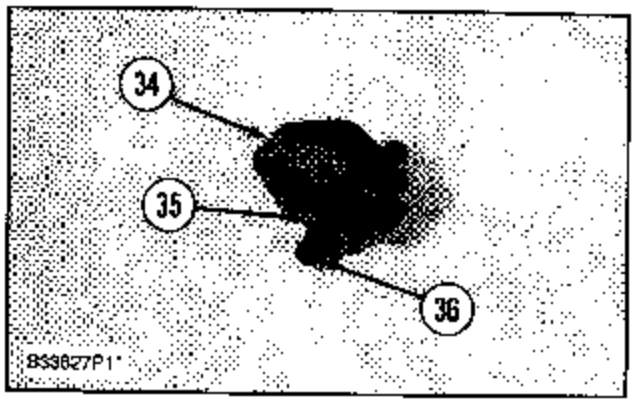
14. Install valve (28) in the governor servo as shown.



15. Install one lockring (32) in the groove near the center of valve (28). Put sleeve (29), spring (broken link spring) (30) and seat (31) in position on valve (28). Install the other lockring (32) to hold the components in place.

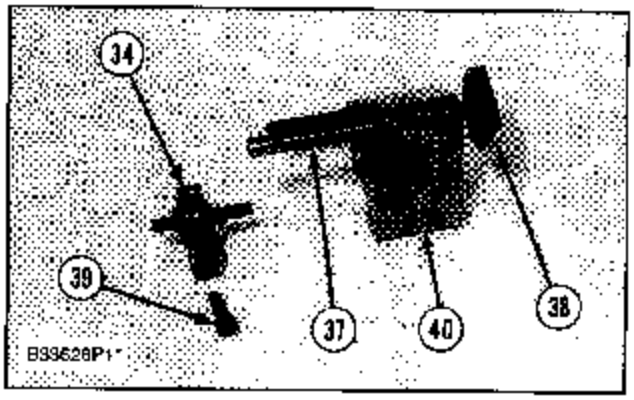


16. Put the governor servo in position on the fuel injection pump housing with piston (26) engaged over rack (33). Install the bolts that hold the governor servo in place.

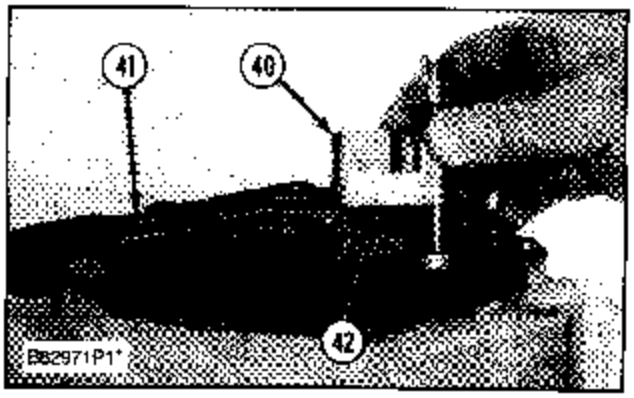


NOTE: The 3306B Engine has two adjustment screws and lock nuts.

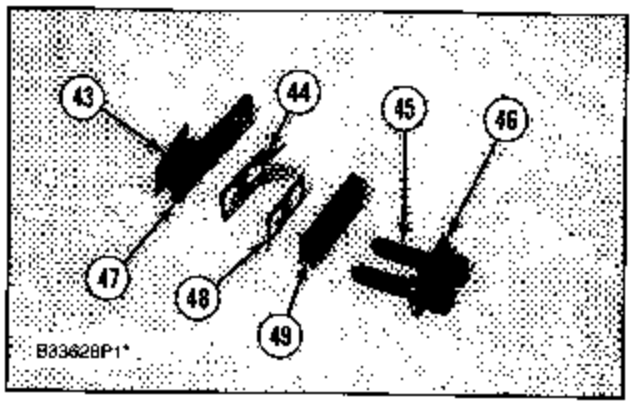
17. Install torque rise adjustment screw (36) in collar (34) as shown. Install locknut (35) on the screw.



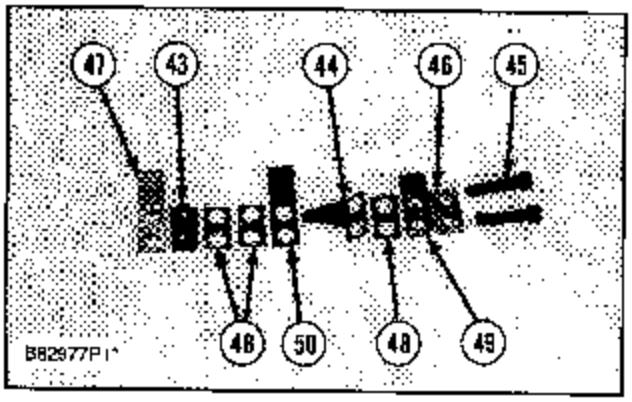
18. Install bolt (38) in block (40) as shown. Install spring (37) on bolt (38) as shown. Put collar (34) in position on bolt (38) with the hole in the collar in alignment with the notch in bolt (38). Install bolt (39) to hold the collar in place.



19. Put block (40) in position on housing (41) with the holes in the block in alignment with dowels (42). Install the bolts that hold the block in place.



3304B Engine Shown

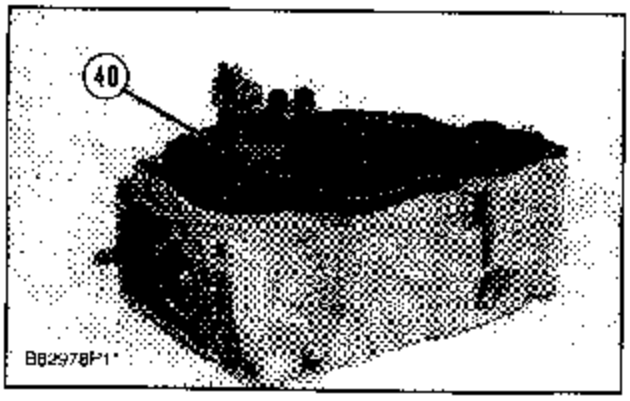


3306B Engine Shown

20. Assemble the torque control group as follows:

a. On 3304B Engines, put retainer (46), bar (49), spacer (48), contact (44), bar (47) and insulator (43) in position on bolts (45).

b. On 3306B Engines, put retainer (46), bar (49), one spacer (48), contact (44), spring (50), two spacers (48), insulator (43) and bar (47) in position on bolts (45).

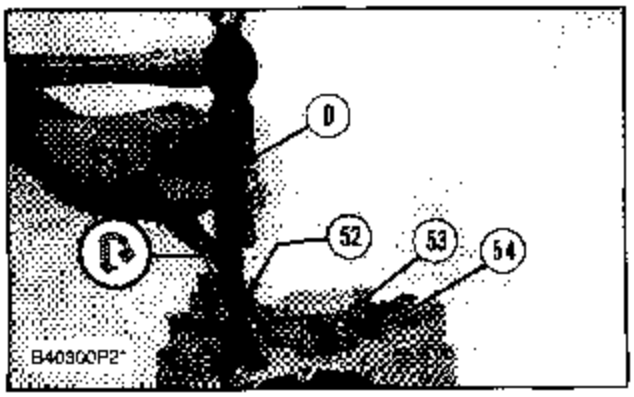


21. Install the torque control group on block (40) as shown.

⚠ WARNING

If housing (41) is installed with the flange on bolt (38) on the wrong side of the dashpot, the riser in the governor will be held in the maximum fuel delivery position. To prevent possible personal injury make sure housing (41) is installed on the fuel injection pump housing with the flange on bolt (38) behind the dashpot.

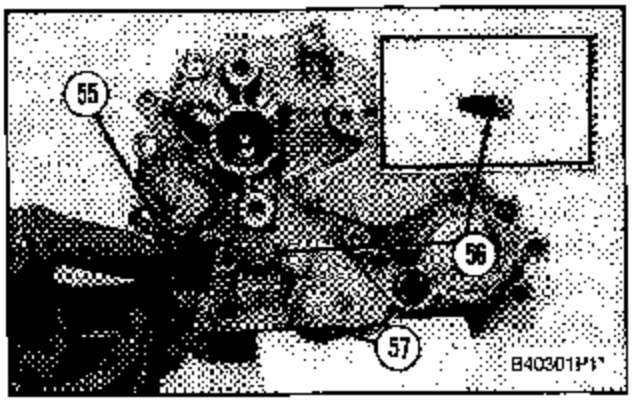
22. Put gasket (51) in position on the fuel injection pump housing. Put housing (41) in position on the fuel injection pump housing with bolt (38) behind the dashpot as shown. Install the bolts that hold housing (41) in place.



23. Use Tool (D) to install lip type seal (52) in the governor outer housing with the lip in as shown.

24. Install adjustment screw (53) and the locknut for the high idle adjustment.

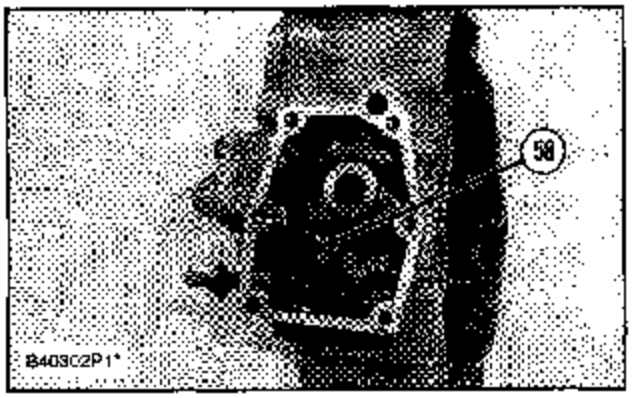
25. Make a replacement of screen assembly (54) and the seal for the fuel ratio control.



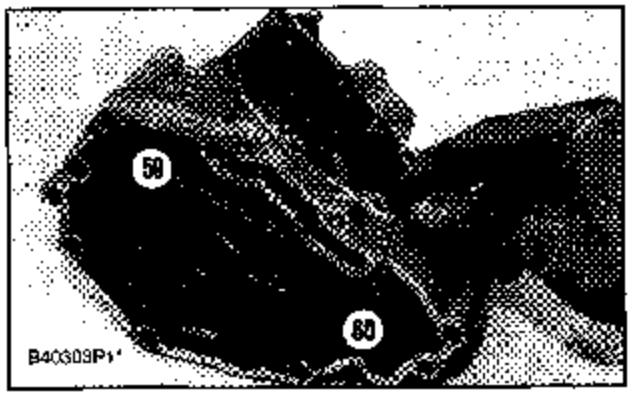
26. Install an O-ring seal on body (56) for the dashpot adjustment and install the body in the housing.

27. Install gasket and cover (57) on the housing.

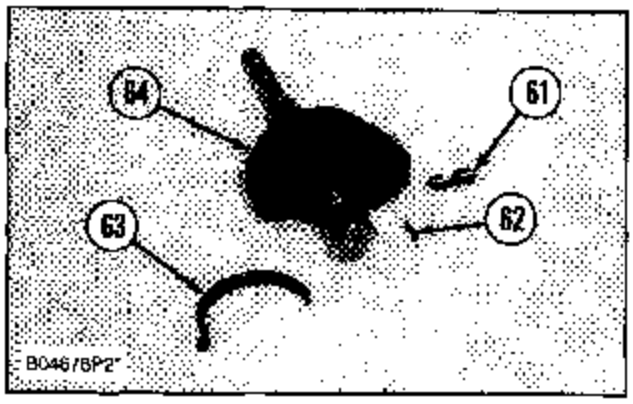
28. Install contact (55) in the housing, and tighten it to a torque of **4.5 ± 0.6 N•m (40 ± 5 lb in)**.



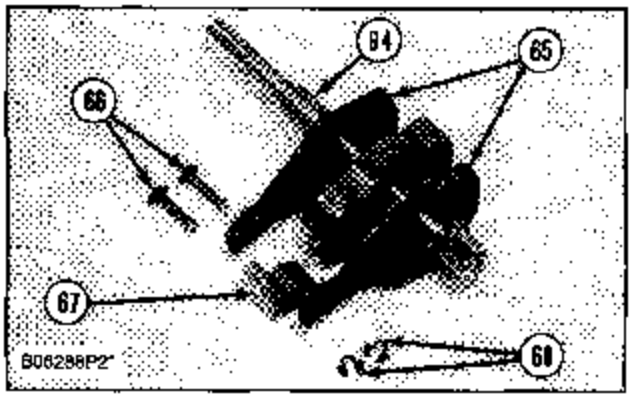
29. Install check valve (58) in the housing as shown.



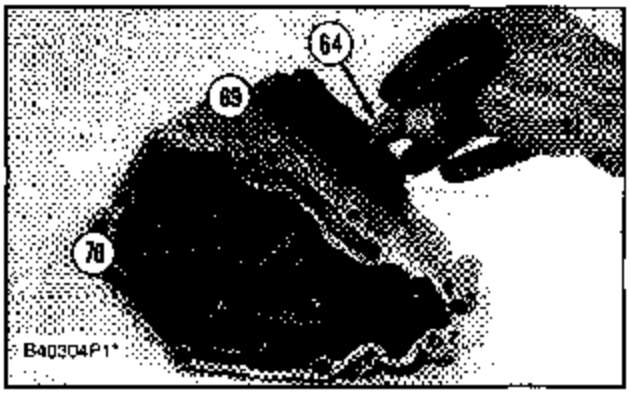
30. Put lever (59) in position in the housing as shown. Install shaft (60) to hold the lever in place.



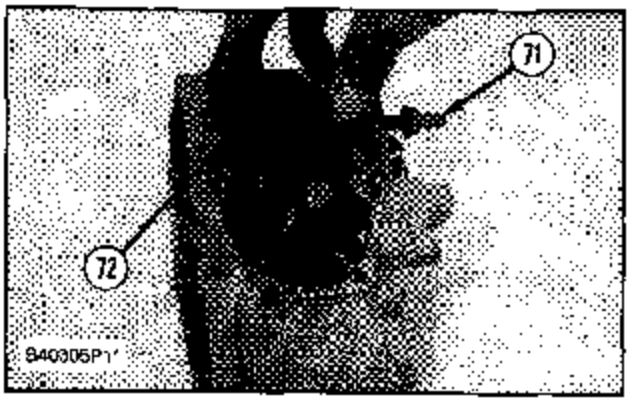
31. Install spring (63) in shaft assembly (64). Install pin (61) in the shaft assembly (64) with the tip of the pin engaged in the hole in spring (63). Install pin (62) in the shaft assembly to hold pin (61) in place.



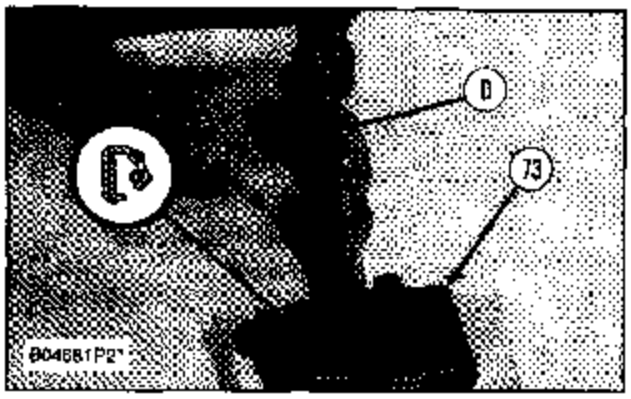
32. Put stop (67) and plates (65) in position on shaft assembly (64). Install pins (66) to hold the plates and stop in place. Install snap rings (68) to hold pins (66) in place.



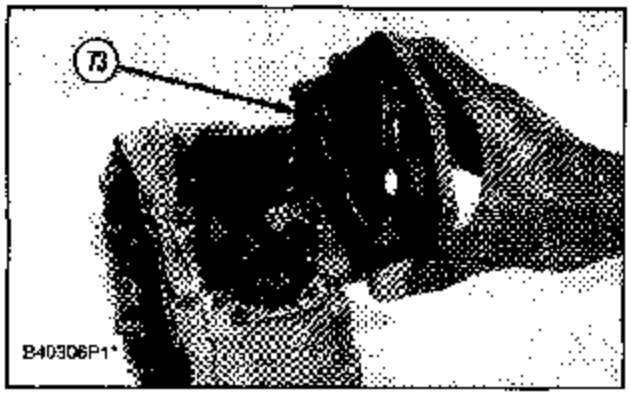
33. Put levers (69) and (70) in position in the housing as shown. Install shaft assembly (64) to hold the levers in place.



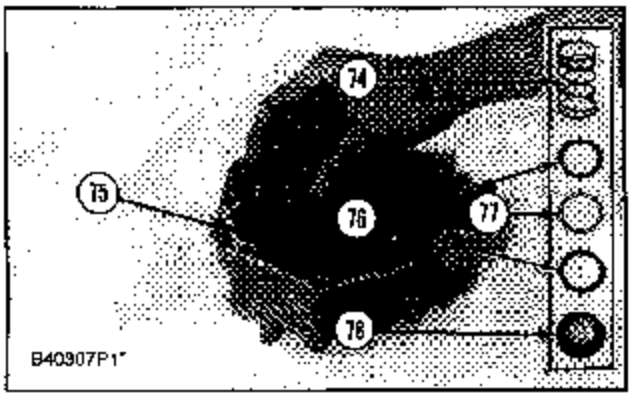
34. Install adjustment screw (71) and the locknut for the low idle adjustment in the housing. Install spring (72) in the hole in the shaft assembly and in the housing.



35. Use Tool (D) to install the lip type seal in cover (73) with the lip in as shown.



36. Put the gasket and cover (73) in position on the housing, and install the bolts that hold it in place.

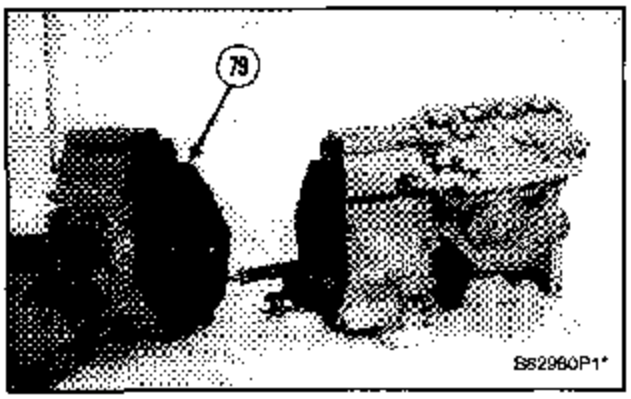


NOTICE

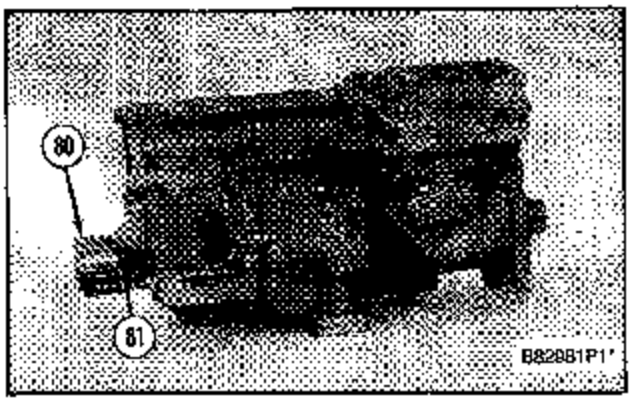
Flat washer (77) must be installed between wave washers (76).

37. Install the governor spring assembly on guide (75) as follows: install seat (78), one wave washer (76), flat washer (77), the other wave washer (76) and spring (74) on guide (75) as shown.

NOTE: Make sure the seal, washers and spring are on top of the lever as shown. These parts must be kept in this position when housing (79) is put in position on the inner governor housing.



38. Put the gasket and housing (79) in position on the inner governor housing. Install the nine bolts that hold it in place.



39. Put service meter (80) (if equipped) in position. Install clamps (81) and the bolts that hold them.

40. Adjust the governor. See "Governor Adjustments" in Testing & Adjusting.

End By:

a. install fuel injection pump housing and governor

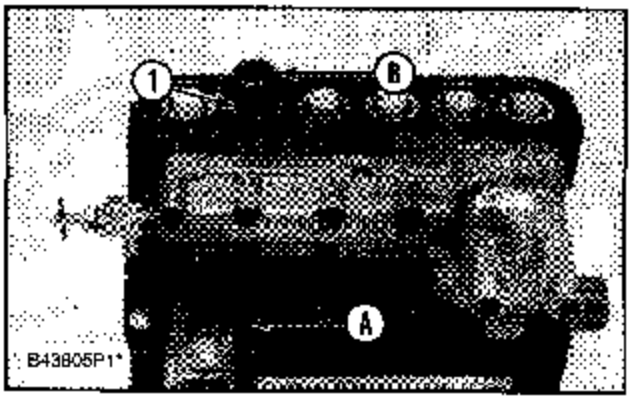
Fuel Injection Pumps

Remove Fuel Injection Pumps 1251-011

Tools Needed		A	B	C
6V4186	Timing Pin	1		
9S4613	Wrench		1	
6S2244	Extractor			1

Start By:

a. remove governor

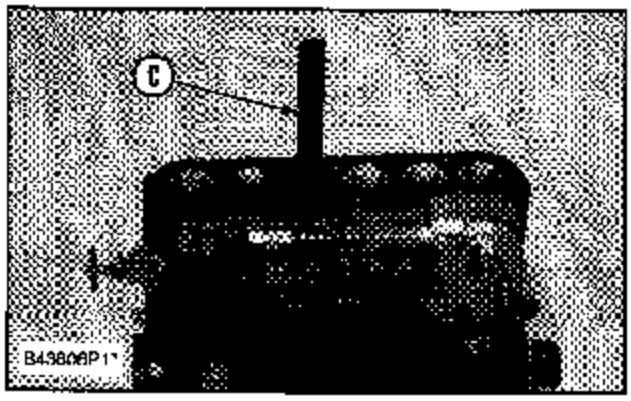


1. Remove the bolts and the plate from the side of the fuel injection pump housing.

2. Install Tool (A) in the fuel injection pump housing. Move the rack until Tool (A) can be installed to hold the rack in the center position. The rack must be in the center position to remove the fuel injection pumps.

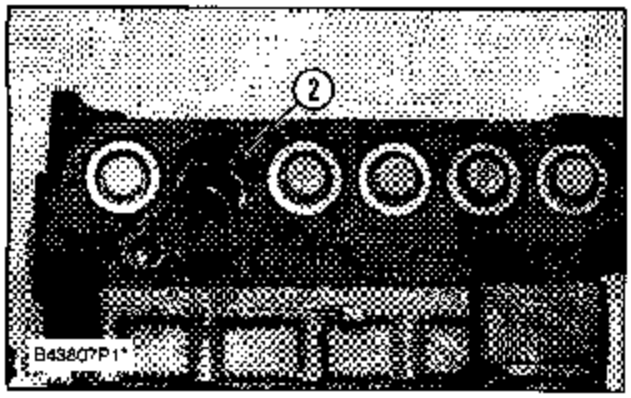
3. Use Tool (B) to remove bushing (1) from the fuel injection pump housing.

4. Remove the O-ring seal from the fuel injection pump housing.



NOTE: Spacers (2) are the same thickness for each fuel injection pump so they can be mixed. The fuel injection pump plungers and barrels are sets and can not be mixed.

5. Install Tool (C) on the bonnet. Remove the fuel injection pump.

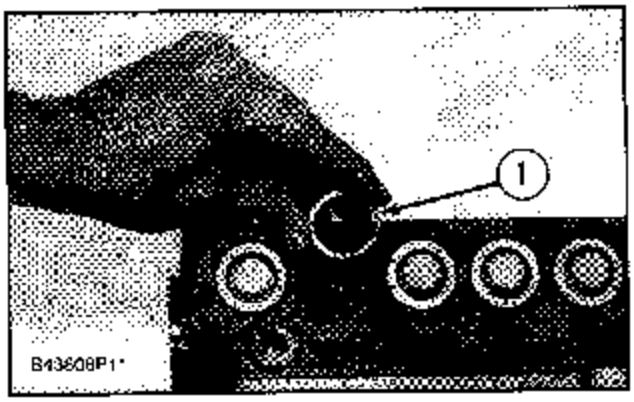


6. Remove spacer (2) from the fuel injection pump housing.

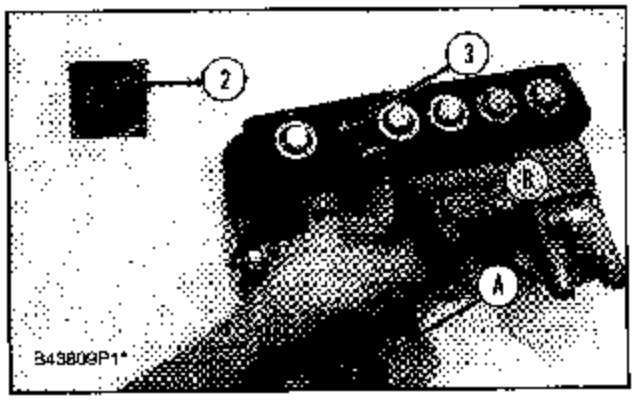
7. Do Steps 3 through 6 to remove the other fuel injection pumps.

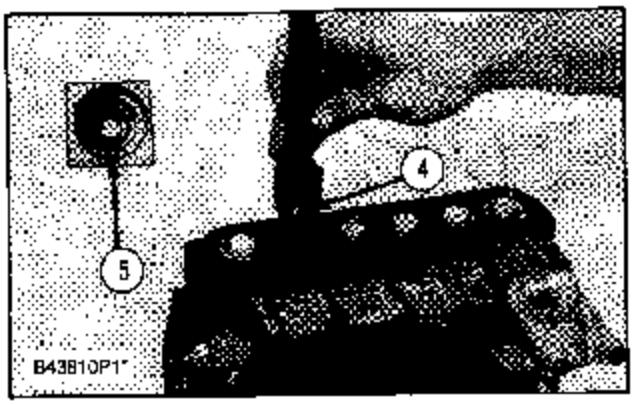
Install Fuel Injection Pumps 1251-012

Tools Needed		A	B	C	D
6V4186	Timing Pin	1			
8S2244	Extractor		1		
8S4613	Wrench			1	
9S0228	Rack Position Tool Group				1
3S3270	Contact Point [44.45 mm (1.75 in) long]				1
	C-Clamp				1



1. Install spacer (1) in the fuel injection pump housing.



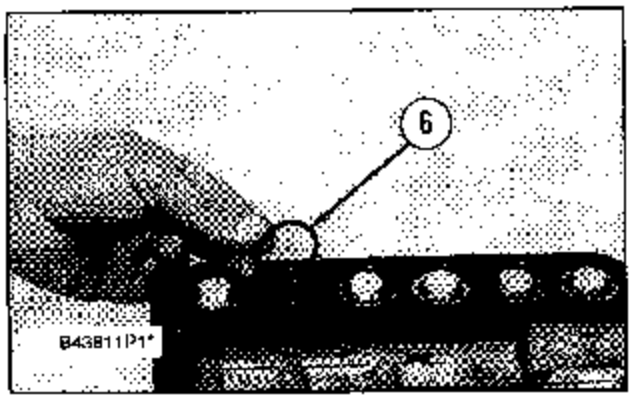


2. Install Tool (A) in the fuel injection pump housing. Move the rack until Tool (A) can be installed to hold the rack in the center position. The rack must be in the center position to install the fuel injection pumps.

3. Turn the camshaft until the lobe of the camshaft is down for the pump to be installed.

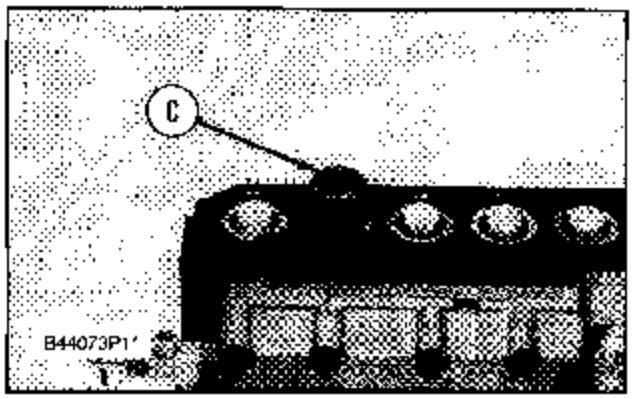
4. Install Tool (B) on the bonnet of the fuel injection pump.

5. Install the fuel injection pump in the pump housing with saw cut (slot) (3) in the gear in alignment with the small pin (2) and groove (4) in the barrel in alignment with dowel (5) in the pump housing.

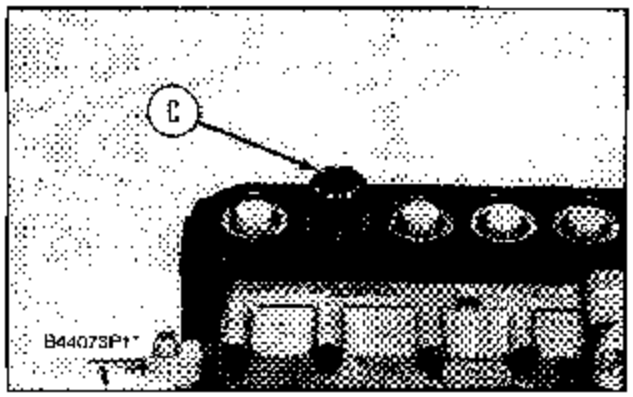


6. Put clean oil on O-ring seal (6). Install it in the fuel injection pump housing.

7. Install the bushing by hand until it is even with the top of the housing. If the bushing can not be installed this far by hand, remove it. Remove the fuel injection pump, and put the pump in alignment again, and install the bushing again.



8. Install Tool (C) on the bushing and tighten the bushing to a torque of **190 ± 14 N•m (140 ± 10 lb ft)**.



9. Install Tool (D) to measure total rack travel. Correct rack travel is **15.7 mm (.618 in)**. A smaller measurement is an indication of incorrect fuel injection pump installation.

10. Do Steps 1 through 9 again for installation of the other fuel pumps.

11. Install the cover and gasket on the fuel injection pump housing.

End By:

a. install governor

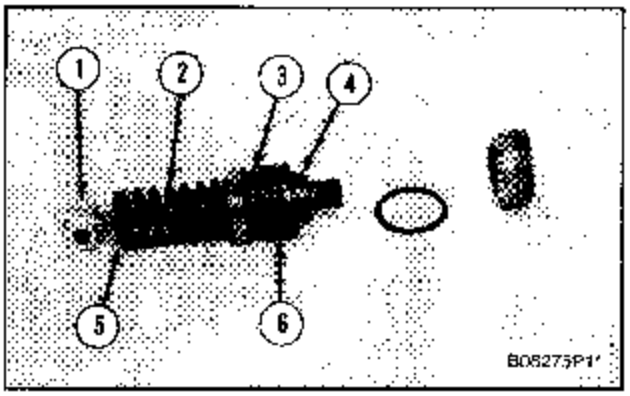
Disassemble Fuel Injection Pumps 1251-015

Start By:

a. remove fuel injection pumps

NOTICE

Be careful when the injection pumps are disassembled. Do not damage the surfaces of the plungers, barrels and bonnets. Any scratches will cause leakage inside the fuel injection pump. The plunger and barrel for each pump are made as a set. Do not put the plunger of one pump in the barrel of another pump. If one part has wear, install a complete new pump assembly. Be careful when the plunger is put into the bore of the barrel.



1. Pull plunger (1) and washer (5) out of barrel (3) and spring (2).

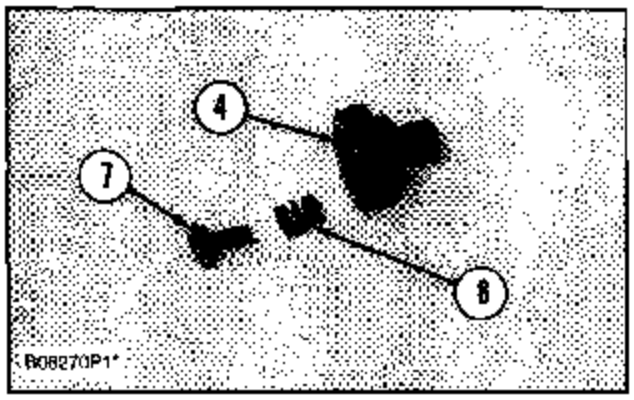
2. Remove washer (5) from plunger (1).

NOTICE

Do not remove the gear from the plunger. The gear and plunger are assembled and adjusted at the factory.

3. Remove spring (2) from barrel (3).

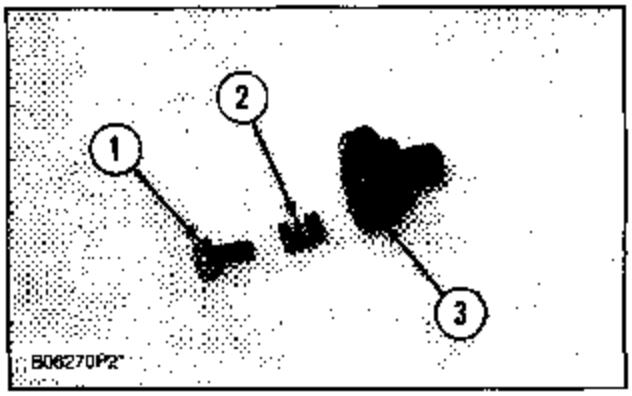
4. Remove ring (6), and separate barrel (3) and bonnet (4).



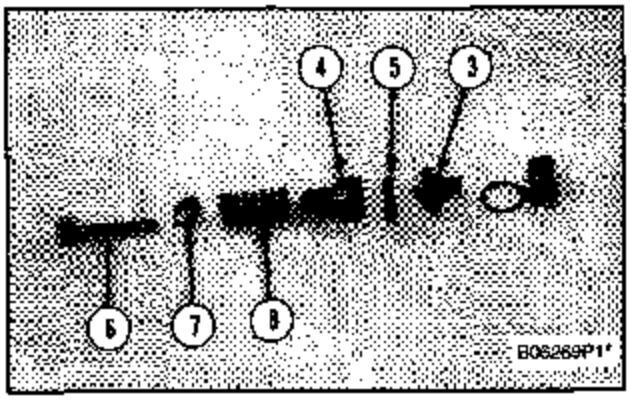
5. Remove check assembly (7) and spring (8) from bonnet (4). If check assembly (7) is disassembled, do not mix parts with parts from another check assembly.

Assemble Fuel Injection Pumps 1251-016

NOTICE
Put clean fuel oil on all parts during assembly.



1. Install spring (2) and check assembly (1) in bonnet (3).



2. Install bonnet (3) on barrel (4). Install ring (5) to hold them together. Do not slice bonnet (3) across barrel (4) because check assembly (1) in the bonnet can damage the face of barrel (4).

3. Install spring (8) on barrel (4).

4. Install washer (7) on plunger (6) with the flat side toward the gear on the plunger.

5. Install plunger (6) in barrel (4) until washer (7) is engaged in the spring.

End By:

a. Install fuel injection pumps

Fuel Injection Pump Housing

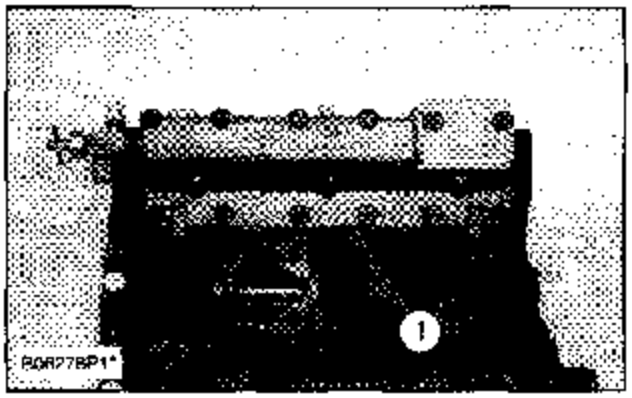
Disassemble Fuel Injection Pump Housing 1253-015

Tools Needed	A
1P1860 Pliers	1

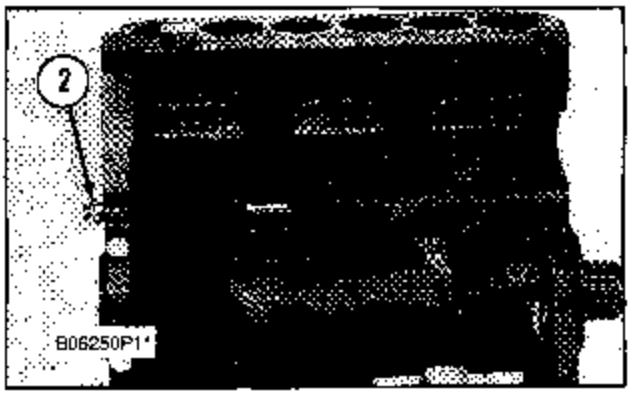
Start By:

a. disassemble governor

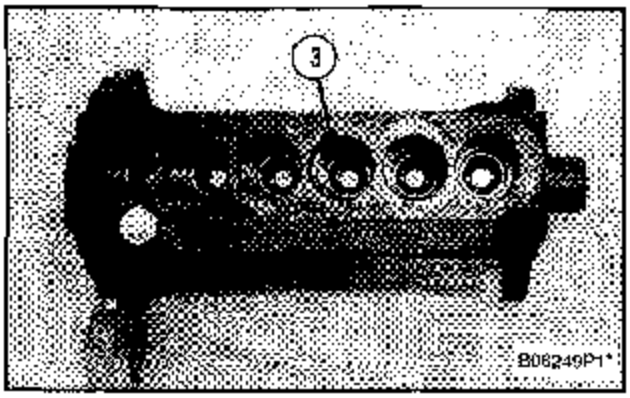
b. remove fuel injection pumps



1. Remove cover (1) from the fuel injection pump housing.



2. Remove rack (2) from the fuel injection pump housing

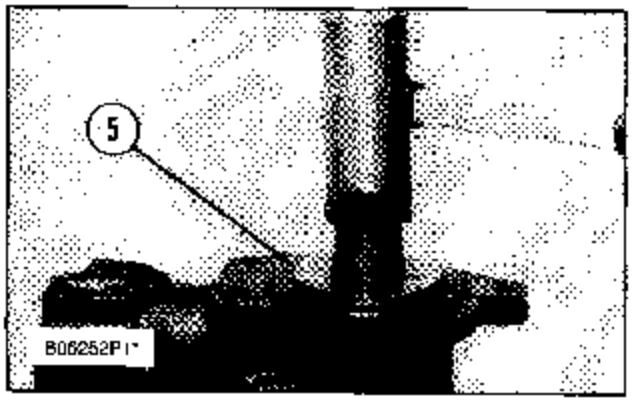


NOTICE

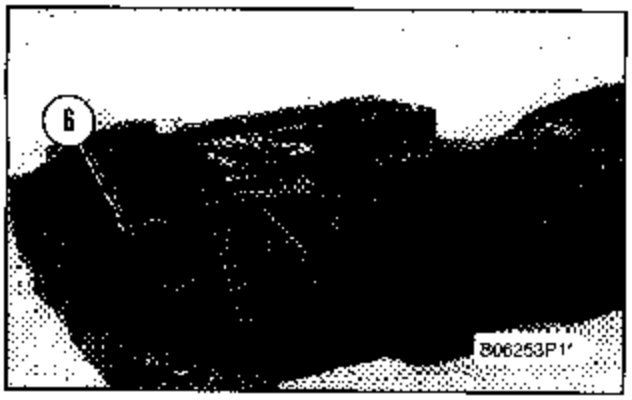
If the original lifters are to be installed in the fuel injection pump housing, put identification marks on them as to their location in the housing.

3. Remove lifters (3) from the fuel injection pump housing.

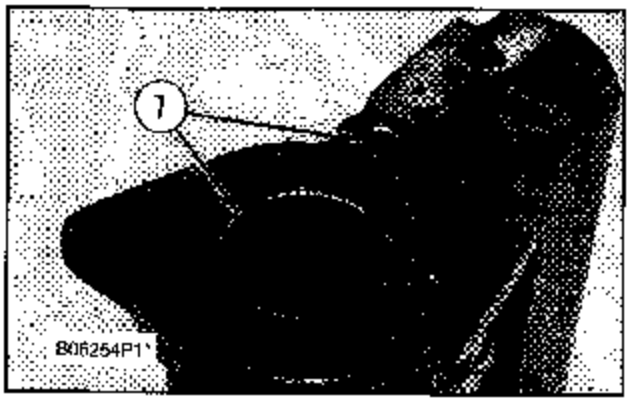
4. Put the fuel injection pump housing on end on blocks, and use Tool (A) to remove snap ring (4) from the camshaft.



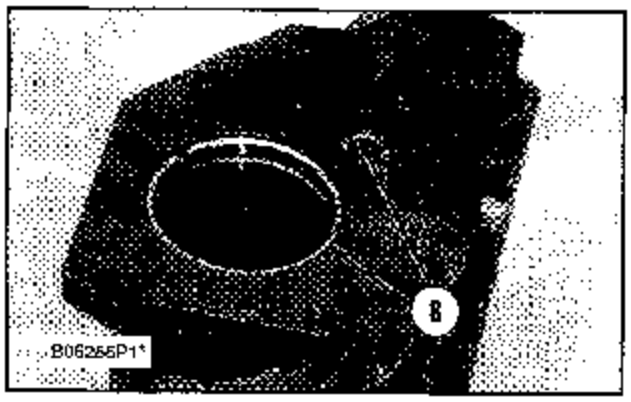
5. Use a soft hammer to push the camshaft toward the governor end of the fuel injection pump housing to loosen washer (5) on the camshaft. Remove washer (5).



6. Remove camshaft (6) from the fuel injection pump housing.



7. Remove bearings (7) from the drive end of the fuel injection pump housing.

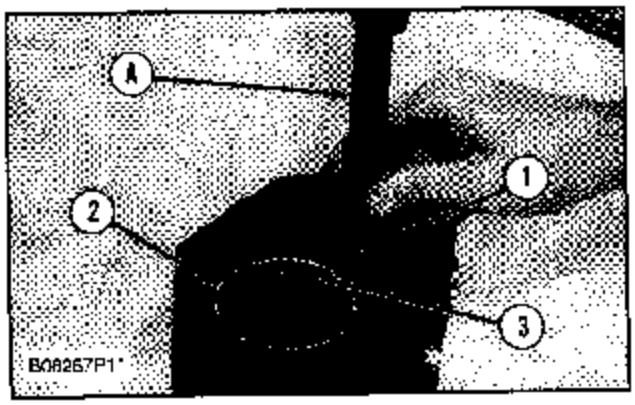


8. Remove bearings (8) from the governor end of the fuel injection pump housing.

Assemble Fuel Injection Pump Housing 1253-016

Tools Needed		A	B	C
1P0510	Driver Group	1		
1P1860	Pliers		1	
6V2016	Plate Assembly*			1
S01594	Bolt (3/8" - 1 in. (25.4 mm) long)			2
6V4818	Driver			1

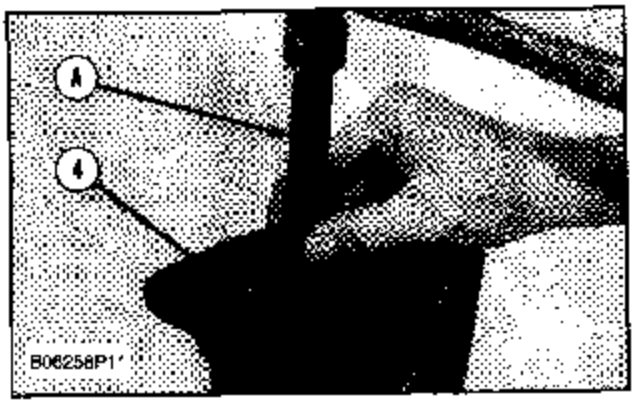
* Part of 6V4095 Pump And Governor Reconditioning Tool Group



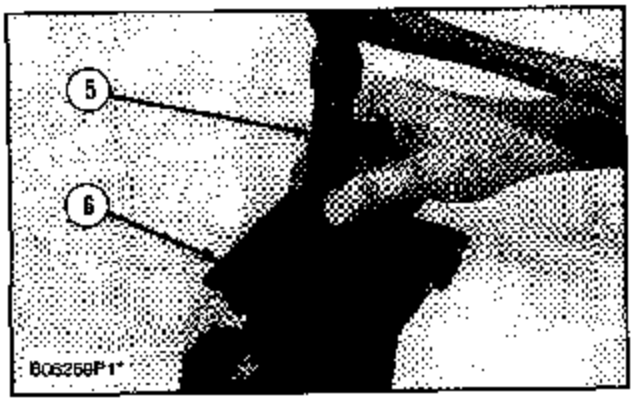
NOTE: Be sure all oil passages are clear and put clean engine oil on all parts before assembly.

1. Use Tool (A) to install bearing (2) in the governor end of the fuel injection pump housing with joint (3) toward the top of the fuel injection pump housing. Install the bearing so it is **0.25 ± 0.20 mm (.010 ± 0.008 in)** below the surface of the housing.

2. Use Tool (A) to install bearing (1) in the governor end of the fuel injection pump housing so it is **7.16 ± 0.13 mm (0.282 ± 0.005 in)** below the surface of the housing.

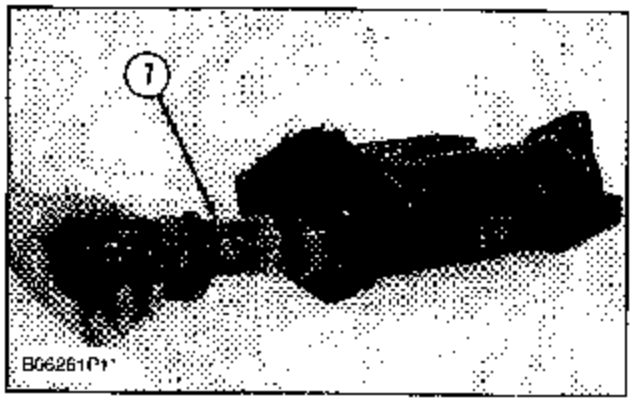


3. Use Tool (A) to install bearing (4) in the drive end of the fuel injection pump housing with the joint in the bearing toward the top of the fuel injection pump housing. Install the bearing so it is **1.00 ± 0.25 mm (0.039 ± 0.010 in)** below the surface of the housing.



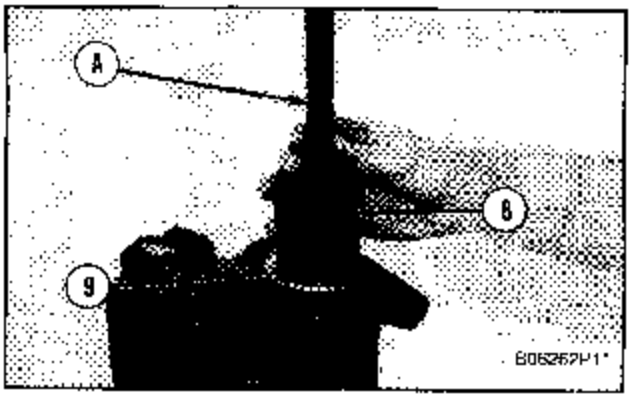
4. Install plate assembly (6) of Tool (C) on the drive end of the fuel injection pump housing to install the bearing for the rack. Use clean grease to hold the new rack bearing on driver (5) of Tool (C). Install the driver and bearing in plate assembly (6) with the groove in the driver in alignment with the pin in the plate. Use a hammer to push the bearing into position. The bearing will be installed to the correct depth when the shoulder of the driver is against plate assembly (6).

5. Remove Tool (C) from the fuel injection pump housing. The rack bearing must be installed so it is **0.25 ± 0.25 mm (0.010 ± 0.010 in)** below the surface of the housing.

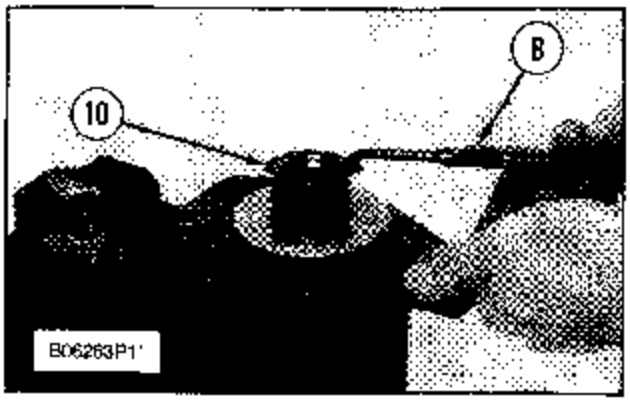


6. Install camshaft (7) in the fuel injection pump housing.

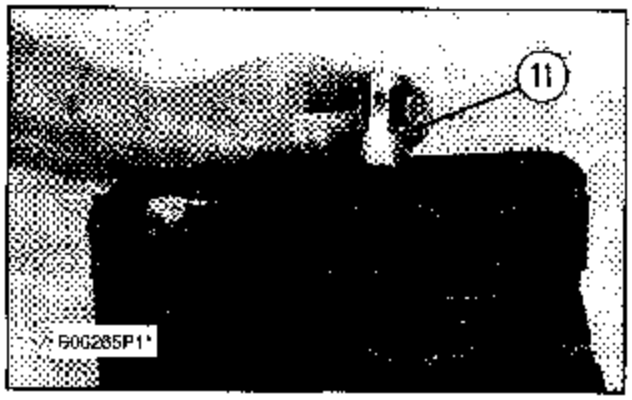
7. Put the fuel injection pump housing on end, and put a block under the camshaft.



8. Put washer (9) over the end of the camshaft, and use Tool (A) and a spacer (8) that has an inside diameter of **38.1 mm (1.5 in)** and a height of **31.75 mm (1.25 in)** to push the washer against its seat on the camshaft. The camshaft must have **0.285 ± 0.235 mm (0.0112 ± 0.0093 in)** of end play when the washer is pushed against the cam shoulder.



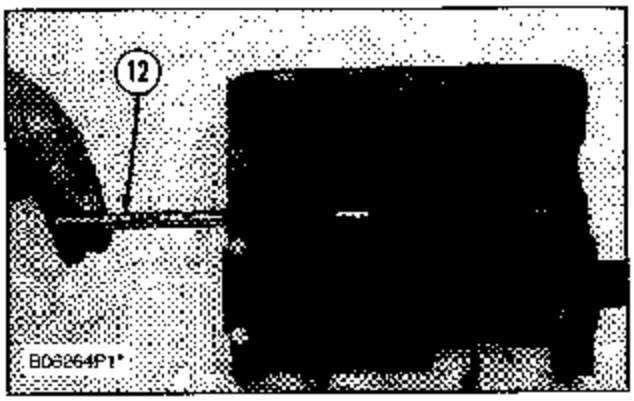
9. Use Tool (B) to install snap ring (10) in the groove in the camshaft.



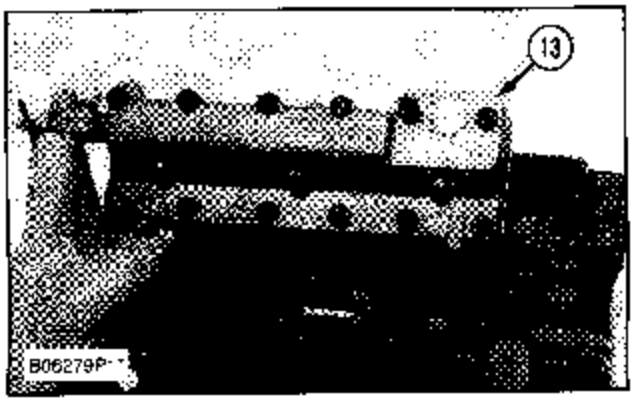
NOTICE

If the original lifters are to be installed in the fuel injection pump housing, be sure they are installed in their original locations. New lifters are the same and can be mixed.

10. Install six lifters (11) in the fuel injection pump housing with the groove in the lifter in alignment with the pin in the housing.



11. Install rack (12) in the fuel injection pump housing with the groove in the end of the rack in alignment with the ear (tab) of the rack bearing at the drive end of the fuel injection pump housing.



12. Install the gasket and cover (13) on the fuel injection pump housing.

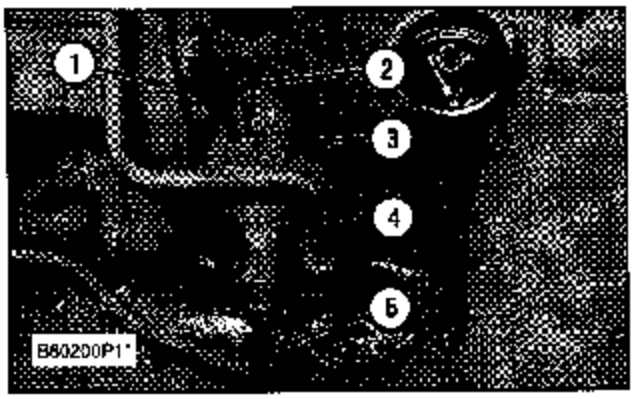
End By:

a. assemble governor

b. install fuel injection pumps

Fuel Transfer Pump

Remove & Install Fuel Transfer Pump 1256-010



3306B Engine Shown

1. Turn the fuel supply line valve to the "OFF" position.

2. Remove the clamp that holds fuel drain line (1) to the fuel transfer pump. Remove fuel lines (4) and (5).

3. Remove bolts (2) and fuel transfer pump (3) from the fuel injection pump housing. Remove the O-ring seal from the fuel transfer pump if necessary.

4. Make sure the O-ring seal is in position on the fuel transfer pump. Put the fuel transfer pump in position on the fuel injection pump housing. Install bolts (2) that hold the fuel transfer pump to the fuel injection pump housing.

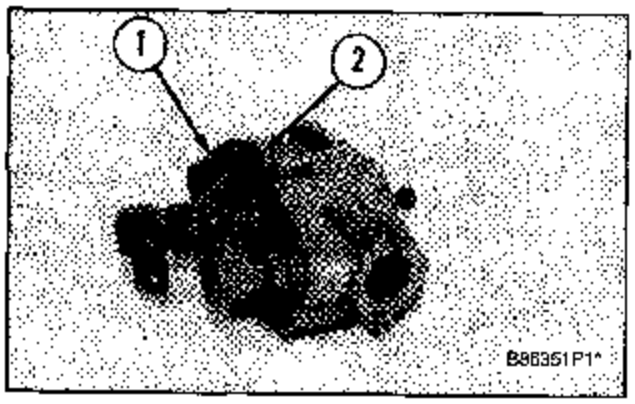
5. Install the clamp that holds fuel drain line (1) to the fuel transfer pump. Install fuel line (4) between the fuel transfer pump and the fuel filter base. Install fuel line (5) between the fuel transfer pump and the fuel priming pump.

6. Turn the fuel supply line valve to the "ON" position.

Disassemble Fuel Transfer Pump 1256-015

Start By:

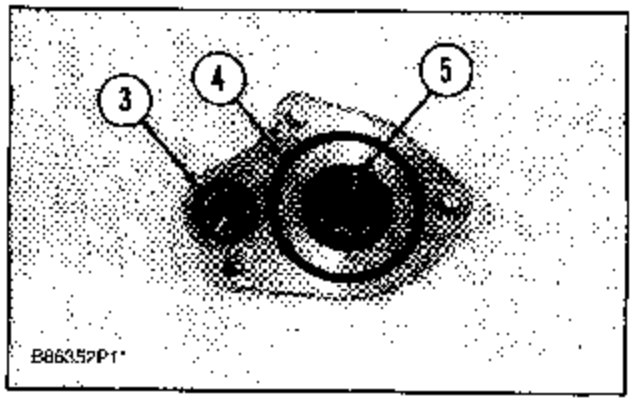
a. remove fuel transfer pump



⚠ WARNING

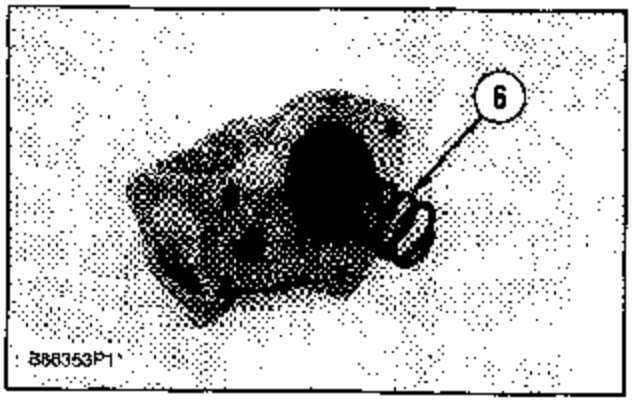
Cover (1) is under spring force. To prevent possible personal injury, carefully remove bolts (2) and cover (1).

1. Remove bolts (2) and cover (1) from the housing.

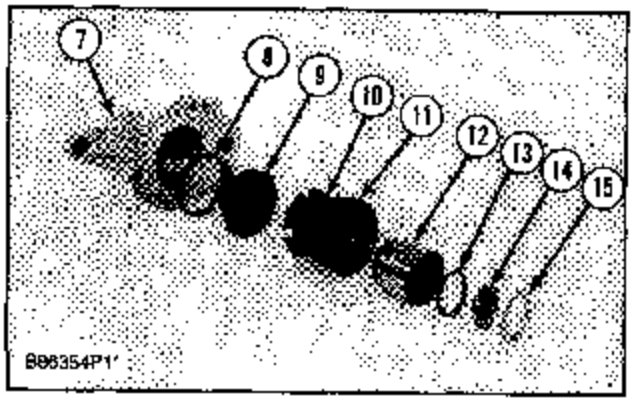


2. Remove O-ring seals (3) and (4) from the cover.

3. Remove valve assembly (5) from the cover.



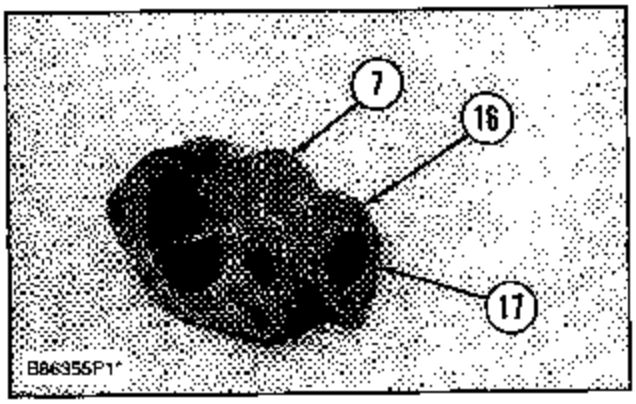
4. Remove spring (6) from the housing.



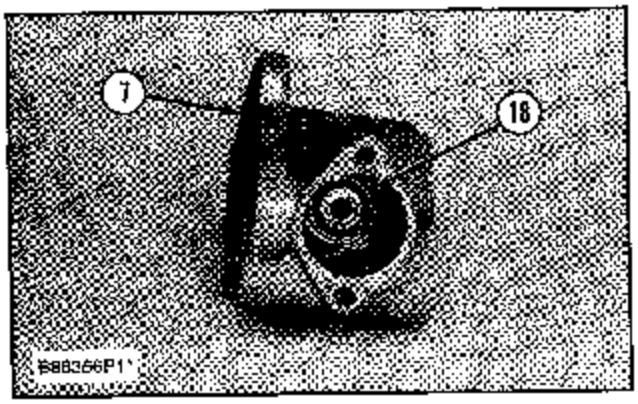
5. Remove piston (12) from sleeve (10). Remove washer (15), valve assembly (14) and seal (13) from piston (12).

6. Remove sleeve (10) from housing (7). Remove O-ring seal (11) from the sleeve.

7. Remove guide and tappet assembly (9) and seal (8) from housing (7).

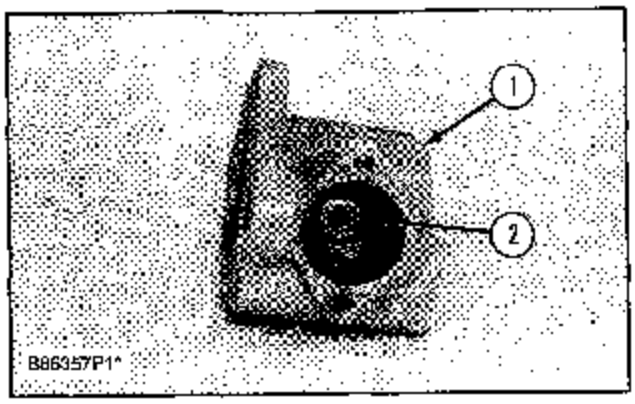


8. Remove two screws (16), cover (17) and the seal from housing (7).



9. Remove valve assembly (18) from housing (7).

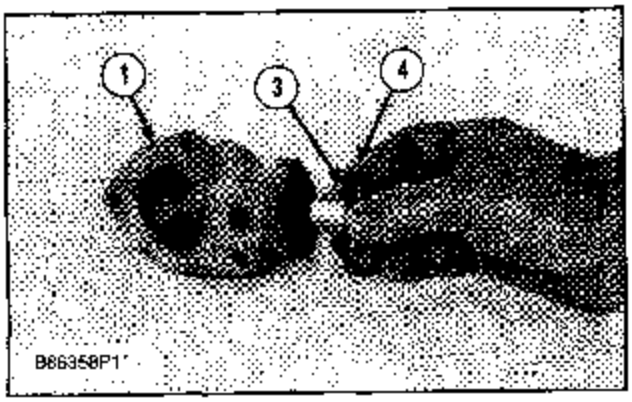
Assemble Fuel Transfer Pump 1256-016



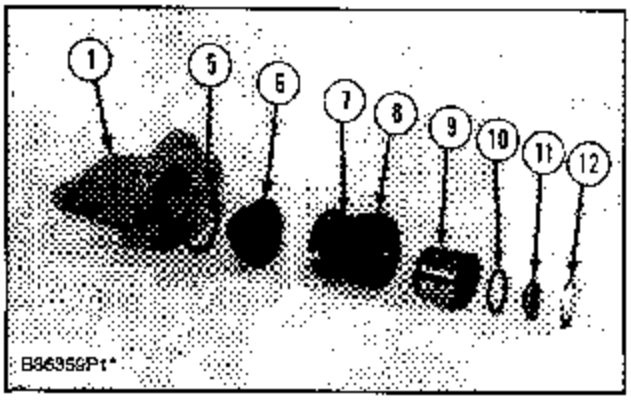
NOTICE

Be sure all parts of the fuel transfer pump are clean before assembly.

1. Install valve assembly (2) in housing (1) as shown.



2. Put clean diesel fuel on seal (2). Put seal (3) in position on cover (4) as shown. Put cover (4) on housing (1). Install the screws that hold the cover.

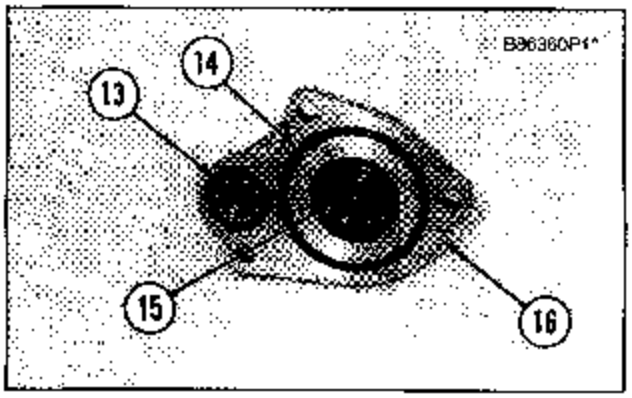


3. Put clean diesel fuel on seal (5). Put seal (5) and guide and tappet assembly (6) in position in housing (1).

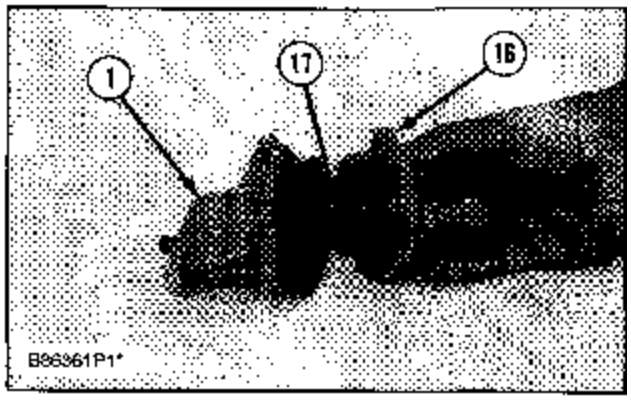
4. Put clean diesel fuel on O-ring seal (8). Put O-ring seal (8) in position on sleeve (7). Install sleeve (7) in housing (1).

5. Install piston (9) in sleeve (7).

6. Put clean diesel fuel on seal (10). Put seal (10), valve assembly (11) and washer (12) in position in piston (7).



7. Put clean diesel fuel on O-ring seals (13) and (14). Put the O-ring seals and valve assembly (15) in position in cover (16) as shown.



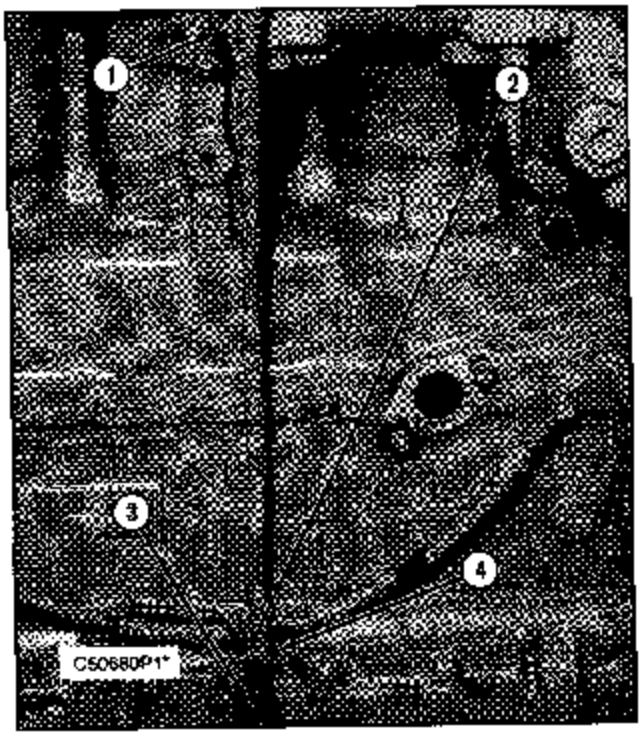
8. Put spring (17) and cover (16) in position on housing (1). Install the bolts that hold the spring and cover.

End By:

a. install fuel transfer pump

Dipstick Assembly

Remove & Install Dipstick Assembly 1326-010



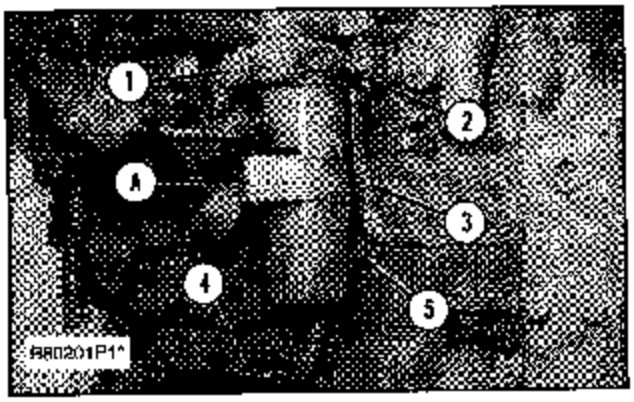
1. Remove bolt (1) and washer.
2. Disconnect tube (2).
3. Disconnect connector (3).
4. Remove dipstick assembly (4).

NOTE: For installation of the dipstick assembly, reverse the removal steps.

Oil Filter & Oil Filter Base

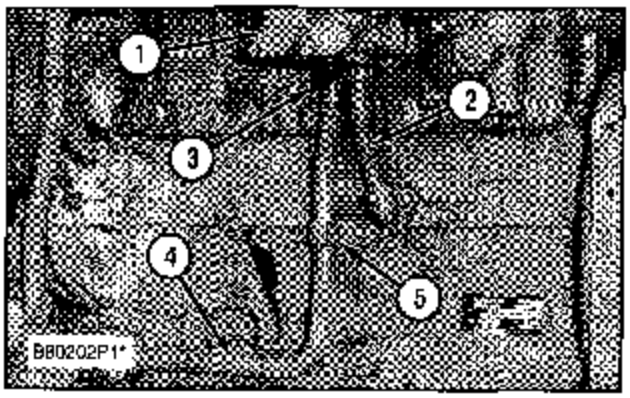
Remove Oil Filter & Oil Filter Base 1318 & 1306-011

Tools Needed	A
2P8250 Strap Wrench	-



1. Remove the oil filter from oil filter base (1) with Tool (A).
2. Remove the bolts that hold clip (5) and tube assembly (3) to the engine. Remove the gasket and tube assembly. Remove the O-ring seal from tube assembly (3) if necessary.
3. Remove the bolts that hold tube assembly (4) to the engine. Remove tube assembly (4) and the gasket. Remove the O-ring seal from tube assembly (4) if necessary.
4. Remove four bolts (2) and oil filter base (1) from the engine.
5. Remove the two O-ring seals from the top of the oil filter base if necessary.

Install Oil Filter & Oil Filter Base 1318 & 1306-012



1. Put clean engine oil on the two O-ring seals that go between the oil filter base and the oil cooler. Put the O-ring seals in position on the top of oil filter base (1). Put oil filter base (1) in position on the engine oil cooler. Install bolts (3) to hold the oil filter base.

2. Install the O-ring seal on tube assembly (4), and put clean engine oil on it. Put the gasket and tube assembly (4) in position as shown. Install the bolts that hold the tube assembly.

3. Install the O ring seal on tube assembly (2), and put clean engine oil on it. Put the gasket, tube assembly (2) and clip (5) in position as shown. Install the bolts that hold them.

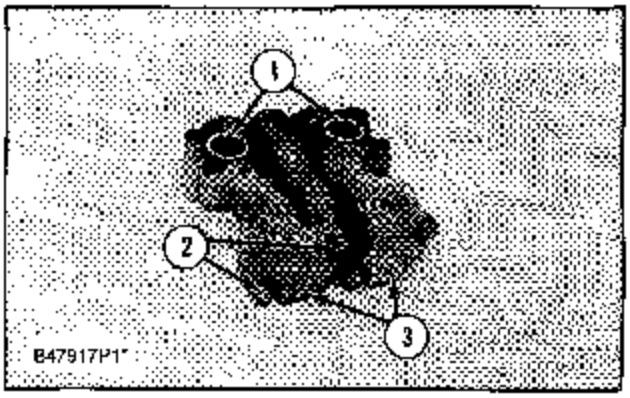
4. Put clean engine oil on the oil filter seal, and install it by following the instruction procedure on the oil filter

Oil Filter Base

Disassemble Oil Filter Base 1306-015

Start By:

a. remove oil filter and oil filter base

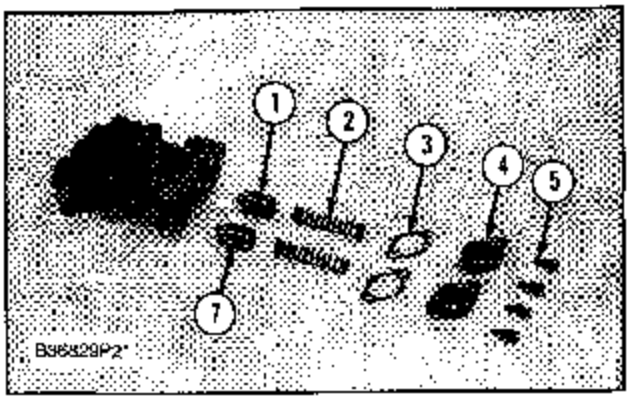


1. Remove O-ring seals (1) from the oil filter base.

2. Remove bolts (2), covers (3) and the gaskets from the oil filter base.

3. Remove the spring and plunger from behind both of the covers.

Assemble Oil Filter Base 1306-016



NOTE: Plunger (1) is for the cooler bypass, and plunger (7) is for the oil filter bypass.

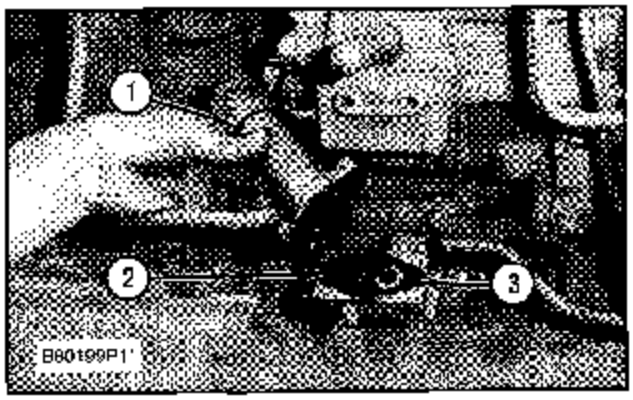
1. Install plungers (1) and (7) and springs (2) in each side of the oil filter base.
2. Put gaskets (3) and covers (4) in position on the oil filter base. Install bolts (5) to hold them.
3. Put clean engine oil on the two O-ring seals that go between the engine oil cooler and the oil filter base. Put the O-ring seals in position on the oil filter base.

End By:

a. install oil filter and oil filter base

Fuel Priming Pump

Remove & Install Fuel Priming Pump 1258-010



3306B Engine Shown

1. Turn the fuel supply line valve to the "OFF" position.
2. Remove the two bolts that hold fuel priming pump (1) to base (3). Remove the fuel priming pump and gasket (2) from the base.
3. Put gasket (2) in position on base (3) as shown.

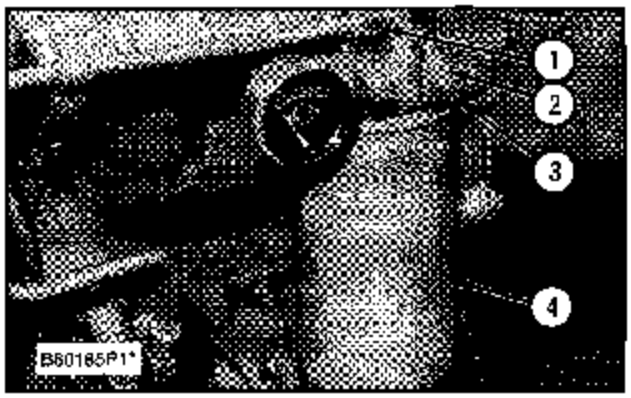
NOTE: The fuel priming pump can only be installed one way.

4. Put fuel priming pump (1) in position on the gasket and base. Install the two bolts that hold them in position.
5. Turn the fuel supply line valve to the "ON" position.

Fuel Filter & Base

Remove & Install Fuel Filter & Base 1261 & 1262-010

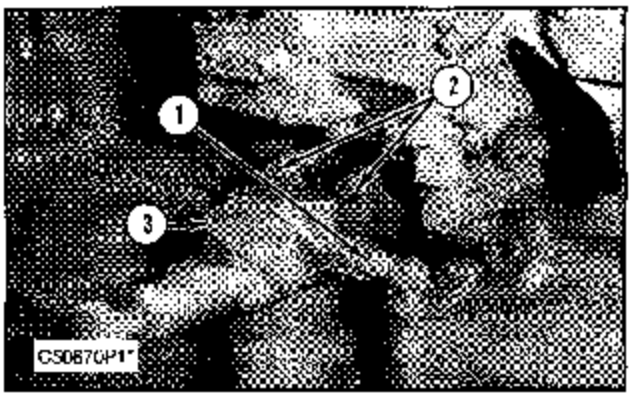
Tools Needed		A
2P8250	Strap Wrench	1



1. Remove fuel filter (4) from the fuel filter base with Tool (A).
2. Disconnect fuel line (1) from the fuel filter base.
3. Remove bolts (3), fuel filter base (2) and the gasket from the fuel injection pump housing.
4. Put the gasket and fuel filter base (2) in position on the fuel injection pump housing. Install bolts (3) to hold them.
5. Connect fuel line (1) to the fuel filter base.
6. Install fuel filter (4). Follow the instructions on the fuel filter for correct installation.

Primary Fuel Filter & Base

Remove & Install Primary Fuel Filter & Base 1260-010



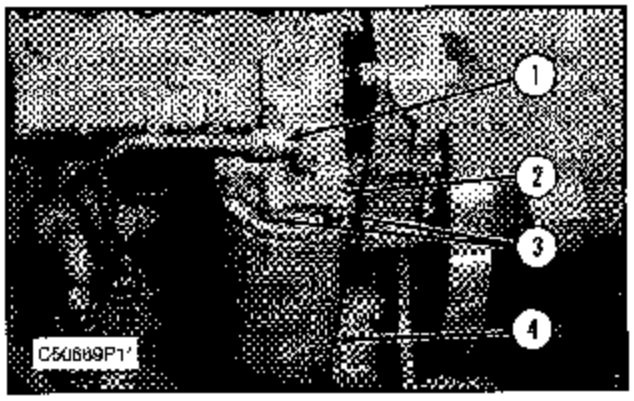
1. Disconnect hose (1).
2. Remove two bolts (2) and washers.
3. Remove primary fuel filter and base (3) as a unit.

NOTE: For installation of the primary fuel filter and base, reverse the removal steps.

Secondary Fuel Filter & Base

Remove & Install Secondary Fuel Filter & Base 1261 & 1262-10

Tools Needed		A
2P8250	Strap Wrench	1



1. Remove fuel filter (4) from the fuel filter base with Tool (A).
2. Disconnect fuel line (1).
3. Remove bolts (3) and washers. Remove fuel filter base (2) and the gasket from the fuel injection pump housing. Check the gasket for wear or damage. Replace if necessary.

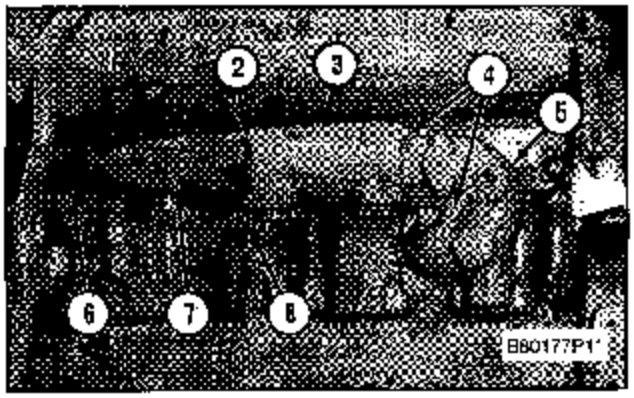
Note: For installation of the secondary fuel filter and base, reverse the removal steps.

Engine Oil Cooler

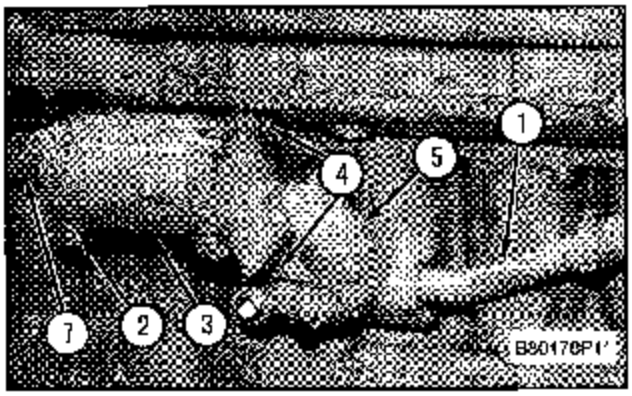
Remove & Install Engine Oil Cooler 1378-010

Start By:

a. remove oil filter and oil filter base

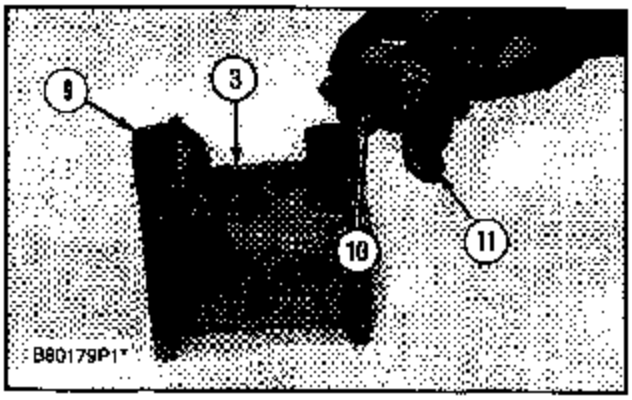


3304B Engine Shown



3306B Engine Shown

1. Drain the coolant from the cooling system.
2. On 3306B engines, loosen the clamp and remove the bolts that hold pipe (1) on the rear side of the oil cooler. Remove the pipe and gasket from the engine.
3. Remove all bolts (4), elbow (5) and the gaskets from the engine.
4. Remove bolts (2), core assembly (3) and the gasket.
5. If necessary, loosen clamp (6), and remove bolt (8) and pipe (7) from the engine.



6. On 3306B engines, remove the bolts and elbows (9) and (11) from core assembly (3). Remove O-ring seals (10) from the elbows.

7. Clean the tube bundles in the core assembly with a **3.18 mm (.125 in)** diameter rod.

8. On 3306B Engines, install O-ring seals (10) in elbows (9) and (11). Put the elbows in position on core assembly (3) as shown. Install the bolts that hold them.

9. Put pipe (7) in position on the engine. Install the bolt and clamp that hold it.

10. Put core assembly (3) and the gasket in position on pipe (2). Install the bolts that hold it.

11. Put the gaskets and elbow (5) in position on the cylinder block and the core assembly. Install the bolts that hold it.

12. On 3306B Engines, install the gasket and pipe (1).

13. Fill the cooling system with coolant to the correct level. See the Operation & Maintenance Manual.

End By:

a. install oil filter and oil filter base

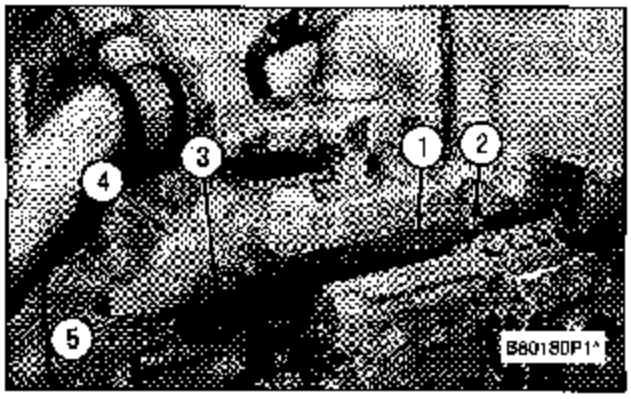
Exhaust Manifold (3304B)

Remove & Install Exhaust Manifold (3304B) 1059-010

Start By:

a. remove turbocharger

b. remove fuel injection lines



1. Remove bolts (2) and the washers that hold shield (1) to the engine. Remove the shield.

2. Remove the nuts, brackets (3) and the washers between the No. 1 and No. 2 cylinders and between the No. 3 and No. 4 cylinder.

3. Remove the remainder of nuts (5) and exhaust manifold (4). Remove the exhaust manifold gaskets.

4. If necessary, remove the studs from the cylinder head.

5. If the studs were removed from the cylinder head, put **5P3931 Anti-Seize Compound** on the threads that fit into the cylinder head. Install the studs and tighten them to a torque of **27 ± 4 N•m (20 ± 3 lb ft)**.

6. Put **5P3931 Anti-Seize Compound** on the threads of the studs. Put the exhaust manifold gaskets and exhaust manifold (4) in position on the studs. Install the washer and nut (5) on the first and last stud.

7. Install brackets (3) between No. 1 and No. 2 cylinder and between No. 3 and No. 4 cylinders with the holes for bolts (2) on top. Install the remainder of the washers and nuts (5).

8. Put shield (1) in position on brackets (3). Install the washers and bolts (2) that hold it.

End By:
a. install fuel injection lines

b. install turbocharger

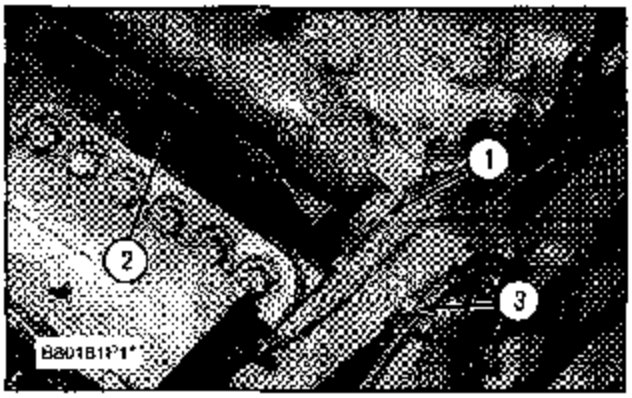
Exhaust Manifold (3306B)

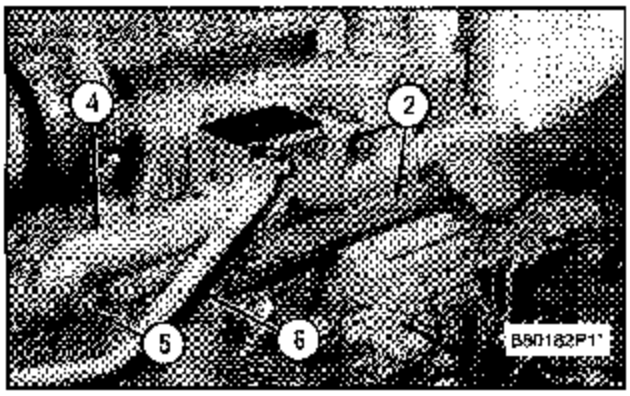
Remove & Install Exhaust Manifold (3306B) 1059-010

Start By:

a. remove turbocharger

b. remove fuel injection lines





1. Remove bolt (3) and the nut from the front cover.

2. Remove the nuts, washers and shield (2). Remove spacers (1) and (6) from behind the shield.

3. Remove nuts (5) and the washers that hold the exhaust manifold in position. Remove exhaust manifold (4) and the gaskets.

4. If it was necessary to remove the studs, put **5P3931 Anti-Seize Compound** on the threads that fit into the cylinder head. Install the studs. Tighten them to a torque of **27 ± 4 N•m (20 ± 3 lb ft)**.

5. Put **5P3931 Anti-Seize Compound** on the threads of the studs. Put the gaskets and exhaust manifold (4) in position on the studs. Install the washers and nuts (5) on all the studs except the front one and the eighth one from the front.

NOTE: Other 3306B engines may require washers and nuts (5) on all the studs except for the second one and the eighth one from the front.

6. Install the washer and short spacer (6) on the eighth stud from the front. Put the washer and long spacer (1) on the front stud. Put shield (2) in position as shown, and install the washers and nuts that hold it.

End By:

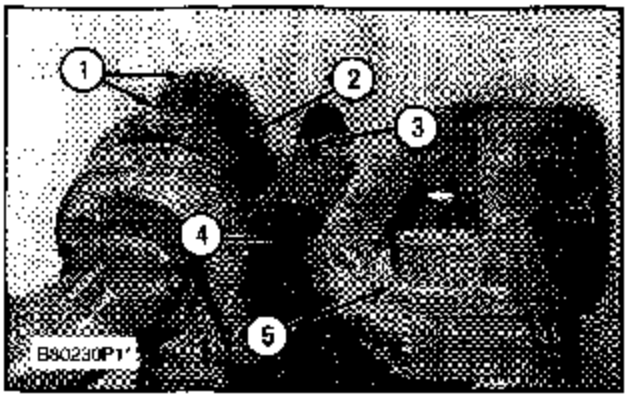
a. install turbocharger

b. install fuel injection lines

Turbocharger

Remove Turbocharger 1052-011

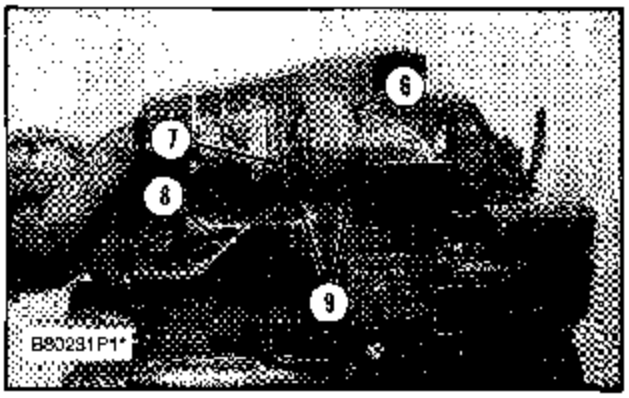
NOTE: The illustrations which follow are of a 3306B engine.



1. Loosen two clamps (1), and slide hose (2) off the turbocharger and on to the pipe.

2. On 3306B Engines remove all bolts (3) and (5) that hold pipe (4) in position. Remove pipe (4) and the gasket.

3. On 3304B Engines loosen the two hose clamps, and slide the hose off the turbocharger and on to the pipe that goes to the cylinder head.

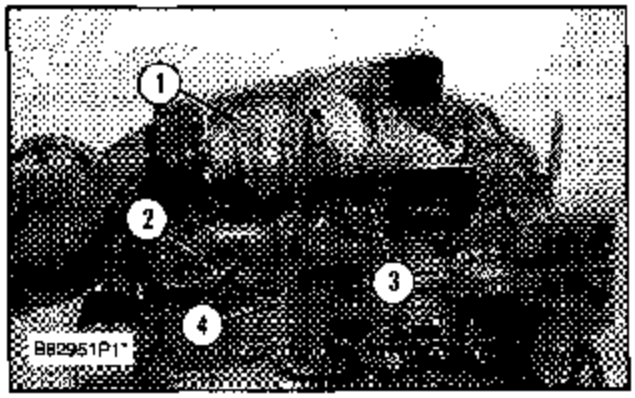


4. Remove oil supply line (7) and oil drain line (8).

5. Remove all bolts (9) that hold turbocharger (6) to the exhaust manifold. Remove the turbocharger and gasket from the exhaust manifold and the exhaust elbow.

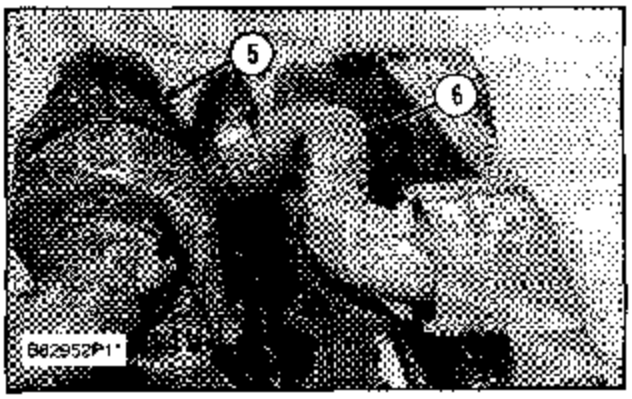
Install Turbocharger 1052-012

NOTE: The illustrations which follow are of a 3306B Engine.



1. Put the gasket and turbocharger (1) in position on the engine, and install bolts (3) that hold it. Tighten bolts (3) to a torque of **54 ± 5 N•m (40 ± 4 lb ft)**.

2. Install the O-ring seal on turbocharger oil drain line (2). Install the gasket and turbocharger oil drain line. Install the gasket and oil supply line (4).



3. Slide hose (5) into position. Tighten the two clamps that hold the hose.

4. On 3306B Engines install the O-ring seals on pipe (6). Put the gasket and pipe (6) in position. Install the bolts that hold the pipe.

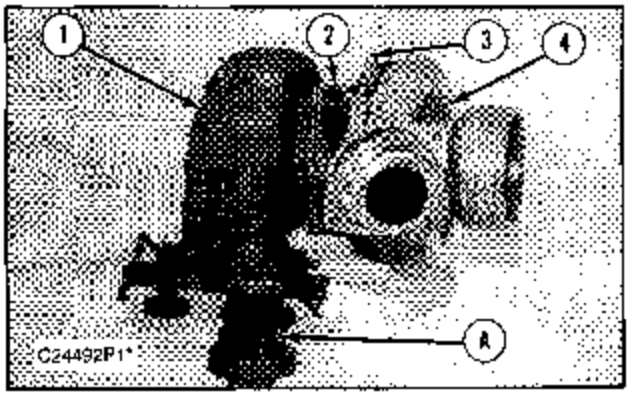
5. On 3304B Engines slide the hose into position on the turbocharger and the pipe that goes to the cylinder head. Tighten the hose clamps that hold it.

Disassemble & Assemble Turbocharger 1052-017

Tools Needed		A	B	C	D	E
9S6363	Turbocharger Fixture Gp	1				
9S6343	Fixture Assembly		1			
1P1861	Retaining Ring Pliers			1		
1P1853	Retaining Ring Pliers				1	
8S2328	Dial Indicator Group					1

Start By:

a. remove turbocharger

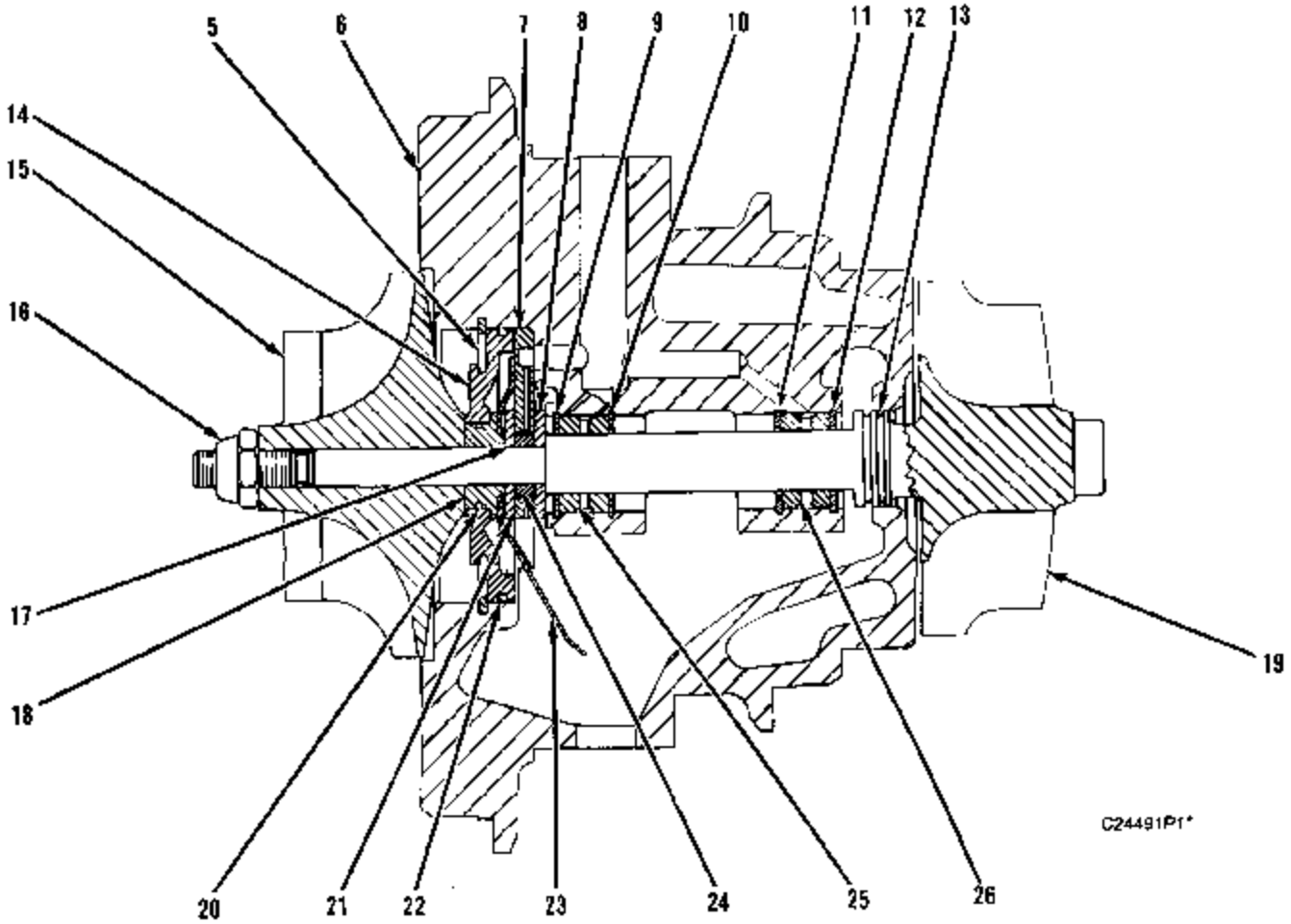


1. Install the turbocharger on Tool (A).

2. Put alignment marks on the two housings and cartridge assembly of the turbocharger for correct alignment during assembly.

3. Loosen clamp (3), and remove compressor housing (4) from cartridge assembly (2).

4. Loosen the remaining clamp, and remove cartridge assembly (2) from turbine housing (1).



Typical Example

5. Put the cartridge group (shown in the illustration) with nut (16) up in Tool (B). Use a **5S9566 Sliding T-Wrench** and a universal socket to remove nut (16) that holds the compressor wheel (15) to the wheel assembly (19).

6. Remove compressor wheel (15) and housing assembly (6) from wheel assembly (19). Remove piston ring (13) from the wheel assembly.

7. Use Tool (C), and remove snap ring (5) from housing assembly (6). Remove insert (14) and sleeve (18) from the housing assembly. Remove seal (22) from insert (14). Remove ring (20) from sleeve (18).

8. Remove oil deflector (23), thrust ring (21), bearing assembly (7), spacer sleeve (24) and thrust ring (8) from housing assembly (6).

9. Use Tool (D), and remove snap ring (9) from the housing assembly. Remove bearing (25). Remove snap ring (10) with Tool (D).

10. Use Tool (D), and remove snap ring (12) from the housing assembly. Remove bearing (26). Remove snap ring (11) with Tool (D).

11. Check all the parts of the turbocharger for damage. If any parts are damaged, use new parts for replacement. See Special Instruction Form No. SMHS6854 for turbocharger reconditioning. Also, see Guidelines For Reusable Parts, Form No. SEBF8018.

NOTE: The following steps are for assembly of the turbocharger.

12. Make sure that all the oil passages in the turbocharger cartridge housing are clean and free of dirt and foreign material.

NOTE: Do not put oil on any parts of the turbocharger until after the compressor wheel has been installed. After the turbocharger has been assembled, put clean engine oil into the oil inlet of the turbocharger.

NOTICE

Make sure the snap rings that hold bearings (25) and (26) in housing assembly (6) are installed with the round edge of the outside diameter toward the bearing.

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13. Install snap ring (11) with Tool (D). Install bearing (26). Install snap ring (12) with Tool (D).

14. Install snap ring (10) with Tool (D). Install bearing (25). Install snap ring (9) with Tool (D).

15. Put wheel assembly (19) in position on Tool (B) with the threaded portion end up.

NOTE: Put **6V2055 High Vacuum Grease** in the groove for piston ring (13) at assembly to one half or more of the depth of the groove all the way around.

16. Install piston ring (13) in the groove in wheel assembly (19).

17. Put housing assemoly (6) in position on wheel assembly (19).

18. Install thrust ring (8) and spacer sleeve (24) on wheel assembly (19).

19. Make sure the screen is in place in bearing assembly (7). Install bearing assembly (7) over spacer sleeve (24). Make sure the screen in the bearing assembly is facing toward housing assembly (6) when it is installed.

20. Install thrust ring (21) and oil deflector (23) on the wheel assembly.

NOTE: Put **6V2055 High Vacuum Grease** in the groove of sleeve (18) to one half or more of the depth of the grooves all the way around.

21. Install seal (22) or insert (14).Install ring (20) in the groove in sleeve (18). Put sleeve (18) in position in insert (14). Install the insert and sleeve as an assembly on the wheel assembly.

22. Use Tool (C), and install snap ring (5) to hold insert (14) in place.

23. Install compressor wheel (15) at room temperature as follows:

a. Put compressor wheel (15) in position on wheel assembly (19).

b. Put a small amount of clean engine oil on the wheel assembly.

NOTICE

Do not put a side force on the shaft when the nut that holds the compressor wheel in position is tightened.

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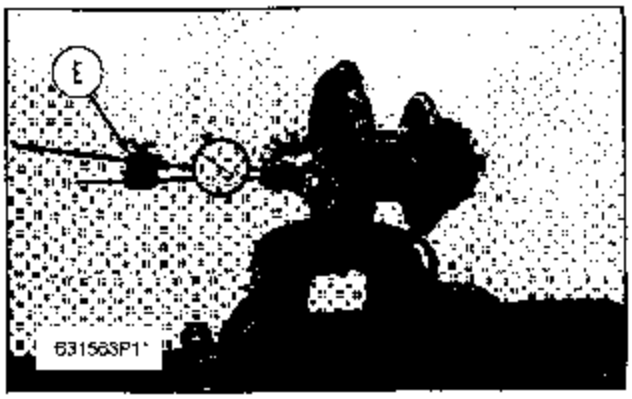
c. Install nut (16) on the wheel assembly. Tighten the nut to a torque of **14 to 17 N•m (125 to 150 lb in)**.

d. Remove the nut. Apply **6V1541 Quick Cure Primer** on the threads of the wheel assembly.

e. Put **9S3265 Retaining Compound** on the threads of the wheel assembly and install the nut. Tighten the nut to a torque of **4 N•m (40 lb in)**.

f. Tighten the nut an additional **90°** .



Typical Example

24. Put the cartridge assembly in position in a vise as shown. Make sure softjaws are used. Install Tool (E) on the cartridge assembly to check the end play. End play for a new wheel assembly must be **0.114 ± 0.038 mm (.0045 ± .0015 in)**.

25. Put turbine housing (1) in position on Tool (A). Put cartridge assembly (2) in position in the housing. Make sure the mark on the cartridge assembly is in alignment with the mark on the turbine housing, and tighten the clamp that fastens cartridge assembly and housing together. Tighten the clamp to a torque of **14 ± 1.1 N•m (125 ± 10 lb in)**. Tap (hit) the clamp lightly all around, and tighten the clamp again to a torque of **14 ± 1.1 N•m (125 ± 10 lb in)**.

26. Put compressor housing (4) in position on cartridge assembly (2). Make sure the mark on the compressor housing is in alignment with the mark on the cartridge assembly, and tighten clamp (3) that fastens cartridge assembly and housing together. Tighten the clamp to a torque of **14 ± 1.1 N•m (125 ± 10 lb in)**. Tap (hit) the clamp lightly all around, and tighten the clamp again to a torque of **14 ± 1.1 N•m (125 ± 10 lb in)**.

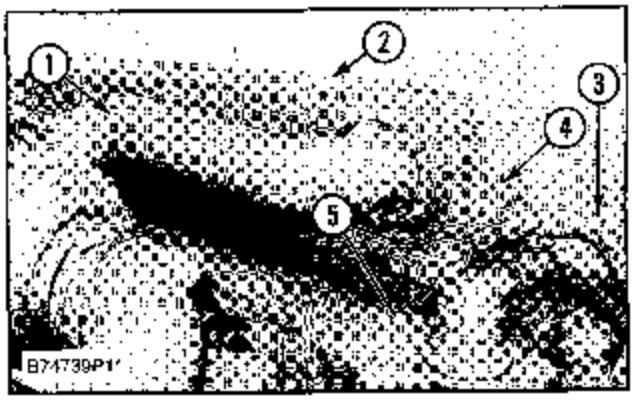
End By:

a. install turbocharger

Aftercooler

Remove Aftercooler 1063-011

1. Drain the coolant from the engine.



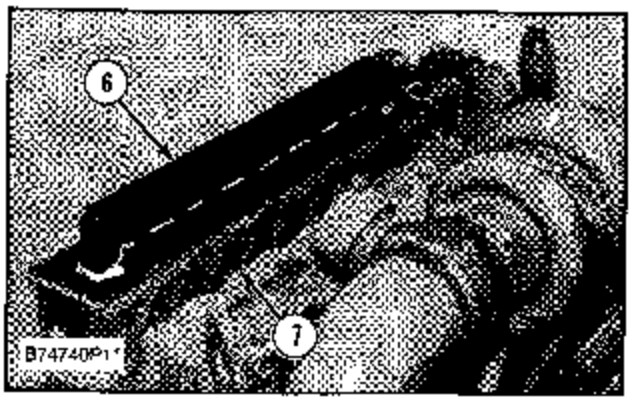
2. Remove pipe (1) and the gasket between aftercooler cover (2) and the turbocharger. If necessary, remove the O-ring seals from the pipe.

3. Remove the bolts and clamps that hold tube assemblies (3) to each end of the aftercooler. Remove tube assemblies (3) from each end of the aftercooler. If necessary, remove the O-ring seals from the tube assemblies.

NOTE: An O-ring seal on each end of the aftercooler core holds the adapters in position.

4. Remove adapters (4) and the gaskets from each end of the aftercooler.

5. Remove all bolts (5) that hold aftercooler cover (2) in position. Remove the aftercooler cover and gasket from the engine.



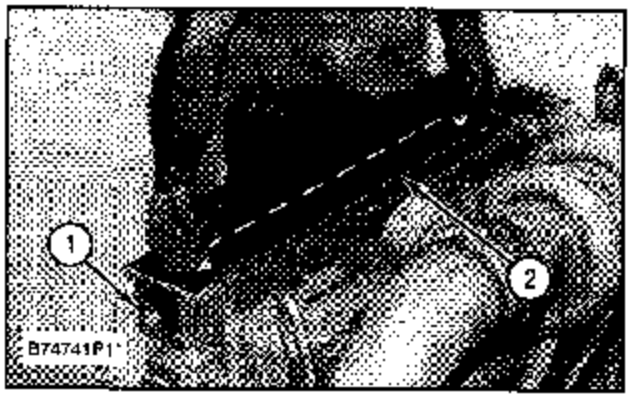
6. Remove aftercooler core (5) and the gasket from the engine. If necessary, remove the O-ring seals from the aftercooler core.

NOTE: Two of the bolts that hold the aftercooler housing in position are on the inside of the aftercooler housing.

7. Remove the bolts and spacers that hold aftercooler housing (7) to the engine. Make a note of the location of the spacers. Remove the aftercooler housing and gaskets from the engine.

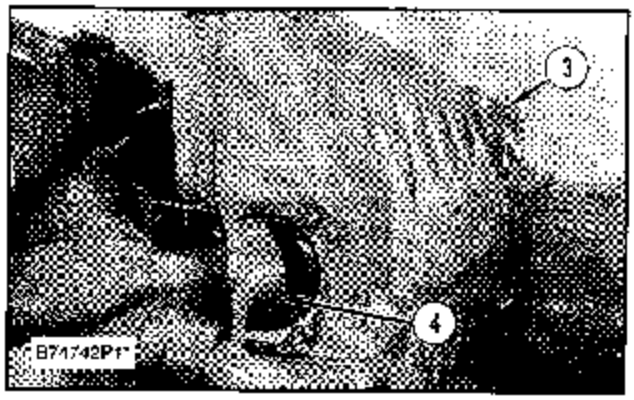
Install Aftercooler 1063-012

NOTE: Inspect all O ring seals and gaskets, and make replacements if necessary.



1. Put the gaskets and aftercooler housing (1) in position on the engine. Install the bolts and spacers that hold the aftercooler housing.

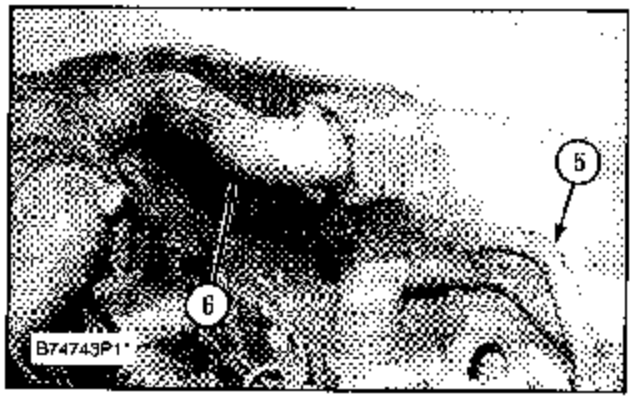
2. Install the O-ring seals on the aftercooler core, and put a thin layer of clean engine oil on them. Put the gasket and aftercooler core (2) in position on the engine.



3. Put the gasket and aftercooler cover (3) in position. Install the bolts that hold the aftercooler cover.

NOTE: Force may be required to push the adapters around the O-ring seals on the aftercooler core. Make sure the O-ring seals stay in position on the aftercooler core.

4. Put a thin layer of clean engine oil in the bores of adapters (4). Install a gasket and adapter on each end of the aftercooler core.



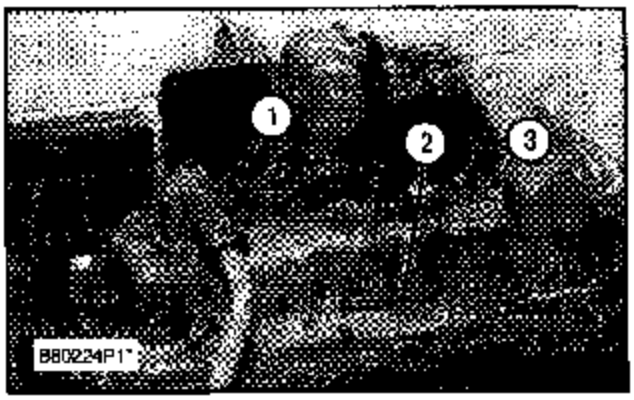
5. Install the O-ring seals on tube assemblies (5), and put a thin layer of clean engine oil on them. Put the tube assemblies in position on each end of the aftercooler, and install the bolts and clamps that hold them.

6. Install the O-ring seals on pipe (6), and put a thin layer of clean engine oil on them. Put the pipe and gasket in position between the aftercooler and the turbocharger. Install the bolts that hold it.

7. Fill the radiator with coolant to the correct level. See the Operation & Maintenance Manual.

Valve Cover (3304B)

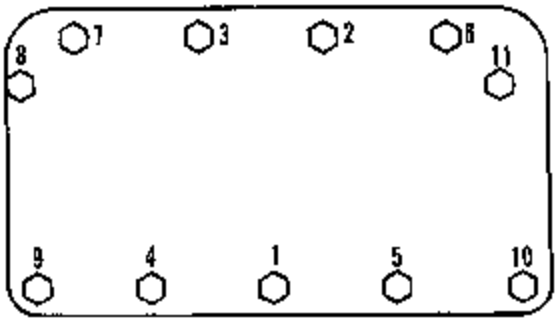
Remove Valve Cover (3304B) 1107-011



1. Loosen hose clamp (1), and slide the hose from the breather cap.
2. Remove all bolts (2) and the washers that hold valve cover (3) in position. Remove the valve cover. Remove the gasket from the valve cover if necessary.

Install Valve Cover (3304B) 1107-012

1. Install a new gasket on the valve cover if needed. Put **5H2471 Cement** on the contact surfaces of the gasket and valve cover when a new gasket is installed.



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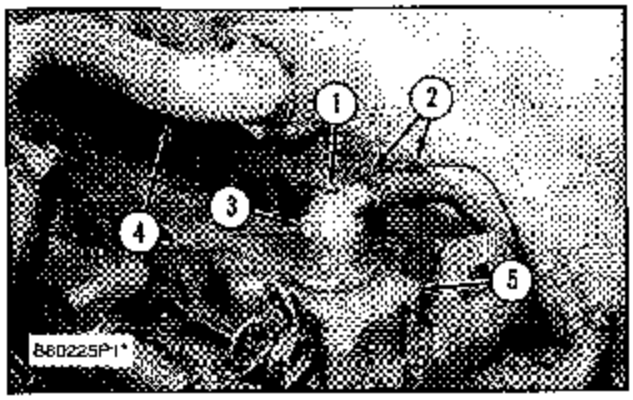
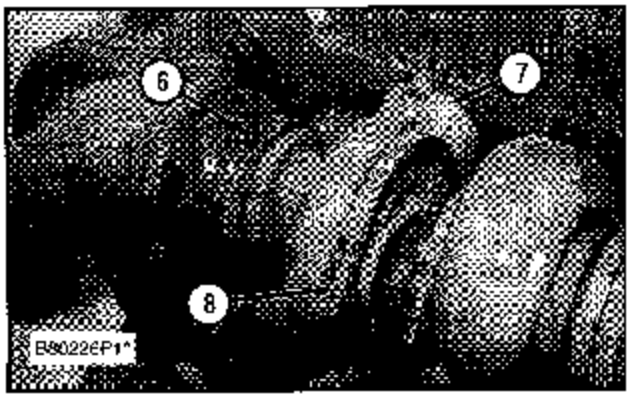
2. Put the valve cover in position on the cylinder head. Install the bolts that hold it. Tighten the bolts in the number sequence shown to a torque of **11 ± 3 N•m (8 ± 2 lb ft)**.
3. Slide the hose on the breather cap. Tighten the clamp that holds it.

Valve Cover (3306B)

Remove Valve Cover (3306B) 1107-011

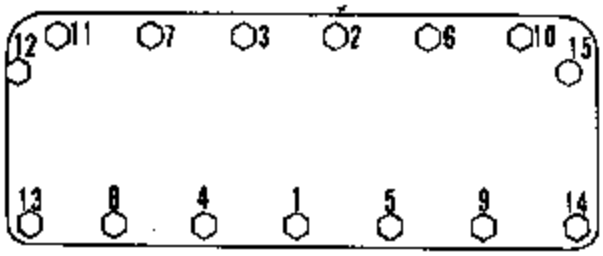




1. Loosen clamps (2), and slide the hose off breather cap (3). Remove bolt (1), the breather cap and O-ring seal from valve cover (5).
2. Remove pipe (4) between the turbocharger and aftercooler.
3. Put an alignment mark on the turbocharger housing and cartridge to show their angle relationship to each other for assembly purposes.
4. Loosen clamps (6) and (8). Rotate turbocharger housing (7) so that the opening for pipe (4) is in a vertical position.
5. Remove the bolts that hold the valve cover in position. Remove valve cover (5). If necessary, remove the gasket from the valve cover.

Install Valve Cover (3306B) 1107-012

1. Install a new gasket on the valve cover if needed. Put **5H2471 Cement** on the contact surfaces of the valve cover and gasket when a new gasket is installed.



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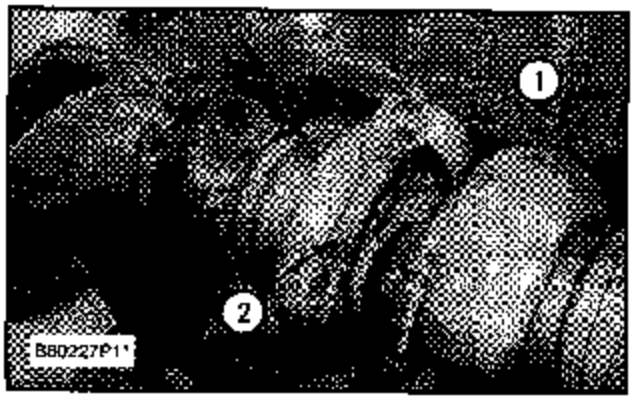
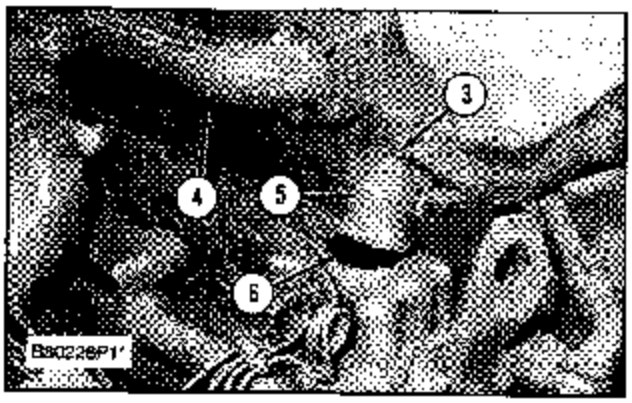
2. Put the valve cover in position on the cylinder head. Install the bolts that hold it. Tighten the bolts in the numbered sequence shown to a torque of **11 ± 3 N•m (8 ± 2 lb ft)**.



3. Rotate turbocharger housing (1) to its original position. Tighten clamps (2). Tighten the clamps to a torque of **14 ± 3 N•m (10 ± 2 lb ft)**.



4. Put the gasket and pipe (4) in position. Install the bolts that hold them.

5. Put O-ring seal (6) and breather cap (5) in position. Install bolt (3). Tighten the bolt to a torque of **14 ± 3 N•m (10 ± 2 lb ft)**.

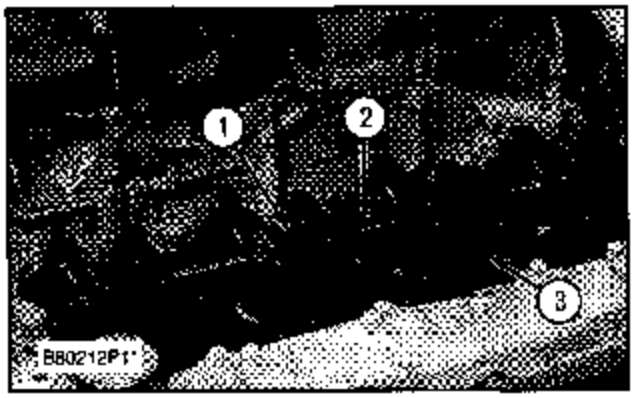
6. Slide the hose into position on the breather cap. Tighten the clamp that holds the hose.

Rocker Shaft Assembly & Push Rods

Remove Rocker Shaft Assembly & Push Rods 1102 & 1208-011

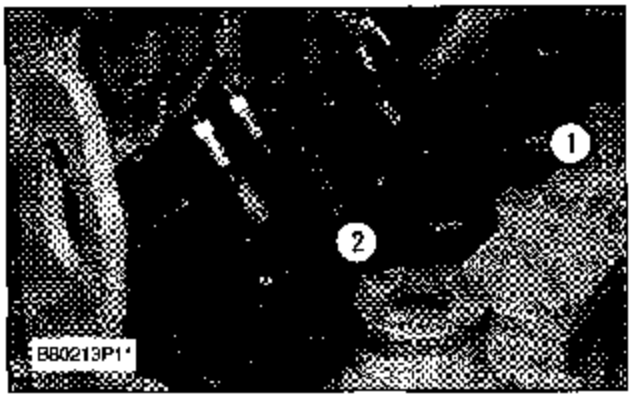
Start By:

a. remove valve cover



1. Remove bolts (1) and the washers that hold rocker shaft assembly (2) in position.
2. Remove rocker shaft assembly (2). Remove the O-ring seal from the rear rocker arm support bracket.
3. Put identification marks on push rods (3) as to their location in the engine. Remove the push rods.

Install Rocker Shaft Assembly & Push Rods 1102 & 1208-012

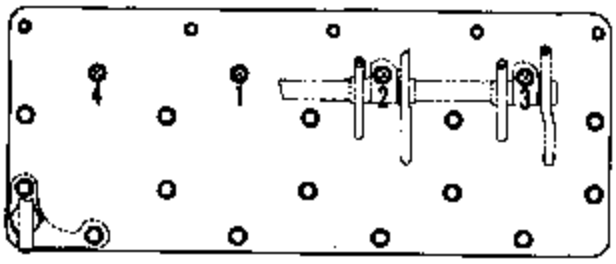


1. Install push rods (1). Make sure they are in their original location in the engine and in position in the valve lifters.

NOTICE

Loosen the adjusting screws on the rocker arms. This will prevent a bent valve or push rod during installation of the rocker shaft assembly.

2. Install a new O-ring seal in the rear rocker arm support bracket. Put **2P2506 Thread Lubricant** on all of the bolts that hold the rocker shaft assembly in position except for the bolt that goes through the rear rocker arm support bracket.
3. Put rocker shaft assembly (2) in position on the engine. Make sure the dowels in the support bracket are in alignment with the dowel holes in the cylinder head. Make sure the rocker arms are engaged with the push rods.
4. Install the bolts and washers that hold the rocker shaft assembly in position. Tighten them until they are finger tight.



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3304B Engine Sequence

77084P1*

3306B Engine Sequence

5. Tighten the bolts that hold the rocker shaft as follows:

a. Tighten the bolts in number sequence to a torque of **156 N•m (115 lb ft)**.

b. Tighten the bolts in number sequence to a torque of **250 ± 17 N•m (185 ± 13 lb ft)**.

c. Tighten the bolts again in number sequence to a torque of **250 ± 17 N•m (185 ± 13 lb ft)**.

6. See "Valve Clearance Setting" in Testing & Adjusting. Make an adjustment to the valves so the intake valves have **0.38 mm (.015 in)** clearance and the exhaust valves have **0.64 mm (.025 in)** clearance. Tighten the locknuts for the adjusting screws to a torque of **29 ± 7 N•m (21 ± 5 lb ft)**.

End By:

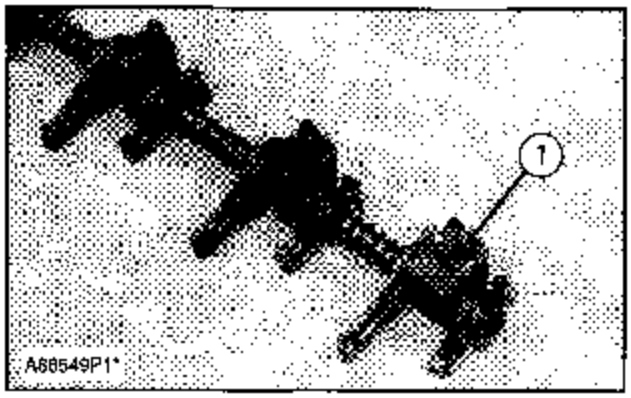
a. install valve cover

Rocker Shaft Assembly

Disassemble Rocker Shaft Assembly 1102-015

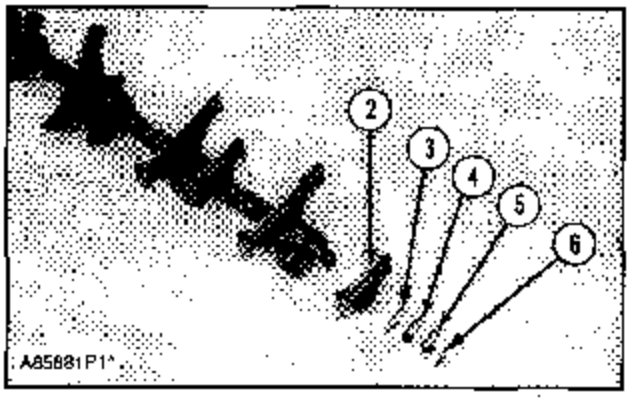
Start By:

a. remove rocker shaft assembly and push rods

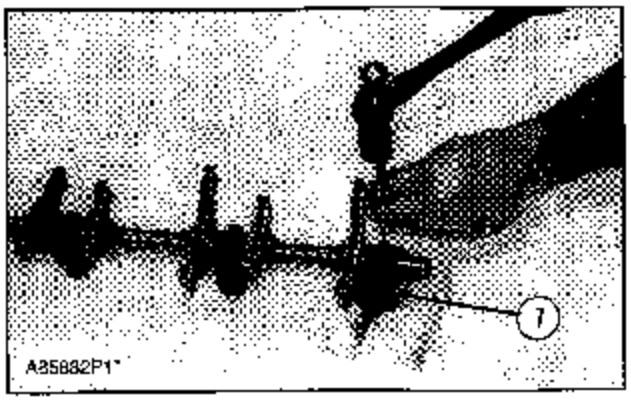


1. Remove O-ring seal (1) from the rear support bracket.

NOTE: A replacement of the O-ring seal must be made each time the head bolt is removed from the rear support bracket.



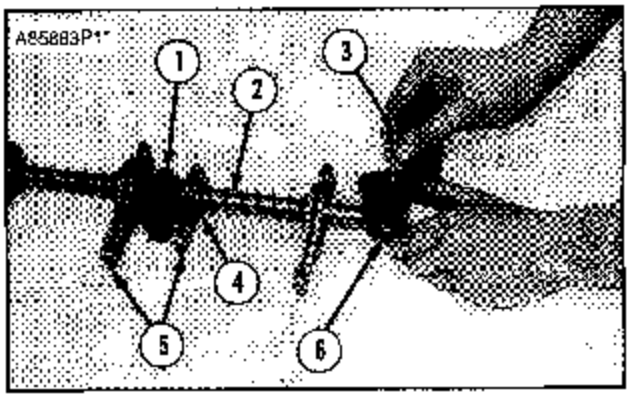
2. Remove retainer ring (6), washer (5), spring (4) and washers (3) from each end of the rocker shaft. Make a note of the number of washers (3) used at each end of the shaft. Remove rocker arms (2) from each end of the rocker shaft. All the rocker arms, springs, washers and brackets, except the rear support bracket, can be removed from the shaft.



3. Remove the pin from the rear support bracket with a hammer and punch. Remove rear support bracket (7) from the shaft.

4. Remove the plugs from each end of the shaft if necessary.

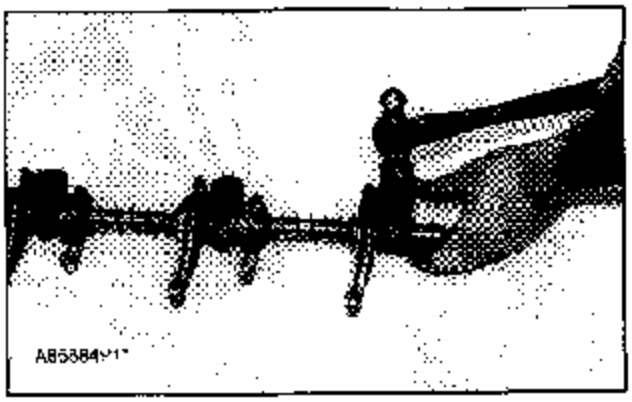
Assemble Rocker Shaft Assembly 1102-016



1. Install rocker arms (5), brackets (1), washers (4) and springs (2) on the rocker shaft.

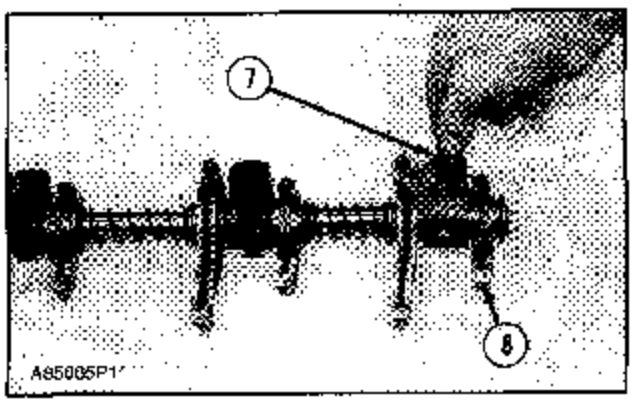
2. Install rear support bracket (6) on the rocker shaft. Make sure the hole in the rear support bracket is in alignment with the hole in the rocker shaft.

3. Put pin (3) in position in the bracket.



4. Install pin (3) through the bracket and shaft with a hammer.

5. Pin (3) must extend **9.60 mm (.378 in)** above the bracket.



6. Install O-ring seal (7) in the rear support bracket. Install rocker arm (8), the original number of washers, spring, washer and the retainer ring on the rocker shaft.

7. Install the front support, rocker arm, original number of washers, spring, washer and the retainer ring on the rocker shaft.

8. Install the plugs in each end of the rocker shaft if they were removed.

End By:

a. Install rocker shaft assembly and push rods

Cylinder Head Assembly & Spacer Plate

Remove Cylinder Head Assembly & Spacer Plate 1100 & 1221-011

Tools Needed	A
5P9736 Link Bracket	2

Start By:

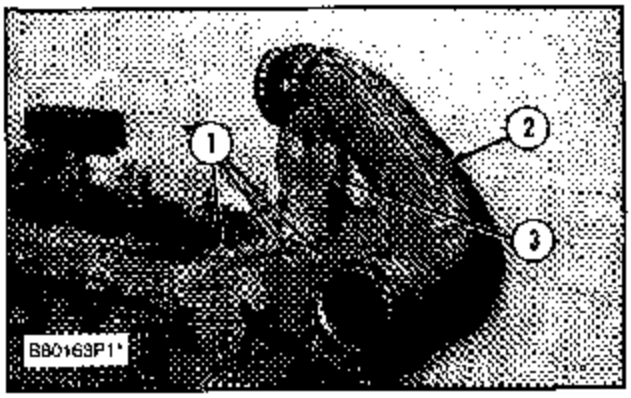
a. remove rocker shaft assembly and push rods

b. remove exhaust manifold

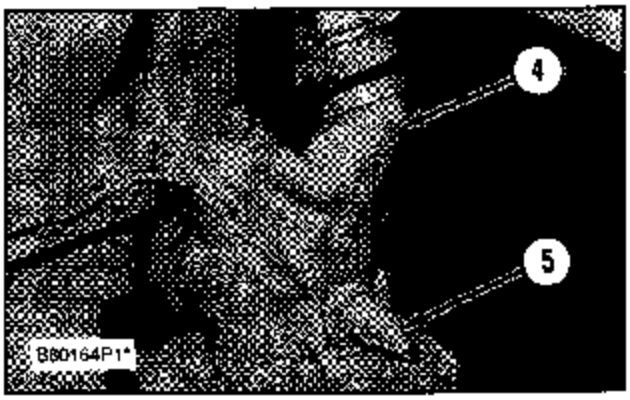
c. remove air cleaner group

d. remove aftercooler

NOTE: The procedure which follows was done on a 3306B Engine.

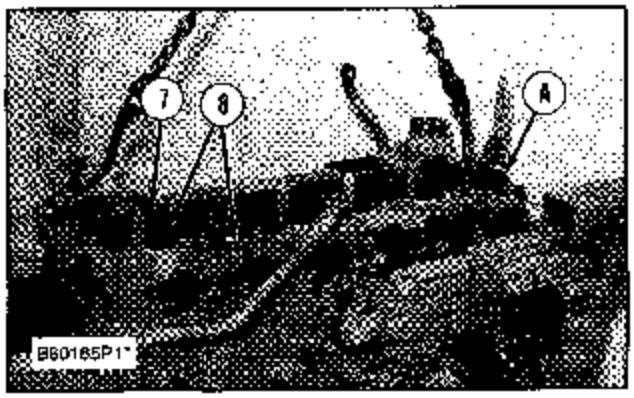


1. Remove bolts (1), mounting bracket and pipe assembly (2) and lifting bracket (3) from the cylinder head assembly.



2. Remove temperature sending unit (5) from elbow (4).

3. Loosen clamp (6), and remove the bolts that hold elbow (4) to the water pump and cylinder head assembly. Remove the elbow and gaskets from the engine.

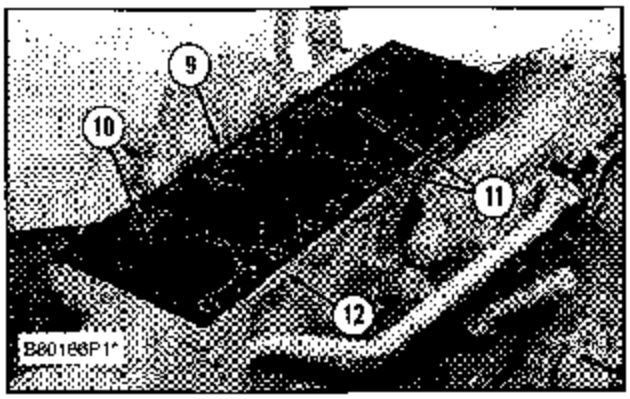


4. Install Tool (A) on the cylinder head assembly as shown, and fasten a hoist on it.

NOTICE

Do not set the cylinder head assembly on a flat surface because of possible damage to the fuel injection nozzle tips.

5. Remove all bolts (7) and (8) that hold the cylinder head assembly to the cylinder block. Remove the cylinder head assembly. The weight of the cylinder head assembly (3304B) is **64 kg (142 lb)**. The weight of the cylinder head assembly (3306B) is **95 kg (210 lb)**.



6. Remove head gasket (9), water seals (11) and the O-ring seal from dowel (10). Remove spacer plate (12), the spacer plate gasket and the O-ring seal from dowel (10).

Install Cylinder Head Assembly & Spacer Plate 1100 & 1221-012

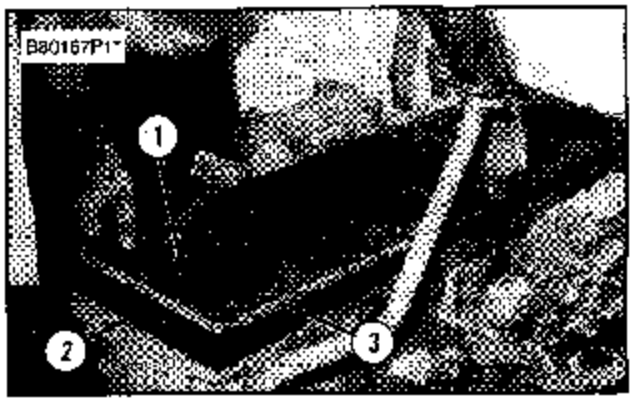
Tools Needed	A
5P9736 Link Bracket	2

NOTE: The procedure which follows was done on a 3306B Engine.

NOTICE

When the cylinder head assembly is removed a new spacer plate gasket and a new cylinder head gasket must be installed. Do not use any adhesive or other substances on these gaskets or the surfaces they contact.

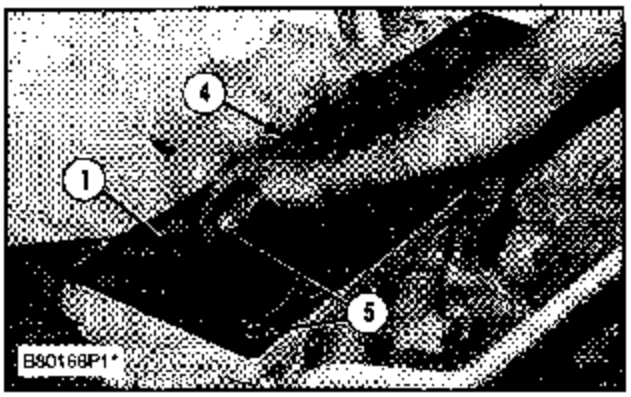
1. Thoroughly clean the spacer plate, cylinder head and cylinder block surfaces.



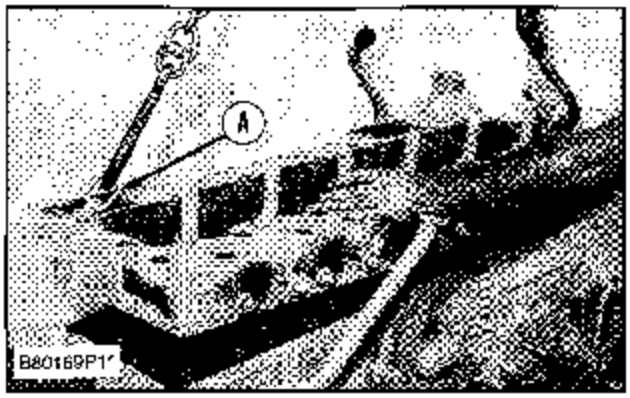
NOTE: If dowel (1) was removed for any reason, install a new dowel until it extends **16.0 ± 0.5 mm (.63 ± .02 in)** from the cylinder block.

2. Install the O-ring seal on dowel (1) against the cylinder block. Install spacer plate gasket (2) and spacer plate (3) on the cylinder block.

3. Check the cylinder liner projection height. See topic, "Install Cylinder Liners".



4. Install the O-ring seal on top of the spacer plate around dowel (1). Install cylinder head gasket (4) and water seals (5).



5. Install Tool (A) on the cylinder head assembly as shown. Fasten a hoist to it. Put the cylinder head assembly in position on the engine.

6. Put **2P2506 Thread Lubricant** on all the cylinder head bolts. Install them until they are finger tight. Remove Tool (A) from the engine.

7. Install push rods (6). Make sure they are installed in their original locations. Be sure the push rods are in position in the valve lifters.

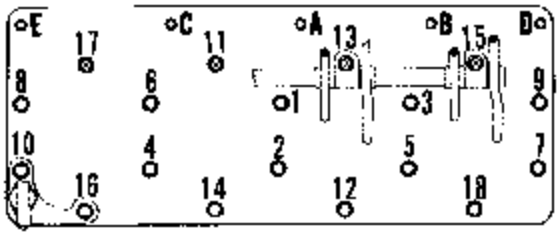
8. Loosen the adjusting screws on the rocker arms for valve clearance. This will prevent a bend valve or push rod during installation of the rocker shaft assembly.

9. Install a new O-ring seal in the rear rocker arm support bracket.

10. Put **2P2506 Thread Lubricant** on all of the rocker shaft bolts except the one that goes through the rear rocker arm support bracket.

11. Put rocker shaft assembly (7) in position on the cylinder head assembly. Make sure the dowels in the support brackets are in the dowel holes in the cylinder head assembly and the rocker arms are engaged with the push rods. Install the bolts that hold the rocker shaft assembly until they are finger tight.

3306B Engine Shown



3304B Engine Shown

12. Hand tighten the large size cylinder head and rocker shaft bolts in the numbered sequence shown for each engine as follows:

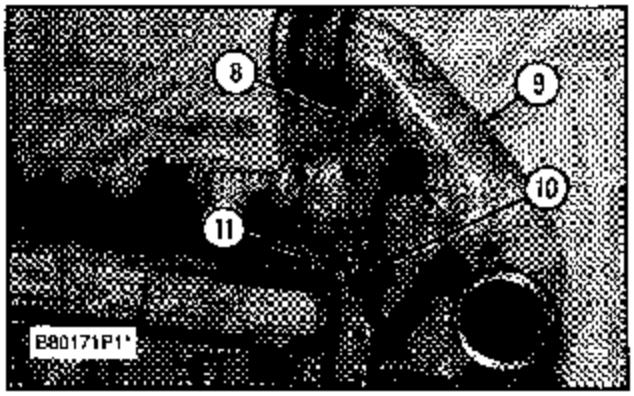
a. Tighten the bolts in the numbered sequence to a torque of **156 N•m (115 lb ft)**.

b. Tighten the bolts in the numbered sequence to a torque of **250 ± 17 N•m (185 ± 13 lb ft)**.

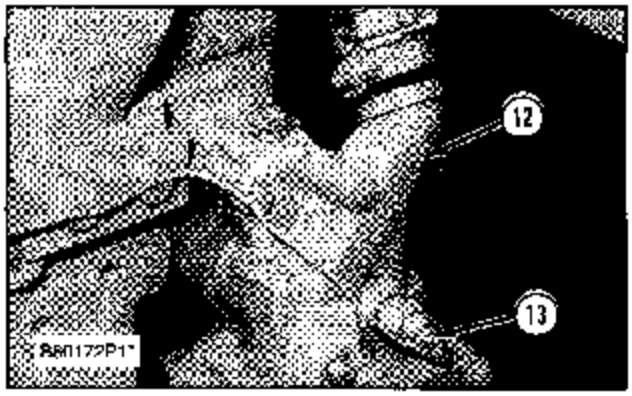
c. Tighten the bolts in the numbered sequence again to a torque of **250 ± 17 N•m (185 ± 13 lb ft)**.

13. Hand tighten the small size cylinder head bolts, in the lettered secuence shown for each engine to a torque of **43 ± 7 N•m (32 ± 5 lb ft)**.

14. See topic, "Valve Clearance" in Testing & Adjusting Manual to make an adjustment to the valves. The intake valves must have a clearance of **0.38 mm (.015 in)**. The exhaust valves must have a clearance of **0.64 mm (.025 in)**.



15. Remove bolt (11). Put lifting bracket (8) and mounting bracket and pipe assembly (9) in position. Install bolts (10). Install bolt (11). Tighten the bolt to a torque of **43 ± 7 N·m (32 ± 5 lb ft)**.



16. Put the gaskets and elbow (12) in position. Install the bolts that hold them. Tighten the hose clamp on the back side of the elbow.

17. Install temperature sending unit (13) in the elbow.

End By:

a. install rocker shaft assembly and push rods

b. install exhaust manifold

c. install air cleaner group

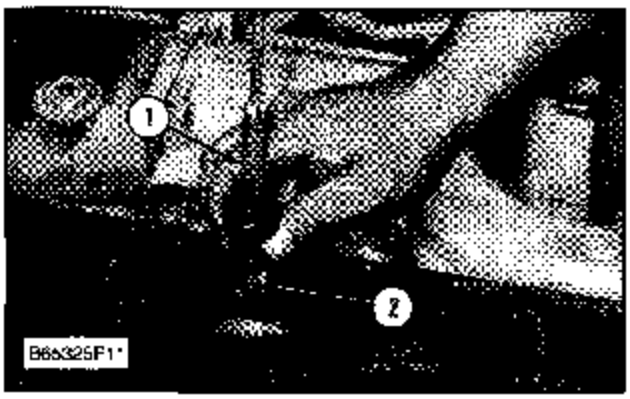
d. install aftercooler

Valve Lifters

Remove & Install Valve Lifters 1209-010

Start By:

a. remove cylinder head assembly and spacer plate



1. Use a magnet (1) to remove valve lifters (2). Put identification marks on lifters for installation purposes.

2. Check the diameter of the valve lifter. The diameter of the valve lifter (new) must be **33.287 ± 1.311 mm (1.3105 ± .0005 in)**. The bore in the block for new valve lifters must be **33.388 ± 0.025 mm (1.3145 ± .0010 in)**. The maximum permissible clearance between the lifter and the bore for the valve lifter (worn) is **0.30 mm (.012 in)**.

3. Put **2P2506 Thread Lubricant** on the valve lifters and camshaft lobes. Install the valve lifters in original positions in the cylinder block.

End By:

a. install cylinder head assembly and spacer plate

Valves

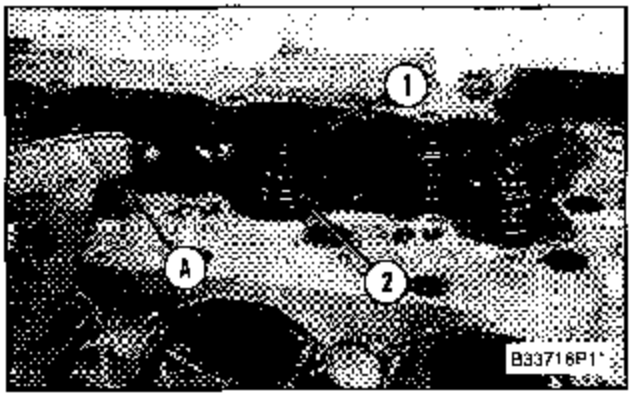
Remove Valves 1105-011

Tools Needed		A	B
5S1330	Valve Spring Compressor Assembly	1	
8S2263	Valve Spring Tester		1

Start By:

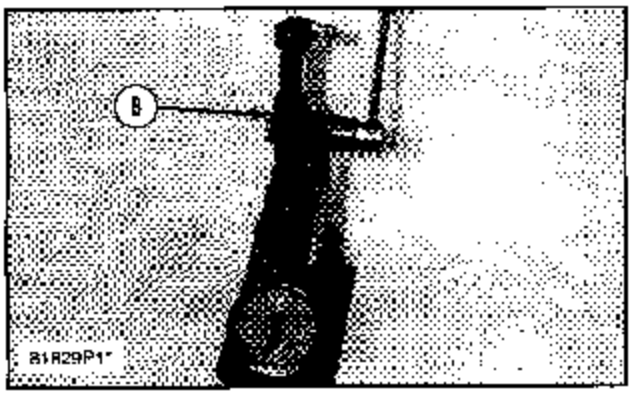
a. remove fuel injection nozzles

b. remove cylinder head assembly and spacer plate



1. Put compression on valve spring (2) with Tool (A). Remove locks (1).

2. Remove Tool (A), rotocoil, spring, valve stem oil shield and valve. Put identification marks on valves with respect to their location in the cylinder head.

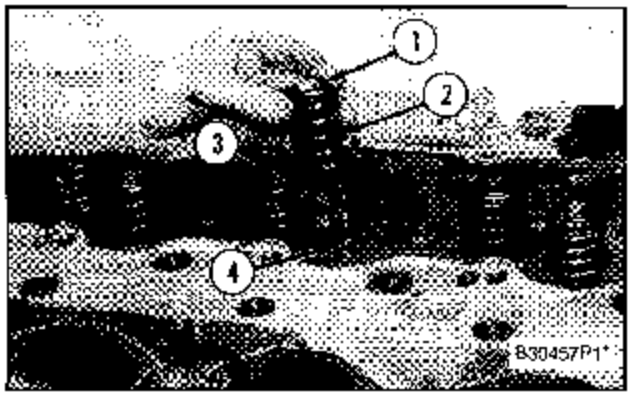


3. Check the spring force with Tool (B). The spring force is **257 ± 25 N (57.8 ± 5.6 lb)**. The length of spring under test force is **44.86 mm (1.766 in)**. The free length after test is **52.07 mm (2.050 in)**.

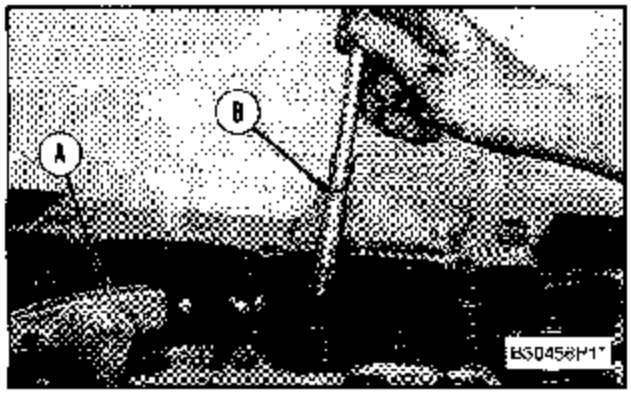
4. Do Steps 1 through 3 again for the remainder of the valves.

Install Valves 1105-012

Tools Needed		A	B
5S1330	Valve Spring Compressor Assembly	1	
5S1322	Valve Keeper Inserter		1



1. Put clean engine oil on the valve stems. Install valve (3), oil shield (4), spring (2) and rotocoil (1) in the cylinder head.



2. Put Tool (A) in position on the valve spring. Install the locks with Tool (B).

⚠ WARNING

Locks can be thrown from valve when the compressor is released if they are not in their correct position on valve stem. Personal injury can be the result if not carefully removed.

3. Remove Tool (A), and hit the top of valve with a plastic hammer to be sure the locks are in their correct position on valve.

4. Do Steps 1 through 3 again for the remainder of the valves.

End By:

a. Install cylinder head assembly and spacer plate

b. install fuel injection nozzles

Valve Guides

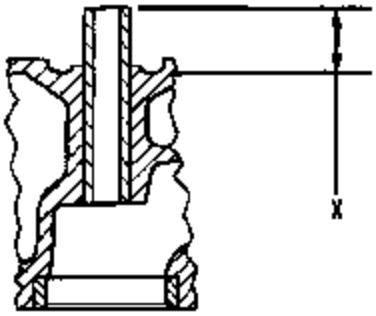
Remove & Install Valve Guides 1104-010

Tools Needed		A	B
7S6850	Guide Driver	1	
7S6858	Bushing		1

Start By:

a. remove valves

1. Remove the valve guides from the cylinder head with Tool (A).



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2. Put clean engine oil on the outside diameter of the valve guide. Install the valve guide with Tool (A) and (B). Dimension "X" from the top of the valve guide to the cylinder head is **22.23 ± .025 mm (.875 ± .010 in)**.

3. The inside diameter of a new valve guide after installation must be a minimum of **9.456 mm (.3723 in)**. The maximum inside diameter for a worn guide must not be more than **9.581 mm (.3772 in)**.

End By:

a. install valves

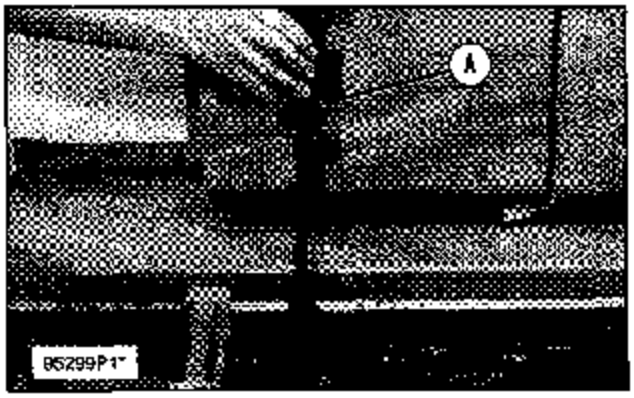
Valve Seat Inserts

Remove & Install Valve Seat Inserts 1103-010

Tools Needed		A
6V4805	Valve Seat Extractor Tool Group	1

Start By:

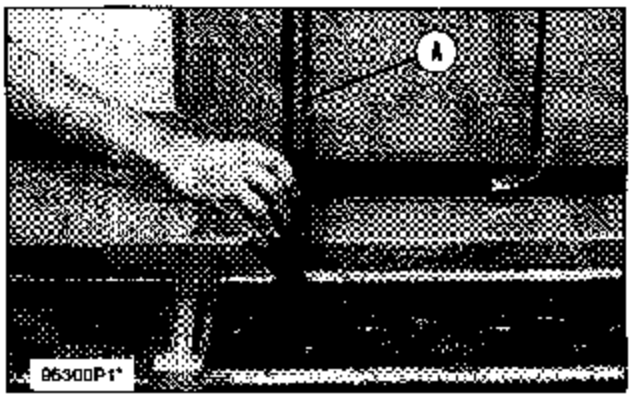
a. remove valves



1. Use Tool (A) to remove the valve seat inserts from the cylinder head.

2. Clean and remove any rough places (burrs) from the valve seat bores.

NOTE: For reconditioning information of the cylinder head, see Service Training Meeting Guide, Form JEG02327.



Typical Example

3. Lower the temperature (freeze) of the new valve seat inserts. Use Tool (A) to install the new valve seat inserts. Do not increase the diameter of the extractor in the valve seat insert when the insert is installed in the cylinder head.

End By:

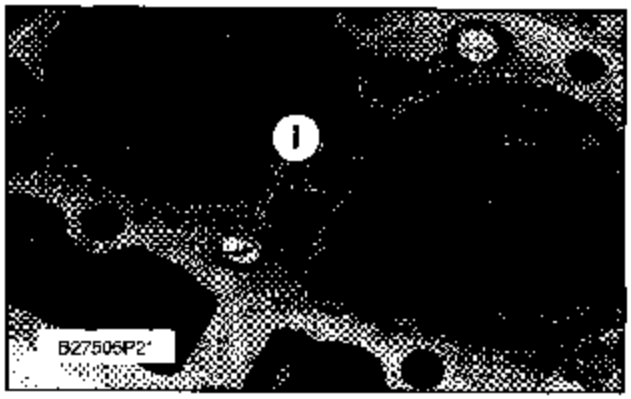
a. install valves

Water Directors

Remove & Install Water Directors 1115-010

Start By:

a. remove cylinder head assembly and spacer plate



1. Remove old water directors (1) from the cylinder head.

2. Clean the cylinder head.

3. Install new water directors in the cylinder head with the notch in the water director in alignment with the "V" mark on the cylinder head. Install the water director to a depth of **0.8 ± 0.6 mm (.03 ± .02 in)** below the surface of the cylinder head.

End By:

a. install cylinder head assembly and spacer plate

Pistons & Connecting Rods

Remove Pistons & Connecting Rods 1225-011

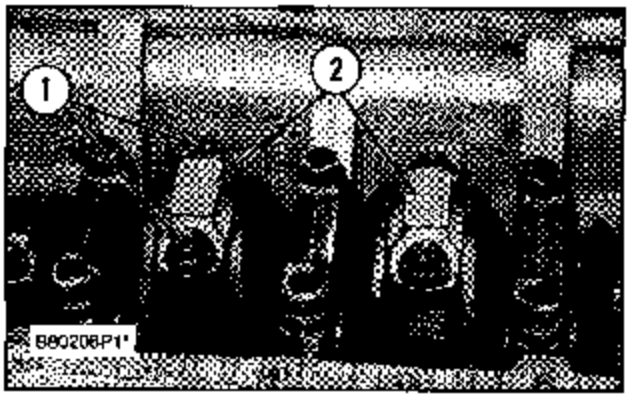
Start By:

a. remove cylinder head assembly and spacer plate

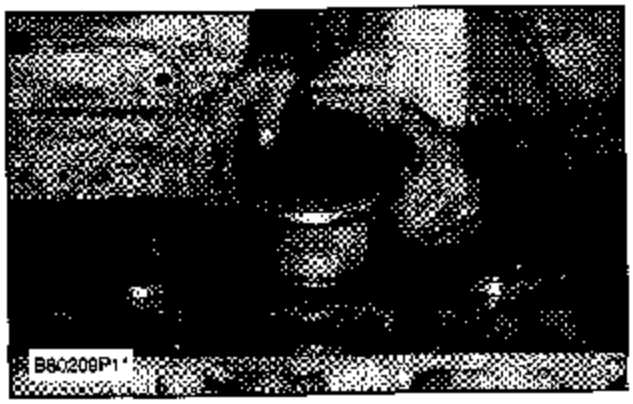
b. remove oil pan plate

c. remove oil pump

1. Remove the carbon ring and lip from the inner surface of the cylinder liner.



2. Turn the crankshaft until two of the pistons are at bottom center. Remove the nuts and bolts (1) from the connecting rods that are at bottom center. Remove connecting rod caps (2). Put identification marks on them for installation purposes.



NOTICE

Do not let the connecting rods hit the crankshaft or the bottom edge of the cylinder liners when the pistons are removed.

3. Push the connecting rods and pistons away from the crankshaft until the piston rings are out of the cylinder liners. Remove the two pistons from the engine.

4. Keep each connecting rod cap with its respective connecting rod and piston. Put identification marks on each piston as to its location in the engine.

5. Do Steps 1 through 4 for the removal of the remaining pistons.

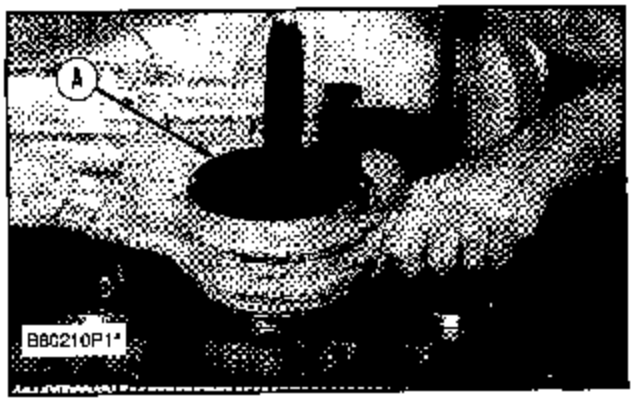
Install Pistons & Connecting Rods 1225-012

Tools Needed		A
5P3525	Ring Compressor	1

1. Turn the crankshaft until the bearing journals for the pistons to be installed are at bottom center.

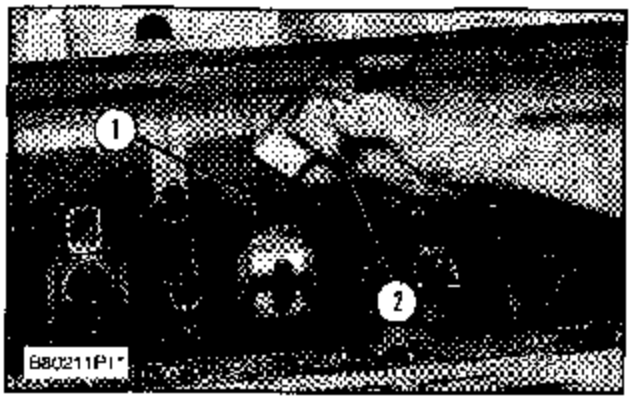
2. Put clean engine oil on the crankshaft journals and on the inside of the cylinder liners. Put clean engine oil on the piston rings and the connecting rod bearings.

3. Move the piston rings on the pistons until the ring openings are **approximately 90°** apart.



4. Put the piston in the cylinder liner with the "V" mark on the piston in alignment with the "V" mark on the cylinder block. Put Tool (A) in position on the cylinder block and compress the piston rings.

5. Push the piston into the cylinder liner and out of the ring compressor.



6. Pull the connecting rod into position on the crankshaft as shown. Install connecting rod bolts (1) in the connecting rods.

7. Put clean engine oil on the lower half of the connecting rod bearing. Put **2P2506 Thread Lubricant** on the bolt threads and on the surfaces of the nuts that make contact with the connecting rod caps.

NOTICE

When the connecting rod caps are installed, make sure the number on the side of the cap is next to and respective with the number on the side of the connecting rod.

8. Install connecting rod caps (2) and the nuts that hold them. Tighten the nuts to a torque of **40 ± 4 N•m (30 ± 3 lb ft). Put a mark on each nut as to its location. Tighten them 90° ± 5°** more.

9. Do Steps 1 through 8 for the remainder of the pistons.

End By:

a. install oil pump

b. install oil pan plate

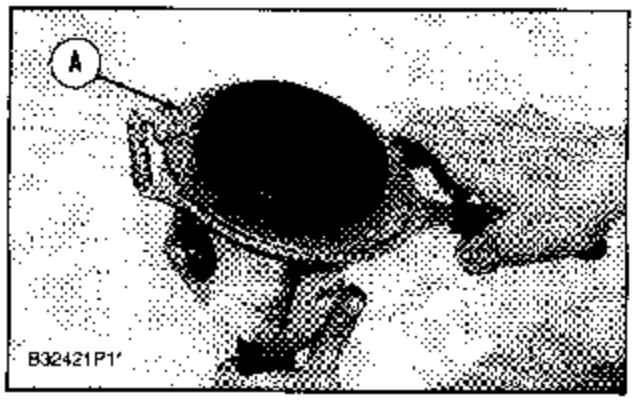
c. install cylinder head assembly and spacer plate

Disassemble Pistons & Connecting Rods 1225-015

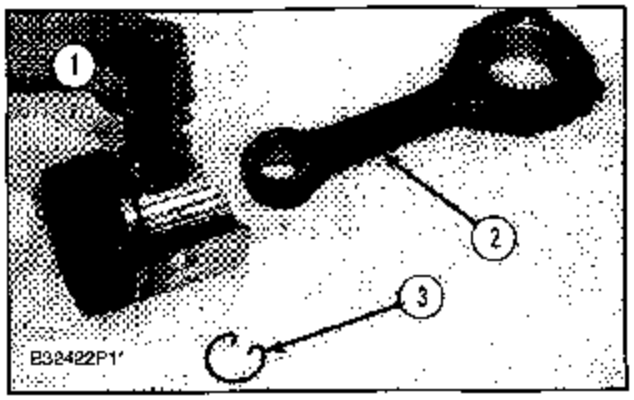
Tools Needed		A	B
7S9470	Ring Expander	1	
5P8639	Press Group		1
5P8645	Adapter		1
6V3029	Spacer		1
6V2049	Adapter		1
2D2825	Hydraulic Pump (or electric)		1
8F0024	Hose Assembly		1
1P2375	Coupler Assembly		1
1P2376	Coupler Assembly		1

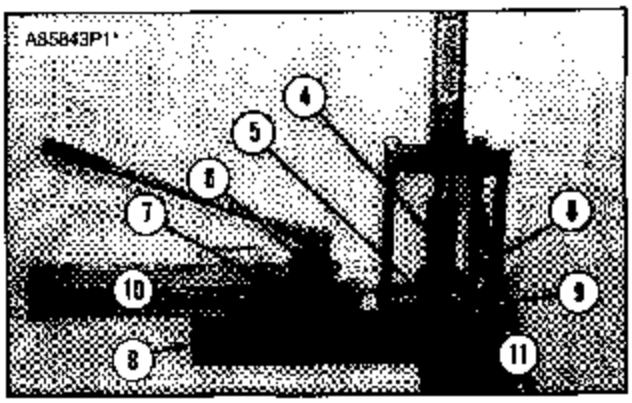
Start By:

a. remove pistons and connecting rods



1. Remove the rings from the pistons with Tool (A).





2. Remove retaining ring (3), piston pin (1) and connecting rod (2) from the piston.

3. Remove the bearings from the crankshaft end of the connecting rod.

4. See Use Of Piston Pin Bearing Removal And Installation Tools, Special Instructions, Form No. SMHS7295-02 for more information about removal and installation of piston pin bearings.

NOTE: Be sure to remove the bearings from the crankshaft end of connecting rod.

5. Heat the connecting rod in an oven to a temperature of **176 to 260° C (350 to 500° F)**. Never use a direct flame to heat a connecting rod.

6. Put **6V3029 Spacer** (11) in the base plate. Put the connecting rod on the base plate of Tool (B).

7. Put the connecting rod piston pin bearing end in the center of the port assembly of Tool (B). Install pin (6) in the center of the bore for the connecting rod bearing.

8. Install **6V2049 Adapter** (9). Put the hole in the adapter in alignment with the hole in the base plate of Tool (B).

9. Install clamp bar (10) and clamp pin (7).

NOTE: The old bearing is pushed out by Tool (B) as the new bearing is installed.

10. Put **5P8645 Pusher Adapter** (8) in position as shown with the taper side down. The piston pin bearing joint must be in alignment with the hole in adapter (9) and the base plate of Tool (B).

11. Put pusher (4) on adapter (8).

12. Use Tool (B) to push the new piston pin bearing (5) into the connecting rod until adapter (8) of Tool (B) makes full contact with the connecting rod surface.

13. Remove the connecting rod and the old piston pin bearing from Tool (B).

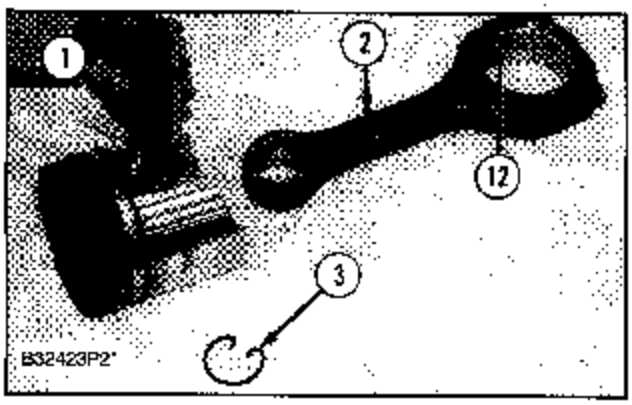
14. Check the piston pin bearing bore diameter after the bearing is installed. The correct dimension is **43.210 ± 0.008 mm (1.7012 ± .0003 in.)**. The maximum permissible clearance between the bearing and piston pin (worn) must not be more than **0.08 mm (.003 in.)**.

Assemble Pistons & Connecting Rods 125-016

Tools Needed		A
7S9470	Ring Expander	1

1. When old pistons are used, clean the piston grooves with an acceptable ring groove tool.

2. Install the connecting rod bearings in the crankshaft end of the connecting rod. Make sure the tabs on the back of the bearings are in the tab grooves of the connecting rod and cap.



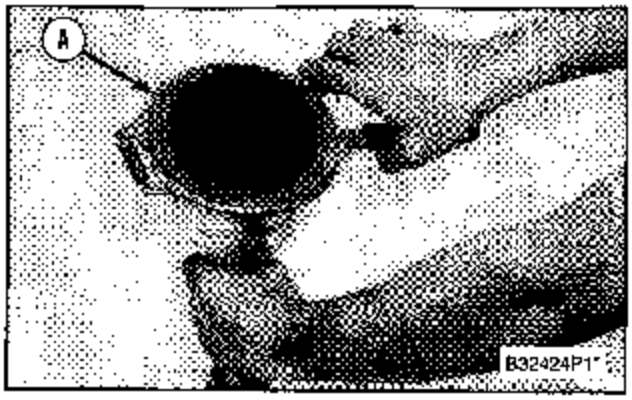
3. Put connecting rod (2) in position in the piston with bearing tab groove (12) and number identification on the same side as the "V" mark on the top of the piston.

4. Install piston pin (1) and retaining ring (3).

5. For correct piston and ring clearances, see the topic, "Pistons & Rings" in Specifications.

6. Install the oil ring spring in the oil ring groove of the piston.

NOTE: The oil ring must be installed on the piston with the ring end gap **180°** from the oil ring spring joint.



7. Install the oil ring on the piston with Tool (A).

8. Install the intermediate piston ring with the side that has the mark "UP-2" toward the top of the piston with Tool (A).

9. Install the top piston ring with the side that has the mark "UP-1" toward the top of the piston. Make sure piston ring end gaps are **90°** apart before the pistons are installed.

End By:

a. install pistons and connecting rods

Cylinder Liners

Remove Cylinder Liners 1216-011

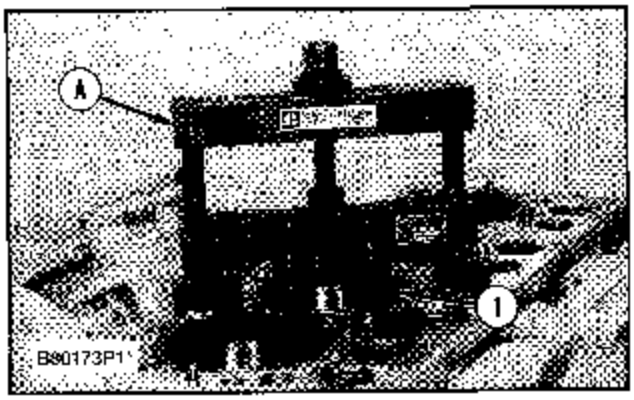
Tools Needed		A
5P8665	Cylinder Liner Puller	1

Start By:

a. remove pistons

1. Drain the coolant from the cylinder block.

2. Put covers on the journals of the crankshaft for protection from dirt or water.

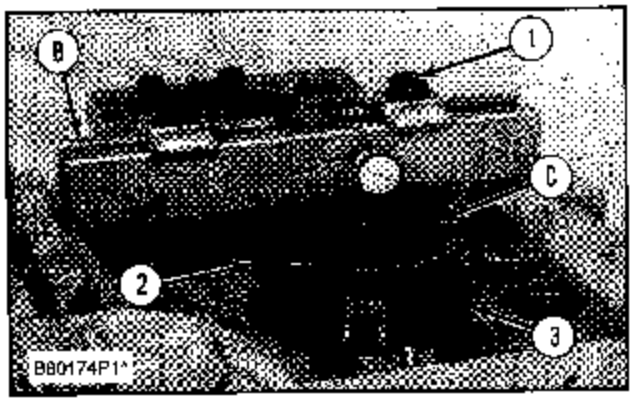


3. Remove cylinder liners (1) with Tool (A).

4. Remove the O-ring seals and filler band from each of the cylinder liners.

Install Cylinder Liners 1216-012

Tools Needed		A	B	C
2P8260	Liner Installer Group	1		
8T0455	Liner Projection Tool Group			1
8B7548	Push-Puller (Crossbar)		1	
1P2394	Puller Plate		1	
3H0465	Plate		2	
S01589	Bolt [5/8" - 11 NC x 1.75 in (44.5 mm) long]		12	
1S0379	Washer (copper)		12	
1D4595	Bolt, 5/8" - 11 NC x 152.4 mm (6.00 in) long		2	
2S0736	Washer		2	



1. Clean cylinder liners (3) and the liner bores in the cylinder block.

2. Install the cylinder liners in the block without the O-ring seals or filler bands.

3. Check the cylinder liner projection as follows:

a. Install the **S1589 Bolts (2)** and **1S379 Washers of Tool (B)** on the cylinder block next to each liner. Tighten the bolts evenly, in four steps: **14 N•m (10 lb ft)**, **35 N•m (25 lb ft)**, **70 N•m (52 lb ft)** and **95 N•m (70 lb ft)**.

b. Put the adapter plate on top of the liner, and install the remainder of Tool (B). Tighten the **1D4595 Bolts (1)** evenly in four steps: **7 N•m (5 lb ft)**, **20 N•m (15 lb ft)**, **35 N•m (25 lb ft)** and **70 N•m (52 lb ft)**.

c. Check to be sure the distance from the bottom edge of the crossbar to the top of the cylinder block is the same on both sides of the liner.

d. Check the cylinder liner projection with Tool (C) at four locations around the liner.

e. Liner projection must be **0.033 to 0.175 mm (.0013 to .0069 in)**. Measurements on the same liner must not be different by more than **0.05 mm (.002 in)**. Average measurements between liners next to each other must not be different by more than **0.05 mm (.002 in)**. The maximum permissible difference between average projection of all cylinder liners is **0.10 mm (.004 in)**.

NOTE: If the liner is turned in the bore, it can make a difference in the liner projection.

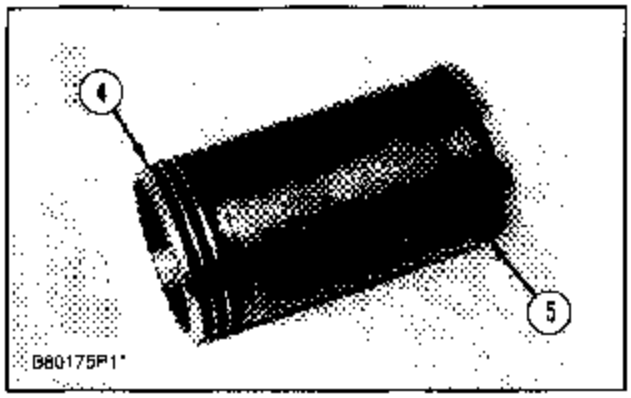
4. If the liner projection is not **0.033 to 0.175 mm (.0013 to .0069 in)**, check the thickness of the following parts: spacer plate, spacer plate gasket and cylinder liner flange. The thickness of the spacer plate must be **9.970 ± 0.025 mm (.3925 ± .0010 in)**. The thickness of the spacer plate gasket must be **0.208 ± 0.025 mm (.0082 ± .0010 in)**. The thickness of the cylinder liner flange must be **10.282 ± 0.020 mm (.4048 ± .0008 in)**.

NOTE: If the liner projection changes from point to point around the liner, turn the liner to a new position in the bore. If the liner projection is still not to specifications, move the liner to a different bore.

5. When the cylinder projection is correct, put an alignment mark on the liner and block so the liner can be installed in the same position from which it was removed.

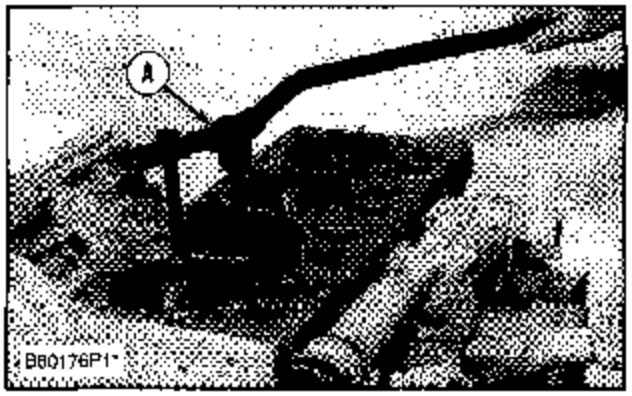
NOTE: Cylinder liner projection can be adjusted by the removal of material from (machining) the contact face of the cylinder block with the use of the 8S3140 Cylinder Block Counterboring Tool Arrangement. Machine to a minimum depth of **0.76 mm (.030 in)** and to a maximum depth of **1.14 mm (.045 in)**. The instructions for the use of the tool group are in Special Instruction, Form No. SMO55228. Shims are available for the adjustment of the liner projection. See topic, "Cylinder Liner Projection" in Testing & Adjusting Manual for the shim thickness and part number.

6. Remove Tool (B) and (C). Remove the liner.



7. Put liquid soap on the bottom of the liner bore in the block, on the grooves in lower liner and on O ring seals (4). Install the O ring seals on the liner.

8. Put filler band (5) in clean **SAE 30** oil for a moment. Install it on the liner. Install the cylinder liner immediately in the cylinder block (before expansion of filler band)



9. Make sure the mark on the liner is in alignment with the mark on the block. Use Tool (A) to push the liner into position.

10. Do Steps 5 through 9 for the remainder of the cylinder liners.

End By:

a. install pistons

Crankshaft Main Bearings

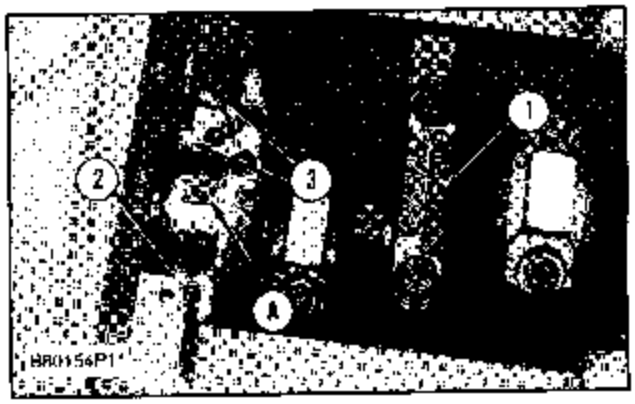
Remove & Install Crankshaft Main Bearings 1203-010

Tools Needed		A	B	C
2P5518	Bearing Tool	1		
	Plastigage		*	
BS2328	Dial Indicator Test Group			1

Start By:

a. remove oil pump

b. remove oil pan plate



1. Remove No. 1, 3, 5 and 7 main bearing caps (1). Remove the lower halves of the main bearings from the main bearing caps.

NOTICE

If the crankshaft is turned in the wrong direction, the tab on the bearing will be pushed between the crankshaft and the bearing area in the cylinder block. This can result in damage to the cylinder block and/or the crankshaft.

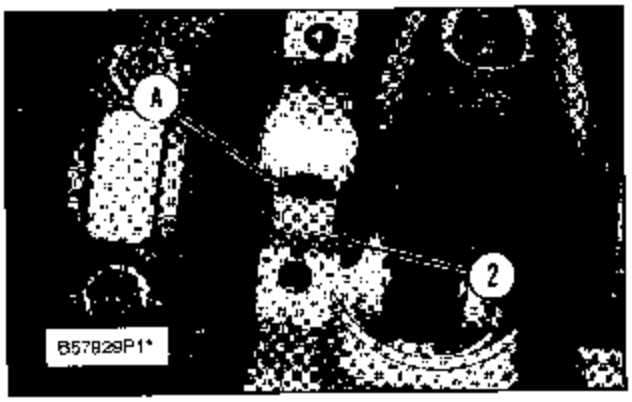
2. Install Tool (A) in the hole in the crankshaft journal, and turn the crankshaft to remove the upper halves of main bearings (2).

3. Remove crankshaft thrust bearings (3) from the rear main bearing.

NOTE: Install the main bearings dry when the clearance checks are made. Put clean engine oil on the main bearings for final assembly.

NOTICE

Make sure the upper and lower halves of the main bearings are installed so the bearing tabs fit into the notch in the cylinder block and the main bearing caps.



4. Use Tool (A), and install new upper halves of main bearings (2) in the cylinder block. Install new lower halves of main bearings (2) in main bearing caps (1).

NOTICE

When the bearing clearance is checked and the engine is in an upright position (vertical position with cylinder head on top), the crankshaft will have to be lifted up and held against the upper halves of the main bearings to get a correct measurement with the Plastigage. The Plastigage will not hold the weight of the crankshaft and give a correct indication. If the engine is in a horizontal position, it is not necessary to hold the crankshaft up. Do not turn the crankshaft when the Plastigage is in position to check clearances.

NOTE: For complete details concerning measuring bearing clearances, see Engine Bearings And Crankshafts, Form No. SEBD0531.

5. Check the main bearing clearance with Plastigage (B) as follows:

a. Put a piece of Plastigage (B) on the crankshaft journals as shown.

NOTICE

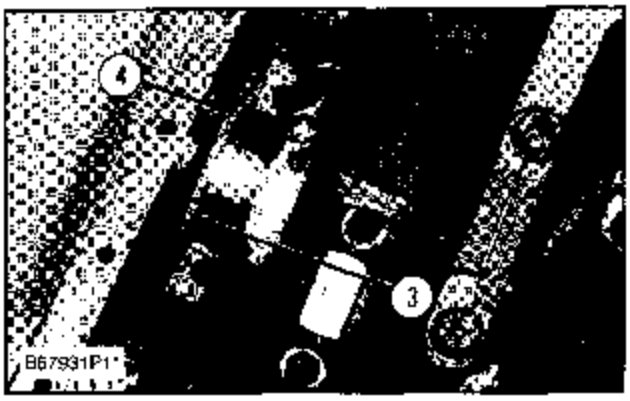
Make sure the part number on the main bearing cap is toward the front of the engine and the number on the main bearing cap is the same as the number on the cylinder block on the left side of each main bearing cap.

---

b. Put main bearing caps (1) in position in the engine. Put **2P2506 Thread Lubricant** on the bolt threads and the face of the washers. Install the bolts. Tighten the bolts to a torque of **40 ± 4 N•m (30 ± 3 lb ft)**.

c. Put a mark on each bolt and main bearing cap; then tighten the bolts **90°** more.

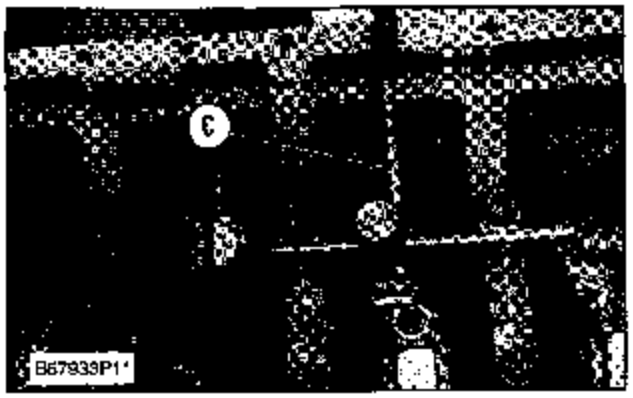
d. Remove the main bearing caps, and measure the Plastigage to find the bearing clearance. The main bearing clearance for new bearings must be **0.076 to 0.165 mm (.0030 to .0065 in.)**. Maximum permissible clearance with used bearings is **0.25 mm (.010 in.)**.



6. Put clean oil on the thrust bearing, and install a new thrust bearing for the rear main bearing. Install the thrust bearing with the identification "BLOCK SIDE" toward the cylinder block and the tabs on the thrust bearings in the machined area in the cylinder block. Tabs (4) on thrust bearing (3) will not let the thrust bearing be installed backward.

7. Install main bearing caps (1). Tighten the bolts as in Steps 5b and 5c.

8. Remove the remainder of the main bearing caps, and do Steps 2, 4, 5 and 7 again.



9. Check the crankshaft end play with Tool (C). The end play is controlled by the thrust bearings on the rear main bearing. End play with new bearings must be **0.064 to 0.368 mm (.0025 to .0145 in.)**. The maximum permissible end play with used bearings is **0.64 mm (.025 in.)**.

End By:

a. install oil pan plate

b. install oil pump

Connecting Rod Bearings

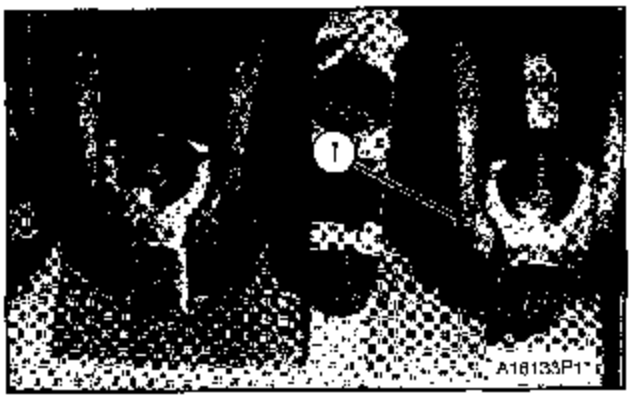
Remove & Install Connecting Rod Bearings 1219-010

Tools Needed	A
Plastigage	*

Start By:

a. remove oil pump

b. remove oil pan plate



1. Turn the crankshaft until two pistons are at the bottom center. Remove connecting rod caps (1) from the two connecting rods. Remove the lower half of the rod bearing from the rod bearing cap.

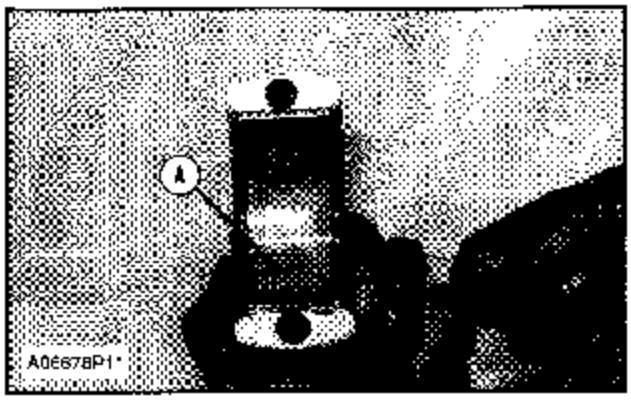
2. Push the connecting rods away from the crankshaft. Remove the upper half of the rod bearing from the connecting rod.

NOTE: Install the connecting rod bearings dry when the clearance checks are made. Put clean engine oil on the connecting rod bearings for final assembly.

3. Install the upper half of the rod bearing in the connecting rod.

4. Install the lower half of the rod bearing in the connecting rod cap.

NOTE: Be sure the tabs in the back of the connecting rod bearings are in the tab grooves of the connecting rod and cap.



5. Use Plastigage (A) to check the connecting rod bearing clearance.

6. Put Plastigage (A) on the connecting rod bearing.

7. Put **2P2506 Thread Lubricant** on the threads of the rod bolts and seat surfaces of the nuts.

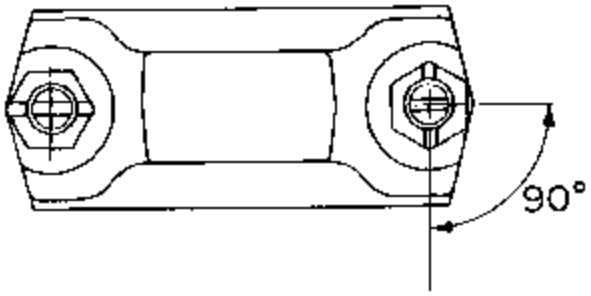
NOTICE

When connecting rod caps are installed, make sure the number on the side of the cap is next to and respective with the number on the side of the connecting rod.

NOTE: Do not turn the crankshaft when Plastigage (A) is in position.

NOTICE

Do not use an impact wrench to tighten the nuts the additional **90°**.



8. Install connecting rod cap (1). Install the nuts. Tighten the nuts to a torque of **40 ± 4 N·m (30 ± 3 lb ft)**. Put a mark on each nut and the end of each bolt. Tighten the nuts **90°** more. Remove the connecting rod caps. Remove Plastigage (A) and measure the width of the Plastigage. The connecting rod clearance must be **0.076 to 0.168 mm (.0030 to .0066 in)** for new bearings. The maximum clearance with used bearings is **0.25 mm (.010 in)**.

9. Install the connecting rod caps and tighten the nuts as in Step 8.

10. Do Steps 1 through 9 for the remainder of the connecting rod bearings.

End By:

a. install oil pan plate

b. install oil pump

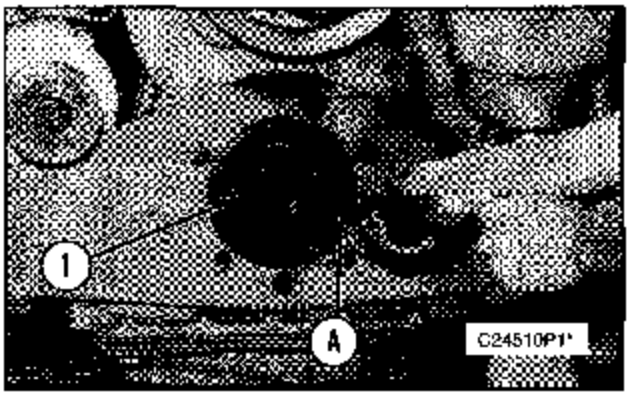
Crankshaft Front Seal & Wear Sleeve

Remove & Install Crankshaft Front Seal & Wear Sleeve 1160-010

Tools Needed		A	B	C	D
1U7600	Puller Assembly	1			
5P7312	Distorter		1		
5P7315	Ring			1	
4C8982	Installer				1
7F8022	Bolt				1

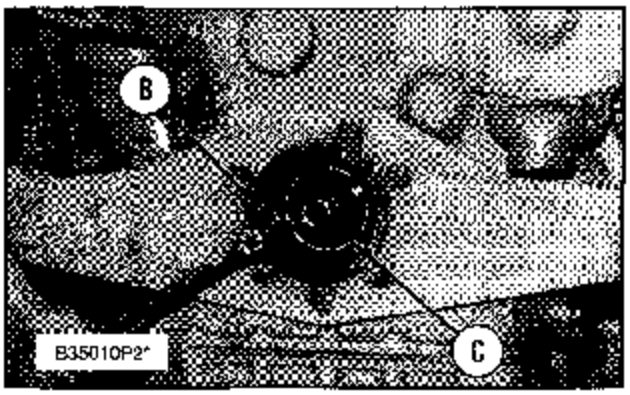
Start By:

a. remove vibration damper and pulley



NOTE: When a replacement of the front seal (1) is made, a replacement of the wear sleeve also must be made.

1. Remove crankshaft front seal (1) with Tool (A).



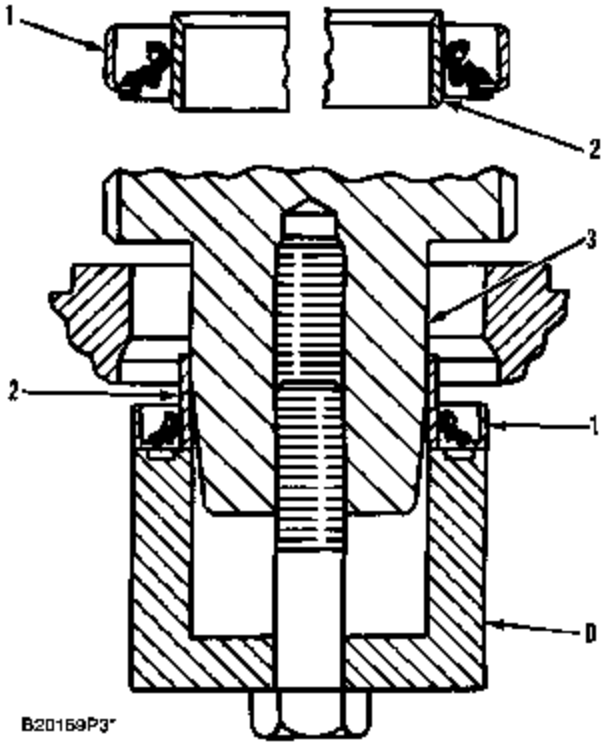
Typical Example

2. Install Tool (C) into the seal bore.

3. Install Tool (B) between Tool (C) and the wear sleeve. Turn Tool (B) until the edge of the Tool makes a flat place (crease) in the wear sleeve. Do this in two or more places until the wear sleeve is loose.

4. Remove Tool (C) and the wear sleeve by hand.

NOTE: The following steps are for installation of the crankshaft front seal and wear sleeve.



5. Install the crankshaft front seal and wear sleeve with Tool (D) as follows:

a. Put clean engine oil on the seal lip of seal (1) and on the outside diameter of wear sleeve (2). Install seal (1) on the wear sleeve as shown, with the lip of the seal toward the side of the wear sleeve that has the chamfer on the inside diameter.

b. Use **6V1541 Quick Cure Primer** to clean the outside diameter of crankshaft (3) and the inside diameter of wear sleeve (2).

c. Put **9S3265 Retaining Compound** on the outside diameter of crankshaft (3) and the inside diameter of wear sleeve (2).

d. Put wear sleeve (2) with seal (1) on the front of the crankshaft as shown.

e. Install Tool (D) as shown and put lubricant between the bolt head and installer.

f. Use Tool (D) to push the wear sleeve and seal on to the crankshaft until the installer is against the end of the crankshaft. The wear sleeve and seal will then be in the correct location.

g. Remove Tool (D).

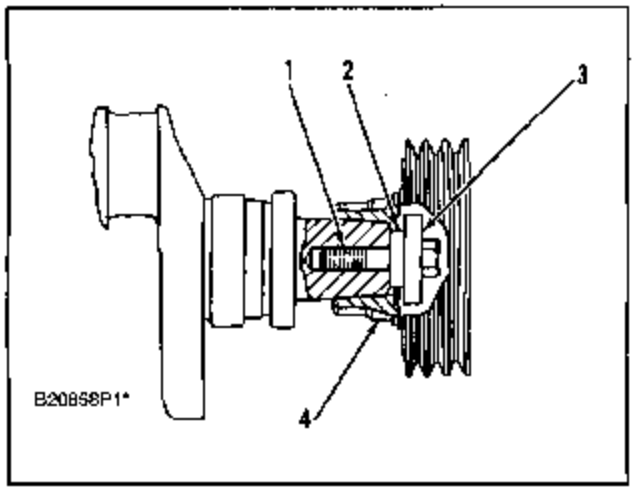
End By:

a. install vibration damper and pulley

Crankshaft Pulley (3304B)

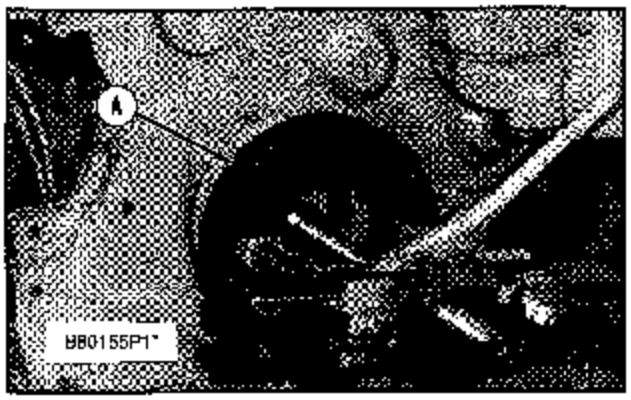
Remove Crankshaft Pulley (3304B) 1205-011

Tools Needed		A
FT0915	Plate	1
S01590	Bolt [3/8" - 16 NC x 2 in. (51 mm) long]	6
5F7342	Adapter	2
8B7550	Leg	2
8B7560	Step Plate	1
8B7548	Push-Puller	1
8H0684	Ratchet Wrench	1



NOTICE
If the spacer is not used, damage to the bolt thread can be the result.

1. Remove hub retaining bolt (1) and washer (3) from the end of the crankshaft. Install a spacer (2), washer (3) and bolt (1) on the crankshaft. The spacer is installed behind the washer to get **approximately 3.18 mm (.125 in)** of clearance between washer (3) and pulley (4).

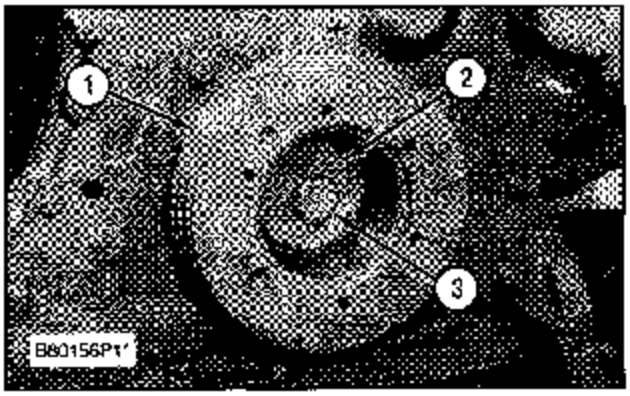


2. Install Tool (A). Loosen the pulley from the crankshaft.

3. Remove Tool (A).

4. Remove the bolt, washer, spacer and crankshaft pulley from the crankshaft.

Install Crankshaft Pulley (3304B) 1205-012



1. Install crankshaft pulley (1) on the crankshaft. Install washer (2) with the maximum flat area next to the crankshaft.

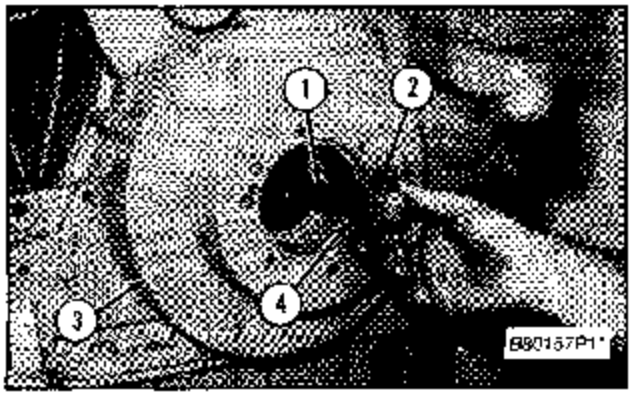
2. Install bolt (3), and tighten it to a torque of **284 to 340 N•m (210 to 250 lb ft)**. Hit the bolt with a hammer, and tighten it again to a torque of **284 to 340 N•m (210 to 250 lb ft)**.

Crankshaft Vibration Damper & Pulley (3306B)

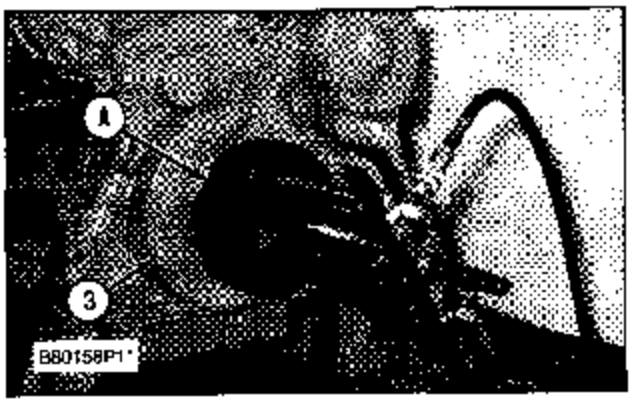
Remove Crankshaft Vibration Damper & Pulley (3306B) 1205-011

Tools Needed		A
FT0915	Adapter	1
S01590	Bolt [3/8" - 16 NC x 2 in (51 mm) long]	6
5F7342	Adapter	2
5F7369	Leg*	2
3H0465	Plate*	4
1B4207	Nut*	2
8B7560	Step Plate	1
1P0820	Hydraulic Puller Group	1
4C4865	Hand Pump (or electric)	1

* Part of 8B7548 Push-Puller



1. Remove bolt (1) and washer (2) from the crankshaft. Put enough spacers (4) on the bolt to get **approximately 3.18 mm (.125 in)** of clearance between washer (2) and vibration damper and pulley assembly (3). Install bolt (1), washer (2), and spacers (4).



NOTICE

If spacers (4) are not used, damage to the bolt and/or crankshaft can result when the vibration damper and pulley are removed from the crankshaft.

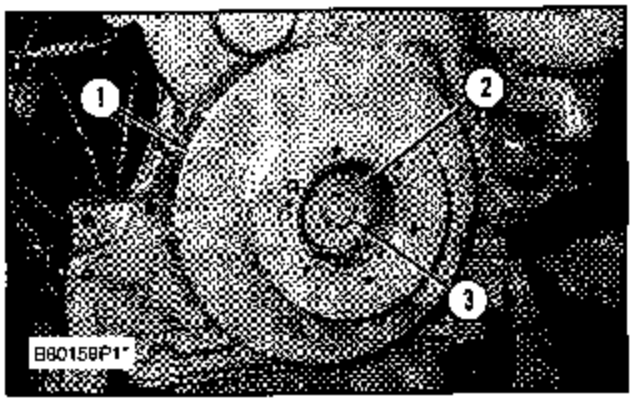
2. Install Tool (A) as shown, and loosen vibration damper and pulley assembly (3) from the crankshaft.

3. Remove Tool (A), bolt (1), washer (2), washer (4) and the vibration damper and pulley assembly from the crankshaft. If necessary, remove the bolts and vibration damper from the pulley.

NOTE: Inspect the vibration damper housing for leakage or dents (damage housing). If either condition exists, a replacement of the vibration damper must be made.

Install Crankshaft Vibration Damper & Pulley (3306B) 1205-012

1. Put the vibration damper in position on the pulley. Install the bolts that hold it.



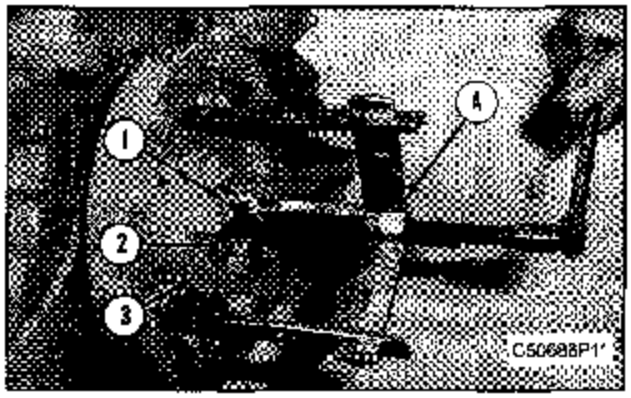
2. Put vibration damper and pulley assembly (1) in position on the crankshaft, and install washer (2) with the maximum flat area against the vibration damper and pulley assembly.

3. Install bolt (3). Tighten the bolt to a torque of **284 to 340 N•m (210 to 250 lb ft)**. Hit the bolt with a hammer, and tighten the bolt again to a torque of **284 to 340 N•m (210 to 250 lb ft)**.

Crankshaft Vibration Damper (3306B)

Remove & Install Crankshaft Vibration Damper (3306B) 1205-010

Tools Needed		A
4C5613	Puller Group	1
1P0510	Driver Group	1



1. Loosen bolt (1) until there is approximately **3.18 mm (.125 in)** clearance between washer (2) and crankshaft vibration damper (3).

2. Install Tool (A) as shown. Loosen crankshaft vibration damper (3) from the crankshaft.

3. Remove Tool (A), bolt (1) and washer (2).

NOTE: When installing bolt (1), tighten to a torque of **284 to 340 N•m (210 to 250 lb ft)**. Hit the bolt head with a hammer and tighten the bolt again to a torque of **284 to 340 N•m (210 to 250 lb ft)**.

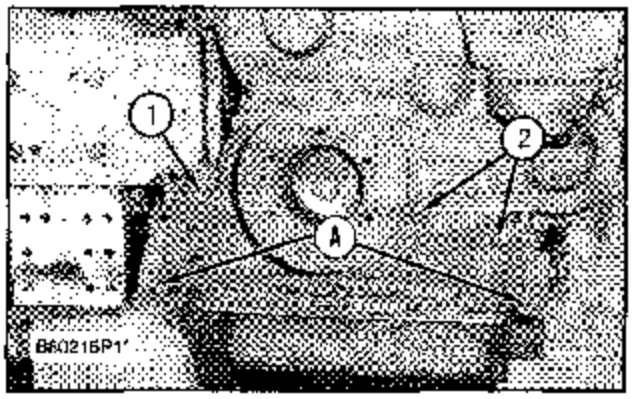
4. Remove crankshaft vibration damper (3).

NOTE: For installation of the crankshaft vibration damper, reverse the removal steps.

Front Support

Remove & Install Front Support 1153-010

NOTE: The engine shown is mounted on an CTC Model 1750A Engine Repair Stand. If the engine is not on a repair stand, it will be necessary to remove the bolts from locations (A); then block the engine in a position so front support (1) is off the mounting brackets.



1. If the engine is equipped with alternator, remove the alternator.

2. Remove all bolts (2) that hold the front support to the engine. Remove the front support.

3. Put front support (1) in position on the engine. Install all bolts (2) that hold it.

4. If the engine is equipped with an alternator, install the alternator.

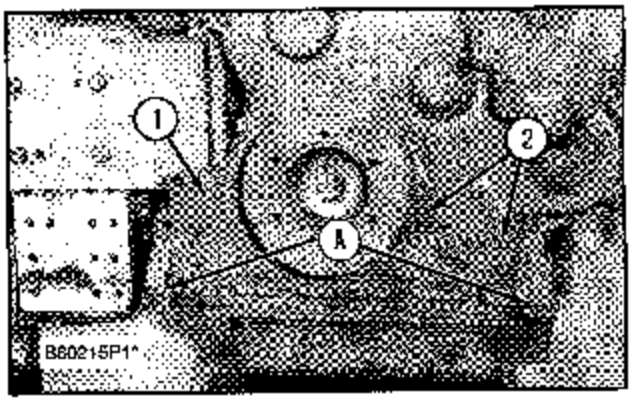
Front Support (3306B)

Remove & Install Front Support (3306B) 1153-010

NOTE: The engine shown is mounted on an OTC Model 1750A Engine Repair Stand.

Start By:

a. remove vibration damper



1. If the engine is equipped with an alternator, remove the alternator.
2. Remove six bolts (1) & washers.
3. Remove front support (2).

NOTE: For installation of the front support, reverse the removal steps.

End By:

a. install vibration damper

Timing Gear Cover

Remove Timing Gear Cover 1166-011

Start By:

a. remove water pump

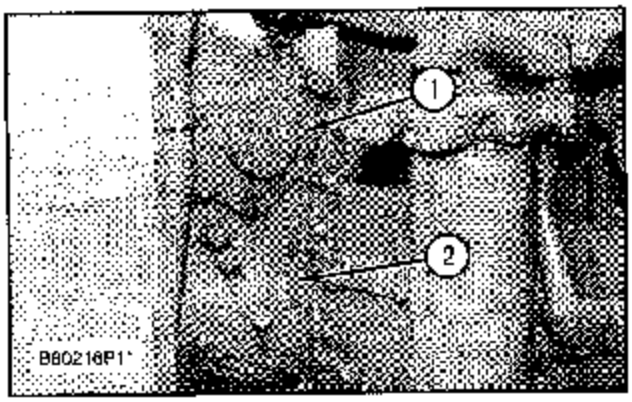
b. remove front support

c. remove gauge group (if equipped)

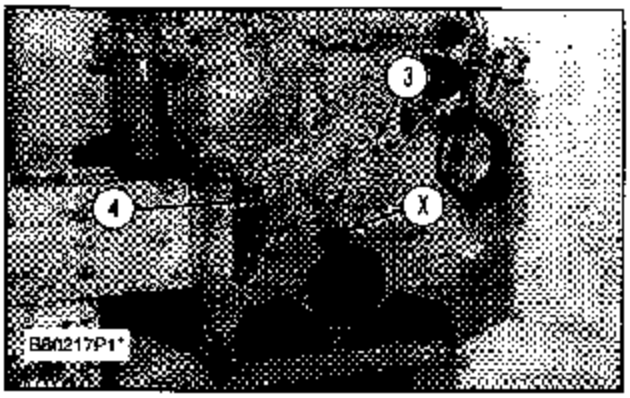
d. remove crankshaft pulley (3304B)

e. remove vibration damper and pulley (3306B)

1. Remove the bolts that hold the oil pan and oil pan plate to the timing gear cover. Loosen the remainder of the bolts that hold the oil pan in position. Put spacers between the block and the oil pan plate gasket to hold the gasket away from the timing gear cover. If the gasket is damaged, remove the oil pan plate. See topic, "Remove & Install Oil Pan Plate".



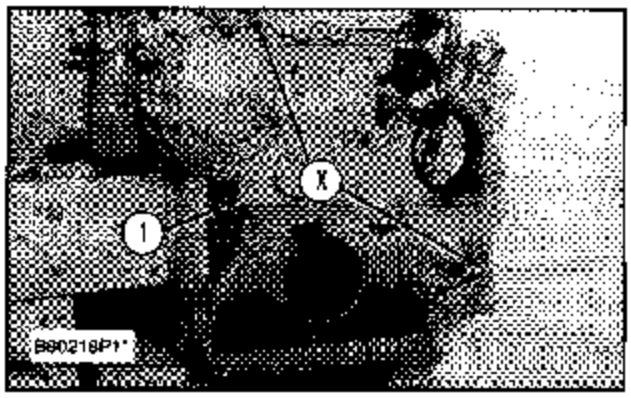
2. Remove covers (1) and (2) from the back side of the timing gear plate.



3. Remove the two bolts and clamp from location (X) that hold the crankshaft front seal adapter in position. Remove the crankshaft front seal adapter and front seal from the engine as a unit.

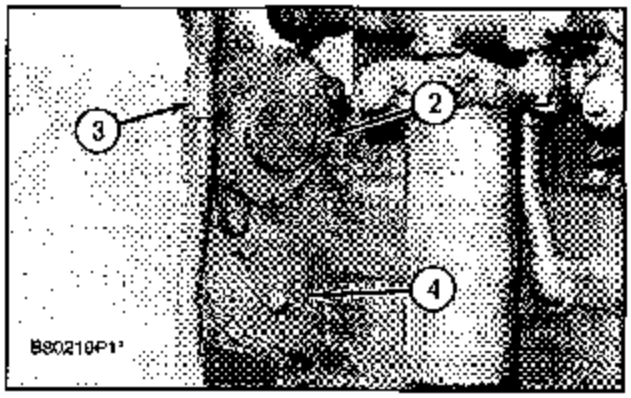
4. Remove all bolts (3) that hold the timing gear cover in position on the engine. Remove timing gear cover (4) and the gasket from the engine.

Install Timing Gear Cover 1166-012



1. Put the gasket and timing gear cover (*) in position on the engine, and install the bolts that hold it. Tighten the two bolts at location (X) to a torque of **23 ± 4 N•m (17 ± 3 lb ft)**.

2. Put the crankshaft front seal adapter and seal in position in the timing gear cover. Install the clamp that holds it.



3. Put the gasket, cover (2) and clamp (3) in position. Install the bolts that hold them. Install the O-ring seal, cover (4) and the bolts that hold them.

4. Trim the timing gear cover gasket so it is even with the bottom of the cylinder block.

5. Put a thin coat of **3S6252 RTV Silicone Adhesive/Sealant** to the bottom surface of the timing gear cover gasket. Remove the shims, and install the oil pan bolts. If it was necessary to remove the oil pan plate, see topic, "Remove & Install Oil Pan Plate". Install the oil pan plate.

End By:

a. install vibration damper and pulley (3306B)

b. install crankshaft pulley (3304B)

c. install gauge group (if equipped)

d. install front support

e. install water pump

Timing Gears

Remove Timing Gears 1206-011

Tools Needed		A	B	C	D
5P7307	Engine Turning Tool Group	1			
6V4186	Timing Pin		1		
8S2264	Puller Group			1	
8B7560	Step Plate			1	
1B3680	Bolt [3/8" - 24 NF x 95.3 mm (3.75 in) long]			2	
5M2894	Flat Washer			2	
1P0510	Driver Group				1

Start By:

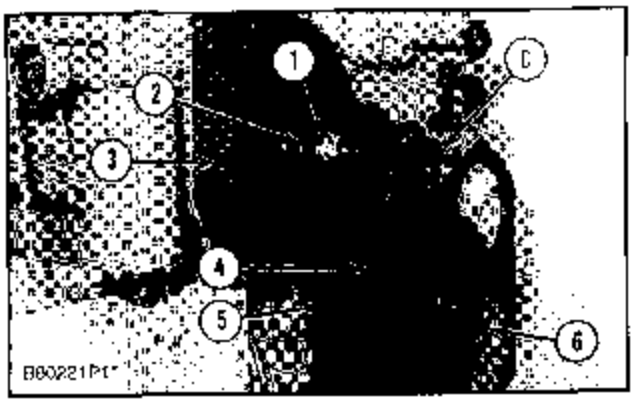
a. remove timing gear cover

1. Time the engine as follows:

a. Install Tool (A) in the flywheel housing.

b. Remove the cover from the side of the fuel injection pump housing so the timing pin can be installed. Remove the plug from the flywheel housing so the timing bolt can be installed.

c. Turn the engine in the direction of engine rotation until Tool (B) can be installed in fuel injection pump housing and located in the groove in the fuel injection pump camshaft, a 3/8" - 16 NC bolt can be installed in the flywheel through the hole in the flywheel housing, and the "C" marks on the crankshaft gear and the camshaft gear are in alignment with each other.



2. Loosen bolt (1) until there is **approximately 3.18 mm (.125 in)** gap between washer (2) and fuel pump drive gear (3).

3. Install Tool (C) as shown, and loosen the fuel pump drive gear from the taper on the fuel injection pump camshaft. Remove Tool (C), the bolt, washer and fuel pump drive gear.

4. Remove the bolts and plate (4) that hold idler gear (5) in position. Remove the idler gear. If necessary, remove the bearing from the idler gear with Tool (D) and a press.

NOTICE

Do not turn the crankshaft after camshaft gear (6) has been removed. Turning the crankshaft will cause damage to the valves.

5. Remove the four bolts that hold camshaft gear (6) to the camshaft. Remove the camshaft gear.

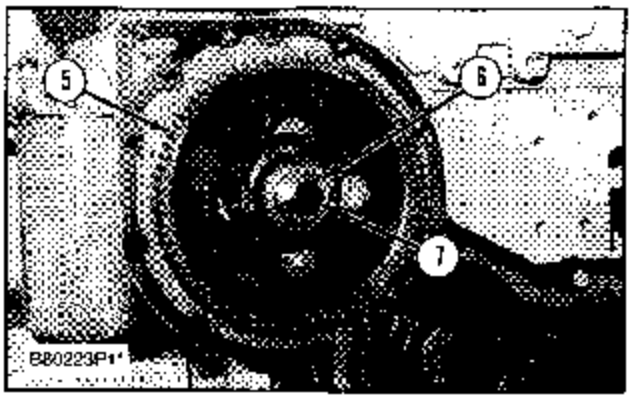
Install Timing Gears 1206-012

Tools Needed		A	B	C
1P0510	Driver Group	1		
5P7307	Engine Turning Tool Group		1	
6V4166	Timing Pin			1

1. Make an alignment of the "C" marks on crankshaft gear (3) and camshaft gear (4). Install the camshaft gear and the bolts that hold it. Tighten the bolts to a torque of **55 ± 7 N•m (41 ± 5 lb ft)**.

2. Install the bearing in idler gear (1) with Tool (A). The end of the bearing must be **1.52 mm (.060 in)** below the face of the gear hub after installation.

3. Be sure the oil hole in the shaft for idler gear (1) is open. Put idler gear (1) and plate (2) in position on the shaft. Install the bolts that hold them.



4. Make sure Tool (C) is in position in the groove of the fuel injection pump camshaft.

5. Put fuel injection pump drive gear (5) in position on the fuel injection pump camshaft. Put washer (6) in position on the gear with the largest diameter toward the front of the engine. Install bolt (7), and tighten it to a torque of **7 N•m (5 lb ft)**.

NOTE: Make sure bolt (7) does not turn while the flywheel is being turned.

6. Remove the timing bolt from the flywheel, and use Tool (B) to turn the flywheel in the opposite direction of engine rotation. Turn the flywheel until the "C" mark on the crankshaft gear moves **30°**.

7. Turn the flywheel in the direction of engine rotation until the timing bolt can be installed in the flywheel and the "C" marks are in alignment. This will remove all of the backlash from the timing gears.

8. Tighten bolt (7) to a torque of **270 ± 25 N•m (199 ± 18 lb ft)**.

9. Remove Tool (B) and (C). Remove the timing bolt from the flywheel. Install the covers on the flywheel housing and fuel injection pump housing. Install the plug in the flywheel housing.

End By:

a. install timing gear cover

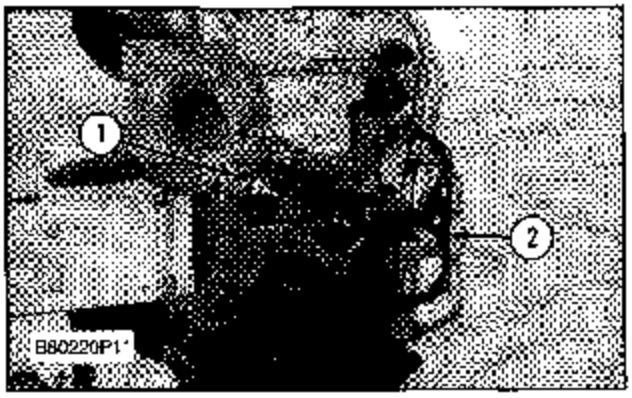
Timing Gear Plate

Remove & Install Timing Gear Plate 1162-010

Start By:

a. remove timing gears

b. remove fuel injection pump housing and governor



1. Remove all bolts (1) that hold the timing gear plate to the engine.
2. Remove timing gear plate (2) and the gasket from the engine.
3. Put the gasket and timing gear plate (2) in position on the engine. Install the bolts that hold it.
4. Trim the gasket so it is even with the bottom of the cylinder block.

End By:

a. install fuel injection pump housing and governor

b. install timing gears

Balancer Shafts (3304B)

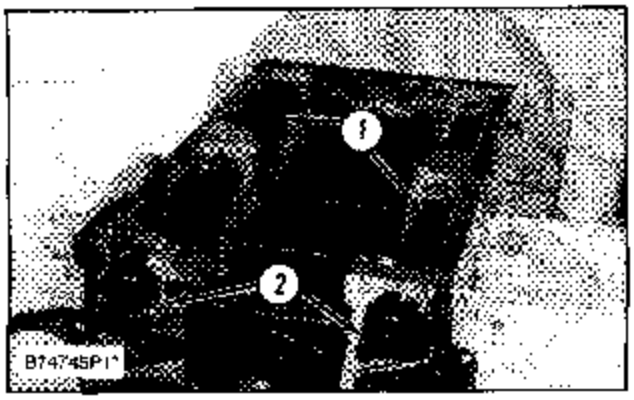
Remove Balancer Shafts (3304B) 1220-011

Start By:

a. remove timing gear cover

b. remove oil pump

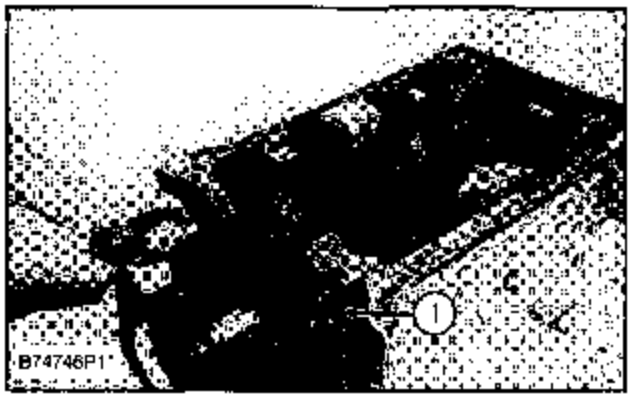
NOTE: The oil pan plate has been removed only for photo illustration.



1. Remove plates (2) that hold the balancer shafts in the cylinder block.
2. Remove balancer shafts (1) from the cylinder block.

Install Balancer Shafts (3304B) 1220-012

NOTE: The oil pan plate has been removed only for photo illustration.



1. Install the balancer shafts in each side of the cylinder block.
2. Install plates (1) and the bolts that hold the balancer shafts in position in the cylinder block.

NOTICE

Make sure the balancer shafts are in time before installing the oil pump. See topic, "Install Oil Pump".

End By:

a. install oil pump

b. install timing gear cover

Balancer Shaft Bearings (3304B)

Remove & Install Balancer Shaft Bearings (3304B) 1220-010

Tools Needed		A
8S2241	Camshaft Bearing Installation And Removal Group	1
8H0684	Ratchet Wrench	1

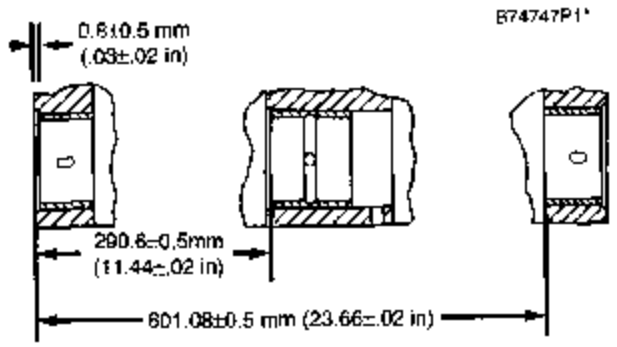
Start By:

a. remove oil pan plate

b. remove balancer shafts (3304B)

c. remove flywheel housing

1. Use Tool (A), and remove the six balancer shaft bearings by pulling them toward the flywheel end of the engine.



2. Install the balancer shaft front bearings with Tool (A). Make sure the oil holes in the bearings are in alignment with the oil holes in the cylinder block. The bearings must be **0.8 ± 0.5 mm (.03 ± .02 in)** inside the front face of the cylinder block after installation.

3. Install the balancer shaft center bearings with Tool (A). Make sure the oil holes in the bearings are in alignment with the oil holes in the cylinder block. The bearings must be **290.6 ± 0.5 mm (11.44 ± .02 in)** from the front face of the cylinder block after installation.

4. Install the balancer shaft rear bearings with Tool (A). Make sure the oil holes in the bearings are in alignment with the oil holes in the cylinder block. The bearings must be **601.0 ± 0.5 mm (23.66 ± .02 in)** from the front face of the cylinder block after installation.

5. Check the bore of the bearings. The bore of the bearings must be **53.05 ± 0.06 mm (2.089 ± .002 in)** after installation.

End By:

a. install flywheel housing

b. install balancer shafts (3304B)

c. install oil pan plate

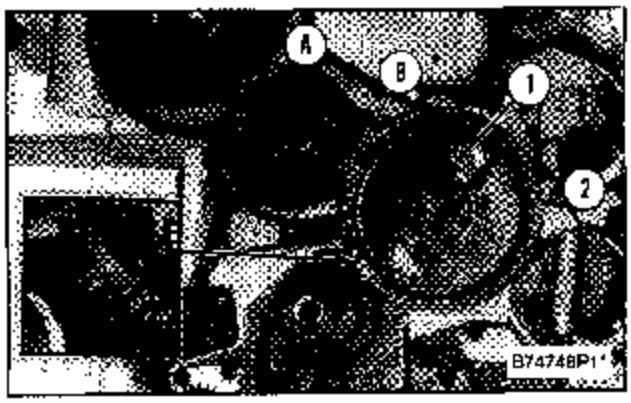
Camshaft

Remove & Install Camshaft 1210-010

Start By:

a. remove valve lifters

b. remove timing gear cover



Typical Example

1. Turn the crankshaft until the "C" mark on the crankshaft gear is in alignment with the "C" mark on the camshaft gear.

NOTE: To keep the engine timing correct during removal and installation of the camshaft, put a mark on the teeth of the fuel injection pump drive gear and idler gear at location (A). Put a mark on the teeth of the idler gear and camshaft gear at location (B). When installing the camshaft, the engine timing will be correct when the marks at locations (A) and (B) are in alignment and the "C" marks on the crankshaft and camshaft gears are in alignment.

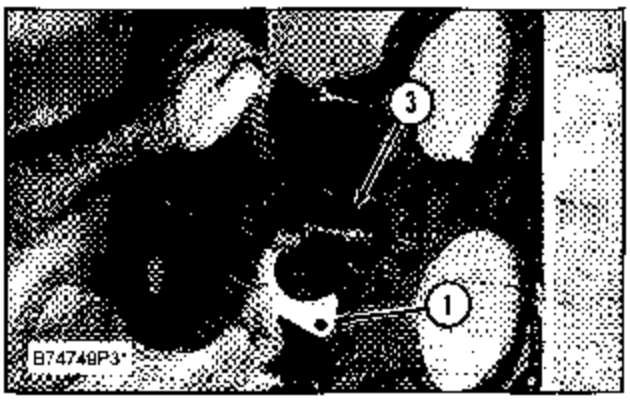
2. Remove the bolts, lock and washer (1) that hold the camshaft in position.

3. Remove the camshaft and gear (2). Do not cause damage to the lobes or bearings when the camshaft is removed.

4. If necessary, remove the bolts and gear from the camshaft.

NOTE: The following steps are for the installation of the camshaft.

5. Put the camshaft drive gear in position on the end of the camshaft, and install the bolts that hold it. Tighten the bolts to a torque of **55 ± 7 N•m (41 ± 5 lb ft)**.



NOTICE
Do not cause damage to the lobes or bearings when the camshaft is installed.

6. Put **2P2506 Thread Lubricant** on the camshaft lobes only, and clean engine oil on the bearing journals. Install camshaft (3) in the cylinder block, and make an alignment of the "C" marks and the marks put on the gears during removal.

7. Install washer (1), the lock and bolts to hold the camshaft in position.

End By:

a. install valve lifters

b. install timing gear cover

Camshaft Bearings

Remove Camshaft Bearings 1211-011

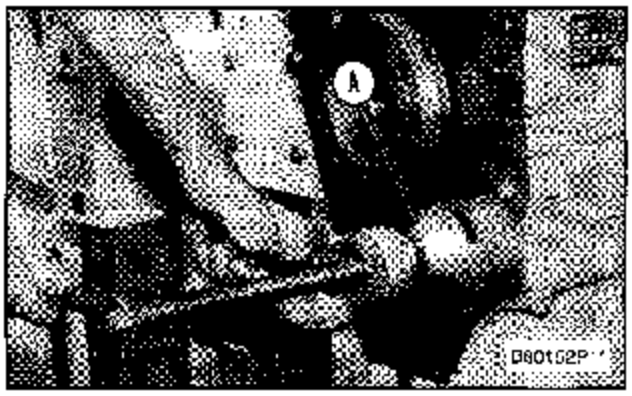
Tools Needed		A
8S2241	Camshaft Bearing Installation And Removal Group	1
8H0684	Ratchet Wrench	1

Start By:

a. remove flywheel housing

b. remove oil pan plate

c. remove camshaft

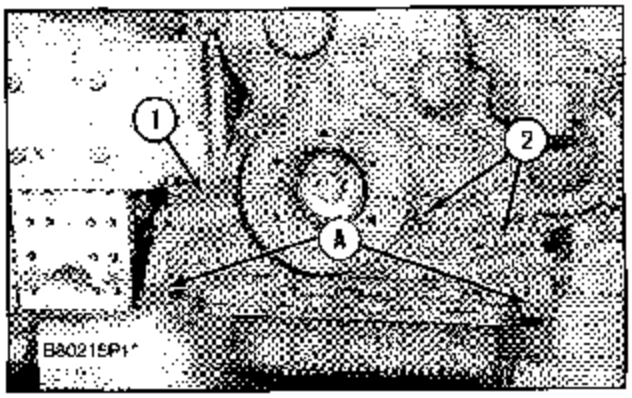


1. Remove the camshaft bearings from the cylinder block with Tool (A). Start with the front bearing and work to the rear.

Install Camshaft Bearings 1211-012

Tools Needed		A
8S2241	Camshaft Bearing Installation And Removal Tool	1
8H0684	Ratchet Wrench	1

1. Use Tool (A) to install the camshaft bearings in both the 3304B and 3306B cylinder blocks.

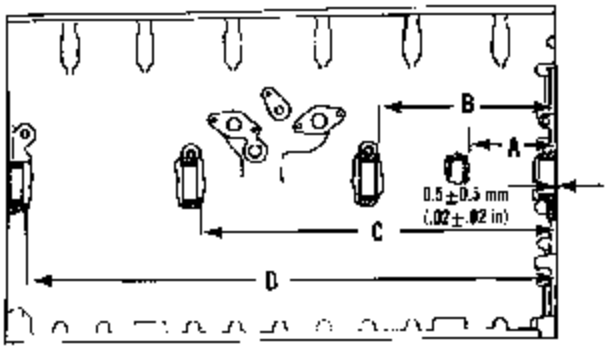


2. Install the camshaft bearings in the 3304B cylinder block as follows:

a. Install the front bearing to a depth of **0.57 ± 0.5 mm (.022 ± .02 in)** and with the oil holes in a horizontal position and the joint at the top of the engine. The joint can not be more than **15°** from vertical in either direction.

b. Install the center bearing to a depth of **303.2 ± 0.5 mm (11.94 ± .02 in)** and with the oil hole in alignment with the oil hole in the cylinder block.

c. Install the rear bearing to a depth of **604.9 ± 0.5 mm (23.81 ± .02 in)** and with the oil hole in alignment with the oil hole in the cylinder block.



3. Install the camshaft bearings in the 3306B cylinder block as follows:

a. Install the front bearing to a depth of **0.5 ± 0.5 mm (.02 ± .02 in)** and with the oil holes in a horizontal position and the joint at the top of the engine. The joint can not be more than **15°** from vertical in either direction.

b. Install the remainder of the bearings with the oil holes in alignment with the oil holes in the cylinder block. Install the bearings to the dimensions given from the front face of the cylinder block:A) **154.0 ± 0.5 mm (6.06 ± .02 in)** , B) **303.2 ± 0.5 mm (11.94 ± .02 in)** , C) **601.7 ± 0.5 mm (23.69 ± .02 in)** , D) **903.4 ± 0.5 mm (35.57 ± .02 in)**.

End By:

a. install camshaft

b. install oil pan plate

c. install flywheel housing

Crankshaft

Remove Crankshaft 1202-011

Tools Needed		A	B	C
	OTC Model 1750A Engine Repair Stand	1		
5P9736	Link Bracket		1	
6V2157	Link Bracket		1	
8B7551	Bearing Pulling Attachment			1
8B7549	Leg			2
3H0465	Plate*			4
1B4207	Nut*			2
8B7560	Step Plate			1
1P0820	Hydraulic Puller Group			1
4C4885	Hand Pump (or electric)			1

* Part of 8B7548 Push-Puller

Start By:

a. remove flywheel housing

b. remove timing gear cover

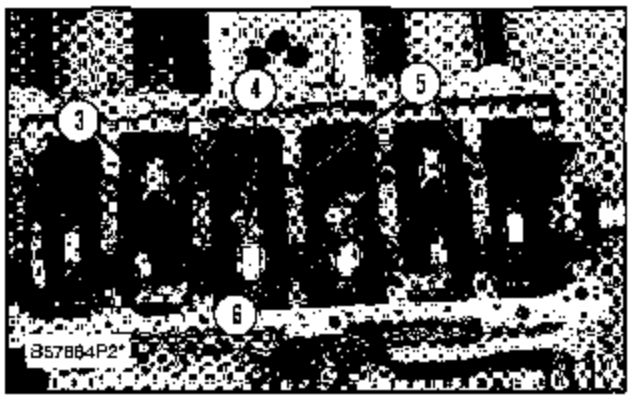
c. remove oil pan plate

d. remove oil pump

NOTE: The procedure for crankshaft removal is the same on both 3304B and 3306B Engines. The illustration in the procedure which follows is of a 3306B Engine.

1. Install the engine on Tool (A) with the crankshaft in a horizontal position and on top.

2. Turn the crankshaft until the timing mark "C" on crankshaft gear (1) is in alignment with the timing mark "C" on camshaft gear (2) as shown in the inset.



3. Remove nuts (4), the connecting rod bolts and connecting rod caps (3) from the connecting rods.

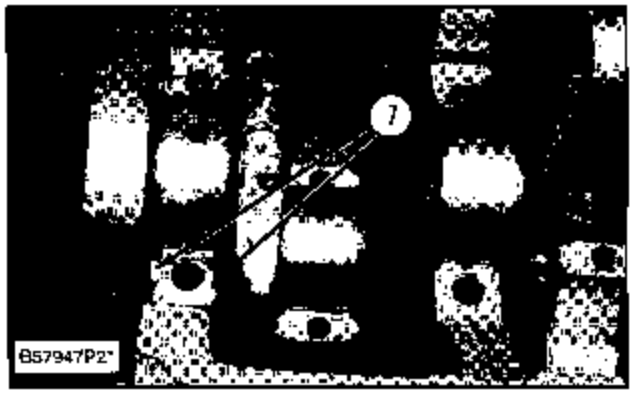
NOTICE

If the piston and connecting rod assemblies are pushed down too far in the cylinder liners, the piston can hit the fuel injection nozzle or the intake exhaust valve which can cause damage to the fuel injection nozzle or the piston.

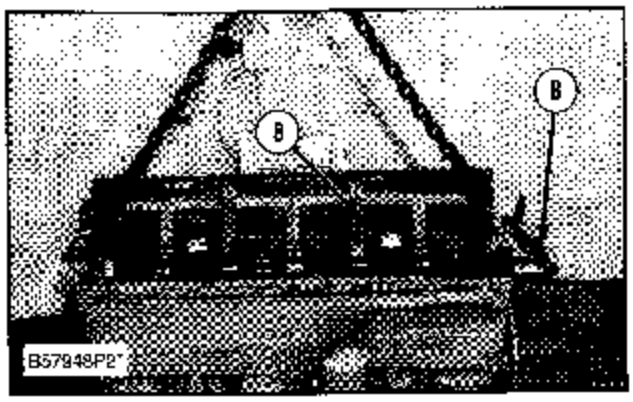
NOTE: If the intake and exhaust valves are closed, it can be difficult to push the piston and connecting rod assembly down in the cylinder liner.

4. Push the pistons that are not at top center down far enough to clear the crankshaft.

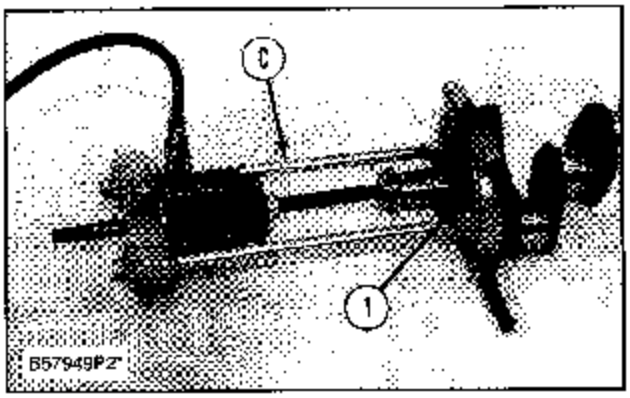
5. Remove main bearing cap bolts (5) and main bearing caps (6) from the engine.



6. Remove thrust bearings (7) from the rear main bearing.



7. Install Tool (B) on crankshaft (6) as shown, and fasten a hoist to it. Lift the crankshaft straight up from the cylinder block. The weight of the crankshaft for 3304B Engines is **65 kg (143 lb)**. The weight of the crankshaft for 3306B Engines is **95 kg (210 lb)**.



8. Use Tool (C), and remove crankshaft gear (1) from the crankshaft.

NOTICE

If the bearings are to be removed, put identification marks on them as to their location for installation purposes.

9. If necessary, remove the main bearings from the cylinder block and main bearing caps. If necessary, remove the connecting rod bearings from the connecting rods and connecting rod caps.

Install Crankshaft 1202-012

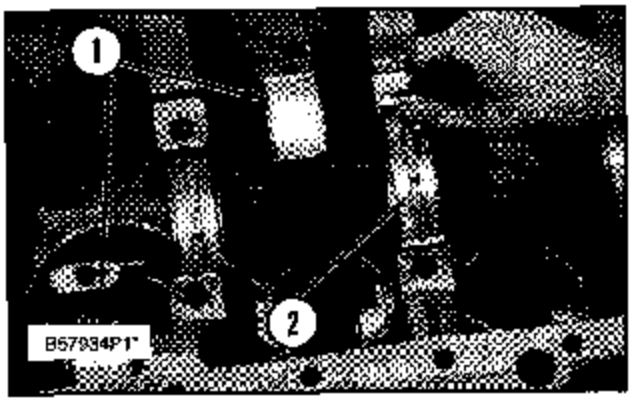
	Tools Needed	A	B	C	D
	OTC Model 1750A Engine Repair Stand	1			
5P9736	Link Bracket		1		
6V2157	Link Bracket		1		
	Plastigage			*	
8S2328	Dial Indicator Test Group				1

1. Put the engine in position on Tool (A).

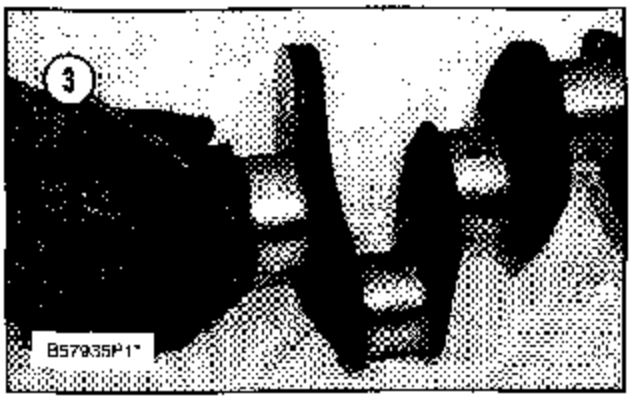
NOTE: Install the bearings dry when the clearance checks are made. Put clean engine oil on all the bearings for final assembly.

NOTICE

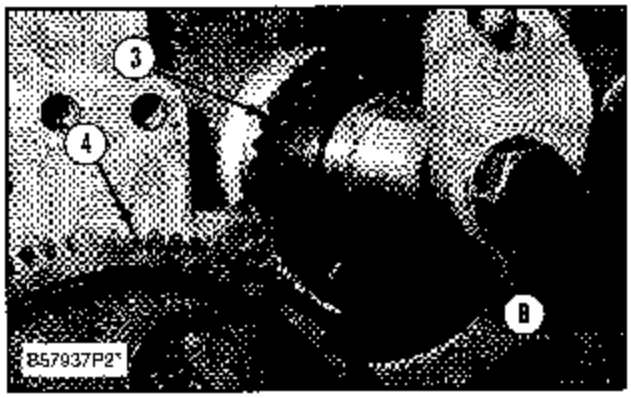
Make sure the upper and lower halves of the main bearings are installed so the bearing tabs fit into the notch in the cylinder block and main bearing caps.



2. If the bearings were removed from the engine, clear the bearing surfaces in the cylinder block and the connecting rods. Install the upper halves of connecting rod bearings (1) and main bearings (2).



3. Heat crankshaft gear (3) to a maximum temperature of **316° C (600° F)**. Install the gear on the crankshaft.

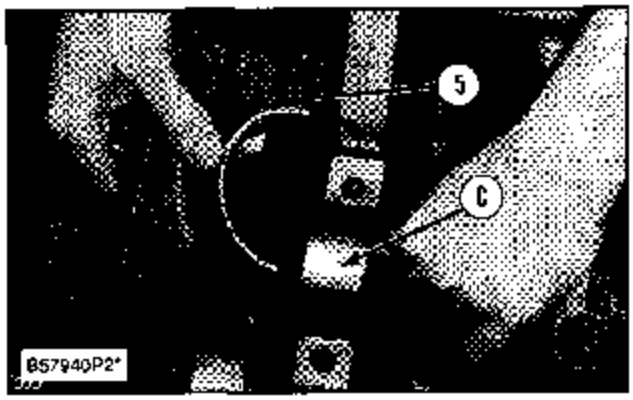


4. Install Tool (B) on the ends of the crankshaft and fasten a hoist to it.

5. Make an alignment of the connecting rods with the crankshaft. Make an alignment of the "C" marks on crankshaft gear (3) and camshaft gear (4). When the connecting rods and the "C" marks are in alignment, lower the crankshaft on to the main bearings, and remove Tool (B).

NOTE: When the bearing clearance is checked and the engine is in a vertical position, such as in a vehicle, the crankshaft will have to be lifted up and held against the upper halves of the main bearings to get a correct measurement with the Plastigage. The Plastigage will not hold the weight of the crankshaft and give a correct measurement. If the engine is in a horizontal position, it is not necessary to hold the crankshaft up. Do not turn the crankshaft when the Plastigage is in position to check clearances. For complete details concerning measuring bearing clearances, see Engine Bearings And Crankshafts, Form No. SEBD0531.

6. Check the main bearing clearances with Plastigage (C) as follows:



a. Put a piece of Plasi gage (C) in position as shown.

NOTICE

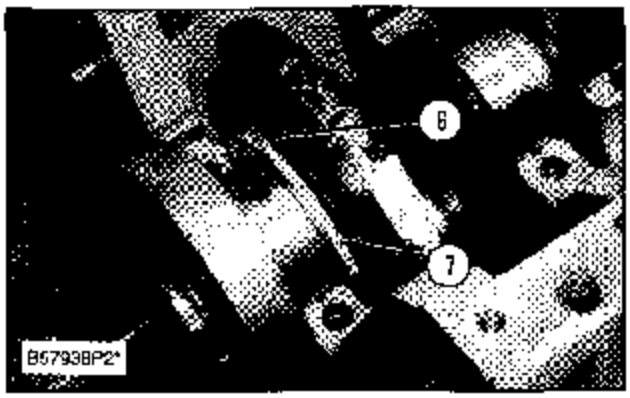
Make sure the part number on the main bearing cap is toward the front of the engine, and the number on the main bearing cap is the same as the number on the cylinder block on the left side of each main bearing cap.

NOTE: Do not turn the crankshaft when Plastigage (C) is in position.

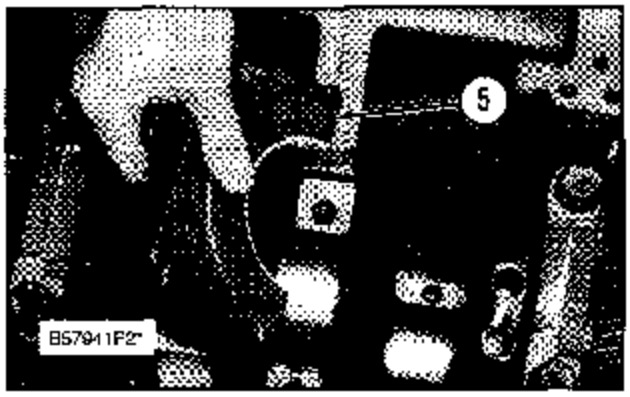
b. Install main bearing cap (5). Put clean engine oil on the bolt threads and the face of the washers, and install the bolts. Tighten the bolts to a torque of **41 ± 4 N•m (30 ± 3 lb ft)**.

c. Put a mark on each bolt and main bearing cap; then tighten the bolts **90° ± 1.5°** more.

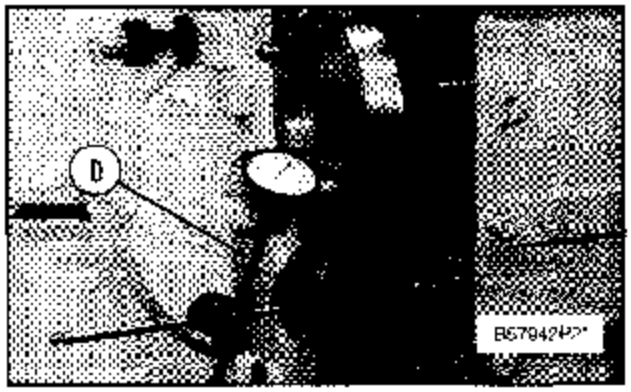
d. Remove the main bearing caps. Remove Plastigage (C), and measure the thickness of the Plastigage. The main bearing clearance must be **0.076 to 0.165 mm (.0030 to .0065 in)**. The maximum permissible clearance with used bearings is **0.25 mm (.010 in)**.



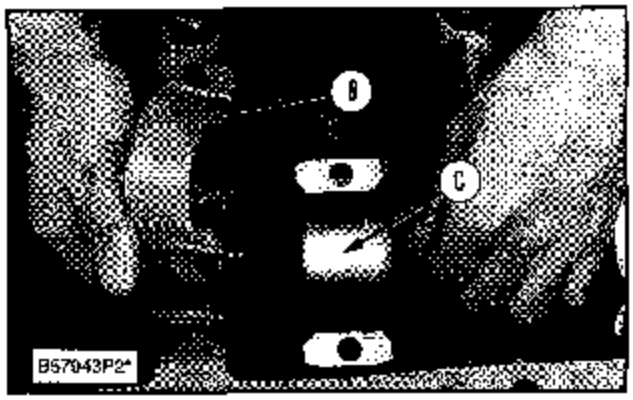
7. Put clean engine oil on thrust bearing (7) for the rear main bearing. Install the thrust bearing with the identification "BLOCK SIDE" toward the cylinder block and the tabs on the thrust bearings in the machined area in the cylinder block. Tabs (6) will not let the thrust bearings be installed backward.



8. Install main bearing caps (5), and tighten the bolts as in Steps 6b and 6c.



9. Check the crankshaft end play with Tool (D) as shown. The end play is controlled by the thrust bearings on the rear main bearing. End play with new bearings is **0.064 to 0.368 mm (.0025 to .0145 in)**. The maximum permissible end play with used bearings is **0.64 mm (.025 in)**.



10. Pull the connecting rod and piston assemblies into position against the crankshaft.

NOTE: Install the connecting rod bearings dry when the clearance checks are made. Put clean engine oil on the connecting rod bearings for final assembly.

11. Install lower half of the rod bearing (8) in the connecting rod cap with the tab in the back of the connecting rod bearing in the tab groove of the connecting rod and cap.

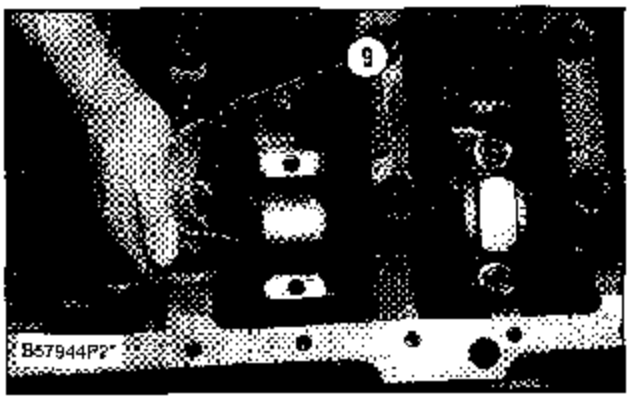
NOTE: Do not turn the crankshaft when Plastigage (C) is in position.

12. Put Plastigage (C) in position on the crankshaft as shown to check the connecting rod bearing clearance.

13. Put clean engine oil on the threads of the rod bolts and seat surfaces of the nuts.

NOTICE

When connecting rod caps are installed, make sure the number on the side of the cap is next to and respective with the number on the side of the connecting rod.



14. Install connecting rod cap (9). Install the nuts. Tighten the nuts to a torque of **41 ± 4 N•m (30 ± 3 lb ft)**. Put a mark on each nut and the end of each bolt. Tighten the nuts **90°** more. Remove the connecting rod caps. Remove Plastigage (C), and measure the thickness of the Plastigage. The connecting rod clearance must be **0.076 to 0.168 mm (.0030 to .0066 in)** for new bearings. The maximum clearance with used bearings is **0.25 mm (0.010 in)**.

15. Install connecting rod cap (9), and tighten the nuts as in Step 14.

16. Do Steps 11 through 15 for the remainder of the rod bearings.

End By:

a. install oil pump

b. install oil pan plate

c. install timing gear cover

d. install flywheel housing

Piston Cooling Orifices

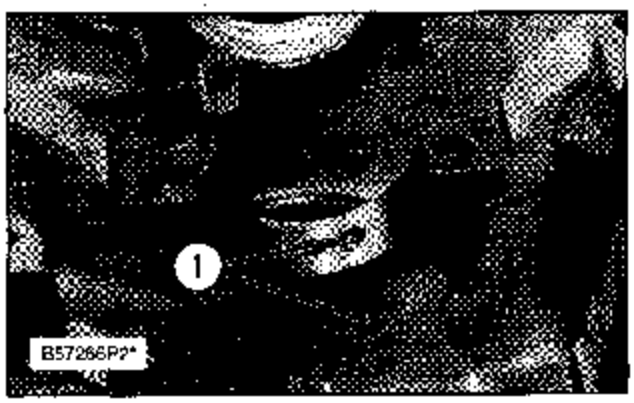
Remove & Install Piston Cooling Orifices 1307-010

Tools Needed	A
FT1542 Orifice Driver	1

Start By:

a. remove crankshaft

NOTE: On 3304B Engines, the piston cooling orifices are installed in the No. 2 and 4 main bearing bosses in the cylinder block. On 3306B Engines, the No. 2 and 6 main bearing bosses each have two orifices. The No. 3 and 5 main bearing bosses each have one orifice. A replacement is necessary only if they are damaged. Normally it will only be necessary to be sure the orifices are clear.



1. Use a soft punch to remove the orifices from the cylinder block.

2. Use Tool (A) to install piston cooling orifice (1) (small end first). Install the orifices in main bearing bosses until they are against the counterbore.

3. Make sure that the passage is open after the piston cooling orifice is installed.

End By:

a. install crankshaft

Flywheel

Remove Flywheel 1156-011

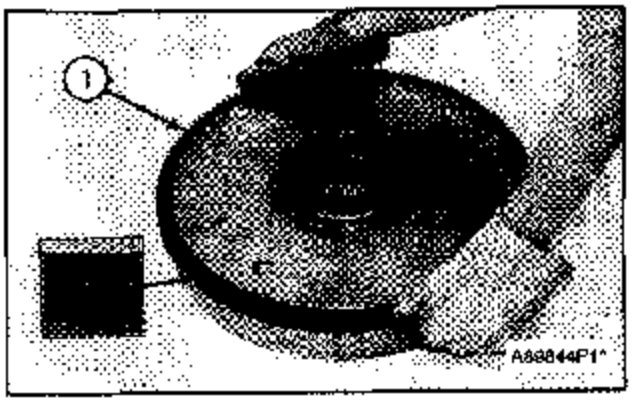
Tools Needed	A
FT0120 Lifting Bracket	1

NOTE: This flywheel procedure is for flywheels that have a bolt pattern that Tool (A) can mount against

1. Install Tool (A) on the flywheel as shown, and fasten a hoist on it.
2. Remove bolts (1) and flywheel (2) from the crankshaft. The weight of the flywheel is **72 kg (160 lb)**.
3. If necessary, remove the ring gear from the flywheel with a hammer and punch.

Install Flywheel 1156-012

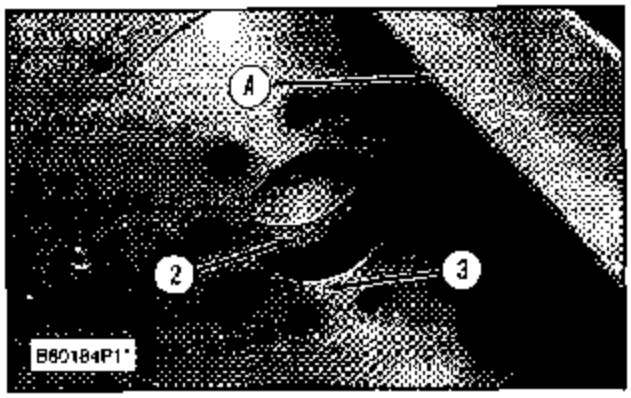
Tools Needed	A
FT0120 Lifting Bracket	1



NOTICE

The ring gear must be installed with the chamfered side of the teeth up as shown in the inset of illustration A89844P1. This will put the chamfered side of the gear teeth toward the starter when the flywheel is installed so the starter will engage correctly.

1. Heat ring gear (1) to a maximum temperature of **320° C (608° F)**. Install the ring gear on the flywheel.



2. Install Tool (A) on the flywheel in the same position it was during removal.

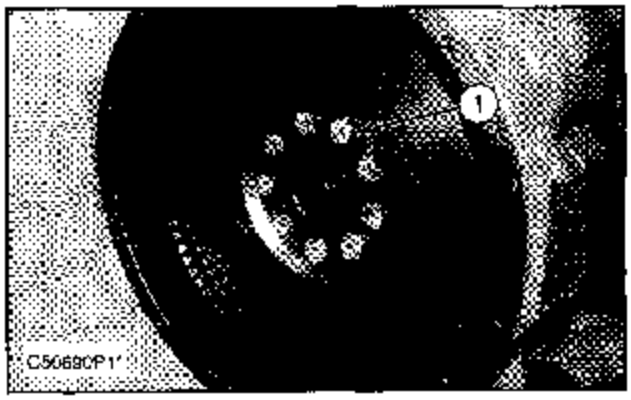
NOTE: Install two **5/8" - 18 NF guide bolts** in the crankshaft if necessary.

3. Make an alignment of timing mark (2) on the crankshaft and timing mark (3) on the flywheel. Hold the flywheel in position. Install the bolts that hold it to the crankshaft. Tighten the bolts to a torque of **205 ± 27 N·m (151 ± 20 lb ft)**.

Flywheel

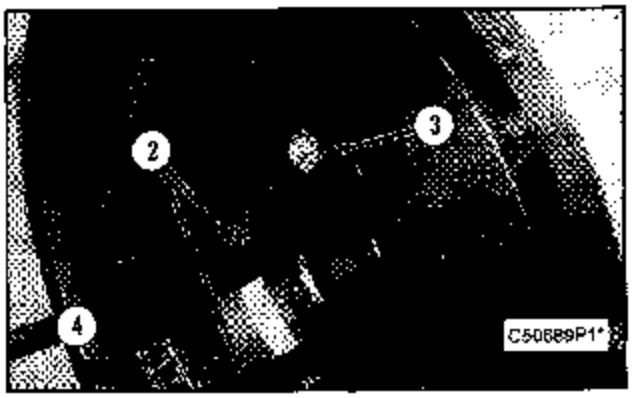
Remove & Install Flywheel 1156-010

NOTE: This flywheel procedure is for flywheels that do not have a bolt pattern that Tool F.0120 Lifting Bracket can mount against.



1. Remove eight bolts (1).

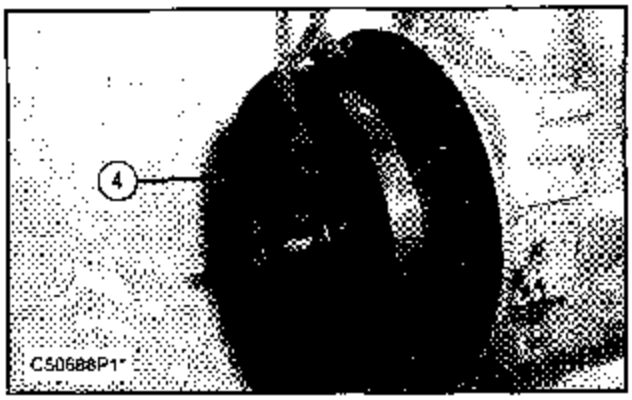
NOTE: Leave one bolt in place at the top of the bolt pattern to secure the flywheel. Mark the flywheel and the crankshaft as to their location to each other for installation purposes.



2. Install two **5/8" - 18 NF bolts** (2).

3. Remove bolt (3).

4. Slide flywheel (4) out of the flywheel housing onto bolts (2).



5. Attach a strap and suitable lifting device to flywheel (4).

6. Remove bolts (2) and flywheel (4) from the engine. The weight of the flywheel is **54 kg (120 lb)**. When installing, tighten the bolts to a torque of **205 ± 27 N·m (151 ± 20 lb ft)**.

7. If necessary, remove the ring gear from the flywheel with a hammer and punch.

NOTE: For installation of the flywheel, reverse the removal steps.

8. If it was necessary to remove the ring gear from the flywheel, heat the ring gear to a maximum of **320° C (608° F)**. Install the ring gear on the flywheel.

Crankshaft Rear Seal & Wear Sleeve

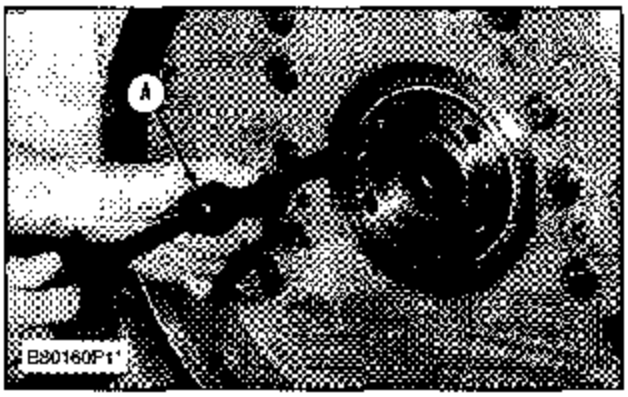
Remove Crankshaft Rear Seal & Wear Sleeve 1161-011

Tools Needed		A	B	C
1U7600	Lip Type Seal Puller	1		
5P7312	Distorter		1	
5P7313	Ring			1

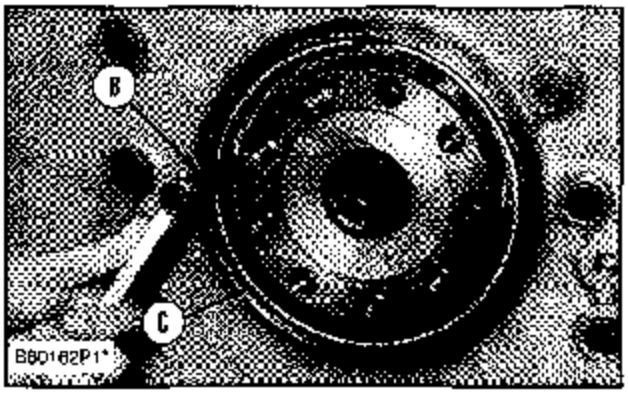
Start By:

a. remove flywheel

NOTICE
When a replacement of the rear seal is made, a replacement of the wear sleeve is to be made also.



1. Remove the crankshaft rear seal with Tool (A).



2. Install Tool (C) in the rear seal bore.

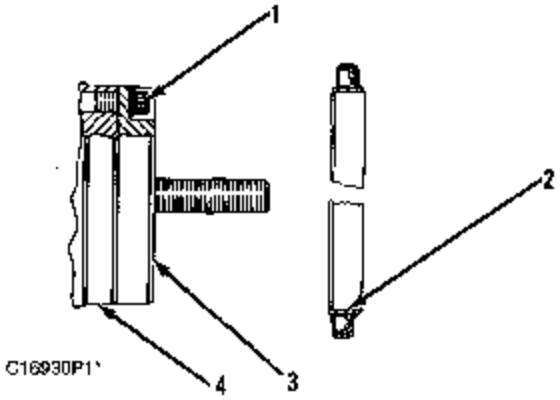
3. Install Tool (B) between Tool (C) and the wear sleeve. Turn Tool (B) until the edge of the Tool makes a flat place (crease) in the wear sleeve. Do this in two or more places until the wear sleeve is loose.

4. Remove Tool (C) and the wear sleeve by hand.

Install Crankshaft Rear Seal & Wear Sleeve 1161-012

Tools Needed		A
9S8871	Locator	1
6V7876	Installer	1
9S8858	Nut	1
9S8890	Bolt	3

NOTICE
Once there is a separation of a seal and wear sleeve they cannot be used again. Used seals cannot be used again.

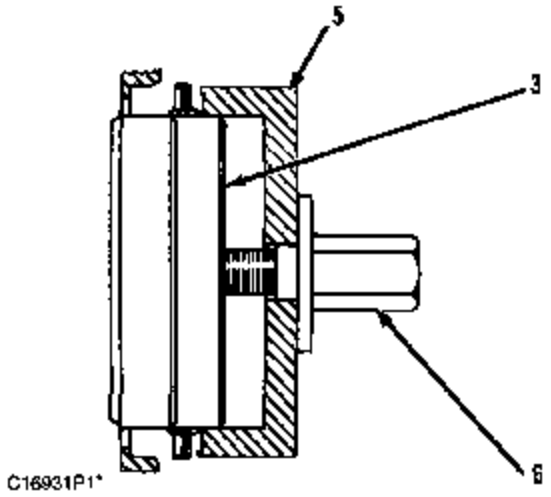


NOTE: Do not use any type of lubrication during the installation of the seal group.

1. Put locator (3) from Tool (A) in position on the crankshaft and install three bolts (1) from Tool (A) that hold the locator in place.

2. Use **6V1541 Quick Cure Primer** to clean the outside of crankshaft flange (4) and the inside diameter of wear sleeve (2).

3. Put **9S3265 Retaining Compound** on the outside diameter of crankshaft flange (4) and the inside diameter of wear sleeve (2).



4. Put the seal group (wear sleeve and seal) on locator (3). Put installer (5) from Tool (A) on locator (3) and install nut (6) from Tool (A). Put lubricant on the face of the washer on nut (6).

5. Tighten nut (6) until installer (5) comes in contact with locator (3).

6. Remove Tool (A), and check the seal group for correct installation.

End By:

a. install flywheel

Flywheel Housing

Remove Flywheel Housing 1157-011

Tools Needed	A
6V2156 Link Bracket	2

Start By:

a. remove flywheel

b. remove crankshaft rear seal and wear sleeve*

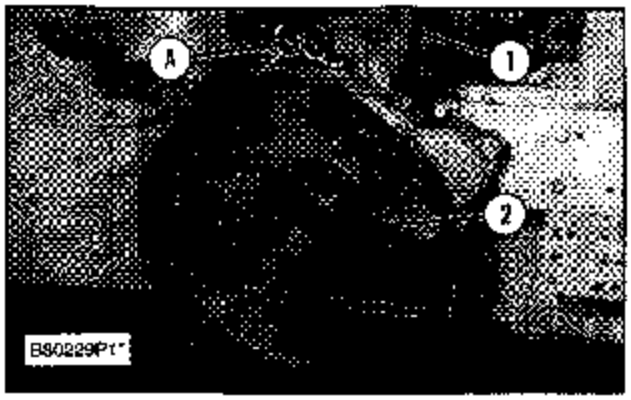
*Remove the crankshaft rear seal and wear sleeve only if the engine is equipped with the later design seal. The later design seal can be identified by the rotation marks on the seal.

NOTICE
Some flywheel housings will have more bolts holding the flywheel housing to the cylinder block.

1. If the engine is equipped with an electric starting motor, remove the electric starting motor from the flywheel housing.

2. Remove the bolts that hold the oil pan plate to the flywheel housing. Loosen the bolts that hold the oil pan plate to the cylinder block.

3. Install spacers between the oil pan plate and the cylinder block to hold the oil pan plate away from the flywheel housing.



3306B Engine Shown

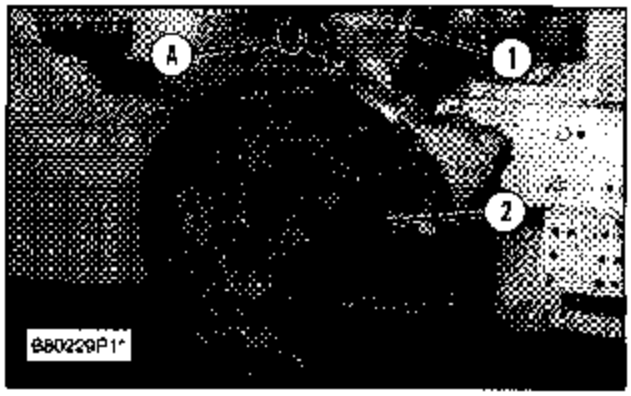
4. On 3306B Engines, remove turbocharger oil drain pipe (1).

5. Install Tool (A) on the flywheel housing as shown, and fasten a hoist to it.

6. Remove all bolts (2) and the flywheel housing from the engine. The weight of the flywheel housing is **37 kg (82 lb)**.

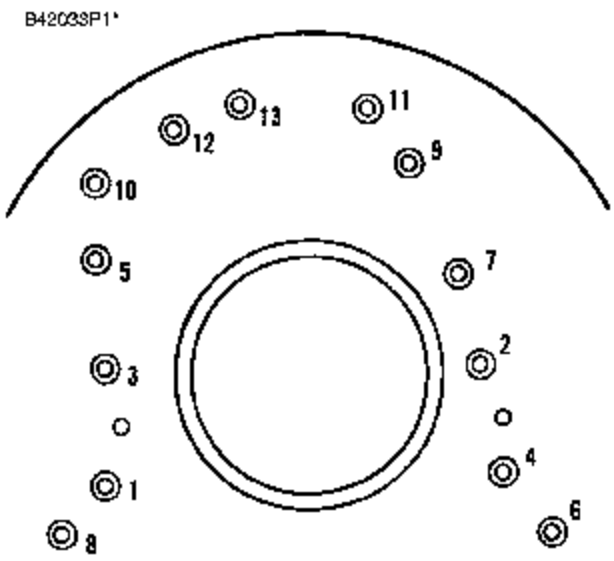
Install Flywheel Housing 1157-012

Tools Needed	A
6V2156 Link Bracket	2



3306B Engine Shown

1. Install Tool (A) on the flywheel housing. Fasten a hoist to the flywheel housing.



2. Put the gasket and flywheel housing in position on the engine. Install bolts (2) that hold it. Tighten the bolts to a torque of **100 ± 14 N•m (74 ± 10 lb ft)** as shown.

3. Remove Tool (A) from the flywheel housing.

4. On 3306B Engines, install turbocharger oil drain line (1).

5. Cut the bottom of the flywheel housing gasket off even with the cylinder block and flywheel housing. Put **3S6252 RTV Silicone Adhesive/Sealant** on the bottom of the gasket where it makes contact with the oil pan plate gasket.

6. Remove the spacers from between the oil pan plate and the cylinder block. Install the bolts that hold the oil pan plate to the flywheel housing. Tighten the bolts that hold the oil pan plate to the cylinder block.

7. If the engine is equipped with an electric starting motor, install it on the flywheel housing.

End By:

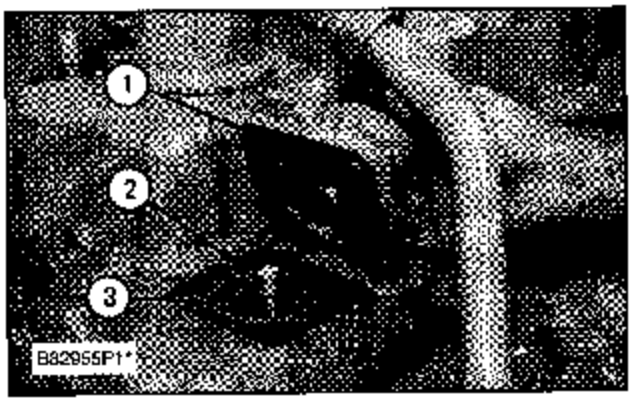
a. install crankshaft rear seal and wear sleeve

b. install flywheel

Water Temperature Regulator

Remove & Install Water Temperature Regulator 1355-010

1. Drain the coolant from the cooling system below the level of the water temperature regulator.



2. Disconnect the hose from pipe (1).

3. Remove four bolts and pipe (1) from the cylinder head. Remove gasket (2) and water temperature regulator (3).

NOTICE

If the water temperature regulator is installed wrong, it will cause the engine to overheat. Make sure the vent hole is open and do not use liquid gasket material on the gasket. The cylinder head can be damaged if the vent hole is not open or if the gasket is installed wrong.

4. Install water temperature regulator (3) and gasket (2) as shown.

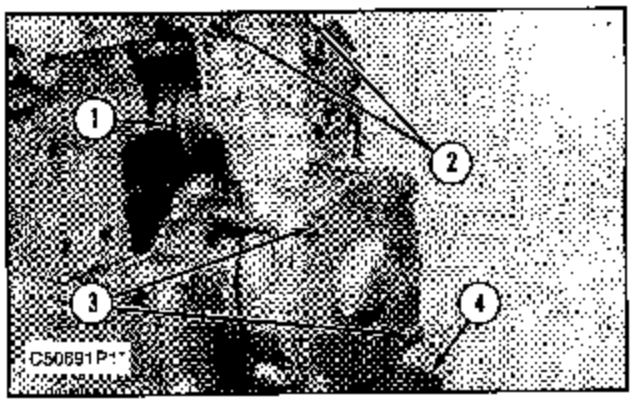
5. Put pipe (1) in position on the cylinder head, with the plug toward the front of the engine. Install the bolts that hold it.

6. Connect the radiator hose to pipe (1) and fill the radiator with coolant to the correct level. See the Operation & Maintenance Manual.

Water Pump

Remove & Install Water Pump 1361-010

1. Drain the coolant from the radiator.



2. Loosen clamp (1).

3. Remove two bolts (2).

4. Remove two bolts (3) and washers.

5. Remove water pump (4) and the gasket. When installing replace the gasket. Make sure all gasket surfaces are clean and free of dirt.

NOTE: For installation of the water pump, reverse the removal steps.

6. Fill the radiator with coolant to the proper level. See the Operation & Maintenance Manual.

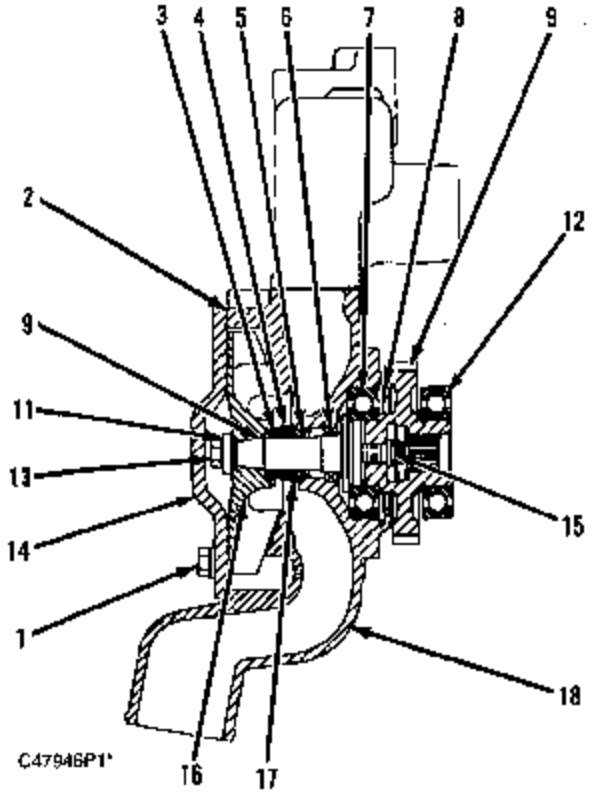
Disassemble & Assemble Water Pump 1361-017

NOTE: The following tools are needed for disassembly.

Tools Needed		A	B	C
8H0663	Bearing Pulling Attachment	1		
1P1861	Retaining Ring Pliers		1	
1P0510	Driver Group			1

Start By:

a. remove water pump



1. Remove bolt (15) and the washer. Remove bearing (12) and gear (10) as a unit.

2. Use Tool (A), (C) and a press, and remove bearing (12) from gear (10).

3. Remove snap ring (8) with Tool (B).

4. Remove two bolts (1), the washers, cover (14) and gasket (2) from water pump housing (18).

5. Loosen bolt (13) approximately **6.4 mm (.25 in)**.Hit the bolt with a soft hammer to loosen impeller (16) from shaft (9).

6. Remove bolt (13), washer (11), impeller (16), spring (3) and seal assembly (4) from shaft (9).

7. Remove bearing (7) and shaft (9) as a unit.

8. Use Tool (A), (C) and a press to remove bearing (7) from shaft (9).

9. Remove ceramic seal (5) and seal (17) from water pump housing (18).

10. Use Tool (C) to remove lip-type seal (6) from the water pump housing.

NOTE: The following steps are for assembly of the water pump. The following tools are needed for assembly.

Tools Needed		B	C	D
1P1861	Retaining Ring Pliers	1		
1P0510	Driver Group		1	
2W9102	Seal Installation Tool			1

11. Install lip-type seal (6) in water pump housing (18) with Tool (C). The lip of the seal must be toward the bearings. Put clean engine oil on the lip of the seal.

12. Install shaft (9) in bearing (7) with a press.

13. Install shaft (9) and bearing (7) as a unit in water pump housing (18).

14. Install snap ring (6) with Tool (B).

NOTICE

Clean water only is permitted for use as a lubricant for assembly. Do not damage or put hands on the wear surface of the carbon ring or the ceramic ring. Install the ceramic ring with the smoothest face of the ring toward the carbon seal assembly.

15. Put ceramic ring (5) in position in seal (17). Use hand pressure and Tool (D) to install the ceramic ring.

16. Remove spring (3) from seal assembly (4). Use hand pressure and Tool (D) to install the seal assembly. Push seal assembly (4) on shaft (9) until it makes light contact with ceramic ring (5).

17. Install spring (3) on seal assembly (4). Put impeller (16) in position on shaft (9), and install washer (11) and bolt (13) that hold it. Tighten bolt (13) to a torque of **38.0 ± 1.5 N•m (28 ± 1 lb ft)**.

18. Put gasket (2) and cover (14) in position on water pump housing (18). Install the two washers and bolts (1) that hold them.

19. Install bearing (12) on gear (10) with a press.

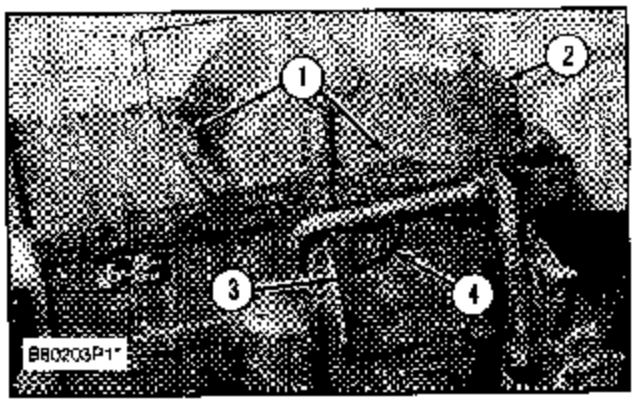
20. Position gear (10) and bearing (12) as a unit on shaft (9). Install the washer and bolt (15) that hold them together. Tighten bolt (15) to a torque of **97 ± 7 N•m (72 ± 5 lb ft)**.

End By:

a. install water pump

Oil Pan

Remove & Install Oil Pan 1302-010



3304B Engine Shown

1. Drain the oil from the engine.

2. Remove tube (4) and dipstick tube (3) from the engine.

3. Remove bolts (1) and the washers that hold the oil pan in position. Remove oil pan (2) and the gasket from the oil pan plate.

4. Put the gasket and oil pan (2) in position on the oil pan plate. Install the washers and bolts (1) that hold them.

5. Install dipstick tube (3) and tube (4) on the engine.

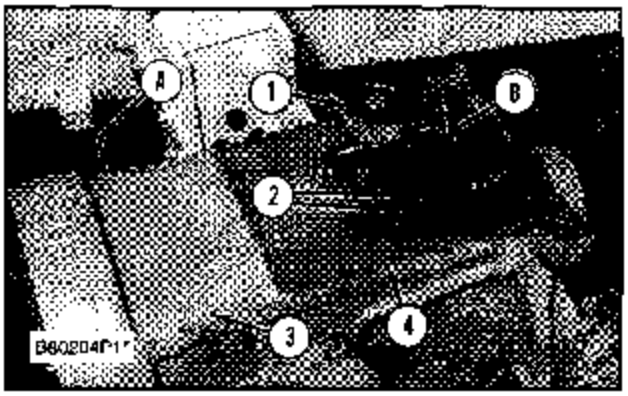
6. Fill the crankcase with oil to the correct level. See the Operation & Maintenance Manual.

Oil Pan Plate

Remove & Install Oil Pan Plate 1302-010

Start By:

a. remove oil pan



3304B Engine Shown

1. On 3306B Engines only, remove the three bolts, locks and suction bell assembly (1) from the oil pan plate and the oil pump.
2. Remove bolts (2) that hold the elbow to the oil pump.
3. Remove bolts (3), oil pan plate (4) and the gasket from the engine.
4. On both sides of the engine, at locations (A) and (B), make an application of **3S6252 RTV Silicone Adhesive/Sealant**.
5. Put the gasket and oil pan plate (4) in position on the engine. Install bolts (3) to hold them.
6. Install bolts (2) that hold the elbow to the oil pump.
7. On 3306B Engines only, install the gasket, suction bell (1) and the locks and bolts that hold them.

End By:

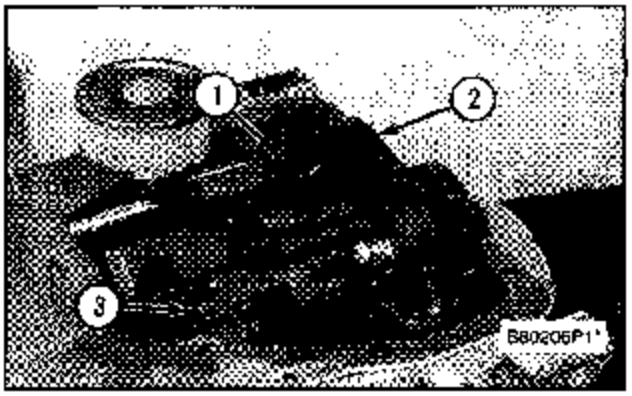
a. install oil pan

Oil Pump (3304B)

Remove Oil Pump (3304B) 1304-011

Start By:

a. remove oil pan



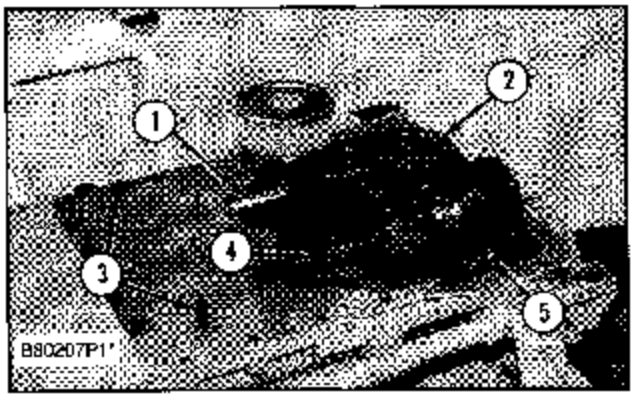
1. Remove bolts (3) that hold the elbow to the oil pump.

⚠ WARNING

Oil pump idler gear (2) can fall off the oil pump when the oil pump is removed. To prevent injury, always hold the gear on the oil pump when it is removed from the engine.

2. Remove the bolts, locks and washers that hold oil pump (1) to the engine. Remove the oil pump from the engine.

Install Oil Pump (3304B) 1304-012



1. Turn the crankshaft until the No. 1 piston is at top center of the compression stroke. See Testing & Adjusting Manual for this procedure.

2. Turn both balancer shafts (1) until the flat part of the shaft is away from the oil pan plate. Install bolts (3) **[3/8" - 16 NC x 51 mm (2 in) long]** through the holes in the oil pan plate and into the threaded holes in the balancer shafts.

3. Install idler gear (2) on the oil pump. Put oil pump (5) in position on the engine as shown. Make sure the oil pump gears are engaged with the balancer shaft gears and the crankshaft gear. Install the bolts, washer and locks that hold the oil pump in position.

4. Install bolts (4) that hold the elbow to the oil pump.

5. Remove bolts (3) from the balancer shafts. Remove the timing bolt from the flywheel.

End By:

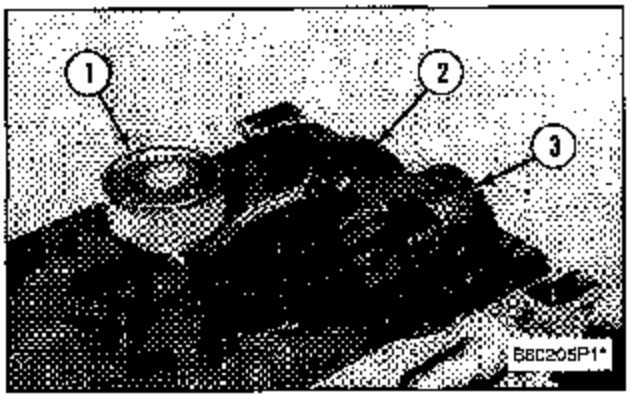
a. install oil pan

Oil Pump (3306B)

Remove & Install Oil Pump (3306B) 1304-010

Start By:

a. remove oil pan



1. Remove the bolt and lock that holds suction bell (1) to the oil pan plate. Remove two bolts (4) that hold the elbow to the oil pump.

⚠ WARNING

Oil pump idler gear (2) can fall off the pump when the pump is removed. To prevent injury, always hold the gear on the pump when the pump is removed.

2. Remove the bolts and locks that hold the oil pump to the engine. Remove oil pump (3).

3. Install idler gear (2) on oil pump (3). Put the oil pump in position on the engine as shown with idler gear (2) engaged with the crankshaft gear. Install the bolts and locks that hold the oil pump to the engine.

4. Install bolts (4) that hold the elbow to the oil pump.

5. Install the bolt and lock that hold suction bell (1) to the oil pan plate.

End By:

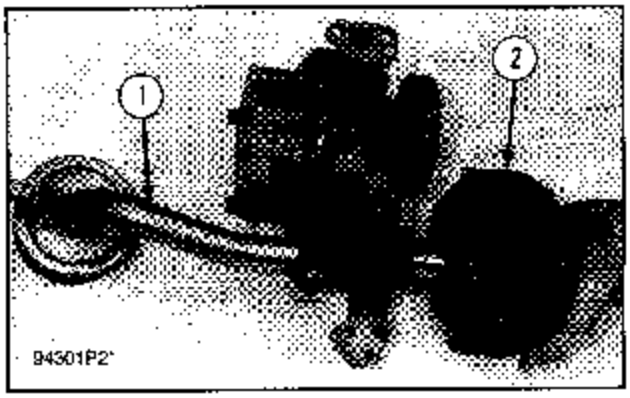
a. install oil pan

Disassemble Oil Pump 1304-015

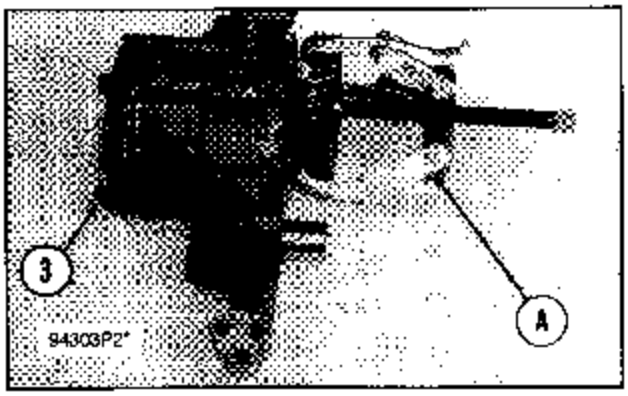
Tools Needed		A	B
1P2320	Puller Assembly	1	
8B7560	Step Plate	1	
1P0510	Driver Group		1

Start By:

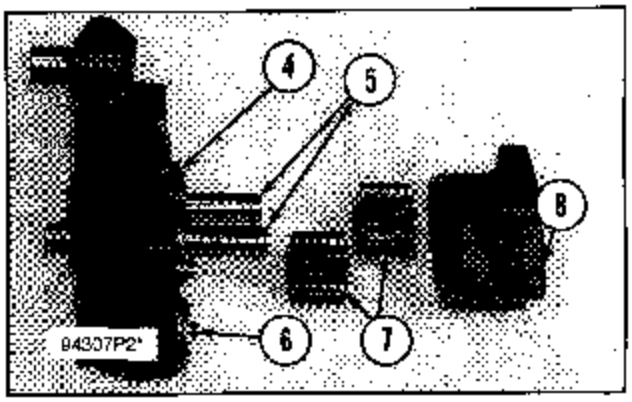
a. remove oil pump (3304B) or remove oil pump (3306B)



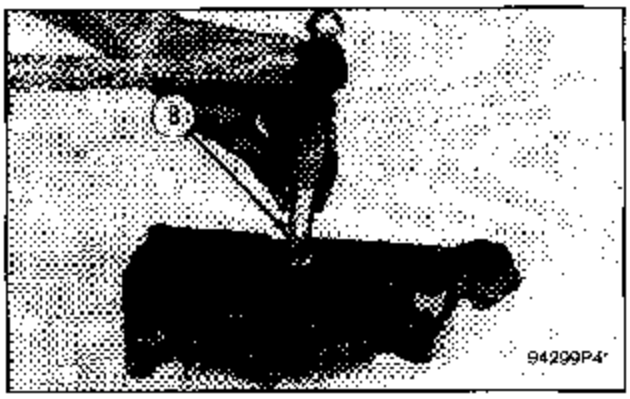
1. Remove idler gear (2). Remove the bearing from the idler gear with Tool (B).
2. Remove suction bell (1).
3. Remove the bolt and the washer from the oil pump drive gear.



4. Remove the drive gear from the shaft with Tool (A).
5. Remove the key from the pump shaft.
6. Remove bolts (3) from the pump body.



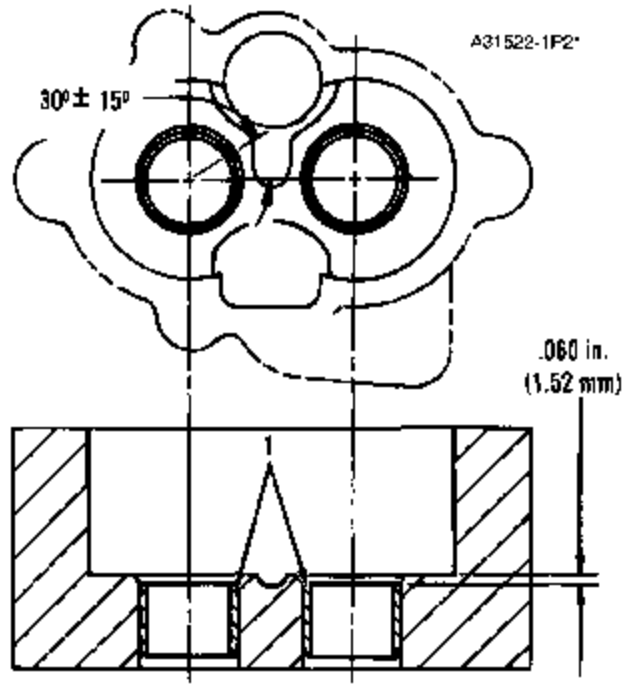
7. Remove body (8), two gears (7), the keys and spacer (4) from the pump.
8. Remove two shafts (5) and the gears.
9. Remove bolts (6), the cover and the pressure relief valve from the body.



10. Remove the bearings from the oil pump body assembly and the scavenge pump body assembly with Tool (B).

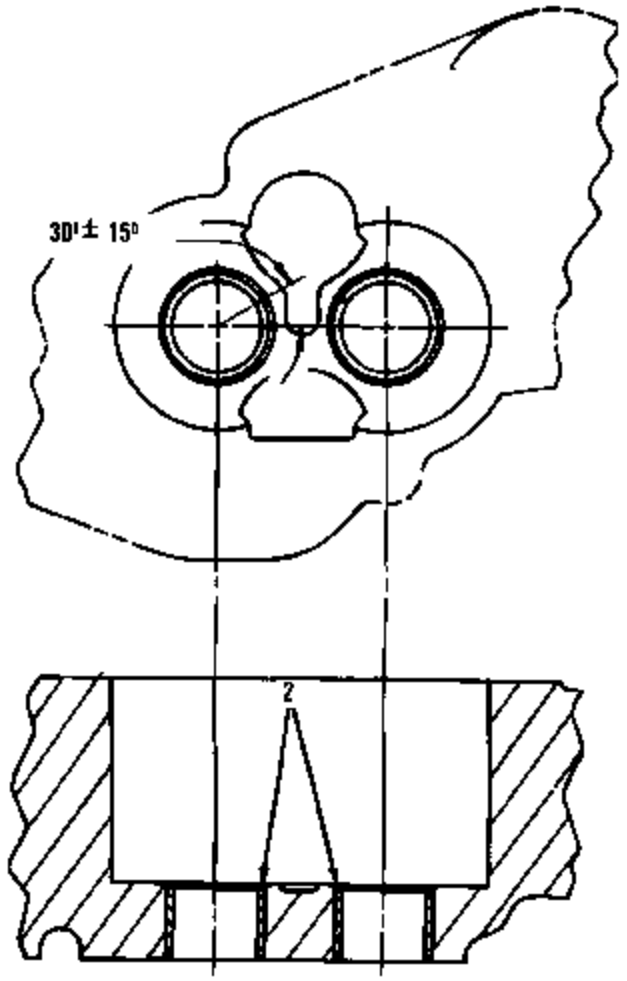
Assemble Oil Pump 1304-016

Tools Needed	A
1P0510 Driver Group	1



1. Install the bearings in the scavenge pump body assembly with Tool (A) and a press as follows:

a. Put bearings (1) in position on the inside of the scavenge pump body assembly with the chamfer on the bearing toward the outside of the pump body. Install the bearing until it is **1.52 mm (.060 in)** below the inside machined surface of the scavenge pump body assembly. Make sure the joints in the bearings are at an angle of **30° ± 15°** from the center line through the bores in the scavenge pump body and toward the outlet passage of the pump. The outlet passage has a cavity between the bearing bores.

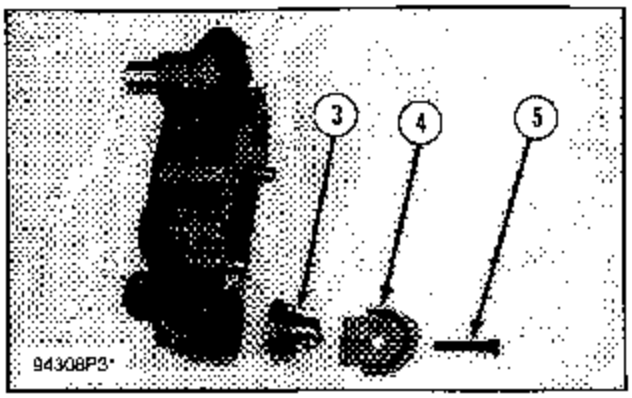


2. Install the bearings in oil pump body assembly with Tool (A) and a press as follows:

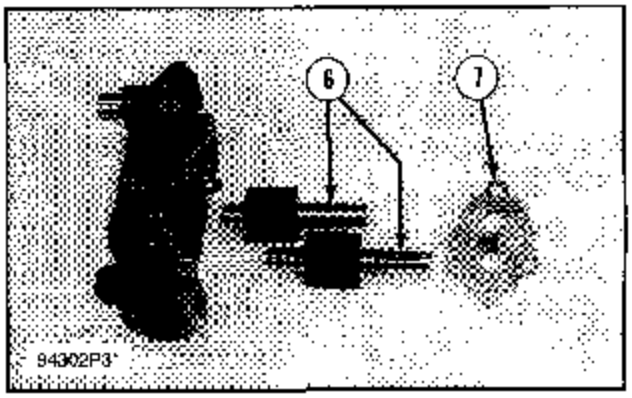
a. Put bearings (2) in position on the inside of the oil pump body assembly with the chamfer on the bearings toward the outside of the pump body. Install the bearings until they are even with the outside of the pump body. Make sure the joints in the bearings are at an angle of **30° ± 15°** from the centerline through the bearing bores and toward the outlet passage of the pump. The outlet passage has a cavity between the bearing bores.

3. Check the condition of the relief valve. Check the condition and specifications for all the parts of the oil pump before it is assembled. See topic, "Oil Pump" in Specifications Manual.

4. Put clean engine oil on all the parts of the oil pump.



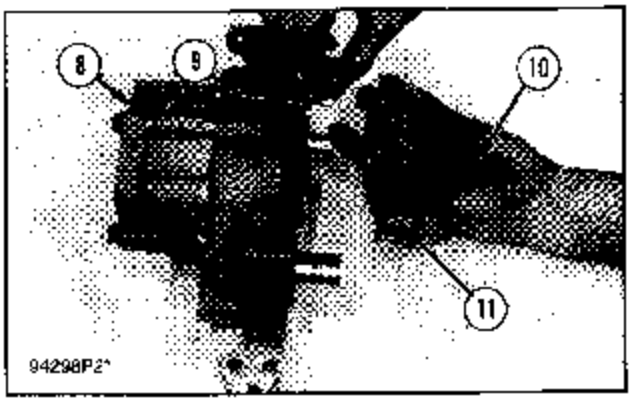
5. Install pressure relief valve (3), cover (4) and bolt (5) in the oil pump body assembly.



6. Install shaft assemblies (6) in the oil pump body assembly.

7. Install spacer (7). Install the key in the shaft assembly.

8. Install the two gears on the shaft assemblies.



8. Install scavenge pump body assembly (8) and the bolts that hold it.

9. Install key (9), drive gear (11), the washer and bolt (10). Tighten the bolt to a torque of **43 ± 7 N•m (32 ± 5 lb ft)**.

10. Install the bearing in the idler gear with Tool (A) and a press until it is even with the outside surface of the gear.

11. Install the suction ball on the oil pump. Install the idler gear on the oil pump.

NOTICE

The oil pump must turn freely by hand after it is assembled.

End By:

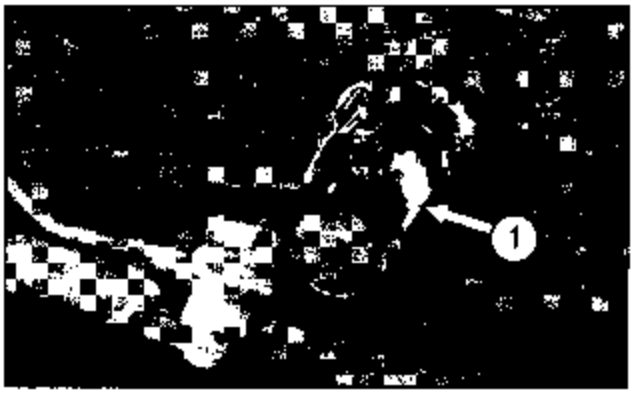
a. install oil pump (3304B) or install oil pump (3306B)

Engine Oil Sampling Valve

Remove and Install Engine Oil Sampling Valve

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance oil inspection, maintenance, testing, adjusting, and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to " TOOLS AND SHOP PRODUCT GUIDE NENG2500" for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose of fluids according to local regulations and mandates.



1. Disconnect engine oil sampling valve (1) from engine block.

NOTE: The following steps are for the installation of the engine oil sampling valve.

2. Connect engine oil sampling valve to engine block.

3. Start the machine and check for leaks.

CATERPILLAR®

GOV #1
May 1996

Disassembly & Assembly

3306 Engine Supplement For 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor

814F:	815F:	816F:
9DM1-UP	1GN1-UP	5FN1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operation that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warning in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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⚠ WARNING

Disconnect batteries before performance of any service work.

FLUID SPILLAGE CONTAINMENT

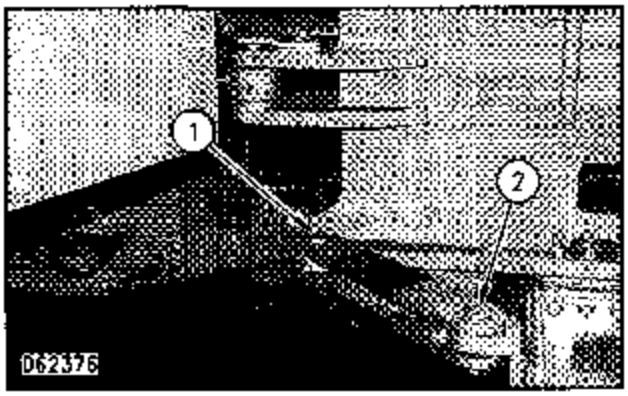
Care must be taken to ensure that fluids are contained duringperformance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassemblingany component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect andcontain fluids in Caterpillar machines. Dispose fluids according to local regulations and manadates.

Steering Frame Lock Link

Separate & Connect Steering Frame Lock Link 7506-029

⚠ WARNING

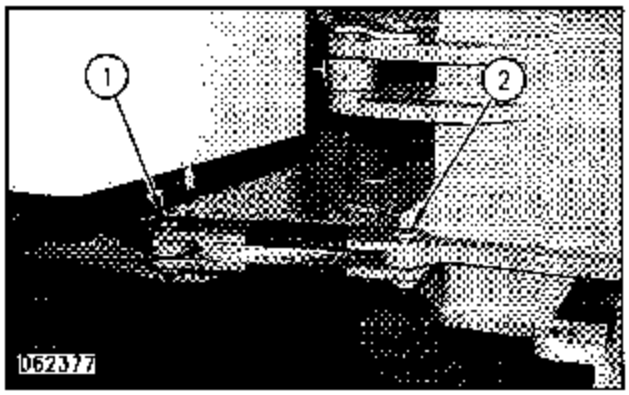
There is no clearance for a person in the area between the front and rear frames of the machine when turning the vehicle. When a machine is to be lifted, transported on another vehicle or service work is being performed near the center of the machine, connect the steering frame lock link between the front and rear frames to keep the machine in a straight ahead position. Before operation and when operating, be sure the steering frame lock link, located near the center of the machine, is disconnected and pinned to the retaining plates.



Steering Frame Lock Link In The Stored Position

1. To connect the steering frame lock link, first put the machine in a straight ahead position.

2. Remove the cotter pins from pins (1) and (2). Remove pins (1) and (2) from the steering frame lock link.



Steering Frame Lock Link In The Locked Position

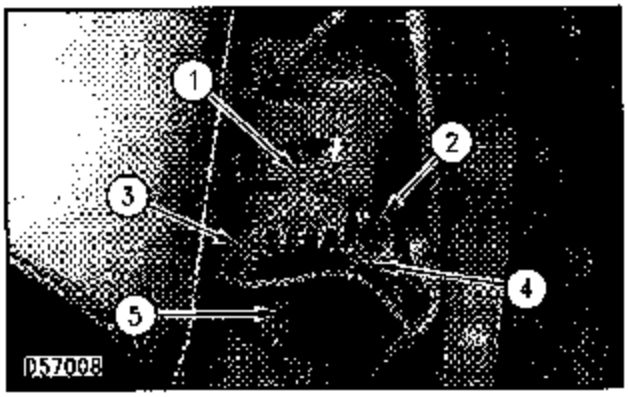
3. Slide the steering frame lock link into the front frame. Be sure the bores in the lock link are in alignment with the bores in the front and rear loader frames. Reinstall pins (1) and (2) and the cotter pins that hold them.

NOTE: the following step is for the separation of the steering frame lock link.

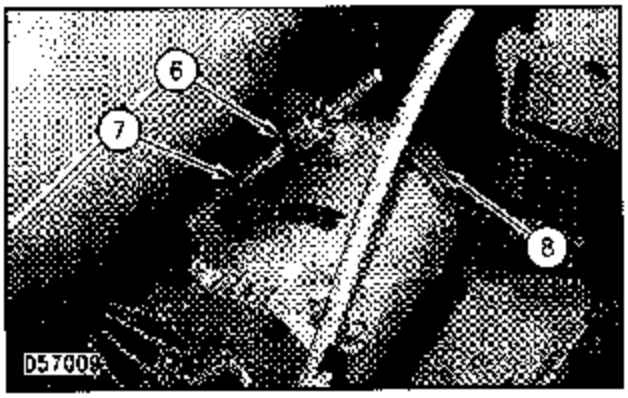
4. Remove the cotter pins from (1) and (2). Slide the steering frame lock link into the storage position in the rear loader frame. Reinstall pins (1) and (2) to hold the steering frame lock link in the stored position. Install the cotter pins to hold pins (1) and (2) in place.

Alternator

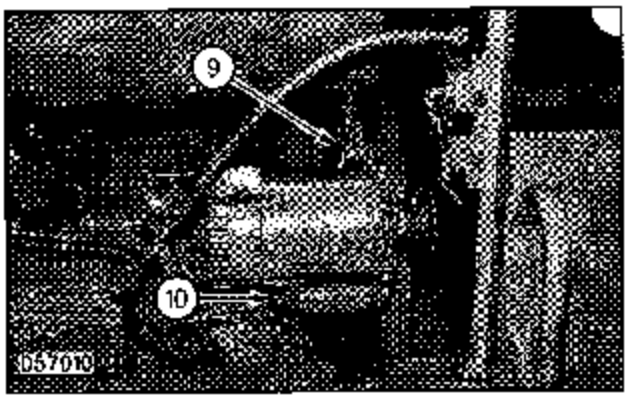
Remove & Install Alternator 1405-010



1. Disconnect wires (1), (2) and (3) from alternator (5).
2. Disconnect wire clip (4) from the alternator (5).

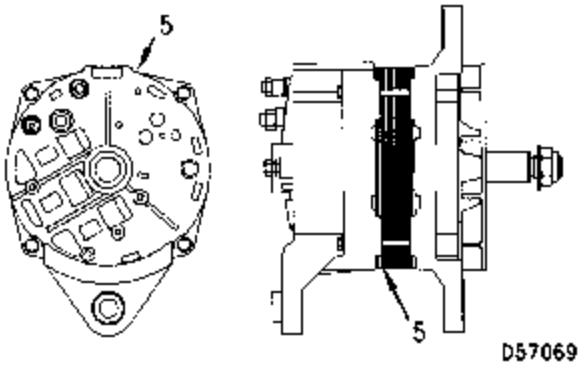


3. Release belt tension by loosening lower nut (6) on adjustment rod (7).
4. Remove V belts (8) from the pulley on alternator (5).



5. Remove bolts (9) and (10) and then remove alternator.

NOTE: Install the alternator in the exact reverse order from disassembly.



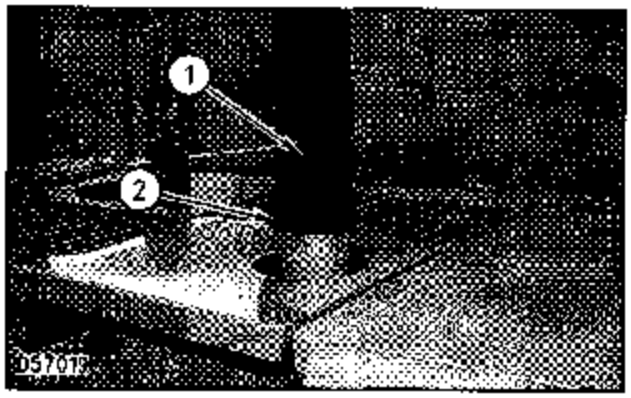
6. Adjust the tension of the alternator V belt. See the topic "Fan and Alternator Belts" in the Operation & Maintenance Manual for the correct adjusting procedure.

Hood

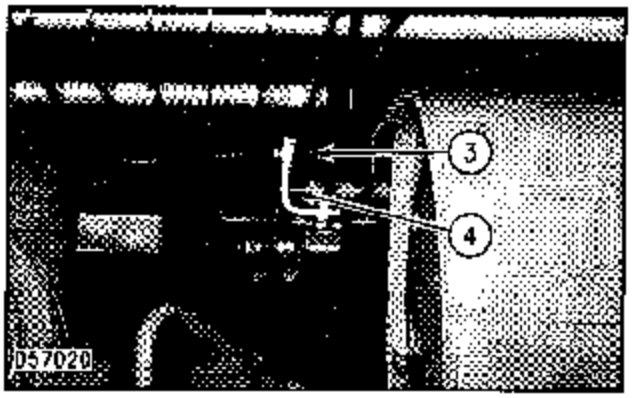
Remove & Install Hood 7251-010

Start By:

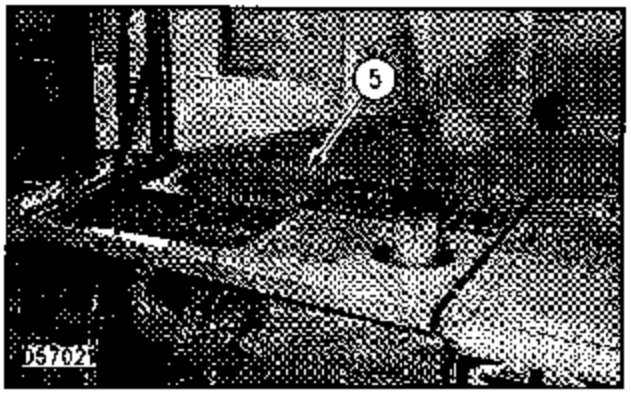
a. remove precleaner



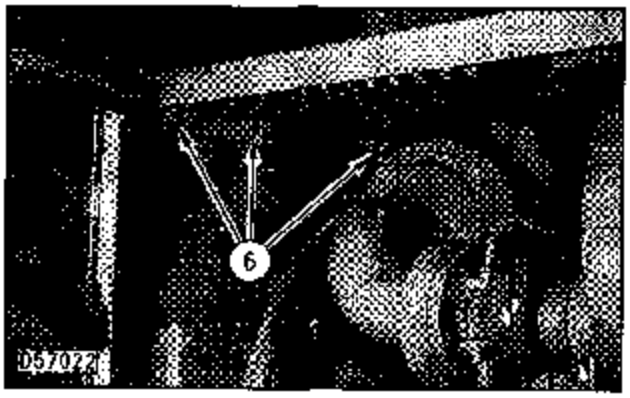
1. Loosen clamp bolt (2) and remove exhaust pipe (1)



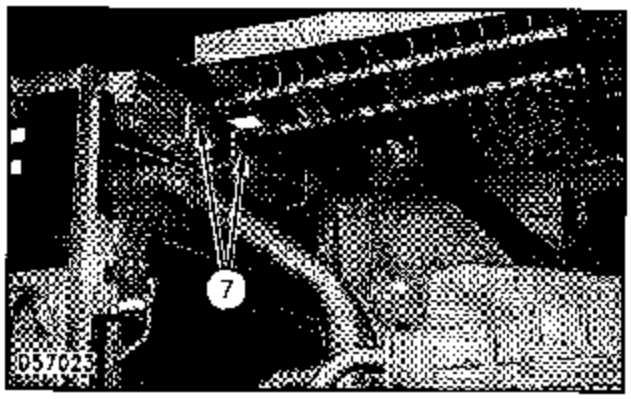
2. Remove bolt (3) to disconnect air hose bracket (4).



3. Fasten lifting straps and a hoist to hood (5) as shown.



4. Remove four bolts and washers (6) from the front of hood (5).



5. Remove hood (5) by lifting up and out of three grommets (7). The weight of the hood is **39 kg (85 lb)**.

NOTE: Install the hood in the reverse order of removal.

6. Apply **5P3931 Anti-Seize Compound** on the threads of bolt (2) and the face of washers for bolts (2).

End By:

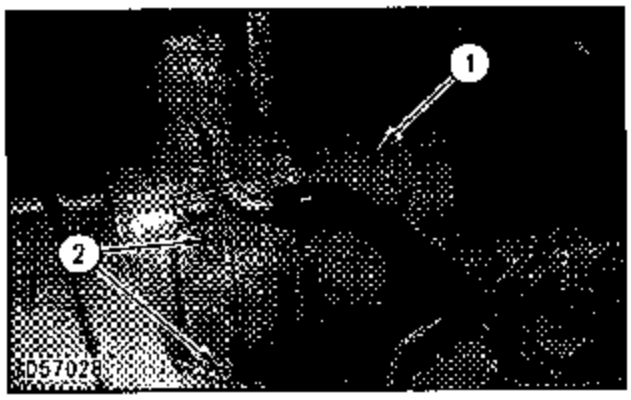
a. install precleaner

Muffler

Remove & Install Muffler 1062-010

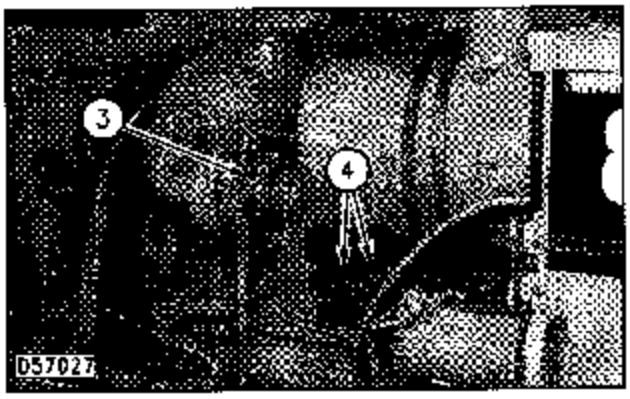
Start By:

a. remove hood

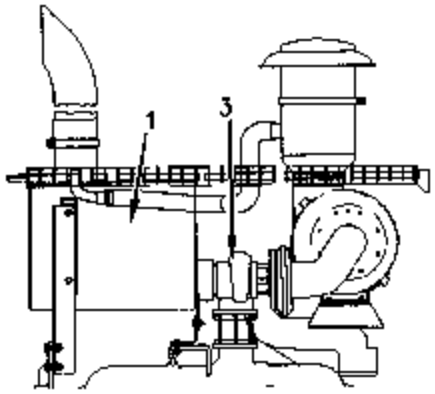


1. Fasten a lifting strap and a hoist to muffler as shown.

2. Remove two bolts and washers (2).



3. Remove two bolts and washers (4). Remove muffler (1) from the turbocharger (3). The weight of the turbocharger is **23 kg (50 lb)**.



NOTE: Install the muffler in the reverse order of removal.

4. Tighten four bolts (2) and (4) only after the muffler has been aligned with the turbocharger.

End By:

a. install hood

Radiator & Guard

Remove & Install Radiator & Guard 1381-010

Tools Needed	A
6V2156 Link Bracket	4

Start By:

a. remove hood

b. remove air conditioning condenser

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure. Steam can cause personal injury. Check the coolant level only after the engine has been stopped and the fill cap is cool enough to touch with your bare hand. Remove the fill cap slowly to relieve pressure. Cooling system conditioner contains alkali. Avoid contact with skin and eyes to prevent personal injury.

1. Release the pressure in the cooling system by slowly loosening the filler cap on the radiator. Drain the coolant from the radiator into a suitable container for storage or disposal. The capacity of the cooling system is **43.3 liters (11.2 U.S. gal).**

⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all hydraulic pressure is released before any fitting, hose or component loosened, tightened, removed or adjusted.

2. Release the pressure in the hydraulic system as follows:

   a. Install the steering frame lock link.

   b. Move the lift control lever to the "Float" position.

   c. Shut off the engine.

   d. Move the lift control lever to the "Hold" position.

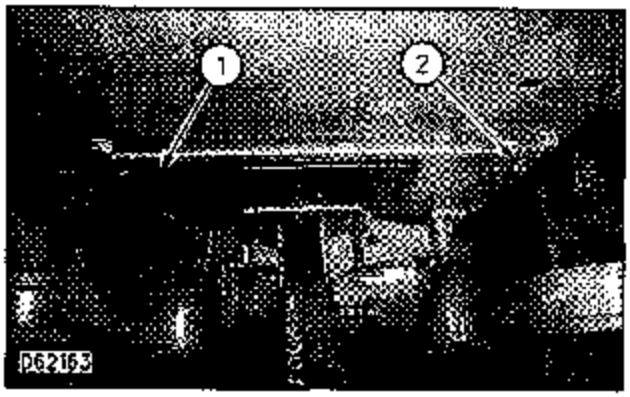
   e. Carefully loosen the filler cap on the hydraulic oil tank to release the pressure in the system.

   f. Carefully loosen the plugs located at the rear of the tilt cylinder. When the oil from the loosened plugs stops running, tighten the two plugs.

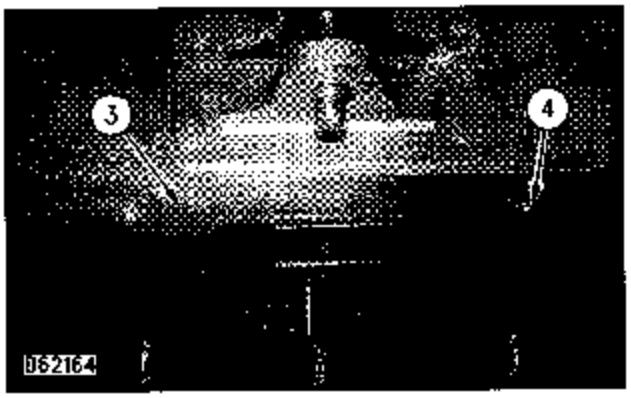
NOTE: To release the pressure in the attachment cylinders, carefully loosen the two large plugs near located near the plugs located at the rear of the tilt cylinder. When the oil from the two plugs stops running, tighten the two plugs.

   g. Tighten the filler cap on the hydraulic oil tank. The system pressure has now been released.

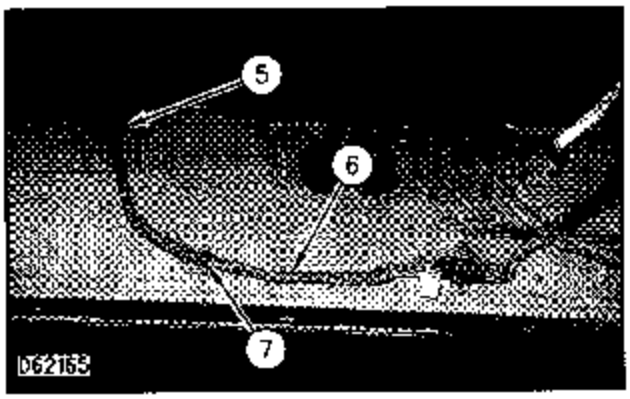
3. Drain the oil from the hydraulic system into a suitable container for storage or disposal. The capacity of the hydraulic system is **140 liters (36.4 U.S. gal).**



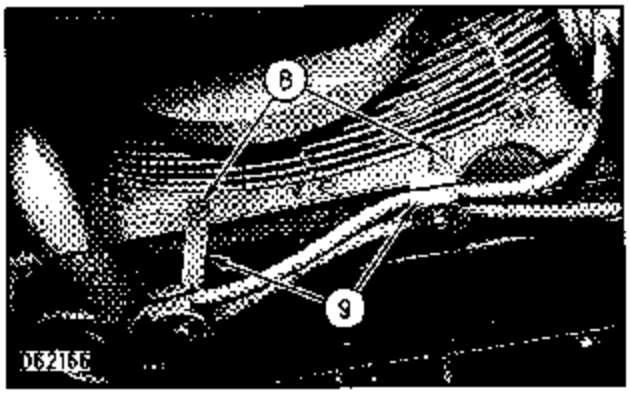
4. Position a suitable floor jack under rear crankcase guard (1). Remove four bolts and washers (2) that hold rear crankcase guard to frame. Remove the guard (1) from under the machine The weight of the rear crankcase guard is **38.6 kg (85 lb).**



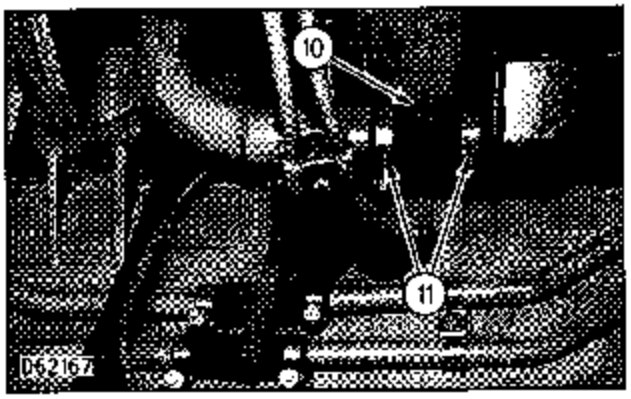
5. Position a suitable floor jack under rear crankcase guard (3). Remove four bolts and washers (4) that hold rear crankcase guard to frame. Remove the guard (3) from under the machine The weight of the rear crankcase guard is **47.7 kg (105 lb)**.



6. Disconnect wiring harness (6). Remove bolt and clamp (5), and tie strap (7) that connect wiring harness (6) to the frame.



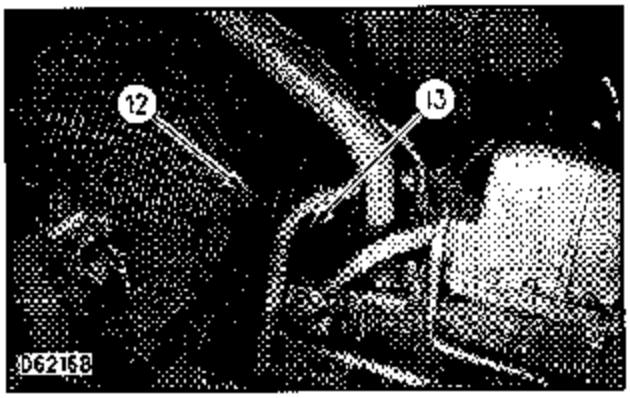
7. Remove two bolts (8) and washer that connect battery cable brackets to the bottom of the fan shroud.



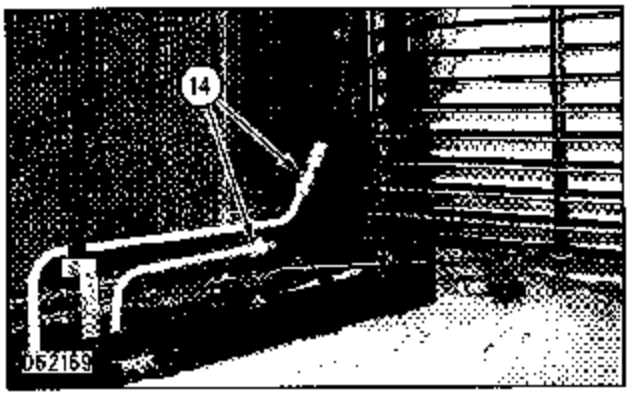
8. Loosen two clamps (11) and slide lower radiator hose (10) away from radiator.

NOTICE

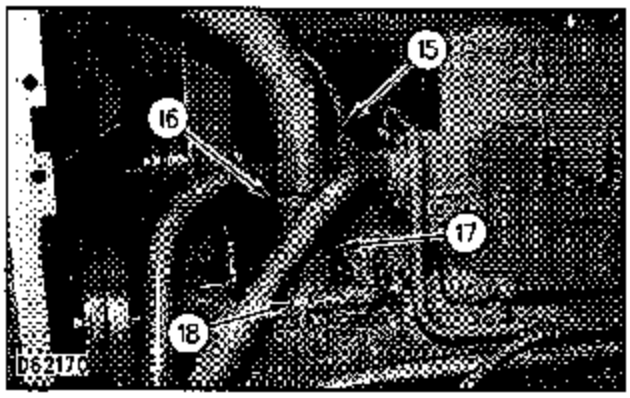
Do not damage the radiator core during removal of the adapter and the fan assembly.



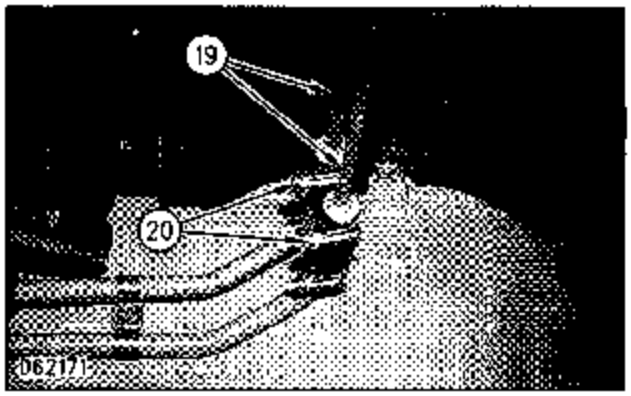
9. Attach a lifting strap and hoist to adapter (12) as shown. Remove six bolts, nuts and washers (13) that connect adapter to pulley. Carefully place fan assembly with adapter against the radiator core.



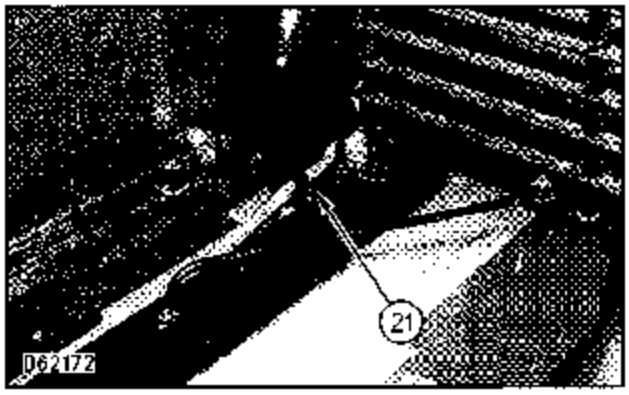
10. Disconnect two hydraulic oil lines (14) and cap ends of both fittings and lines to prevent damage and leaking.



11. Disconnect small tube (15) from aftercooler. Loosen two clamps (16) and slide hose (17) up and away from water temperature regulator housing (18).

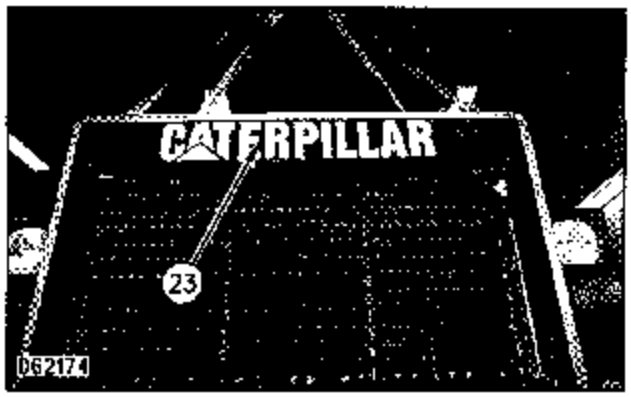


12. Loosen two clamps (20) and remove two hydraulic oil cooler lines (19).



13. Remove six bolts (21) and washers on the back of the radiator group which hold the radiator and guard group to the frame.

14. Remove four bolts and washers (22) on the front side of the radiator group which hold the radiator and guard group to the frame.



15. Fasten tool (A) straps and a hoist to radiator and guard (23) as shown. Remove the radiator and guard as a unit. The weight of the unit is **636 kg (1400 lb)**

NOTE: The following steps are required for the installation of the radiator and guard.

16. Install the radiator and guard in the reverse order of removal.

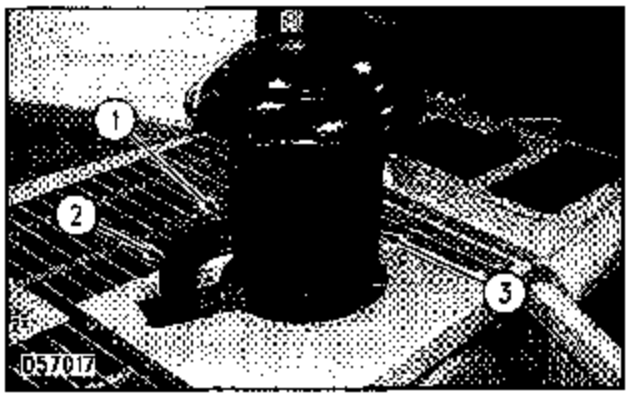
17. Fill the cooling system with coolant and the hydraulic oil tank with oil to the correct fluid levels. Consult the Operation And Maintenance Manual for the correct filling procedures.

18. Start the engine and check for a fluid leaks.

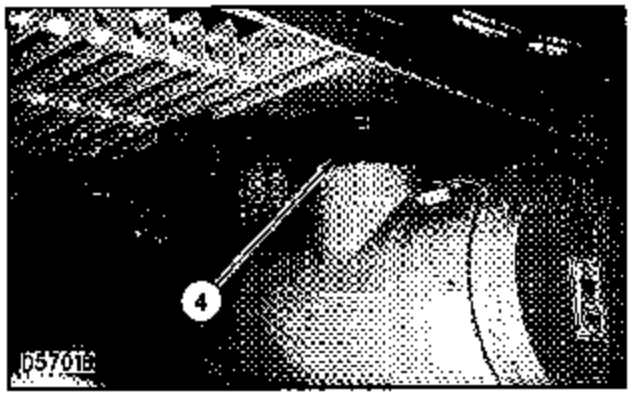
Air Pre-cleaner

Remove & Install Air Pre-cleaner 1054-010

1. Open right engine access door



2. Loosen hose clamp (1) and disconnect dust ejector hose (2) from precleaner (3).



3. Loosen clamp (4) and remove precleaner (4).

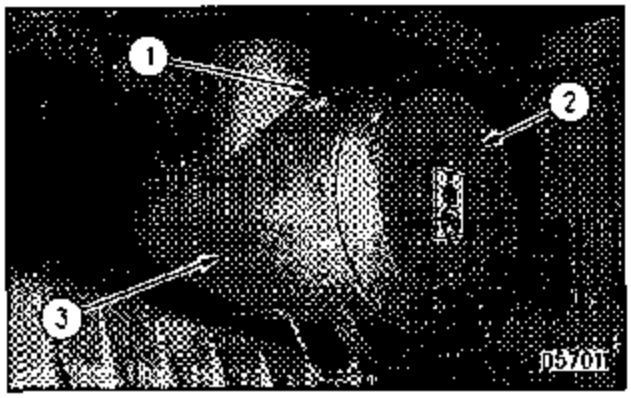
NOTE: Install in reverse order.

Air Cleaner Elements & Housing

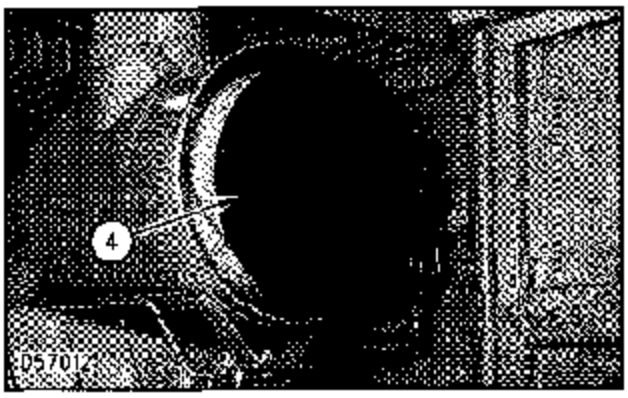
Remove & Install Air Cleaner Elements & housing 1051-010

Start By:

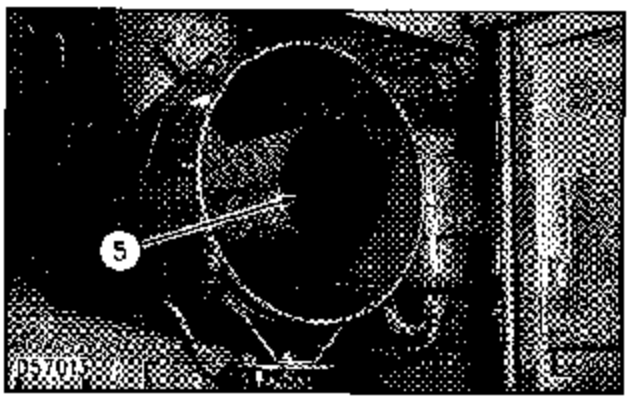
a. remove pre-cleaner



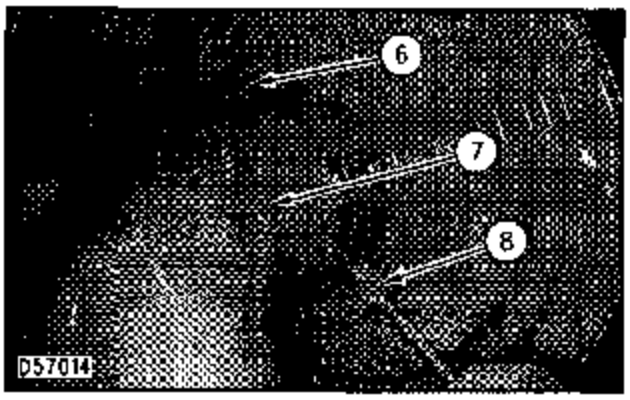
1. Release two air cleaner clamps (1), and remove cover assembly (2) from the air cleaner housing (3).



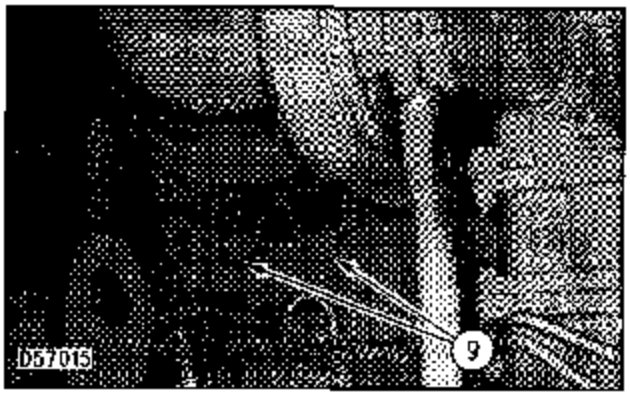
2. Remove primary element (4) from the air cleaner housing (3).



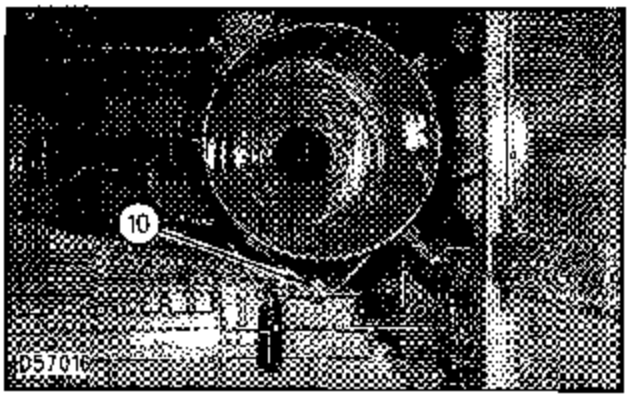
3. Remove secondary element (5) from air cleaner housing (3).



4. Loosen clamp (6) and disconnect hose (7) from air cleaner housing (3). Disconnect tube assembly (8).



5. Remove two bolts and washers (9) from the air cleaner housing (3).



6. Remove one bolt and washer (10) from air cleaner housing (3).

Remove air cleaner housing (3).

NOTE: Install the air cleaner elements and housing in the reverse order of removal.

End By:

a. Install pre-cleaner

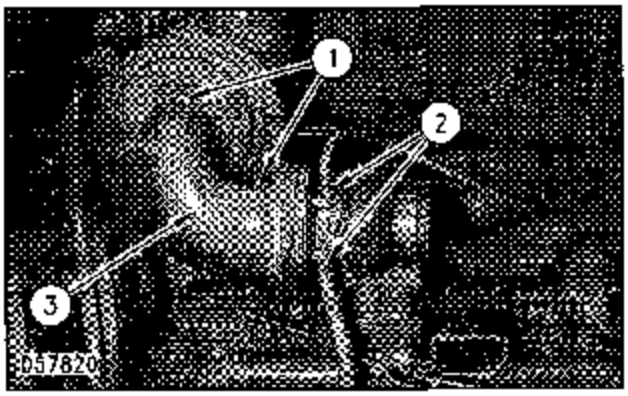
Turbocharger

Remove & Install Turbocharger 1052-010

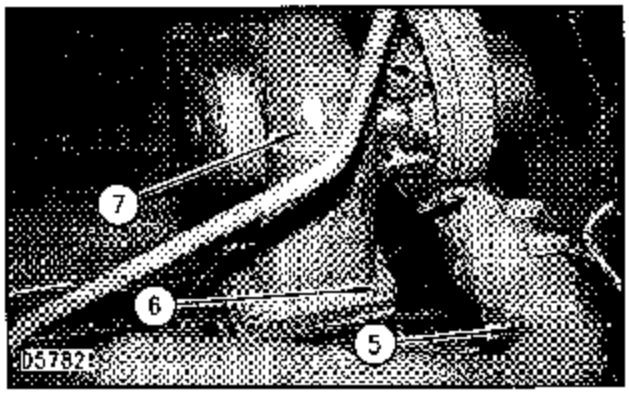
Start By:

a. remove hood

b. remove muffler



1. Loosen two hose clamps (1) and remove air hose (3). Disconnect two oil lines (2) at turbocharger.



2. Loosen hose clamp (4) and disconnect air line (5). Remove four bolts (6) and the nuts that hold turbocharger (7) to the exhaust manifold. Remove the turbocharger.

NOTE: The following steps are for the installation of the turbocharger.

NOTICE

Before four bolts (6) and the nuts which hold the turbocharger to the exhaust manifold are tightened, all oil tubes, air pipes and exhaust pipes should be aligned and tightened without binding.

3. Check the condition of the gasket used between the turbocharger and the exhaust manifold. If the gasket is worn or damaged, use a new part for replacement. Put the gasket and turbocharger (7) in position on the exhaust manifold and in the elbow assembly for the air cleaner. Put **5P3931 Anti-Seize Compound** on the threads of bolts (6) that hold the turbocharger to the exhaust manifold. Install the four bolts and nuts, but do not tighten them at this time.

4. Check the condition of the gaskets used on oil supply tube and oil drain tube (2). If the gaskets are worn or damaged, use new parts for replacement. Connect the oil supply tube and tighten to a torque of **25 ± 6 N•m (18 ± 4 lb ft)**. Connect the oil drain tube to the turbocharger and tighten to a torque of **47 ± 9 N•m (35 ± 79 lb ft)**.

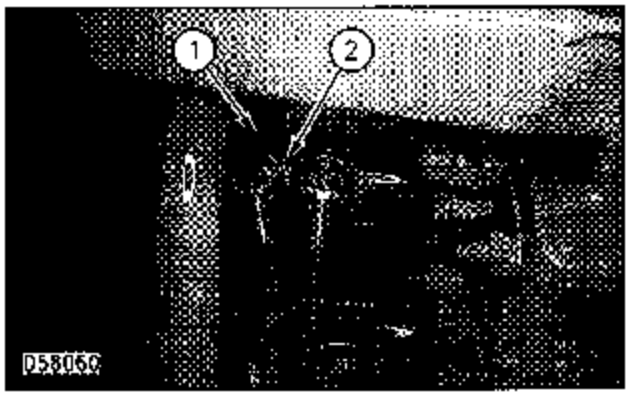
5. Install clamp (1) that holds the air cleaner elbow assembly to the turbocharger. Tighten clamp to a torque of **14 ± 1 N•m (10 ± 1 lb ft)**.

6. Install clamp (4) and tighten to a torque of **14 ± 1 N•m (10 ± 1 lb ft)**.

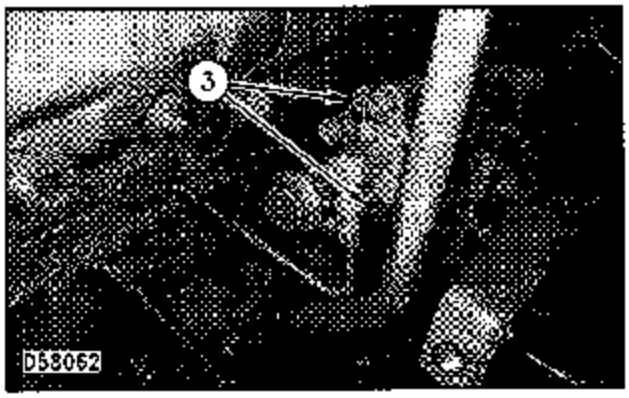
7. Tighten four bolts (6) that hold turbocharger (7) to the exhaust manifold to a torque of **54 ± 5 N•m (40 ± 4 lb ft)**.

Fuel Shut-Off Solenoid

Remove & Install Fuel Shut-Off Solenoid 1259-010



1. Put identification marks on two wires (2) as to their location on the fuel shut-off solenoid (1). Disconnect the wires from the fuel shut-off solenoid.



2. Remove two bolts (3), fuel shut-off solenoid (1) and the gasket .

NOTE: The following steps are for the installation of the fuel shut-off solenoid.

3. Check the condition of the gasket used between the fuel shut-off solenoid and the governor. If the gasket is worn or damaged, use new parts for replacement.

4. Install the gasket and fuel shut-off solenoid on the governor. Install the two bolts that hold it.

5. Connect the two wires to the fuel shut-off solenoid in their original positions.

Fan Assembly

Remove & Install Fan Assembly 1356-010

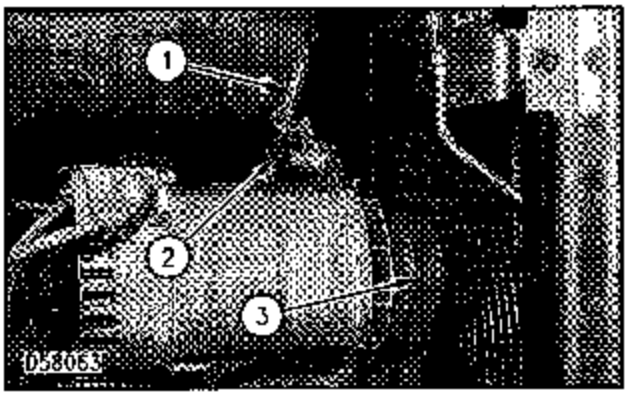
Start By:

a. remove hood

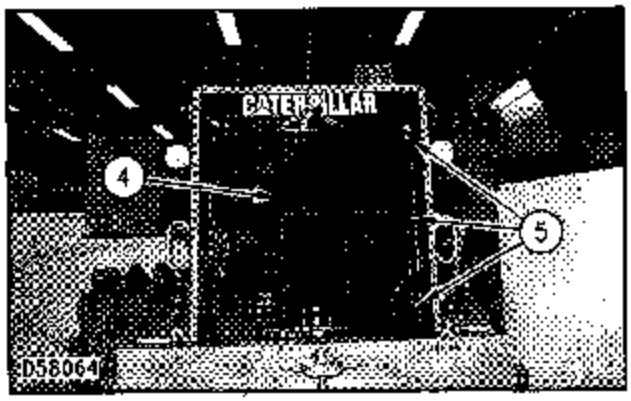
⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure. Steam can cause personal injury. Check the coolant level only after the engine has been stopped and the fill cap is cool enough to touch with your bare hand. Remove the fill cap slowly to relieve pressure. Cooling system conditioner contains alkali. Avoid contact with skin and eyes to prevent personal injury.

1. Release the pressure in the cooling system. Drain the coolant from the radiator into a suitable container for storage or disposal. The capacity of the cooling system is **44 liters (11.4 U.S. gal.)**.

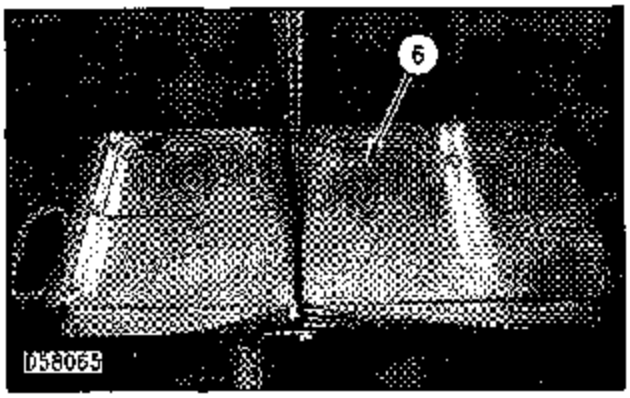


2. Loosen nut (2) on alternator adjustment rod (1) to loosen the tension on the V-belts. Remove V belts (3) from the pulley on the alternator.



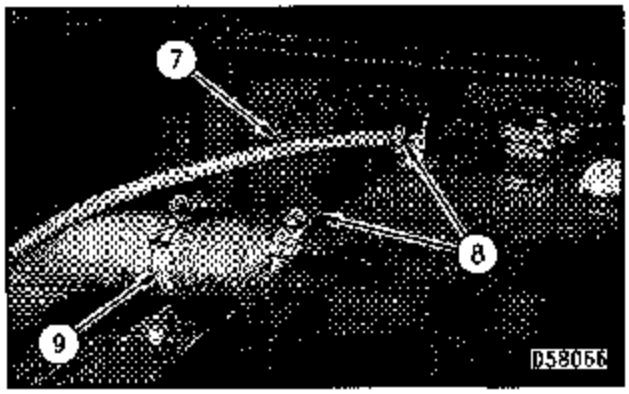
3. Remove six bolts and washers (5) and remove grille door (4). Weight of door (4) is **57 kg (125 lb)**.

NOTE: Three bolts (5) are reached by opening the grill door.

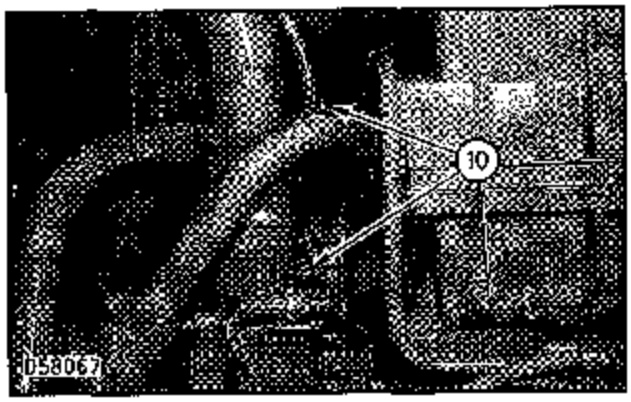


4. Remove radiator cover assembly (6) by removing eight bolts and washers. Weight of cover assembly (6) is **34 kg (75 lb)**.

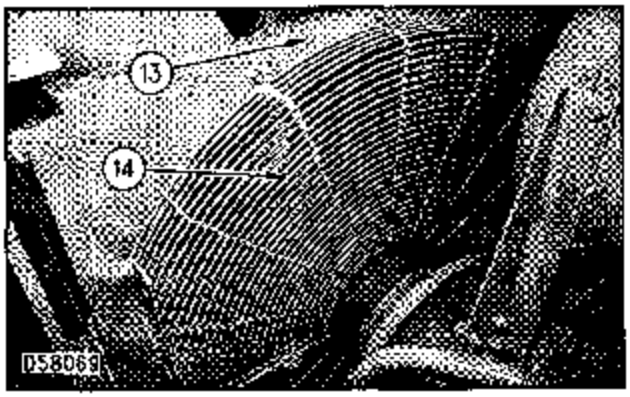
NOTE: Two bolts located under grill door (4).



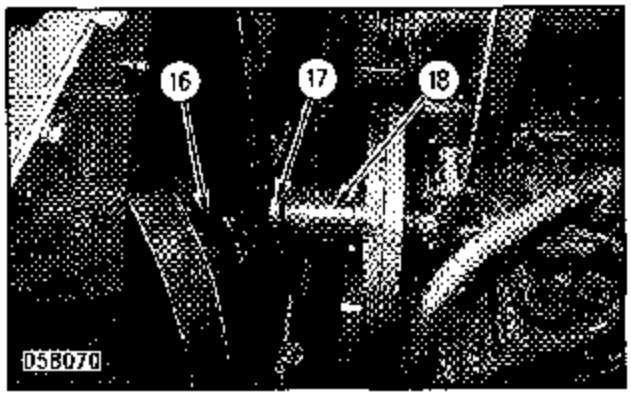
5. Loosen hose clamps (8) on both vent hoses (7) and coolant hose (9).



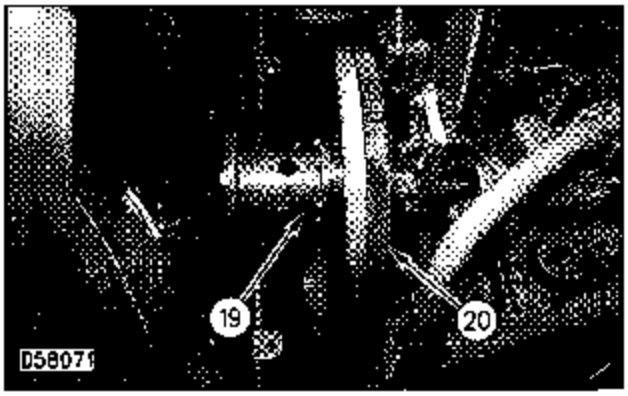
6. Loosen hose clamps (10) and remove vent hose (7) and coolant hose (9).



7. Remove four nuts and washers (13) and four bolts and washers (15) and remove fan guard (14).



8. Fasten a hoist to fan assembly (16). Remove eight nuts and washers that hold the fan assembly to the fan adapter. Carefully place the fan assembly against the radiator core. Weight of the fan assembly is **34 kg (75 lb)**.



9. Remove six nuts, bolts, and washers (19) that hold the fan adapter to fan pulley (20). Remove fan assembly (16) ensuring that blades do not puncture the radiator.

NOTE: The following steps are for the installation of the fan assembly.

10. Fasten a hoist to fan assembly (16), and carefully put in position against the radiator core.

11. Put fan adapter (18) in position on fan pulley (20), and install the six bolts, washers and nuts that hold it.

12. Put fan assembly (16) in position on fan adapter (18). Install eight bolts and washers that hold it.

13. Reinstall fan guard assembly (14).

14. Install vent hose (7) and coolant hose (9).

15. Install two V-belts (3) in the pulley on the alternator. Adjust the V-belt tension. See the topic "Fan and Alternator Belts" in the Operation & Maintenance Manual.

16. Reinstall radiator cover assembly (6).

17. Fill the cooling system with coolant to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

18. Reinstall grill door.

End By:

a. install hood

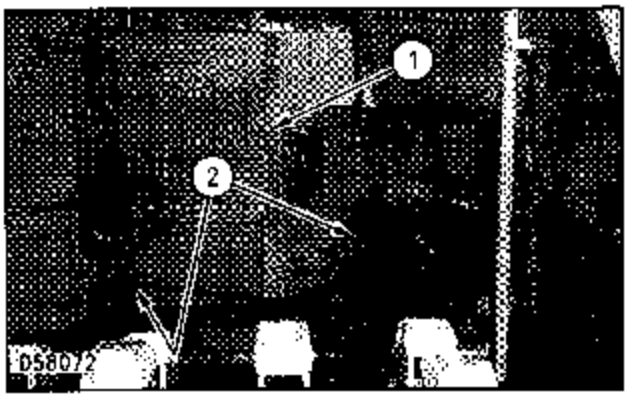
Cab

Remove & Install Cab 7301-010

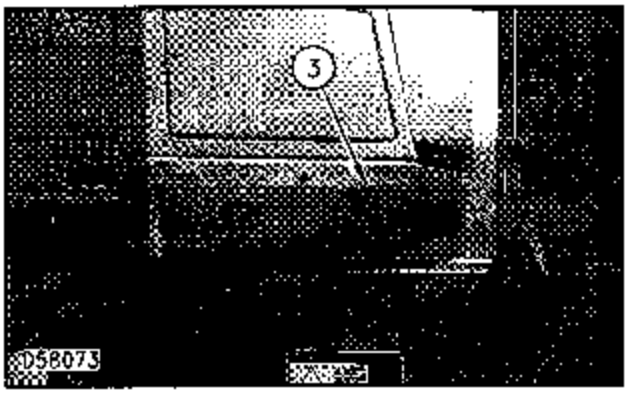
Tools Needed	A
6V-2156 Link Bracket	4

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

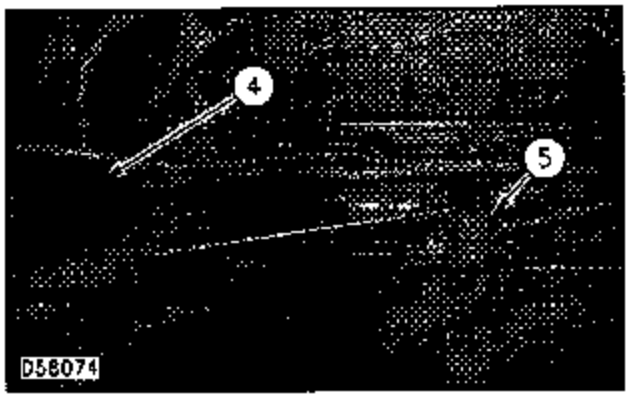


1. Remove two bolts and washers (2) and open platform assembly (1).

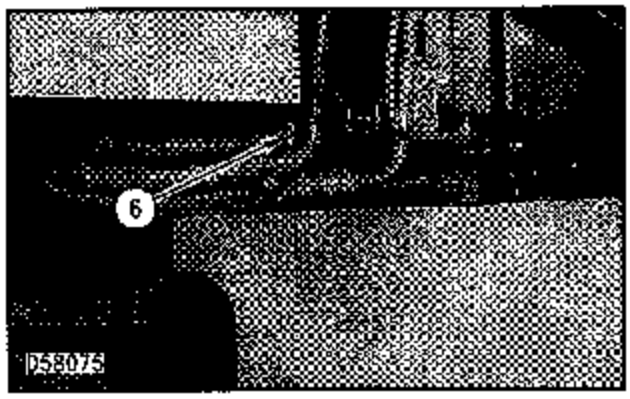


2. Remove eleven bolts and washers from front shroud (3) and remove front shroud (3).

NOTE: Two bolts on the left side are under the shroud.



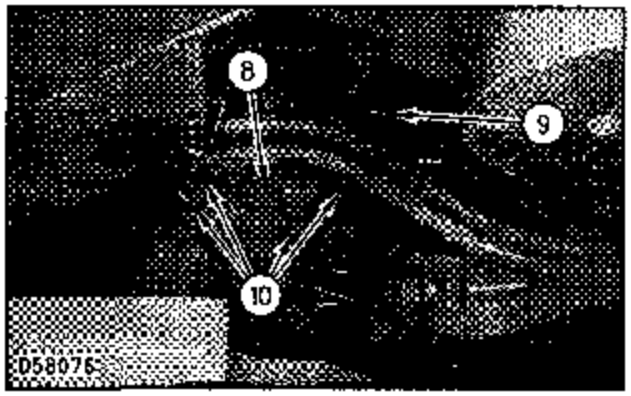
3. Turn heater hose valves (4) and (5) to the **OFF** position.



4. Disconnect two heater hoses (6).

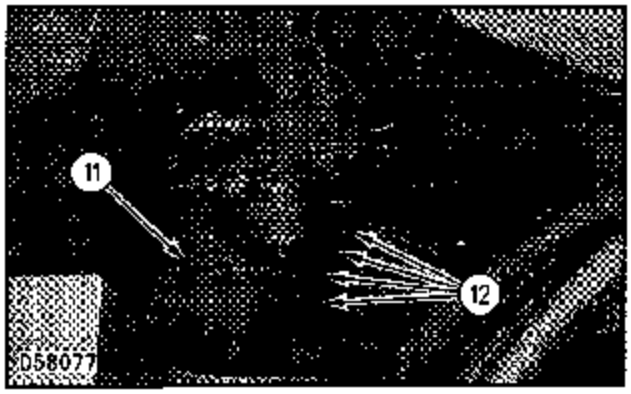
⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure. Steam can cause personal injury. Check the coolant level only after the engine has been stopped and the fill cap is cool enough to touch with your bare hand. Remove the fill cap slowly to relieve pressure. Cooling system conditioner contains alkali. Avoid contact with skin and eyes to prevent personal injury.

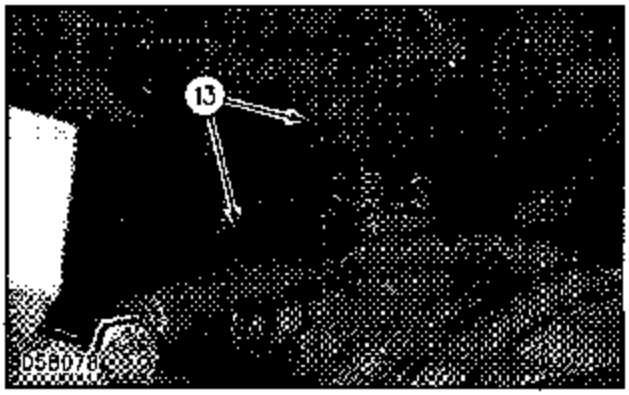


5. Identify and disconnect four hydraulic hoses (10) from brake valve (8). Disconnect electrical connection (9).

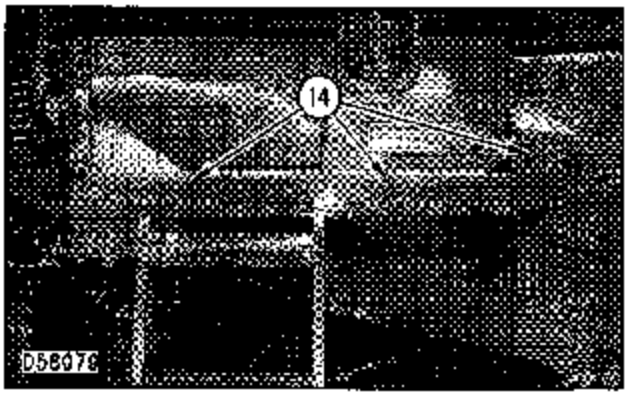
NOTE: Cap and plug all lines and fittings as they are removed to prevent excess fluid loss and to prevent dirt or debris from entering the system.



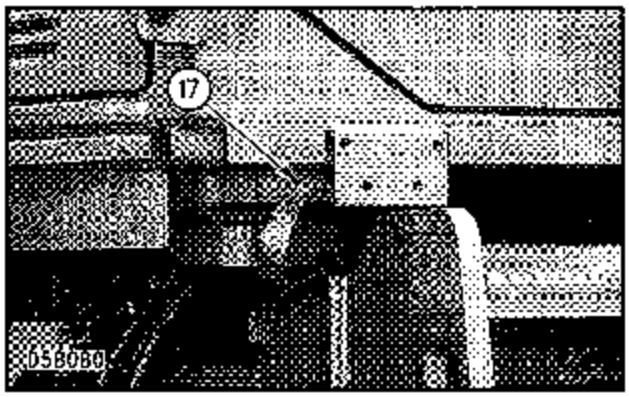
6. Identify and disconnect four hydraulic hoses (12) from steering valve (11).



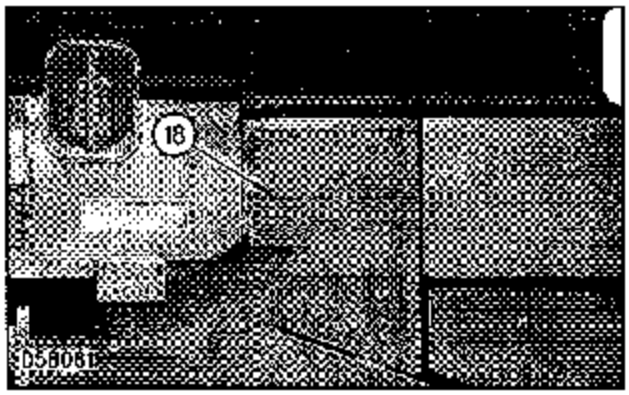
7. Cut plastic tie wraps (13) securing wiring harness to bottom of the cab.



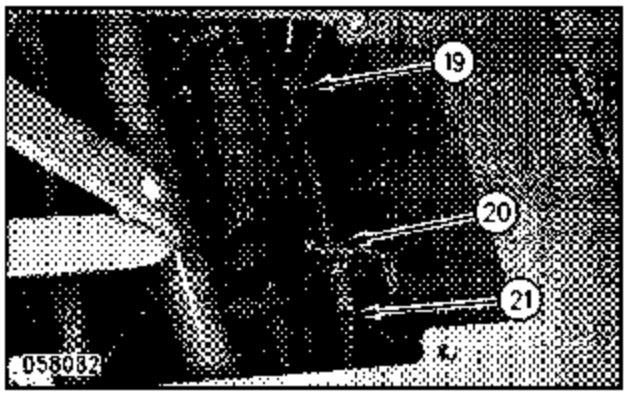
8. Remove guards (15) and (16) by removing ten bolts and washers (14).Disconnect electrical wires to horn which is mounted on the back of guard (15).



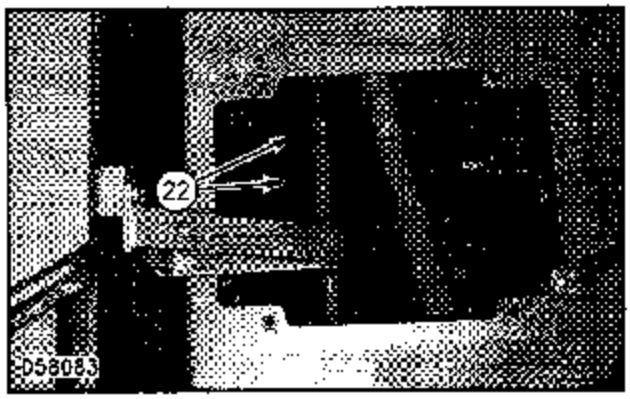
9. Disconnect ground strap (17).



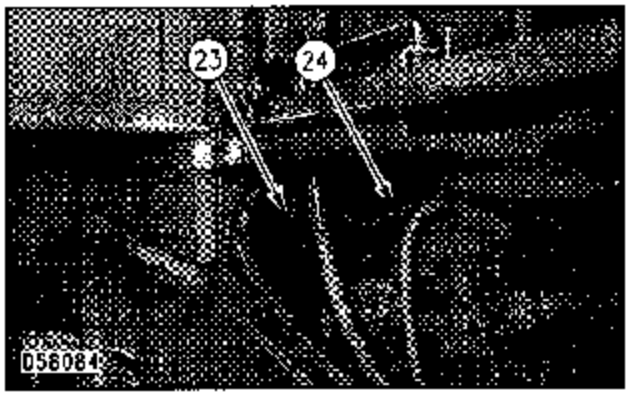
10. Remove cover (18) by removing four bolts and washers.



11. Disconnect parking brake cable (21) by removing pin and cotter pin (19), loosen cam nut (20) and remove from retaining bracket.

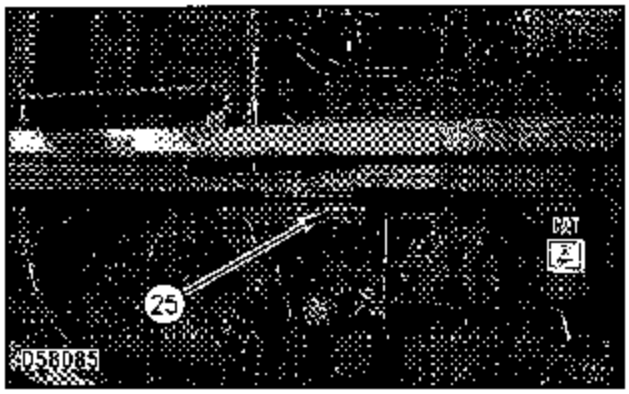


12. Disconnect two windshield washer hoses (22).

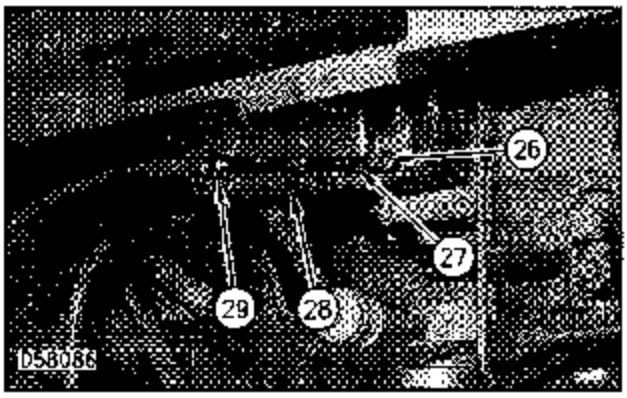


13. Disconnect two clips (23) which secures accelerator cable (24) to frame.

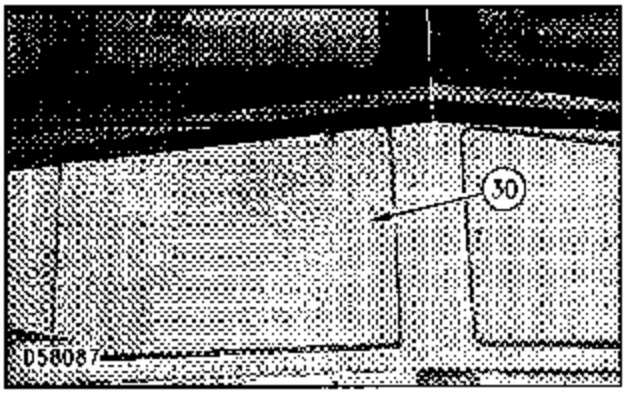
NOTE: There is a second clip located under cab directly under rear of door.

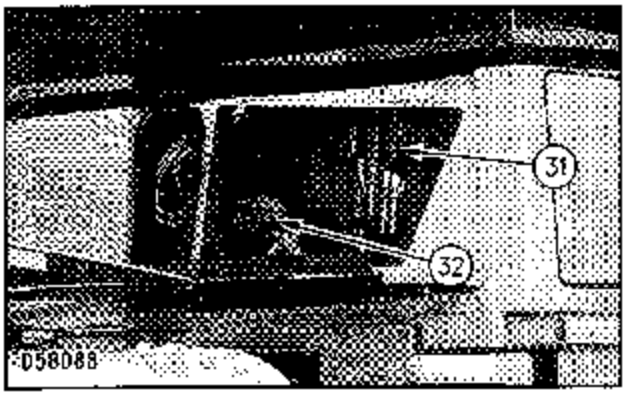


14. Remove six screws and cover (25) from fuel injection pump.

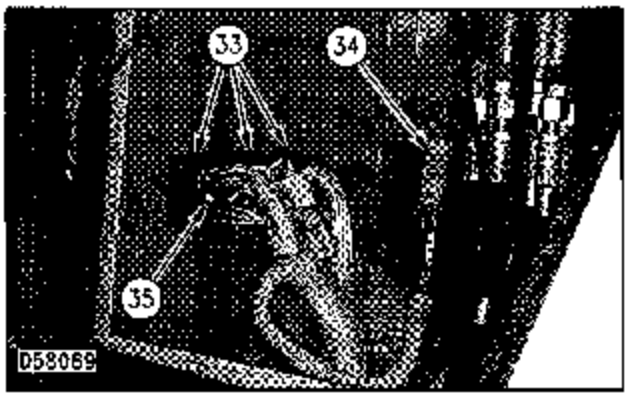


15. Remove bolt (26) and remove rod end (27) from accelerator cable (24). Remove nut and washer (29) and remove accelerator cable (24) from housing (28).

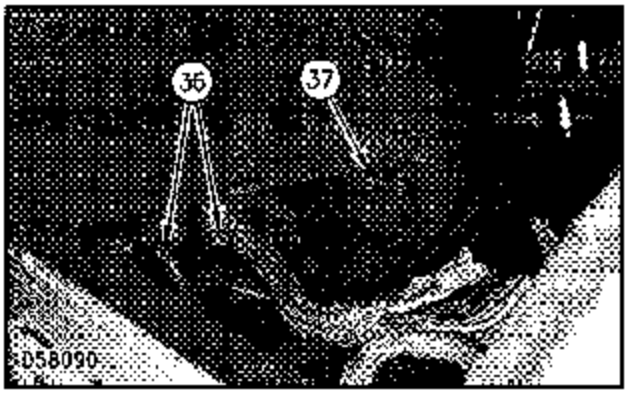




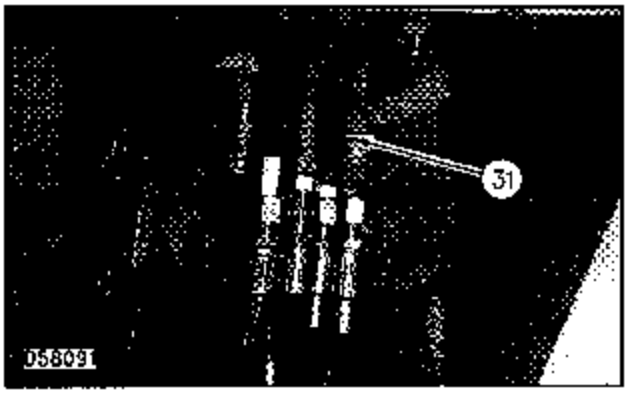
16. Open panel door (30) on the right side of the cab to access wiring harness (32) and dozer control valve (31).



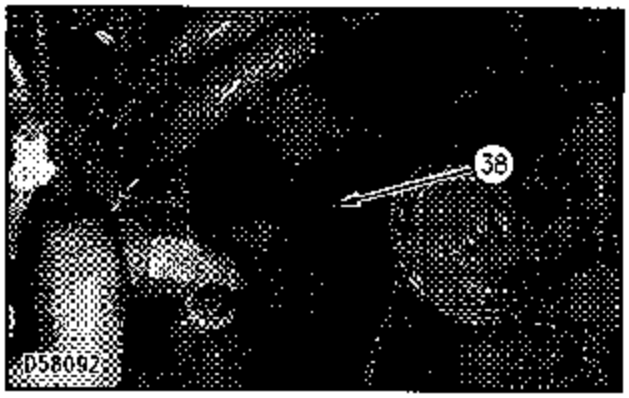
17. Disconnect three plug assemblies (33) by loosening screws (35). Disconnect electrical clip (34).



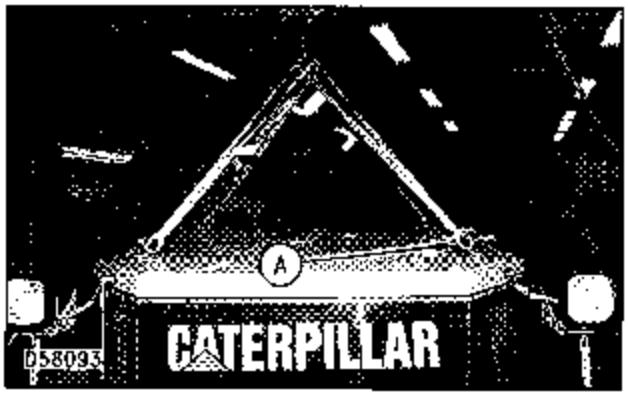
18. Disconnect three harness clips (36). (One clip is not shown. It is located under the cab.) Disconnect electrical connection (37).



19. Identify and disconnect six hydraulic hoses to dozer control valve (31).

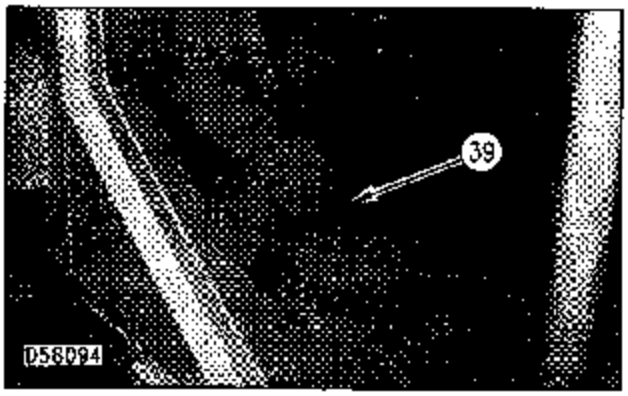


20. Disconnect electrical connection (38) located behind hydraulic tank (not shown).



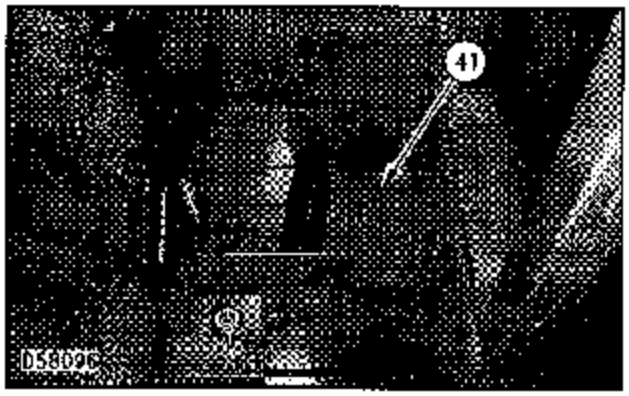
21. Install a hoist and tooling (A) to the cab.

22. Remove the floor mats from the inside of the cab.

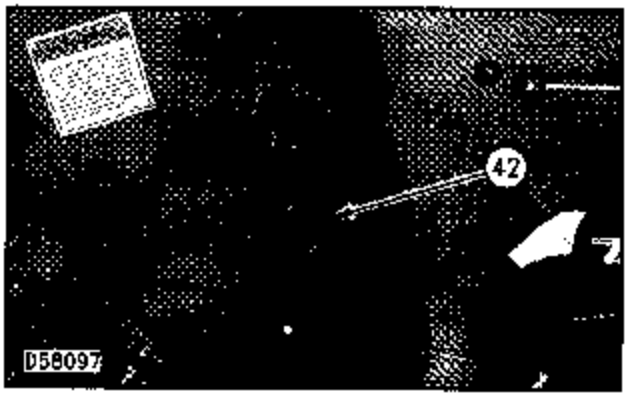


23. Remove two covers (39) from both sides of the front of the cab.

24. Remove cover (40) at right rear of seat.

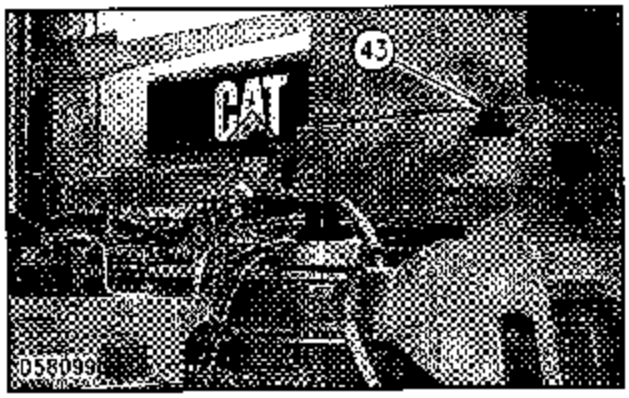


25. Remove compartment (41) by removing four screws to access cab bolt.



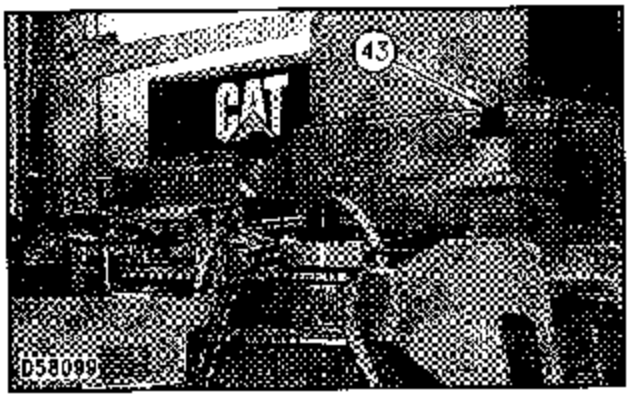
26. Remove bolt and two washers (42) from four corners of cab.

27. Using a hoist and tooling (A) remove cab from the frame. Weight of the cab is **1045 kg (2300 lb)**

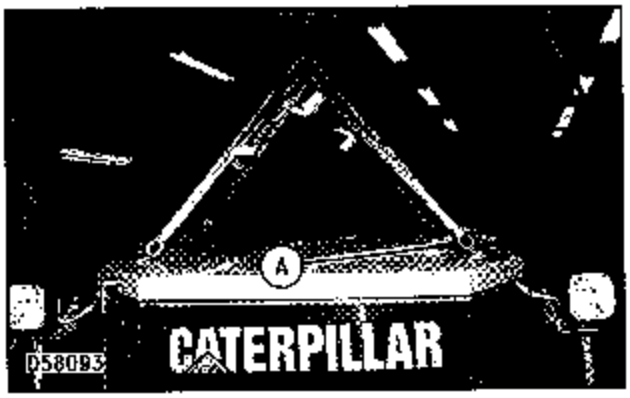


28. Remove four mount assemblies (43) from frame.

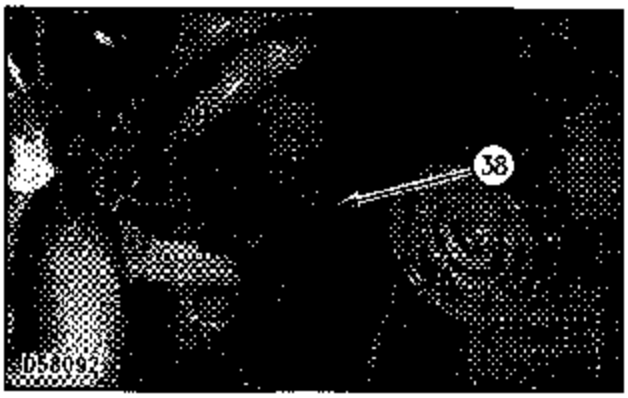
NOTE: Install the cab in the following order.



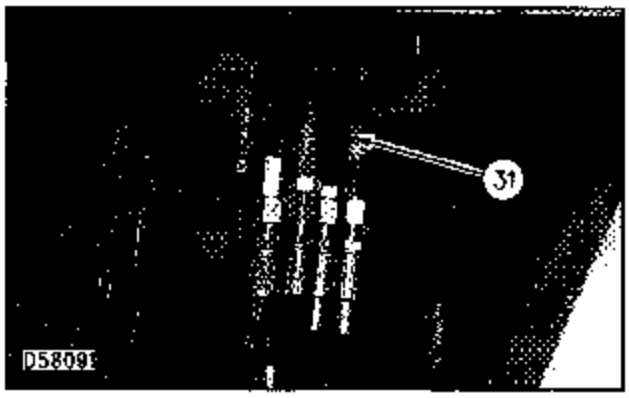
29. Install four mounting assemblies (43) onto the frame.



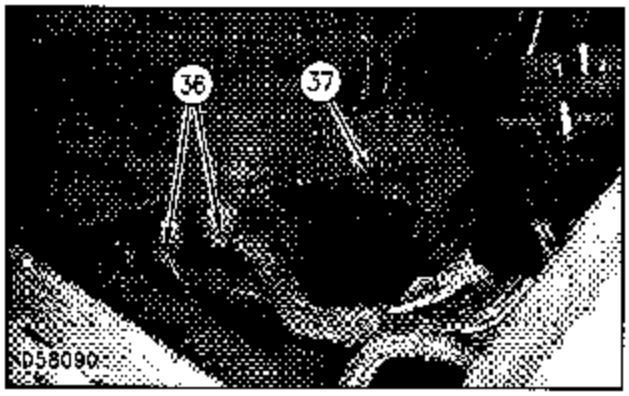
30. Using a hoist and tooling (A) install the cab in position above the mounting assemblies, but do not lower it onto the mounting assemblies at this time. Leave the cab suspended approximately six to eight inches above the mounting to allow easier connection of the electrical and hydraulic connections. Weight of the cab is **1045 kg (2300 lb)**.



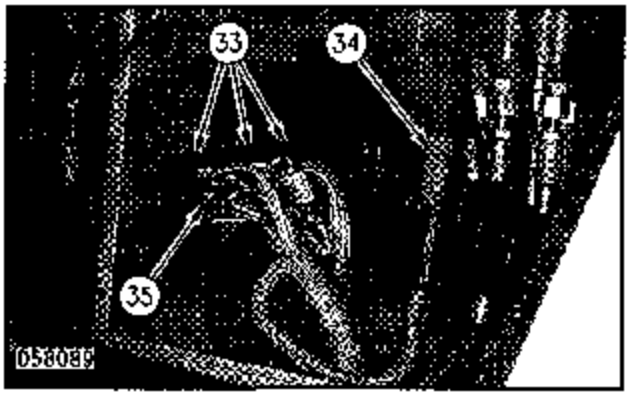
31. Connect electrical connection (38) located behind hydraulic tank (not shown).



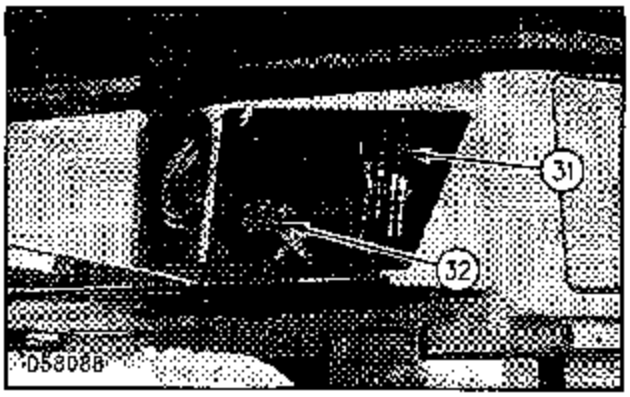
32. Connect six hydraulic hoses to dozer control valve (31). Note the identification marks placed on each of the connections during disassembly. Insure that each of the hydraulic lines is properly connected.

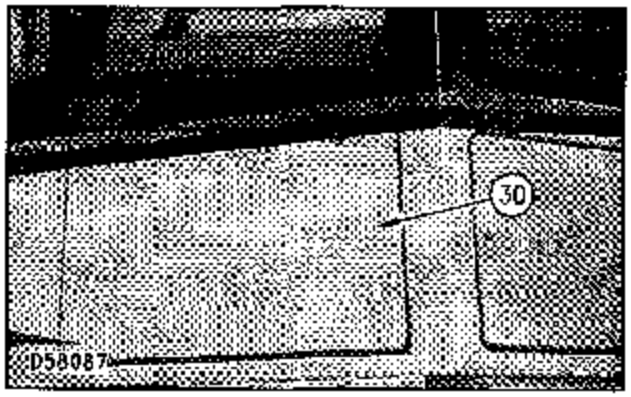


33. Connect electrical connection (37). Connect three harness clips (36). (One clip is not shown. It is located under the cab.

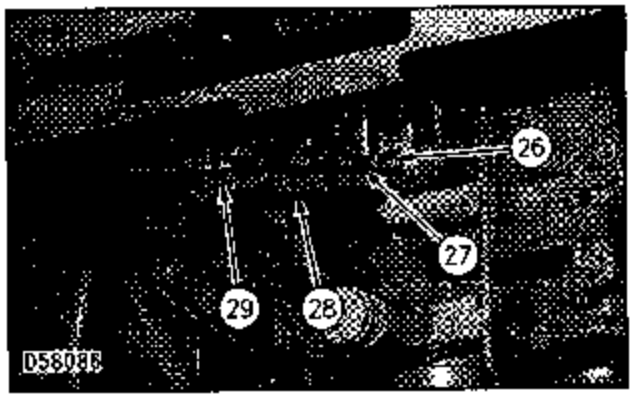


34. Connect three plug assemblies (33) and tighten screws (35). Connect electrical clip (34).

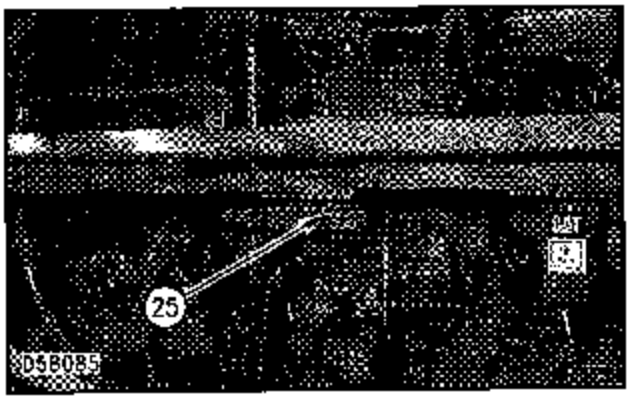




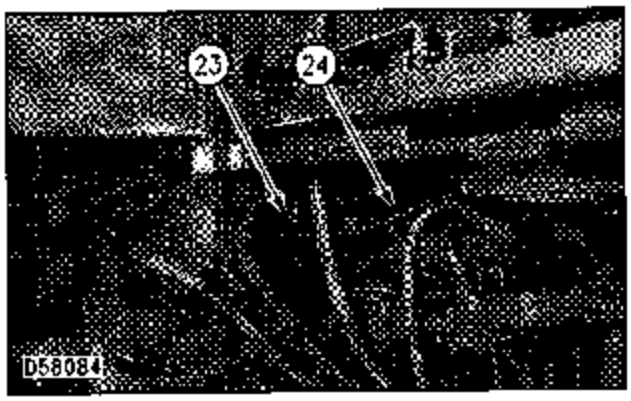
35. Connect wiring harness (32) and connect dozer control valve (31). Both of these can be accessed behind door panel (3) on the right side of the cab. Install door panel (30).



36. Install accelerator cable (24) into housing (28) using nut and washer (29). Install rod end of accelerator cable (27) and install bolt (26).

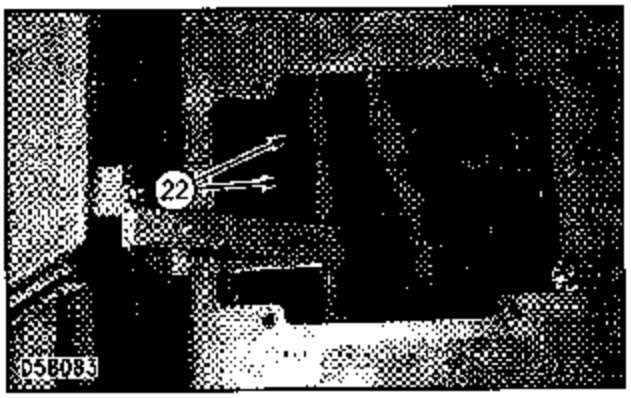


37. Install six screws and cover (25) onto the fuel injection pump.

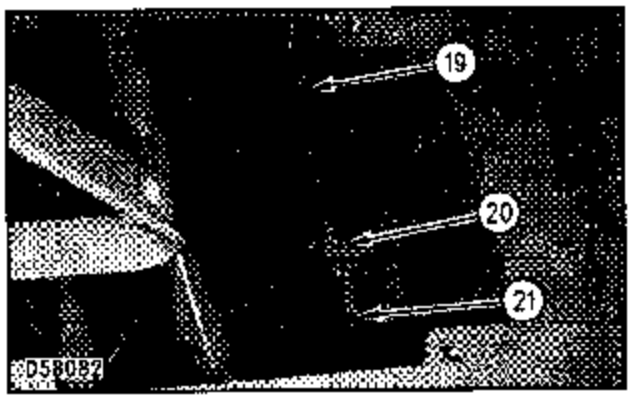


38. Connect two clips (23) which secure accelerator cable (24) to the frame.

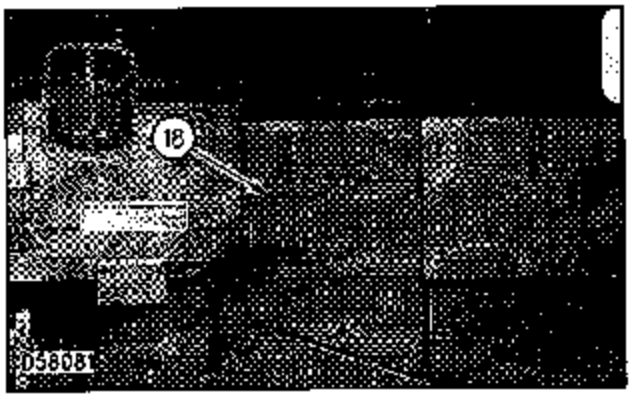
NOTE: The second clip is located under the cab directly under rear portion of the door.



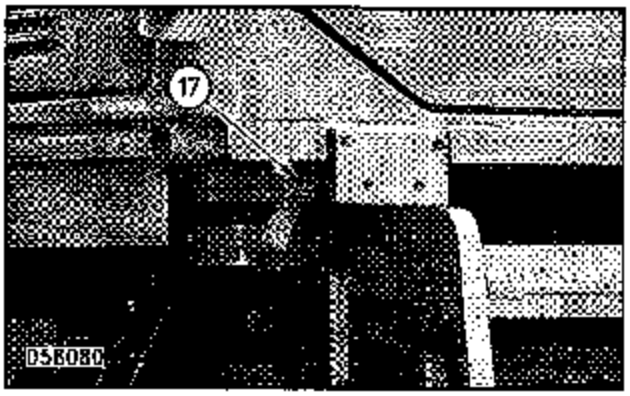
39. Connect two windshield washer hoses (22).



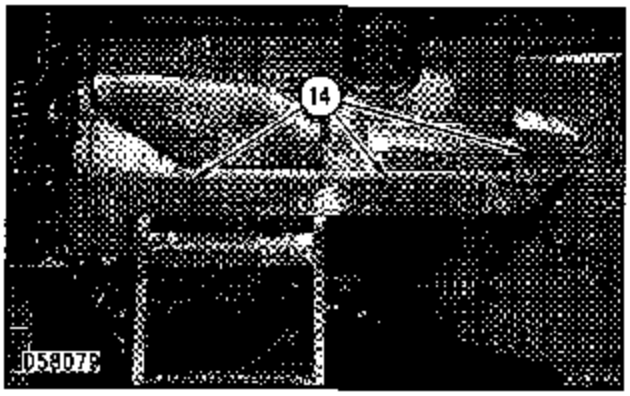
40. Install the parking by cable (21), by installing the cable through the bracket, installing cam nut (20 and installing nut and cotter pin (19).



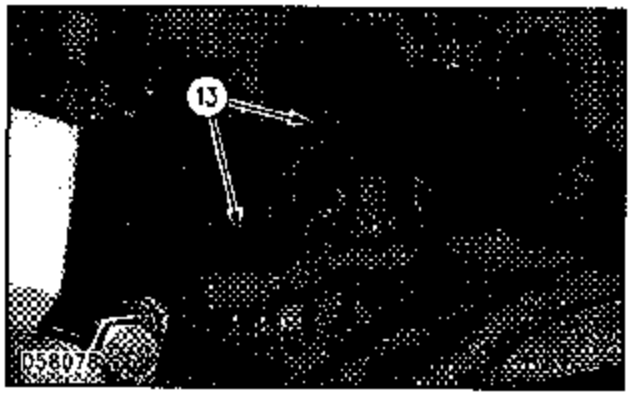
41. Install cover (18) and secure with bolts and washers.



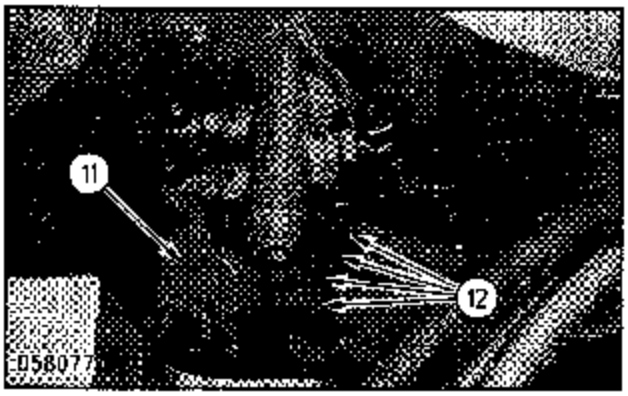
42 Install ground strap (17).



43. Install electrical wires to the horn, which is located on the back of guard (15). Install guards (15) and (16) using bolts and washers (14).

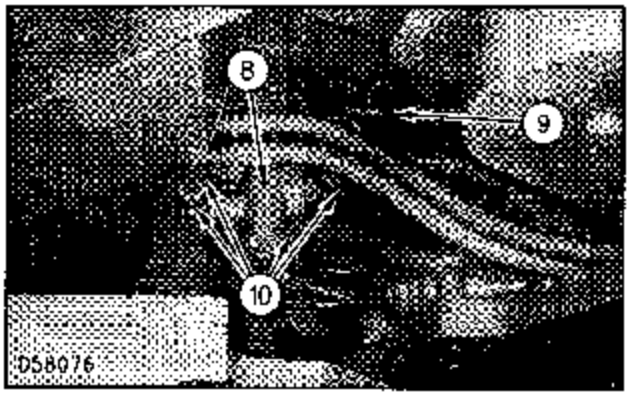


44. Secure wiring harness to the bottom of the cab using plastic plastic tie wraps (13).

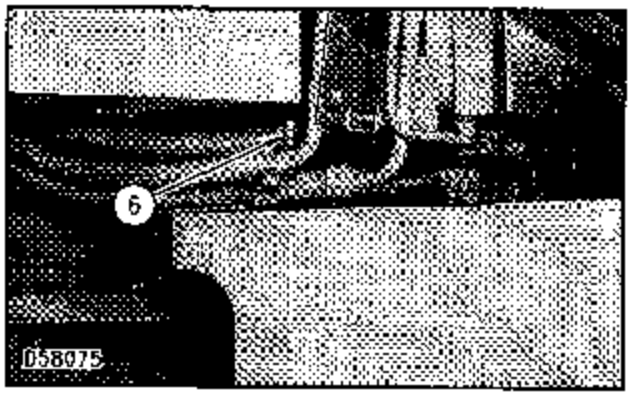


45. Connect four hydraulic hoses (12) from steering control valve (11)

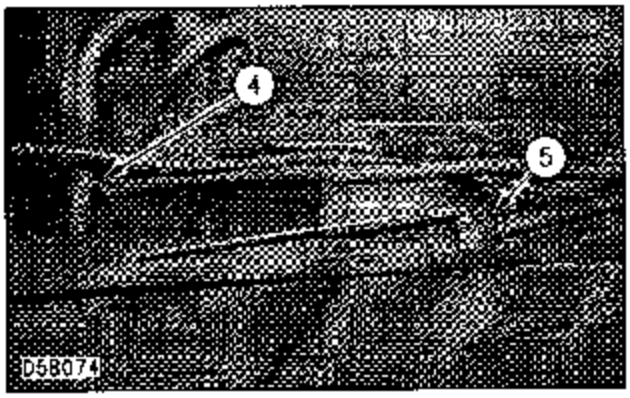
NOTE: the identification marks placed on each of the connections during disassembly. Insure that each of the hydraulic lines is properly connected.



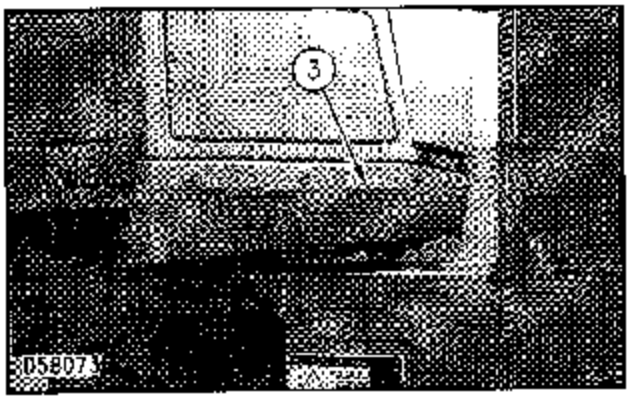
46. Connect electrical connection (9). Connect four hydraulic hoses (10) to brake valve. Note the identification marks placed on each of the connections during disassembly. Insure that each of the hydraulic lines is properly connected.



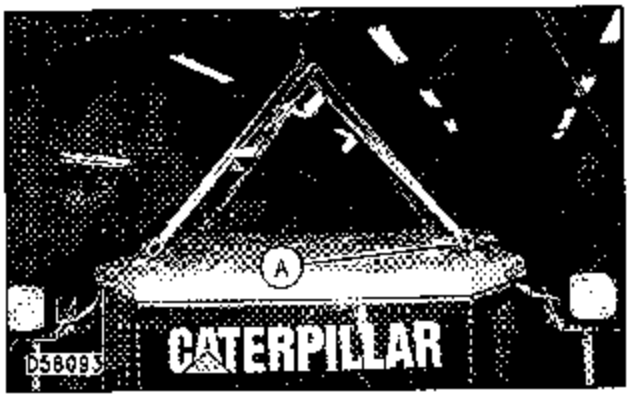
47. Connect two heater hoses (6).



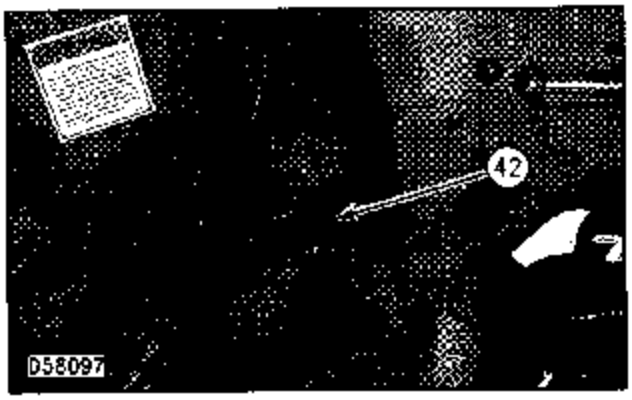
48. Turn heater hose valves (4) and (5) to the **ON** position.



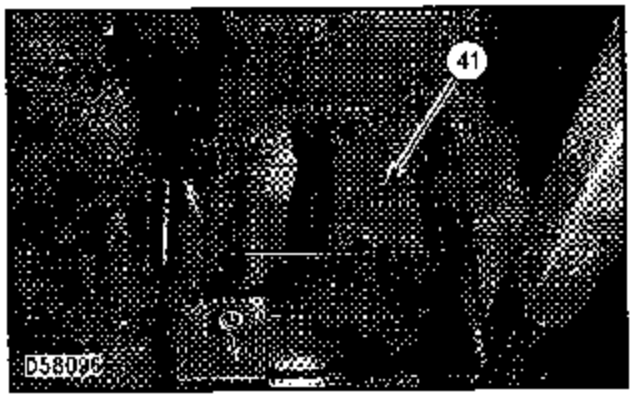
49. Install front shroud (3) and install eleven bolts that hold the front shroud.



50. Slowly lower the cab assembly down using tooling (A) onto the assembly bushings.

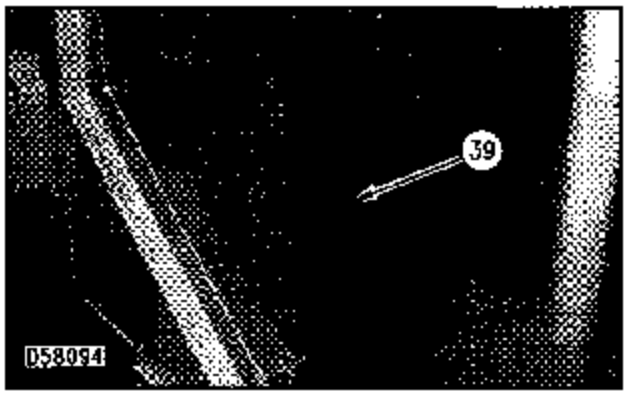


51 Install four bolts (42) securing the cab to the frame. Tighten cab bolts to a torque of **850 ± 100 N•m (626 ± 74 lb ft)**.

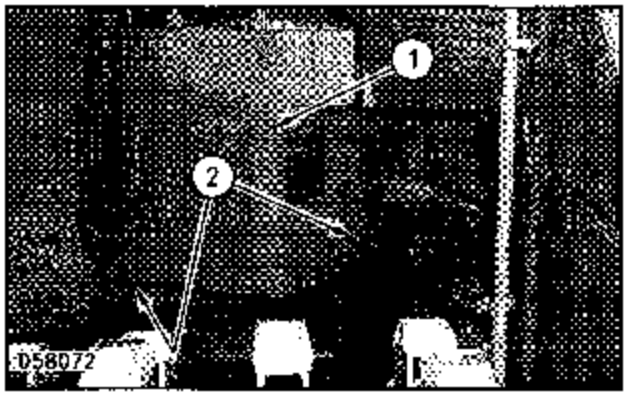


52. Install compartment (41) and secure by installing four bolts.

53. Install cover (40) at right rear of seat and secure with one bolt.



54. Install two covers (39) on both sides of the front of the cab. Secure with one bolt in each cover.



55 Install platform assembly (1) and secure using two bolts (2).

56. Check all hoses and electrical connections prior to starting the engine. Check both the cooling system and the hydraulic system for proper fluid level. Replace any fluid lost during cab removal. Consult the Operation And Maintenance Manual for proper type and quantity of fluids.

57. Start engine and check all electrical connections and all hydraulic connections for leaks.

Radiator & Hydraulic Oil Cooler

Remove & Install Radiator & Hydraulic Oil Cooler 1353 & 1374-010

Tools Needed		A
6V2156	Link Bracket	2

Start By:

a. remove hood

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure. Steam can cause personal injury. Check the coolant level only after the engine has been stopped and the fill cap is cool enough to touch with your bare hand. Remove the fill cap slowly to relieve pressure. Cooling system conditioner contains alkali. Avoid contact with skin and eyes to prevent personal injury.

1. Release the pressure in the cooling system by slowly loosening the filler cap on the radiator. Drain the coolant from the radiator into a suitable container for storage or disposal. The capacity of the cooling system is **43 liters (11.2 U.S. gal).**

⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all hydraulic pressure is released before any fitting, hose or component loosened, tightened, removed or adjusted.

2. Release the pressure in the hydraulic system as follows:

   a. Install the steering frame lock link.

   b. Move the lift control lever to the "Float" position.

   c. Shut off the engine.

   d. Move the lift control lever to the "Hold" position.

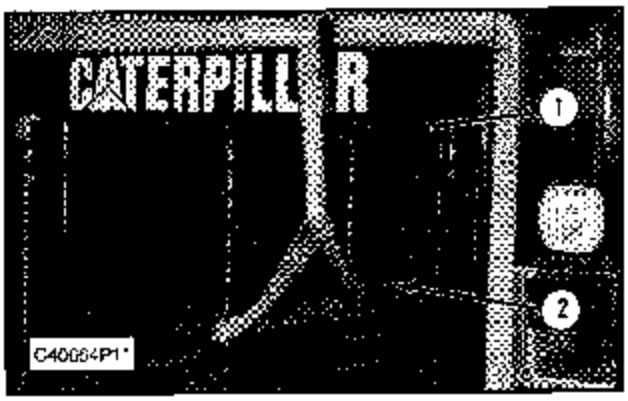
   e. Carefully loosen the filler cap on the hydraulic oil tank to release the pressure in the system.

   f. Carefully loosen the plugs located at the rear of the tilt cylinder. When the oil from the loosened plugs stops running, tighten the two plugs.

NOTE: To release the pressure in the attachment cylinders, carefully loosen the two large plugs near located near the plugs located at the rear of the tilt cylinder. When the oil from the two plugs stops running, tighten the two plugs.

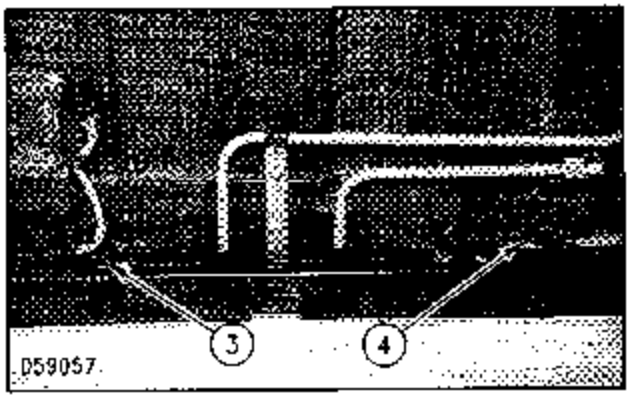
   g. Tighten the filler cap on the hydraulic oil tank. The system pressure has now been released.

3. Drain the oil from the hydraulic system into a suitable container for storage or disposal. The capacity of the hydraulic system is **87 liters (22.6 U.S. gal).**

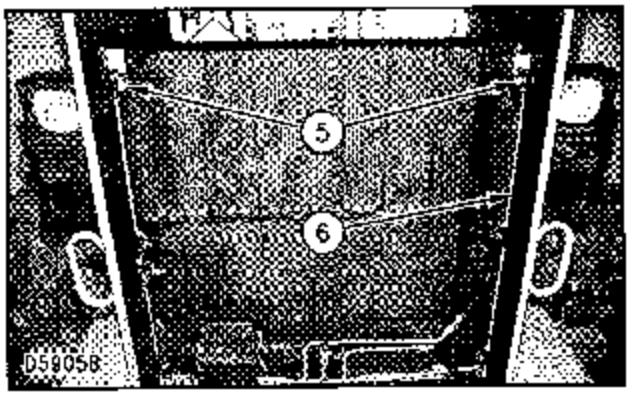


4. Fasten a lifting strap and a hoist to grill (2) as shown.

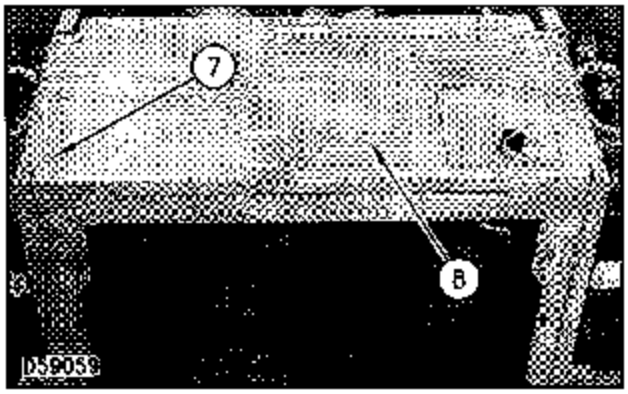
5. Remove bolt (1) and the washer. Open the grill. **Do not** remove the hoist from the grill at this time.



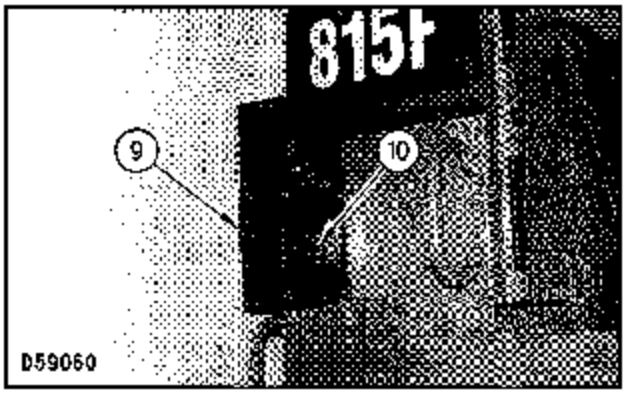
6. Disengage rod assembly (4) through hole (3) in the lower channel for the radiator guard. Remove the grill (2) from the machine. The weight of the grill is **34 kg (75 lb).**



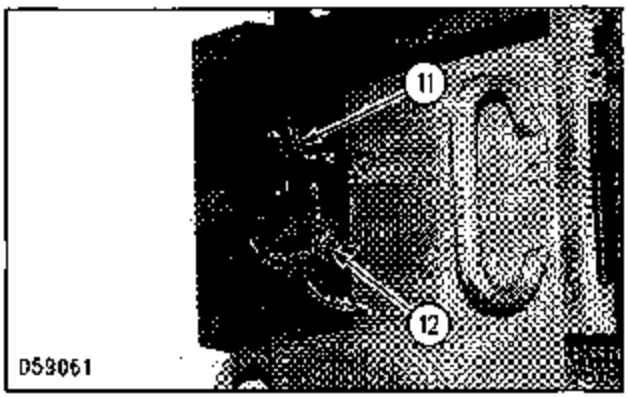
7. Remove six bolts (5) and the washers that hold frame (6) in position. Remove the frame.



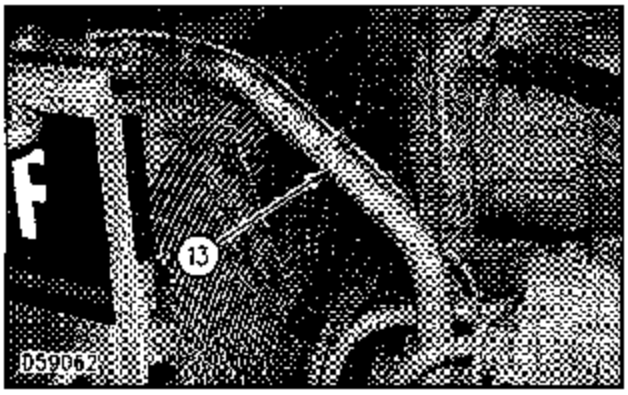
8. Remove eight bolts (7) and the washers that hold cover assembly (8) in position. Using two persons, remove the cover assembly. The weight of the cover assembly is **23 kg (50 lb).**



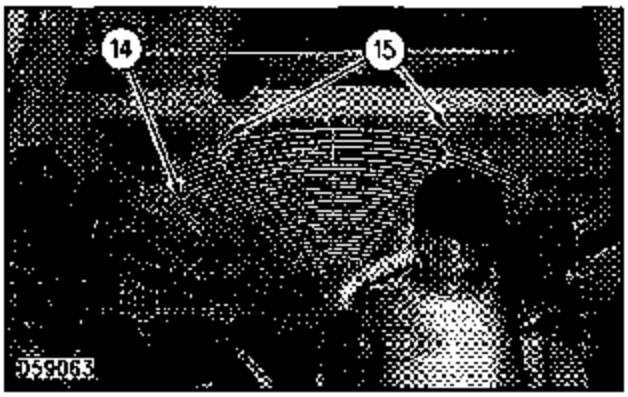
9. Remove cover (10) from each tail light (9).



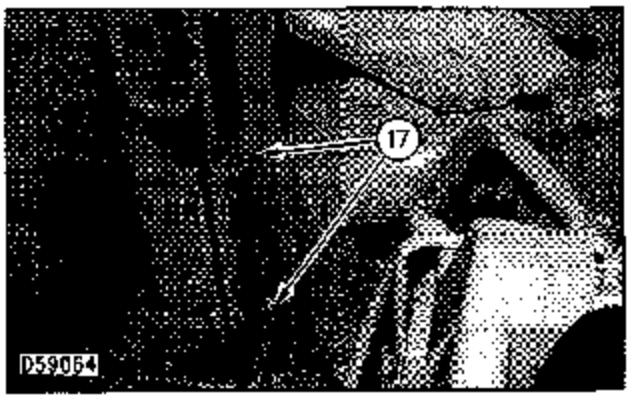
10. Disconnect wires (11) and wiring harness (12) from each tail light.



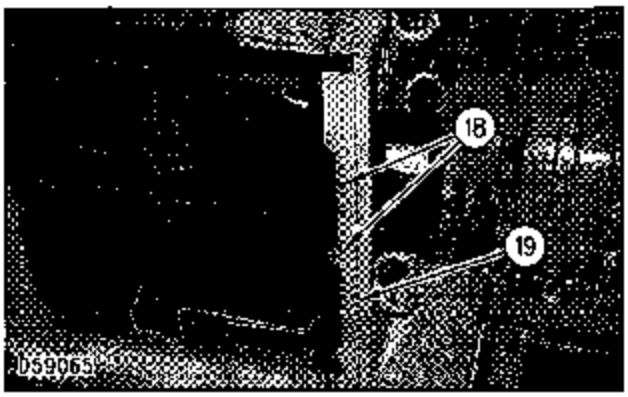
11. Loosen the clamps, and remove tube assembly (13) from the radiator top tank assembly.



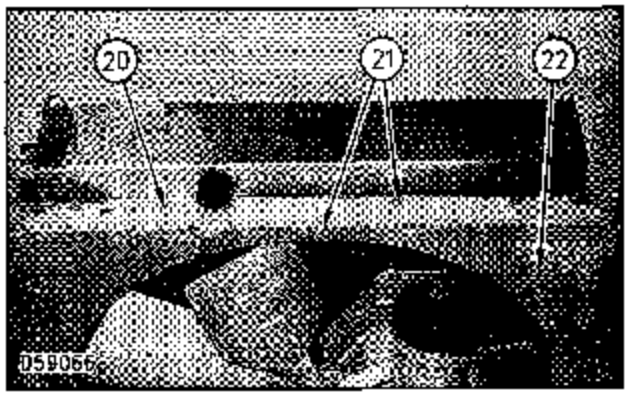
12. Remove bolts (15) and the washers that hold upper and lower fan guards (14) in position. Remove the fan guards.



13. Remove four bolts (17) and the washers (two on each side of the radiator guard) that hold the right and left panel assemblies of the radiator guard to the fan shroud.

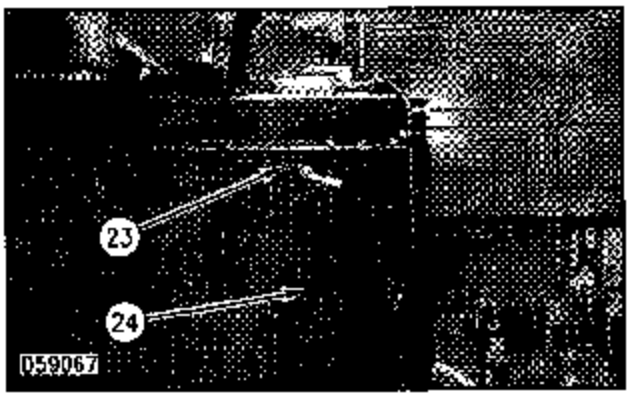


14. Fasten a hoist to right hand panel assembly (19). Remove eight bolts (18) that hold the panel assembly in position. Remove the right hand panel assembly. Remove the left hand panel assembly the same way. The weight of each panel assembly is **50 kg (110 lb).**

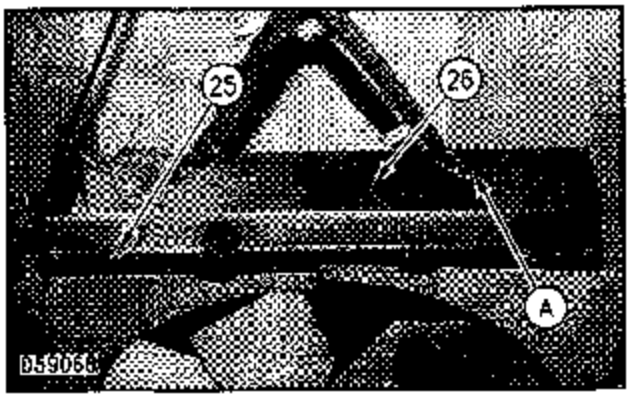


15. Remove twelve bolts (21) and the washers from fan shroud (22) and plate (20). Remove plate (20).

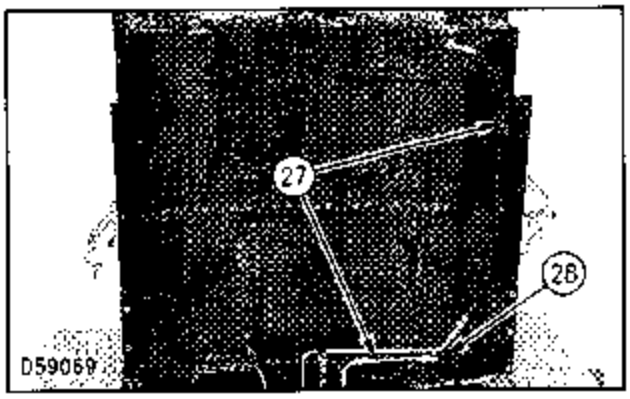
NOTE: One bolt (21) has to be removed from the bottom side of plate (20) behind the fan assembly.



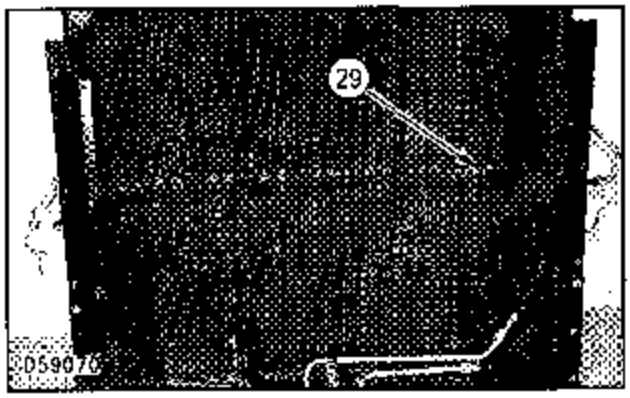
16. Remove four bolts (23) and the washers that hold the hydraulic oil cooler core (24) to the radiator top tank assembly. Two of the bolts are on the back side of the radiator top tank assembly.



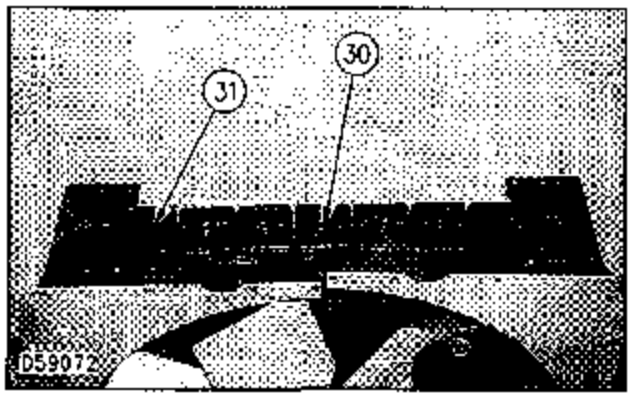
17. Remove ten bolts (25) and the washers that hold the radiator top tank assembly in place. Attach tooling (A), and a suitable lifting device to the radiator top tank assembly (26). Remove top tank assembly (26). Weight of the radiator top tank assembly is **32 kg (70 lb)**.



18. If the hydraulic oil coolers core is to be removed, remove two lines (27). Remove four bolts (28) and the washers that hold the cooler cores to the lower radiator tank assembly. Two of the bolts are located on the back side of the lower radiator tank assembly.

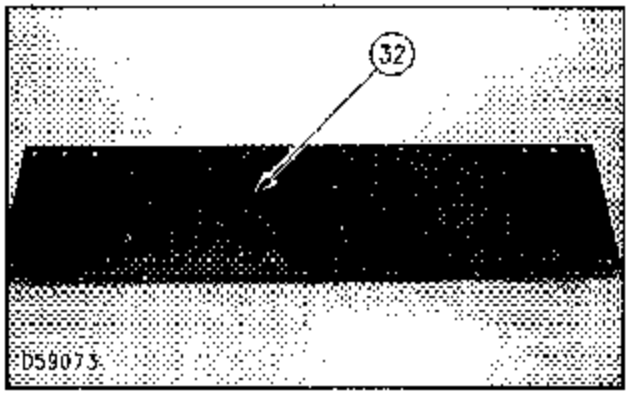


19. Remove appropriate bolts (29), the washers and nuts that hold the core together in the center.



20. Remove radiator cores (30) or hydraulic oil cooler cores (31) from the lower radiator tank assembly. The weight of a radiator core is **13 kg (29 lb).** The weight of a hydraulic oil cooler core is **21 kg (46 lb).**

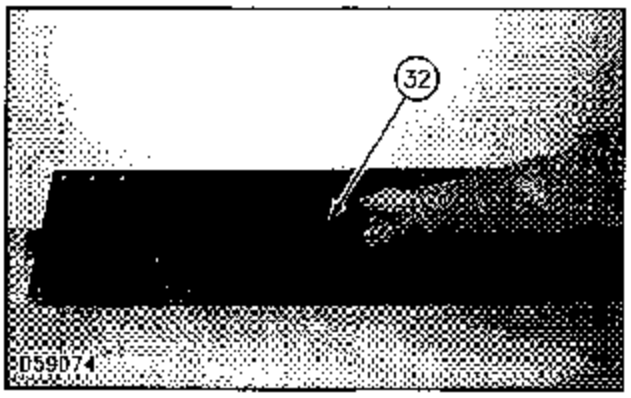
21. Remove the twelve bolts and washers that hold the lower radiator tank assembly to the frame of the machine. Fasten a hoist to the lower radiator tank assembly, and remove it from the machine. The weight of the lower radiator tank assembly is **24 kg (53 lb).**



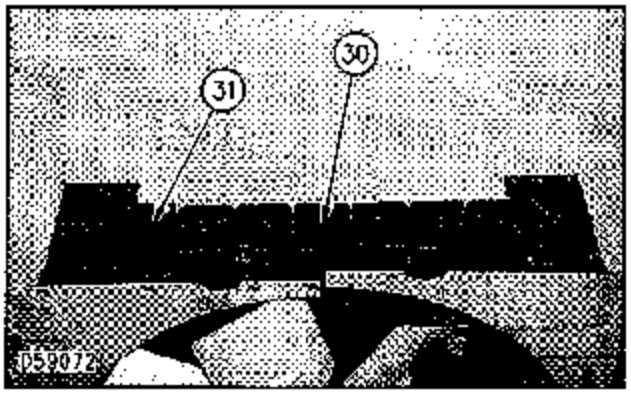
22. Remove end seals (32) from the radiator top tank assembly and the lower radiator tank assembly.

NOTE: The following steps are for the installation of the radiator and hydraulic oil cooler.

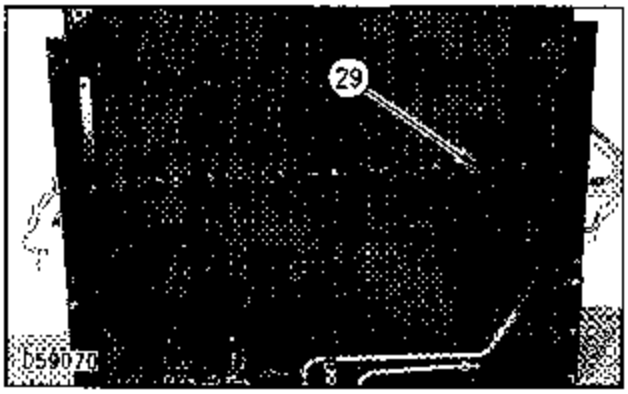
23. Fasten a hoist to the lower radiator tank assembly, and put it in its original position on the frame of the machine. Install the twelve bolts and washers that hold it.



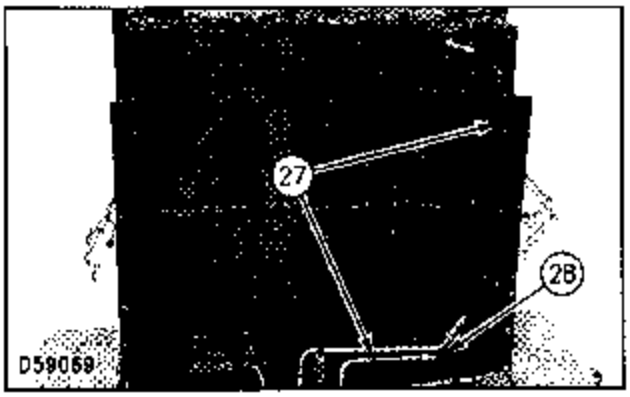
24. Check the condition of end seals (32) which are used in the radiator top tank assembly and the lower radiator tank assembly. If the seals are worn or damaged, use new parts for replacement. Install end seals (32) in the radiator top tank assembly and the lower radiator tank assembly as shown.



25. Put a coat of **5P3975 Rubber Lubricant** on the center mounting tube of radiator cores (30) or hydraulic oil cooler cores (31). Install the cores in the lower radiator tank assembly.

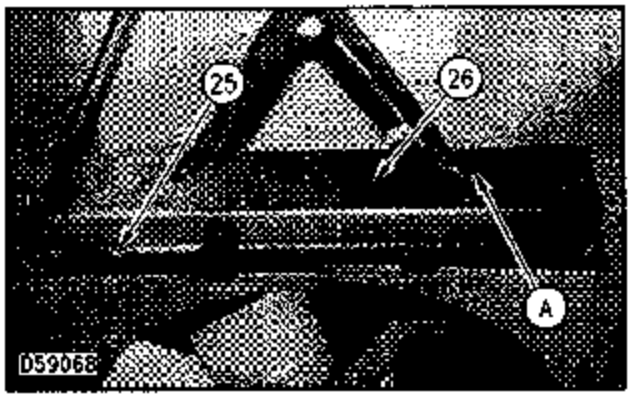


26. Install bolts (29) and the washers that hold the cores together in the center as shown.



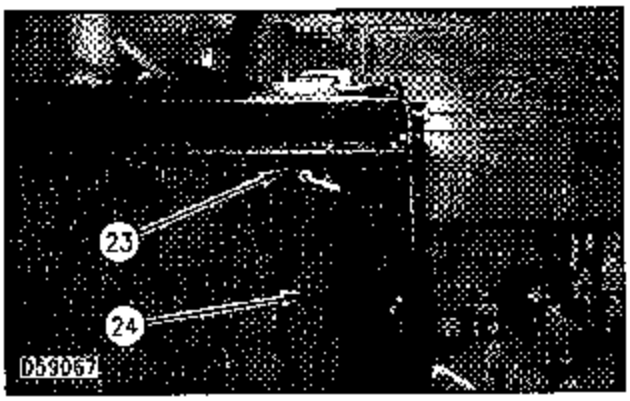
27. If the hydraulic oil cooler was removed, reinstall four bolts (28) and the washers that hold the cores to the lower radiator tank assembly.

28. Install two lines (27) to the hydraulic oil cooler.



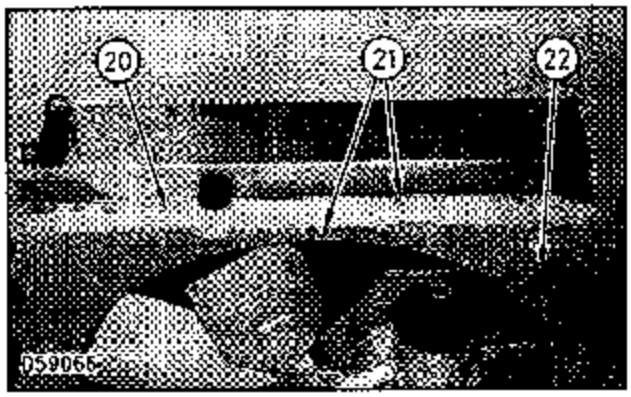
29. Fasten tool (A) and a hoist to radiator top tank assembly (26). Put a coat of **5P3975 Rubber Lubricant** in the center mounting tube of each core. Put the radiator top tank assembly in position on the radiator cores and the hydraulic oil cooler cores.

30. Reinstall ten bolts (25) and the washers that hold the radiator top tank assembly in place.

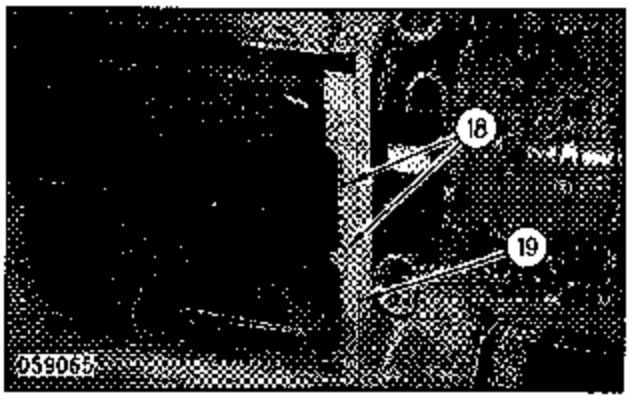


31. Install four bolts (23) and the washers that hold the hydraulic oil cooler core (24) to the radiator top tank assembly.

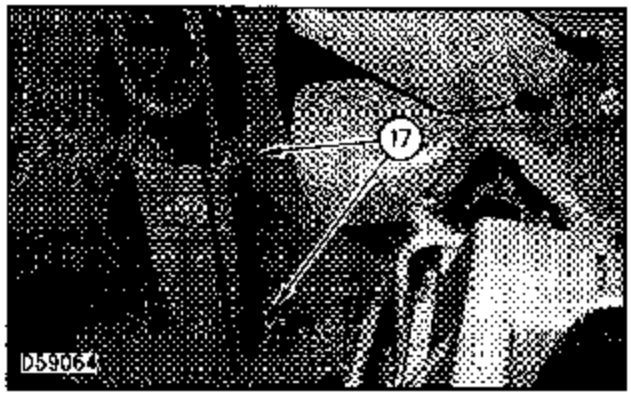
32. Install two hoses (24) and the clamps which hold them.



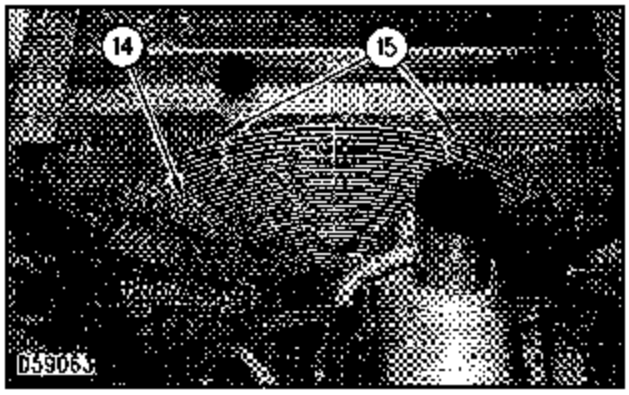
33. Install twelve bolts (21) that hold the fan shroud (22) and plate (20) in position at the top.



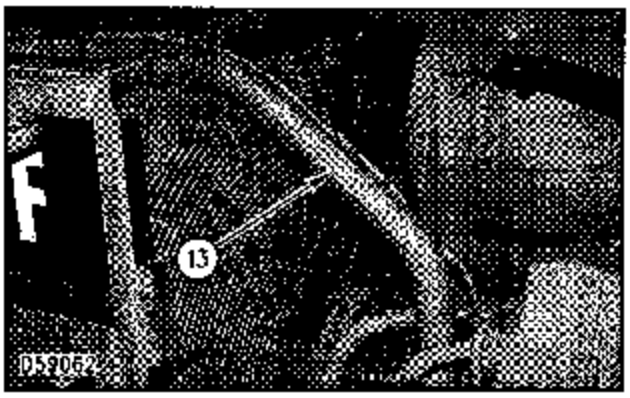
34. Fasten a hoist to left hand panel assembly (19). Put the panel assembly in place, and install eight bolts (18) which hold it. Install the left hand panel assembly the same way.



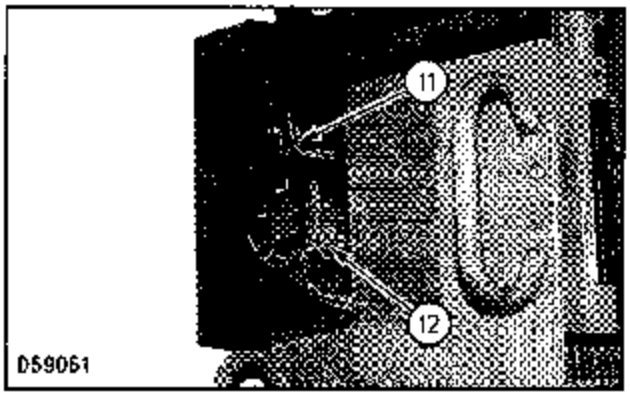
35. Install four bolts (17) and the washers (two on each side of the radiator guard) that hold the right and left hand panel assemblies of the radiator guard to the fan shroud.

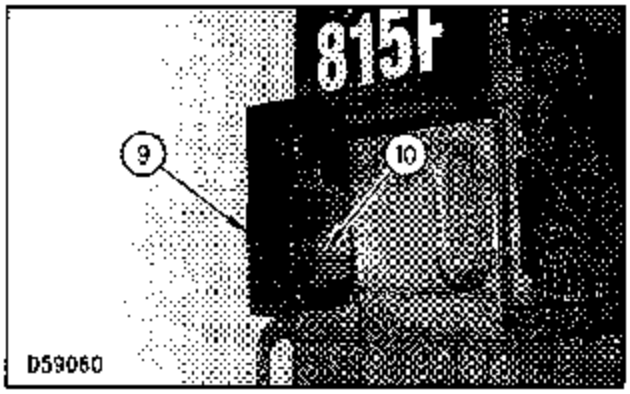


36. Install upper and lower fan guards (14) and twelve bolts (15) and washers that hold them in place.

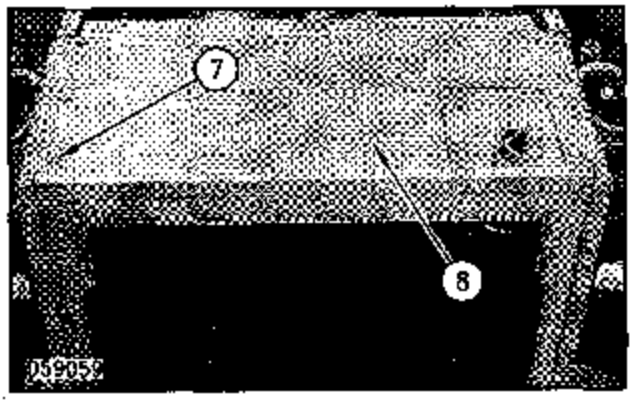


37. Connect tube assembly (13) to the radiator top tank assembly and tighten the clamps that hold it in place.

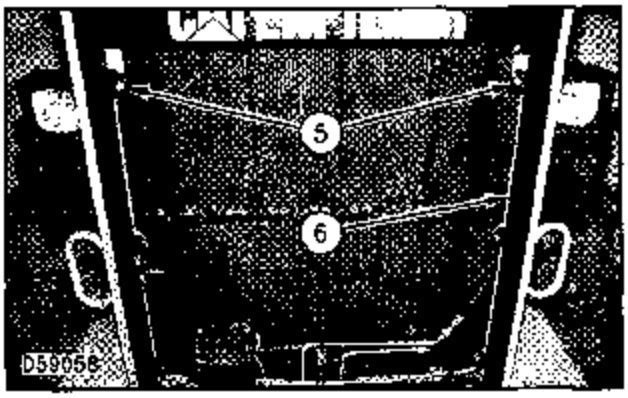




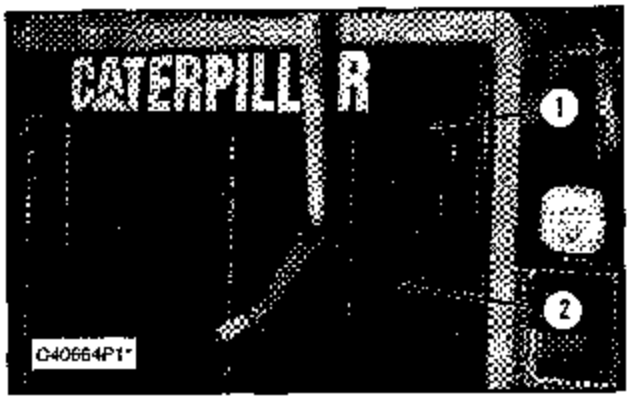
38. Connect wiring harness (12) and install wires (11) in each light assembly. Reinstall cover (10) on each tail light.

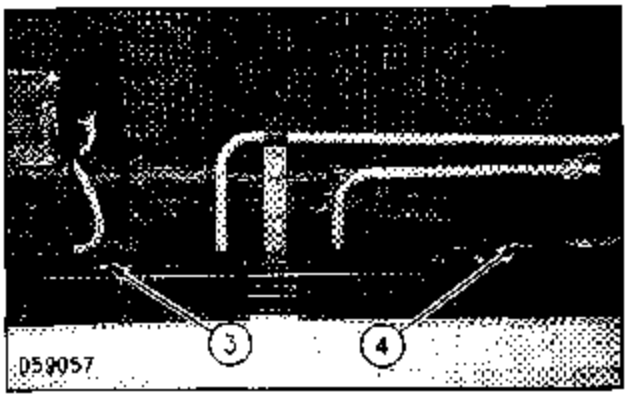


39. Using two persons, reinstall cover assembly (8) on the radiator guard. Install eight bolts (7) and the washers which hold it.



40. Reinstall frame (6) and six bolts (5) and the washers which hold it.





41. Fasten a hoist to grill (2), and put it on the radiator guard. Install rod assembly (4) in hole (3) located in the lower channel of the radiator guard. Install the bolts and washers that hold the grill in place.

42. Fill the cooling system with coolant and the hydraulic system with oil to the correct levels. See the Operation & Maintenance Manual for the correct filling procedures.

43. Start the machine, and check for leaks.

End By:

a. install hood

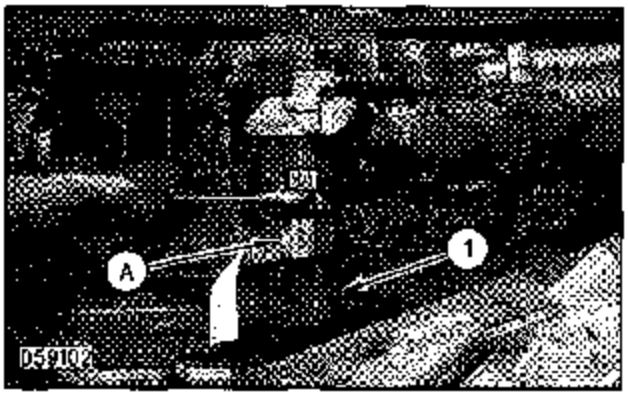
Engine Oil Filter & Oil Filter Base

Remove & Install Engine Oil Filter & Oil Filter Base 1318 & 1306-010

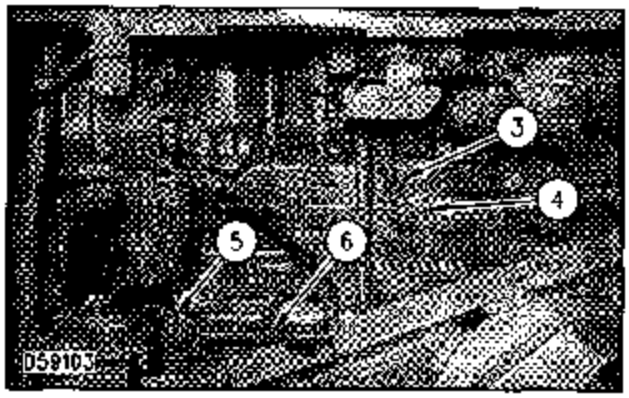
Tools Needed	A
2P-8250 Strap Wrench	1

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

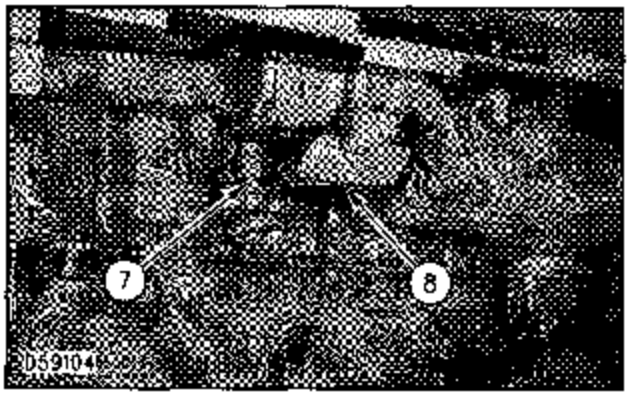


1. Using tooling (A), remove engine oil filter (1).



2. Remove two bolts (4) and tube assembly (3). Remove the O-ring seal from the end of the tube assembly.

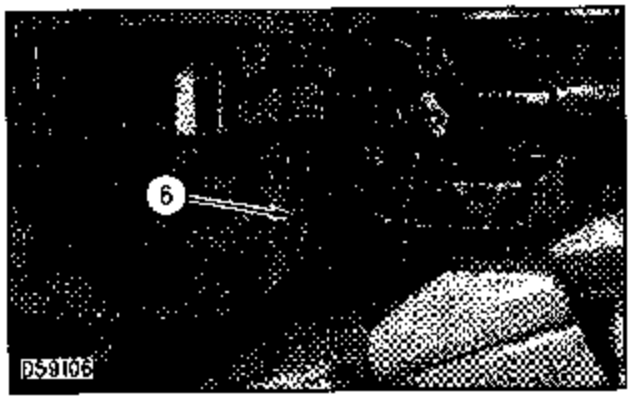
3. Remove two bolts (5) and tube assembly (6). Remove the O-ring seal from the end of the tube assembly.



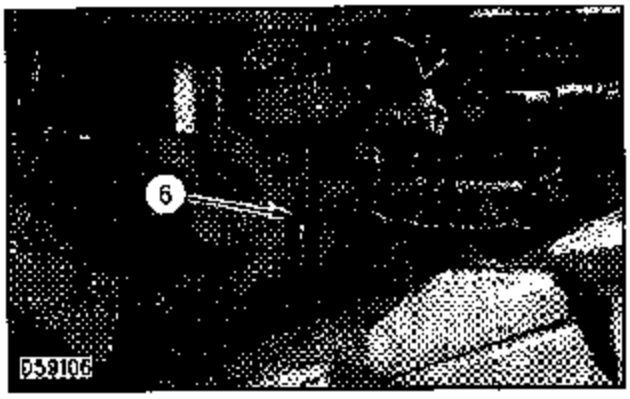
4. Remove four bolts (7) and oil filter base (8). Remove the two O-ring seals from the oil filter base.

NOTE: The following steps are for the installation of the oil filter base and the engine oil filter.

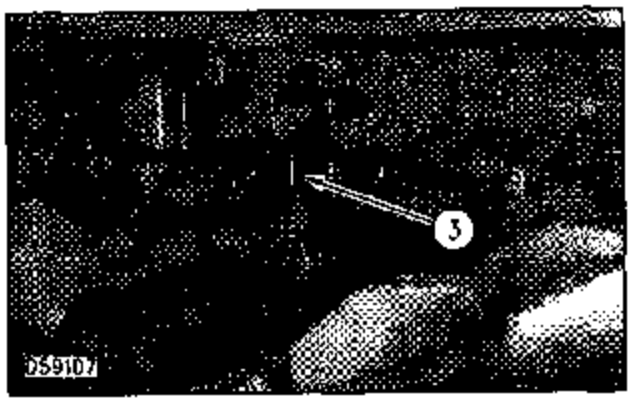
5. Check the condition of the O-ring seals used on the ends of tube assemblies (3) and (6), and the two O-ring seals used in the oil filter base. If the seals are worn or damaged, use new parts for replacement. Install the O-ring seals on the tube assemblies, and in the oil filter base. Lubricate the O-ring seals with clean engine oil.



6. Place oil filter base (8) in position on the cylinder block and install the four bolts that hold it.



7. Install tube assembly (6), by inserting top end into oil filter base then installing two bolts at lower end that secure it to the engine block.



8. Install tube assembly (3) by inserting top end into oil filter base then install two bolts at lower end that connect it to the engine block.

Install the engine oil filter. If additional information is required about the oil and filter, consult "Engine Oil And Filter" in the Operation And Maintenance Manual.

Engine Oil Filter Base

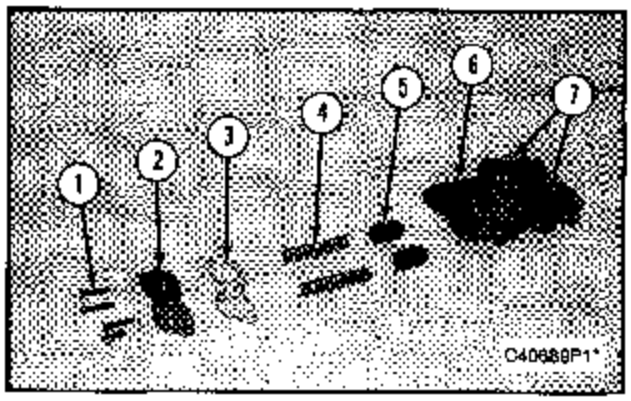
Disassemble & Assemble Engine Oil Filter Base 1306-017

Start By:

a. remove engine oil filter and oil filter base

⚠ WARNING

There is a small amount of spring force against cover (2) of the oil filter base. To prevent possible personal injury when the cover is being removed, hold the cover in place until the mounting bolts which hold it are completely removed; then release the spring force on the cover.



1. While holding cover (2) in position, remove four bolts (1). Slowly release the spring pressure against cover (2). Remove the cover and gasket (3).

NOTICE

Put identification marks on springs (4) and plungers (5) as to there location in the oil filter base. The plungers and springs should be reinstalled in their original bores.

2. Remove two springs (4) and two plungers (5) from oil filter base (6).

3. Remove two O-ring seals (7) from the oil filter base.

NOTE: The following steps are for the assembly of the engine oil filter base.

4. Check the condition of O-ring seals (7) and gasket (3). If the seals or gasket are worn or damaged, use new parts for replacement.

5. Be sure all parts of the engine oil filter base are clean and free of dirt and debris. Put clean engine oil in the bores of oil filter base (6), on O-ring seals (7) and plungers (5).

6. Install plungers (5) and springs (4) in their original bores in the filter base.

7. Install gasket (3), cover (2) and four bolts (1) that hold the cover in place. Tighten the bolts evenly to prevent binding of the cover.

End By:

a. install engine oil filter and oil filter base

Water Pump

Remove & Install Water Pump 1361-010

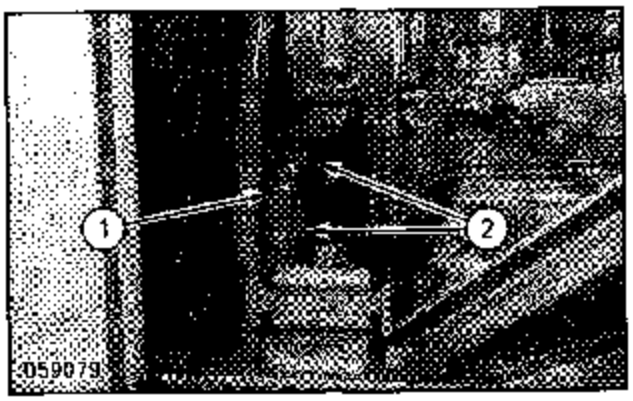
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

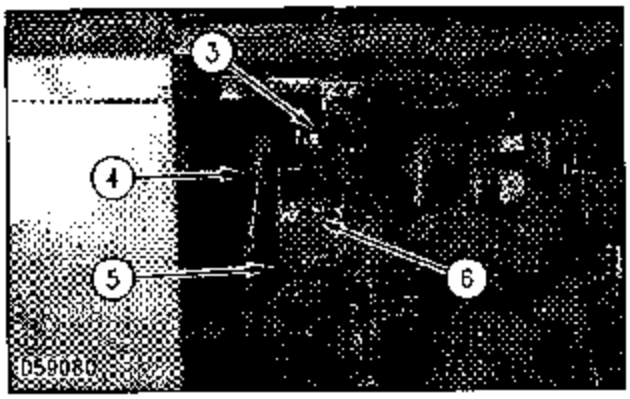
⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot water or steam. Any contact can cause severe burns. Look at the sight gauge to check the coolant level. The coolant level should be in the green range. If necessary, remove the fill cap only after the engine has been stopped and the cap is cool enough to remove with your bare hand. Remove the cooling system fill cap slowly to relieve pressure. Cooling system condition contains alkali that can cause personal injury. Avoid contact with the skin and eyes and do not drink. Allow cooling system components to cool before draining.

1. Release the pressure in the cooling system. Drain the coolant from the radiator into a suitable container for storage or disposal. The capacity of the cooling system is **43 Liters (11.2 U.S. Gal.)**



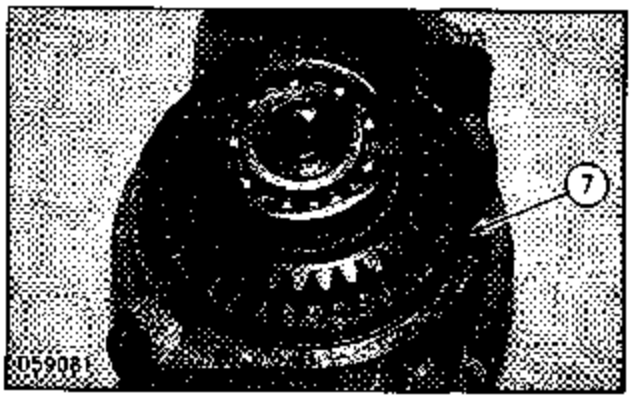
2. Loosen two clamps (2) and slide hose (1) down.



3. Remove hose clip (4) from the water pump housing. Remove two bolts (3) on top of the water pump. Remove two bolts (5) that hold the timing gear cover.

4. Remove water pump (6). Weight of the water pump is **11.4 kg (25 lb)**.

NOTE: The following steps are for the installation of the water pump.



5. Check the condition of the O-ring seal (7) in the water pump housing. If the seal is worn or damaged, use a new part for replacement. Install the O-ring seal in the water pump housing.

6. Install water pump in reverse order of removal.

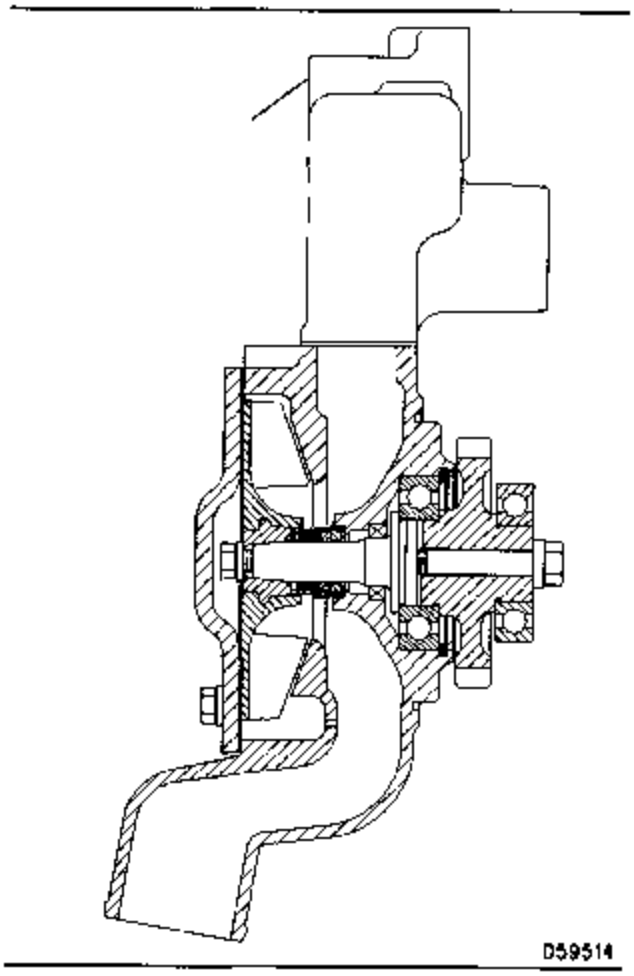
7. Fill the cooling system with coolant to the correct level. See the Operation And Maintenance Manual for the correct filling type and level.

Disassemble Water Pump 1361-015

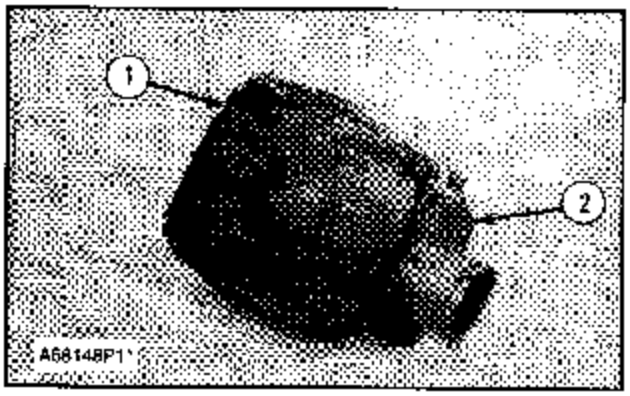
Tools Needed		A	B	C
8H0663	Bearing Puller Assembly	1		
5P4758	Pliers (Internal)		1	
1P0510	Driver Group			1

Start By:

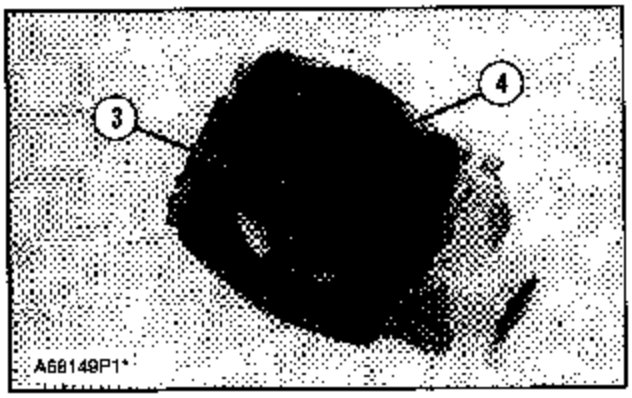
a. remove water pump



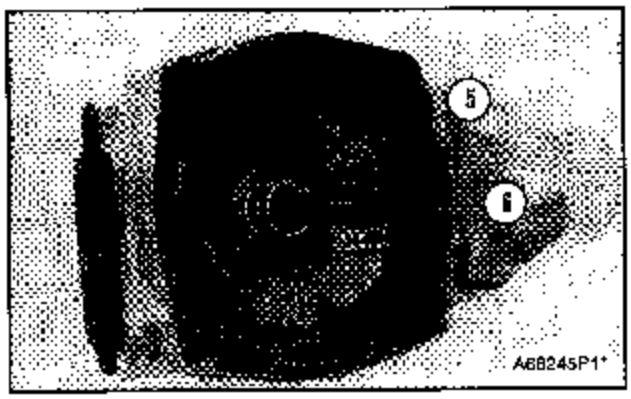
1. Be sure the outside of the water pump is thoroughly clean prior to disassembly.



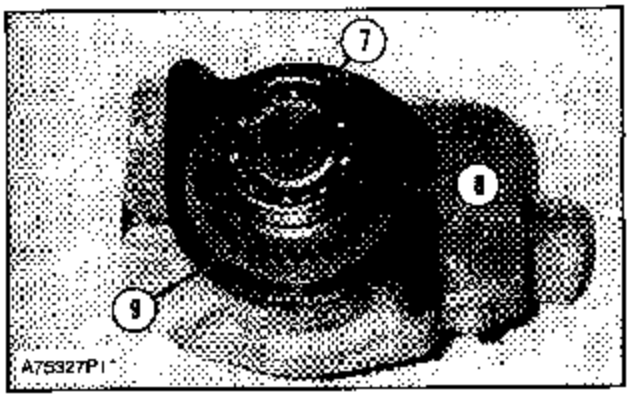
2. Remove cover (1) and the gasket from water pump (2).



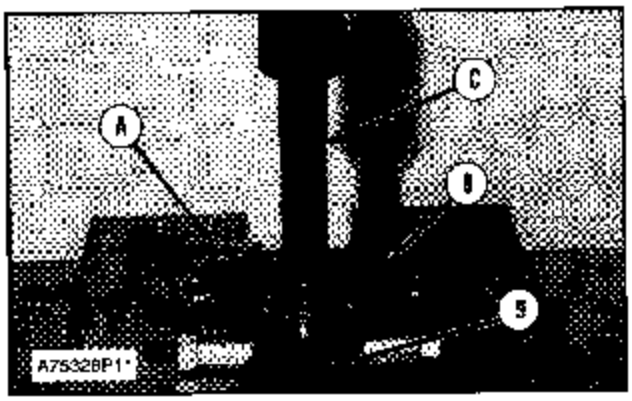
3. Loosen bolt (3) **approximately 6.35 mm (.25 in).** Hit the end of the bolt with a soft faced hammer to loosen impeller (4) from the taper on the shaft. Remove bolt (3), the washer and impeller (4) from the shaft.



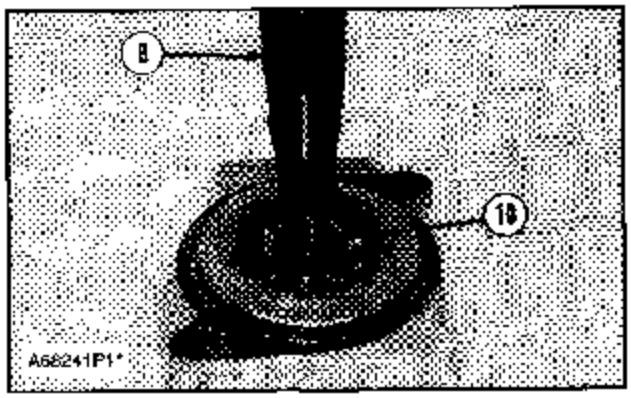
4. Remove seal group (5) from shaft (6).



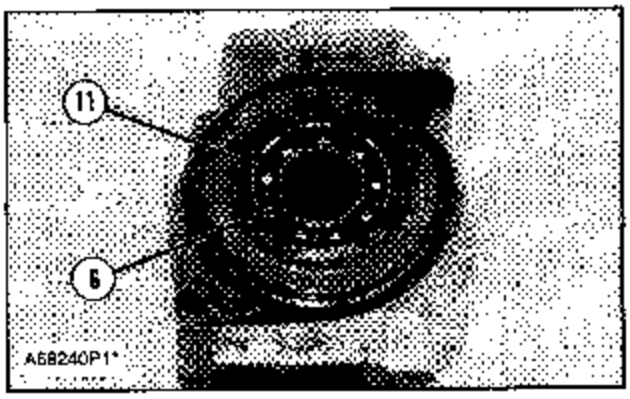
5. Turn the water pump housing over. Remove bolt (7) and the washer. Remove bearing (8) and drive gear (9) as a unit.



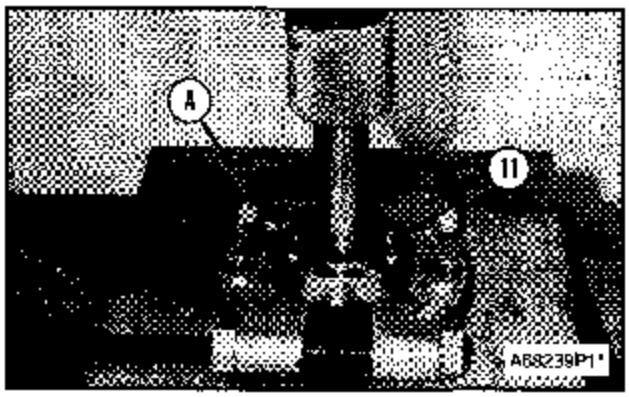
6. Using tool (A), tool (C) and a press, remove drive gear (9) from bearing (8).



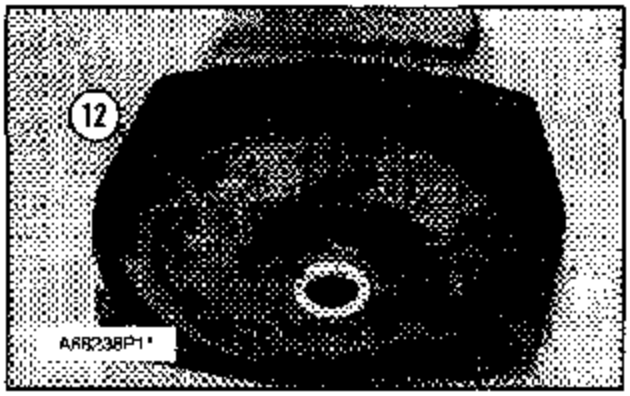
7. Using tool (B), remove retaining ring (10) from the pump housing.



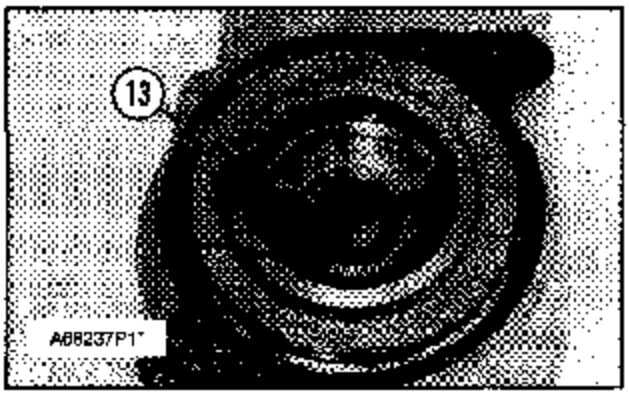
8. Remove bearing (11) and shaft (6) as a unit.



9. Using tool (A) and a press, remove bearing (11) from shaft (6).



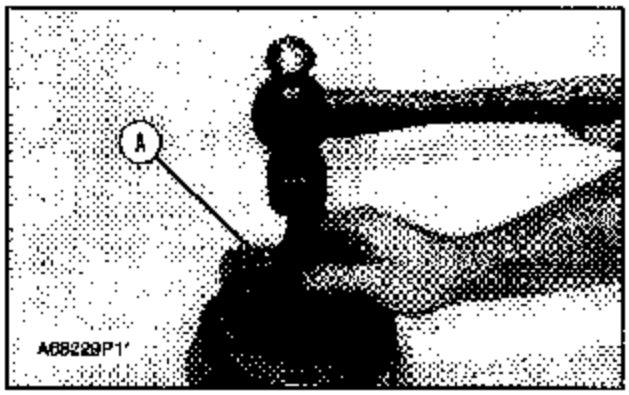
10. Remove the ceramic ring and seal (12) from the pump housing.



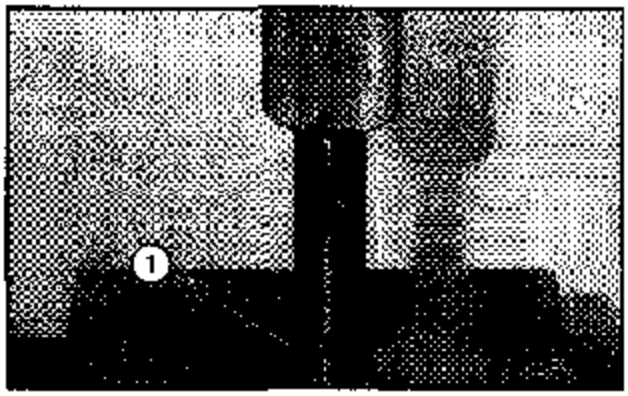
11. Remove seal (13) from the pump housing with tool (C).

Assemble Water Pump 1361-016

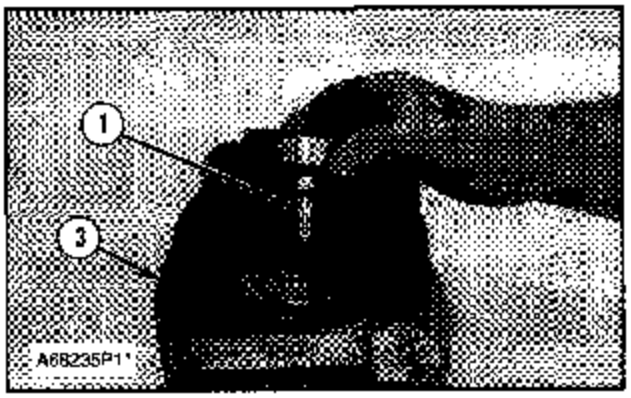
Tools Needed		A	B
1P0510	Driver Group	1	
5M4758	Pliers (Internal)		1



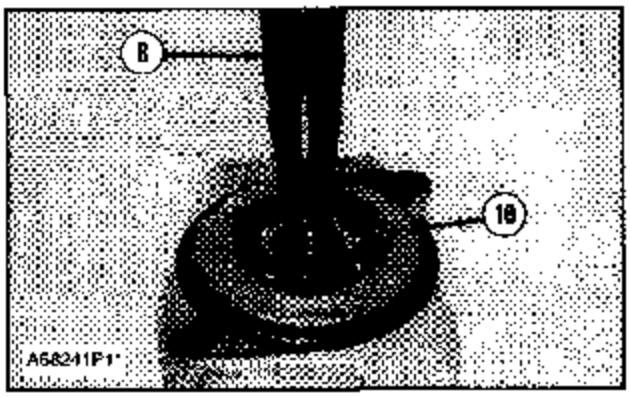
1. Install a new lip seal in the pump housing with tool (A). Install the seal with the lip facing toward the drive gear side of the housing and until it makes contact with the counterbore in the housing. **Do not** lubricate the sealing lip.



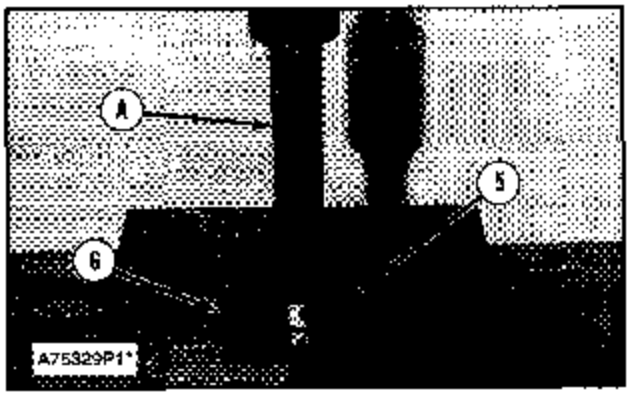
2. Using a press, install shaft (1) in bearing (2). Install the shaft until the flange makes contact with the bearing.



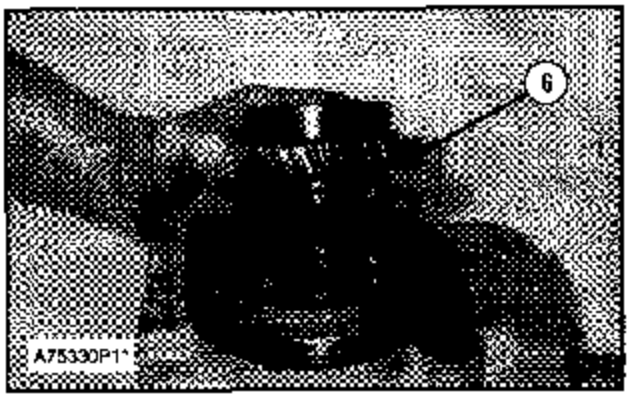
3. Install shaft (1) and the bearing in pump housing (3).



4. Install retaining ring (4) in the pump housing with tool (B).



5. Using a press and tool (A), install bearing (5) on drive gear (6). Install the bearing until it makes contact with the shoulder on the drive gear.

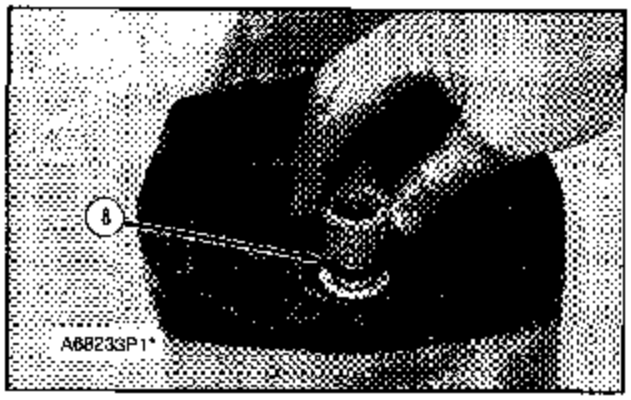


6. Put drive gear (6) and the bearing in position in the pump housing and on shaft (1). Install the bolt and washer that hold the drive gear to the shaft. Tighten the bolt to a torque of **97 ± 7 N•m (71 ± 5 lb ft).**

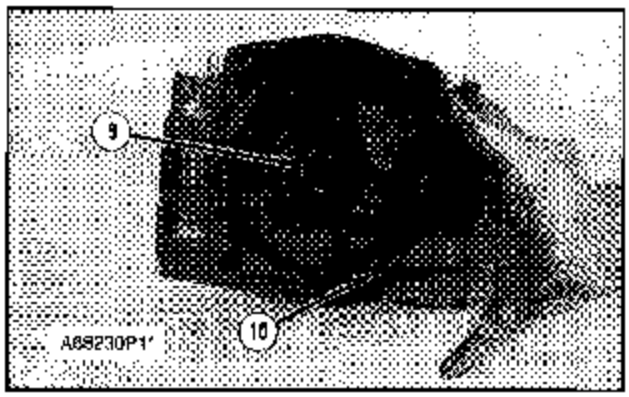
NOTICE

Only clean water is permitted as a lubricant for installation of the carbon ring and the ceramic ring. Do not damage or put hands on the wear surface of the carbon ring or the ceramic ring. Install the ceramic ring with the smoothest face of the ring toward the carbon seal assembly.

7. Put ceramic ring (7) in position in the rubber seal in the pump housing. Using the tool which comes with the replacement ring, install the ceramic ring only with hand pressure.

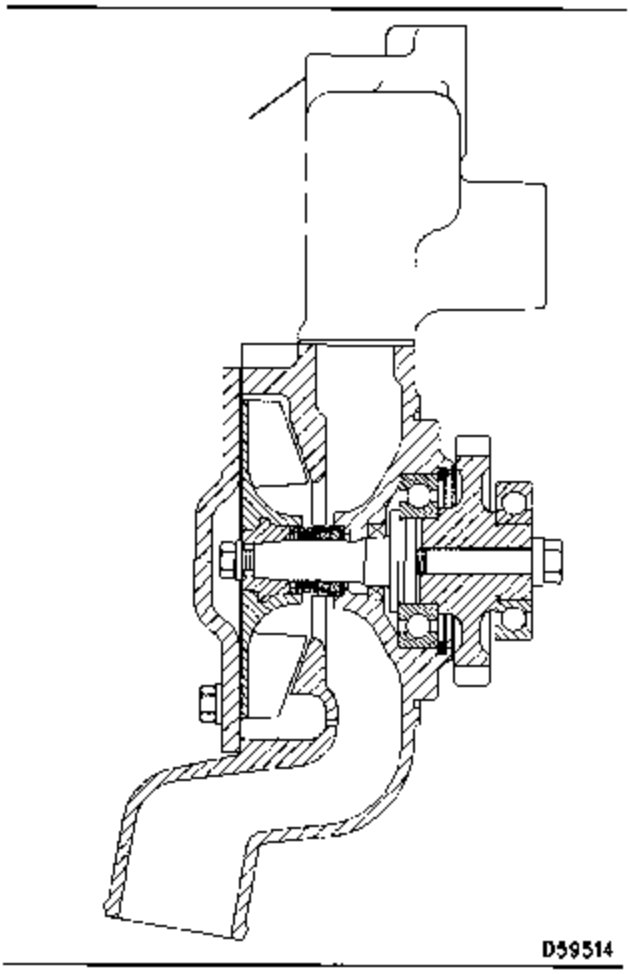


8. Remove the spring from seal assembly (8). Using the tool which comes with the replacement ring, install the seal assembly only with hand pressure. Install the seal assembly until it makes light contact with the ceramic ring.



9. Install spring (9) over the shaft in the water pump. Put impeller (10) in position on the shaft, and install the washer and bolt that hold it. Tighten the bolt to a torque of **38 ± 1.5 N•m (28 ± 1 lb ft).**

10. Install a new gasket and the cover on the water pump.



End By:

a. install water pump

Water Temperature Regulator

Remove & Install Water Temperature Regulator 1355-010

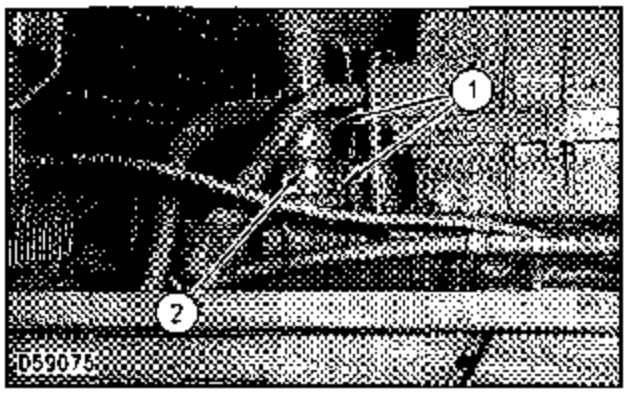
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

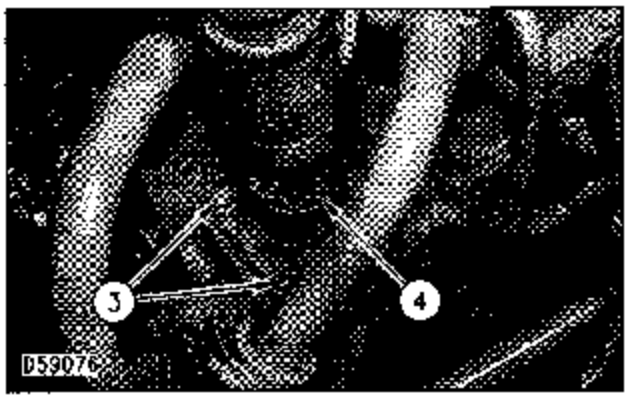
⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot water or steam. Any contact can cause severe burns. Look at the sight gauge to check the coolant level. The coolant level should be in the green range. If necessary, remove the fill cap only after the engine has been stopped and the cap is cool enough to remove with your bare hand. Remove the cooling system fill cap slowly to relieve pressure. Cooling system condition contains alkali that can cause personal injury. Avoid contact with the skin and eyes and do not drink. Allow cooling system components to cool before draining.

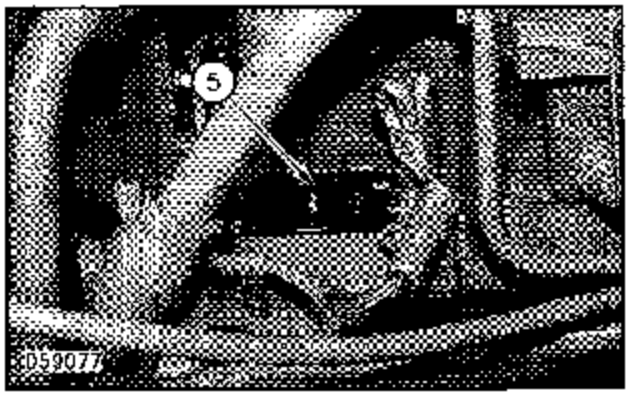
1. Release the pressure in the cooling system. Drain the coolant from the radiator into a suitable container for storage or disposal. The capacity of the cooling system is **43.7 Liters (11.2 U.S. Gal.).**



2. Loosen two clamps (1) and slide hose (2) away from the housing.



3. Remove four bolts and washers (3) from the water temperature regulator housing (4). Remove water temperature regulator housing from the cylinder head assembly.

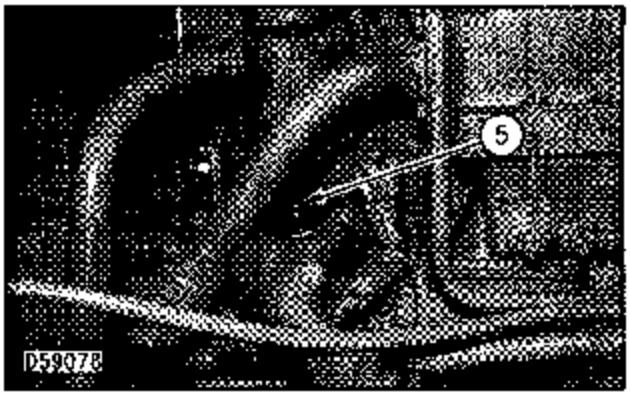


4. Remove water temperature regulator (5) from cylinder head assembly.

NOTE: The following steps are for the installation of the water temperature regulator.

NOTICE

If the water temperature regulator is installed incorrectly, it will cause the engine to overheat.



5. Install water temperature regulator (5) as shown.

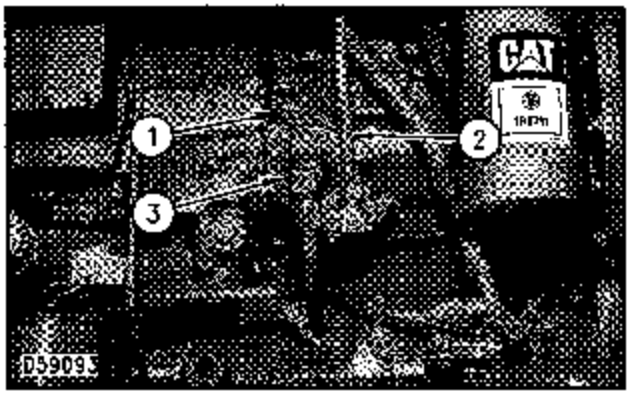
6. Reinstall water temperature regulator housing (4) and the four bolts and washers (3) that hold it in place.

7. Slide hose (2) over housing and tighten two clamps (1).

8. Fill the cooling system with coolant to the correct level See the Operation And Maintenance Manual for the correct type and level of coolant.

Fuel Transfer Pump

Remove & Install Fuel Transfer Pump 1256-010



1. Disconnect tube assemblies (2) and (4) from the fuel transfer pump.

2. Remove two bolts (1) and fuel transfer pump (3). Remove the O-ring seal from the fuel transfer pump.

NOTE: The following steps are for the installation of the fuel transfer pump.

3. Check the condition of the O-ring seal for the fuel transfer pump. If the seal is worn or damaged, use a new part for replacement. Install the O-ring seal on the fuel transfer pump.

4. Put clean engine oil on the O-ring seal and in the bore of the fuel injection pump housing. Install fuel transfer pump (3) and two bolts (1) which hold it.

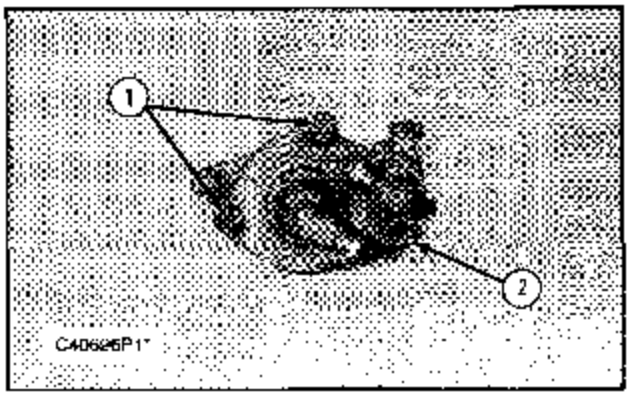
5. Connect tube assemblies (2) and (4) to the fuel transfer pump.

Disassemble & Assemble Fuel Transfer Pump 1256-017

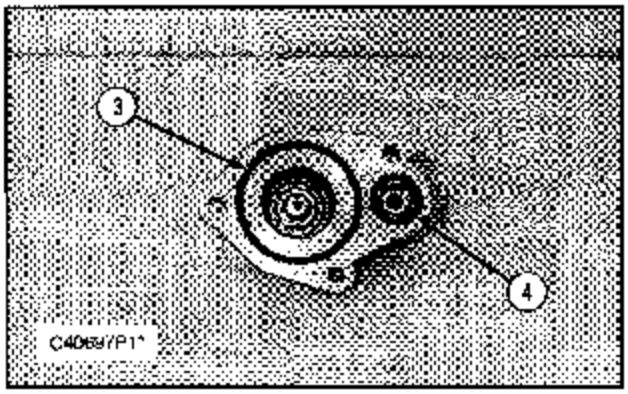
Start By:

a. remove fuel transfer pump

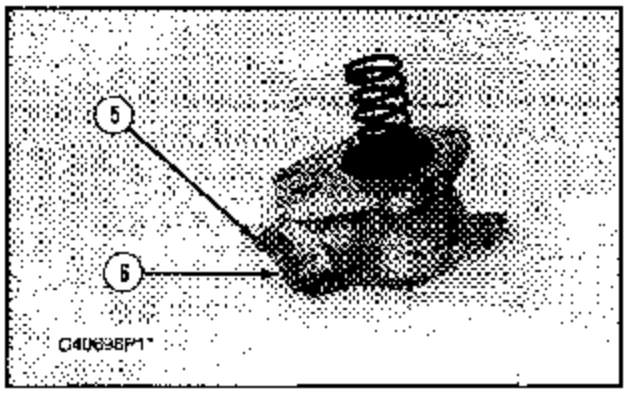
1. Be sure the outside of the fuel transfer pump is thoroughly clean prior to disassembly.



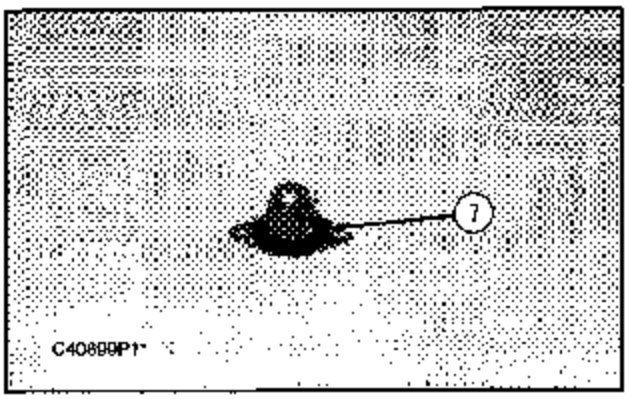
2. Remove two bolts (1) and cover (2).



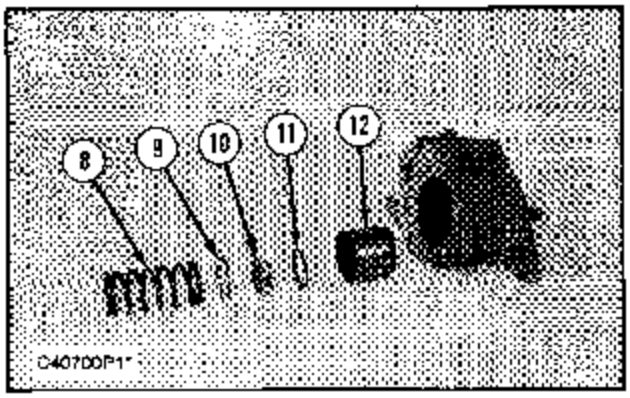
3. Remove O-ring seals (3) and (4) from cover (2).



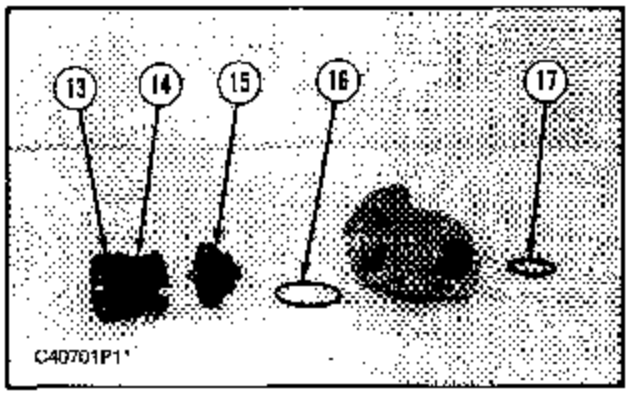
4. Remove two screws (5) and cover (6).



5. Remove O-ring seal (7) from cover (6).



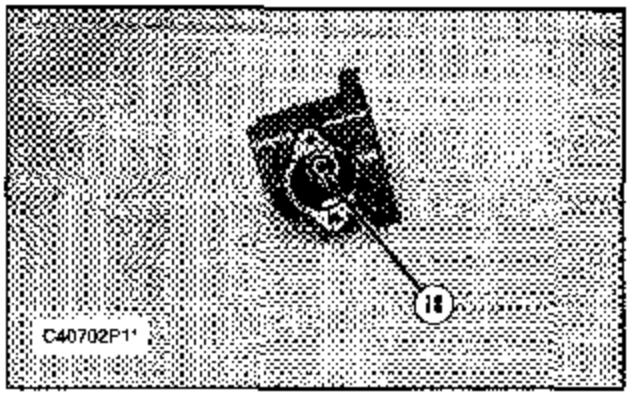
6. Remove pump spring (8), washer (9), valve assembly (10), spacer (11) and piston (12) from the transfer housing.



7. Remove sleeve (14) and guide and tappet assembly (15) from the transfer housing.

8. Remove O-ring seal (13) from sleeve (14).

9. Remove O-ring seals (16) and (17) from the transfer housing.



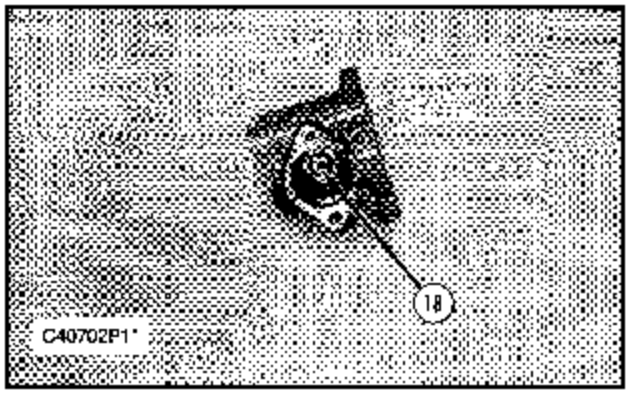
10. Tap valve assembly (18) out of the transfer housing.

NOTE: The following steps are for the assembly of the fuel transfer pump.

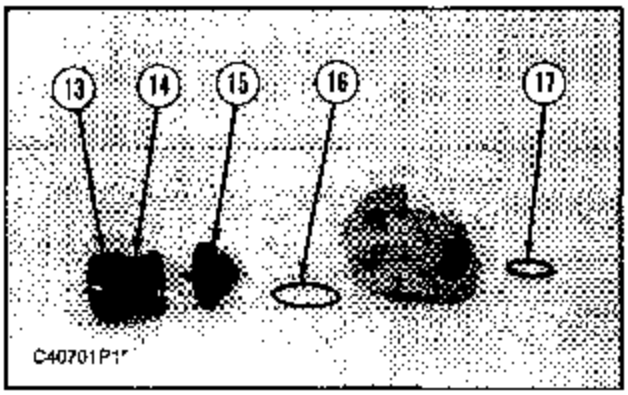
11. Be sure all internal parts of the fuel transfer pump are clean and free of dirt and debris.

12. Check the condition of all O-ring seals used in the fuel transfer pump. If any of the seals are worn or damaged, use new parts for replacement.

13. Lubricate the internal parts of the fuel transfer pump with clean Diesel fuel prior to assembly.



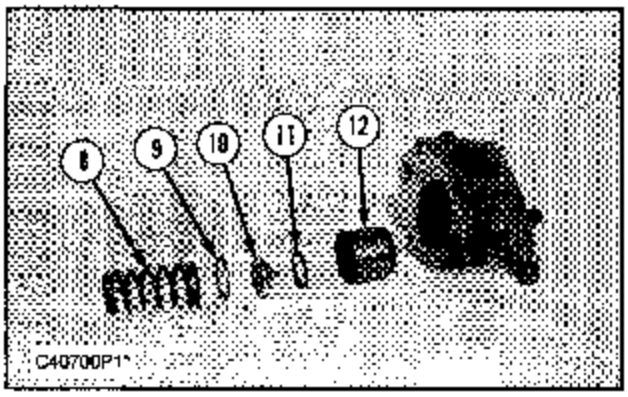
14. Install valve assembly in the transfer housing as shown.



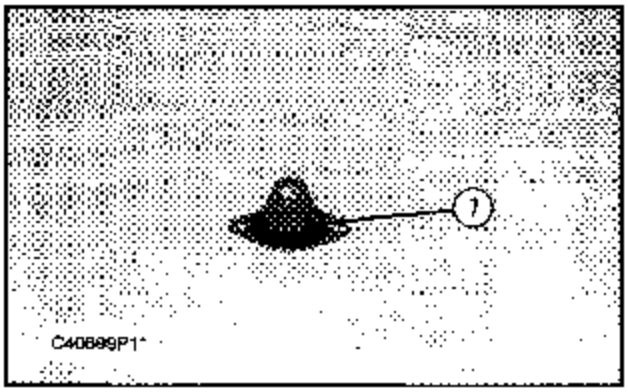
15. Install O-ring seals (16) and (17) in the transfer housing.

16. Install O-ring seal (13) on sleeve (14).

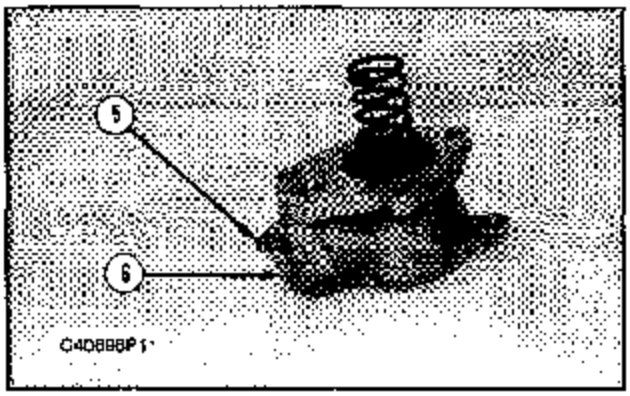
17. Install guide and tappet assembly (15) and sleeve (16) in the transfer housing as shown.



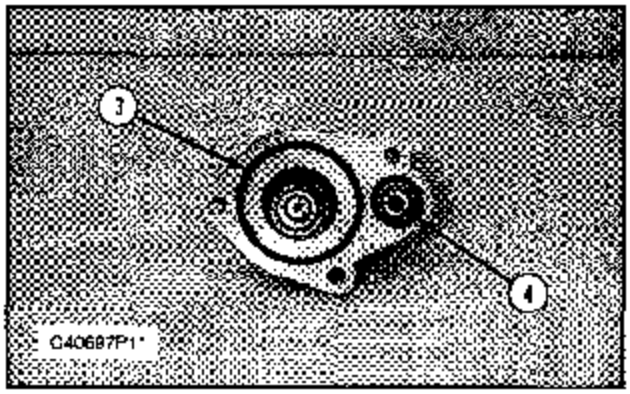
18. Install piston (12), spacer (11), valve assembly (10), washer (9) and pump spring (8) in the transfer housing.



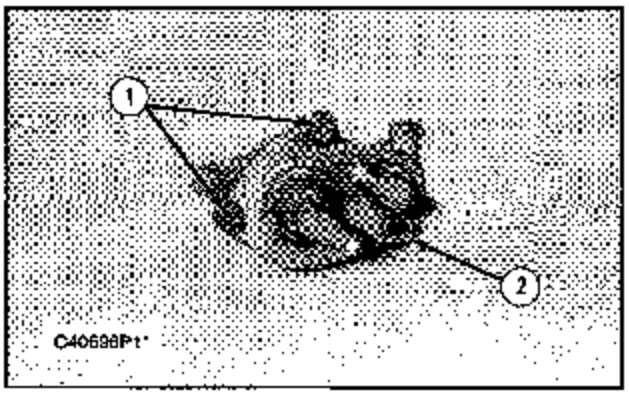
19. Install O-ring seal (7) on cover (6).



20. Install cover (6) and two screws (5).



21. Install O-ring seals (3) and (4) in cover (2).



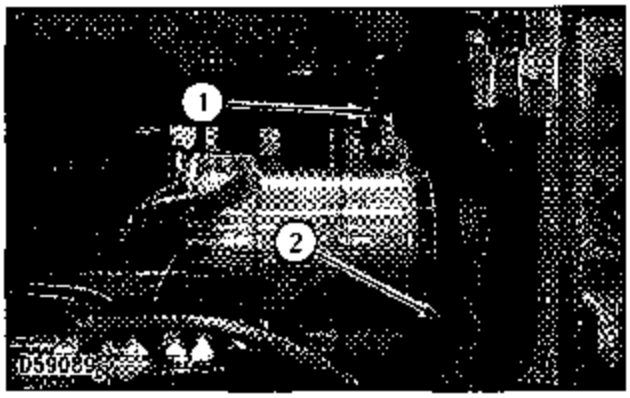
22. Install cover (2) on the transfer housing.

End By:

a. install fuel transfer pump

Fan Drive

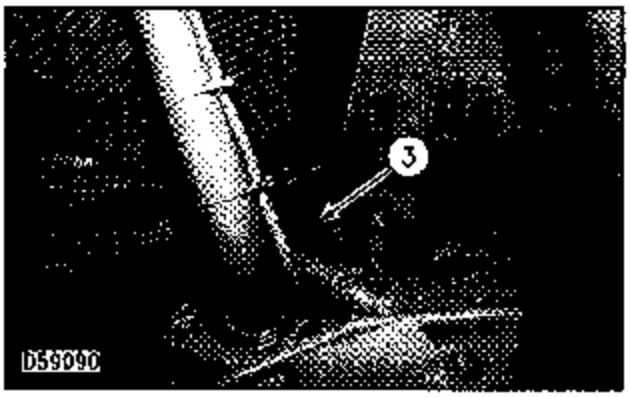
Remove & Install Fan Drive 1359-010



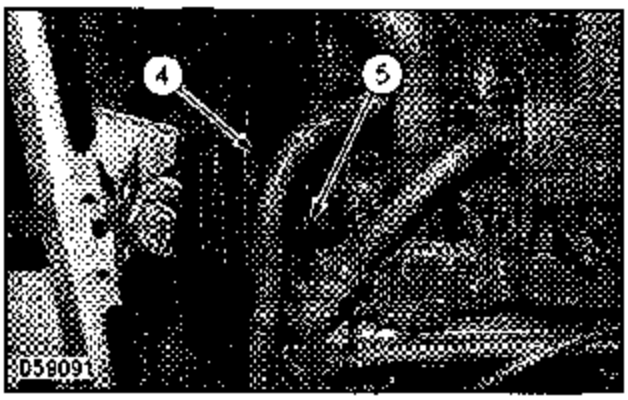
1. Loosen nut and bolt (1) to relieve tension on V-belts. Remove V-belts (2) from the pulley on the alternator.

NOTICE

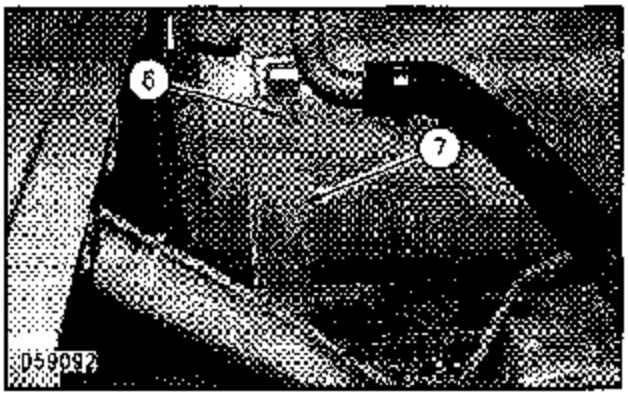
Be careful not to damage the radiator core when removing the fan drive. Do not push or press the fan against the radiator core while removing the fan drive.



2. Attach a strap and a hoistto the fan assembly and adapter. Remove six bolts, washers and nuts (3) that hold the fan assembly to the fan pulley. Carefully place the fan assemoly and adapter against the radiator core.



3. Fasten strap and hoist to fan pulley and fan drive (4) as shown. Remove four bolts (5) and spacer that hold the fan drive to the cylinder head assembly.



4. Remove two bolts and washers (6) connecting support bracket (7) to muffler. Remove the fan pulley, fan drive and support bracket as a unit. The weight of the unit is **23 kg (50 lb)**.

NOTE: The following steps are required for the installation of the fan drive.

4. Fasten a strap and hoist to fan pulley and fan drive (4). Place the unit in position on the front of the cylinder head assembly and support bracket (7). Install six bolts and spacer that hold the fan drive in place. Be sure the V-belts are in position on the fan pulley.

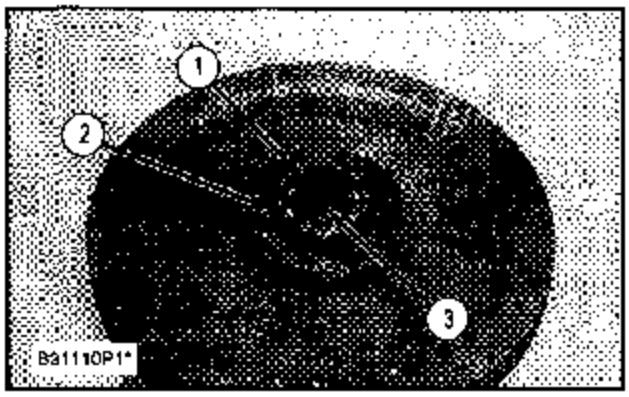
5. Fasten a strap and hoist to the fan assembly and adapter. Place the unit in position on the fan pulley and install six bolts, nuts and washers (3) that hold it in position.

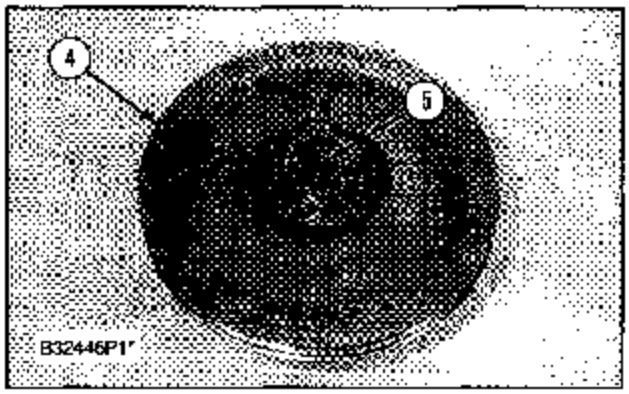
6. Install two V-belts (2) in the pulley groove on the alternator. Adjust the V belt tension. See the topic "Fan And Alternator Belts" in the Operation And Maintenance Manual.

Disassemble Fan Drive 1359-015

Start By:

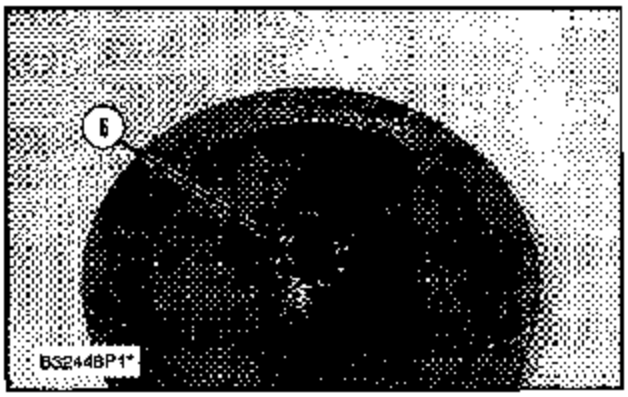
a. remove fan drive



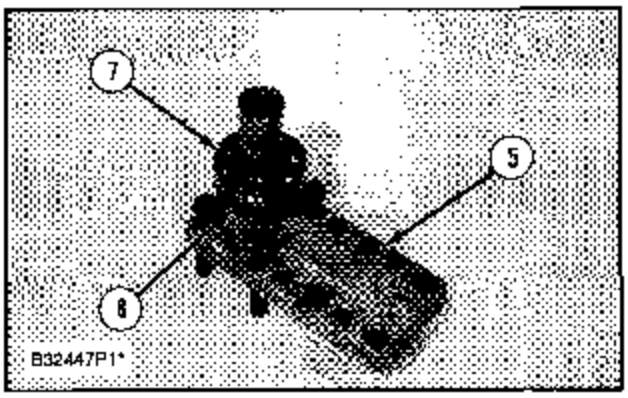


1. Remove two bolts (1) and retaining washer (3) from the end of the shaft in the fan bracket.

2. Remove pulley (4), the spacer and hub (2) from fan bracket (5) as a unit.



3. Remove front bearing (6) from the hub (2). Remove the pulley from the hub.



NOTE: Rear bearing (7), and seal (8) may have stayed with pulley (4) when it was removed from the fan shaft.

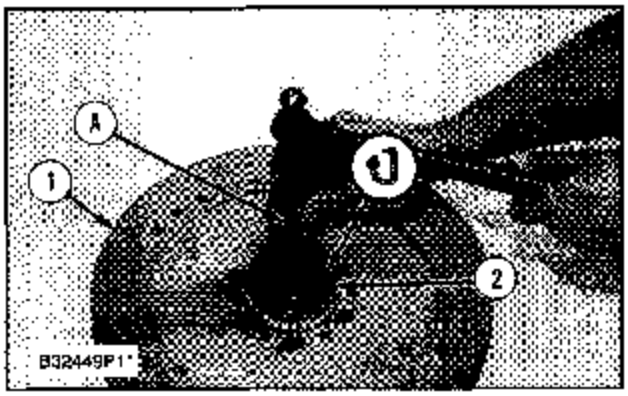
4. Remove rear bearing (7) and seal (8) from fan bracket (5).

5. Remove the spacer from the fan bracket.

Assemble Fan Drive 1359-016

Tools Needed		A
1P510	Driver Group	1

1. Be sure all parts of the fan drive are thoroughly clean and free of dirt and debris. Also, hand pack the bearings in the fan drive with **5P0960 Multipurpose Grease** prior to assembly.

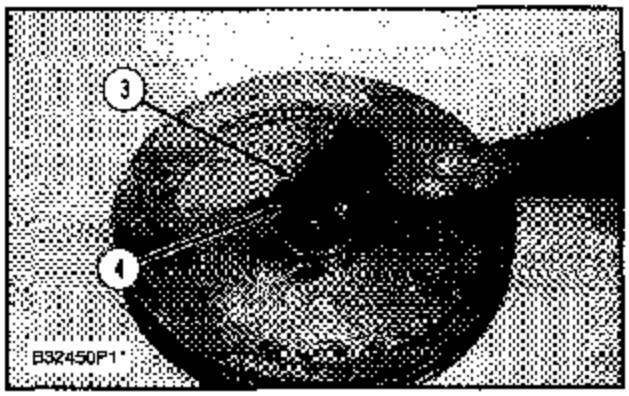


NOTE: The pulley must be installed on the hub with the spacer down against the shoulder of the hub.

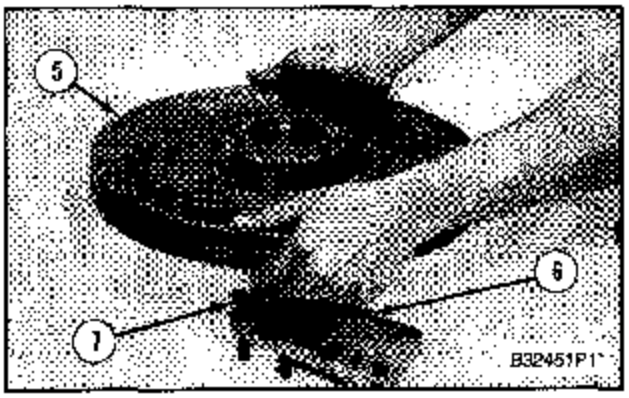
2. Install pulley (1) on hub (2) as shown.

3. Install the rear bearing in the hub

4. Using tool (A), install seal (4) in the hub. Install the seal until it is even with the outside of the hub and with the lip of the seal facing out as shown. Put a thin coat of **5P0960 Multipurpose Grease** on the lip of the seal.

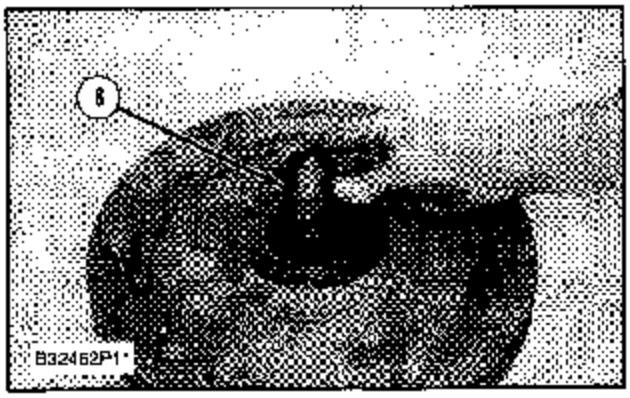


5. Install spacer (3) in seal (4).

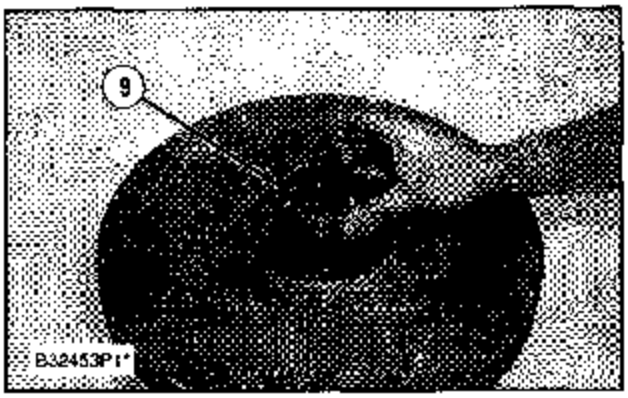


NOTE: Be sure four mounting bolts (7) are installed in the fan bracket prior to installation of the pulley on the fan bracket.

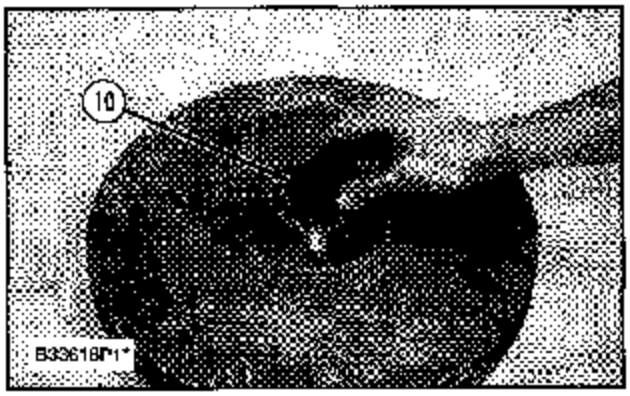
6. Put pulley and hub assembly (5) on fan bracket (6).



7. Install spacer (8) over the shaft of the fan bracket.



8. Install front bearing (9) in the hub until it makes contact with the counterbore in the hub.



9. Put retaining washer (10) in position on the end of the shaft of the fan bracket. Install the two bolts that hold the fan drive unit together.

End By:

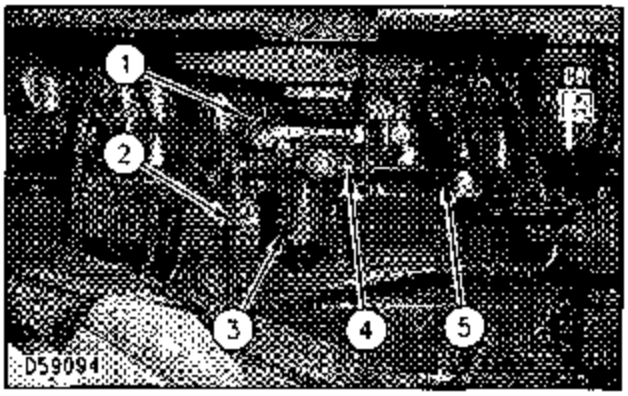
a. install fan drive

Fuel Priming Pump & Primary Fuel Filter

Remove Fuel Priming Pump & Primary Fuel Filter 1258 & 1260-010

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



1. Disconnect tube assemblies (2) and (5) from the fuel filter base.
2. Remove bolt (4), the washer and clip which holds the fuel tube assembly to the fuel priming pump.
3. Remove two bolts (1) and the washers that hold the fuel filter base in position. Remove the fuel priming pump and primary fuel filter and base (3) as a unit.

NOTE: Install the fuel priming pump and primary fuel filter in the reverse order of removal. For service of the fuel filters, see the topic "Fuel System Filters" in the Operation & Maintenance Manual.

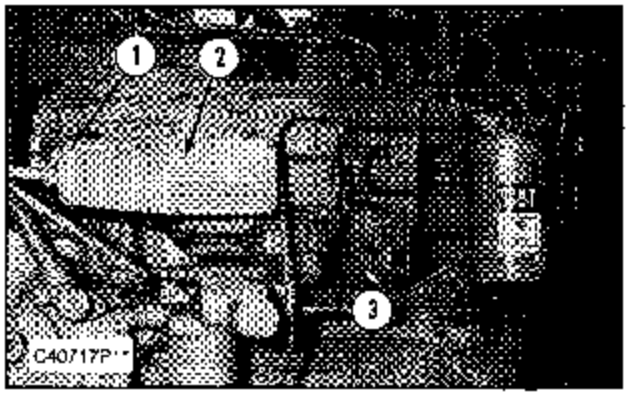
Fuel Injection Pump Housing & Governor

Remove & Install Fuel Injection Pump Housing & Governor 1286-010

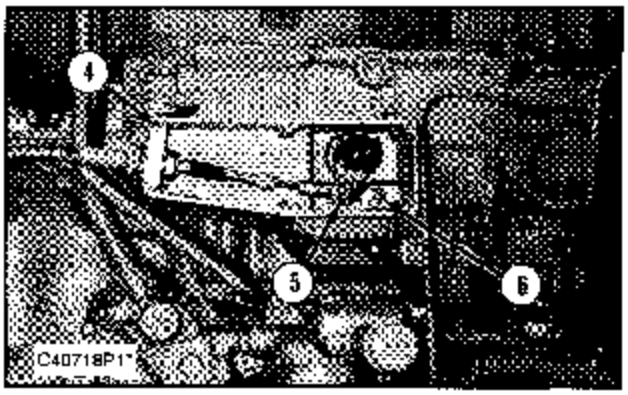
Tools Needed		A	B	C	D	E
2P8250	Strap Wrench	1				
5P7307	Engine Turning Tool		1			
6V4186	Timing Pin			2		
8S2264	Puller Group				1	
5P0144	Socket					1

Start By:

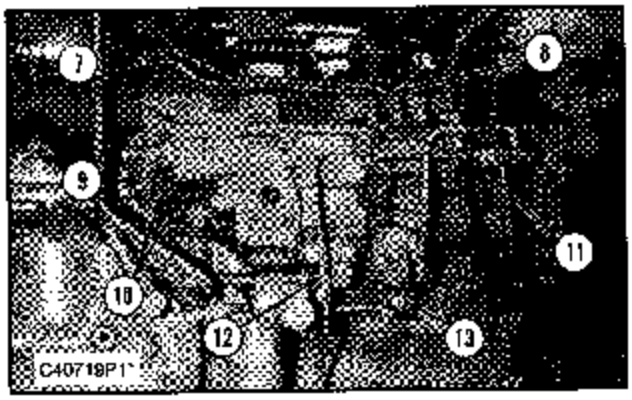
a. remove electric starting motor



1. Remove six screws (1) and the lockwashers that hold cover (2) in position. Remove the cover.
2. Use tool (A) to remove fuel filter (3).



3. Mark the location of the governor control lever in relation to the shaft. Disconnect governor linkage (5).
4. Remove two bolts (6) and the washers that hold housing (4) in position. Remove the housing.



5. Put identification on two wires (10) that are connected to the fuel shut-off solenoid. Disconnect the two wires.

6. Disconnect tube assembly (9) from air fuel ratio control (7).

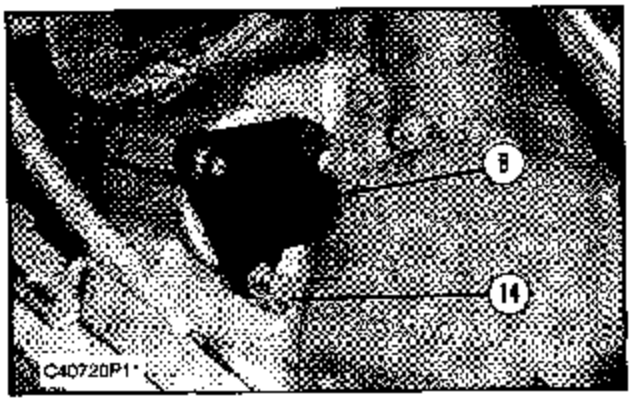
7. Disconnect two tube assemblies (13) from the fuel transfer pump and the fuel filter base.

8. Disconnect tube assembly (12) from the fuel injection pump housing. Remove clip (11) from the fuel injection pump housing.

NOTICE

Two wrenches must be used when the fuel injection lines are loosened to prevent damage to the nozzles.

9. Remove six fuel injection lines (8). Put protective caps in the fuel injection lines and on the fuel injection pumps to keep dirt and debris out of the fuel system.



NOTE: The bolts used to hold the electric starting motor to the flywheel housing can be used to hold tool (B) in position.

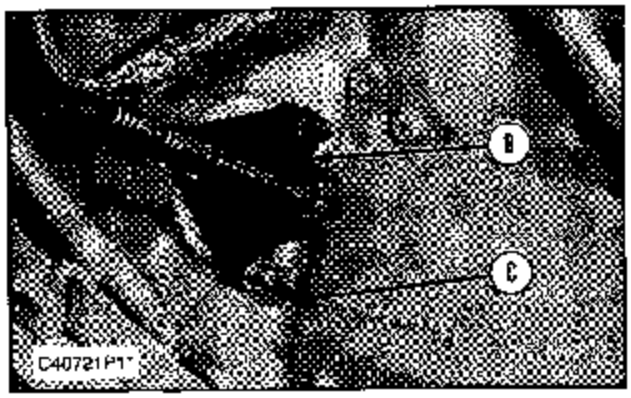
10. Install tool (B) in the flywheel housing at the location for the electric starting motor.

11. Remove timing pin plug (14) from the flywheel housing.

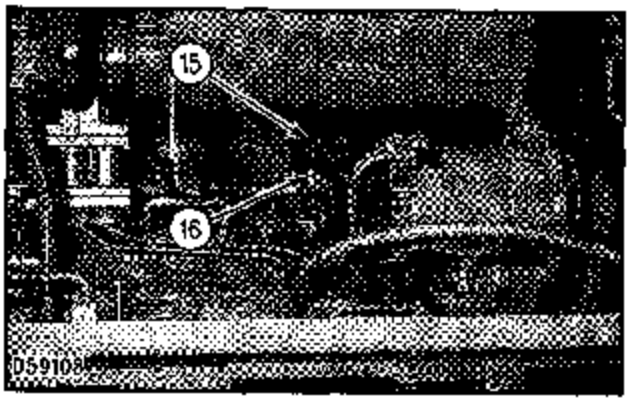
12. Use the following procedure to put the No. 1 piston at top center on the compression stroke. No. 1 piston, at top center (TC) on the compression stroke, is the starting point for all timing procedures:

NOTICE

The engine is viewed from the flywheel end when the direction of rotation is given. Do not turn the flywheel backwards.

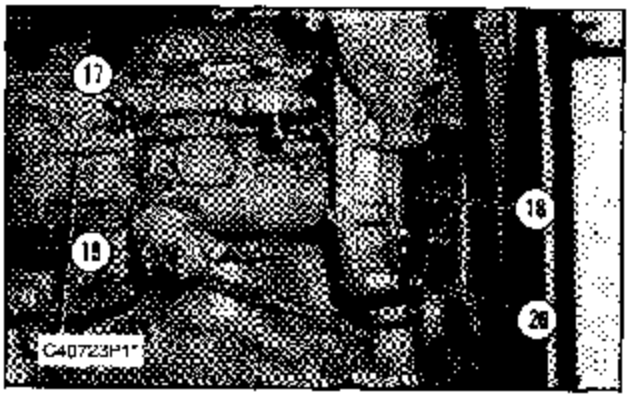


a. Using tool (B), rotate the flywheel counter-clockwise until tool (C) can be installed through the opening in the flywheel housing and into a hole in the flywheel. **Do not** turn the flywheel backwards.



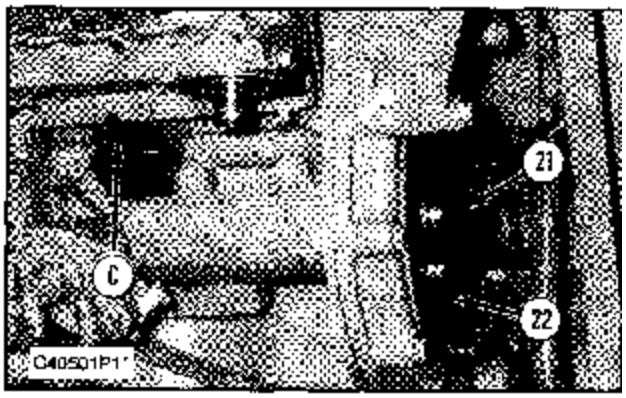
b. Remove bolt (15) and breather assembly (16) from the valve cover. By looking through the breather hole in the valve cover, check to see if both rocker arms for the No. 1 piston are loose and can be moved backward and forward by hand. If both rocker arms **do not** move, then the No. 1 piston is not at top center of the compression stroke.

c. If the No. 1 piston is not at top center of the compression stroke, remove tool (C) from the flywheel. Using tool (B), rotate the flywheel counterclockwise 360°. Reinstall tool (C) into the hole in the flywheel. Check to see if both rocker arms for the No. 1 piston are loose and can be move backward and forward by hand. If free movement is felt, the No. 1 piston is at top center of the compression stroke.



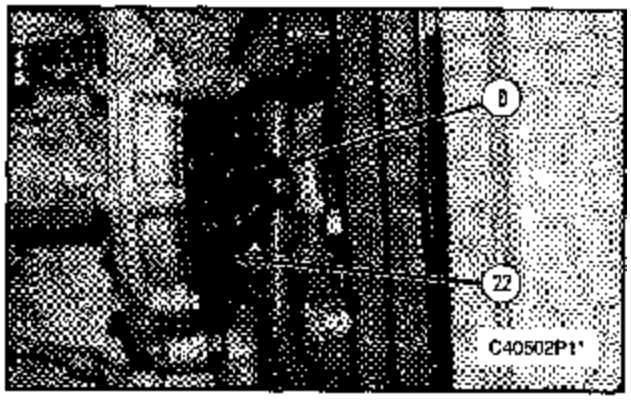
13. Remove four bolts (17), cover (19) and the gasket from the side of the fuel injection pump housing.

14. Remove six nuts (20), the washers, cover (18) and the gasket from the front housing.

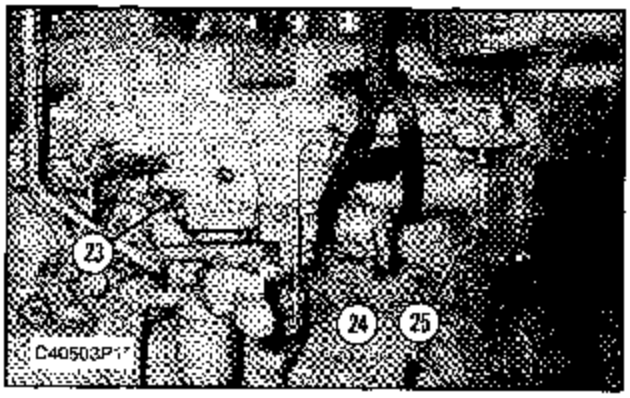


15. With cover (19) removed, install tool (C) into the groove of the injection pump camshaft.

16. Remove bolt (21) and the washer that hold fuel pump drive gear (22) in position.



17. Install tool (D) as shown, and loosen fuel pump drive gear (22) from the end of the camshaft.



18. Fasten a lifting strap and a hoist to fuel injection pump housing and governor (23) as shown.

19. Remove two bolts (24) and the washers that hold the fuel injection pump housing and governor to the oil manifold.

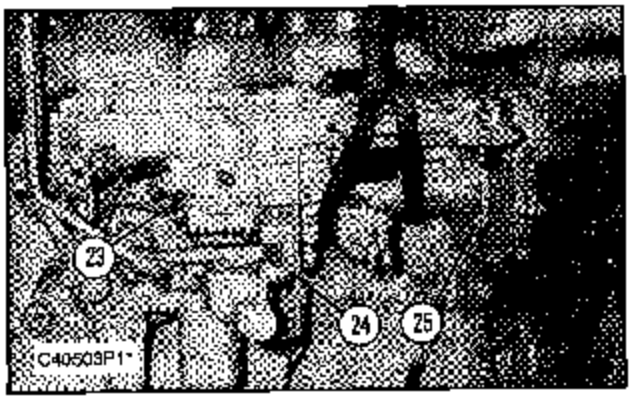
NOTICE

Be sure tool (C) stays in the groove of the camshaft when the fuel system is removed from the machine.

20. Remove three nuts (25) and the washers that hold the fuel injection pump housing and governor to the timing gear plate. Remove fuel injection pump housing and governor (23). The weight of the fuel injection pump housing and governor is **27 kg (60 lb).**

NOTE: The following steps are for the installation of the fuel injection pump housing and governor.

21. Check the condition of the two O-ring seals used on the front of the fuel injection pump housing. If the seals are worn or damaged, use new parts for replacement. Install the O-ring seals on the fuel injection pump housing. Put clean engine oil on the O-ring seals.

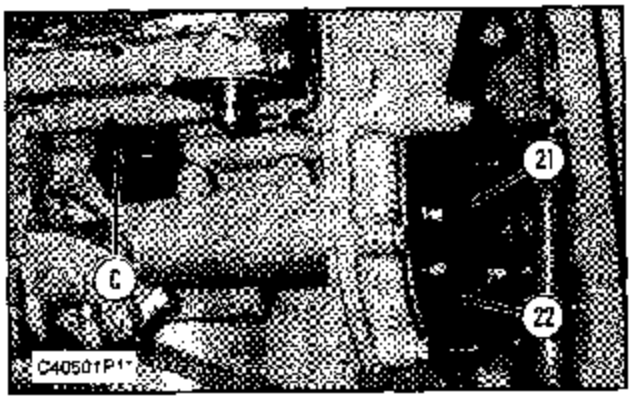


22. Fasten a lifting strap and a hoist to fuel injection pump housing and governor (23) as shown. Put the fuel system in position on the three stud in the timing gear plate. Install the three washers and nuts (25) which hold it.

23. Install the two washers and bolts (24) that hold the fuel system to the oil manifold.

⚠ WARNING

After the fuel injection pump housing and governor are installed on the timing gear plate, be sure the rack is free to move. It is possible for the O-ring seal on the drive end of the fuel injection pump housing to hold the rack and prevent free movement. If the rack does not move freely, remove the fuel injection pump housing and governor, and check the O-ring seal on the drive end of the fuel injection pump housing.



24. Put fuel pump drive gear (22) in position on the end of the camshaft. Install bolt (21) and the washer to hold the drive gear in place. Install the washer with the larger outside diameter toward the head of bolt (21). Tighten bolt (21) only finger tight.

25. Install two nuts of the appropriate size on one a the outside mounting stud for cover (18). Put a piece of round stock in one of the lightening holes in the fuel pump drive gear. Using a pry bar, put a force of **60 to 70 N•m (45 to 50 lb ft)** on the fuel pump drive gear in a clockwise direction (as seen from the front of the engine). With a clockwise force on the drive gear, tighten bolt (21) to a torque of **270 ± 30 N•m (200 ± 20 lb ft).**

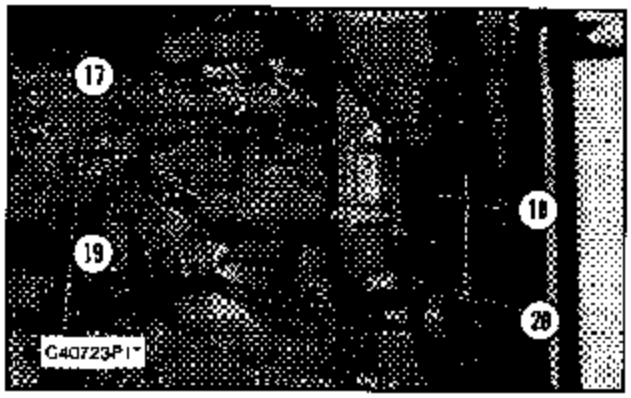
26. Remove tool (C) from the fuel injection pump housing.

27. Remove tool (C) from the flywheel.

28. Turn the engine flywheel counterclockwise (as seen from the rear of the engine) two complete revolutions. If tools (C) goes into the groove in the camshaft in the fuel system and into the hole in the flywheel at the same time, the timing is correct.

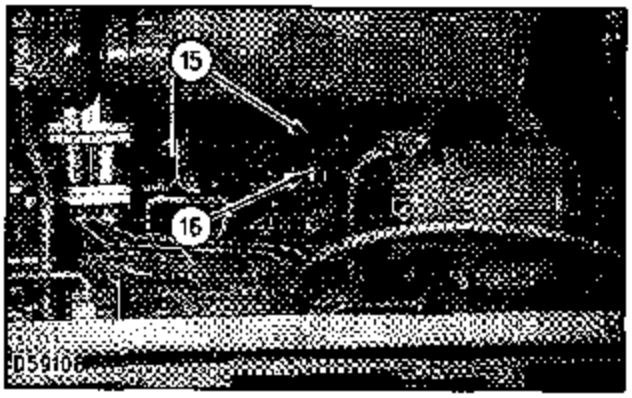
29. If tools (C) can not both be installed at the same time, the timing procedure must be done again. Loosen the fuel pump drive gear, and repeat Steps 24 and 25.

30. Remove tools (C) from the fuel injection pump housing and the flywheel.

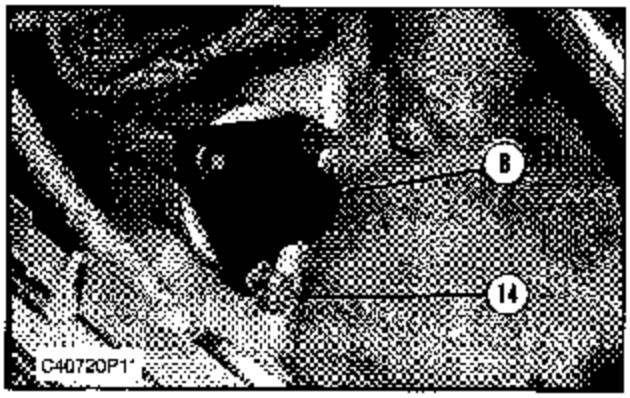


31. Check the condition of the gasket used with cover (18). If the gasket is worn or damaged, use a new part for replacement. Reinstall the gasket and cover (18) on the front housing. Install the six washers and nuts (20) which hold it.

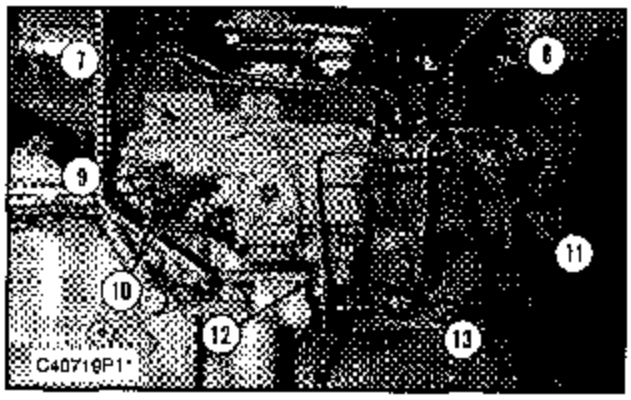
32. Check the condition of the gasket used with cover (19). If the gasket is worn or damaged, use a new part for replacement. Reinstall the gasket and cover (18). Install four bolts (17) that hold it.



33. Reinstall breather assembly (16) and bolt (15) which holds it. Tighten bolt (15) to a torque of **14 ± 3 N•m (10 ± 2 lb ft).**



34. Remove tool (B) from the flywheel housing. Reinstall timing pin plug (14).



NOTICE

Two wrenches must be used when the fuel injection lines are tightened to prevent damage to the nozzles.

35. Be sure fuel injection lines (8) are clean and dry. Reinstall the fuel injection lines.

36. Tighten the nuts on the fuel injection lines with tool (E) to a torque of **40 N•m (30 lb ft). Do not over tighten.**

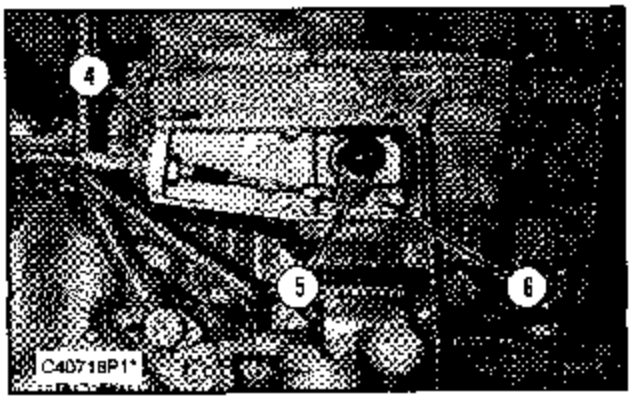
37. Install clip (11) on the side of the fuel injection pump housing.

38. Connect tube assembly (12) to the fuel injection pump housing.

39. Connect two tube assemblies (13) to the fuel transfer pump and the fuel filter base.

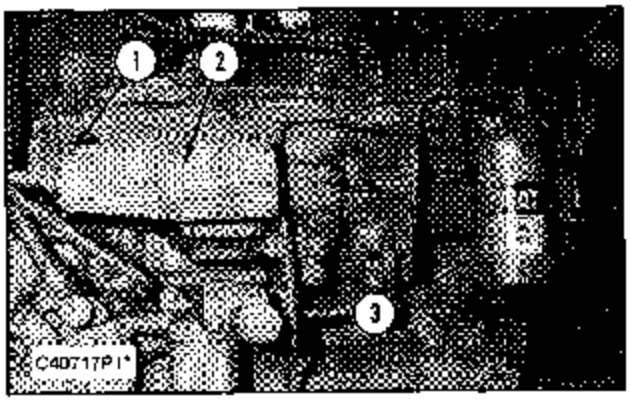
40. Connect tube assembly (9) to air fuel ratio control (7).

41. Connect two wires (10) to the fuel shut-off solenoid in their original locations.



42. Install housing (4) and two bolts (6) that hold it.

43. Reinstal governor linkage (5).



44. Install cover (2) and six screws (1) which hold it.

45. Install a new fuel filter. See the Operation & Maintenance Manual for the correct installation procedure and service intervals.

46. Bleed the air from the fuel system. See the topic "Fuel Priming Pump" in the Operation & Maintenance Manual.

End By:

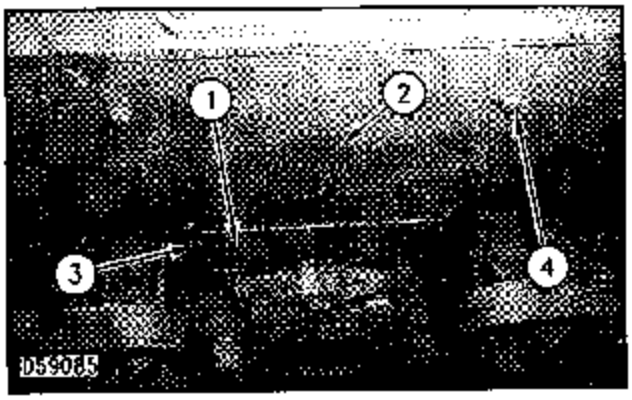
a. install electric starting motor.

Oil Pan

Remove & Install Oil Pan 1302-010

FLUID SPILLAGE CONTAINMENT

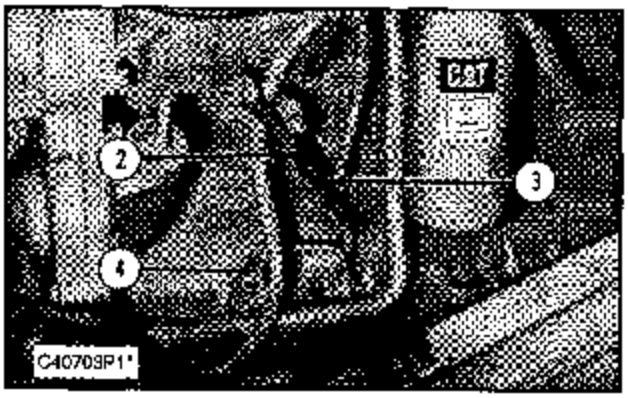
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



1. Position a suitable floor jack under front crankcase guard (1) and remove four bolts and washers (3). Remove the guard under the machine. The weight of the front crankcase guard is **39 kg (85 lb)**.

2. Position a suitable floor jack under rear crankcase guard (2) and remove four bolts and washers (4). Remove the guard from under the machine. The weight of the rear crankcase guard is **48 kg (105 lb)**.

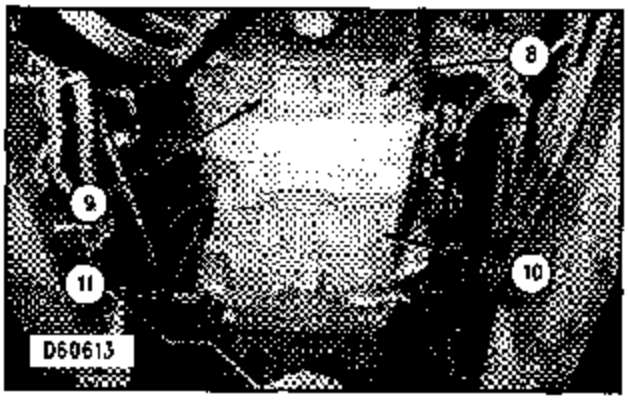
3. Drain the oil from the engine into a suitable container for storage or disposal. The capacity of the engine crankcase is **28 liters (7.3 U.S. gal).**



4. Disconnect tube assembly (7) at the oil level gauge guide tube.

5. Remove the bolt and washer that holds support clip (5) for the oil level gauge guide tube.

6. Remove oil level gauge and guide tube (6) from the oil pan.



View From Under Machine

7. Remove the bolt, washer and bracket (11) from the side of the oil pan.

8. Remove the two bolts, washers and bracket (8) from the front of the oil pan.

9. Remove the remaining twenty five bolts (9) and washers that hold the oil pan in place. Remove oil pan (10) and the gasket from the cylinder block.

NOTE: The following steps are for the installation of the oil pan.

10. Put a new gasket and oil pan (10) in position on the cylinder block. Install twenty five bolts (9) that hold the oil pan in place. Tighten to a torque of **47 ± 5 N•m (35 ± 7 lb ft)**.

11. Put bracket (8) in position on the front of the oil pan, and install the two washers and bolts which hold it.

12. Put bracket (11) in position on the side of the oil pan, and install the washer and bolt which holds it.

13. Install oil level gauge guide tube (6) in the oil pan.

14. Reinstall support clip (5) for the oil level gauge guide tube.

15. Connect tube assembly (7) to the oil level gauge guide tube.

16. Fill the engine crankcase with oil to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

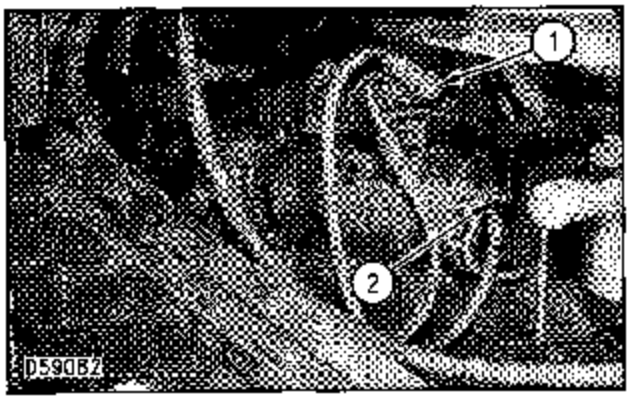
17. Start the engine and check for leaks.

18. Reinstall crankcase guards (1) and (2).

Electric Starting Motor

Remove & Install Electric Starting Motor 1518-010

1. Turn the main battery disconnect switch to the **OFF** position.



2. Place identification marks on wires (1) and (2) as to their location on the starter. Disconnect the wires from the starter.

3. Remove three bolts (3) that hold starter motor (4) to the flywheel housing. Using two people, remove the electric starting motor and gasket from the flywheel housing. Weight of the starting motor is **32 kg (70 lb).**

NOTE: Look at the condition of the teeth on the flywheel after the starter is removed. It may be necessary to use an engine rotation tool to inspect all teeth. If any teeth are excessively worn or missing it may be necessary to replace the flywheel.

NOTE: The following steps are necessary for the installation of the electric starting motor.

4. Replace the gasket between the electric starting motor and the flywheel housing.

5. Install the electric starting motor. Install three bolts and tighten to a torque of **43 ± 7 N•m (32 ± 5 lb ft)**.

6. Connect all wires to their proper locations, based on previous identification marks. Insure that all connections are clean and free of corrosion.

7. Check all connections, connect the battery and turn the disconnect switch to the **ON** position. Start the machine several times to insure that all portions of the starter are working properly.

Transmission Oil Cooler

Remove & Install Transmission Oil Cooler 1375-010

FLUID SPILLAGE CONTAINMENT

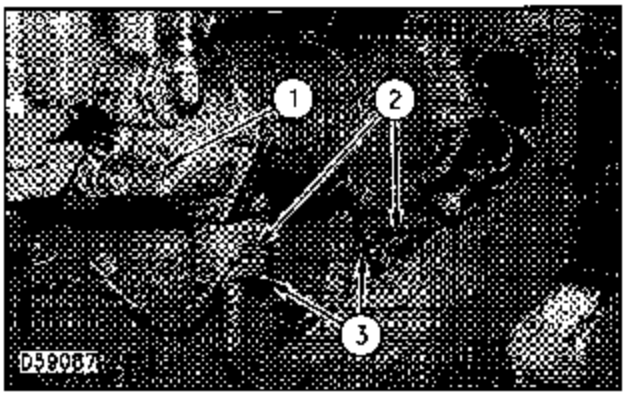
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

NOTE: The brace for the engine compartment enclosure was removed for better photo illustration of the transmission oil cooler.

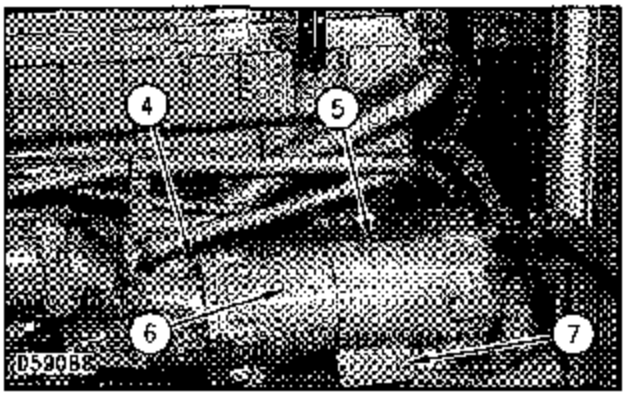
⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure. Steam can cause personal injury. Check the coolant level only after the engine has been stopped and the fill cap is cool enough to touch with your bare hand. Remove the fill cap slowly to relieve pressure. Cooling system conditioner contains alkali. Avoid contact with skin and eyes to prevent personal injury.

1. Release the pressure in the cooling system. Drain the coolant from the radiator into a suitable container for storage or disposal. The capacity of the cooling system is **44 liters (11.2 U.S. gal).**



2. Remove drain plug (1) from the front bonnet of the transmission oil cooler.
3. Remove eight bolts and washers (3) that hold two tube assemblies (2) to the bottom of the transmission oil cooler.



4. Remove six bolts (4) connecting front bonnet to transmission oil cooler.
5. Support transmission oil cooler. Remove four bolts and washers (7) and remove clamp (5).
6. Remove cooler (6). Weight of transmission oil cooler is **18.2 kg (40 lb)**.
7. Remove rear bonnet from transmission oil cooler core.
8. Using a **4.0 mm (.156 in)** diameter rod, clean the tube bundles in the transmission oil cooler.

NOTE: The following steps are for the installation of the transmission oil cooler.

9. Install new gaskets between front and rear bonnets.

10. Put transmission oil cooler (6) in position on the side of the engine.

11. Install transmission oil cooler in clamp (5) and secure with four bolts (7). Do not tighten bolts (7) at this time.

12. Install six bolts (4) connecting front bonnet to transmission oil cooler. Tighten bolts (4) to a torque of **105 ± 20 N•m (78 ± 15 lb ft)**

13. Install two tube assemblies (2) and secure with eight bolts and washers (3).

14. After all connections are completed and correctly tightened, tighten bolts (7) securing the transmission oil cooler to the engine.

15. Reinstall drain plug (7) in the rear bonnet of the transmission oil cooler. Reinstall drain plug (3) in the front bonnet of the transmission oil cooler.

16. Fill the cooling system with coolant to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

Engine Oil Cooler

Remove & Install Engine Oil Cooler 1378-010

Start By:

a. remove engine oil filter and oil filter base

FLUID SPILLAGE CONTAINMENT

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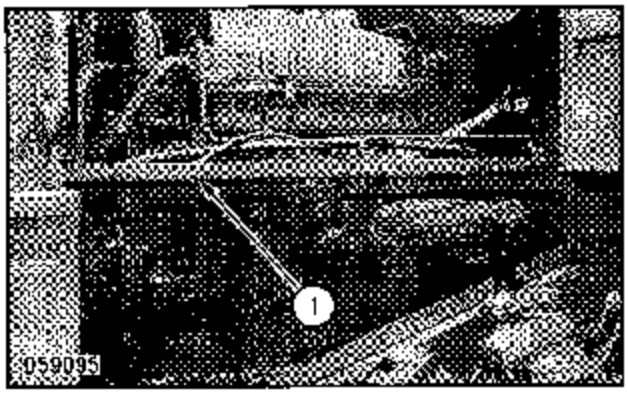
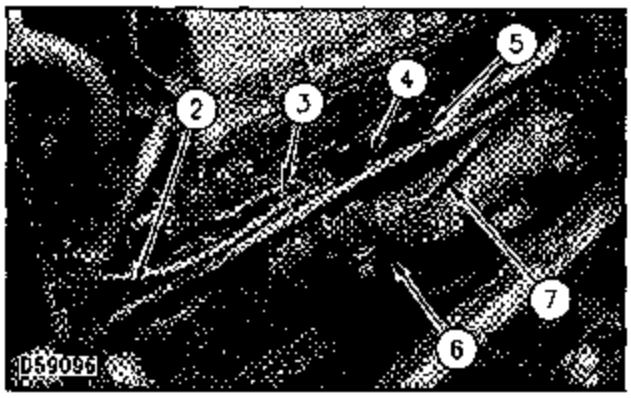


1. Remove lower door frame (1). Two bolts and washers are located at the back of the door frame.

2. Release the pressure in the cooling system. Drain the coolant below the level of the engine oil cooler.



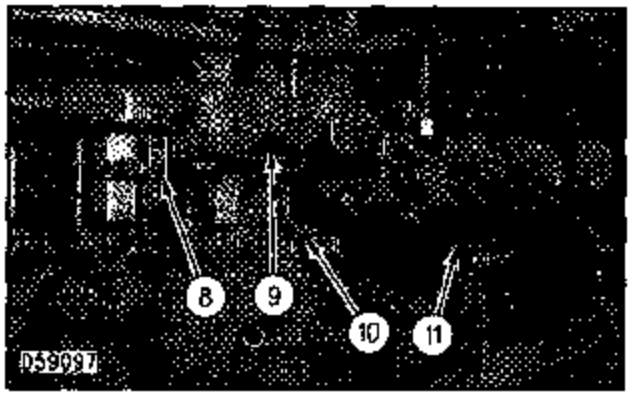
3. Remove drain plug (6) from engine oil cooler and allow coolant to drain. Reinstall when oil has drained.

4. Loosen two hose clamps and slide hose (2) back over end of engine oil cooler bonnet.

5. Remove clamp bolt (3) connecting heater hose to the top of the engine oil cooler.

6. Remove bolts (4) and loosen hose clamp (5). Remove short from the top front of engine oil cooler bonnet.

7. Loosen hose clamp and disconnect heater hose (7).

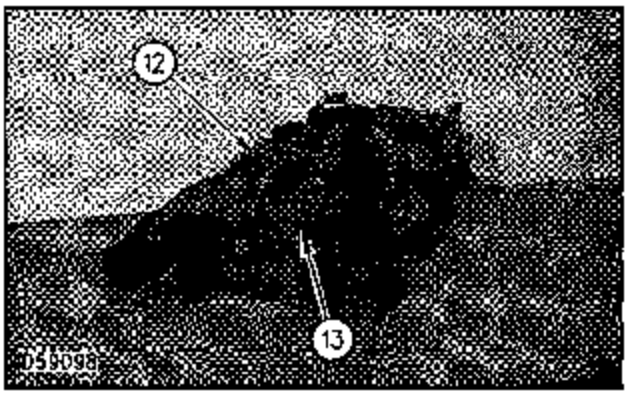


8. Support engine oil cooler assembly with a strap and hoist. Remove bolt (8) supporting rear of engine oil cooler.

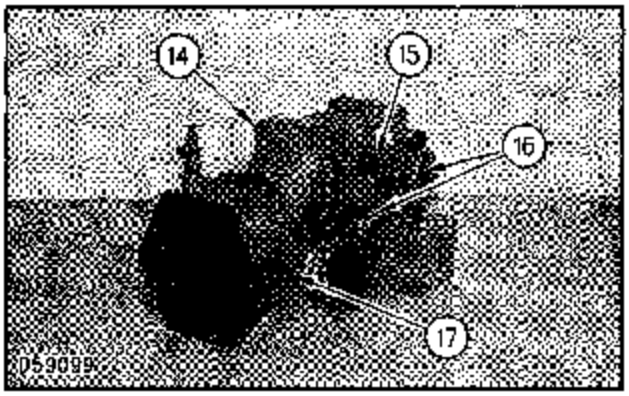
9. Remove six bolts (10) connecting front engine oil cooler bonnet to engine block.

10. Remove six bolts (11) connecting front engine oil cooler bonnet to transmission oil cooler.

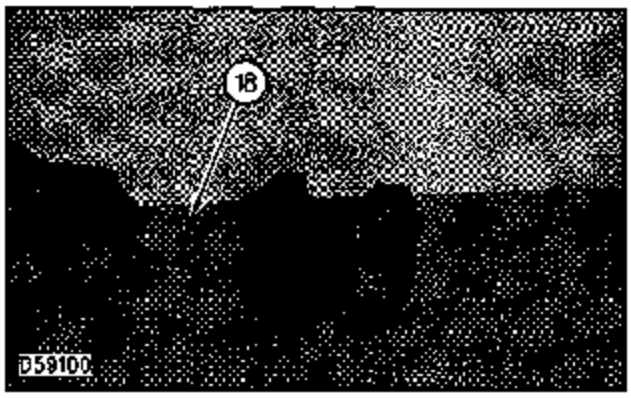
11. Remove engine oil cooler assembly (9).



12. Remove four bolts (12) connecting rear engine oil cooler bonnet (13) to engine oil cooler.



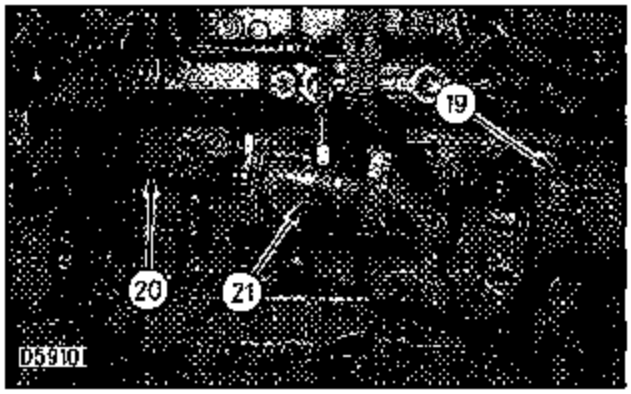
13. Remove four bolts (14) connecting front engine oil cooler bonnet (17) to engine oil cooler. Remove four bolts (15) and two flanges (16) from engine oil cooler.



14. Using a **30 mm (.12 in)** diameter rod (18) clean the tube bundles in the engine oil cooler.

NOTE: The following steps are for the installation of the engine oil cooler.

15. Check the condition of the gaskets and O-rings used with the engine oil cooler. If gaskets or O-rings are damaged, use new parts for replacement.



16. Install engine oil cooler in almost the exact reverse order from removal. The only difference involves the installation of cooler assembly (21).

17. Connect the hose on the rear of the bonnet first, then connect front bonnet to transmission oil cooler (19).

18. Fill cooling system with coolant to the correct level. See the Operation and Maintenance Manual for the correct filling procedure.

End By:

a. install engine oil filter and oil filter base.

Engine And Transmission

Remove & Install Engine And Transmission 1000-010

Tools Needed	A	B
6V-2156 Link Brackets	4	
6V-6146 Load Leveler		1

Start By:

a. remove cab

b. remove radiator and guard group

c. remove front and rear drive shafts

d. remove hood

e. remove precleaner

f. remove exhaust pipe

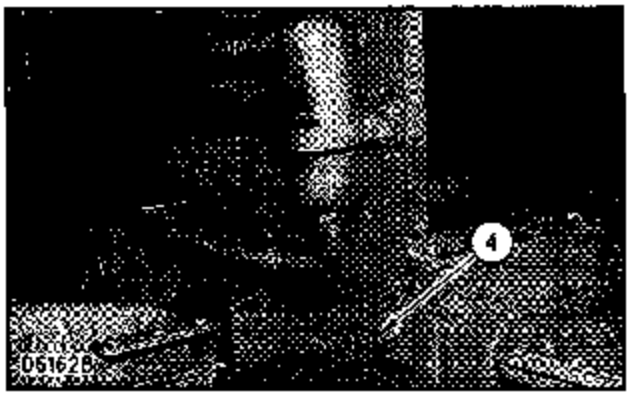
g. remove air cleaner

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

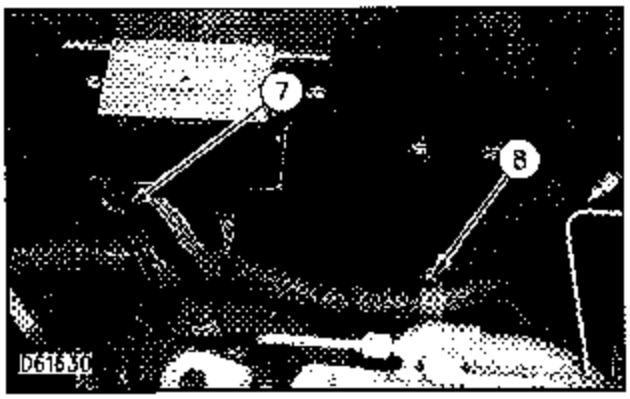
NOTE: Although it is possible to remove just the engine alone, it is difficult to install and align the engine to the torque converter in chassis. Additional support is required for safety and stability. For the purposes of this procedure the engine torque converter transmission and output gears will be removed as a unit. The engine will be separated from the drive train in the following story of this publication.

1. Fasten straps and hoist to side door (1) and remove six bolts and washers that connect side door (1) to fire wall group. Repeat for opposite side.

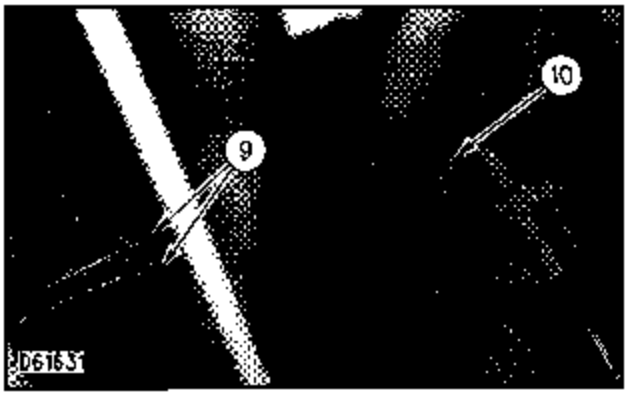


2. Disconnect wire (4) from the fire wall.

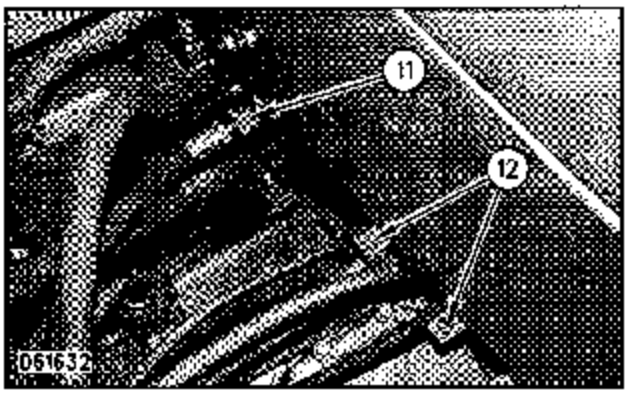
3. Remove four bolts and washers (5) from electrical box (6) and lay cover to the side.



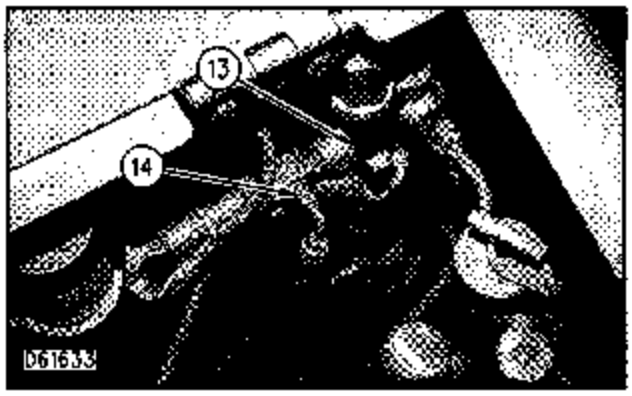
4. Remove three straps (8) that hold wiring harness to back of firewall group. Disconnect electrical connector (7).



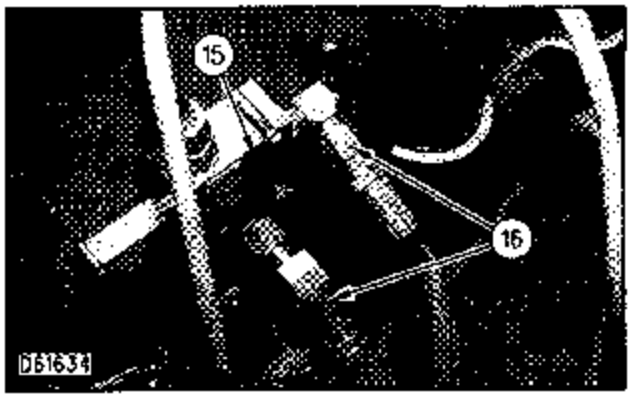
5. Disconnect two hoses (9) and one line (10) located inside the firewall group. Cap or plug all ends to prevent fluid loss.



6. Remove two bolts (12) and straps that hold three hoses to the lower front of the firewall group. Disconnect line (11) from the manifold. Cap or plug ends to prevent fluid loss.

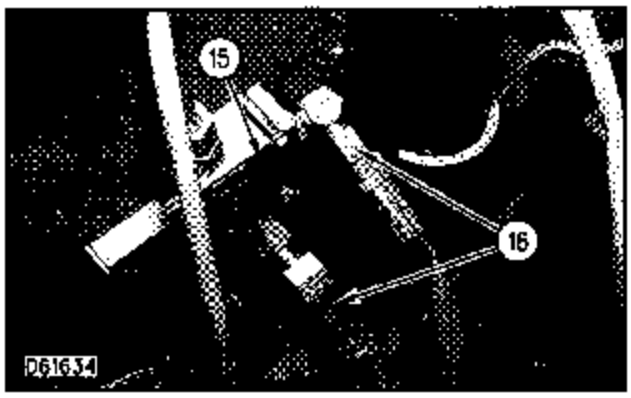


7. Disconnect hose (14) from parking brake valve (13) and from firewall. Cap or plug ends to prevent fluid loss.

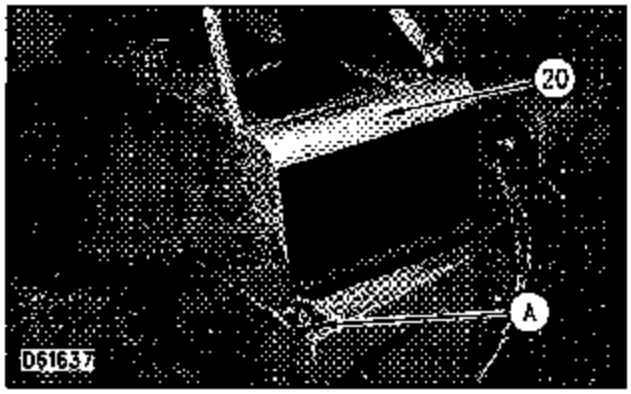


8. Disconnect two hoses (16) from pressure reducing valve (15). Cap and plug ends to prevent fluid loss.

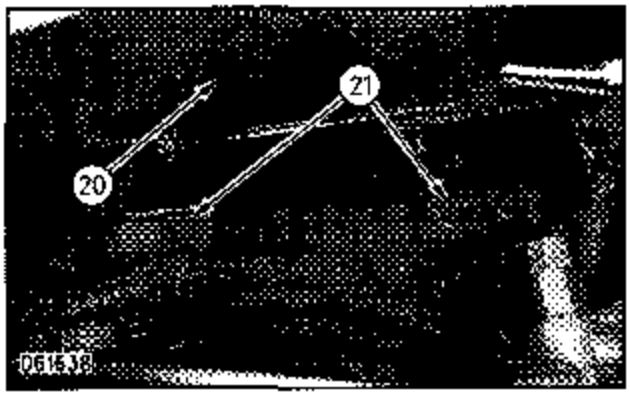
9. disconnect wiring harness (17) on the inside of the firewall.



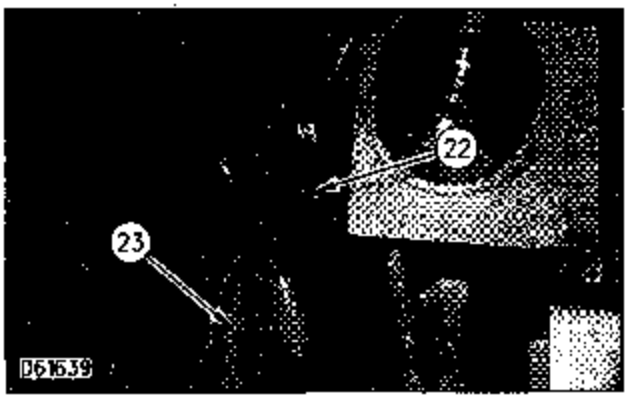
10. Remove bolt, washer (19) and strap that hold wiring harness (18) to firewall.



11. Attach tooling (A), straps and a hoist to firewall group (20) as shown.

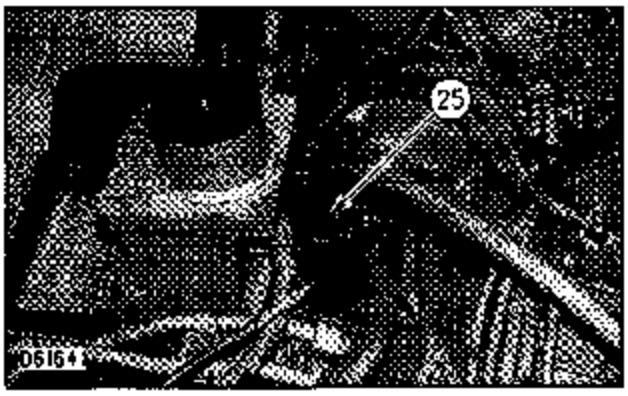


12. Remove eight bolts and washers (21) that hold firewall group (20) to frame. Remove firewall group (20). Weight of the firewall group is **114 kg (250 lb)**.

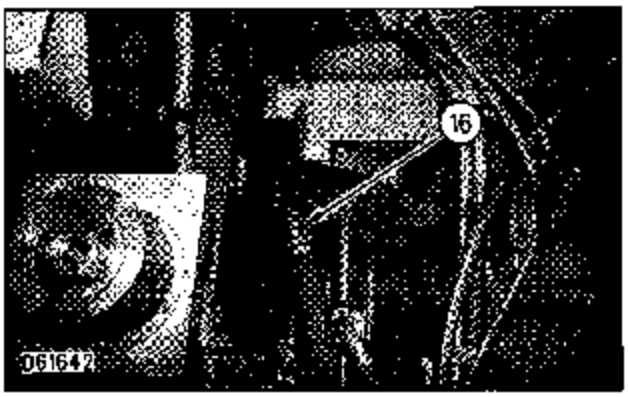


13. Disconnect hydraulic oil line (22) from front of hydraulic oil pump (23).

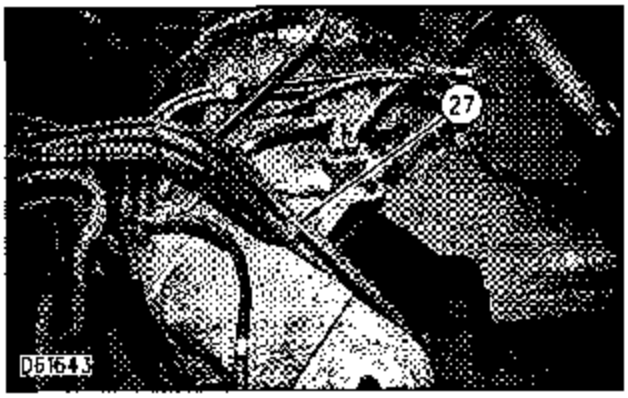
14. Remove bolt, washer and nut (24) and bracket that connect hard line and hose together.



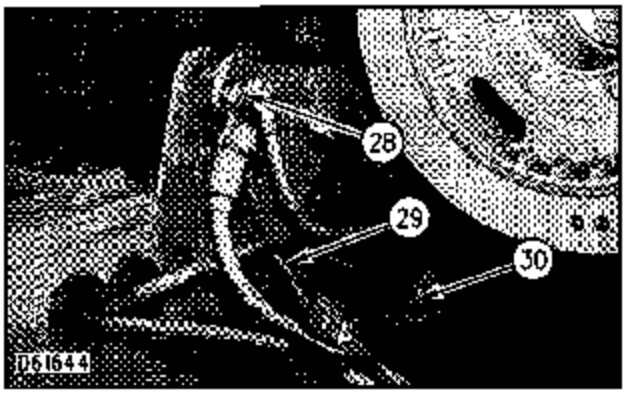
15. disconnect hose (25) from hydraulic oil pump.



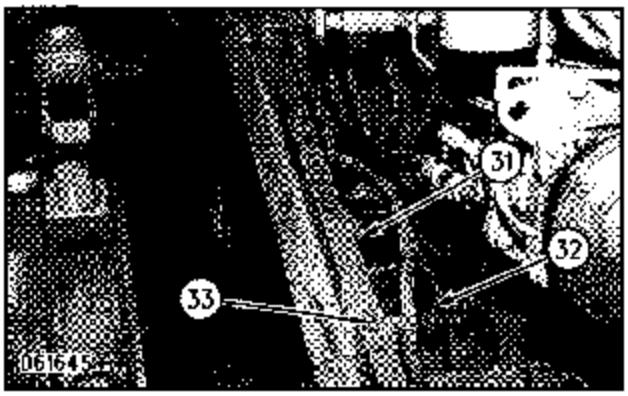
16. disconnect hose (26) from hydraulic oil pump.



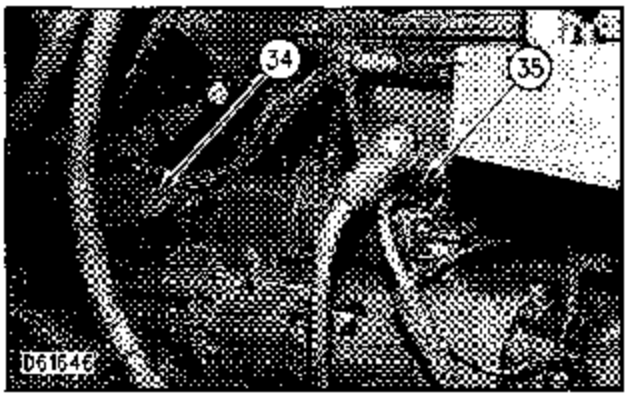
17. Remove bolt, washer and bracket (27) securing hoses to the frame.



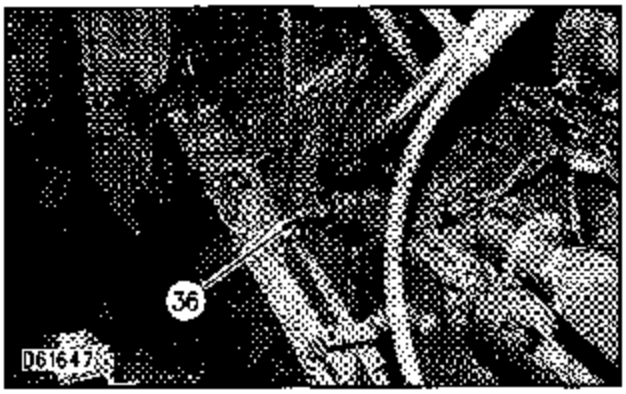
18. Remove nut (28), battery cable and wiring harness (29) from main disconnect switch. Remove nut (30) and bracket holding wiring harness to inside of frame rail.



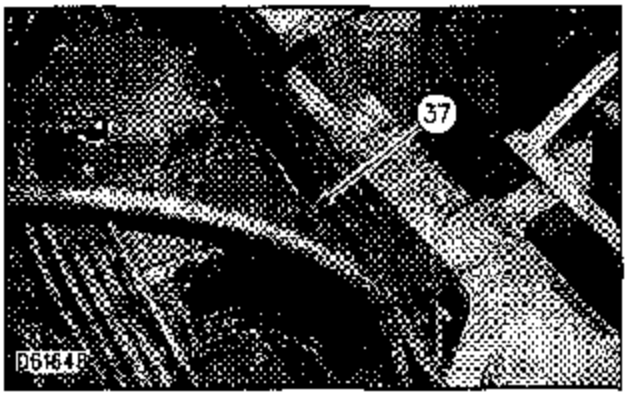
19. Remove two bolts (33) and brackets from frame rail. Remove nut (31) and washer that connect starter cable and wiring harness to frame. Remove bolt (32), washer and nut that holds starter cable to frame.



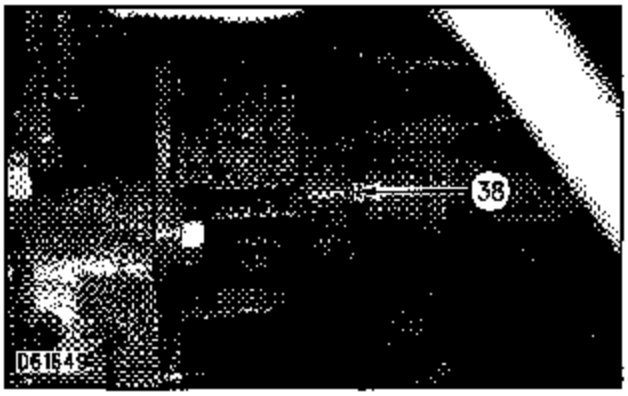
20. Disconnect three wires (35) from starter solenoid. Disconnect three electrical connectors (34).



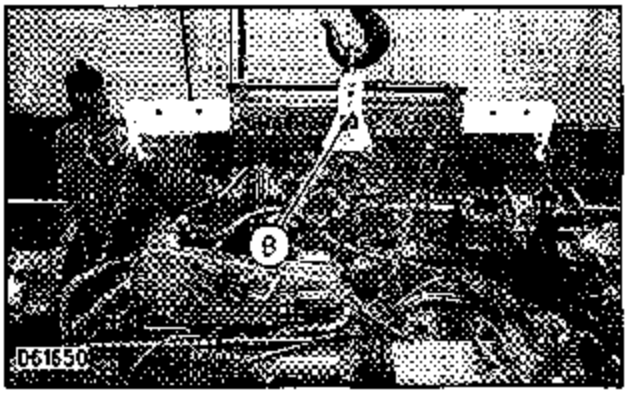
21. Remove four bolts, washers and transmission filter tube assembly (36) from left side of transmission.



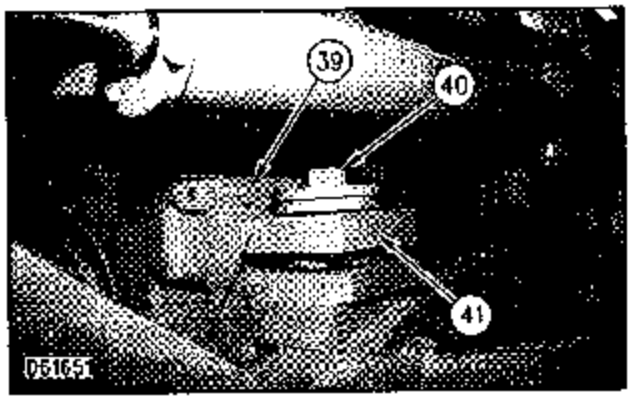
22. Disconnect two fuel lines (37) from inside the frame rail.



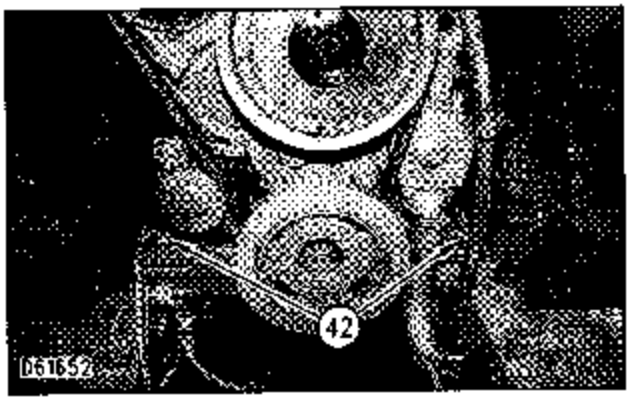
23. Remove four bolts and washers (38) and disconnect oil line from bracket on the front of the transfer case



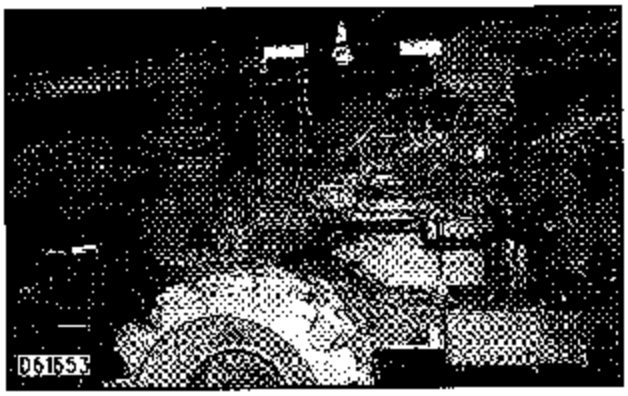
24. Using tooling (B) hooks and a hoist, support engine and transmission assembly as shown.



25. Remove eight bolts and washers (39) (four from each side) from mounting bracket (41). Remove two bolts and washers (40) and spacers from mounting brackets (41). Remove two brackets (41) (one from each side).



26. Remove two engine mounting bolts and washers (42).

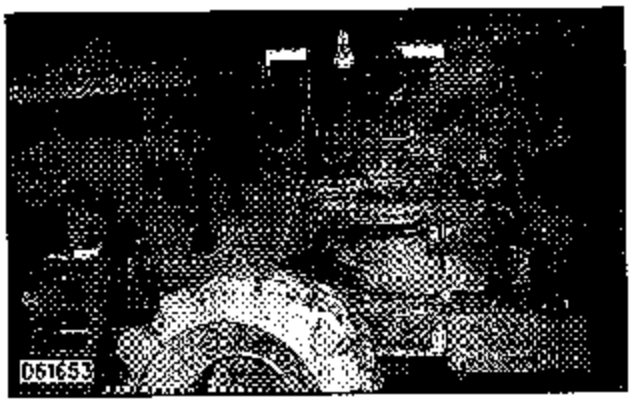


27. Remove engine and transmission as a unit from the vehicle. Insure that no lines or hoses are snagged or entangled as the engine and transmission are removed. Weight of the unit is **2384 kg (5250 lb).**

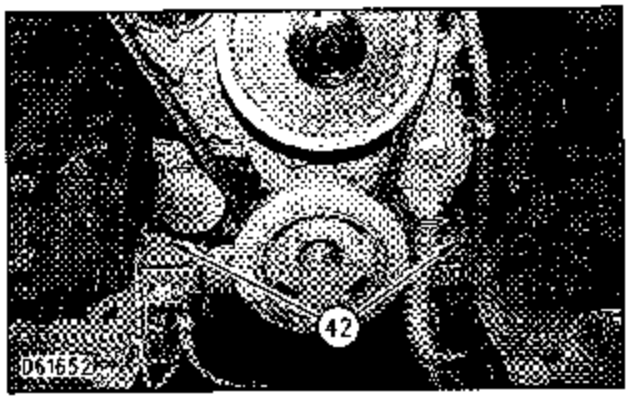
NOTE: The following steps are for the installation of the engine, torque converter, transmission and output gears.

NOTE: Check to insure that the battery disconnect switch is still in the **OFF** position and that the batteries are disconnected.

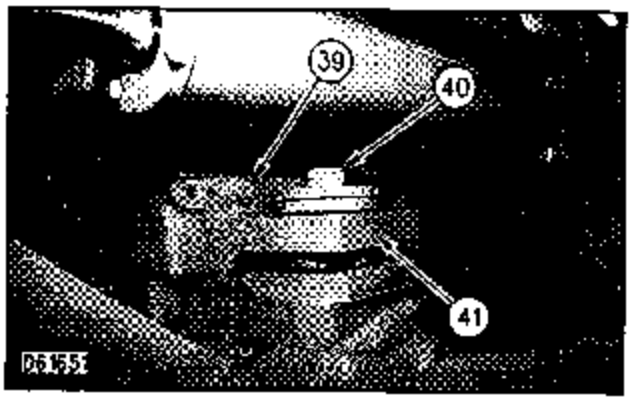
28. Inspect all motor mounts prior to the installation and replace any worn or damaged mounts prior to installation.



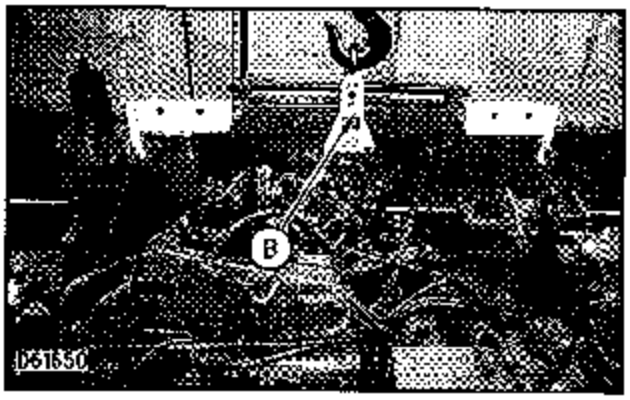
29. Install engine, torque converter, transmission and output gears as a unit. Lay all hoses, lines, cables and wires aside on the frame rails so that they do not become either snagged or crushed by the engine and power train as they are installed into the chassis. Weight of the engine and power train is **2384 kg (5250 lb)**.



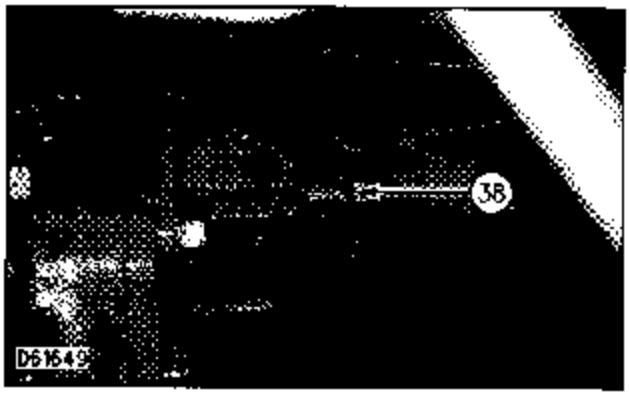
30. Install two engine mounting bolts and washers (42).



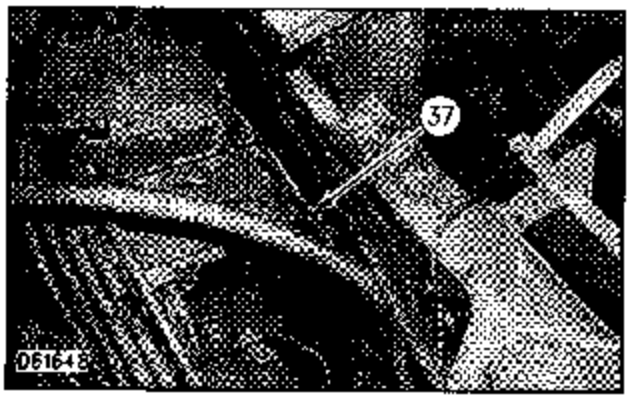
31. Install two brackets (41) (one on each side of the engine). Install eight bolts (39) (four on each side). Install two bolts (40) washers and spacers. Tighten bolts (40) to a torque of **1800 ± 200 N•m (1332 ± 148 lb ft)**



32. Using tooling (B) hooks and a hoist, support the engine and transmission assembly until it is in place and stabilized in chassis.

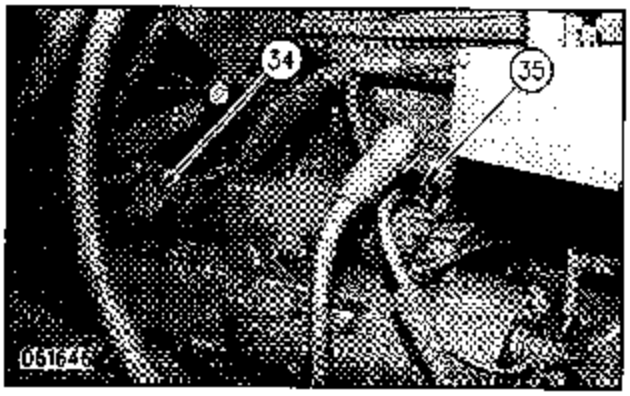


33. Connect hydraulic hose in front of transfer case and secure with four bolts and washers (38).

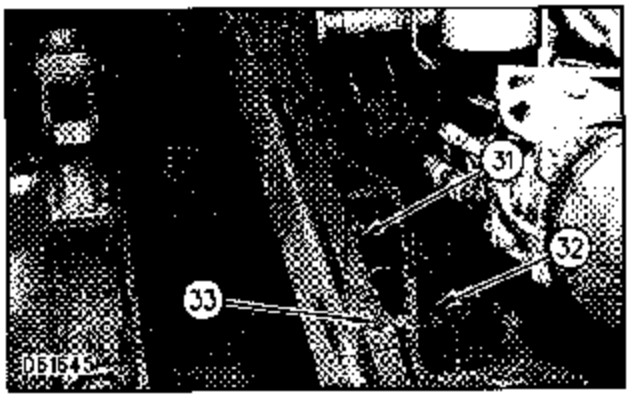


34. Connect two fuel lines (37) located beside the frame rail.

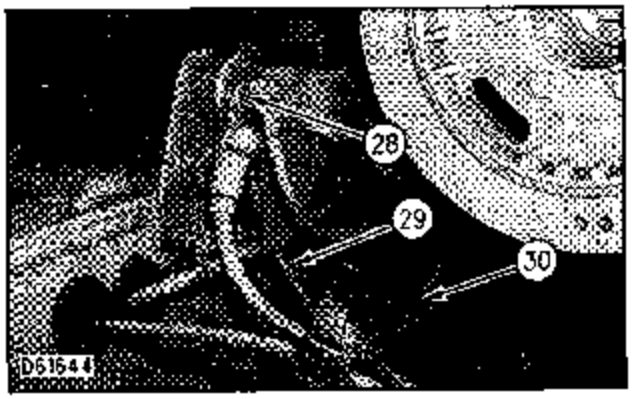
35. Install transmission filter tube assembly (36) located on the left side of the transmission. Secure with four bolts and washers.



36. Install three electrical connectors (34). Connect three wires (35)to the starter solenoid.



37. Install bolt (32) and washer and nut that hold starter to frame. Install nut (31) and washer that connect starter cable and wiring harness to the frame. Install bracket and secure with two bolts (33) to the frame rail.

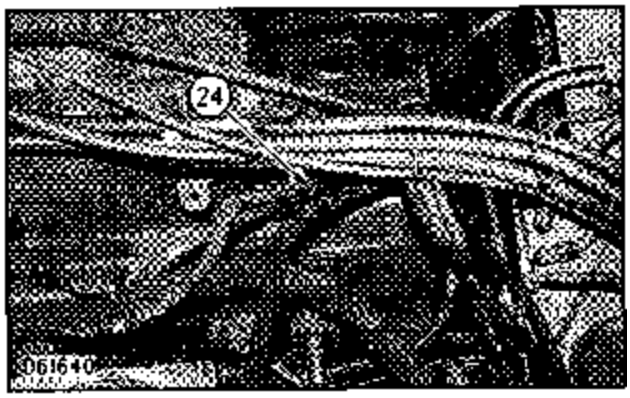


38. Install nut (30 and bracket holding harness to inside of frame rail. Install battery cable and wiring harness (29) and secure to main disconnect switch with nut (28).

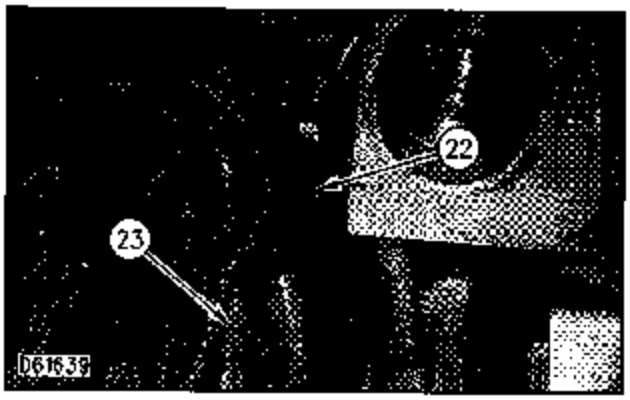
39. Instal bracket (27) holding hoses to frame rail and secure with a bolt and washer.

40. Connect hose (26) to hydraulic oil pump.

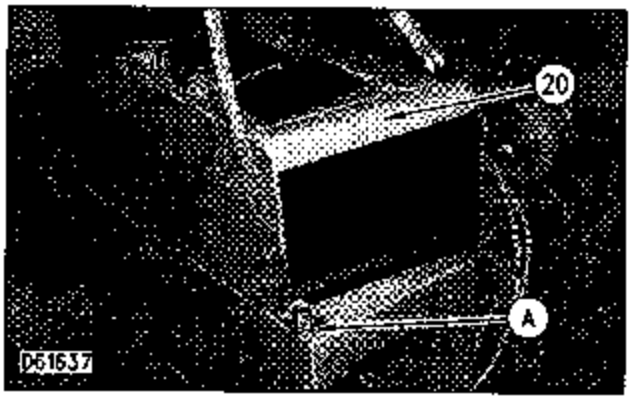
41. Connect hose (25) to hydraulic oil pump.



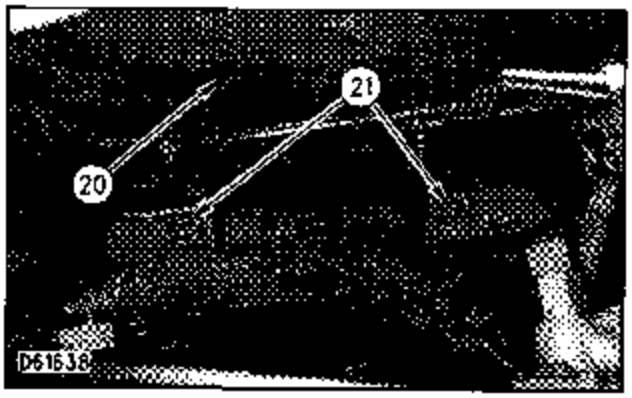
42. Connect hard line and hose together by use of bolt, washer and nut (24).



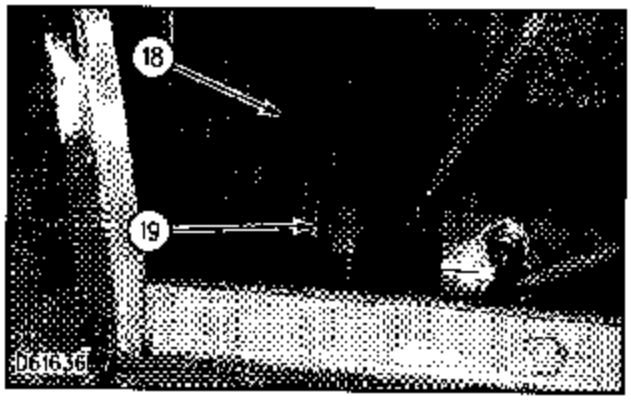
43. Connect hydraulic oil line (22) to the front of hyoraulic oil pump (23).



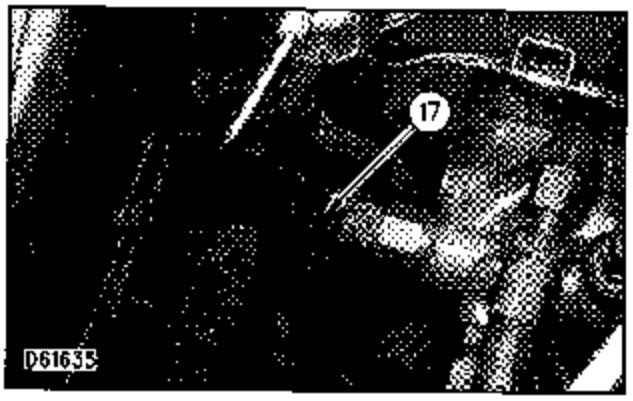
44. Attach tooling (A) straps and a hoist to firewall group (20) as shown.



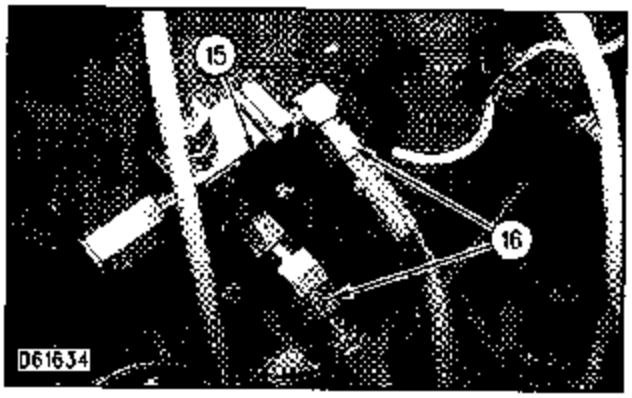
45. Install the firewall group (20). Weight of the frowall group is **114 kg (250 lb)**. Install eight bolts and wasners (21) that hold firewall group (20) to the frame.



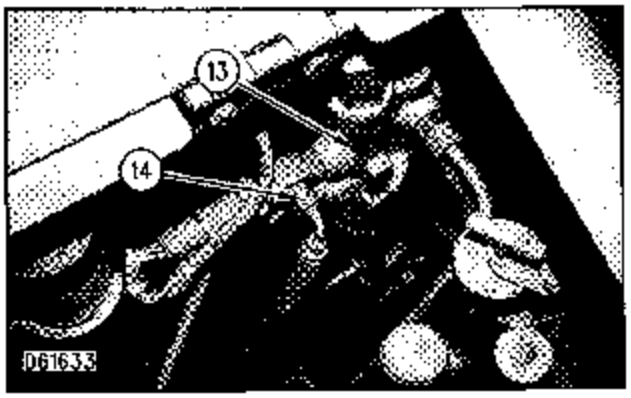
46. Install strap that holds wiring harness (18) to the firewall. Secure by using bolt and washer (19).



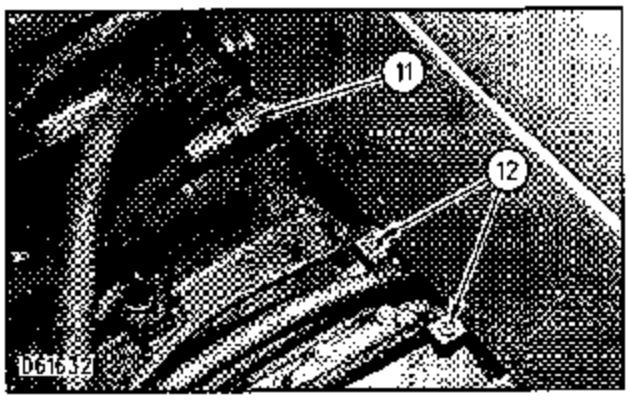
47. Connect wiring harness (17) on the inside of the firewall.



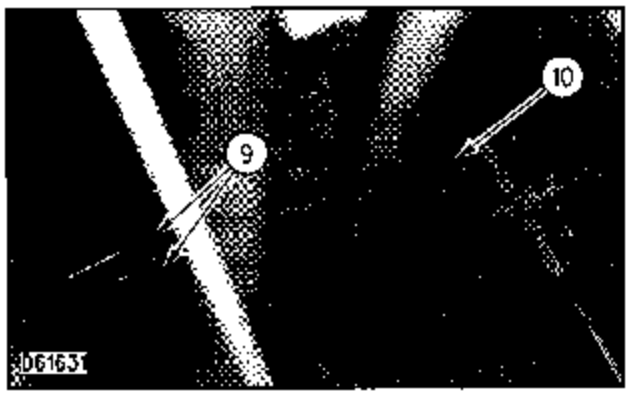
48. Remove plugs from hoses (16). Connect hoses (16) to pressure reducing valve.



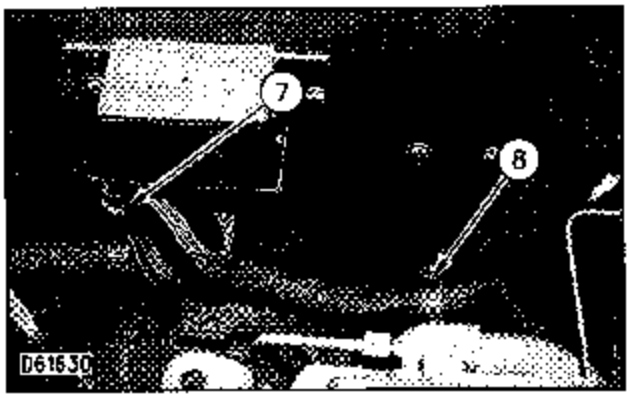
49. Remove plugs from hoses (14). Connect hose (14) to parking brake valve and secure to firewall.



50. Remove plugs from hoses (11). Connect line (11) as shown. Install two bolts (12) and straps that hold three hoses to lower front of the firewall group.

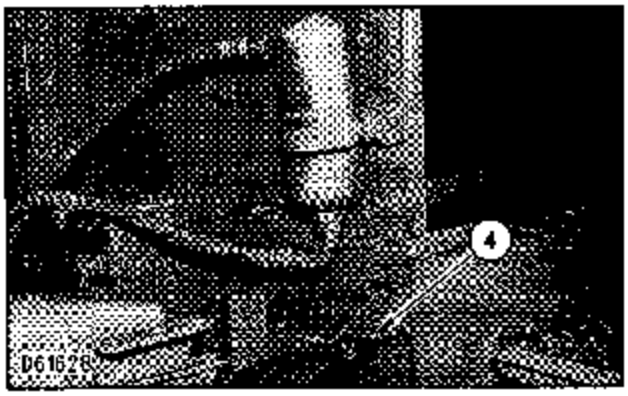


51. Remove plugs from hoses (9) and (10). Connect two hoses (9) and one line (10) located inside the firewall group.



52. Connect electrical connector (7). Install three straps (8) that hold the wiring harness to the back of the firewall group.

53. Install cover onto electrical box (6) and secure with four bolts (5).



54. Connect wire (4) to fire wall.

55. Attach straps and a hoist to side door (1). Hoist the door into place and align. Install six bolts that secure the door to th firewall group. Repeat the process for the opposite side.

56. Check all hoses and lines and hoses to insure that all are connected and tightened properly to prevent leaks. Check all electrical connections for correctness and good contact.

End By:

a. Install air cleaner

b. install exhaust exhaust pipe

c. Install hood

d. Install precleaner

e. install front and rear drive shafts

f. install radiator guard group

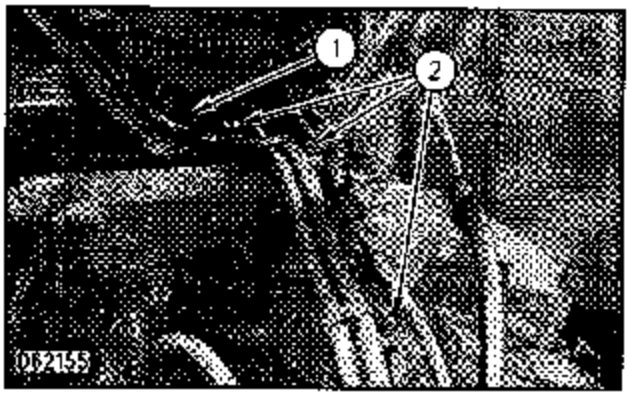
g. install cab

Engine & Transmission

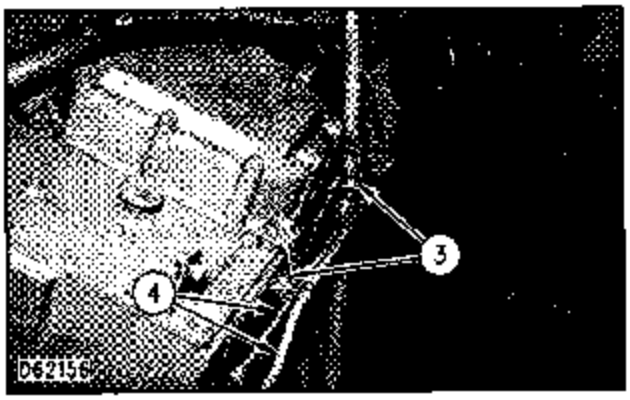
Separate & Connect Engine And Transmission 1000-029

Tools Needed		A	B	C	D
1U-9780	Stands	2			
6V-6146	Load Leveler		1		
6V-2157	Link Bracket			1	
1U-9759	Stand				1

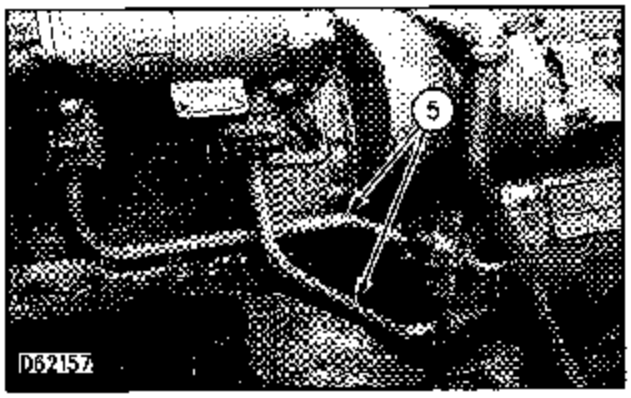
1. Using blocks and tooling (A), support engine and transmission assembly as shown.



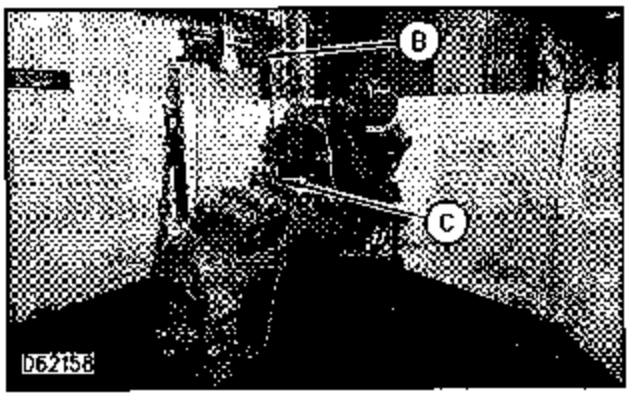
2. Remove three bolts, washers and brackets from transmission. Disconnect electrical connector (1).



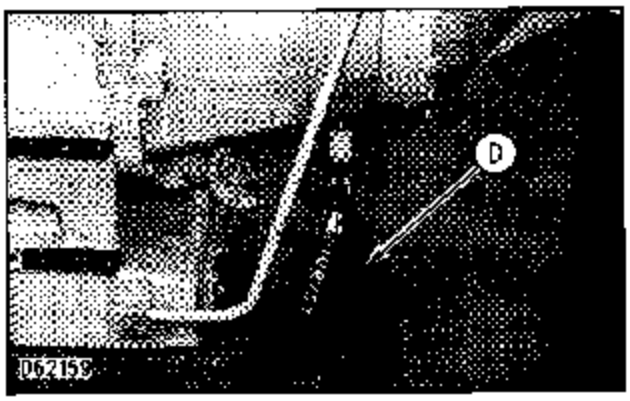
3. Remove two bolts, nuts and washers (3) that connect fuel lines (4) to the transmission.



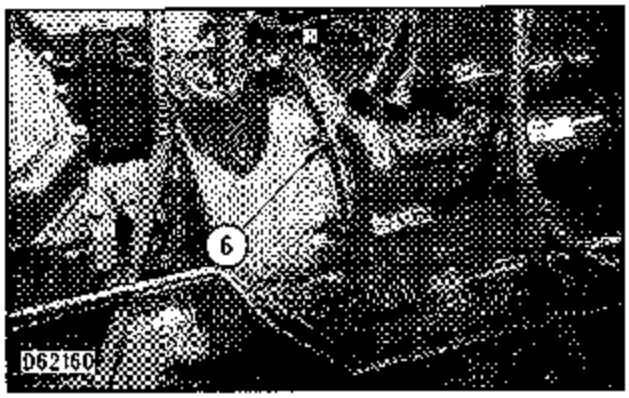
4. Remove bolts and washers necessary to remove hard lines (5) from relief valve to transmission oil cooler.



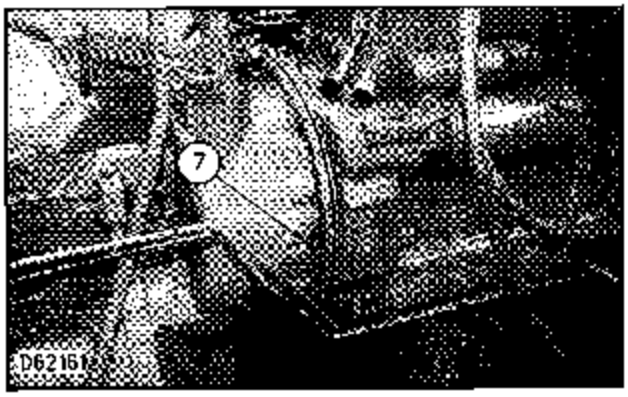
5. Attach chains , hoist, tooling (B) and tooling (C) to the transmission as shown.



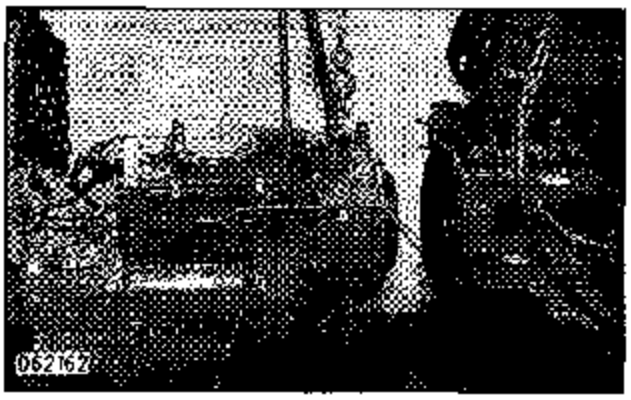
6. Place tooling (D) under rear of transmission as shown.



7. Remove twelve bolts (6) and washers connection transmission and engine.



8. Thread two forcing screw bolts (one on each side of the engine) into the torque converter housing and against the flywheel housing. Add pressure to each side equally.



9. Separate the transmission from the engine. Weight of the transmission is **1226 kg (2700 lb).** Weight of the engine is **1158 kg (2550 lb).**

NOTE: Connect the engine to the torque converter, transmission and output gears in the exact reverse order from separation.

Engine

Remove & Install Engine 1000-010

Tools Needed	A
6V3145 Load Leveler	1

Start By:

a. remove air cleaner

b. remove exhaust exhaust pipe

c. remove hood

d. remove precleaner

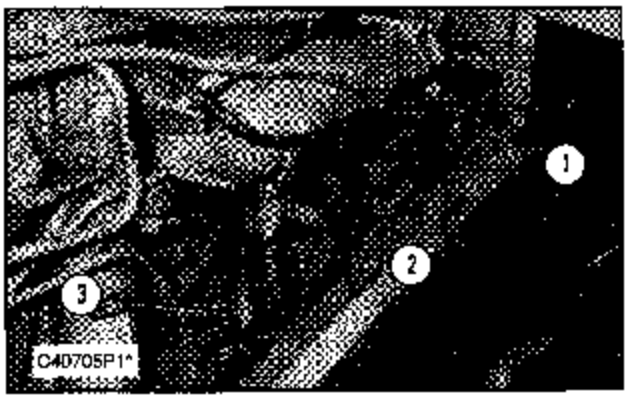
e. remove radiator guard group

f. remove engine side panels

NOTE: This story will display the removal of the engine alone while leaving the torque converter, transmission and output gears in chassis. Even though the engine can be removed in this manner, safety must be emphasized. Stability and alignment are critical. Do not attempt to remove or install the engine alone until the proper jacks and cribbing have been installed to completely stabilize the torque converter, transmission and output gears.

FLUID SPILLAGE CONTAINMENT

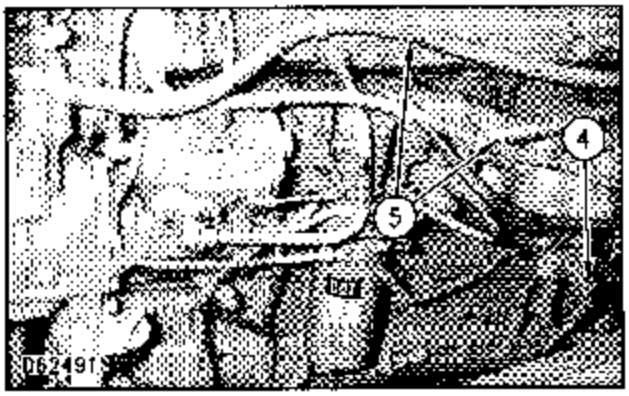
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



1. Remove eight bolts (2) that hold the two tube assemblies to the bottom of the transmission oil cooler.

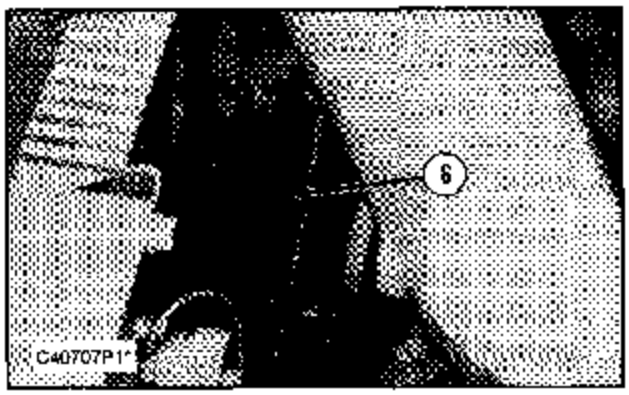
2. Disconnect wire harness (3).

3. Remove bracket (1) from the transmission oil cooler.

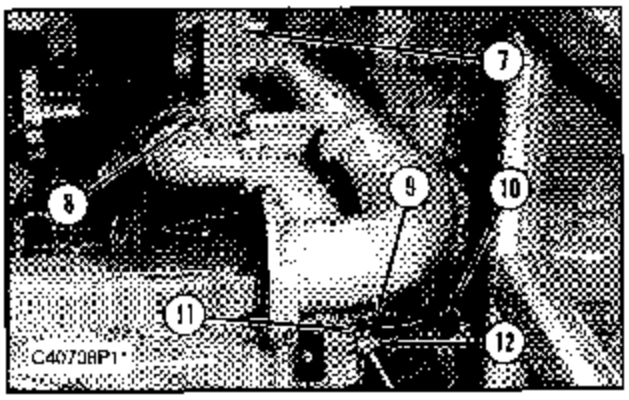


4. Close the two valves for the cab heater hoses. Disconnect two hoses (5). Remove all clips that hold the heater hoses to the side of the engine.

5. Disconnect wiring harness (4).

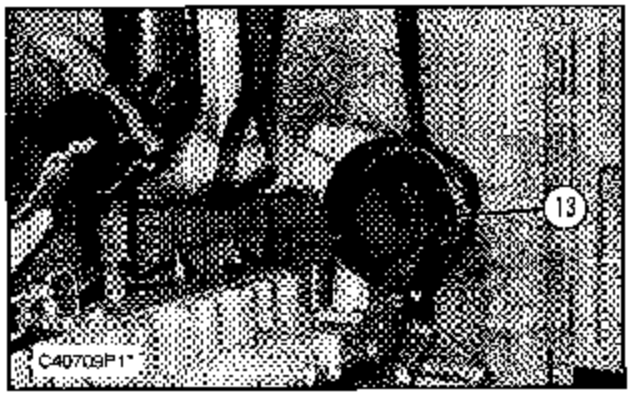


6. Disconnect wiring harness (6) at the rear of the engine.

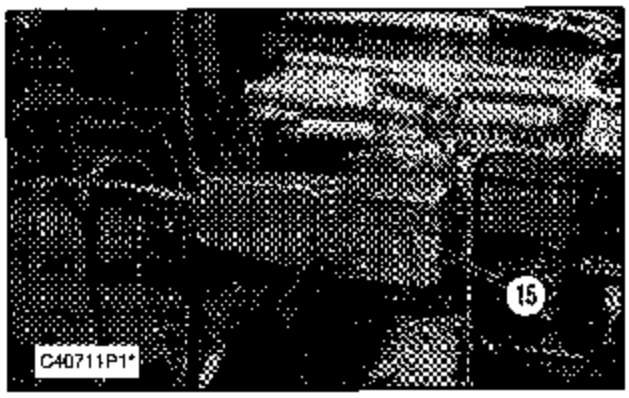


7. Disconnect tube assemblies (9) and (10).

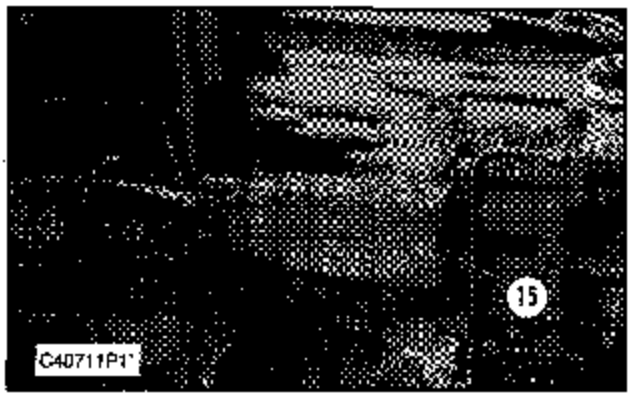
8. Remove two bolts (8) and the retainers. Loosen clamp (7). Remove four bolts (11) and two bolts (12) and the washers.



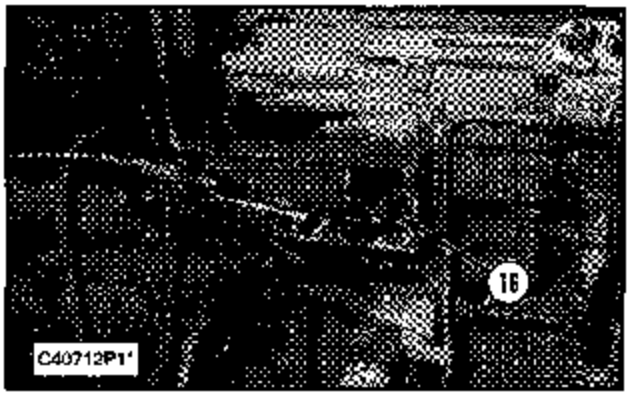
9. Fasten a lifting strap and a hoist to elbow (13). Remove the elbow from the rear of the engine. The weight of the elbow is **36 kg (80 lb).**



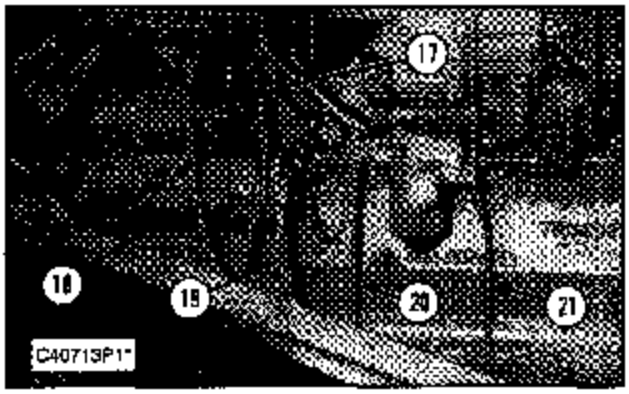
10. Put identification marks on two wiring harnesses (14). Disconnect the wiring harnesses.



11. Remove cover (15) from the fuel system.



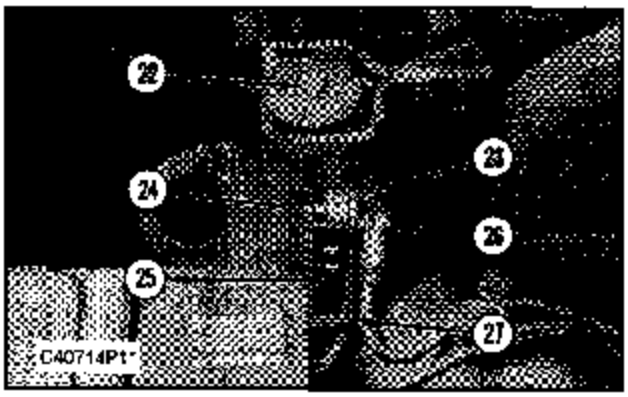
12. Remove bolts (16) and the washers that hold the control cable housing to the side of the governor. Remove the housing from the governor.



13. Disconnect tube assembly (20) from the fue filter housing.

14. Disconnect tube assembly (21) from the fue system.

15. Put identification marks on all wires that are connected to electric starting motor (18). Disconnect three wires (17) from the so enoid. Disconnect wire (19) from the electric starting motor.

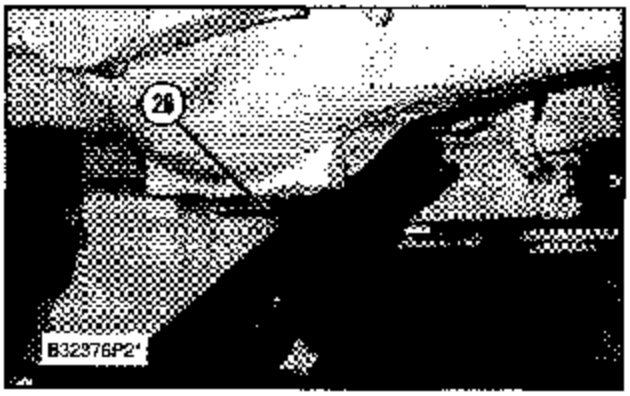


16. Disconnect four grease tubes (25). Disconnect wire cable (23).

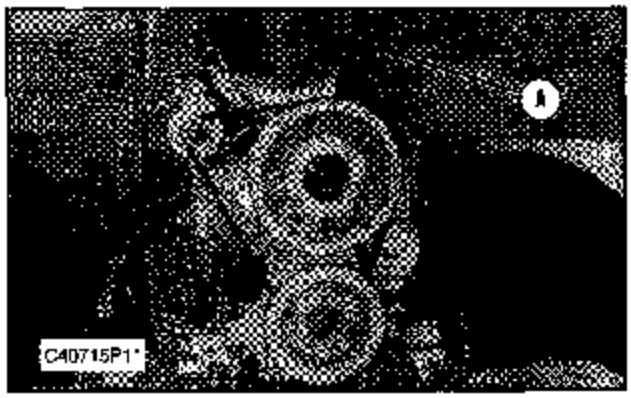
17. Put identification marks on the wires that are connect to the disconnect switch. Remove wires (26) from the disconnect switch.

18. Remove the bolts, washers and spacers that hold disconnect switch (24) to the frame of the machine. Remove the disconnect switch.

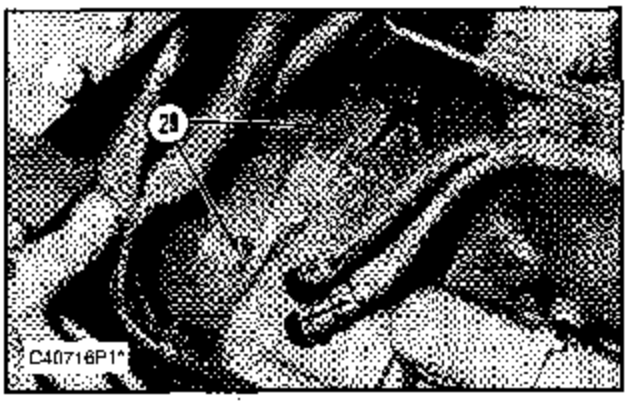
19. Remove front engine mounting bolts (22).



20. Put a suitable floor jack (28) in position under the transmission so it will not fall when the engine is removed. Put slight lifting tension on the transmission.



21. Fasten tool (A) and a hoist to the engine lifting brackets. Put slight lifting tension on the engine.

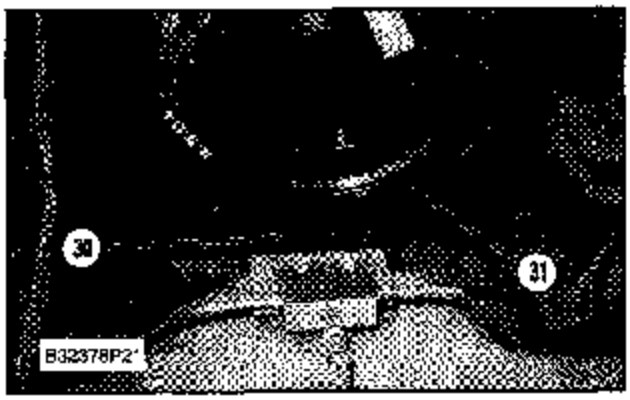


22. Remove twelve bolts (29) and the washers that hold the torque converter housing to the flywheel housing.

NOTE: If necessary, use forcing screws to separate to the torque converter housing from the flywheel housing.

23. Lift up on the engine a small amount, and remove it from the machine. The weight of the engine is **1089 kg (2400 lb).**

24. Remove the O-ring seal from the outside diameter of the torque converter housing.



25. Put spacer blocks (30) between torque converter housing (31) and the front support of the rear axle.

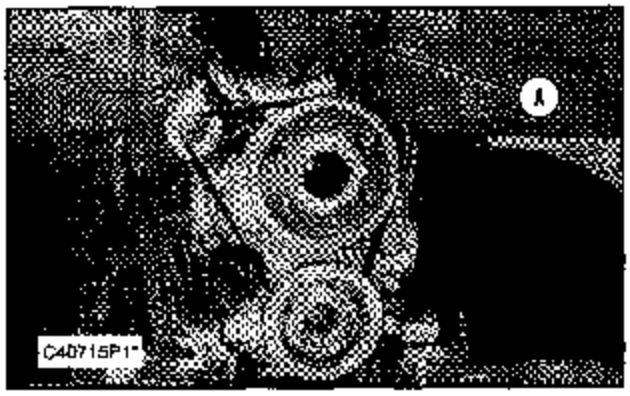
NOTE: The following steps are for the installation of the engine.

26. Check the condition of the O-ring seal used on the outside diameter of the torque converter housing. If the seal is worn or damaged, use a new part for replacement.

27. Install the O-ring seal on the torque converter housing, and put clean oil on it.

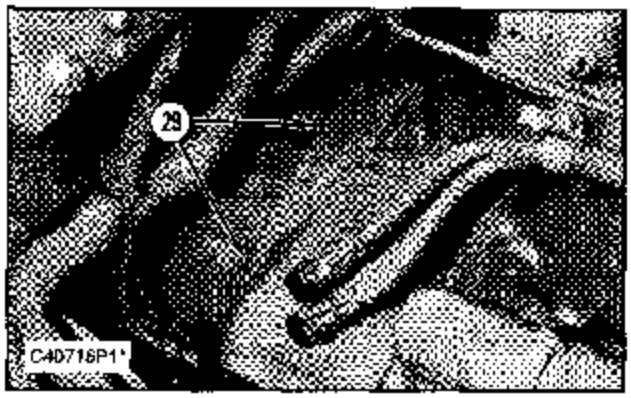
28. Check the condition of the front engine mount assemblies. If the mount assemblies are worn or damaged, use new parts for replacement.

29. Install the front mount assemblies in the front engine mounting brackets.



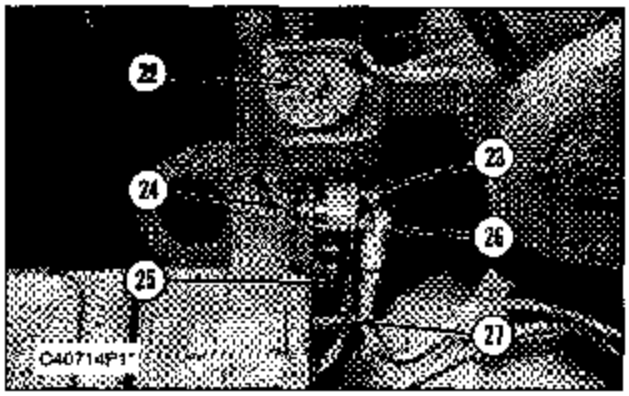
30. Fasten tool (A) and a hoist to the engine. Prior to installing the engine in the machine, be sure it hangs level.

31. Install the engine in the machine, aligning the flywheel with the torque converter.



32. Install twelve bolts (29) and the washers that hold the torque converter housing to the flywheel housing.

33. Remove spacer blocks (30) from between the torque converter housing and the front support of the rear axle. Remove floor jack (28) from under the transmission.

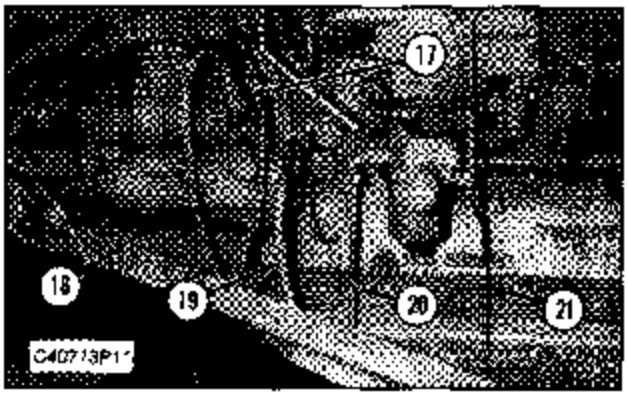


34. Install front mounting bolts (22) and the washers. Tighten the mounting bolts.

35. Put disconnect switch (24) in position on the frame of the machine. Install the spacers, washers and bolts (27) which hold it.

36. Reconnect wires (26) to the disconnect switch in their original locations.

37. Reconnect wire cable (23). Connect grease tubes (25) to the fittings on the mounting bracket for the disconnect switch.

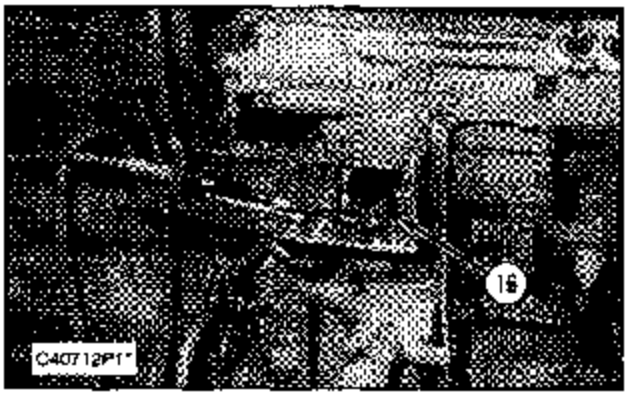


38. Connect tube assembly (21) to the fuel system.

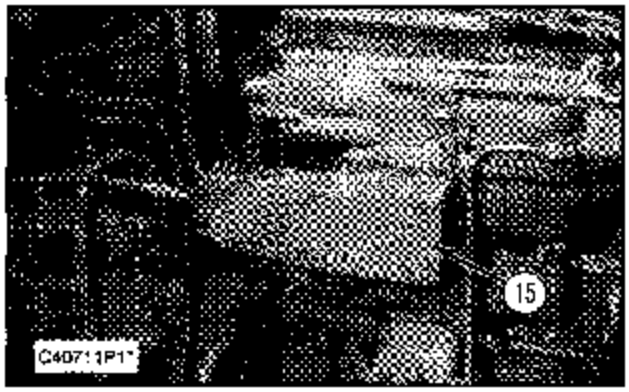
39. Connect tube assembly (20) to the fuel filter base.

40. Connect three wires (17) to the starter solenoid in their original locations.

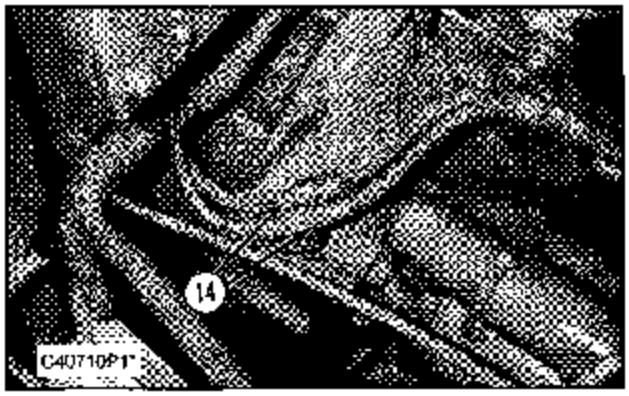
41. Connect wire (19) to the electric starting motor.



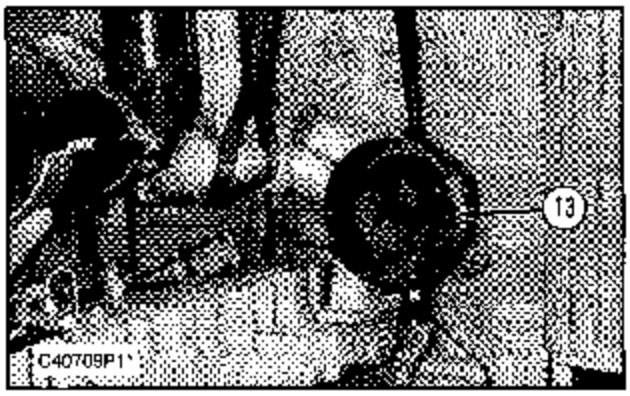
42. Put control cable housing in position on the side of the governor. Install bolts (16) that hold it.



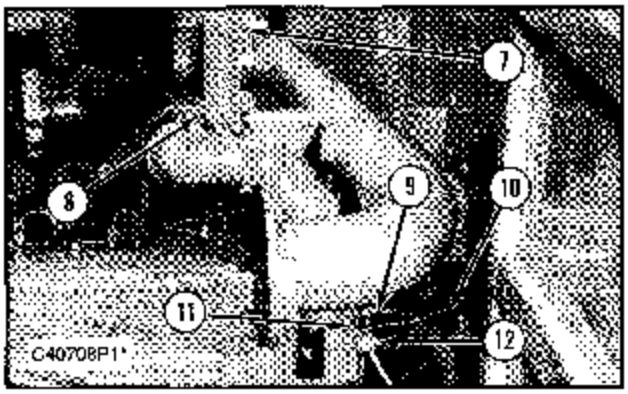
43. Install cover (15) on the fuel system.



44. Reconnect two wiring harnesses (14).

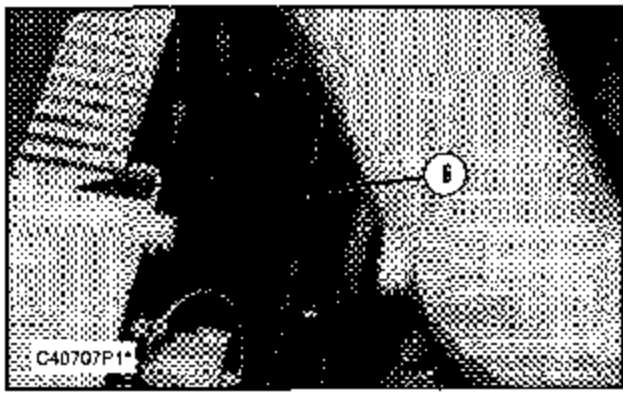


45. Fasten a lifting strap and a hoist to elbow (13) and put it in position on the rear of the engine.

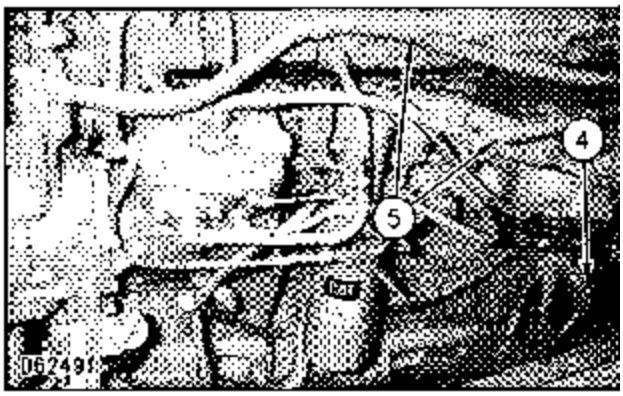


46. Install two bolts (12) and four bolts (11) and the washers that hold elbow (13). Install the retainers and two bolts (8), reinstall clamp (7), and tighten it.

47. Reconnect tube assemblies (9) and (10).



48. Reconnect wiring harness (6) at the rear of the engine.



49. Connect wiring harness (4).

50. Reconnect two heater hoses (5). Install all clips which hold the heater hoses to the side of the engine. Open the two heater hose valves.

51. Check the condition of the O-ring seals used in the two tube assemblies which are connected to the bottom of the transmission oil cooler. If the seals are worn or damaged, use new parts for replacement. Install the O-ring seals in the tube assemblies, and connect them to the bottom of the transmission oil cooler.

52. Connect wiring harness (3).

53. Reinstall bracket (1) on the side of the transmission oil cooler.

End By:

a. install air cleaner

b. install exhaust exhaust pipe

c. install hood

d. install precleaner

e. install radiator guard group

f. install engine side panels

CATERPILLAR®

SENR1307
February 1996

Specifications

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Train

814F	815F	816F	Transmission
9DM1-UP	1GN1-UP	5FN1-UP	1XY1-UP 1YY1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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Introduction

When the words "use again" are in the description, the specification given can be used to determine if a part can be used again. If the part is equal to or within the specification given, use the part again.

When the word "permissible" is in the description, the specification given is the "maximum or minimum" tolerance permitted before adjustment, repair and/or new parts are needed.

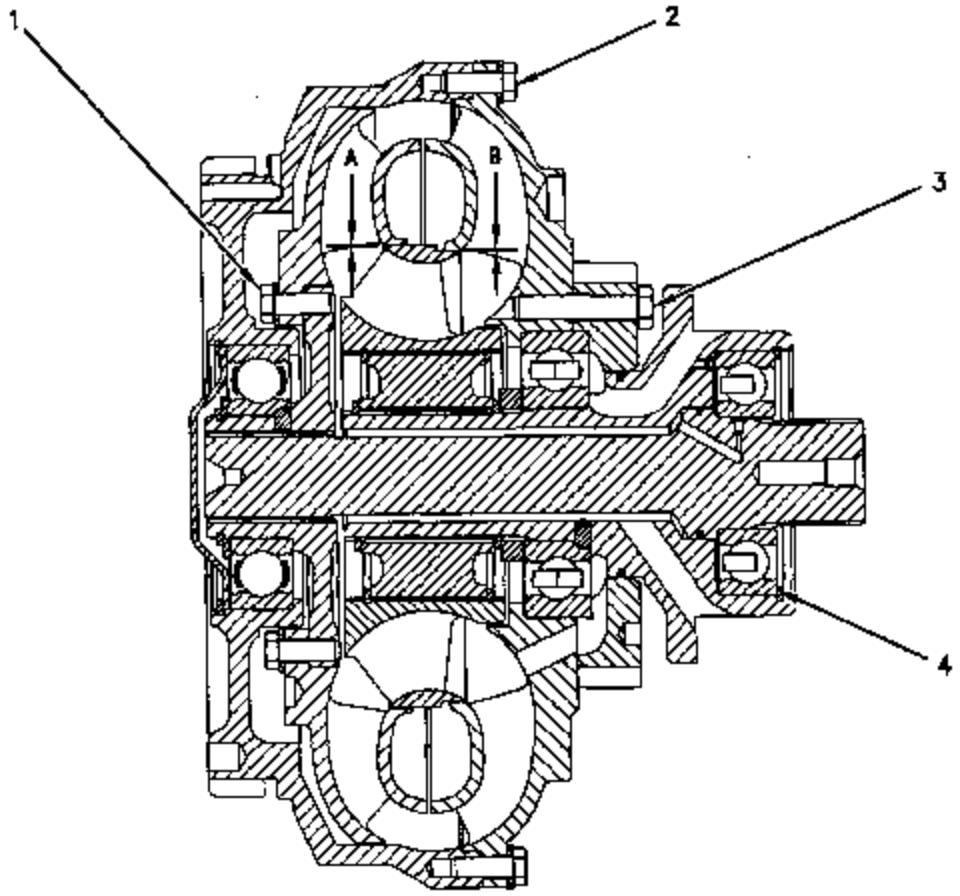
A comparison can be made between the measurements of a worn part and the specifications of a new part to find the amount of wear. A part that is worn can be used if an estimate of the remainder of its service life is good. If a short service life is expected, replace the part.

Reference: For Systems Operation and Testing and Adjusting make reference to SENR1308, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Train. See SENR1309 for 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Shift Transmission Testing and Adjusting.

Specifications

Torque Converter

61-9798



D53084

(1) Torque for 16 bolts that fasten turbine to hub assembly ..... 60 ± 7 N•m (44 ± 5 lb ft)

(2) Torque for 18 bolts that fasten impeller to housing ..... 60 ± 7 N•m (44 ± 5 lb ft)

(3) Torque for 8 bolts that fasten gear to impeller ..... 105 ± 15 N•m (75 ± 11 lb ft)

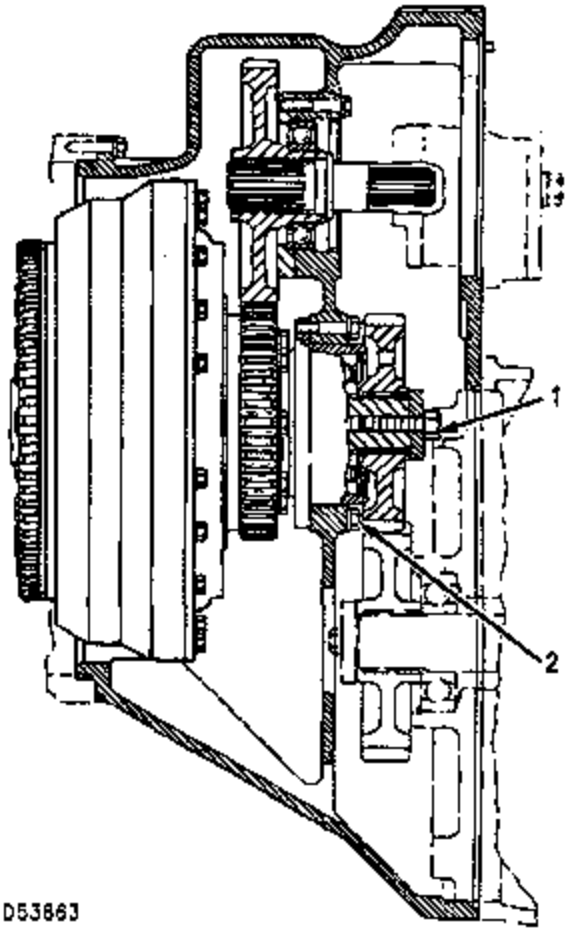
(4) Install bearing with closed end of retainer towards seal ring.

Clearance between		Across the diameter	Running*
(A) Stator & Turbine	new	0.49 to 1.01 mm (.019 to .040 in)	0.25 to 0.51 mm (.010 to .020 in)
	max. worn	1.50 mm (.059 in)	0.75 mm (.030 in)
(B) Stator & Impeller	new	0.49 to 1.01 mm (.019 to .040 in)	0.25 to 0.51 mm (.010 to .020 in)
	max. worn	1.50 mm (.059 in)	0.75 mm (.030 in)

* Half the clearance across the diameter.

Torque Converter And Pump Drive Housing

122-4880

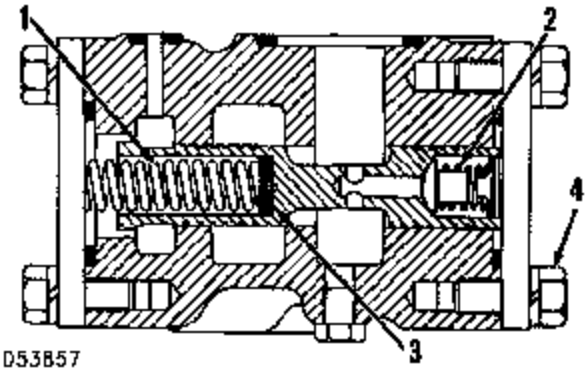


(1) Tighten bolt to a torque of ... 120 ± 20 N•m (90 ± 15 lb ft)

(2) Torque for eight bolts ..... 50 ± 10 N•m (37 ± 7 lb ft)

Torque Converter Outlet Relief Valve

3S-2695



Pressure setting ..... 414 ± 14 kPa (60 ± 2 psi)
at a flow of ..... 76 ± 0.8 L/min (20 ± .2 gpm)

(1) 2S-1382 Spring for relief valve:
Length under test force ..... 44.2 mm (1.74 in)
Test force ..... 103 ± 8 N (23.1 ± 1.8 lb)
Free length after test ..... 50.04 mm (1.97 in)
Outside diameter ..... 15.09 mm (.594 in)

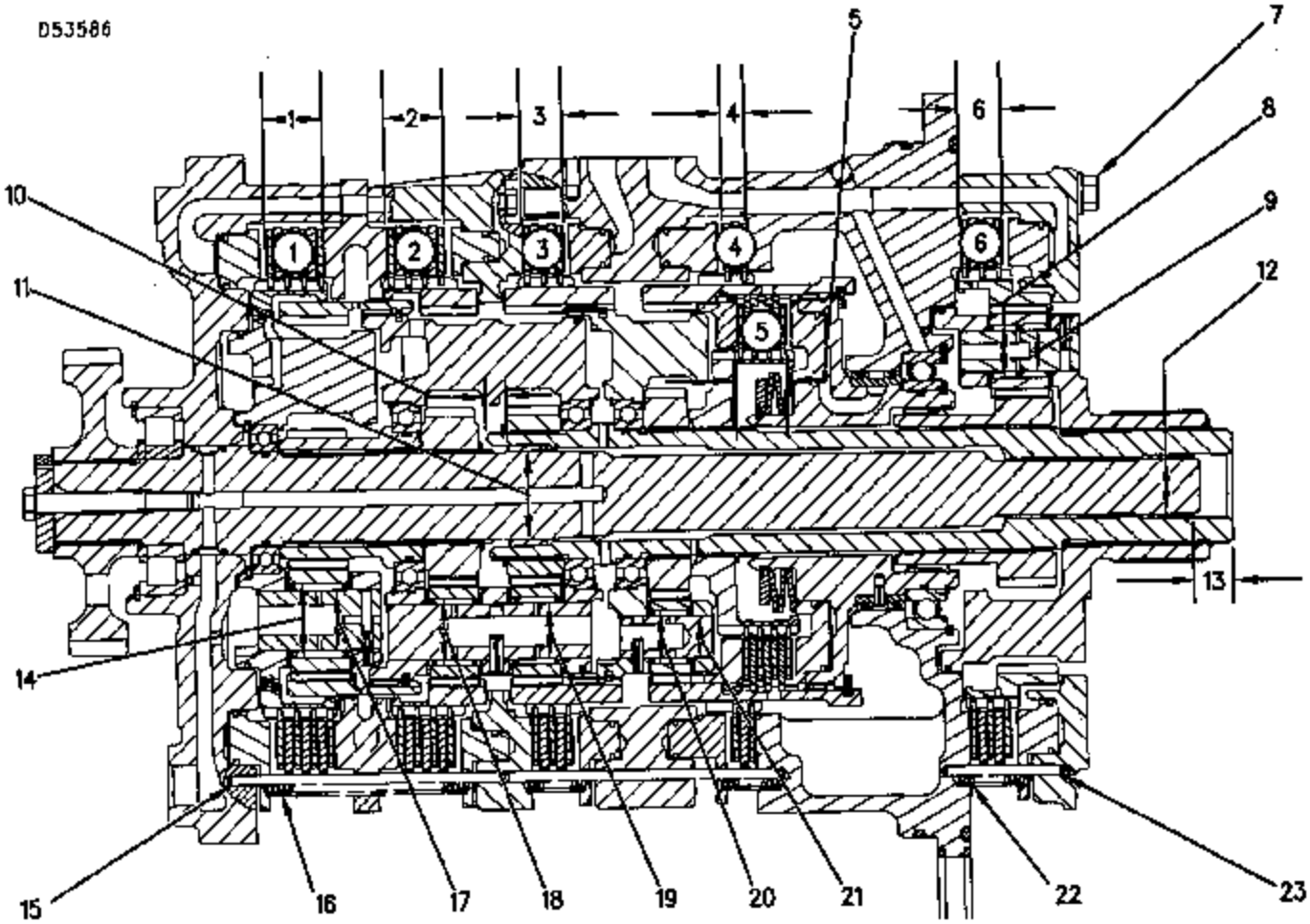
(2) 5M-9548 Spring for poppet valve:
Length under test force ..... 21.3 mm (.84 in)
Test force ..... 4.4 ± 0.4 N (1.00 ± .08 lb)
Free length after test ..... 34.0 mm (1.34 in)
Outside diameter ..... 12.2 mm (.48 in)

(3) 4M-1751 Spacer:
Thickness of spacer ..... 0.41 mm (.016 in)
Outside diameter of spacer ..... 15.09 ± 0.25 mm (.594 ± .010 in)
One spacer will change pressure ..... 19 kPa (2.7 psi)
5S-7001 Spacer:
Thickness of spacer ..... 0.91 mm (.036 in)
Outside diameter of spacer ..... 14.15 ± 0.05 mm (.557 ± .002 in)
One spacer will change pressure ..... 40 kPa (6 psi)

(4) Torque for bolts that attach end covers to valve body ..... 48 ± 7 N•m (35 ± 5 lb ft)

Transmission Planetary

122-3775



(1), (2) Thickness of four new disc assemblies and three new plates for the NO. 1 and NO. 2 clutch ..... 37.36 ± 0.56 mm (1.471 ± .022 in)

Thickness of one new 9P-7390 Disc Assembly ..... 5.59 ± 0.08 mm (.220 ± .003 in)

Thickness of one new 8P-2051 Plate ..... 5.00 ± 0.08 mm (.197 ± .003 in)

(3), (6) Thickness of three new discs and two new plates for the NO. 3 and NO. 6 clutch ..... 26.77 ± 0.46 mm (1.054 ± .018 in)

Thickness of one new 6Y-5911 Disc ..... 5.59 ± 0.10 mm (.220 ± .004 in)

Thickness of one new 6I-8500 Plate ..... 5.00 ± 0.08 mm (.197 ± .003 in)

(4) Thickness of two new discs and one new plate for the NO. 4 clutch ..... 16.18 ± 0.28 mm (.637 ± .011 in)

Thickness of one new 6Y-5911 Disc ..... 5.59 ± 0.10 mm (.220 ± .004 in)

Thickness of one new 6I-8500 Plate ..... 5.00 ± 0.08 mm (.197 ± .003 in)

(5) Thickness of four new discs and three new plates for the NO. 5 clutch ..... 31.80 ± 0.64 mm (1.252 ± .025 in)

Thickness of one new 6Y-5912 Disc ..... 4.95 ± 0.10 mm (.195 ± .004 in)

Thickness of one new 8P-1964 Plate ..... 4.00 ± 0.08 mm (.157 ± .003 in)

(7) Torque for ten bolts ..... 115 ± 7 N•m (85 ± 5 lb ft)

(8) Inside diameter of planet gear (new) ..... 34.399 ± 0.010 mm (1.3543 ± .0004 in)

(9) Diameter of the shaft for the planet gears (new) ..... 26.439 ± 0.005 mm (1.0409 ± .0002 in)

(10) Depth to install bearing ..... 13.00 ± 0.25 mm (.512 ± .010 in)

(11) Inside diameter of bearing (new) ..... 56.650 ± 0.061 mm (2.230 ± .002 in)

Outside diameter of input shaft ..... 56.500 ± 0.013 mm (2.2244 ± .0005 in)

(12) Inside diameter of bearing (new) ..... 35.629 ± 0.039 mm (1.4027 ± .0015 in)
Outside diameter of input shaft ..... 35.500 ± 0.020 mm (1.3976 ± .0008 in)

(13) Depth to install bearing ..... 25.50 ± 0.25 mm (1.004 ± .010 in)

(14) Inside diameter of planet gear (new) ..... 47.653 ± 0.010 mm (1.8761 ± .0004 in)

(15) 3K-2511 Dowel:
Quantity 10
Length ..... 176.23 mm (6.938 in)
Outside diameter ..... 12.637 ± 0.013 mm (.4975 ± .0005 in)

(16) 7H-7658 Spring for NO. 1 and NO. 2 clutches:
Quantity 10
Length under test force ..... 105.7 mm (4.16 in)
Test force ..... 190 ± 14 N (42 ± 3 lb)
Free length after test ..... 140.5 mm (5.53 in)
Outside diameter ..... 14.2 mm (.56 in)

(17) Diameter of the shaft for the planet gear (new) ..... 38.095 ± 0.008 mm (1.4998 ± .0003 in)

(18) Inside diameter of planet gears (new) for NO. 2 and NO. 3 clutch..... 43.221 ± 0.010 mm (1.7016 ± .0004 in)

(19) Diameter of the shaft for the planet gear (new) ..... 35.255 ± 0.008 mm (1.3880 ± .0003 in)

(20) Inside diameter of planet gears (new) ..... 34.399 ± 0.010 mm (1.3543 ± .0004 in)

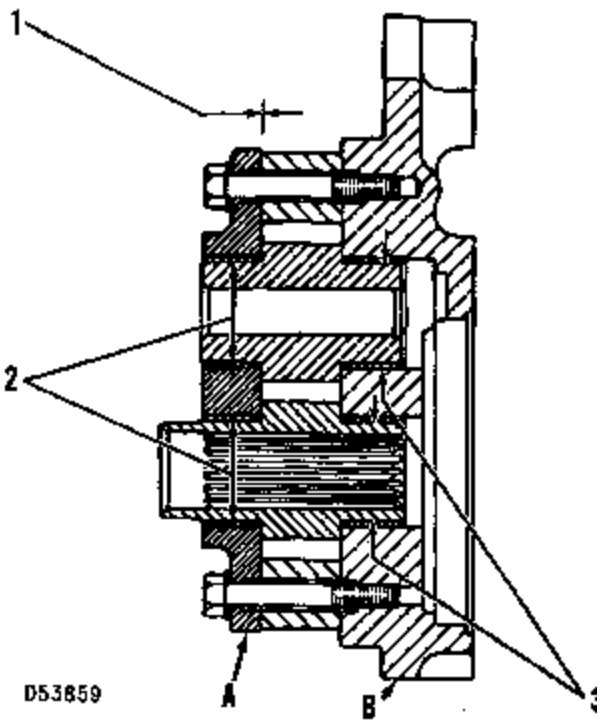
(21) Diameter of the shaft for the planet gear (new) ..... 26.439 ± 0.005 mm (1.0409 ± .0002 in)

(22) 4M-9592 Spring for NO. 3, NO. 4 and NO. 6 clutches:
Quantity 30
Length under test force ..... 34.93 mm (1.375 in)
Test force ..... 116 ± 6 N (26.2 ± 1.3 lb)
Free length after test ..... 44.704 mm (1.76 in)
Outside diameter ..... 14.224 mm (.56 in)

(23) 9M-4335 Dowel:
Quantity ..... five
Length ..... 76.20 mm (3.0 in)
Outside diameter ..... 12.637 ± 0.013 mm (.4975 ± .0005 in)

Transmission Oil Pump

122-6658



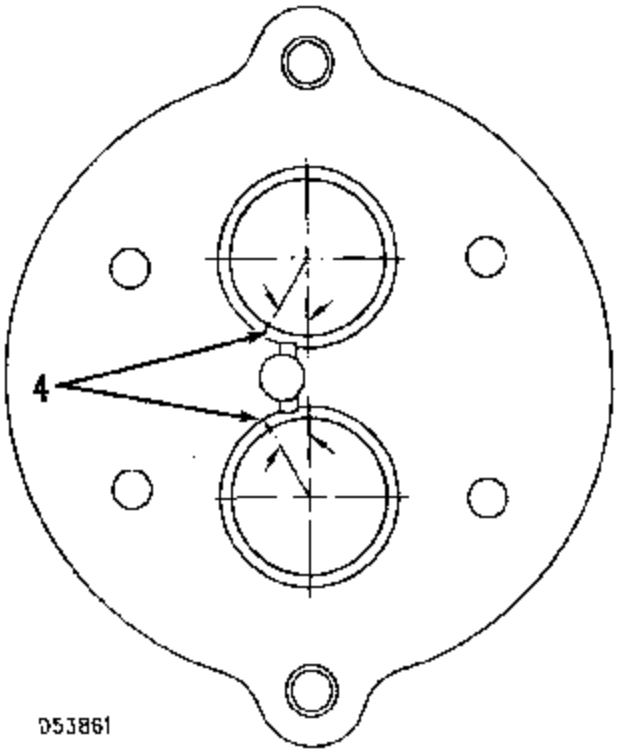
Type ..... Gea
Number of sections ..... On
Rotation (seen from drive end) ..... Counterclockwis
Output [bench test using SAE 10W oil at 49°C (120°F)] ..... 99 liter/min (26 U.S. gpm
At a speed of ..... 1800 rpm
At a pressure of ..... 2550 kPa (370 psi

(1) Clearance between gears and covers (new) ..... 0.081 ± 0.021 mm (.0032 ± .0008 in)

(2) Diameter of shafts (new) ..... 41.232 ± 0.005 mm (1.6233 ± .0002 in)

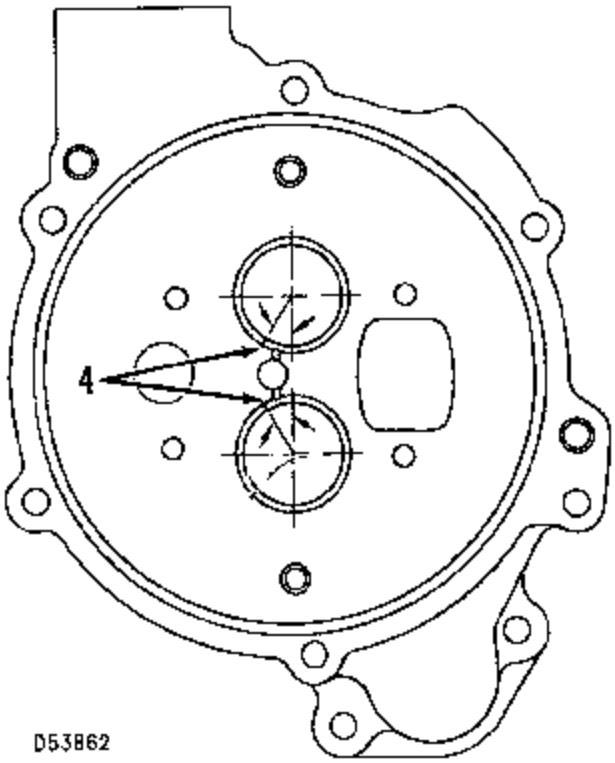
(3) Bore of bearings after installation (new) ..... 41.283 ± 0.008 mm (1.6253 ± .0003 in)

NOTE: Pump must rotate freely by hand.



Cover [A (typical example)]

NOTE: Install bearings into cover (A) 1.5 mm (.060 in) below the surface. Install bearings with joints (4) 30 ± 15° from the shaft centerlines as shown.

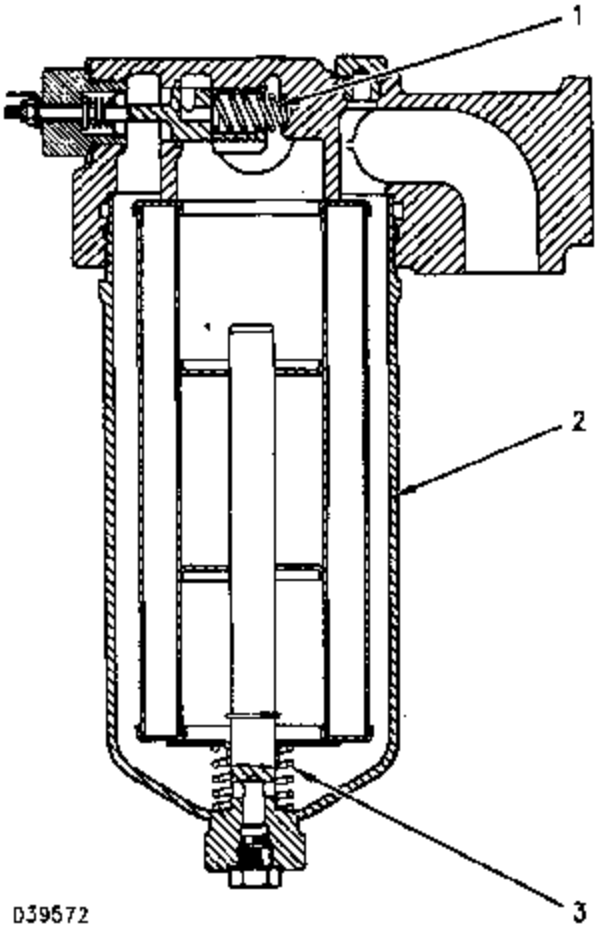


Manifold [B (typical example)]

NOTE: Install bearings into manifold (B) 1.5 mm (.060 in) below the surface. Install bearings with joints (4) 30 ± 15° from the shaft centerlines as shown.

Transmission Oil Filter

6P-4603



NOTICE
Do not use air wrench to tighten housing assembly (2).

Difference in pressure at which the bypass valve will open ..... 248 ± 21 kPa (36 ± 3 psi)

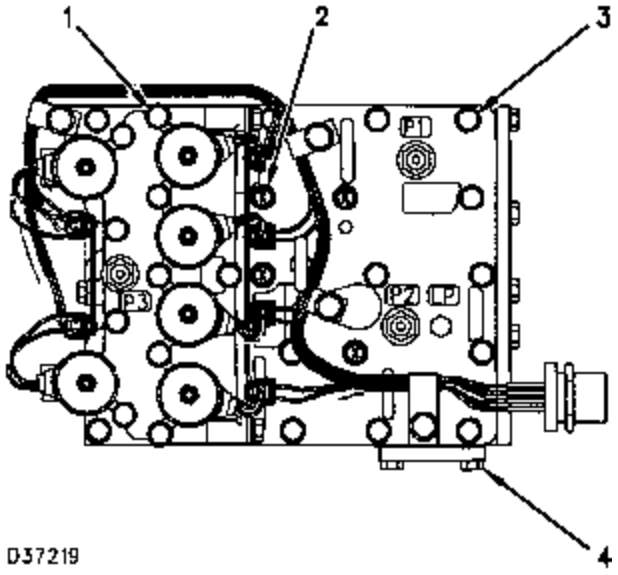
(1) 9M-1986 Spring for the bypass valve:
- Length under test force ..... 25.4 mm (1.00 in)
- Test force ..... 111 + 9 N (24.9 + 2.0 lb)
- Free length after test ..... 47.2 mm (1.86 in)
- Outside diameter ..... 12.7 mm (.50 in)

(2) Tighten housing assembly by hand.

(3) 3S-8652 Spring for the filter element:
- Length under test force ..... 25.4 mm (1.00 in)
- Test force ..... 153 ± 12.5 N (34.4 ± 2.80 lb)
- Free length after test ..... 96.5 mm (3.80 in)
- Outside diameter ..... 35.1 mm (1.38 in)

Transmission Hydraulic Controls

122-7187



(1) Torque for ten bolts ..... 30 ± 4 N•m (22 ± 3 lb ft)

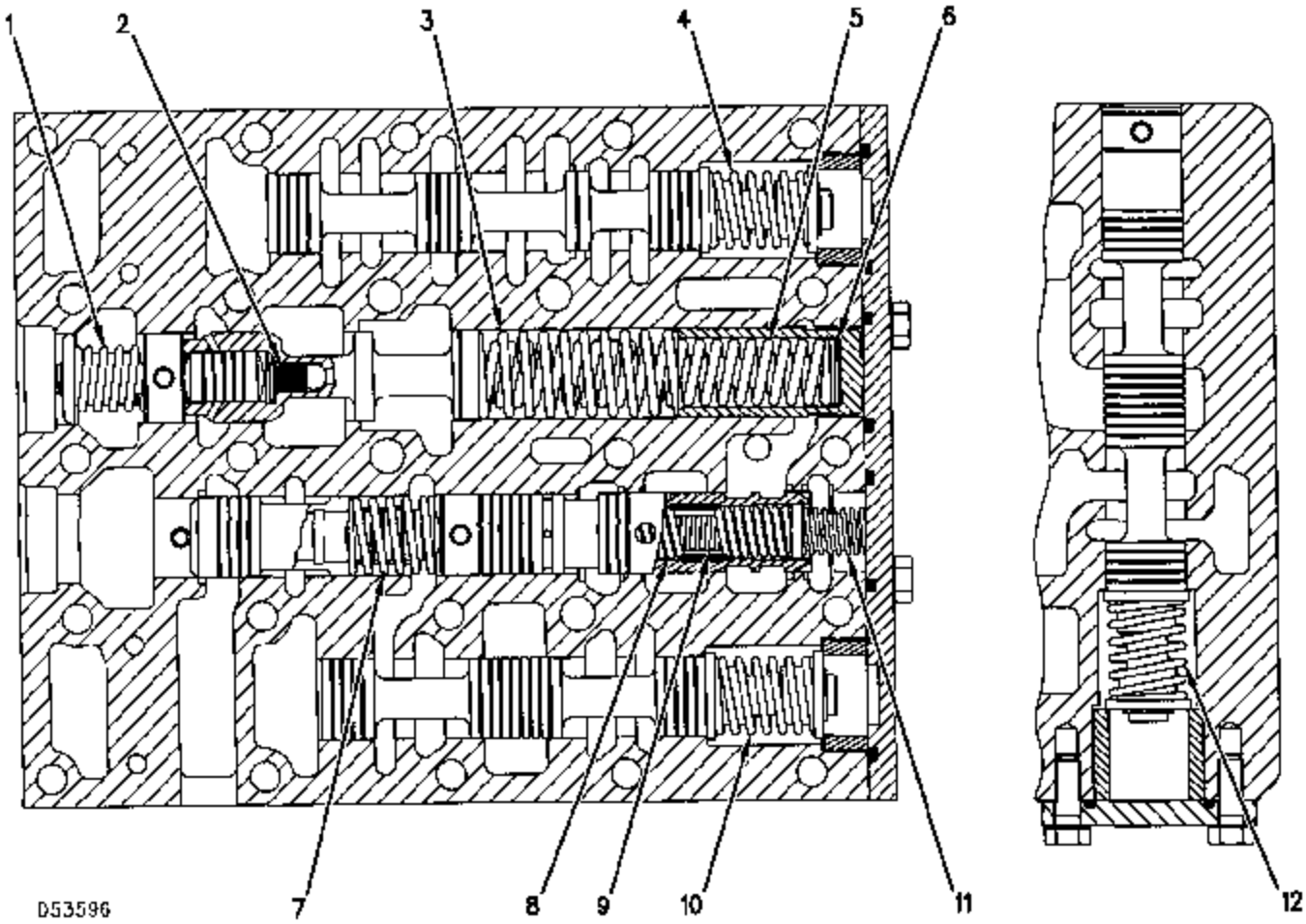
(2) Torque for four bolts marked with an "X" that fasten valve group to planetary housing ..... 48 ± 4 N•m (35 ± 3 lb ft)

(3) Torque for 21 bolts ..... 30 ± 4 N•m (22 ± 3 lb ft)

(4) Torque for two bolts ..... 30 ± 7 N•m (22 ± 5 lb ft)

Transmission Selector And Pressure Control Valve

128-2758



(1) 118-0287 Spring:
- Length under test force ..... 22.15 mm (.872 in)
- Test force ..... 93.4 ± 4.7 N (21.00 ± 1.06 lb)
- Free length after test ..... 33.73 mm (1.328 in)
- Outside diameter ..... 21.0 mm (.83 in)

(2) 4M-2381 Spring:
- Length under test force ..... 12.2 mm (.48 in)
- Test force ..... 2.30 ± 0.18 N (.517 ± .041 lb)
- Free length after test ..... 22.6 mm (.89 in)
- Outside diameter ..... 7.62 mm (.300 in)

(3) 7G-4842 Spring (outer):
- Color ..... two red stripes
- Length under test force ..... 36.3 mm (1.43 in)
- Test force ..... 175 ± 6 N (39 ± 1.3 lb)
- Free length after test ..... 68.45 mm (2.695 in)
- Outside diameter ..... 27.79 mm (1.094 in)

(4), (10), (12) 6L-9519 Spring:
- Length under test force ..... 31.3 mm (1.23 in)
- Test force ..... 64.5 + 3.2 N (14.50 ± .70 lb)
- Free length after test ..... 47.18 mm (1.857 in)
- Outside diameter ..... 24.5 mm (.964 in)

(5) 9P-3041 Spring (inner):
- Color ..... two red stripes
- Length under test force ..... 85.5 mm (3.36 in)
- Test force ..... 313 ± 11 N (70 ± 2.5 lb)
- Free length after test ..... 117.40 mm (4.622 in)
- Outside diameter ..... 21.21 mm (.835 in)

(6) Spacer

5M-9622 Spacer:

Thickness of one spacer ..... 1.60 mm (.063 in)
Outside diameter ..... 20.63 mm (.812 in)
One spacer will change pressure approximately .. 98 kPa (14.2 psi)

5M-9623 Spacer:

Thickness of one spacer ..... 0.90 mm (.035 in)
Outside diameter ..... 20.63 mm (.812 in)
One spacer will change pressure approximately .. 57 kPa (8.3 psi)

5M-9624 Spacer:

Thickness of one spacer ..... 0.25 mm (.010 in)
Outside diameter ..... 20.63 mm (.812 in)
One spacer will change pressure approximately .. 16 kPa (2.3 psi)

(7) 6P-4978 Spring:

Length under test force ..... 27.15 mm (1.069 in)
Test force ..... 67.3 ± 3.4 N (15.10 ± .80 lb)
Free length after test ..... 38.10 mm (1.500 in)
Outside diameter ..... 24.61 mm (.969 in)

(8) 6P-9784 Spring (outer):

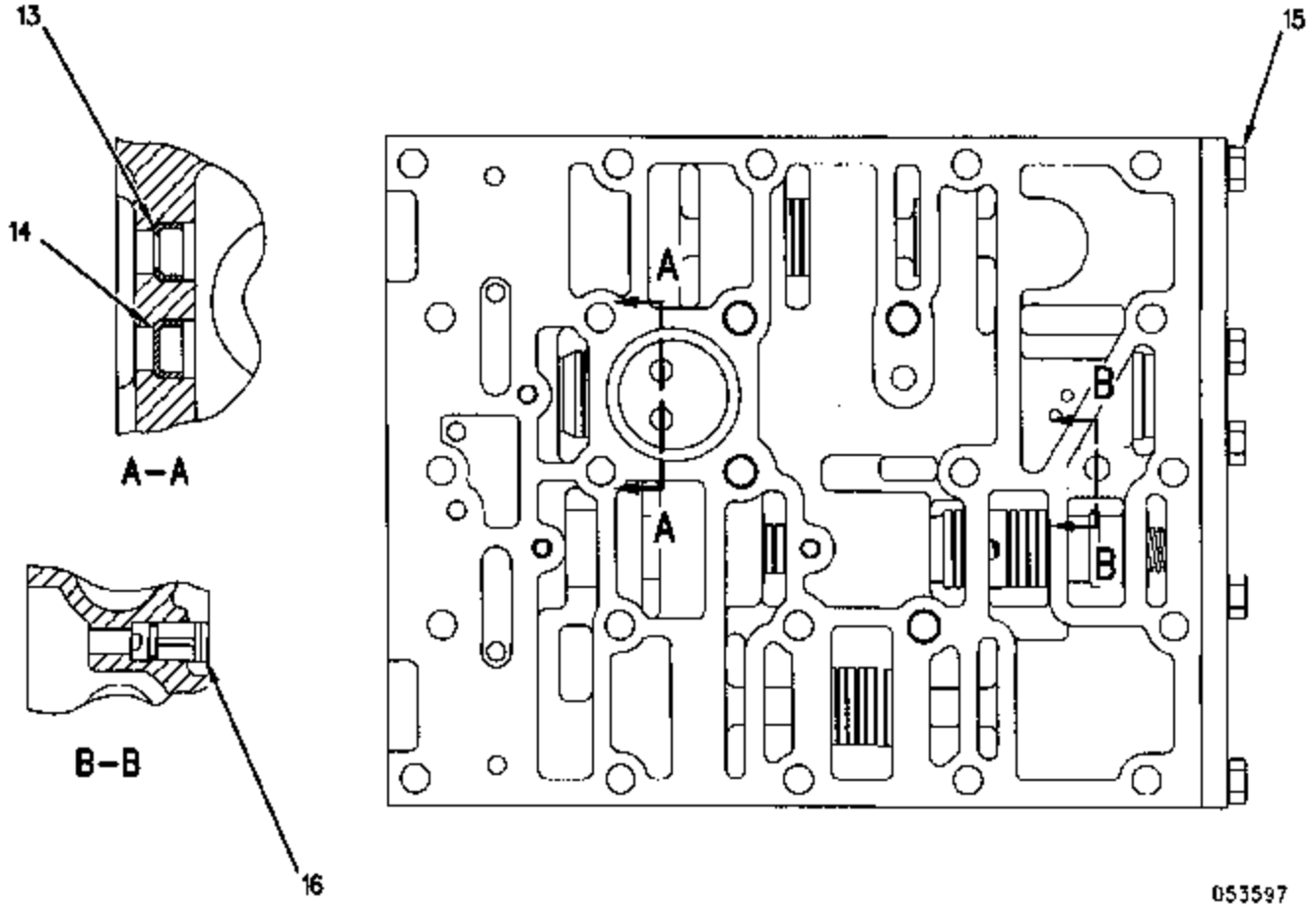
Color ..... yellow stripe
Length under test force ..... 56.39 mm (2.220 in)
Test force ..... 130 ± 6.5 N (29.0 ± 1.50 lb)
Free length after test ..... 88.60 mm (3.488 in)
Outside diameter ..... 16.26 mm (.640 in)

(9) 6P-9783 Spring (inner):

Color ..... yellow stripe
Length under test force ..... 56.39 mm (2.220 in)
Test force ..... 62 ± 3 N (13.9 ± .7 lb)
Free length after test ..... 88.60 mm (3.488 in)
Outside diameter ..... 11.02 mm (.434 in)

(11) 6P-9785 Spring:

Color ..... yellow stripe
Length under test force ..... 19.48 mm (.767 in)
Test force ..... 23.5 ± 1.2 N (5.30 ± .27 lb)
Free length after test ..... 32.00 mm (1.260 in)
Outside diameter ..... 14.83 mm (.584 in)



(13) Install orifice in this position.

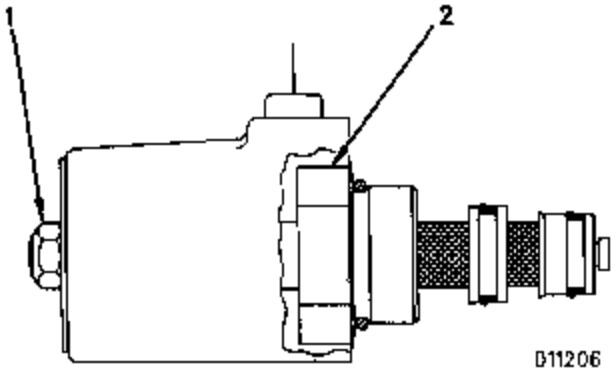
(14) Install plug in this position.

(15) Torque for five bolts ..... 30 ± 7 N•m (22 ± 5 lb ft)

(16) Install orifice with screen out.

lutch Solenoid

3E-3748



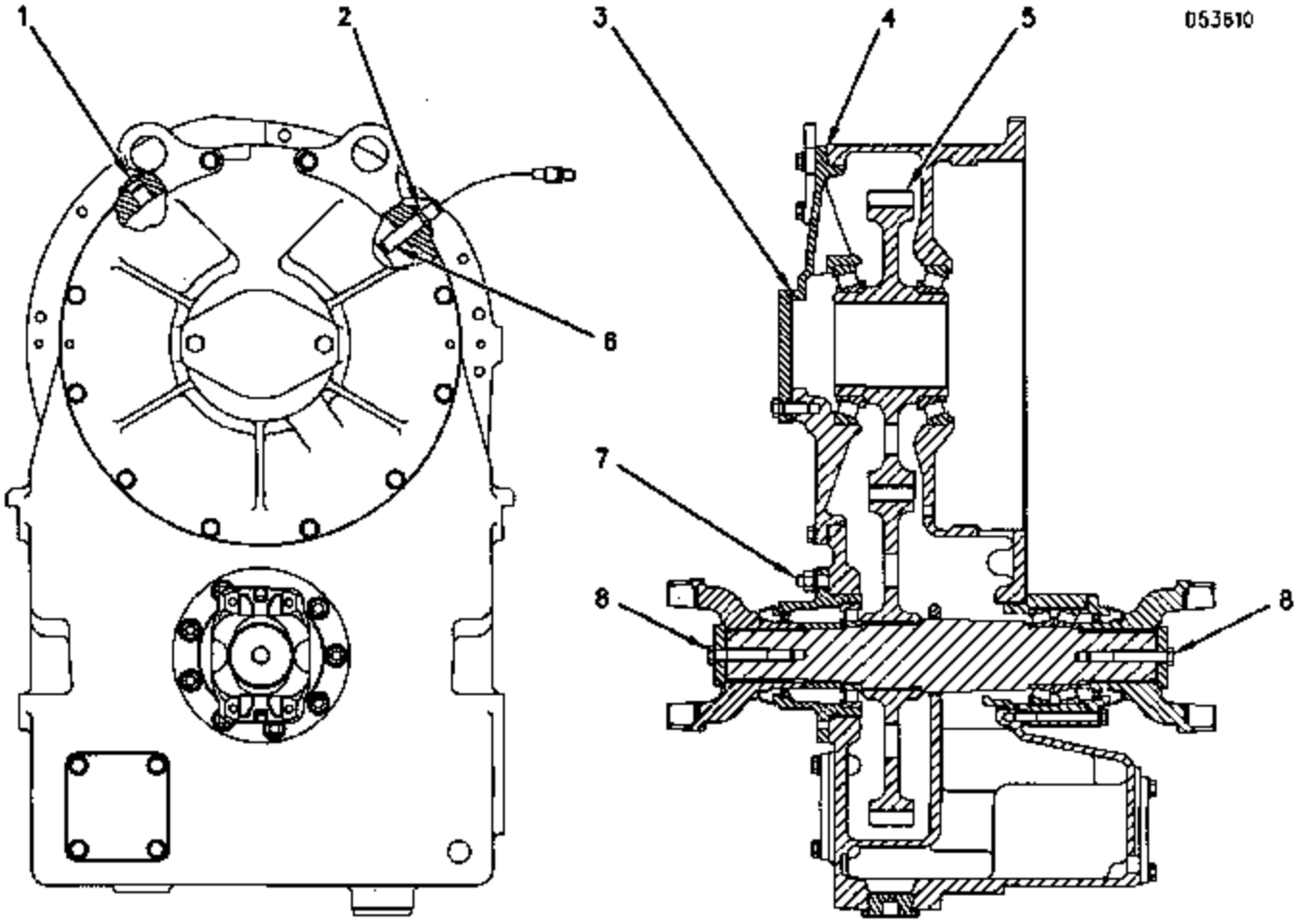
(1) Tighten nut to ..... 5.0 ± 0.5 N•m (44 ± 4.5 lb in)

(2) Tighten cartridge assembly to ..... 50 ± 5 N•m (37 ± 4 lb ft)

Coil voltage 12VDC
Current at 25 ± 5°C (77 ± 9°F) ..... 1.3 Amps
Coil resistance at 25 ± 5°C (77 ± 9°F) ..... 8.5 Ohms

Transfer Gears (Output)

122-3776
128-2480



(1) Torque for plug ..... 4 ± 1 N•m (35 ± 9 lb in)

(2) Tighten locknut to a torque of ... 25 ± 5 N•m (18 ± 4 lb ft)

(3) Apply 5C 5300 Sealant to sealing surface of cover before installation.

(6) Magnetic pickup:
Apply 5P-3413 Sealant to the threads of the magnetic pickup before installation.
Install the magnetic pickup until the end of the pickup contacts the tip of the gear tooth. Loosen pickup one half turn and tighten the locknut to obtain a gap between the gear tooth and the end of the magnetic pickup of ..... 0.71 mm (.028 in)
Pin 2 ..... Signal+
Socket 1 ..... Signal-

(7) Torque for eight studs ..... 55 ± 10 N•m (41 ± 7 lb ft)

(8) Torque for two bolts ..... 115 ± 7 N•m (85 ± 5 lb ft)

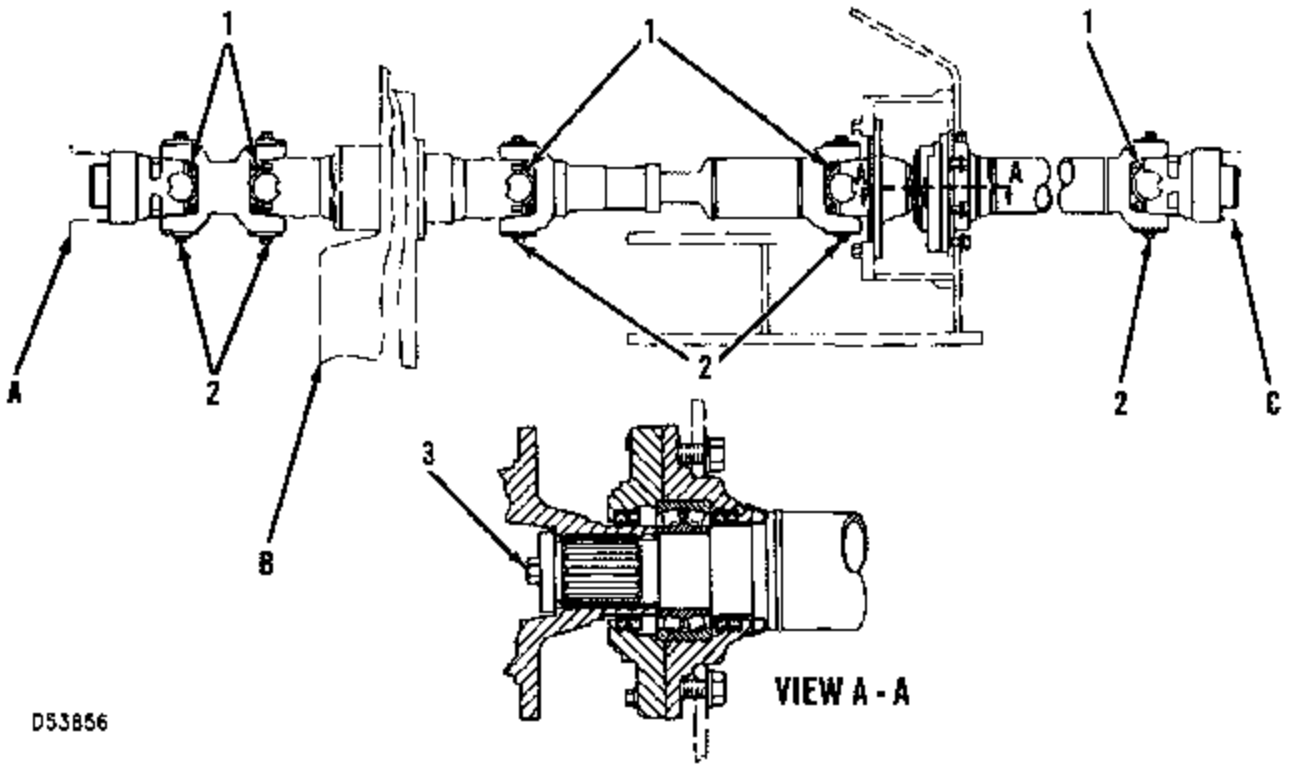
End play Adjustment Procedure:

NOTE: Before assembly of components, make sure bearing cups and cones are sealed in the housing by using 0.038 mm (.0015 in) shim stock or a standard feeler gauge.

1. Use shim pack (4) as required to obtain 0.10 ± 0.05 mm (.004 ± .002 in) end play of gear (5).
2. Use a dial indicator and measure end play at gear (5).
3. If end play is less than 0.05 mm (.002 in) add to shim pack (4). If end play is greater than 0.15 mm (.006 in), remove from shim pack (4).

Drive Shaft Group

2V-4226



NOTICE

All yokes must be in alignment when the drive shafts are installed (as shown).

Align flanges with the joint groups in front of the transfer gear when installing the flange at the rear of the transfer gear.

(A) To rear differential.

(B) Transfer gear.

(C) To front differential.

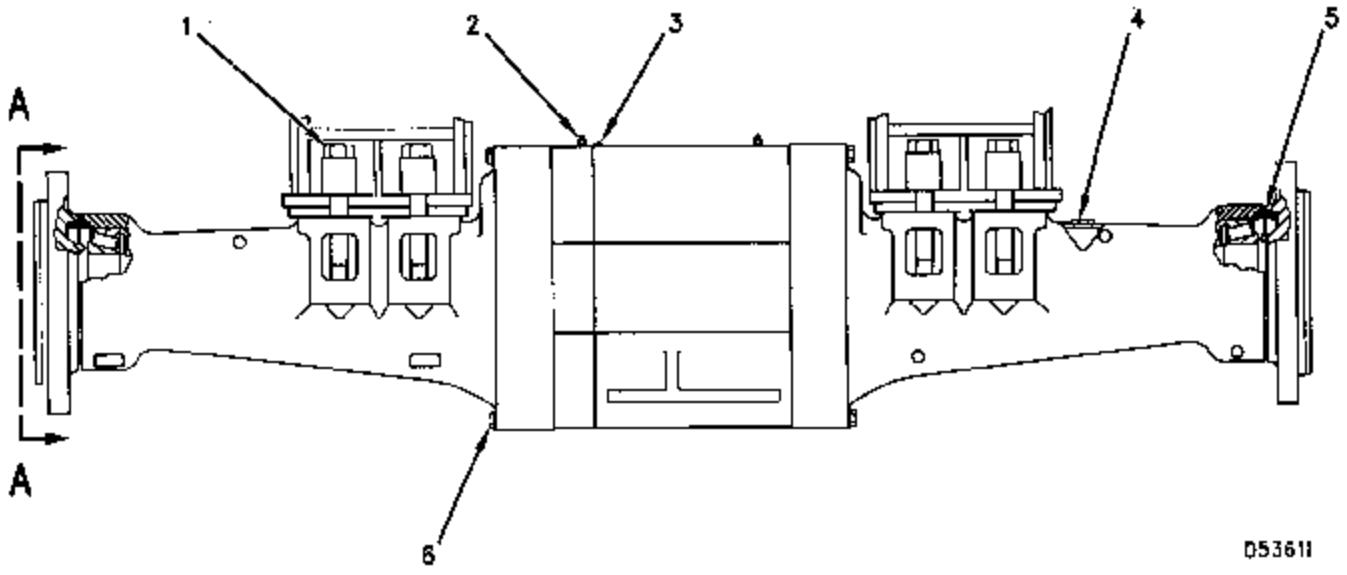
(1) Torque for 20 bolts that hold the universal joint ..... 135 ± 15 N•m (100 ± 11 lb ft)

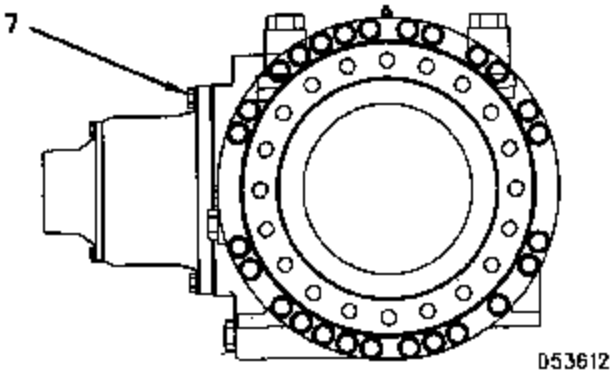
(2) Torque for 20 spider bearing retainer plate bolts ..... 50 ± 7 N•m (37 ± 5 lb ft)

(3) Torque for retaining bolt .... 135 ± 15 N•m (100 ± 11 lb ft)

Axle Housing Group (Fixed)

119-1085
128-2566





(1) Torque for eight bolts ..... 1800 ± 200 N•m (1320 ± 150 lb ft)

(2) Torque for bleeder screw ..... 11 ± 4 N•m (8 ± 3 lb ft)

(3) Torque for pressure relief fitting ..... 13 ± 4 N•m (10 ± 3 lb ft)

(4) Torque for gage ..... 45 ± 6 N•m (33 ± 4 lb ft)

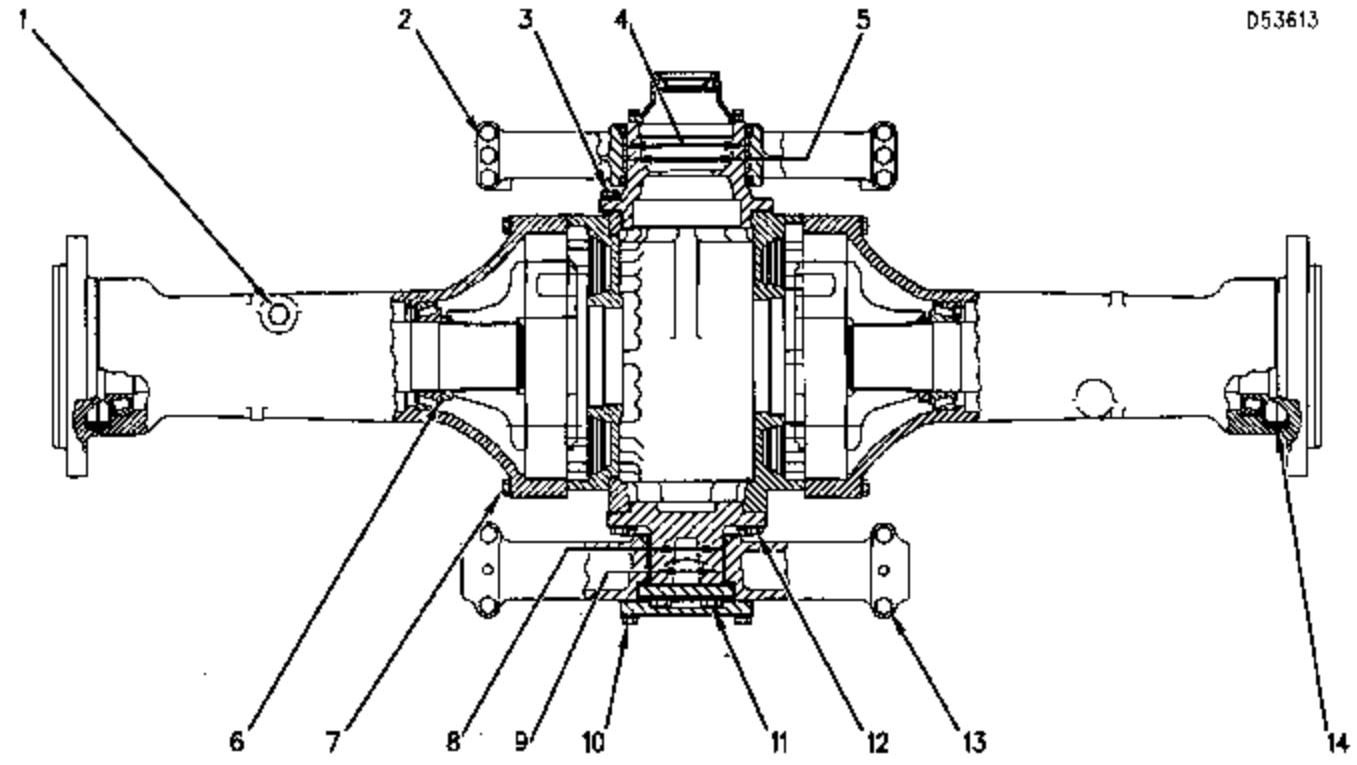
(5) Rubber toric seals and all surfaces in contact with them must be clean and dry at assembly. Put a thin layer of oil on the surfaces of the metal seals that are in contact just before installation. Seal must be assembled square with the bore and the toric seal must not be bulged or twisted.

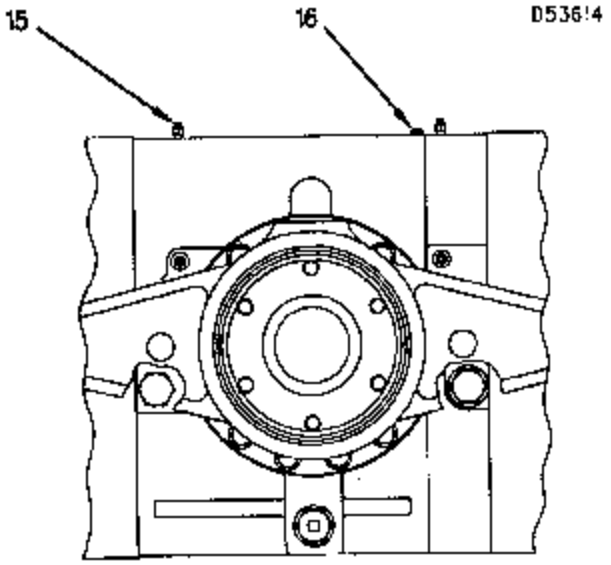
(6) Torque for 52 bolts ..... 300 ± 40 N•m (220 ± 30 lb ft)

(7) Torque for 12 bolts ..... 300 ± 40 N•m (220 ± 30 lb ft)

814F Axle Housing Group (Oscillating)

133-6505





(1) Torque for gage ..... 45 ± 6 N•m (33 ± 4 lb ft)

(2) Torque for eight bolts ..... 475 ± 60 N•m (350 ± 45 lb ft)

(3) Torque for 12 bolts ..... 300 ± 40 N•m (220 ± 30 lb ft)

(4) Outside diameter of new trunnion ..... 126.80 ± 0.08 mm (4.992 ± .003 in)

Inside diameter of new bearing ..... 127.79 ± 0.13 mm (5.031 ± .005 in)

(5) Inside diameter of new support ..... 139.75 ± 0.05 mm (5.502 ± .002 in)

Outside diameter of new bearing ..... 140.23 ± .13 mm (5.521 ± .005 in)

(6) See Axle Housing Assembly And Axle Bearing Preload Adjustment

(7) Torque for 52 bolts ..... 300 ± 40 N•m (220 ± 30 lb ft)

(8) Inside diameter of new support ..... 225.00 ± 0.05 mm (8.858 ± .002 in)

Outside diameter of new bearing ..... 225.48 ± 0.08 mm (8.877 ± .003 in)

(9) Outside diameter of new housing ..... 209.55 ± 0.08 mm (8.250 ± .003 in)

Inside diameter of new bearing ..... 210.46 ± 0.22 mm (8.286 ± .009 in)

(10) Torque for six bolts ..... 270 ± 40 N•m (200 ± 30 lb ft)

(11) Torque for four bolts ..... 570 ± 80 N•m (420 ± 60 lb ft)

(12) Torque for 12 bolts ..... 300 ± 40 N•m (220 ± 30 lb ft)

(13) Torque for eight bolts ..... 475 ± 60 N•m (350 ± 45 lb ft)

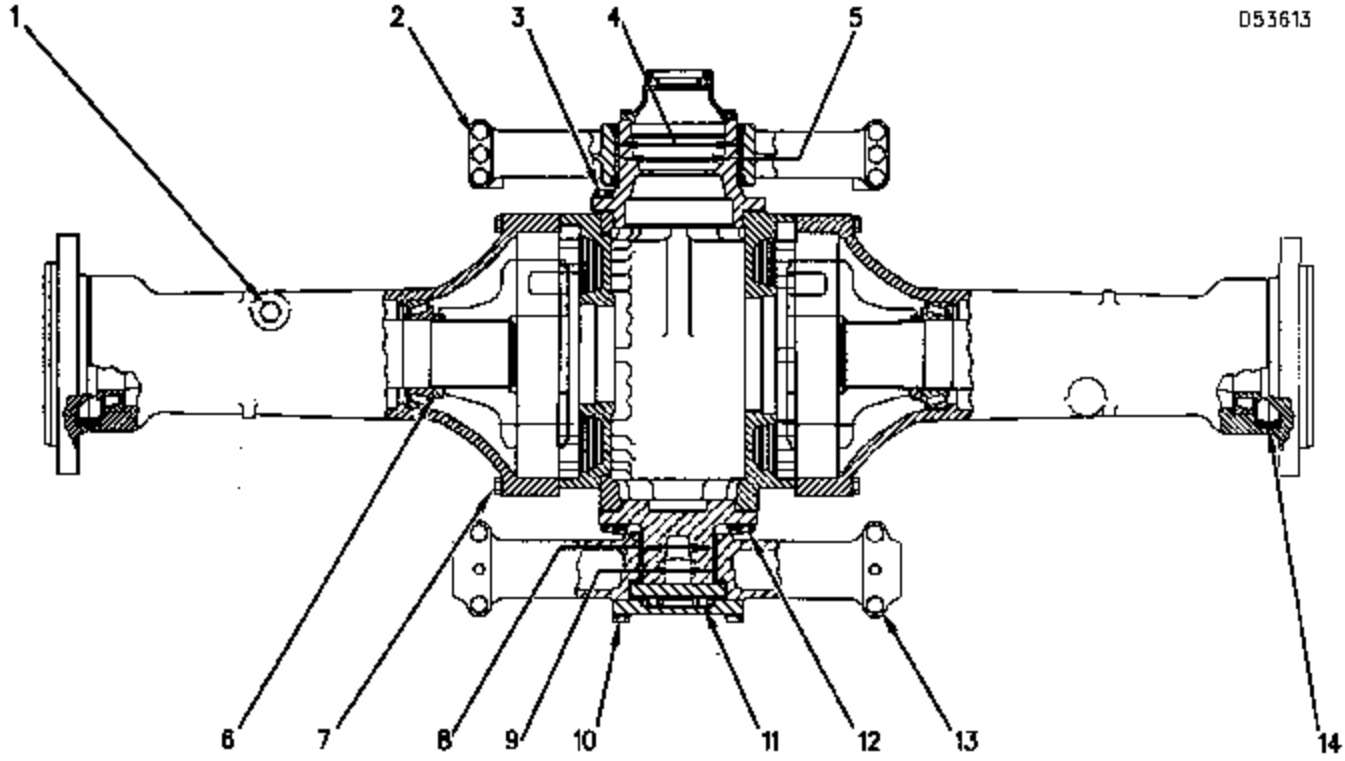
(14) Rubber toric seals and all surfaces in contact with them must be clean and dry at assembly. Put a thin layer of oil on the surfaces of the metal seals that are in contact just before installation. Seal must be assembled square with the bore and the toric seal must not be bulged or twisted.

(15) Torque for bleeder screw ..... 11 ± 4 N•m (8 ± 3 lb ft)

(16) Torque for pressure relief screw ..... 13 ± 4 N•m (10 ± 3 lb ft)

815F and 816F Axle Housing Group (Oscillating)

119-1089



(1) Torque for gage ..... 45 ± 6 N•m (33 ± 4 lb ft)

(2) Torque for eight bolts ..... 475 ± 60 N•m (350 ± 45 lb ft)

(3) Torque for 12 bolts ..... 300 ± 40 N•m (220 ± 30 lb ft)

(4) Outside diameter of new trunnion ..... 126.80 ± 0.08 mm (4.992 ± .003 in)

Inside diameter of new bearing ..... 127.79 ± 0.13 mm (5.031 ± .005 in)

(5) Inside diameter of new support ..... 139.75 ± 0.05 mm (5.502 ± .002 in)

Outside diameter of new bearing ..... 140.23 ± .13 mm (5.521 ± .005 in)

(6) See Axle Housing Assembly And Axle Bearing Preload Adjustment

(7) Torque for 52 bolts ..... 300 ± 40 N•m (220 ± 30 lb ft)

(8) Inside diameter of new support ..... 225.00 ± 0.05 mm (8.858 ± .002 in)

Outside diameter of new bearing ..... 225.48 ± 0.08 mm (8.877 ± .003 in)

(9) Outside diameter of new housing ..... 209.55 ± 0.08 mm (8.250 ± .003 in)

Inside diameter of new bearing ..... 210.46 ± 0.22 mm (8.286 ± .009 in)

(10) Torque for six bolts ..... 270 ± 40 N•m (200 ± 30 lb ft)

(11) Torque for four bolts ..... 570 ± 80 N•m (420 ± 60 lb ft)

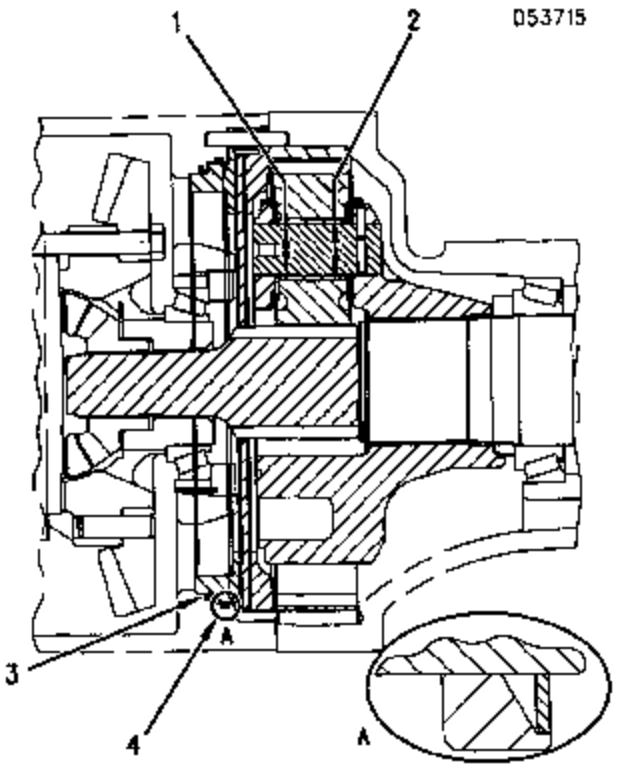
(12) Torque for 12 bolts ..... 300 ± 40 N•m (220 ± 30 lb ft)

(13) Torque for eight bolts ..... 475 ± 60 N•m (350 ± 45 lb ft)

(14) Rubber toric seals and all surfaces in contact with them must be clean and dry at assembly. Put a thin layer of oil on the surfaces of the metal seals that are in contact just before installation. Seal must be assembled square with the bore and the toric seal must not be bulged or twisted.

Planetary And Brake Group

9C-8185; 814F Rear
9U-2788; 814F, 815F & 816F Front



(1) Diameter of planet shaft ..... 47.981 ± 0.008 mm (1.8890 ± .0003 in)

(2) Inside Diameter of planetary gear .... 57.536 ± 0.010 mm (2.2652 ± .0004 in)

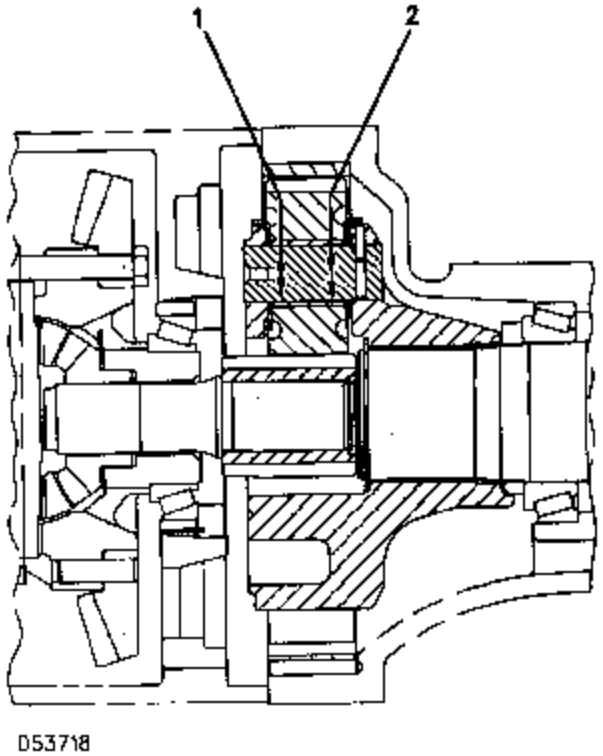
Installation Of Seals

A. Install seals (3) and (4) dry, then coat entire assembly with petroleum jelly.

B. Seal (4) also includes a fiber back-up ring with a radius corner on one face. The radius must be installed against the rubber part of the seal.

Planetary Group

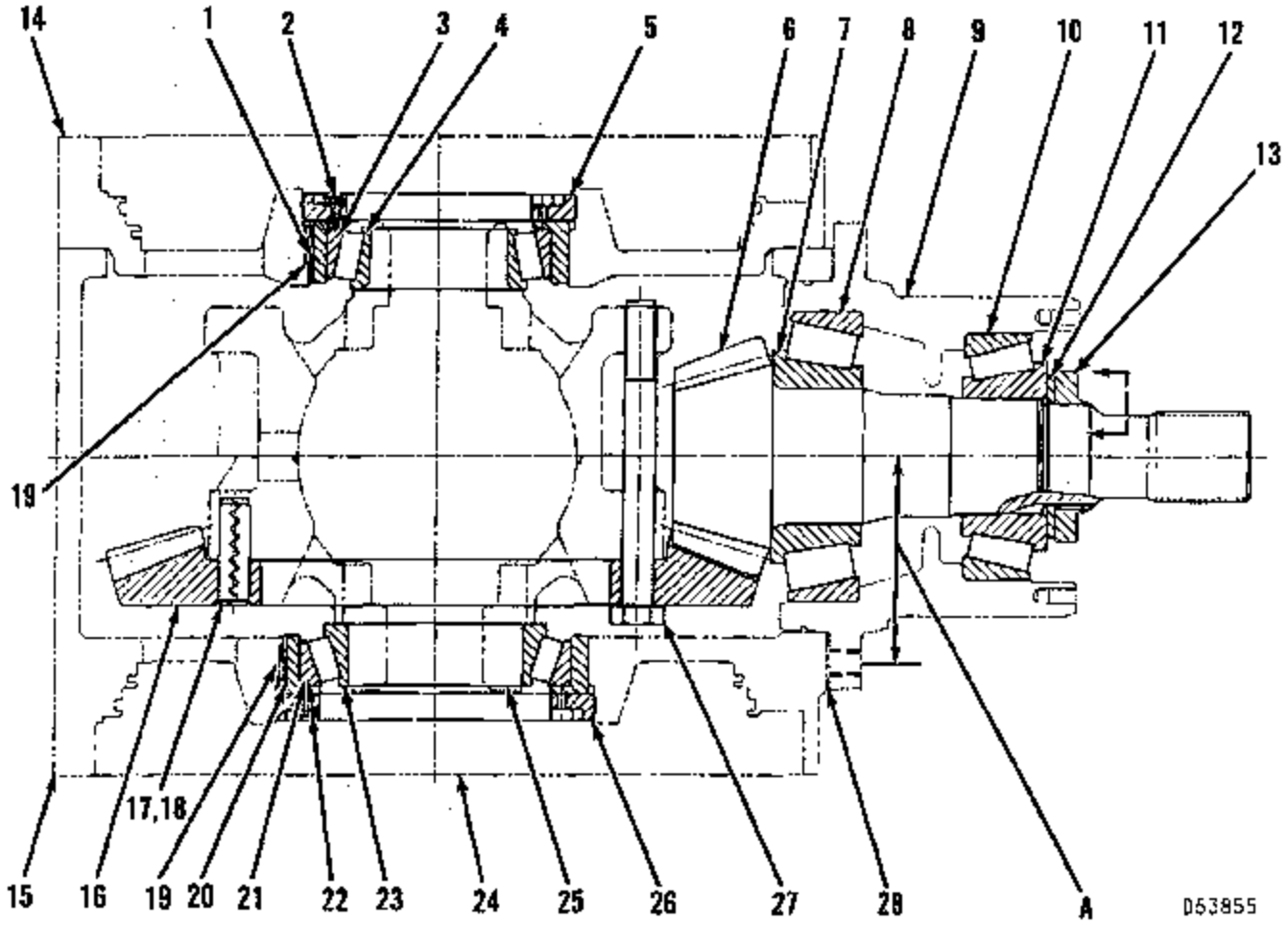
119-1095; 815F & 816F Rear



(1) Diameter of planet shaft ..... 47.981 ± 0.008 mm (1.8890 ± .0003 in)

(2) Inside Diameter of planetary gear ..... 57.536 ± 0.010 mm (2.2652 ± .0004 in)

Axle Arrangement Adjustments



Pinion Preload Adjustment

NOTE: The same adjustment is used for both the front and rear pinion assemblies.

1. Install bearing cups (8) and (10) in housing (9). Bearing cups must be against (seated) the shoulders in housing (9).
2. Install bearing cone (7) on pinion (6). Bearing cone (7) must be against (seated) the shoulder on pinion (6). Lubricate bearing cone (7).
3. Install pinion (6) in housing (9). Press bearing cone (11) into place leaving a small amount of end play. Lubricate bearing cone (11). Lubricate and install washer (12) and nut (13).

NOTE: Cup freezing or cone heating may be used if cups or cones are reset with a driver or press after parts have reached a uniform temperature. Limit cone heating to 135°C (275°F) maximum for a maximum of four hours. Lubricate bearings after they have cooled to prevent rusting.

4. Position the assembly vertically in a soft jawed vise. Tighten the vise against the teeth of pinion (6). Tighten an appropriate bolt and nut through an outer bolt hole in pinion housing (9).
5. Place a 203 mm (8.0 in) torque wrench on this bolt so that it is in line with the center of pinion (6).
6. While turning housing (9) with the torque wrench, tighten nut (13) until the torque wrench reading in the following chart is reached.

PINION ROLLING TORQUE		
	Actual Torque At The Pinion	Torque Wrench Reading*
New Bearings	0.9–1.8 N•m (8–16 lb in)	0.5–1.1 N•m (5–10 lb in)
Used Bearings	0.45–0.90 N•m (4–8 lb in)	0.25–0.55 N•m (2.5–5.0 lb in)

* When using a 203 mm (8.0 in) torque wrench.

Check to be sure that there is zero end play of pinion shaft (6).

7. If pinion rolling torque exceeds the specification, back off nut (13) one-eighth turn and reseal bearing cone (11) and washer (12) against nut (13). Perform Steps 5 and 6 again.

NOTE: If any other length torque wrench is used, find the torque wrench reading by using the following formula:

$$C = \frac{B \times T}{B + A}$$

Where:

"C" is the reading on the torque wrench (in N•m).

"B" is the length of the torque wrench (in meters).

"A" is the bolt circle radius of pinion housing (9) in meters and is equal to 0.135 m (5.31 in).

"T" is the rolling torque specification for pinion bearing preload which is 0.9 to 1.8 N•m (8 to 16 lb in).

8. When the torque needed to turn the pinion is correct, stake nut (13) by peening the collar on the nut into the key slot in pinion shaft (6), see Illustration A for the correct tooling and dimensions.

NOTE: The nut may be reused if the collar is not cracked during removal or restaking.

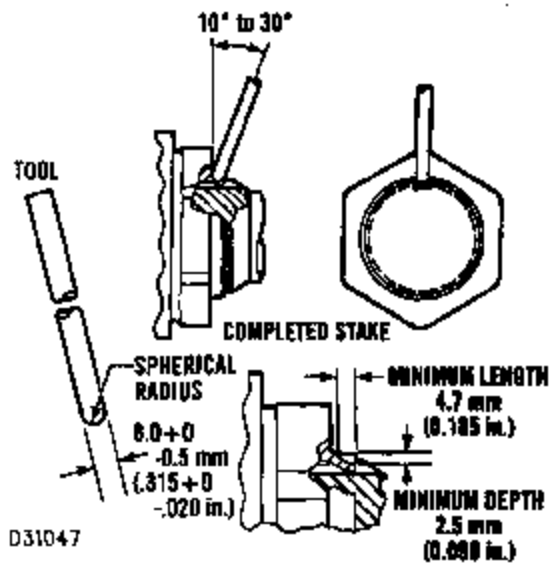


Illustration A

Differential Backlash and Bearing Adjustment

NOTE: The following procedure controls bearing preload and gives the same results for new and used bearings.

1. Assemble the differential group (15).
2. Heat bevel gear (16) to 135°C (275°F) for a maximum of four hours. Install the bevel gear on the differential group.
3. Install four large pins (17) partially into bevel gear (16). Install four small pins (18) into large pins (17) and press all pins (17) and (18) flush with bevel gear (16) surface. Torque 16 bolts (27) to 285 ± 40 N•m (210 ± 30 lb ft), then turn an additional 120° ± 5°. Check to make sure the bevel gear is seated on the differential group shoulder.
4. Press bearing cone (4) and bearing cone (23) on differential case (25). Check for full seating of the cones.

NOTE: Cup freezing or cone heating may be used if cups or cones are reset with a driver or press after parts have reached a uniform temperature. Limit cone heating to 135°C (275°F) maximum for a maximum of four hours. Lubricate bearings after they have cooled to prevent rusting.

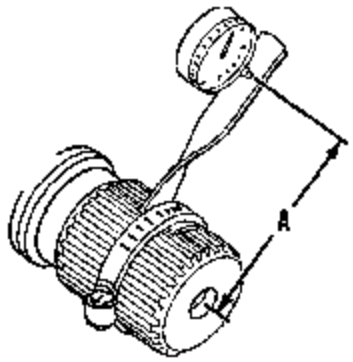
5. Remove intermediate housing (14) from center housing (24).
6. Install bearing cups (3) and (21), bearing sleeves (1) and (20) and two pins (19). Lubricate the threads of adjusting nuts (5) and (26) and install them in intermediate housing (14) and center housing (24).
7. Position center housing (24) in an appropriate support fixture with the open side facing upward. With a lifting device, lower differential group (15) and bevel gear into position on three dowels in center housing (24).
8. Install intermediate housing (14) on center housing (24). Tighten four bolts.
9. Lubricate and install O-ring seal on pinion housing (9). Install pinion housing (9) on center housing (24). Torque 12 bolts to 300 ± 40 N•m (200 ± 30 lb ft). Use the original thickness of shims (28) or a new shim pack measured to the same thickness as the original pack. If the original shim pack is not available, use 60% of a new shim pack.

NOTE: Shim pack thickness may have to be changed when adjusting the tooth contact pattern.

10. Reposition center housing (24) in the support fixture so that center housing (24) and pinion housing (9) are horizontal (the same position as they are in the machine).
11. Tighten adjusting nuts (5) and (26) to a position that maintains gear backlash (but not tight gear mesh) and a slight bearing end play.
12. Measure the torque required to rotate pinion shaft (6). Record the measured torque. Use a 1U6690 Socket on pinion shaft nut (13) for this measurement.
13. While rotating pinion shaft (6) back and forth tighten adjusting nut (26) to zero backlash position. Then back off adjusting nut (26) 20° plus the increment to the nearest lock position.
14. Tighten adjusting nut (5) while rotating pinion shaft (6). Tighten nut (5) until a torque increase of 0.2 to 0.6 N•m (2.0 to 5.0 lb in) over the torque recorded in Step 13 is measured. This is the seated position.
15. Tighten adjusting nut (5) 60° plus the increment to the nearest lock position.

NOTE: As a check for correct assembly and adjustment, the rolling torque of the bevel gear group measured at the pinion shaft should be 1.8 to 3.6 N•m (16 to 32 lb in) for new bearings and 0.9 to 1.8 N•m (8 to 16 lb in) for used bearings.

16. Measure the backlash between bevel gear (16) and pinion shaft (6). The backlash must be 0.30 + 0.12 − 0.10 mm (.011 + .005 − .004 in). Perform this by placing a dial indicator (as shown) tangent to the spline, making sure the yoke or spline adapter is tight to the spline.



Pinion Shaft Spline (backlash measurement)
(A) Distance of dial indicator from pinion centerline.

17. The following chart gives examples of backlash at the pinion shaft, by showing the different distances from the pinion centerline to the dial indicator.

EXAMPLES OF BACKLASH AT PINION SHAFT			
Dimension (A) mm (in)	Nominal Backlash mm (in)	Maximum Backlash mm (in)	Minimum Backlash mm (in)
50 (2)	0.28 (.011)	0.40 (.016)	0.18 (.007)
100 (4)	0.55 (.022)	0.80 (.032)	0.35 (.014)
150 (6)	0.83 (.033)	1.20 (.047)	0.53 (.021)
200 (8)	1.10 (.043)	1.60 (.063)	0.70 (.028)

18. If the backlash does not meet specifications, loosen one nut the same amount as the opposite nut is tightened. This will maintain the bearing preload.

Checking Pinion And Bevel Gear Tooth Contact

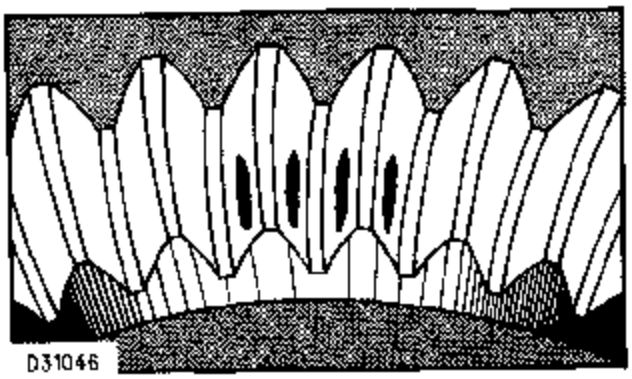


Illustration A

1. After the backlash and preload adjustments have been made, the tooth contact between pinion shaft (6) and bevel gear (16) must then be checked. Perform the procedure that follows:
   a. Put a small amount of Prussian blue, red lead or paint on three or four adjacent teeth of bevel gear (16).
   b. Rotate pinion shaft (6) several revolutions in one direction and then several revolutions in the opposite direction. Then turn pinion shaft in one direction until the marked teeth can be seen.
   c. The correct area of tooth contact starts near the inside end of the teeth of bevel gear (16) and goes a maximum of 50 percent of the length of the teeth. See Illustration A for an example of the correct area of tooth contact.

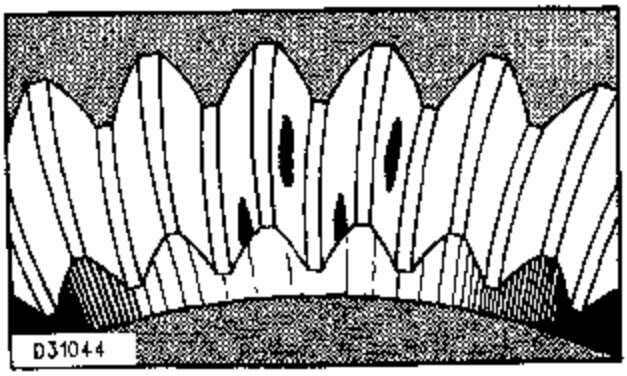


Illustration B

2. If the tooth contact looks like the marks in Illustration B, perform the procedure that follows
   a. Remove some of shims (28).
   b. Perform Steps 16, 17 and 18 for Backlash Adjustment Procedure again.
   c. Perform Step 1 of Checking Pinion And Bevel Gear Tooth Contact again.

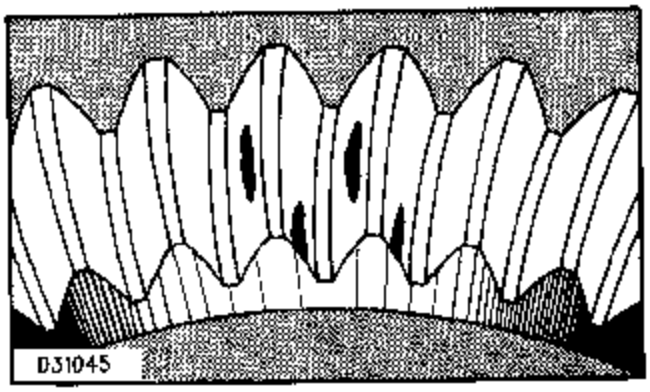


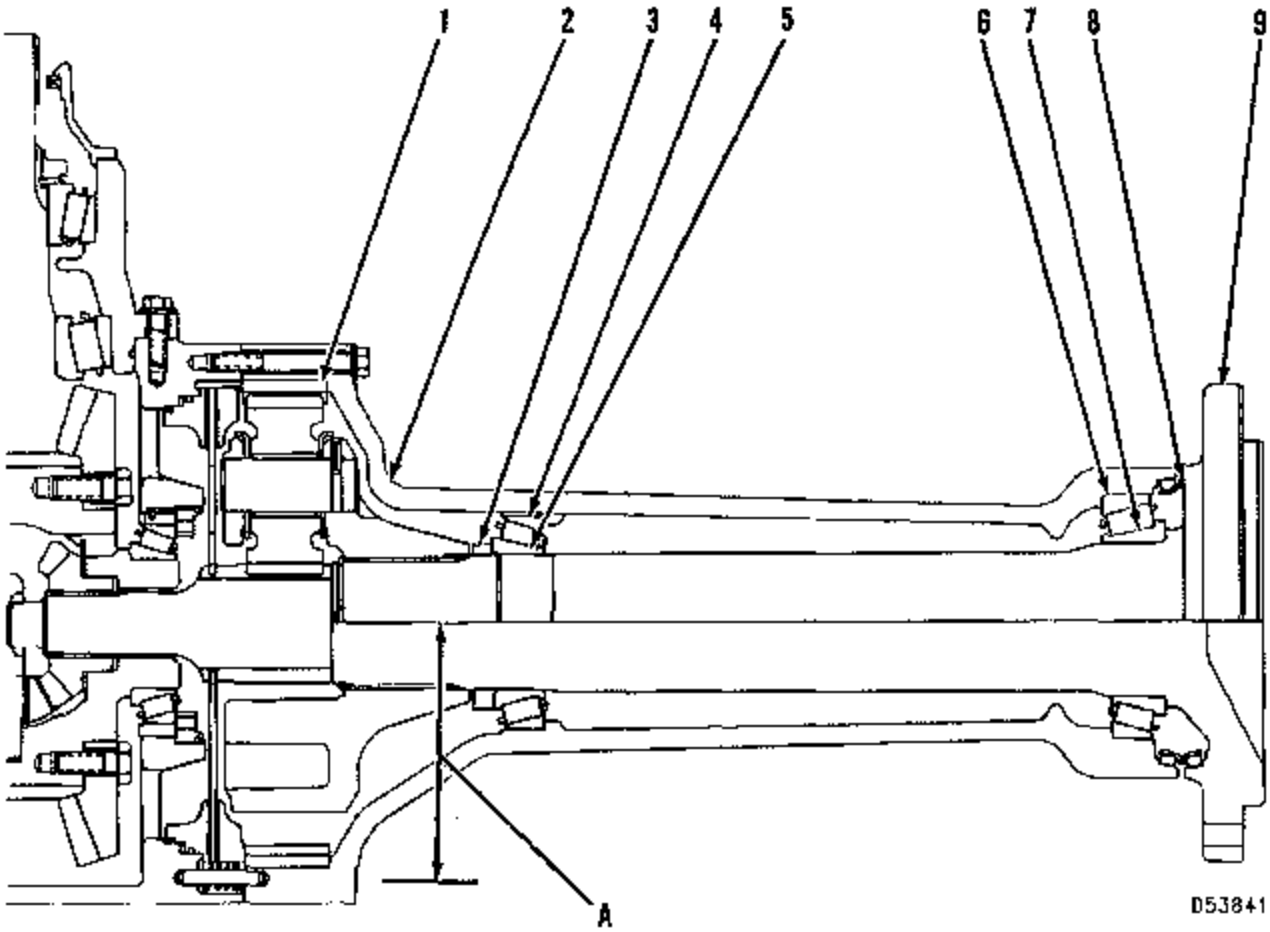
Illustration C

3. If the tooth contact looks like the marks in Illustration C, perform the procedure that follows:
   a. Add some of shims (28).
   b. Perform Steps 16, 17 and 18 for Backlash Adjustment Procedure again.
   c. Perform Step 1 of Checking Pinion And Ring Gear Tooth Contact again.

NOTE: Always make sure the backlash adjustment is correct before an adjustment is made to the area of tooth contact. Several adjustments to the backlash and tooth contact may be necessary to get the correct adjustments. Always remember that a change to gear clearance (backlash) will also change the gear contact. A change in gear contact will also change gear clearance (backlash).

4. After adjustments are made, remove the Prussian blue, red lead or paint from the gears.
5. Install one bolt and lock (2), (22) in each adjusting nut (5) and (26), tighten both bolts and bend locks.

Axle Housing Assembly And Bearing Preload Adjustment



1. Using four dowels (not shown) as guides freeze ring gear (1) and press into axle housing (2) with chamfer side of ring gear toward the axle housing. Check for full seating of the ring gear against the housing shoulder and the four dowels are flush with ring gear (1).
2. Press bearing cups (4) and (6) into housing and check for full seating of bearing cups against housing shoulders.
3. Press bearing cone (7) on axle (9) and check for full seating of cone against the axle shoulder. Lubricate the cone roller assembly.
4. Install Duo-Cone seals (8) to both axle (9) and housing (2).

NOTE: Rubber toric seals and all surfaces in contact with them must be clean and dry at assembly. Put a thin layer of oil on the surfaces of the metal seals that are in contact just before installation. Seal must be assembled square with the bore and toric must not be bulged or twisted.

5. Secure axle (9) in a vertical position with the rim flange down.
6. Lower housing (2) over the axle.
7. Press bearing cone (5) onto axle (9) with end play remaining in the bearing. Lubricate the cone roller assembly
8. Lubricate and install adjusting nut (3) with part numbered side of the adjusting nut facing away from the bearing cone. Tighten the nut until only a small amount of end play remains in the axle/bearing assembly.

9. Measure the torque required to rotate housing (2). This is the seal drag torque. To perform this, tighten an appropriate bolt and nut through an outer bolt hole in axle housing (2). Place a 203 mm (8.0 in) torque wrench on this bolt so that it is in line with the center of axle shaft (9). While turning housing (2) with the torque wrench, note the reading on the torque wrench and calculate the actual seal drag torque with the following formula.

$$SDT = \frac{C \times (B + A)}{B}$$

Where:

"SDT" is the actual seal drag torque (in N•m)

"C" is the reading on the torque wrench (in N•m).

"B" is the length of the torque wrench (in meters).

"A" is the bolt circle radius of axle housing (2) in meters and is equal to 0.234 m (9.213 in).

10. While turning housing (2) with the torque wrench, tighten nut (3) until the torque wrench reading calculated with the following formula is reached.

$$C = \frac{(T + SDT) \times B}{(B + A)}$$

Where:

"C" is the reading on the torque wrench (in N•m).

"B" is the length of the torque wrench (in meters).

"A" is the bolt circle radius of axle housing (2) in meters and is equal to 0.234 m (9.213 in).

"T" is the rolling torque specification for axle bearing preload which is 10.4 to 11.6 N•m (92 to 103 lb in).

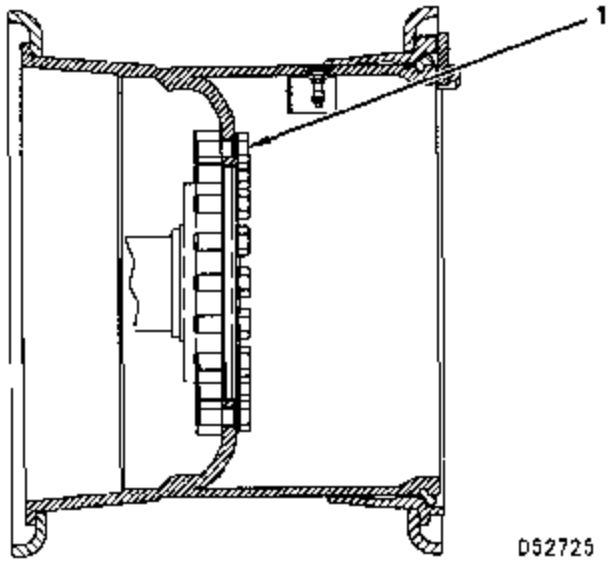
"SDT" is the actual seal drag torque (in N•m) from Step 9.

Check to be sure that there is zero end play of axle shaft (9).

11. If axle bearing preload rolling torque exceeds the specification, back off nut (3) one-eighth turn and reseat bearing cone (5) against nut (3). Perform Step 10 again.

814F Rim Group

8R-4310

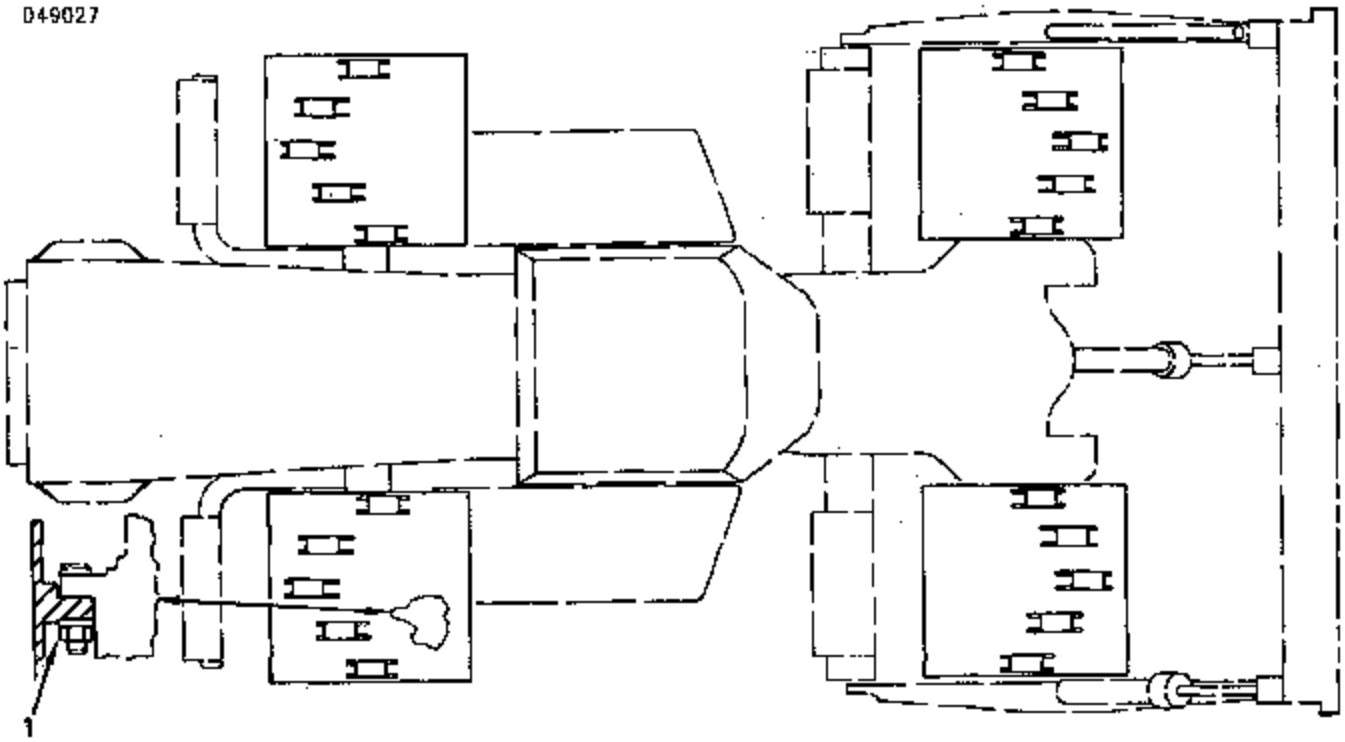


(1) Torque for 20 bolts that fasten the rim to the wheel assembly ..... 570 ± 80 N•m (420 ± 60 lb ft) +

Turn bolt an additional 60° ± 5°.

815F Wheel Group

121-3179

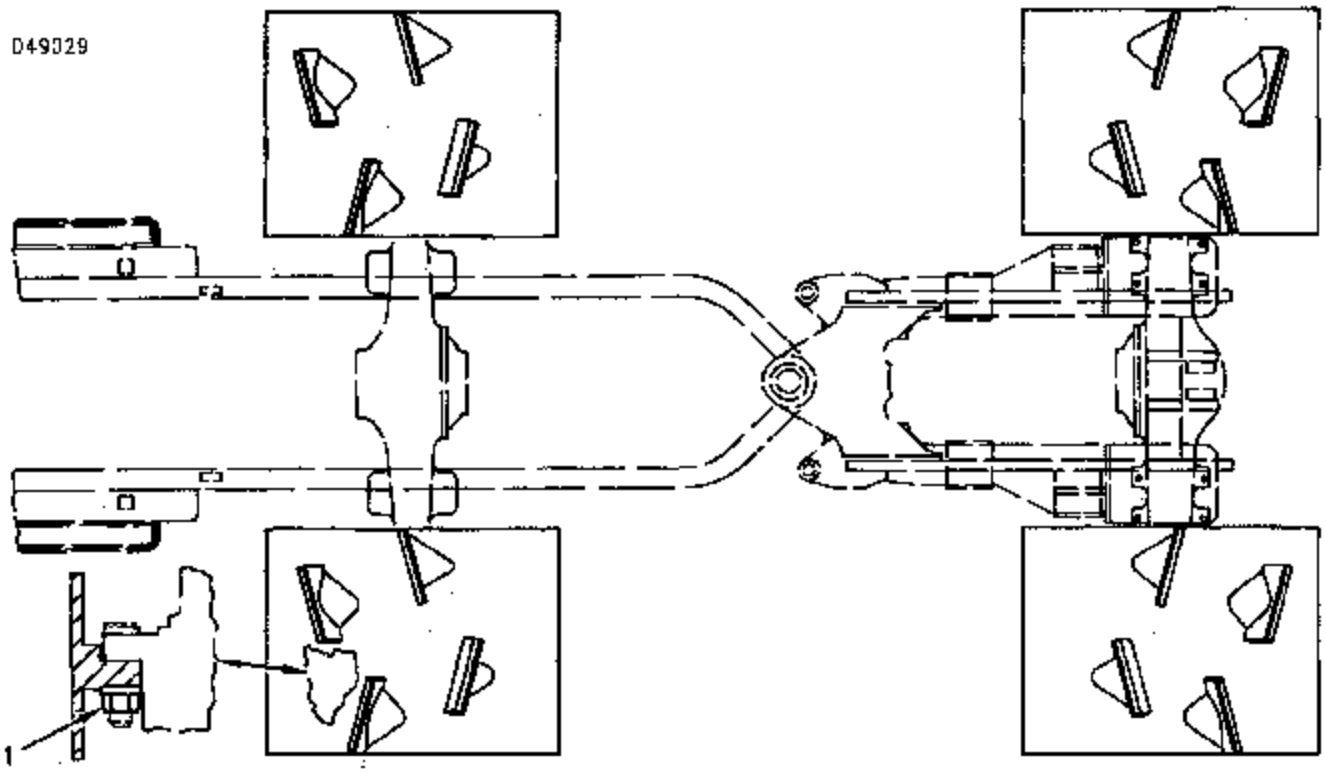


(1) Tighten 20 nuts to a torque of ..... 570 ± 80 N•m
(420 ± 60 lb ft) +

Turn an additional 60 ± 5°

816F Wheel Group

128-8108



(1) Tighten 20 nuts to a torque of ..... 570 ± 80 N•m (420 ± 60 lb ft) +

Turn an additional 60 ± 5°

NOTE: Install wheel assemblies with chevron pattern as shown.

CATERPILLAR®

SENR1308
February 1996

Systems Operation Testing & Adjusting

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Train

814F	815F	816F	Transmission
9DM1-UP	1GN1-UP	5FN1-UP	1XY1-UP
			1YY1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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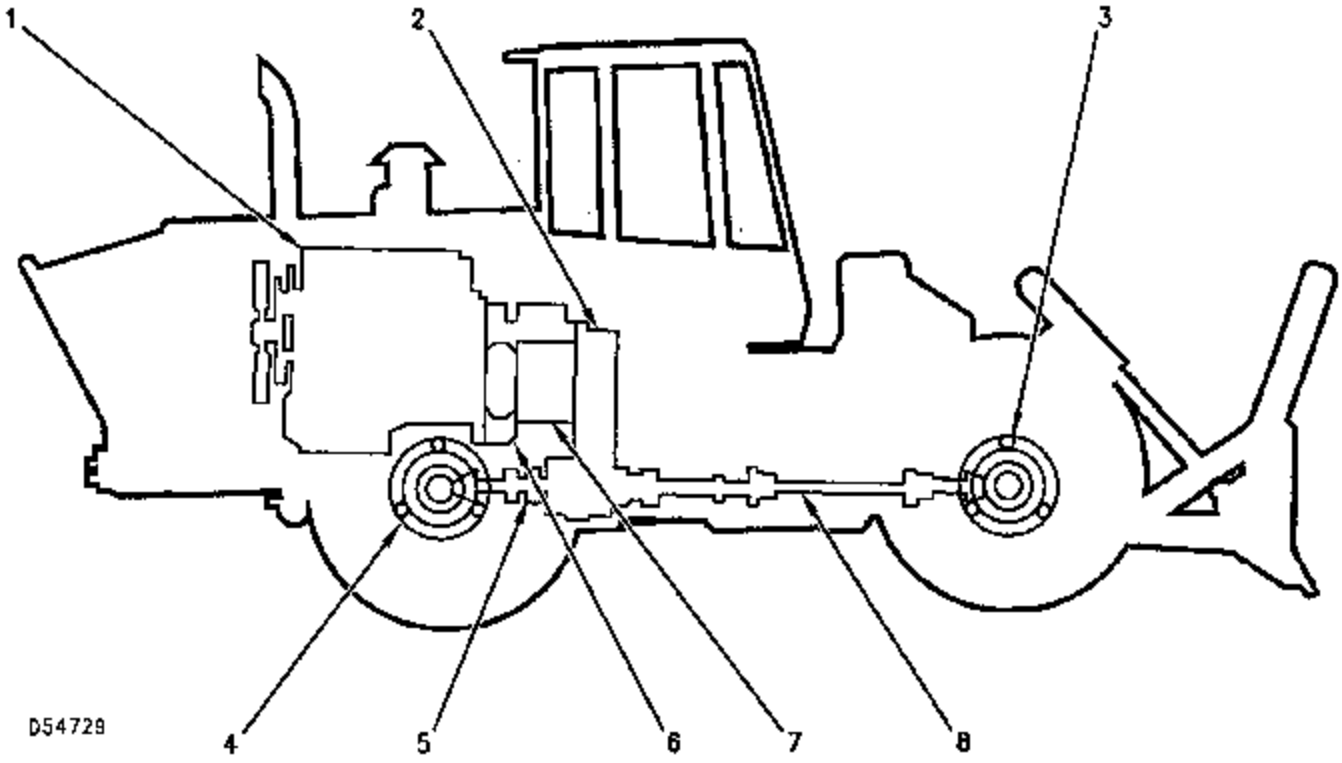
Reference: For Power Shift Transmission Testing And Adjusting, make reference to SENR1309, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Shift Transmission Testing And Adjusting.

Systems Operation

General Information



Power Train Components Locations
(1) Diesel engine. (2) Output transfer gears. (3) Front final drives. (4) Rear final drives. (5) Rear drive shaft. (6) Torque converter. (7) Transmission. (8) Front drive shaft.

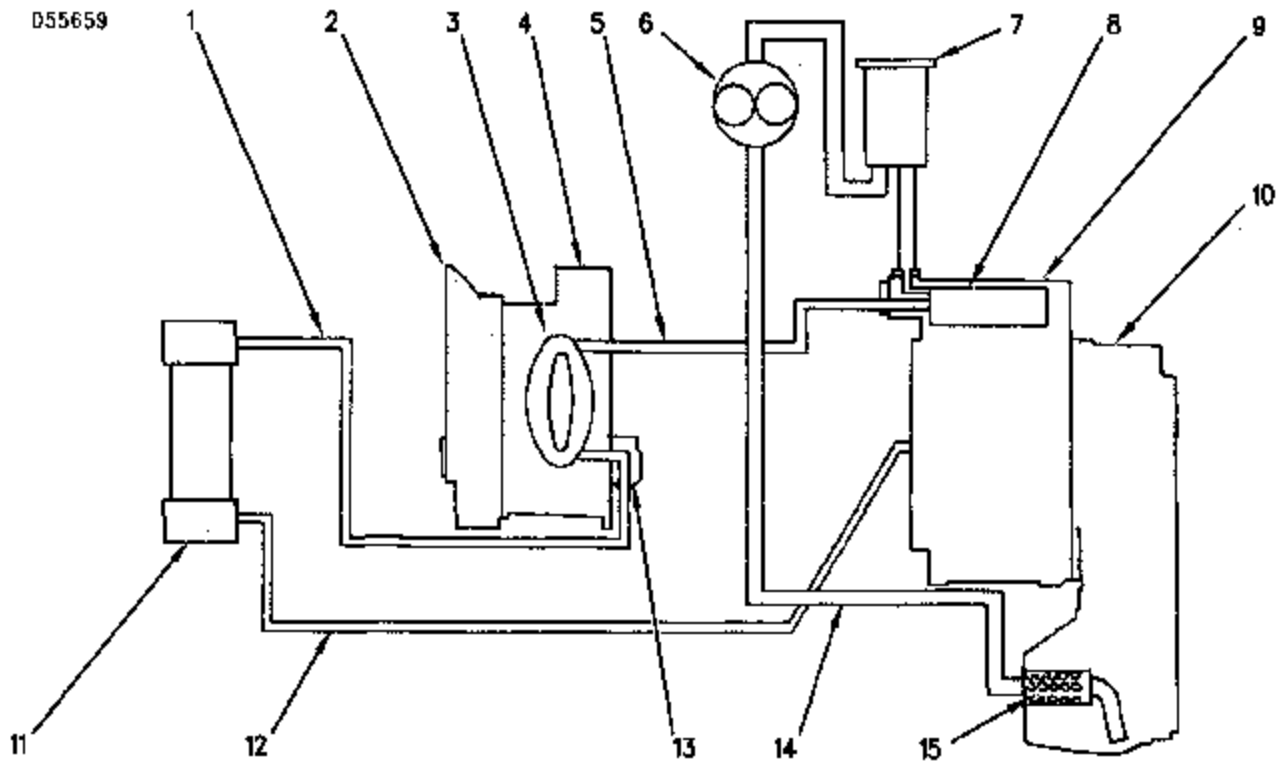
Power from diesel engine (1) is sent from the flywheel to torque converter (6). The torque converter output gear is connected to the transmission input gear.

Six hydraulically activated clutches in the transmission, give four forward speeds and four reverse speeds. Speed and direction selections are made manually.

The transmission output shaft is connected to a gear in the output transfer gear case by splines. Power is sent through the gear to the output gear. The output gear sends power through drive shaft (5) to the rear drive pinion. The output gear also sends power to the front drive pinion through drive shaft (8).

The pinions, bevel gears and gears of each differential turn their respective final drives. The axles are connected to final drives (3) and (4). The axles turn the wheels.

Power Train Hydraulic System



Hydraulic System Schematic
(1) Outlet line from torque converter. (2) Flywheel housing. (3) Torque converter. (4) Torque converter case. (5) Inlet line to torque converter. (6) Oil pump. (7) Oil filter. (8) Transmission hydraulic controls. (9) Transmission case. (10) Output transfer gear case. (11) Oil cooler. (12) Relief valve (for converter outlet). (13) Outlet line (from oil cooler). (14) Supply line to oil pump. (15) Magnetic screen.

The hydraulic system has a common reservoir. The reservoir is at the bottom of output transfer gear case (10). It supplies oil for the operation of the torque converter and transmission. It also gives lubrication oil for the different components in the system

Oil is pulled from the reservoir through magnetic screen (15) by oil pump (6). Pump (6) sends pressure oil to oil filter (7). The oil flows through the filter. If restrictions are present in the oil filter, a bypass valve in the filter housing allows the oil to bypass the filter.

From filter (7), the oil flows to transmission hydraulic controls (8). The transmission selector and pressure control valve (part of the transmission hydraulic controls), the pressure and flow of the oil to the transmission clutches for engagement. It also controls the inlet oil to the torque converter.

Inlet oil, for operation of the torque converter, flows through line (5). The inlet pressure valve for the torque converter (part of the selector and pressure control valve) controls the oil pressure to the converter.

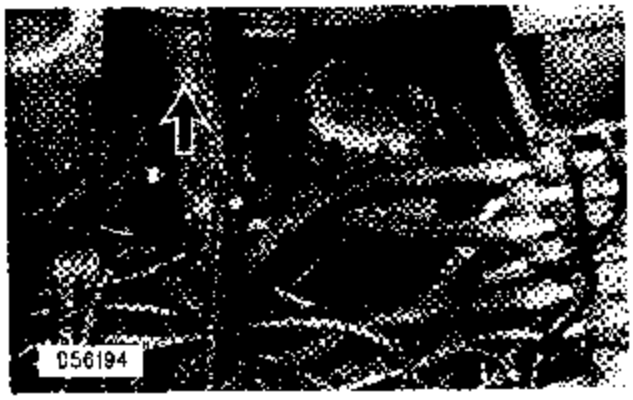
Leakage oil from torque converter (3) is for lubrication of the internal components.

After lubrication of the components, oil flows to the bottom of torque converter case (4). A passage at the bottom of converter case (4) allows the oil to flow to the bottom of transmission case (9). The transmission case also has a passage at the bottom that allows all the oil to flow to the main reservoir in case (10).

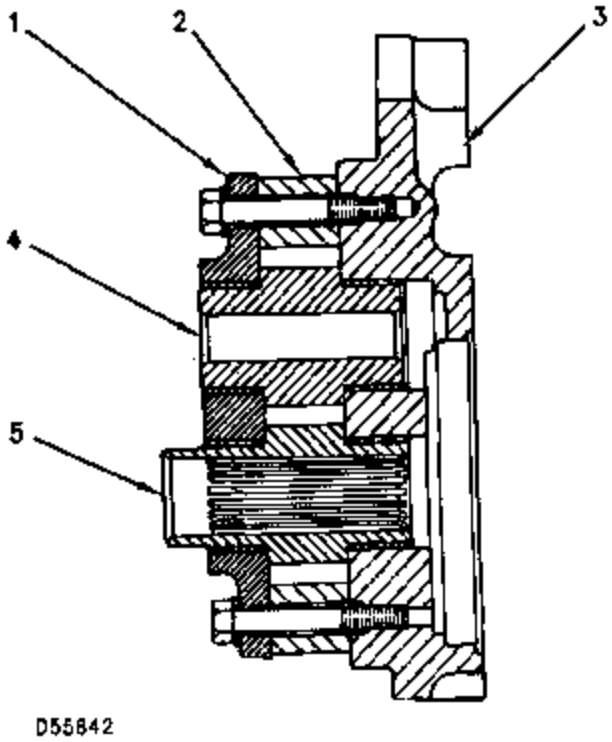
Outlet oil from the converter flows to relief valve (12) for converter outlet. Relief valve (12) maintains the pressure inside the converter at 415 kPa (60 psi) minimum. From the outlet relief valve, the oil flows through line (1) to oil cooler (11).

After flowing through the cooler, the oil at a lower temperature, flows through outlet line (13) to the transmission planetary. This oil is for lubrication of the transmission.

Oil Pump



Oil Pump Location



Oil Pump Construction
(1) Cover assembly. (2) Body assembly. (3) Manifold assembly. (4) Drive gear. (5) Gear.

The oil pump is a single-section gear-type mounted between the hydraulic implement pump and the housing assembly (torque converter housing).

The main components of the oil pump are: body assembly (2), cover assembly (1), manifold assembly (3), drive gear (4) and gear (5).

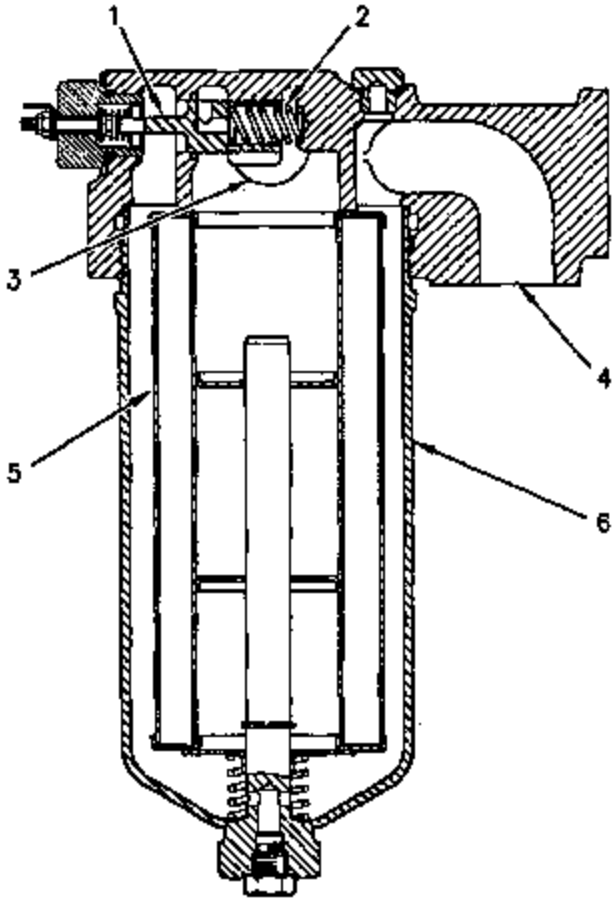
Drive gear (4) is connected by splines to the pump drive. The hydraulic implement pump is driven by drive gear (4).

In operation, oil comes from the reservoir in the output transfer gear case, through the magnetic screen to an opening in manifold assembly (3). The oil fills the spaces between the teeth of gears (4), and (5) and body (2). As the gears turn, oil is pushed from body (2). The oil flows through another passage in manifold assembly (3) to an oil line. The oil then flows to the filter.

Oil Filter

Oil Filter Location

The oil filter is located under and to the left side of the upper articulating hitch assembly.



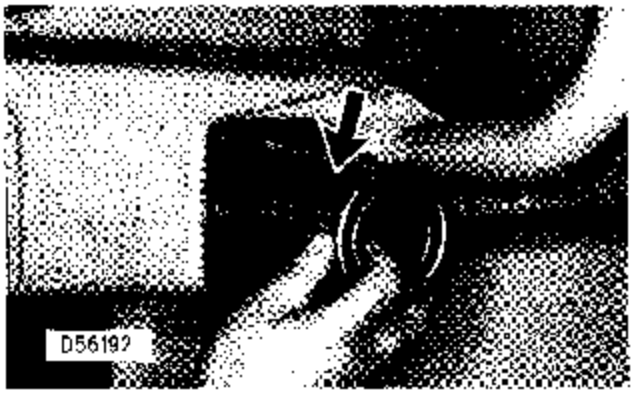
Oil Filter Components
(1) Bypass valve. (2) Spring. (3) Outlet passage. (4) Inlet passage. (5) Element. (6) Housing.

Pressure oil, from the oil pump, flows into inlet passage (4). The oil flows through the filter base to housing (6). Oil fills the space between the inside of housing (6) and filter element (5). Normally, oil flows through the filter element and then to the outlet passage. The oil then flows to the remainder of the hydraulic system. The filter element stops any debris that is in the oil.

If the filter element becomes full of debris, the restriction to the flow of oil causes a pressure increase inside the filter. The increase in pressure causes bypass valve (1) to open. The oil then flows to the hydraulic system. When the oil does not flow through the filter element, it is dirty and the debris in the oil can cause damage to other components in the hydraulic system.

Correct maintenance must be used to make certain that filter element (5) does not become full of debris and stop the flow of clean oil to the hydraulic system.

Magnetic Screen



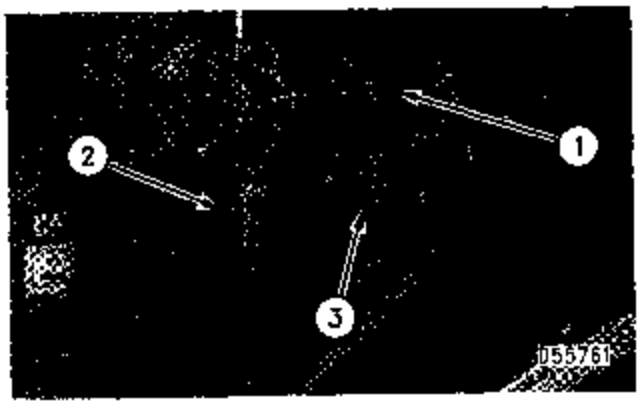
Magnetic Screen Location

A magnetic screen is inside of the transfer gear case. Oil from the bottom of the transfer gear case flows through an inlet passage. As the oil flows through the screen, particles that are in the oil are stopped by the screen and can not go into the transmission hydraulic system.

After the oil flows through the screen, it flows around and through magnets. The magnets are installed on the tube assembly so that the same magnetic ends are next to each other. Smaller metal particles that go through the screen are stopped and held by the magnets. These magnets will not allow the metal particles go with the oil through the hydraulic system.

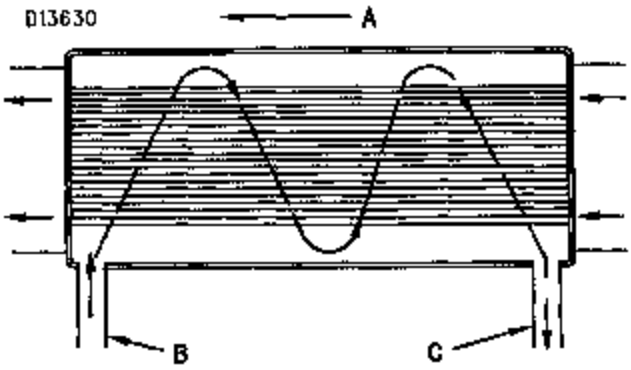
The oil then flows through the tube assembly to the transmission pump.

Power Train Oil Cooler



Power Train Oil Cooler
(1) Oil cooler. (2) Oil from Torque converter outlet. (3) Outlet passage to transmission lubrication.

Coolant from the engine comes in at the end. The coolant flows through the many long tubes that are in cooler (1). After the coolant flows through the tubes, it flows out through the other end of the cooler and returns to the engine cylinder block.

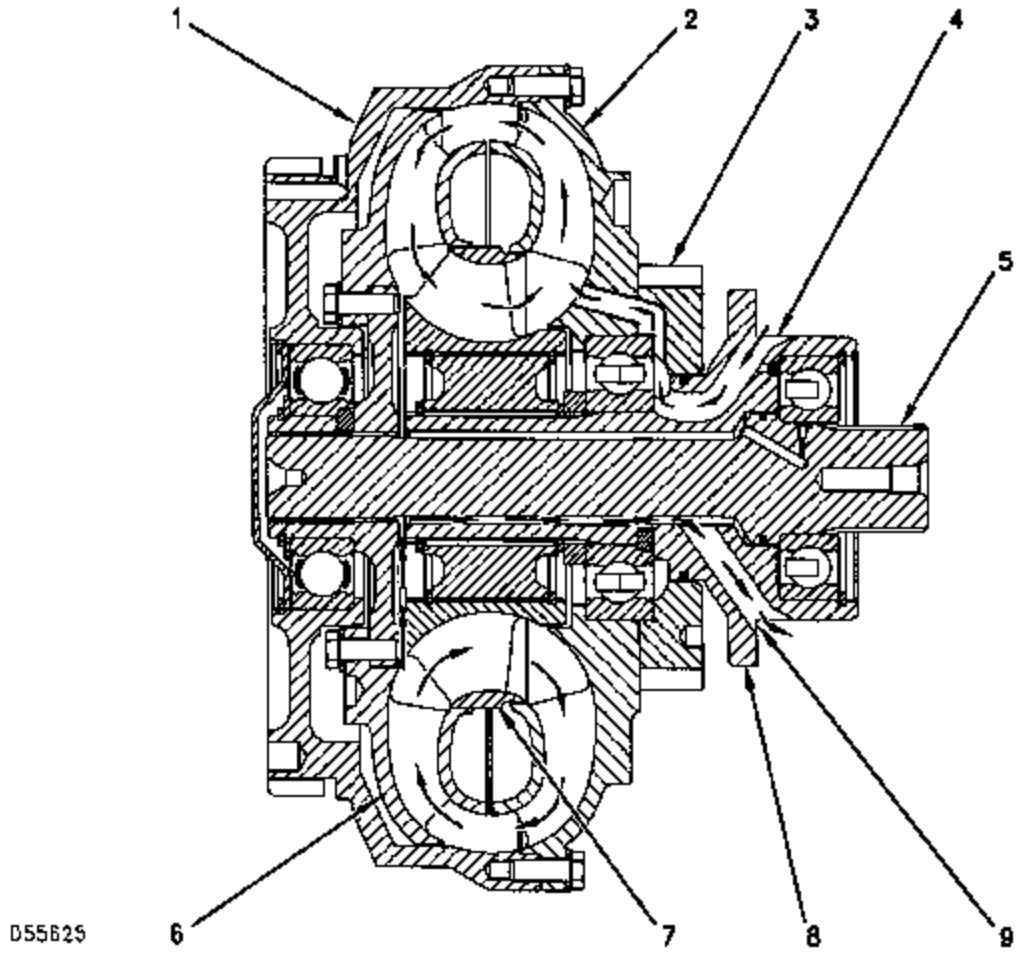


Transmission Oil Cooler Schematic

Transmission system oil with a high temperature comes from torque converter outlet (2). This oil comes in at the side of the cooler. The flow of oil is around and along the many tubes inside the cooler. In this procedure, heat is removed from the oil and is given to the coolant of the engine. The engine coolant flows through the tubes inside the cooler and takes the heat from the oil. The coolant is then cooled by the cooling system of the engine.

After the oil flows along the tubes in the cooler, it flows out through the outlet passage at the bottom and has a lower temperature. The colder oil then flows to the transmission for lubrication and cooling.

Torque Converter



Torque Converter
(1) Rotating housing. (2) Impeller. (3) Gear. (4) Inlet port. (5) Output shaft. (6) Turbine. (7) Stator. (8) Carrier assembly. (9) Outlet port.

The torque converter is located at the input end of the transmission. The converter housing is bolted to the flywheel housing. Output torque from the converter enters the planetary transmission through either the No. 1 or No. 2 sun gear. The gear that receives the output, is dependent upon the directional clutch engaged.

Oil for the operation of the converter is supplied by the transmission oil pump. The converter inlet oil pressure is controlled by the inlet pressure valve for the torque converter. This valve limits the pressure to the converter to 980 kPa (142 psi) maximum when the oil is cold. It is part of the selector and pressure control valve group in the transmission hydraulic controls.

The outlet oil pressure is controlled by the relief valve for torque converter outlet. This valve is mounted on the right side of the converter cover and maintains converter outlet pressure at 415 kPa (60 psi).

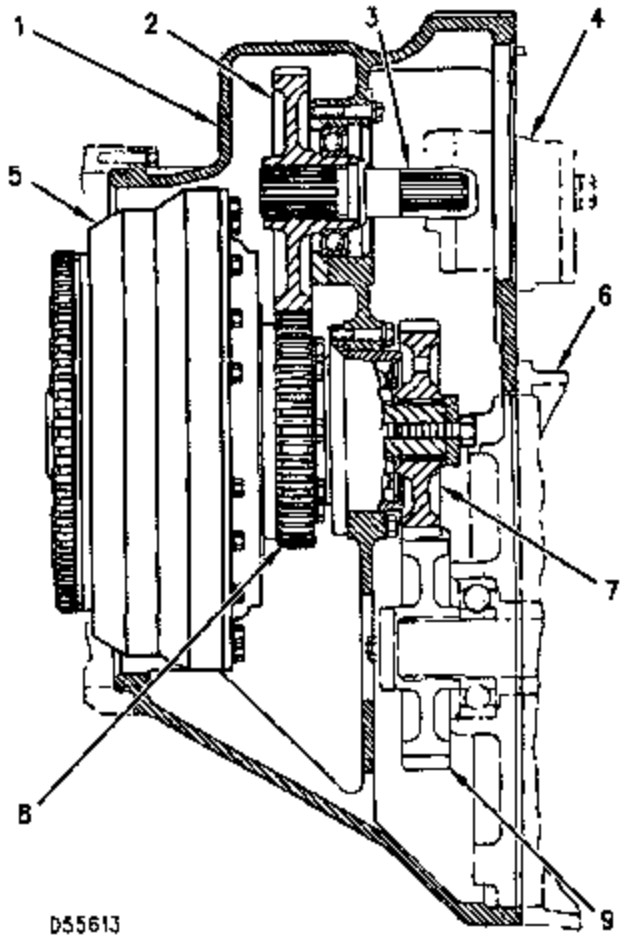
Rotating housing (1), impeller (2), and oil pump drive gear (3) are driven by the flywheel and rotate as a unit at engine speed.

Oil from the transmission hydraulic controls enters the torque converter through inlet port (4) in carrier (8). Oil is directed to the inlet port by a passage in the converter housing. From inlet port (4), the oil flows through carrier (8) and through a passage in the hub.

As impeller (2) rotates, it acts as a pump to direct oil to turbine (6). The turbine is fastened to a hub, which is connected to output shaft (5) by splines. The turbine directs oil to stator (7), which is held stationary. The stator is connected to carrier (8) by bolts. Carrier (8) is bolted to the torque converter housing.

The oil flows through a passage in carrier (8) to outlet port (9). From outlet port (9), oil is directed to the converter outlet relief valve. All the oil from the outlet relief valve flows to the oil cooler, where the temperature of the oil is lowered. From the oil cooler, the oil is then sent to the transmission where it is used to cool and lubricate the internal components.

Torque Converter And Pump Drive Housing

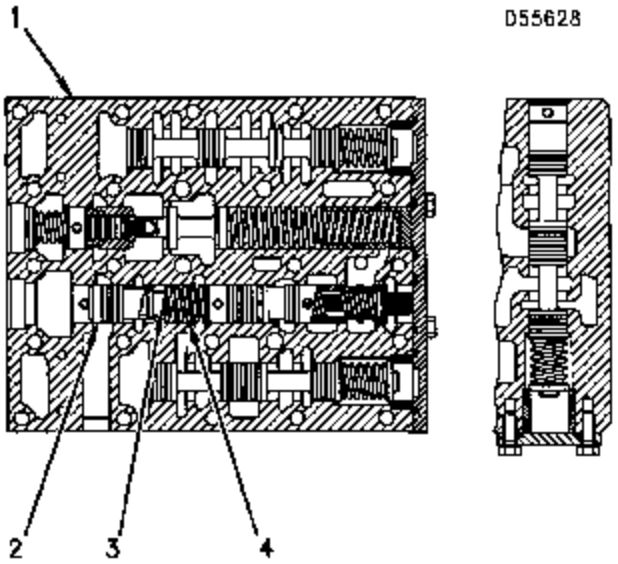


Torque Converter And Pump Drive Housing
(1) Housing. (2) Transmission and implement pump drive gear. (3) Pump drive shaft. (4) Transmission oil pump. (5) Torque converter. (6) Transmission housing. (7) Torque converter output gear. (8) Drive gear. (9) Input gear for planetary transmission.

Transmission oil pump (4) and the hydraulic implement pump are mounted on torque converter housing (1). Housing (1) is between the engine flywheel housing and transmission housing (6).

Gear (8) turns transmission and implement pump drive gear (2). Pump drive shaft (3) is connected by splines to transmission oil pump (4). The hydraulic implement pump is fastened to transmission oil pump (4). Torque converter output gear (7) sends power to input gear (9) for the planetary transmission.

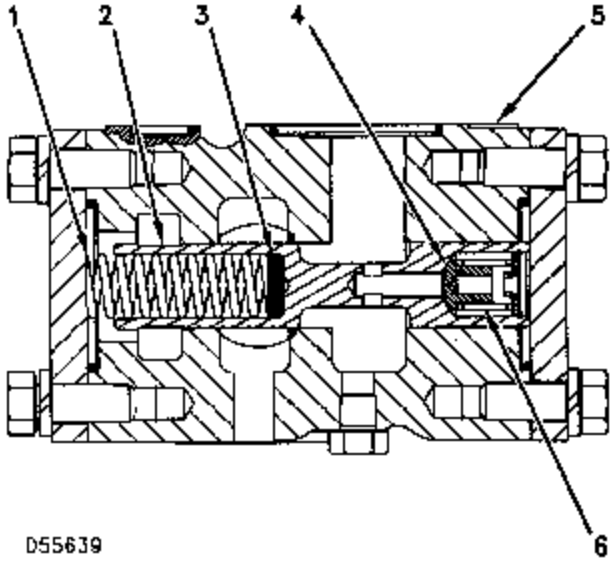
Torque Converter Ratio Valve



Torque Converter Ratio Valve Location
(1) Transmission selector and pressure control valve. (2) Ratio valve for the torque converter. (3) Slug. (4) Spring.

The torque converter ratio valve controls the maximum pressure to the converter. The main purpose of the ratio valve is to prevent damage to converter components when the engine is started and the oil is cold. It limits the maximum pressure to the converter to approximately 980 kPa (142 psi). This pressure is not adjustable.

Converter Outlet Relief Valve



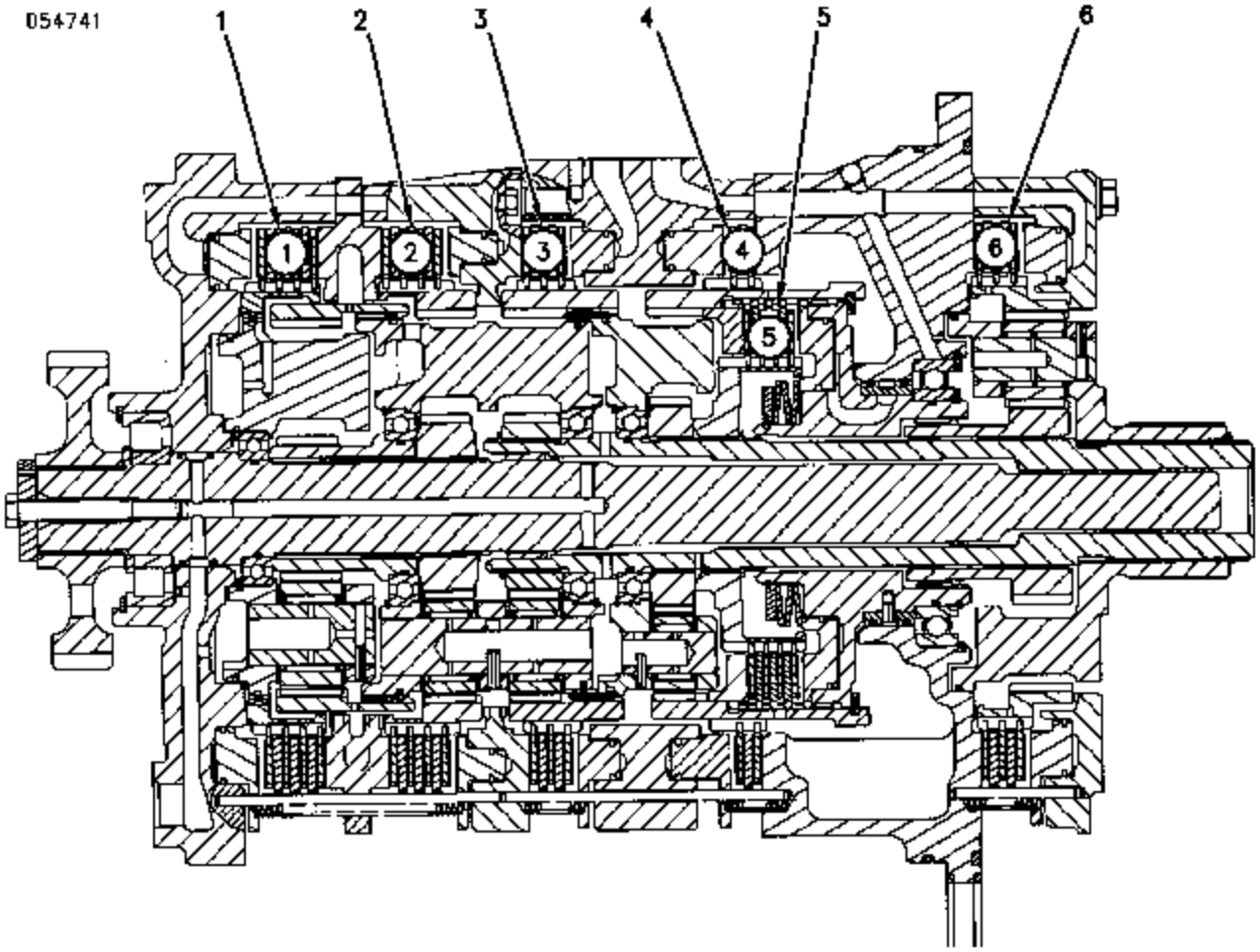
Converter Outlet Relief Valve
(1) Spring. (2) Valve spool. (3) Spacers. (4) Poppet. (5) Valve body. (6) Spring.

The relief valve for converter outlet controls the minimum pressure in the torque converter. When the pressure in the converter is approximately 415 kPa (60 psi) or less, spool (2) moves with the force of spring (1) to limit oil to the oil cooler.

The outlet relief valve is mounted to the right side of the converter cover.

Spacers (3) are used to make an adjustment to the opening pressure of the valve.

Transmission



Transmission Components
(1) No. 1 clutch (2) No. 2 clutch. (3) No. 3 clutch. (4) No. 4 clutch. (5) No. 5 clutch. (6) No. 6 clutch.

The transmission has six hydraulically activated clutches that give four speeds FORWARD and four speeds REVERSE. Speed and direction are both manually selected.

The transmission is fastened between the torque converter cover and the case for the output transfer gears. Input power to the transmission comes from the torque converter.

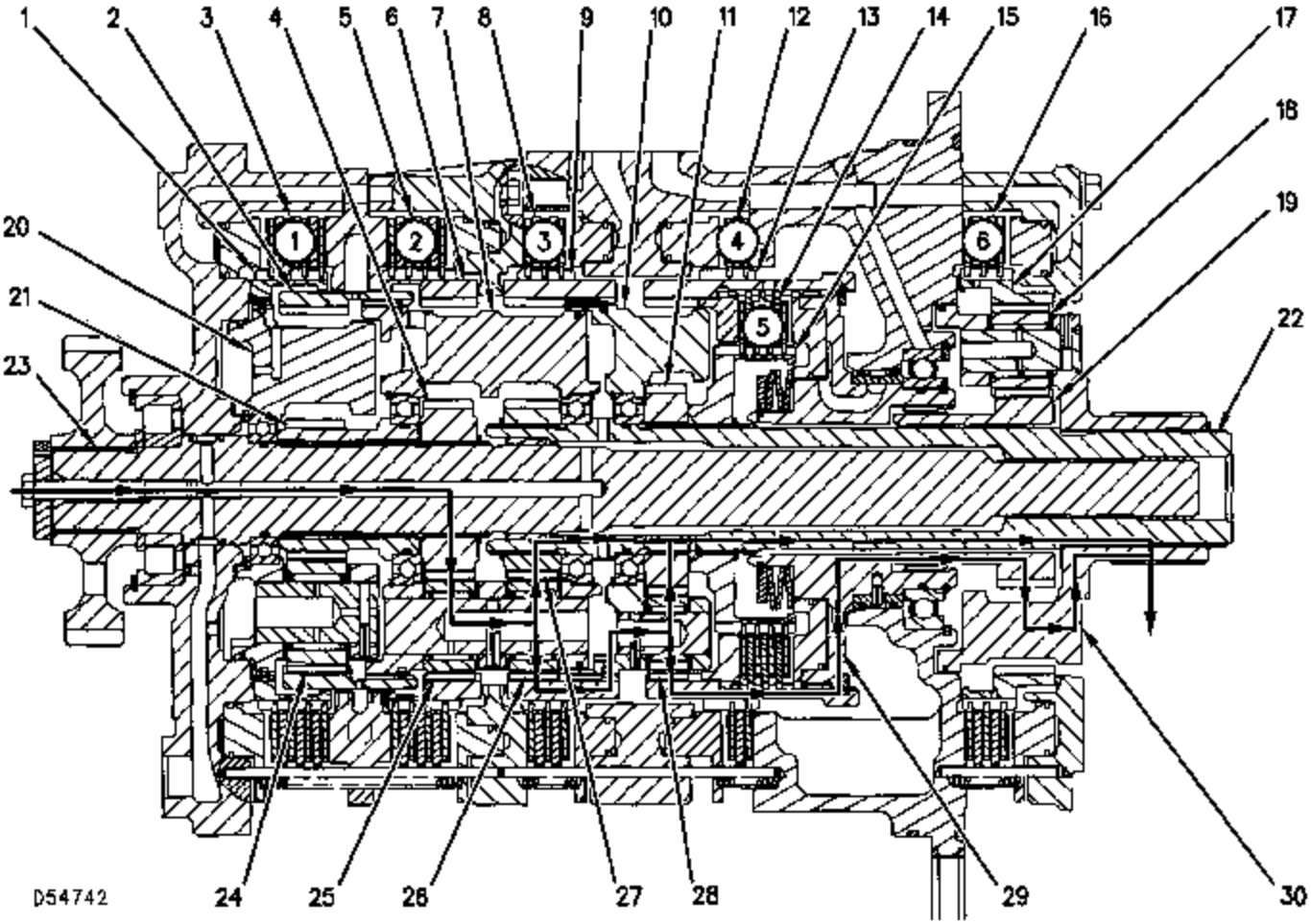
A speed clutch and a direction clutch must both be engaged, in that order, to send power through the transmission. The chart gives the combination of the clutches engaged for each FORWARD and REVERSE speeds.

The two clutches, No. 1 and No. 2, nearest the input end of the transmission are the direction clutches. The No. 1 clutch is the REVERSE direction clutch. The No. 2 clutch is the FORWARD direction clutch.

The No. 3, No. 4, No. 5 and No. 6 clutches are the speed clutches. The No. 3 clutch gives FOURTH speed. The No. 4 clutch gives THIRD speed. The No. 5 clutch gives SECOND speed. The No. 6 clutch gives FIRST speed.

Transmission Selection	Clutches Engaged In Transmission
Neutral	3
First Speed Forward	2 and 6
Second Speed Forward	2 and 5
Third Speed Forward	2 and 4
Fourth Speed Forward	2 and 3
First Speed Reverse	1 and 6
Second Speed Reverse	1 and 5
Third Speed Reverse	1 and 4
Fourth Speed Reverse	1 and 3

First Speed Forward



Transmission Components Power Flow In First Speed Forward (No. 2 and No. 6 clutches engaged)
(1) Coupling. (2) Ring gear for No. 1 clutch. (3) No. 1 clutch (reverse direction). (4) No. 2 sun gear. (5) No. 2 clutch (forward direction). (6) Ring gear for No. 2 clutch. (7) No. 2 and No. 3 carrier. (8) No. 3 clutch (fourth speed). (9) Ring gear for No. 3 clutch. (10) No. 4 carrier. (11) No. 4 sun gear. (12) No. 4 clutch (third speed) (13) Ring gear for No. 4 clutch. (14) No. 5 clutch (second speed). (15) Rotating hub. (16) No. 6 clutch (first speed). (17) Ring gear for No. 6 clutch. (18) No. 6 planetary gears. (19) No. 6 sun gear. (20) No. 1 carrier. (21) No. 1 sun gear. (22) Output shaft. (23) Input shaft. (24) No. 1 planetary gears. (25) No. 2 planetary gears. (26) No. 3 planetary gears. (27) No. 3 sun gear. (28) No. 4 planetary gears. (29) Housing assembly. (30) No. 6 carrier.

When the transmission is in FIRST SPEED FORWARD, No. 6 and No. 2 clutches are engaged. The No. 2 clutch holds ring gear (6) stationary. The No. 6 clutch holds ring gear (17) stationary. Input shaft (23) turns No. 2 sun gear (4). No. 2 sun gear turns No. 2 planetary gears (25).

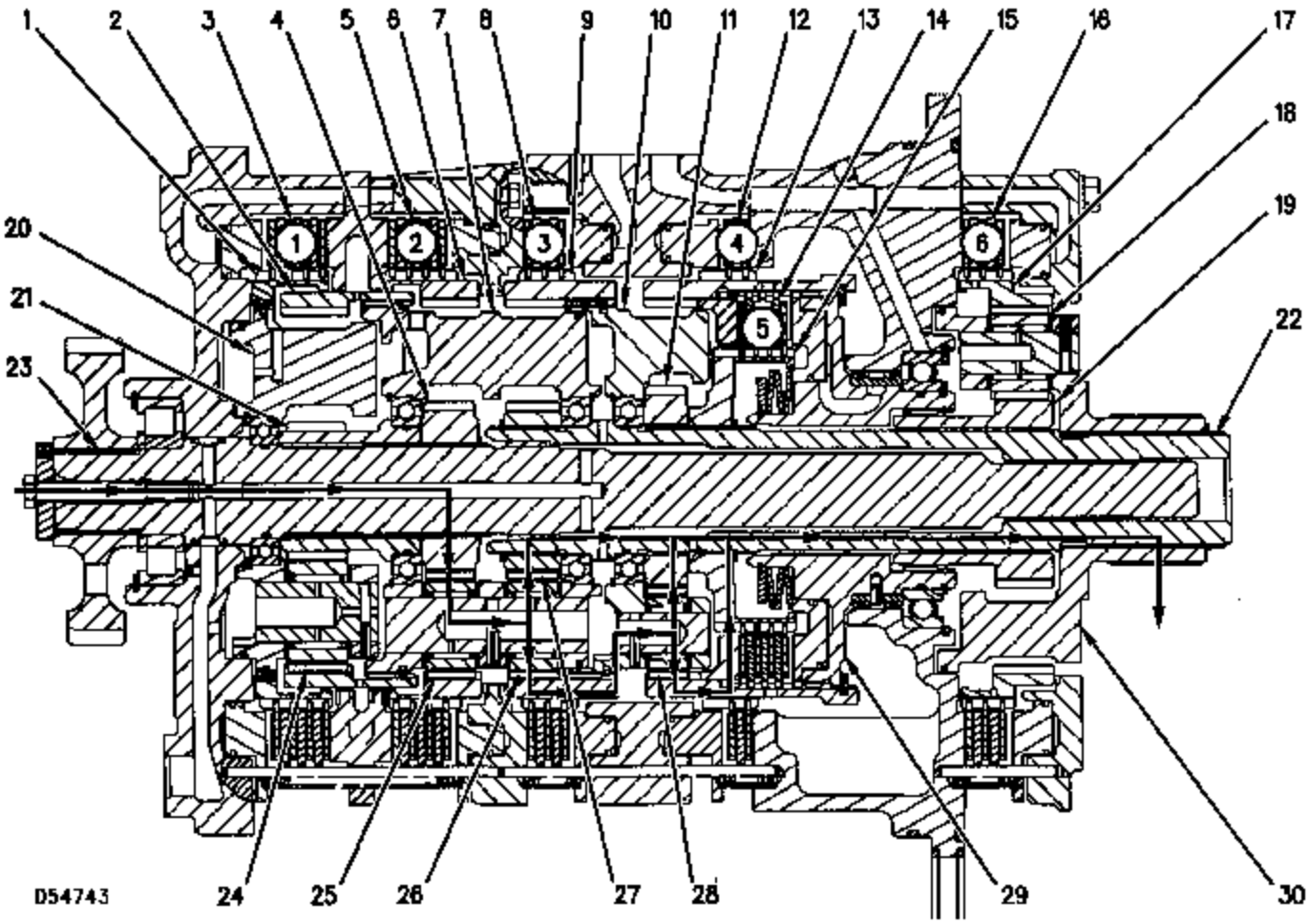
Since ring gear (6) is held stationary by the No. 2 clutch, planetary gears (25) move around the inside of the ring gear. The movement of planetary gears (25) causes No. 2 and No. 3 carrier (7) to turn in the same direction as input shaft (23). As the No. 2 and No. 3 carrier turns, No. 3 planetary gears (26) turn. The No. 3 planetary gears turn ring gear (9) and sun gear (27). Sun gear (27) turns output shaft (22).

Ring gear (9) turns No. 4 carrier (10). As the No. 4 carrier turns, No. 4 planetary gears (28) turn. The No. 4 planetary gears turn ring gear (13), which is fastened to housing assembly (29). The No. 4 planetary gears also turn No. 4 sun gear (11). No. 4 sun gear turns output shaft (22). Housing assembly (29) is fastened to and turns No. 6 sun gear (19).

No. 6 sun gear (19) turns No. 6 planetary gears (18). Since ring gear (17) is held stationary by the No. 6 clutch, planetary gears (18) move around the inside of the ring gear. The movement of planetary gears (18) causes No. 6 carrier (30) to turn. No. 6 carrier (30) is fastened to and turns output shaft (22).

As a result, torque to output shaft (22) is divided through No. 3 sun gear (27), No. 4 sun gear (11) and No. 6 carrier (30). From the output shaft, power goes through the output transfer gears to the differentials.

Second Speed Forward



Transmission Components Power Flow In Second Speed Forward (No. 2 and No. 5 clutches engaged)
(1) Coupling. (2) Ring gear for No. 1 clutch. (3) No. 1 clutch (reverse direction). (4) No. 2 sun gear. (5) No. 2 clutch (forward direction). (6) Ring gear for No. 2 clutch. (7) No. 2 and No. 3 carrier. (8) No. 3 clutch (fourth speed). (9) Ring gear for No. 3 clutch. (10) No. 4 carrier. (11) No. 4 sun gear. (12) No. 4 clutch (third speed) (13) Ring gear for No. 4 clutch. (14) No. 5 clutch (second speed). (15) Rotating hub. (16) No. 6 clutch (first speed). (17) Ring gear for No. 6 clutch. (18) No. 6 planetary gears. (19) No. 6 sun gear. (20) No. 1 carrier. (21) No. 1 sun gear. (22) Output shaft. (23) Input shaft. (24) No. 1 planetary gears. (25) No. 2 planetary gears. (26) No. 3 planetary gears. (27) No. 3 sun gear. (28) No. 4 planetary gears. (29) Housing assembly. (30) No. 6 carrier.

When the transmission is in SECOND SPEED FORWARD, No. 5 and No. 2 clutches are engaged. The No. 2 clutch holds ring gear (6) stationary. The No. 5 clutch connects rotating hub (15) and No. 4 ring gear (13). Input shaft (23) turns No. 2 sun gear (4). No. 2 sun gear turns No. 2 planetary gear (25).

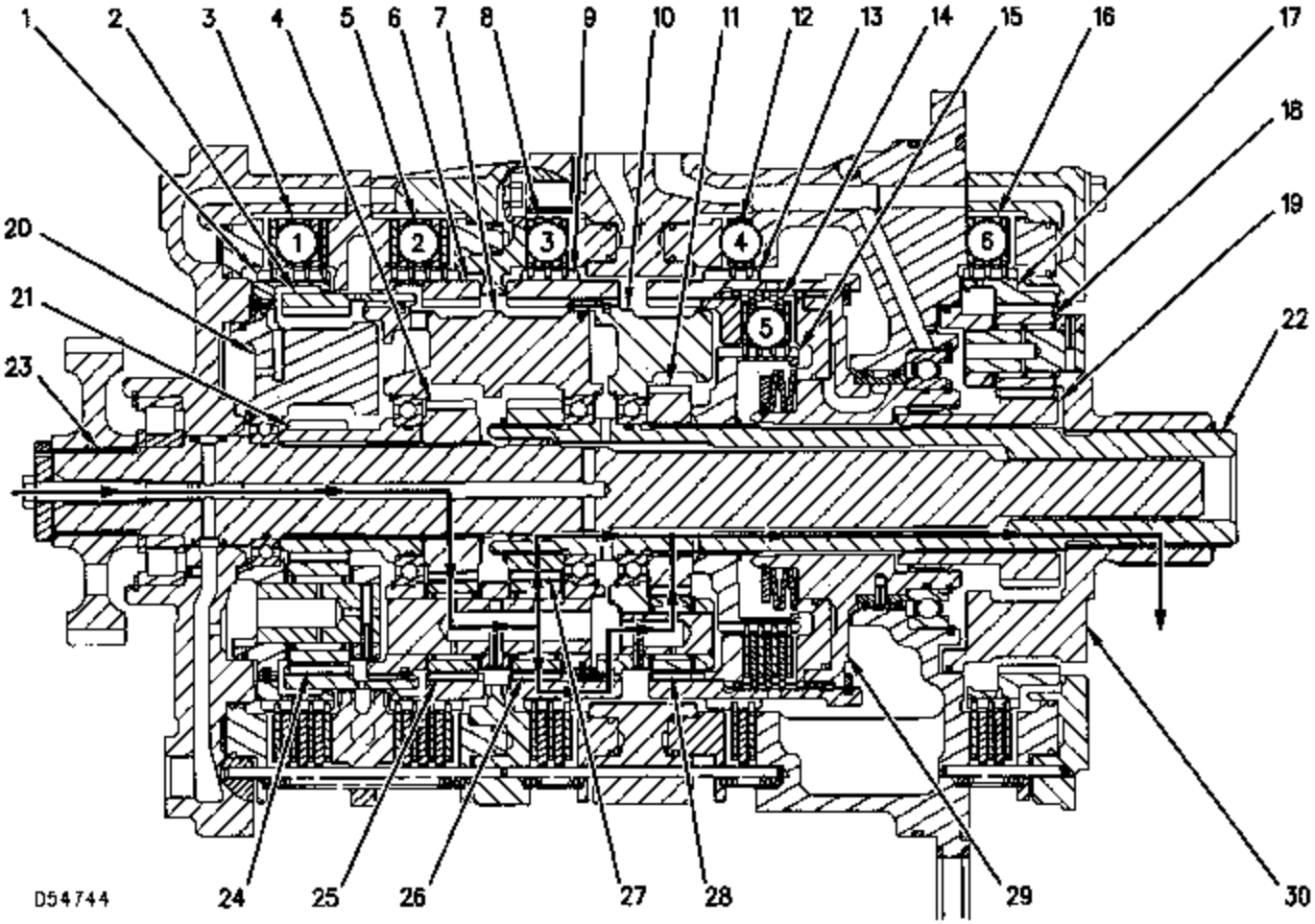
Since ring gear (6) is held stationary by the No. 2 clutch, planetary gears (25) move around the inside of the ring gear. The movement of planetary gears (25) causes No. 2 and No. 3 carrier (7) to turn in the same direction as input shaft (23). As the No. 2 and No. 3 carrier turns, No. 3 planetary gears (26) turn. The No. 3 planetary gears turn ring gear (9) and sun gear (27).

Sun gear (27) turns output shaft (22). Ring gear (9) turns No. 4 carrier (10). As the No. 4 carrier turns, No. 4 planetary gears (28) turn. The No. 4 planetary gears turn ring gear (13), which is fastened to housing assembly (29). The No. 4 planetary gears also turn No. 4 sun gear (11). No. 4 sun gear turns output shaft (22).

No. 5 clutch connects rotating hub (15) to No. 4 ring gear (13). Rotating hub (15) turns output shaft (22).

As a result, torque to output shaft (22) is divided through No. 3 sun gear (27), No. 4 sun gear (11) and rotating hub (15). From the output shaft power goes through the output transfer gears to the differentials.

Third Speed Forward



Transmission Components Power Flow In Third Speed Forward (No. 2 and No. 4 clutches engaged)
(1) Coupling. (2) Ring gear for No. 1 clutch. (3) No. 1 clutch (reverse direction). (4) No. 2 sun gear. (5) No. 2 clutch (forward direction). (6) Ring gear for No. 2 clutch. (7) No. 2 and No. 3 carrier. (8) No. 3 clutch (fourth speed). (9) Ring gear for No. 3 clutch. (10) No. 4 carrier. (11) No. 4 sun gear. (12) No. 4 clutch (third speed) (13) Ring gear for No. 4 clutch. (14) No. 5 clutch (second speed). (15) Rotating hub. (16) No. 6 clutch (first speed). (17) Ring gear for No. 6 clutch. (18) No. 6 planetary gears. (19) No. 6 sun gear. (20) No. 1 carrier. (21) No. 1 sun gear. (22) Output shaft. (23) Input shaft. (24) No. 1 planetary gears. (25) No. 2 planetary gears. (26) No. 3 planetary gears. (27) No. 3 sun gear. (28) No. 4 planetary gears. (29) Housing assembly. (30) No. 6 carrier.

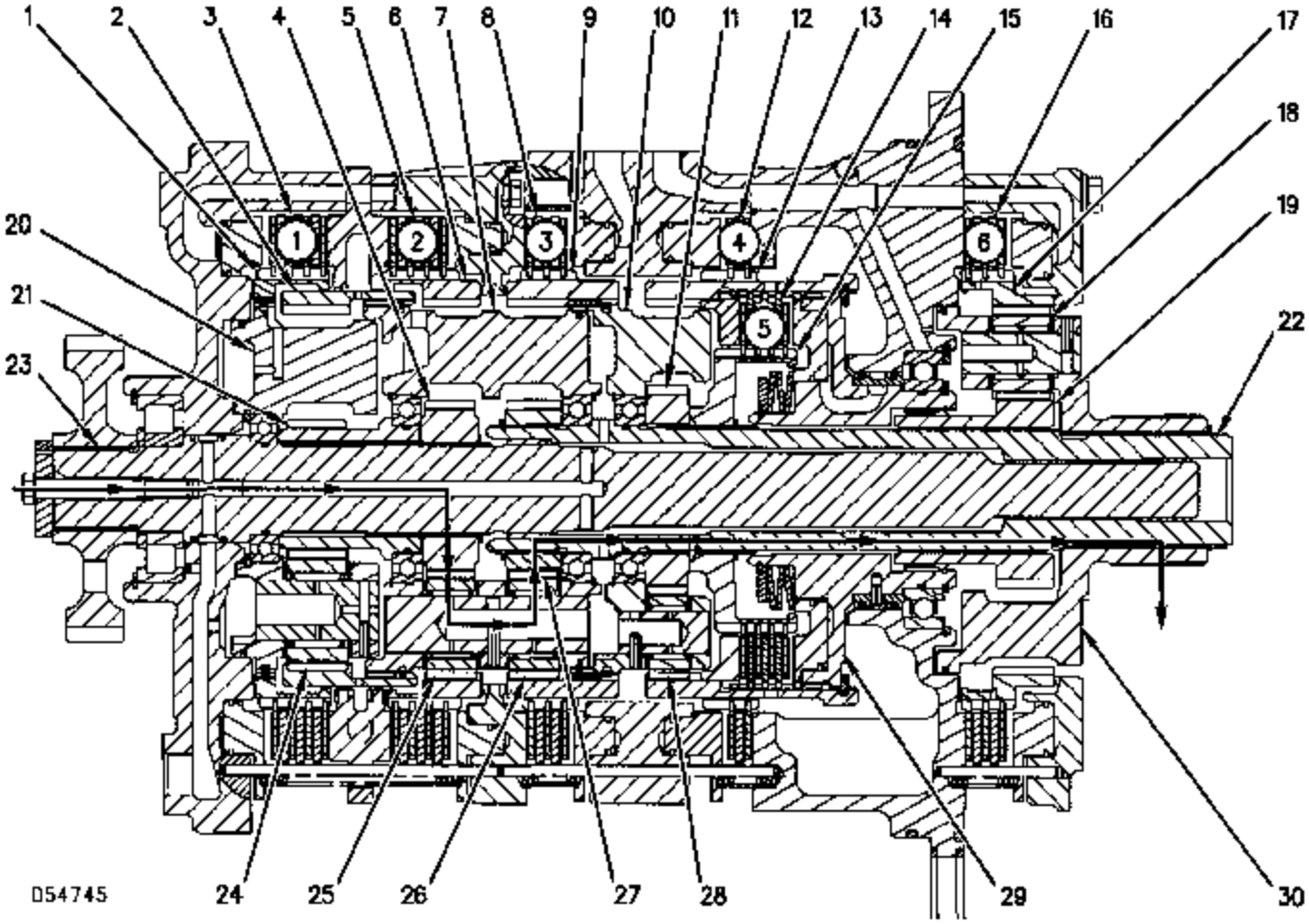
When the transmission is in THIRD SPEED FORWARD, No. 4 and No. 2 clutches are engaged. The No. 2 clutch holds ring gear (6) stationary. The No. 4 clutch holds ring gear (13) stationary. Input shaft (23) turns No. 2 sun gear (4). No. 2 sun gear turns No. 2 planetary gear (25).

Since ring gear (6) is held stationary by the No. 2 clutch, planetary gears (25) move around the inside of the ring gear. The movement of planetary gears (25) causes No. 2 and No. 3 carrier (7) to turn in the same direction as input shaft (23). As the No. 2 and No. 3 carrier turns, No. 3 planetary gears (26) turn. The No. 3 planetary gears turn ring gear (9) and sun gear (27).

Sun gear (27) turns output shaft (22). Ring gear (9) turns No. 4 carrier (10). Since ring gear (13) is held stationary by No. 4 clutch (12), planetary gears (28) move around the inside of ring gear (13). The movement of planetary gears (28) and No. 4 carrier (10), causes No. 4 sun gear (11) to turn. No. 4 sun gear turns output shaft (22).

As a result, torque to output shaft (22) is divided through No. 3 sun gear (27) and No. 4 sun gear (11). From the output shaft, power goes through the output transfer gears to the differentials.

Fourth Speed Forward



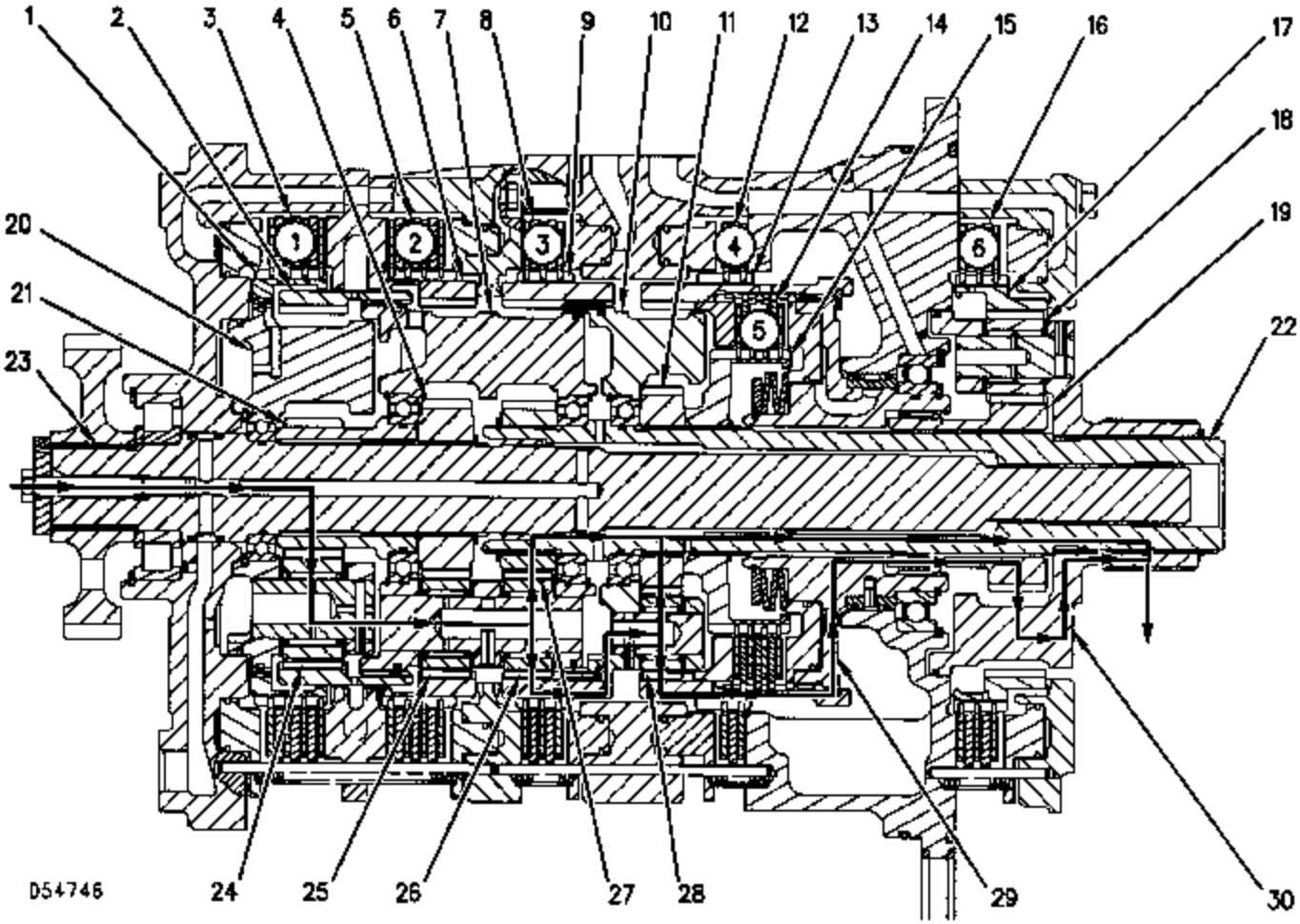
Transmission Components Power Flow In Fourth Speed Forward (No. 2 and No. 3 clutches engaged)
(1) Coupling. (2) Ring gear for No. 1 clutch. (3) No. 1 clutch (reverse direction). (4) No. 2 sun gear. (5) No. 2 clutch (forward direction). (6) Ring gear for No. 2 clutch. (7) No. 2 and No. 3 carrier. (8) No. 3 clutch (fourth speed). (9) Ring gear for No. 3 clutch. (10) No. 4 carrier. (11) No. 4 sun gear (12) No. 4 clutch (third speed) (13) Ring gear for No. 4 clutch. (14) No. 5 clutch (second speed). (15) Rotating hub. (16) No. 6 clutch (first speed). (17) Ring gear for No. 6 clutch. (18) No. 6 planetary gears. (19) No. 6 sun gear. (20) No. 1 carrier. (21) No. 1 sun gear. (22) Output shaft. (23) Input shaft. (24) No. 1 planetary gears. (25) No. 2 planetary gears. (26) No. 3 planetary gears. (27) No. 3 sun gear. (28) No. 4 planetary gears. (29) Housing assembly. (30) No. 6 carrier.

When the transmission is in FOURTH SPEED FORWARD, No. 2 and No. 3 clutches are engaged. The No. 2 clutch hold ring gear (6) stationary. The No. 3 clutch holds ring gear (9) stationary. Input shaft (23) turns No. 2 sun gear (4). No. 2 sun gear turns No. 2 planetary gears (25).

Since ring gear (6) is held stationary by the No. 2 clutch, planetary gears (25) move around the inside of ring gear (6). The movement of planetary gears (25) causes No. 2 and No. 3 carrier (7) to turn in the same direction as input shaft (23).

Since ring gear (9) is held stationary by the No. 3 clutch, the movement of No. 2 and No. 3 carrier (7) causes No. 3 planetary gears (26) to move around the inside of ring gear (9). The No. 3 planetary gears turn sun gear (27). Sun gear (27) turns output shaft (22) From the output shaft, power goes through the output transfer gears to the differentials.

First Speed Reverse



Transmission Components Power Flow In First Speed Reverse (No. 1 and No. 6 clutches engaged).
(1) Coupling. (2) Ring gear for No. 1 clutch. (3) No. 1 clutch (reverse direction). (4) No. 2 sun gear. (5) No. 2 clutch (forward direction). (6) Ring gear for No. 2 clutch. (7) No. 2 and No. 3 carrier. (8) No. 3 clutch (fourth speed). (9) Ring gear for No. 3 clutch. (10) No. 4 carrier. (11) No. 4 sun gear. (12) No. 4 clutch (third speed) (13) Ring gear for No. 4 clutch. (14) No. 5 clutch (second speed). (15) Rotating hub. (16) No. 6 clutch (first speed). (17) Ring gear for No. 6 clutch. (18) No. 6 planetary gears. (19) No. 6 sun gear. (20) No. 1 carrier. (21) No. 1 sun gear. (22) Output shaft. (23) Input shaft. (24) No. 1 planetary gears. (25) No. 2 planetary gears. (26) No. 3 planetary gears. (27) No. 3 sun gear. (28) No. 4 planetary gears. (29) Housing assembly. (30) No. 6 carrier.

When the transmission is in FIRST SPEED REVERSE, No. 1 and No. 6 clutches are engaged. The No. 1 clutch holds coupling (1) stationary. The No. 6 clutch holds ring gear (17) stationary. Input shaft (23) turns No. 1 sun gear (21). No. 1 sun gear turns No. 1 planetary gears (24). No. 1 carrier (20) is in direct mechanical connection with coupling (1).

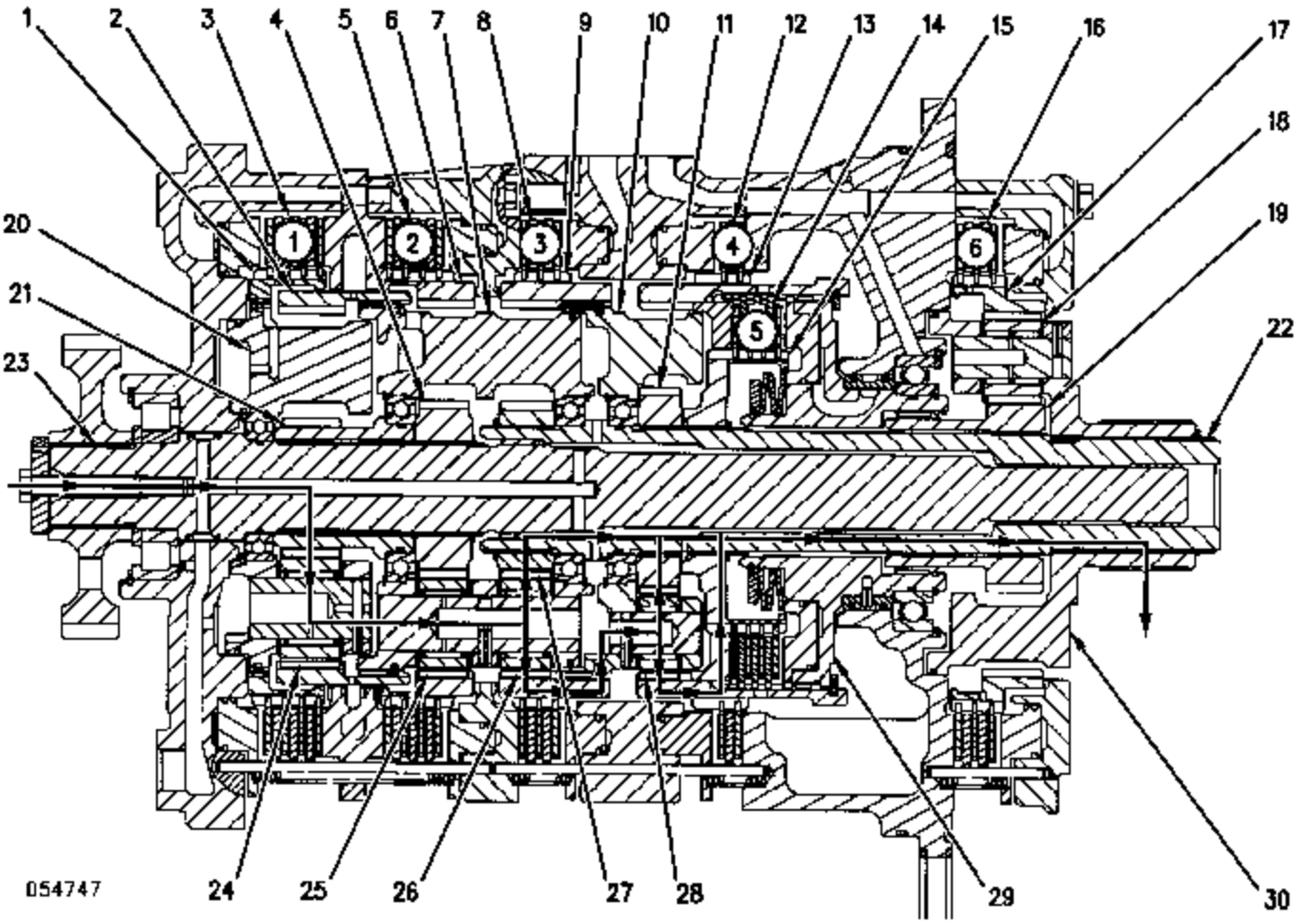
Since coupling (1) is held stationary by the No. 1 clutch, so is No. 1 carrier (20). The movement of No. 1 planetary gears (24) causes ring gear (2) to turn in the opposite direction of input shaft (23). Ring gear (2) is in direct mechanical connection with No. 2 and No. 3 carrier (7). As the No. 2 and No. 3 carrier turns, No. 3 planetary gears (26) turn. The No. 3 planetary gears turn ring gear (9) and sun gear (27). Sun gear (27) turns output shaft (22).

Ring gear (9) turns No. 4 carrier (10). As the No. 4 carrier turns, No. 4 planetary gears (28) turn. The No. 4 planetary gears turn ring gear (13), which is fastened to housing assembly (29). The No. 4 planetary gears also turn No. 4 sun gear (11). No. 4 sun gear turns output shaft (22). Housing assembly (29) is fastened to and turns No. 6 sun gear (19).

No. 6 sun gear (19) turns No. 6 planetary gears (18). Since ring gear (17) is held stationary by the No. 6 clutch, planetary gears (18) move around the inside of the ring gear. The movement of planetary gears (18) causes No. 6 carrier (30) to turn. No. 6 carrier (30) is fastened to and turns output shaft (22).

As a result, torque to output shaft (22) is divided through No. 3 sun gear (27), No. 4 sun gear (11) and No. 6 carrier (30). From the output shaft, power goes through the output transfer gears to the differentials.

Second Speed Reverse



Transmission Components Power Flow In Second Speed Reverse (No. 1 and No. 5 clutches engaged)
(1) Coupling. (2) Ring gear for No. 1 clutch. (3) No. 1 clutch (reverse direction). (4) No. 2 sun gear. (5) No. 2 clutch (forward direction). (6) Ring gear for No. 2 clutch. (7) No. 2 and No. 3 carrier. (8) No. 3 clutch (fourth speed). (9) Ring gear for No. 3 clutch. (10) No. 4 carrier. (11) No. 4 sun gear. (12) No. 4 clutch (third speed) (13) Ring gear for No. 4 clutch. (14) No. 5 clutch (second speed). (15) Rotating hub. (16) No. 6 clutch (first speed). (17) Ring gear for No. 6 clutch. (18) No. 6 planetary gears. (19) No. 6 sun gear. (20) No. 1 carrier. (21) No. 1 sun gear. (22) Output shaft. (23) Input shaft. (24) No. 1 planetary gears. (25) No. 2 planetary gears. (26) No 3 planetary gears. (27) No. 3 sun gear. (28) No. 4 planetary gears. (29) Housing assembly. (30) No. 6 carrier.

When the transmission is in SECOND SPEED REVERSE, No. 1 and No. 5 clutches are engaged. The No. 1 clutch holds coupling (1) stationary. The No. 5 clutch connects rotating hub (15) with No. 4 ring gear (13).

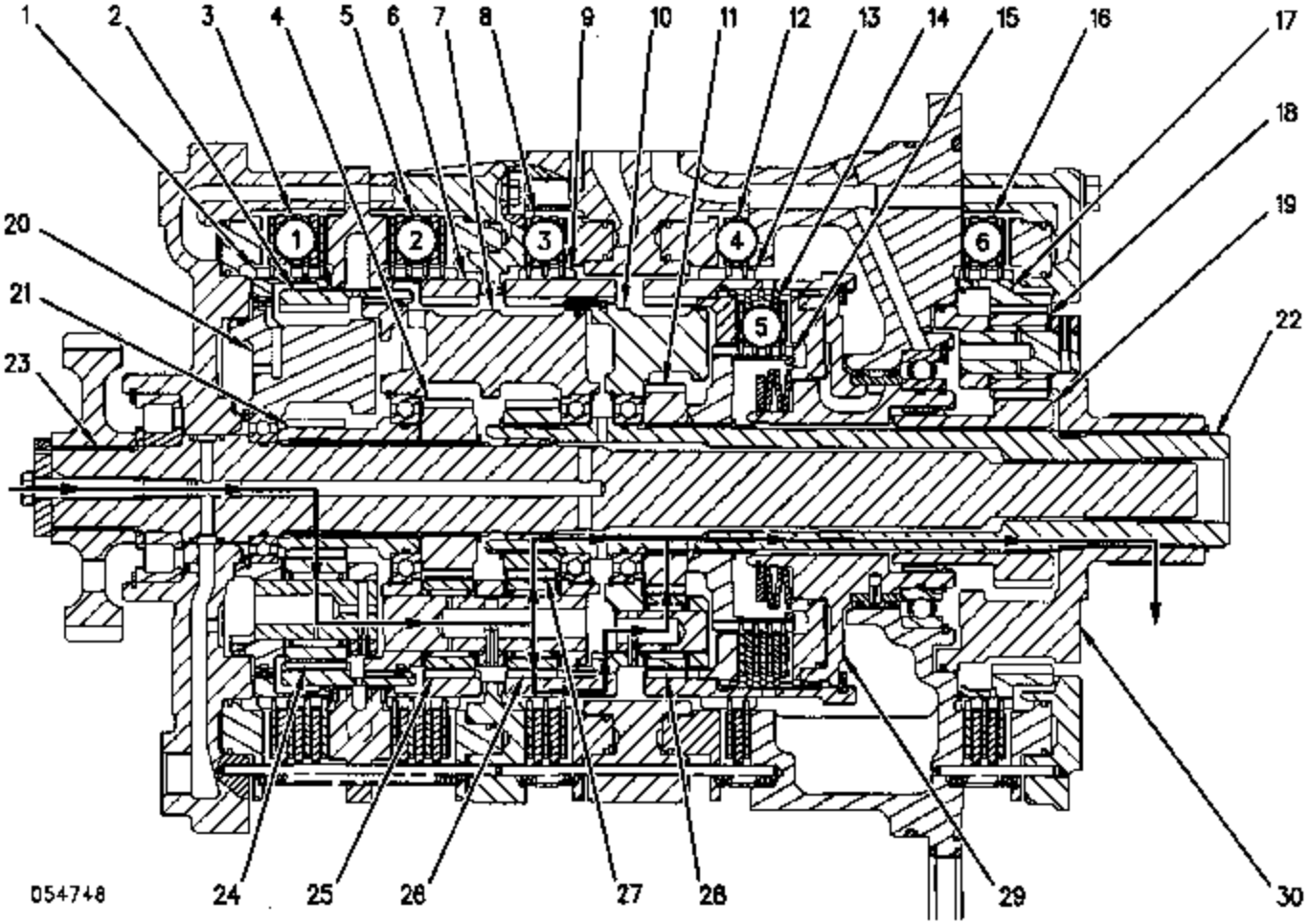
Input shaft (23) turns No. 1 sun gear (21). No. 1 sun gear turns No. 1 planetary gears (24). No. 1 carrier (20) is in direct mechanical connection with coupling (1).

Since coupling (1) is held stationary by the No. 1 clutch, so is No. 1 carrier (20). The movement of No. 1 planetary gears (24) causes ring gear (2) to turn in the opposite direction of input shaft (23). Ring gear (2) is in direct mechanical connection with No. 2 and No. 3 carrier (7). As the No. 2 and No. 3 carrier turns, No. 3 planetary gears (26) turn. The No. 3 planetary gears turn ring gear (9) and sun gear (27). Sun gear (27) turns output shaft (22). Ring gear (9) turns No. 4 carrier (10). As the No. 4 carrier turns, No. 4 planetary gears (28) turn. The No. 4 planetary gears turn ring gear (13), which is fastened to housing assembly (29). The No. 4 planetary gears also turn No. 4 sun gear (11). No. 4 sun gear turns output shaft (22).

No. 5 clutch connects rotating hub (15) to No. 4 ring gear (13). Rotating hub (15) turns output shaft (22).

As a result, torque to output shaft (22) is divided through No. 3 sun gear (27), No. 4 sun gear (11) and rotating hub (15). From the output shaft, power goes through the output transfer gears to the differentials.

Third Speed Reverse



Transmission Components Power Flow In Third Speed Reverse (No. 1 and No. 4 clutches engaged)
(1) Coupling. (2) Ring gear for No. 1 clutch. (3) No. 1 clutch (reverse direction). (4) No. 2 sun gear. (5) No. 2 clutch (forward direction). (6) Ring gear for No. 2 clutch. (7) No. 2 and No. 3 carrier. (8) No. 3 clutch (fourth speed). (9) Ring gear for No. 3 clutch. (10) No. 4 carrier. (11) No. 4 sun gear. (12) No. 4 clutch (third speed) (13) Ring gear for No. 4 clutch. (14) No. 5 clutch (second speed). (15) Rotating hub. (16) No. 6 clutch (first speed). (17) Ring gear for No. 6 clutch. (18) No. 6 planetary gears. (19) No. 6 sun gear. (20) No. 1 carrier. (21) No. 1 sun gear. (22) Output shaft. (23) Input shaft. (24) No. 1 planetary gears. (25) No. 2 planetary gears. (26) No. 3 planetary gears. (27) No. 3 sun gear. (28) No. 4 planetary gears. (29) Housing assembly. (30) No. 6 carrier.

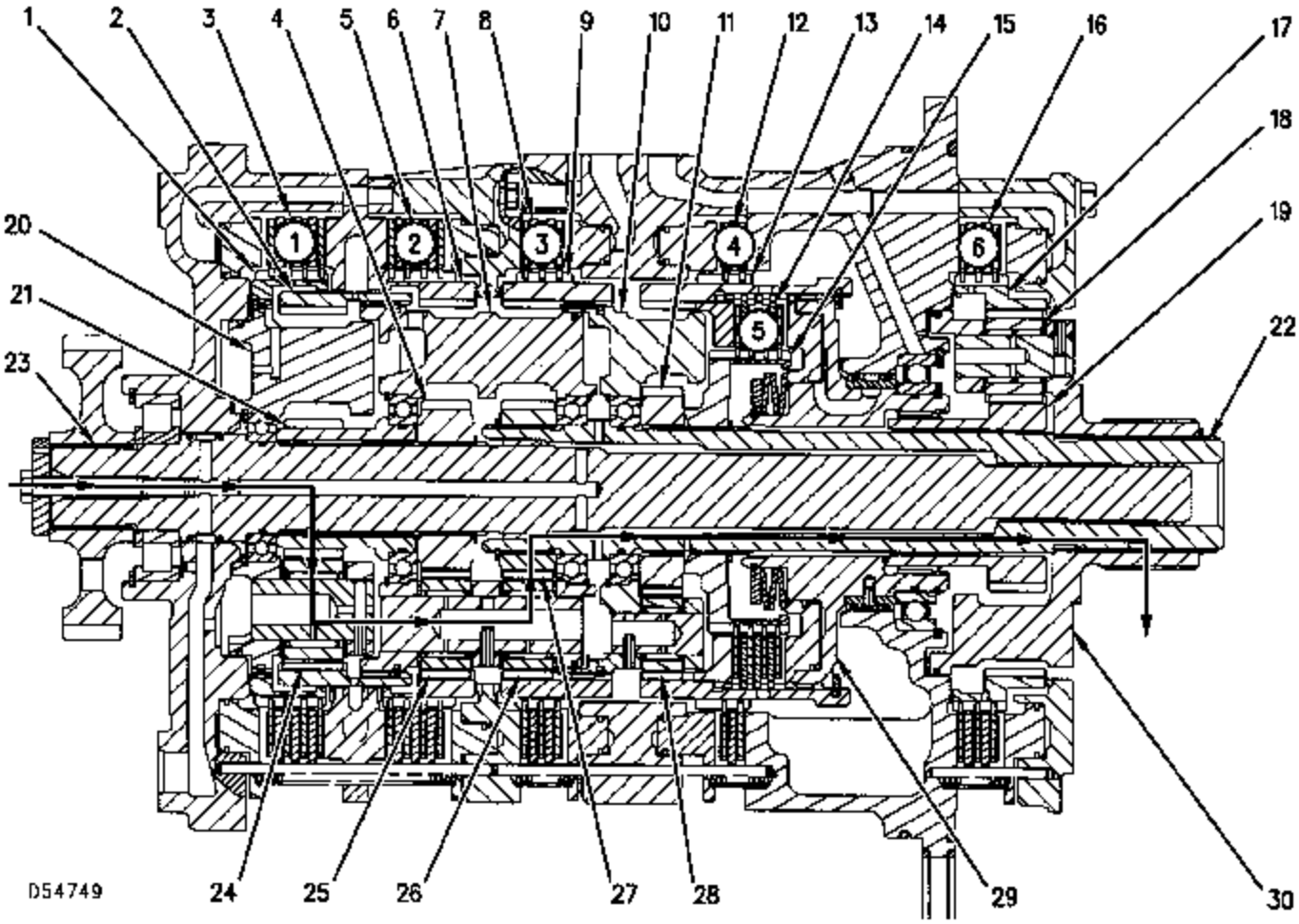
When the transmission is in THIRD SPEED REVERSE, No. 1 and No. 4 clutches are engaged. The No. 1 clutch holds coupling (1) stationary. The No. 4 clutch holds ring gear (13) stationary. Input shaft (23) turns No. 1 sun gear (21). No. 1 sun gear turns No. 1 planetary gears (24). No. 1 carrier (20) is in direct mechanical connection with coupling (1).

Since coupling (1) is held stationary by the No. 1 clutch, so is No. 1 carrier (20). The movement of No. 1 planetary gears (24) causes ring gear (2) to turn in the opposite direction of input shaft (23). Ring gear (2) is in direct mechanical connection with No. 2 and No. 3 carrier (7). As the No. 2 and No. 3 carrier turns, No. 3 planetary gears (26) turn. The No. 3 planetary gears turn ring gear (9) and sun gear (27). Sun gear (27) turns output shaft (22). Ring gear (9) turns No. 4 carrier (10)

Since ring gear (13) is held stationary by the No. 4 clutch, planetary gears (28) move around the inside of the ring gear. The movement of planetary gears (28) and No. 4 carrier (10), causes No. 4 sun gear (11) to turn. No. 4 sun gear turns output shaft (22).

As a result, torque to output shaft (22) is divided through No. 3 sun gear (27) and No. 4 sun gear (11). From the output shaft, power goes through the output transfer gears to the differentials.

Fourth Speed Reverse



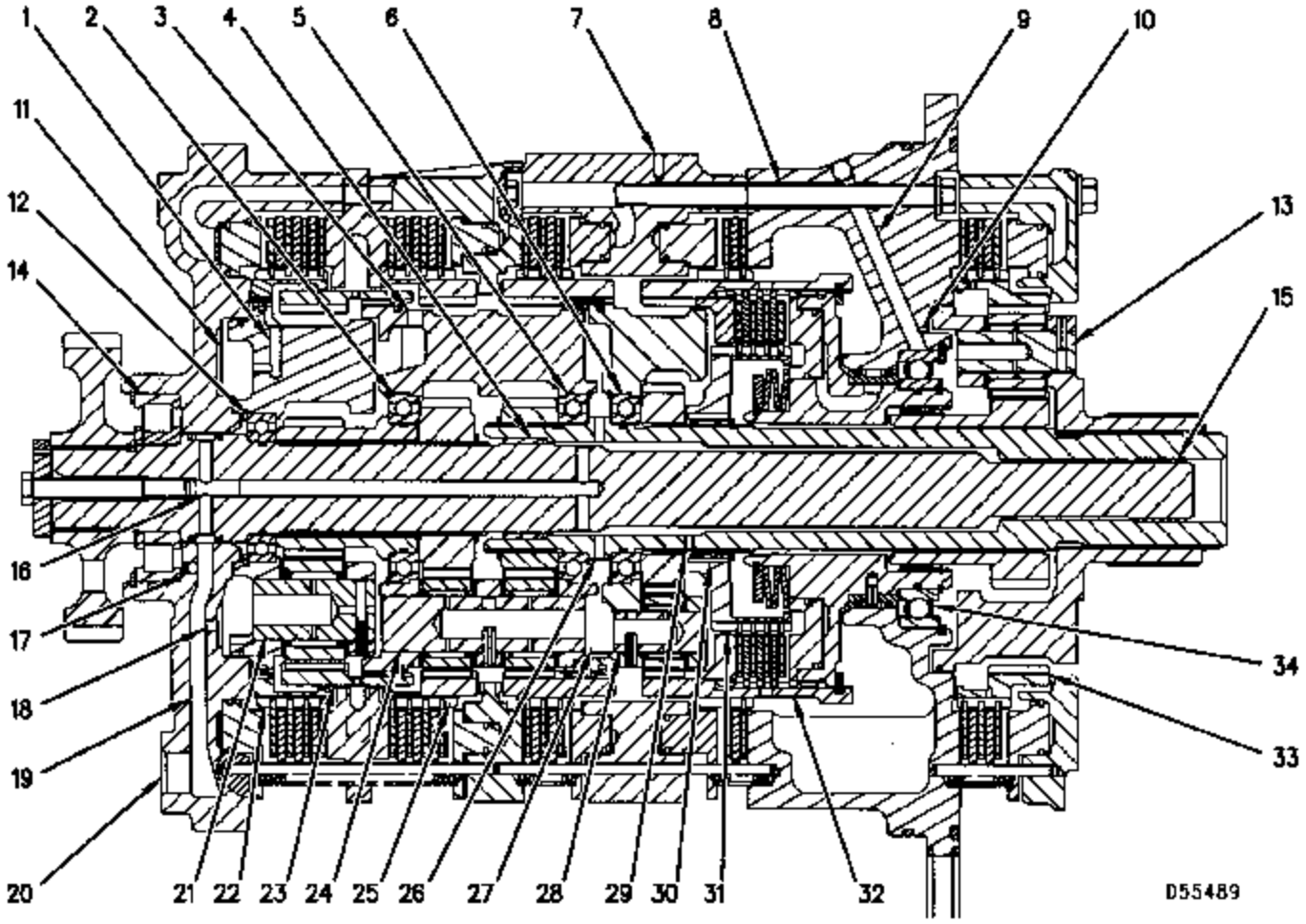
Power Flow In Fourth Speed Reverse (No. 1 And No. 3 Clutches Engaged)
(1) Coupling. (2) Ring gear for No. 1 clutch. (3) No. 1 clutch (reverse direction). (4) No. 2 sun gear. (5) No. 2 clutch (forward direction). (6) Ring gear for No. 2 clutch. (7) No. 2 and No. 3 carrier. (8) No. 3 clutch (fourth speed). (9) Ring gear for No. 3 clutch. (10) No. 4 carrier. (11) No. 4 sun gear. (12) No. 4 clutch (third speed) (13) Ring gear for No. 4 clutch. (14) No. 5 clutch (second speed). (15) Rotating hub. (16) No. 6 clutch (first speed). (17) Ring gear for No. 6 clutch. (18) No. 6 planetary gears. (19) No. 6 sun gear. (20) No. 1 carrier. (21) No. 1 sun gear. (22) Output shaft. (23) Input shaft. (24) No. 1 planetary gears. (25) No. 2 planetary gears. (26) No. 3 planetary gears. (27) No. 3 sun gear. (28) No. 4 planetary gears. (29) Housing assembly. (30) No. 6 carrier.

When the transmission is in FOURTH SPEED REVERSE, No. 1 and No. 3 clutches are engaged. The No. 1 clutch holds coupling (1) for the No. 1 clutch stationary. The No. 3 clutch holds ring gear (9) for the No. 3 clutch stationary. Input shaft (23) turns No. 1 sun gear (21). No. 1 sun gear turns No. 1 planetary gear (24). No. 1 carrier (20) is in direct mechanical connection with coupling (1).

Since coupling (1) is held stationary by the No. 1 clutch, so is No. 1 carrier (20). The movement of No. 1 planetary gears (24) causes ring gear (2) to turn in the opposite direction of input shaft (23). Ring gear (2) is in direct mechanical connection with No. 2 and No. 3 carrier (7).

Since ring gear (9) is held stationary by the No. 3 clutch, the movement of No. 2 and No. 3 carrier (7) causes No. 3 planetary gears (26) to move around the inside of the ring gear. The No. 3 planetary gears turn output shaft (22). From the output shaft, power flows through the output transfer gears to the differentials.

Planetary Lubrication



Planetary Lubrication
(1) Oil passage. (2) Bearing. (3) Passage. (4) Bearing. (5) Bearing. (6) Bearing. (7) Passage. (8) Bolt hole. (9) Passage. (10) Passage. (11) Oil chamber. (12) Bearing. (13) No. 6 planetary shafts. (14) Bearing. (15) Bearing. (16) Passage. (17) Passage. (18) Passage. (19) Passage. (20) Oil inlet. (21) No. 1 planetary shafts. (22) Coupling. (23) Ring gear for the No. 1 clutch. (24) No. 2 and No. 3 planetary shafts. (25) Ring gear for the No. 2 clutch. (26) Passage. (27) Oil chamber. (28) No. 4 planetary shafts. (29) Passage. (30) Passage. (31) Rotating hub. (32) Ring gear for No. 4 clutch. (33) Ring gear for the No. 6 clutch. (34) Bearing.

All outlet oil from the torque converter oil cooler flows through an external line to oil inlet port (20). The oil flows through passage (19) to passage (16) in the input shaft. Some of the oil in passage (19) flows through passage (17) to lubricate bearing (14).

The oil from passage (19) flows to No. 1 planetary shafts (21). No. 1 planetary shafts (21) have drilled passages to allow the oil to flow to the bearings. The oil flows around the planetary shaft bearings. Oil also flows out of the holes in the ends of shafts (21) and then flows to bearings (2) and (12). Oil also flows through passage (3) to cool and lubricate the discs and plates of the No. 2 clutch.

The remainder of the oil flows from oil chamber (11) through passage (1). From passage (1), the oil flows through holes in coupling (22) and ring gear (23) to lubricate and cool the discs and plates of the No. 1 clutch.

Oil flows from passage (16) in the input shaft into the area between the input and output shafts. This oil lubricates bearings (4) and (15). Oil flows from the area between the input and output shafts through passage (26) to oil chamber (27). The oil in chamber (27) lubricates bearings (5) and (6). The oil in chamber (27) also flows into No. 2 and 3 planetary shafts (24) and No. 4 planetary shafts (28).

No. 2 and 3 planetary shafts (24) have drilled passages to allow the oil to flow to the bearings. The oil is also used to lubricate and cool the discs and plates of the No. 3 clutch.

No. 4 planetary shafts (28) have drilled passages to allow the oil to flow to the bearings. The oil is also used to lubricate and cool the discs and plates of the No. 3 and No. 4 clutches.

The oil between the input and output shafts also flows through passage (29) and then through passage (30). This oil then flows through holes in rotating hub (31) to lubricate and cool the discs and plates of No. 5 clutch. Oil also flows through holes in ring gear (32) to lubricate and cool the discs and plates of No. 4 clutch.

Oil from the converter inlet flows through passages in the hydraulic control valve to passage (7). There is an orifice in passage (7) to reduce oil flow. Oil flows from passage (7) to bolt hole (8). The bolt hole is enlarged in this area to allow oil to flow between the bolt and the hole to passage (9). Oil then flows through passage (10) into the passages inside of planetary shafts (13). Oil from passage (10) also flows to bearing (34)

Planetary shafts (13) have drilled passages to allow the oil to flow to the planet gear bearings. The oil flows around the planet gears and bearings and then flows through the holes in ring gear (33) to cool and lubricate the discs and plates of the No. 6 clutch.

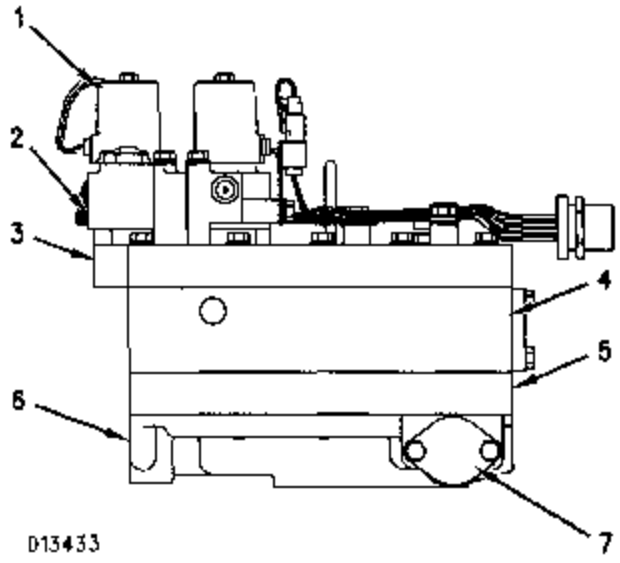
All clutch leakage oil and return oil flows to the bottom of the transmission case. This oil then flows through a passage to the main oil reservoir in the output transfer gear case.

Transmission Hydraulic Controls

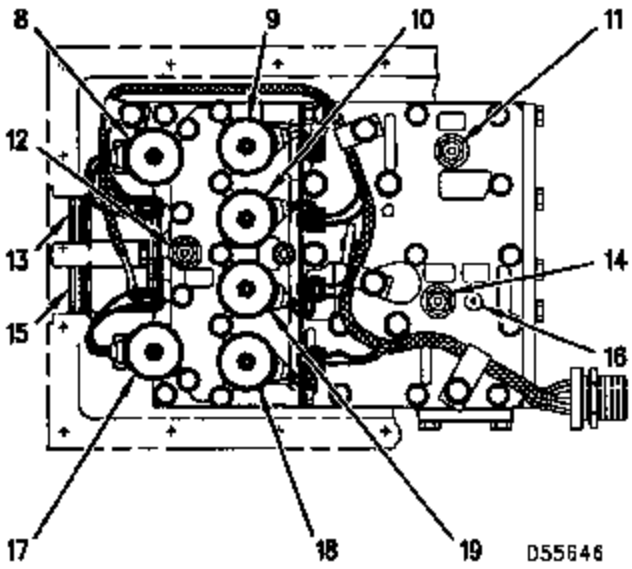
Introduction

The transmission hydraulic controls control the oil pressure to the torque converter and transmission clutches and lubrication circuits, and, controls the flow of oil to the clutches.

The transmission hydraulic controls are installed on the top of the transmission planetary group. The controls consist of solenoids (1), manifold (2), top manifold (3), selector and pressure control valve group (4), plate (5), and selector valve group (6). Speed selector spool for first and third speed is behind cover (7).



Transmission Hydraulic Controls
(Side View)
(1) Solenoids. (2) Solenoid manifold. (3) Top manifold. (4) Selector and pressure control valve. (5) Plate. (6) Selector valve group. (7) Cover.

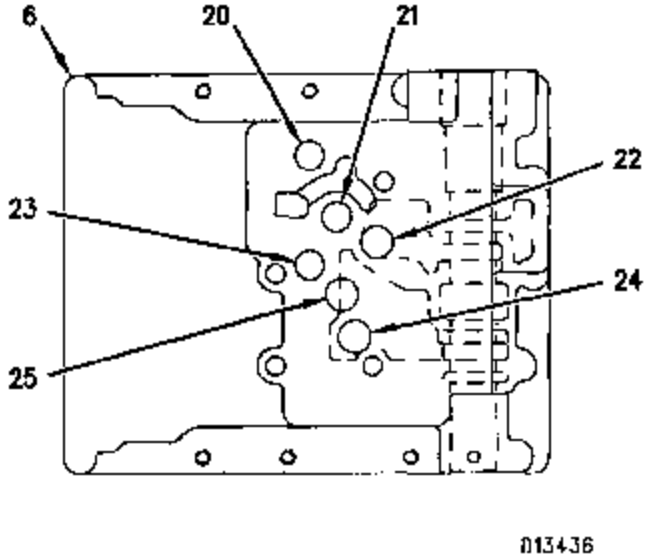


Transmission Hydraulic Controls
(Top View)
(8) No. 3 Clutch solenoid. (9) No. 4 Clutch solenoid. (10) No. 5 Clutch solenoid. (11) P1 Pressure tap. (12) P3 Pressure tap. (13) Oil tube (inlet from pump). (14) P2 Pressure tap. (15) Oil tube (outlet to torque converter). (16) Plug for load piston. (17) No. 2 Clutch solenoid. (18) No. 6 Clutch solenoid. (19) No. 1 Clutch solenoid.

Inlet oil for operation of the hydraulic controls comes from the transmission oil filter and flows through tube (13) to the selector and pressure control valve.

Oil for the operation of the torque converter flows through tube (15) and an oil line to the torque converter.

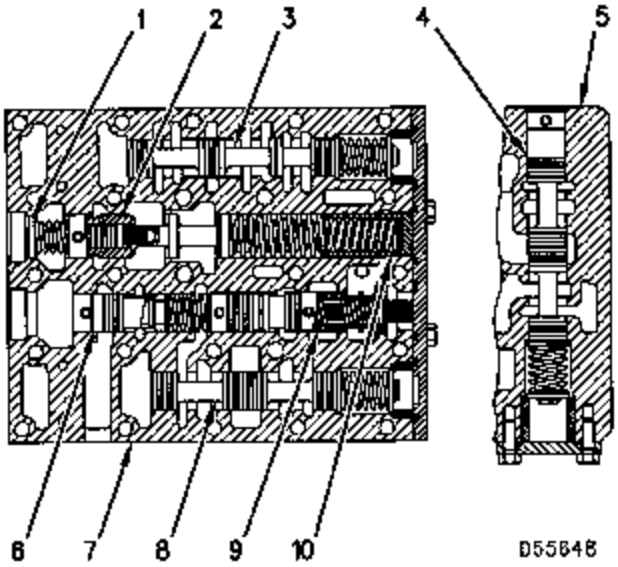
The clutch solenoids direct pump oil to the ends of the selector spools. The selector spools move to send oil to engage a clutch.



Transmission Hydraulic Controls
(Bottom View)
(6) Selector valve group. (20) Passage to No. 3 Clutch. (21) Passage to No. 5 Clutch. (22) Passage to No. 2 Clutch. (23) Passage to No. 1 Clutch. (24) Passage to No. 6 Clutch. (25) Passage to No. 4 Clutch.

Oil to the clutches is sent through openings (20), (21), (22), (23), (24), and (25) in the selector valve group. The selector valve group is attached to the top of the planetary group.

Selector And Pressure Control Valve Group And Selector Valve Group

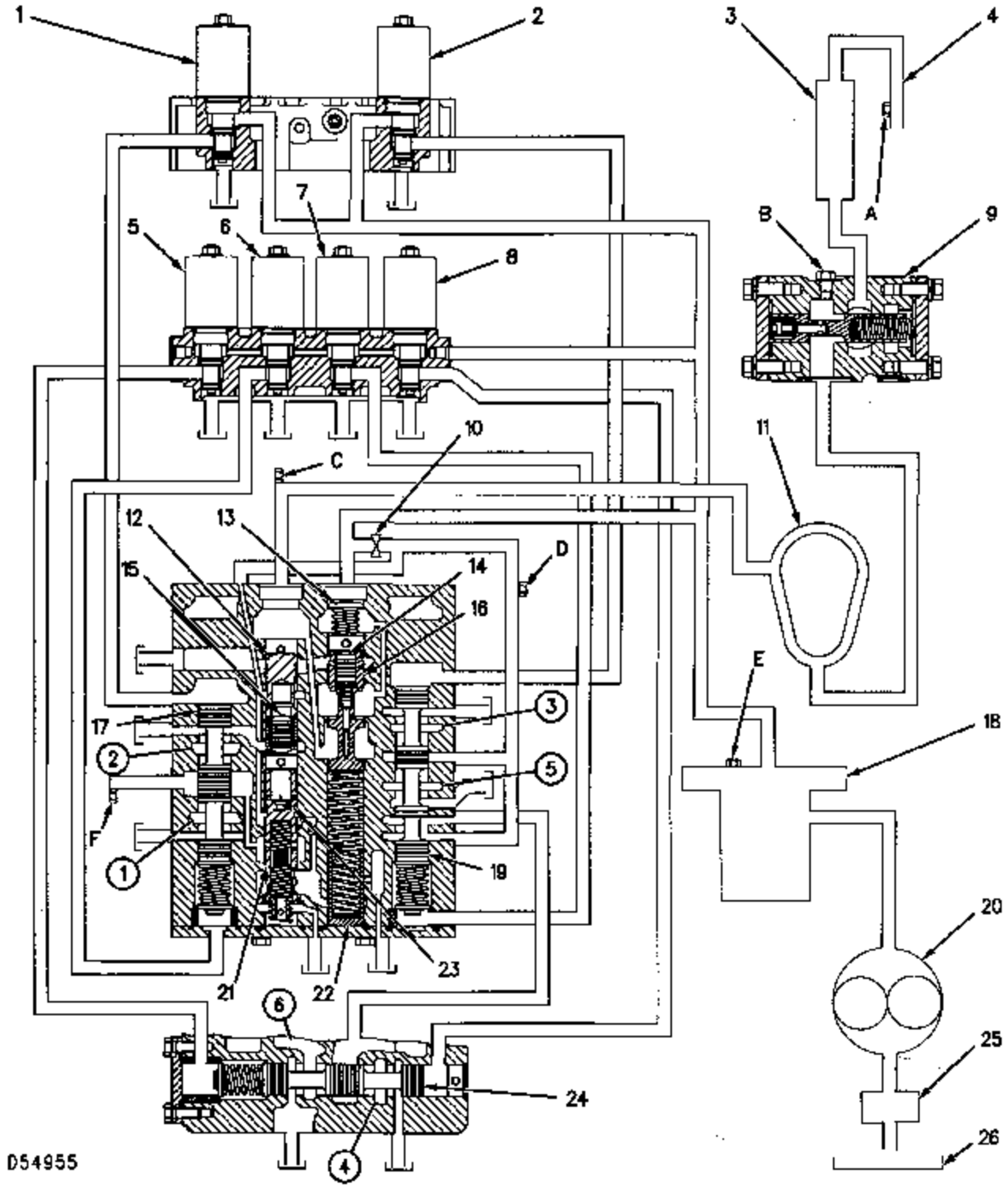


Selector And Pressure Control Valve Group And Selector Valve Group
(1) Differential valve. (2) Modulation relief valve. (3) Second and fourth speed selection spool. (4) First and third speed selection spool. (5) Selector control valve group. (6) Converter inlet ratio valve. (7) Direction selection spool. (8) Selector and pressure control valve group. (9) Pressure differential valve. (10) Load piston.

Valve	Function
(1) Differential valve.	Maintains oil pressure to the solenoid valves.
(2) Modulation relief valve.	Controls the maximum pressure in the system.
(3) Second and fourth speed selection spool.	Directs oil to No. 3 or No. 5 clutch.
(4) First and third speed selection spool.	Directs oil to No. 4 or No. 6 clutch.
(6) Converter inlet ratio valve.	Limits the maximum pressure to the torque converter.
(8) Direction selection spool.	Directs oil to a direction clutch.
(9) Pressure differential valve.	Keeps a pressure differential between the speed and direction clutches.
(10) Load piston.	Controls the rate of pressure increase in the clutches.

The selector and pressure control valve group and selector valve group are inside the top cover of the transmission.

Selector spools (3), (4), and (7) are moved when oil pressure is applied to one end of the spool. Each solenoid controls oil pressure to the end of one spool. If there is no pressure to the end of a spool, that end is open to drain. Switches in the transmission control lever activate the solenoids to control speed and direction of the transmission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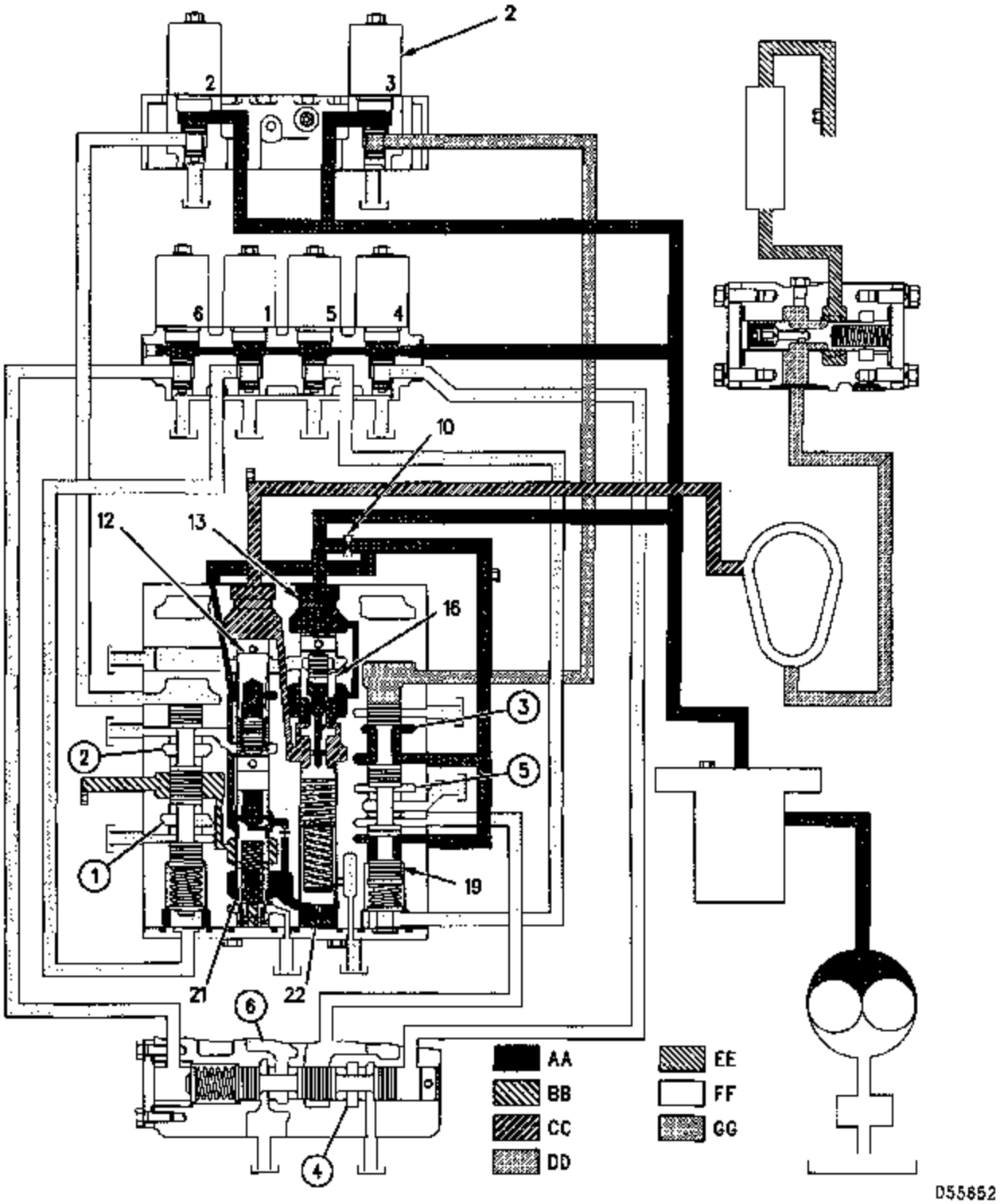
Transmission Hydraulic Controls (Neutral, Engine Stopped)

(1) No. 2 clutch solenoid.
(2) No. 3 clutch solenoid.
(3) Oil cooler.
(4) Transmission lubrication passage.
(5) No. 6 clutch solenoid.
(6) No. 1 clutch solenoid.
(7) No. 5 clutch solenoid.
(8) No. 4 clutch solenoid.
(9) Torque converter outlet relief valve.
(10) Flow control orifice.
(11) Torque converter.
(12) Converter inlet ratio valve.
(13) Differential valve.
(14) Slug.
(15) Slug.
(16) Modulating relief valve.
(17) Direction selection spool.
(18) Transmission oil filter.
(19) Second and fourth speed selector spool
(20) Oil pump.
(21) Pressure differential valve.
(22) Load piston.
(23) Orifice.
(24) First and third speed selector spool.
(25) Screen.
(26) Reservoir.
(A) Pressure tap for lubrication..
(B) Pressure tap for converter outlet.
(C) Pressure tap for converter inlet [P3].
(D) Pressure tap for speed clutches [P1].
(E) Pressure tap for pump.
(F) Pressure tap for direction clutches [P2].

When the engine is started, oil pump (20) pulls oil from reservoir (26) through magnetic screen (25). The pump sends the oil through filter (18) to the selector and pressure control valve group, which is part of the transmission hydraulic controls.

Differential valve (13) maintains oil pressure to the solenoid valves when the engine is at low idle.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Transmission Hydraulic Controls (Neutral, Engine Running)

(2) No. 3 clutch solenoid.
(10) Flow control orifice.
(12) Converter inlet ratio valve.
(13) Valve.
(16) Modulating relief valve.
(19) Second and fourth speed selector spool.
(21) Pressure differential valve.
(22) Load piston.
(AA) Speed clutch oil [P1].
(BB) Direction clutch oil [P2].
(CC) Converter inlet oil [P3].
(DD) Converter outlet oil.
(EE) Lubrication oil.
(FF) Return oil.
(GG) Pilot oil.

When the transmission control lever is in NEUTRAL, a switch in the lever activates solenoid (2). The solenoid moves a spool and directs oil to the end of spool (19). Spool (19) moves down and pump oil flows around the spool to No. 3 clutch.

No. 3 clutch is now applied. All of the remaining clutches are open to the reservoir.

Oil, from the pump, flows through flow control orifice (10) to No. 3 clutch and to pressure differential valve (21). Oil also flows through valve (13) to modulating relief valve (16) and converter inlet ratio valve (12).

The oil to pressure differential valve (21) flows through a small orifice in the valve spool and starts to fill the chamber at the top end of the spool. The pressure in the chamber at the top of valve spool (21) increases.

The increase in pressure moves the valve down against the force of the springs. The movement of the valve spool closes a passage from the area behind the bottom end of load piston (22) and the reservoir. At this time, pressure differential valve (21) is in the position shown in the schematic. This allows the pressure in the system to increase.

As the pressure increases in the chamber at the top of pressure differential valve (21), the valve moves down farther. This opens the direction clutch circuit to pump oil. It also closes the bottom end of valve (21) to the reservoir. The pressure in the direction clutch circuit increases. The increase is felt in the spring chamber of valve (21).

When the pressure in the direction clutch circuit is at its maximum, the pressure in the spring chamber, plus the force of the springs, moves valve (21) up. The valve moves up until the flow of pump oil to the direction clutch circuit is stopped. At this time, the movement of the valve spool stops. Now the valve spool moves down and then up, (meters) to keep a constant pressure in the direction clutch circuit.

Oil, from the pump, also flows to modulation relief valve (16). It fills the chamber around the modulation relief valve. The oil flows through an orifice in the valve spool and opens the poppet valve at the top of the valve spool. This allows oil to fill the slug chamber at the top of the valve spool.

When the No. 3 clutch is full of oil, the pressure in the speed clutch circuit starts to increase. The increase is felt in the slug chamber at the top of modulation relief valve (16). When the pressure in the speed clutch circuit is at the initial setting of the modulation relief valve, the modulation relief valve moves down. This allows extra oil to flow to the torque converter.

At the same time, pump oil also flows through an orifice to the area between the bottom of load piston (22) and the cover on the selector and pressure control valve body. This area is closed to the reservoir by the position of differential valve (21). The rate of flow to the area behind load piston (22) is restricted by the orifice.

The pressure felt by the modulation relief valve, because of the increase in pressure in the speed clutch circuit, is also felt behind load piston (22). The orifice in the supply passage causes the oil to flow to the area behind the load piston at a specific rate. As the modulation relief valve moves toward the bottom, the load piston moves towards the top. This causes the pressure in No. 3 clutch to increase gradually.

This gradual increase in pressure is known as modulation. The load piston moves more toward the top, against the force of its springs, until the area behind the load piston is open to a drain passage. At this time, modulation stops. As the oil flows out the drain passage, oil continues to fill the area behind the load piston. This keeps the load piston in a position without any further movement.

The operation of the load piston and the modulation relief valve keeps the system pressure at a constant rate.

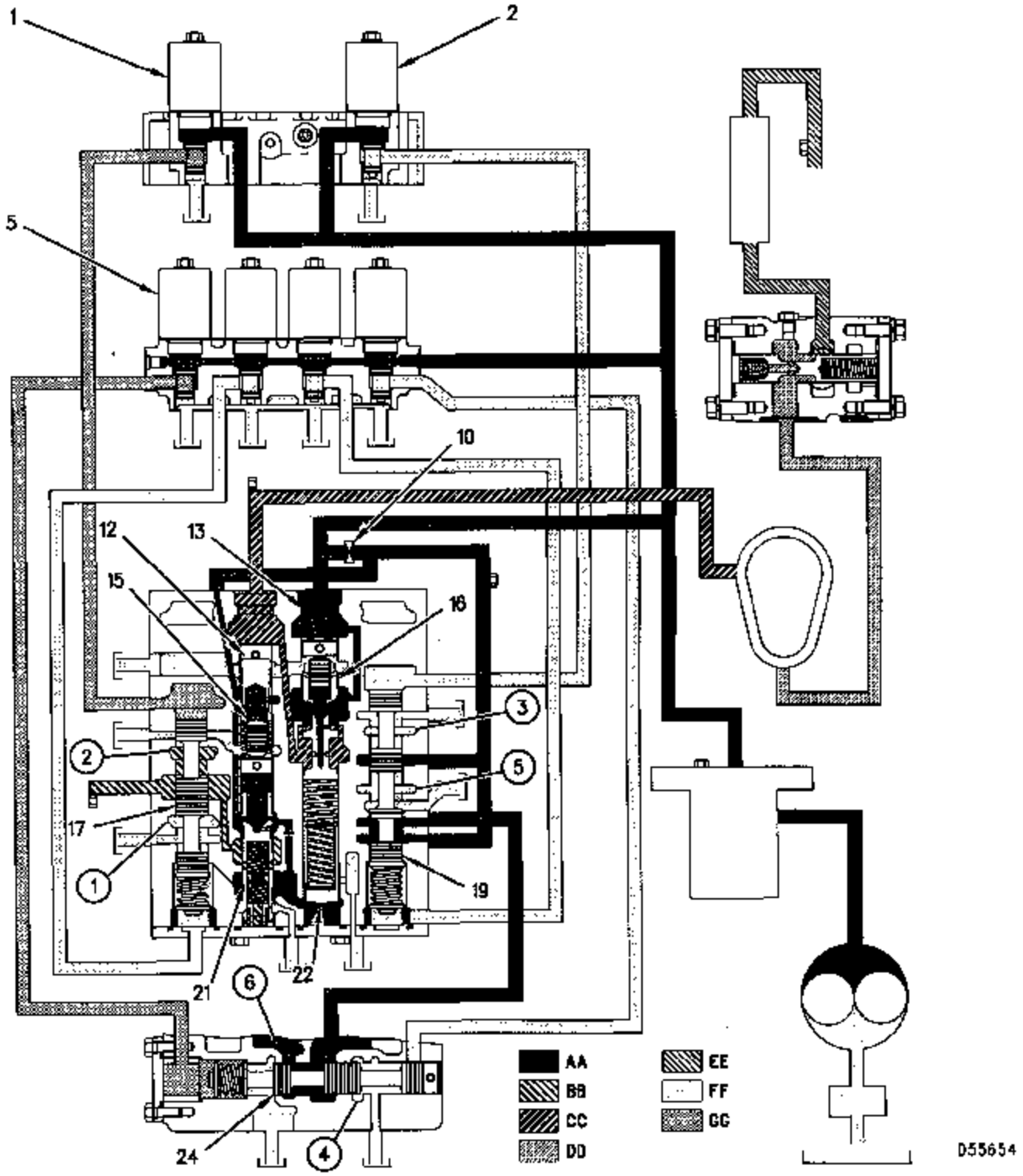
Pump oil also flows through flow control orifice (10) to converter inlet ratio valve (12). It flows through an orifice in the valve spool and fills the slug chamber. This pressure pushes against only the diameter of the slug.

The oil pressure to the torque converter is felt against the top of valve spool (12). This pressure pushes against the whole diameter of the valve spool.

The pressure on the top of the valve needed to move the valve down is less than the pressure in the slug chamber needed to move the valve up.

When the inlet pressure to the torque converter rises to its maximum, the valve spool moves down. This allows the extra oil to flow to the reservoir. When the pressures are again in balance, the valve moves back up.

All oil, not used by the clutches flows to the torque converter ratio valve.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Transmission Hydraulic Controls

(First Speed Forward)
(1) No. 2 clutch solenoid.
(2) No. 3 clutch solenoid.
(5) No. 6 clutch solenoid.
(10) Flow control orifice.
(12) Converter inlet ratio valve.
(13) Differential valve.
(15) Slug.
(16) Modulating relief valve.
(17) Direction selection spool.
(19) Second and fourth speed selector spool..
(21) Pressure differential valve.
(22) Load piston.
(24) First and third speed selector spool.
(AA) Speed clutch oil [P1].
(BB) Direction clutch oil [P2].
(CC) Converter inlet oil [P3].
(DD) Converter outlet oil.
(EE) Lubrication oil.
(FF) Return oil.
(GG) Pilot oil.

When the transmission control lever is moved to FIRST SPEED FORWARD, switches in the lever activates solenoids (1) and (5), and deactivates solenoid (2). Solenoid (1) moves a spool and directs oil to the top end of direction selection spool (17). Spool (17) moves down and pump oil flows around the spool to No. 2 clutch.

Solenoid (5) moves a spool and directs oil to the left end of speed selection spool (24). Spool (24) moves to the right and pump oil flows around the spool to No. 6 clutch. Solenoid (2) deactivates and directs oil from the top end of speed selection spool (19) to the reservoir. Spool (19) moves up and pump oil is closed to No. 3 clutch.

When the shift to FIRST SPEED FORWARD is made, the No. 3 clutch is opened to the reservoir. The pressure in the system decreases. Springs move modulation relief valve (16) up. Springs move pressure differential valve (21) up until the large orifice at the top end of valve (21) is closed to pump oil by the valve body.

As the pressure differential valve moves up, the chamber behind load piston (22) opens to the reservoir. This allows the springs to move the load piston down.

The speed clutch oil starts to fill No. 6 clutch.

When the No. 6 clutch is full of oil, the pressure in the speed clutch circuit starts to increase. The increase is felt in the slug chamber of modulation relief valve (16) and the chamber at the top of pressure differential valve (21).

The oil to pressure differential valve (21) starts to fill the chamber at the top of the valve spool, through the small orifice.

When the pressure in the No. 6 clutch is approximately 380 kPa (55 psi), pressure differential valve (21) starts to move down. The movement of the valve spool opens No. 2 clutch to pump oil. It also closes a passage from the chamber behind load piston (22) to the reservoir.

When the No. 2 clutch is full of oil, the pressure in the direction clutch circuit increases. The increase is felt in the spring chamber of pressure differential valve (21). The pressure in the spring chamber and the force of the springs moves the valve up against the speed clutch pressure at the top of the valve spool.

As the pressure in the speed clutch circuit increases, the pressure increases in the chamber at the top of pressure differential valve (21).

The increase in pressure moves the valve spool down against the force of the springs. This opens No. 2 clutch to pump oil.

As the pressure in the No. 2 clutch increases, the pressure increases in the spring chamber of valve (21). The increased pressure in the spring chamber and the force of the springs, moves the valve spool up.

This stops the flow of pump oil to the No. 2 clutch. This function continues until the pressure in the No. 2 clutch is at its maximum. At this time, the pressure in the spring chamber and the force of the springs moves the valve spool up, until the flow of oil to the clutch is stopped. Now the valve moves up and down (meters) to keep a constant pressure in the No. 2 clutch. This pressure is approximately 380 kPa (55 psi) less than the pressure in the speed clutch. This difference is determined by the force of the springs of the pressure differential valve.

Oil, from the pump, also flows through valve (13) to modulation relief valve (16). It fills the chamber around the valve spool. The oil flows through an orifice in the valve spool and opens the poppet valve at the top end of the valve spool. This allows oil to fill the slug chamber at the top of the valve spool.

The function of modulation relief valve (16) and load piston (22), is to control the rate of the pressure increase in the speed clutch circuit.

As the pressure in the No. 6 clutch increases, modulation relief valve (16) moves down and load piston (22) moves up. The orifice in the supply passage to the load piston, causes the oil to flow to the area behind the load piston at a specific rate. As the modulation relief valve moves down and the load piston moves up, the pressure in No. 6 clutch increases gradually. This gradual increase in pressure is known as modulation.

The load piston moves more toward the top against the force of its springs, until the area behind the load piston is open to a drain passage. At this time, modulation stops. As the oil flows out the drain passage, oil continues to fill the area behind the load piston. This keeps the load piston in this position. After the pressures in the clutches are at their maximum, modulation relief valve (16) allows the extra oil to flow to the torque converter.

The operation of the load piston and the modulation relief valve keeps the system pressure at a constant rate.

Pump oil also flows through flow control orifice (10) to converter inlet ratio valve (12). It flows through an orifice in the valve spool and fills the slug chamber. This pressure pushes against only the diameter of slug (15).

The oil pressure to the torque converter is felt against the top of valve spool (12). This pressure pushes against the whole diameter of the valve spool.

The pressure on the top of the valve needed to move the valve down is less than the pressure in the slug chamber needed to move the valve up.

When the inlet pressure to the torque converter rises to its maximum, the valve spool moves down. This allows the extra oil to flow to the reservoir. When the pressures are again in balance, the valve moves back up.

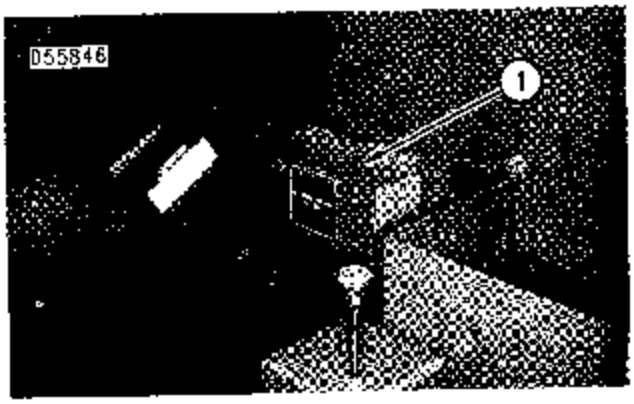
All oil, not used by the clutches flows to the torque converter ratio valve.

Transmission Electrical System

The main components of the transmission electrical system are the transmission control group, electronic control module, and six solenoid valves.

Transmission Electronic Control Module

Electronic control module (1) for the transmission is located in the cab, behind the operator seat. The main function of the electronic control module is to shift the transmission. The electronic control module receives operator input from the transmission control group to shift the transmission to the desired speed and direction.

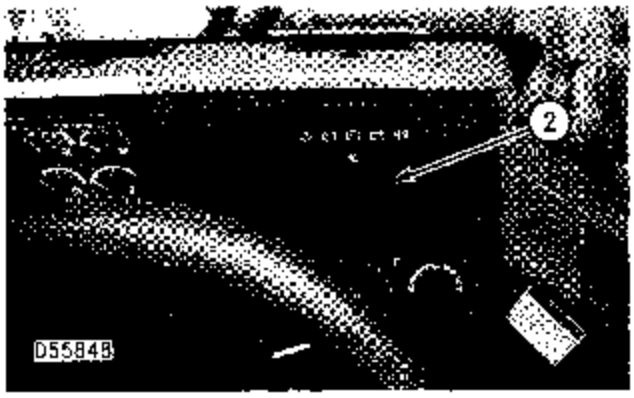


Rear of cab
(1) Transmission control module.

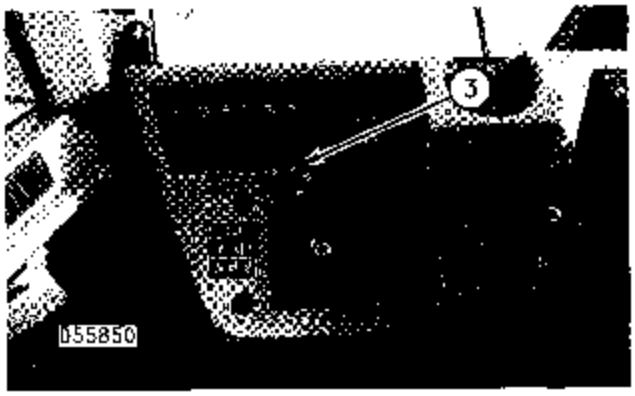
The electronic control module also controls engine starting and the back-up alarm. The electronic control module will not allow the engine to be started unless the direction control switch is in the neutral position.

The back-up alarm is activated any time the direction control switch is in the reverse position.

The electronic control module has built-in system diagnostics to detect faults in the transmission system. The diagnostic codes are output to diagnostic display (2) on the right front dash. For information on troubleshooting the transmission electronic control system, see SENR5922, Electronic Transmission Control.



Front Dash
(2) Diagnostic display.



Right Console (815F and 816F)
(3) Shift switch.

NOTE: The 814F does not have the shift switch function.

Shift switch (3) is located on the hydraulic control lever. The shift switch is a momentary contact switch that will shift between first and second speed each time the switch is depressed. The switch is not functional in third or fourth speed.

Transmission Control Group

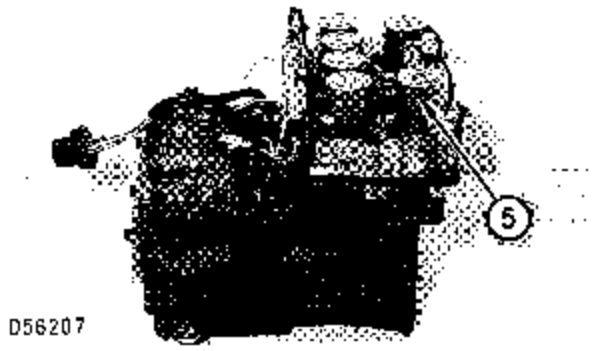
Cab
(4) Transmission control group.

The transmission control group is a sealed unit. The control group is mounted on the steering column and allows the operator to select a speed range by rotating the control lever, and a direction by moving the lever forward or backward.

The transmission control group contains switches that tell the electronic transmission control what direction and speed the operator has selected.

If the transmission control group is not in neutral when the key is turned ON, the control must be returned to neutral before a direction can be selected

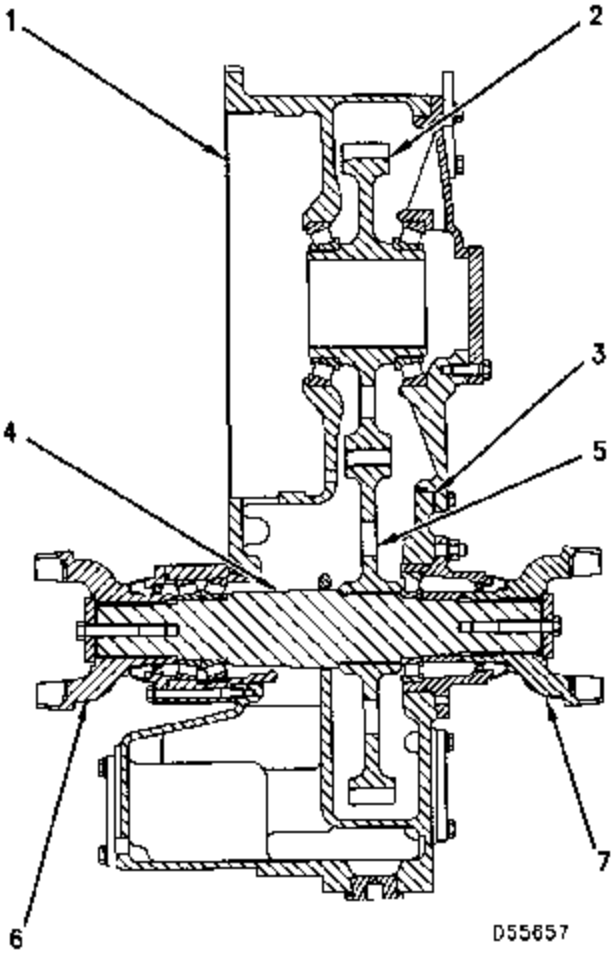
Solenoid valves



Transmission Hydraulic Control Valve
(5) Solenoid valve.

Solenoid valves (5) are installed in the transmission hydraulic controls. The solenoid valves are two position-three way and are normally open to drain. When energized, the solenoid valve spool moves to direct pressure oil to one end of a transmission control valve spool. The transmission control valve spool directs pressure oil to a clutch.

Output Transfer Gears



Output Transfer Gears
(1) Case assembly. (2) Drive gear. (3) Shims. (4) Shaft. (5) Gear
(6) Yoke assembly. (7) Yoke assembly.

The output transfer gears are at the output side of the transmission. The transmission output shaft is connected to drive gear (2) by splines.

Drive gear (2) is engaged with gear (5). Driven gear (5) is connected to shaft (4) by splines. Yoke assemblies (6) and (7) are connected to shaft (4) by splines. Yoke assembly (6) is connected to the short drive shaft that goes to the rear differential. Yoke assembly (7) is connected to the drive shaft that goes to the bearing cage and then to the front differential.

The flow of power through the output transfer gears is:

From transmission output shaft to drive gear (2).
From gear (2) to driven gear (5).
From driven gear (5) to shaft (4).

At shaft (4) the flow of power divides as follows:

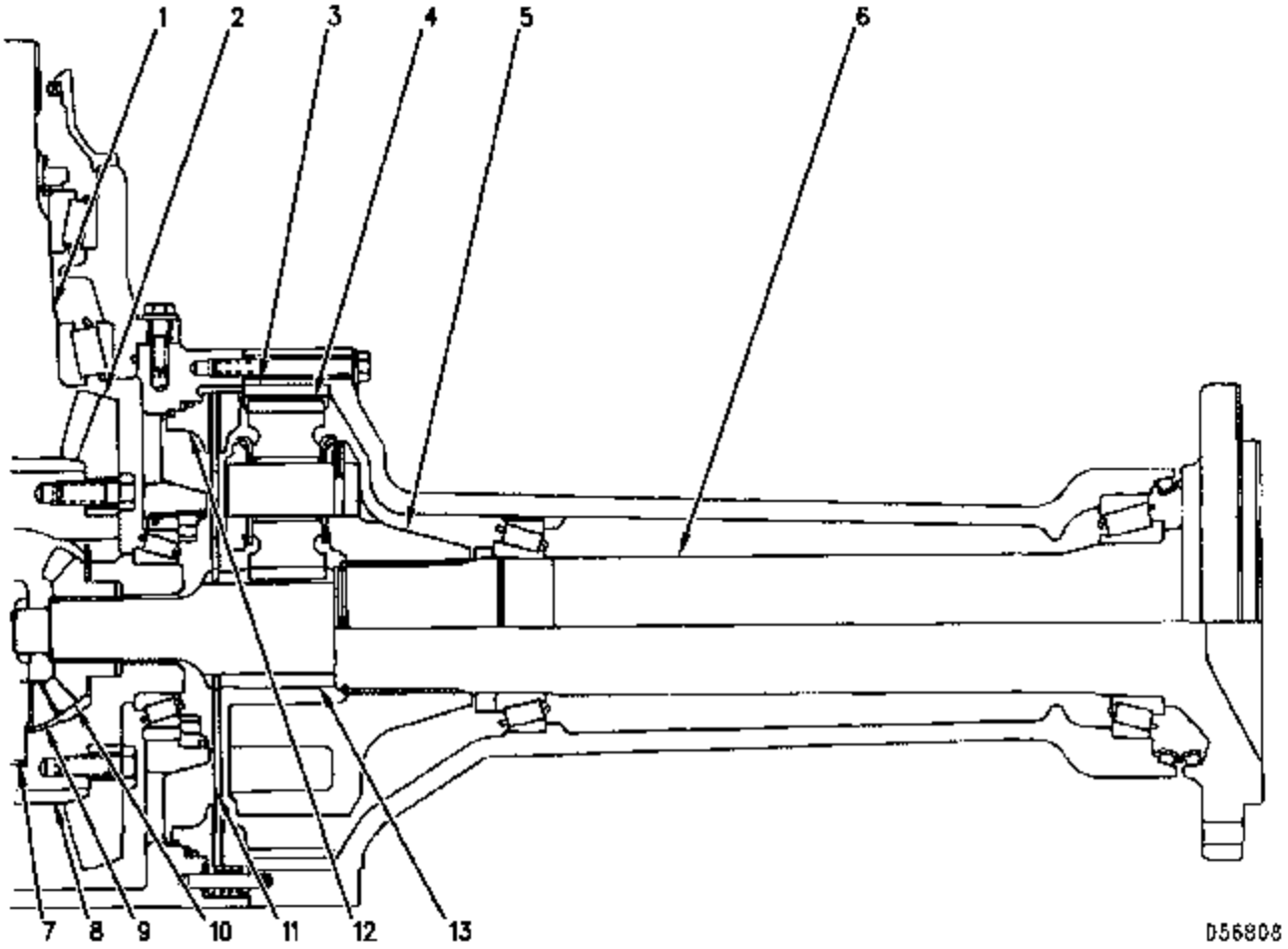
Part of the power goes from yoke assembly (6) through a drive shaft to the rear differential.
Part of the power goes from yoke assembly (7) through a drive shaft and bearing cage to the front differential

Shims (3) are used to make an adjustment to the end play of gear (2).

Output Transfer Gear Lubrication

Since the transfer gear case is also the reservoir for the transmission circuit, all return oil flows to the bottom of the case. The movement of the gears in the oil causes oil to be thrown on all the components.

Front And Rear Axle Groups



Typical Illustration
(1) Bevel pinion. (2) Bevel gear. (3) Ring gear. (4) Planet gear. (5) Carrier. (6) Axle shaft. (7) Shaft. (8) Differential case. (9) Pinion. (10) Side gear. (11) Brake disc. (12) Brake piston. (13) Sun gear.

The front and rear axle groups incorporate the pinion and bevel gear set, the differential, the final drives, and the disc brakes. While the front and rear axle housings are slightly different, the internal components and operation are identical. A NoSPIN differential is available in only the front axle.

NOTE: The 814F has service brakes in the front and rear axles. The 815F and 816F have service brakes in the front axle only.

Power from the transmission ouput shaft is transferred to the front and rear axle groups by the drive shafts. The power enters the axle groups through bevel pinion (1). Bevel pinion (1) turns bevel gear (2) which is fastened to differential case (8).

Power is transferred through the differential by pinions (9) and side gears (10) to the final drives. The main components of the final drives are carrier (5), planet gears (4), ring gear (3), and sun gear (13). Each final drive has the same components. The final drives cause the last speed reduction and torque increase in the drive train.

Sun gear (13) is splined into side gear (10) of the differential. Ring gear (3) is pressed into the axle housing. Three planet gears (4) are mounted in carrier (5). Carrier (5) has internal splines into which the splines of axle shaft (6) fit.

As sun gear (13) is driven by the differential, planet gears (4) are forced to revolve around the inside of ring gear (3). The movement of the planet gears (4) around ring gear (3) causes carrier (5) and axle shaft (6) to rotate. This transfers power to the rim and tire which bolts to the flange on axle shaft (6).

NOTE: For axle group adjustments, refer to SENR1307, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Train Specifications.

The axle groups contain the service brakes. Brake disc (11) is splined to sun gear shaft (13) and rotates at sun gear speed. When the brakes are applied, the cavity behind brake piston (12) is pressurized and the brake piston clamps brake disc (11) between the piston and the brake reaction plate.

NOTE: For more information on the brake system, refer to SENR1313 and SENR1314, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Brake Systems.

Differential Group (standard)

A differential divides or causes a balance of the power which is sent to the wheels. When one wheel turns slower than the other, as in a turn, the differential allows the inside wheel to go slower in relation to the outside wheel. The differential still sends the same amount of torque to each wheel.

Operation

Straight FORWARD or REVERSE

When the machine moves in a straight direction with the same amount of traction under each drive wheel, the same amount of torque on each axle holds the pinions so they do not turn on the spider.

Bevel pinion (1) turns bevel gear (2). Bevel gear (2) turns case (8). Case (8) turns shaft (11). Shaft (7) turns side gears (10) through pinions (9). Pinions (9) do not turn on the shaft. The side gears turn final drive sun gears (13). The same amount of torque is sent through the final drives to each wheel.

This gives the same effect as if both drive wheels were on one axle shaft.

FORWARD or REVERSE Turn

When the machine is in a turn, the inside wheel has more resistance to turn than the outside wheel. This resistance causes different torques on the opposite sides of the differential. It is easier for the outside wheel to turn than it is for the inside wheel. The outside wheel starts to turn faster than the inside wheel.

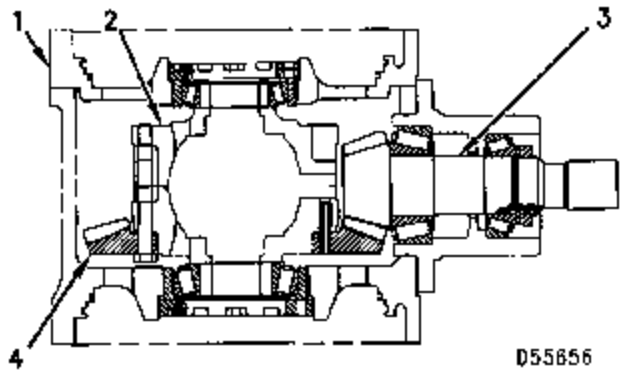
Bevel pinion (1) turns bevel gear (2). Bevel gear (2) turns case (8). Case (8) turns shaft (7). Shaft (7) turns side gears (10) through pinions (12). Since it takes more force to turn one side gear than it does the other, pinions (12) turn around shaft (11). As the pinions turn, they move around the side gears. This allows the outside wheel turn faster than the inside wheel.

The same amount of torque is sent through the final drives to both the inside and outside wheels. This torque is only equal to the amount needed to turn the outside wheel.

Loss of Traction (Wheel Slippage)

When one wheel has more traction than the other, the operation of the differential is the same as in a turn. The same amount of torque is sent to both wheels. This torque is only equal to the amount needed to turn the wheel with the least resistance.

NoSPIN Differential Group



NoSPIN Differential Group
(1) Axle housing. (2) NoSPIN differential and case. (3) Bevel pinion. (4) Bevel gear.

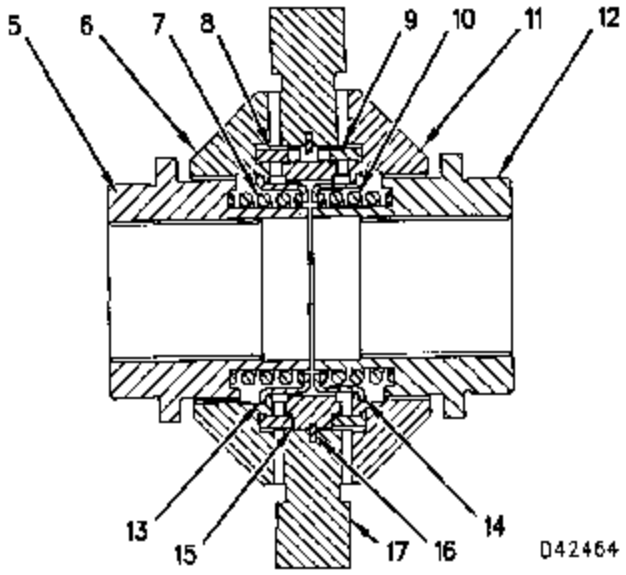
The NoSPIN Differential is a locking type differential designed to deliver power to both wheels of an axle when ground slip conditions are encountered on one wheel and disengage one side when good traction conditions require overrun, such as the outside wheel in a turn. The NoSPIN differential group is a direct replacement for the standard differential. It is available only in the rear axle group.

When the speeds of the wheels are the same, the NoSPIN differential sends the same amount of torque to each wheel. When the speeds of the wheels are different, the NoSPIN differential sends the torque to the wheel that turns slower. A difference in the speeds of the wheels is caused by a turn.

The NoSPIN differential allows a wheel (axle) to turn faster than the speed of the bevel gear by not engaging it with the bevel gear. For example: During a turn with power, the outside wheel (axle) is not engaged with the bevel gear and turns faster while the inside wheel axle is engaged with the bevel gear and turns at the same speed as the bevel gear. The inside wheel gives the power which moves the machine through the turn.

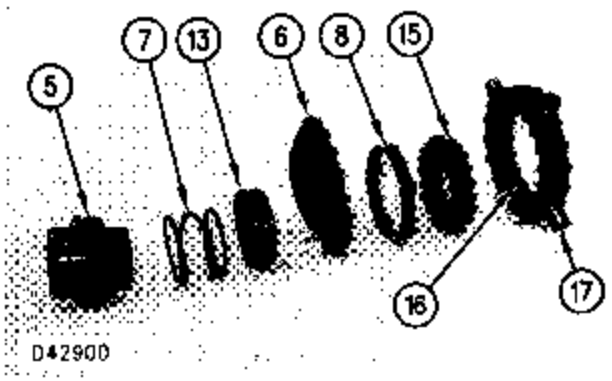
The NoSPIN differential is the same on one side of the spider (17) as it is on the other side (symmetrical). The NoSPIN has two springs (7) and (10), two side gears (5) and (12), two driven clutches (6 and 11), two holdout rings (8) and (9), a center cam (15), a snap ring (16) and a spider (17).

The inside splines of side gears (5) and (12) are connected to the sun gears for the final drives. The outside splines of the side gears are connected to the inside splines of drive clutches (6) and (11). The side gears send the power through the sun gears to the final drives.



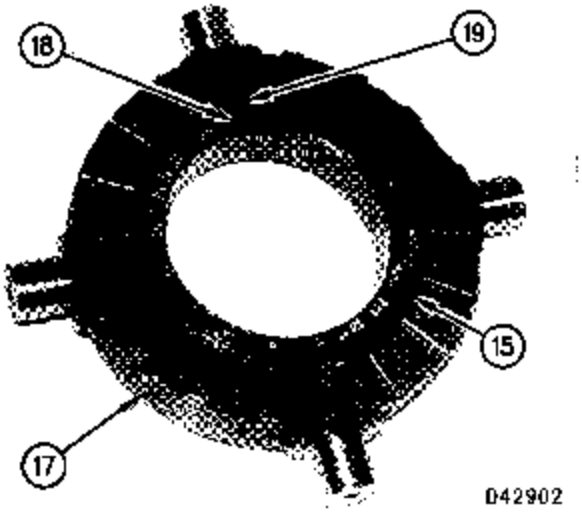
NoSPIN Differential
(Typical)
(5) Side gear. (6) Driven clutch. (7) Spring. (8) Holdout ring. (9) Holdout ring. (10) Spring. (11) Driven clutch. (12) Side gear. (13) Spring retainer. (14) Spring retainer. (15) Center cam. (16) Snap ring. (17) Spider

Spider (17) is fastened to the differential case and turns at the speed of bevel gear (4). The spider has clutch teeth on both sides. The spider also has one long tooth. The long tooth is spider key (19). Center cam (15) fits inside the spider and is held in position by snap ring (16). The center cam is turned by spider key (19) which fits inside notch (18). Spider key (19) pushes on either side of notch (18). The direction of the machine, forward or reverse, controls which way the spider turns and which side of notch (18) receives the force.



NoSPIN Differential
(Left Side Disassembled)
(5) Side gear. (6) Driven clutch. (7) Spring. (8) Holdout ring. (13) Spring retainer. (15) Center cam. (16) Snap ring. (17) Spider.

Springs (7) and (10) fit, between the side gears and spring retainers (13) and (14). The force of the springs holds the driven clutches against spider (17) and the side gears against the differential case.

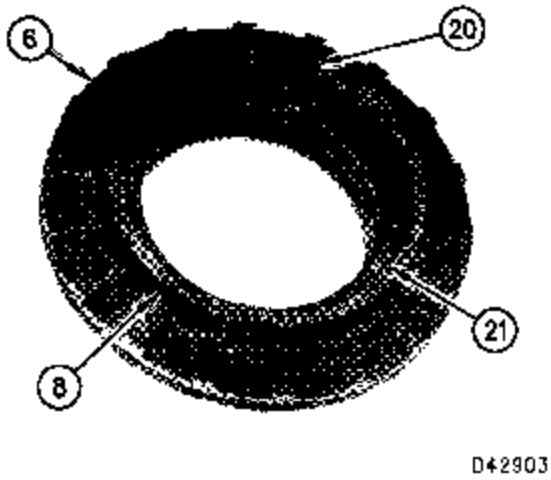


Spider And Center Cam
(15) Center cam. (17) Spider. (18) Notch in center cam. (19) Spider key.

Driven clutches (6) and (11) are the same. Each driven clutch has a cam (21) which is part of the clutch. The teeth on the cam engage with the teeth of center cam (15). The teeth of the drive clutches engage with the teeth of spider (17). An annular (in the shape of a circle) groove is between the teeth of the driven clutches and the teeth of the cams.

Holdout rings (8) and (9) are the same. Each holdout ring fits in the annular groove between the teeth of the driven clutches and the teeth of the cams. The teeth of the holdout rings engage with the notches in the center cam.

Notch (20) in the holdout ring engages with spider key (19). The spider key controls the movement of the holdout ring in relation to the spider. There is no connection, except friction, between the holdout rings and the driven clutches.



Clutch And Holdout Ring
(6) Driven clutch. (8) Holdout ring. (20) Notch in holdout ring. (21) Cam.

NoSPIN Differential Operation

When a wheel is made to turn faster than the speed of the bevel gear, the "clutch action" (the stopping of power to drive axle) of the NoSPIN differential will let this axle turn faster than the speed of the bevel gear.

The "clutch action" of the NoSPIN differential is as follows: If spider (17) turns, spider key (19) locates center cam (15) and the spider and the center cam turn at the speed of the bevel gear. The center cam turns holdout ring (8) and cam (21) at the speed of the bevel gear. The spider turns driven clutch (6) at the speed of the bevel gear. The driven clutch turns the side gear, axle and wheel at the speed of the bevel gear.

When the wheel is made to turn faster than the speed of the bevel gear, the teeth of center cam (15) work like ramps and the teeth of cam (21) move up the teeth of the center cam. This action causes driven clutch (6) to become disengaged with the spider.

The driven clutch pulls holdout ring (8) out of the grooves in the center cam. The friction between the holdout ring and driven clutch turns the holdout ring until notch (20) in the holdout ring engages with spider key (19).

The holdout ring is now turned by the spider key at the speed of the bevel gear. The teeth of the holdout ring are now in a position so they can not engage the notches in the center cam.

The driven clutch and cam move around the holdout ring at a speed faster than the speed of the bevel gear. The holdout ring keeps the driven clutch and cam from being engaged with the center cam and spider. The driven clutch, cam, axle shaft and wheel now turn freely.

The opposite side clutch, cam and holdout ring are held engaged to the center cam and spider by spring (7) as long as the driven wheel turns slower.

When the speed of the wheel that is not engaged becomes slower and near the speed of the bevel gear, the resistance of the ground to the wheel causes the torque on this wheel to be in a small reverse direction. This causes the driven clutch and cam to turn in a direction opposite the direction of the bevel gear.

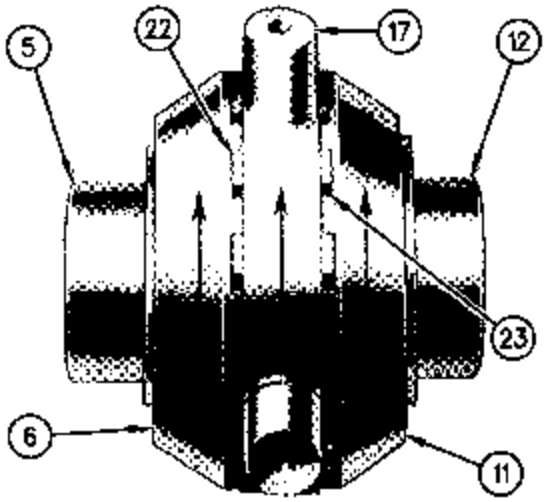
The friction between the holdout ring and the driven clutch causes the holdout ring to move in a direction opposite the direction of the bevel gear.

Notch (20) in the holdout ring moves away from spider key (19). When the teeth of the holdout ring are in a position to engage the notches in center cam (15), the force of the spring causes the driven clutch and cam to move to the inside.

The driven clutch pushes the holdout ring. The holdout ring now engages the center cam and is turned at the speed of the bevel gear. The teeth of cam (21) now engage the center cam and the teeth of the drive clutch engage the spider. At this time, both wheels are turned at the same speed.

NOTE: When both wheels are turned at the same speed they do not necessarily have equal torque. For example. When one wheel starts to turn faster on ice (tends to spin), both clutches engage and both wheels turn at the same speed. The wheel that is on ice will have less torque.

Straight Forward Operation



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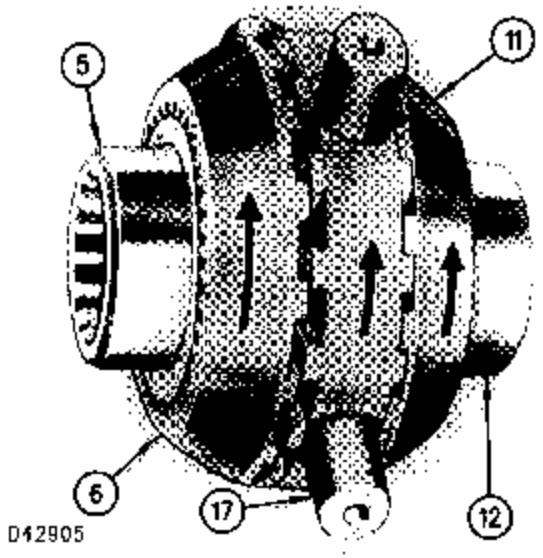
Straight Forward Operation
(5) Side gear. (6) Driven clutch. (11) Driven clutch. (12) Side gear. (17) Spider. (22) Teeth of the spider. (23) Teeth of the driven clutches.

When the machine has straight forward movement, teeth (22) on both sides of spider (17) are fully engaged with teeth (23) of driven clutches (6) and (11). The teeth of cams (21) are engaged with the teeth of center cam (15). The negative angle of the teeth on the clutches and spider, along with the force of springs (7) and (11), cams (21) and center cam (15), push together and the teeth engage.

In this condition, driven clutches (6) and (11) are fully engaged with spider (17). The driven clutches turn side gears (5) and (12) at the same speed as the bevel gear. The two side gears turn the axle shafts and wheels at the same speed as the bevel gear.

Forward Turn With Power

The travel of the outside wheel, during a turn, is at a longer distance than the travel of the inside wheel. When the machine turns with power, the NoSPIN differential allows the outside wheel to turn faster than the speed of the bevel gear. But it does not allow the inside wheel to turn slower than the speed of the bevel gear. The inside wheel turns at the same speed as the bevel gear.



Forward Right Turn With Power
(5) Side gear. (6) Driven clutch. (11) Driven clutch. (12) Side gear. (17) Spider.

The teeth of the spider send the drive force to the inside driven clutch. The inside driven clutch turns the inside wheel at the same speed as the bevel gear and gives the power that is needed to move the machine through the turn.

The outside wheel is made to turn (by the traction of the road) at a speed faster than the speed of the bevel gear. This causes the driven clutch for the outside wheel to turn faster than the speed of the bevel gear. The movement of one wheel faster than the other wheel starts the "clutch action" of the NoSPIN differential.

The teeth of the cam for the driven clutch for the inside wheel are engaged with the teeth of center cam (15) and stay in the same position in relation to spider (17). The teeth of the inside drive clutch are engaged with the spider. The teeth on the other side of center cam (15) are used as ramps.

The teeth of the cam for the driven clutch for the outside wheel move up the teeth of the center cam. This causes the outside driven clutch and cam to move away from the spider and center cam. The outside driven clutch and cam are not engaged with the spider and center cam.

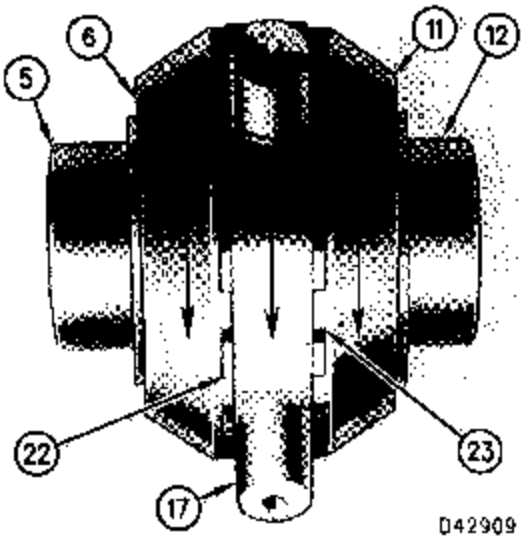
The driven clutch for the outside wheel can not be engaged with the spider until the speed of the outside wheel becomes slower and equal to the speed of the bevel gear. The holdout ring keeps the driven clutch and cam from being engaged with the spider and center cam until the machine moves in a straight direction. At this time the operation of the differential is the same as Straight Forward Operation.

Forward Turn With No Power

The operation of the NoSPIN differential is the same as for Forward Turn With Power. The outside wheel is still made to turn faster (by the traction of the road) than the speed of the bevel gear. The inside wheel is turned at the speed of the bevel gear.

Straight Reverse Operation

When the machine moves in a straight reverse direction, teeth (22) on both sides of spider (17) are fully engaged with teeth (23) of driven clutches (6) and (11). Spider (17) turns in the opposite direction than it turns in straight forward. Since the spider turns in an opposite direction, teeth (22) of the spider push against the opposite face of teeth (23) of the driven clutches.

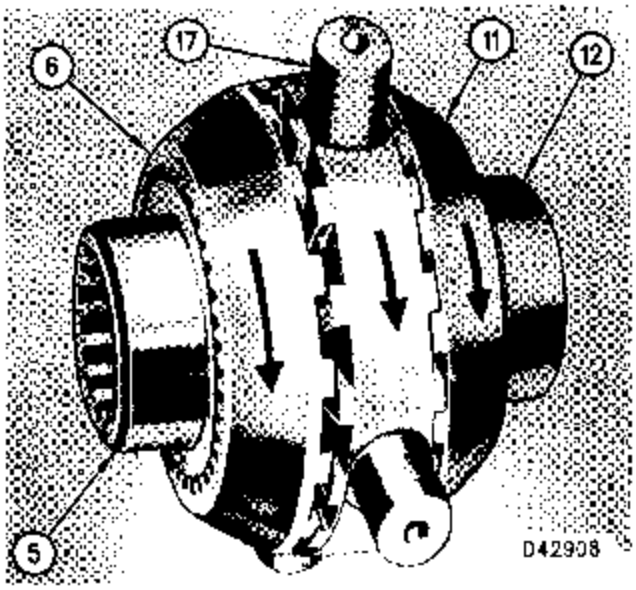


Straight Reverse
(5) Side gear. (6) Driven clutch. (11) Driven clutch. (12) Side gear. (17) Spider. (22) Teeth of the spider. (23) Teeth of the driven clutches.

The action of the differential is the same as it is in the Straight Forward Direction.

Reverse Turn With Power

The action of the differential is the same as it is in the Forward Turn With Power condition except spider (17) turns in the opposite direction.



Reverse Right Turn With Power
(5) Side gear. (6) Driven clutch. (11) Driven clutch. (12) Side gear. (17) Spider.

Reverse Turn With No Power

The operation of the NoSPIN differential is the same as for Reverse Turn With Power. The outside wheel is still made to turn faster (by the traction of the road) than the speed of the bevel gear. The inside wheel is turned at the speed of the bevel gear

Testing And Adjusting

Troubleshooting

⚠ WARNING

Sudden movement of the machine or release of oil under pressure can cause injury to persons on or near the machine.

To prevent possible injury, perform the procedure that follows before testing and adjusting the power train.

1. Move the machine to a smooth horizontal location. Move away from working machines and personnel.
2. Permit only one operator on the machine. Keep all other personnel either away from the machine or in view of the operator.
3. Move the transmission direction switch to the neutral position.
4. Lower the implement to the ground.
5. Engage the parking brake.
6. Stop the engine.
7. Move the hydraulic control levers to all positions to release the pressure in the implement hydraulic system.
8. Put blocks in front of and behind the wheels.
9. Install the steering frame lock link.
10. Loosen the fill cap slowly on the hydraulic tank to release the pressure in the tank.
11. Make sure all hydraulic pressure is released before any fitting, hose or component is loosened, tightened, removed or adjusted.
12. Tighten the fill cap on the hydraulic tank.
13. The pressure in the system has now been released and lines or components can be removed.

Procedure

When defining a power train problem, the following procedure should be followed. First check for any active electronic transmission control service codes using the Caterpillar Monitoring System. Refer to Service manual, SENR5922, Electronic Transmission Control System. Correct all service codes and then perform visual checks.

Next perform Visual Checks. If when complete the problem has not been identified, perform operation checks. If the problem is still not fully understood, perform Instrument Tests. This procedure will help identify power train problems.

As soon as the problem is defined, go to Troubleshooting. The Troubleshooting section will list the probable causes of a known problem. Since there may be more than one cause for a problem, the Troubleshooting section may suggest specific inspections or instrument tests be done.

These inspections and tests will help identify which of the causes is most probable. This list cannot give all possible problems and corrections. The service personnel must find the problem and its source, then make the necessary repairs

Use this as a reference for the location and correction of problems in the power train. When more checks are necessary, use 1U-5481 Gauge Group, Pressure and 1U-5482 Adapter Group, Pressure. Locations of the pressure taps and procedures for testing and adjusting are given in SENR1309, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Shift Transmission Testing and Adjusting.

Visual Checks

A visual inspection of the power train and its components is the first step when a diagnosis of a problem is made.

⚠ WARNING

Personal injury or death can result from improperly checking for a leak.

Always use a board or cardboard when checking for a leak. Escaping fluid under pressure, even a pin-hole size leak, can penetrate body tissue, causing serious injury, and possible death. If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.

NOTE: If the machine will not move, check the transmission shift fuse on the right rear inside of the cab.

During these checks, if necessary, use a magnet to separate ferrous (iron) particles from non-ferrous particles (o ring seals, aluminum, bronze, etc.).

Check 1:

Check the oil level in the differentials.

Check 2:

Check the oil level in the transmission. Look for air or water in the oil. Many problems in the transmission are caused by low oil level or air in the oil. Add oil to the transmission if it is needed. See Operation And Maintenance Manual for recommended oil grade and viscosity.

a. Air (bubbles) may be caused by a loose or damaged fitting that allows air to enter the suction side of the system along with allowing oil to leak out. Air may also be the result of gears agitating oil in the sump if the transmission oil level is too high (overfill).

b. Coolant in the oil can be caused by a leaking transmission oil cooler. Water may enter the system if the filler cap or dipstick is not properly installed.

Check 3:

Inspect all oil lines, hoses, and connections for damage or leaks. Look for oil on the ground under the machine.

NOTE: If oil can leak out of a fitting or connection, air can leak in. Air in the system can be as harmful as not enough oil.

Check 4:

Remove the drain plug in the bottom of the output transfer gear case. This will drain all of the oil out of the transmission. Remove and clean suction screen. Inspect the oil and suction screen for foreign material. Remove and inspect (cut apart if necessary) the transmission oil filter for foreign material.

NOTE: There is an oil filter bypass valve on the inlet side of the transmission oil filter. The oil filter bypass will open and let oil bypass the oil filter element whenever the pressure difference between inlet oil and outlet oil through the oil filter is above 248 ± 21 kPa (36 ± 3 psi). Any oil that does not flow through the filter element flows directly into the hydraulic control circuit. This dirty oil may cause restrictions in valve orifices, sticking valves, etc.

a. Rubber particles indicate seal or hose failure.

b. Shiny steel particles indicate mechanical failure or gear wear of the transmission or pump.

c. A heavy accumulation of fibrous material indicates worn clutch discs in the transmission.

d. Aluminum particles indicate torque converter wear or failure, clutch piston wear, or worn control valve body, selector spools, or load piston in the transmission control valve.

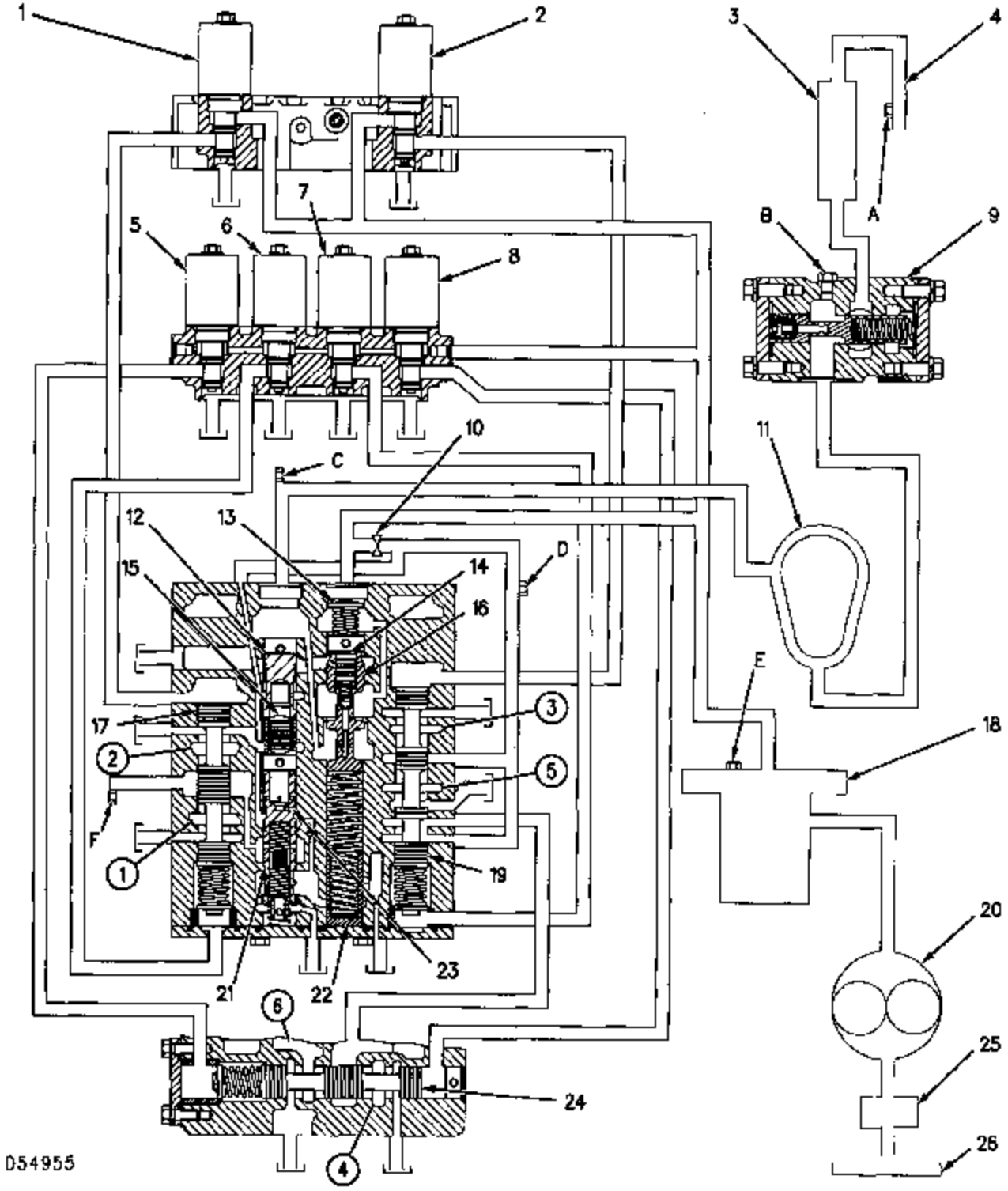
e. Iron or steel chips indicate broken components in transmission.

NOTE: If any of the above particles are found during any visual check, all components of the transmission hydraulic system must be cleaned. Do not use any damaged parts. Any damaged parts must be removed and new parts installed.

Check 5:

The drive shaft(s) and universal joints must be free to rotate except when cold oil causes a resistance. If the shafts are not free to turn, disconnect them and see if the transmission will turn

Power Train Hydraulic System Schematic



Transmission Hydraulic Controls (Neutral, Engine Stopped)

(1) No. 2 clutch solenoid.
(2) No. 3 clutch solenoid.
(3) Oil cooler.
(4) Transmission lubrication passage.
(5) No. 6 clutch solenoid.
(6) No. 1 clutch solenoid.
(7) No. 5 clutch solenoid.
(8) No. 4 clutch solenoid.
(9) Torque converter outlet relief valve.
(10) Flow control orifice..
(11) Torque converter.
(12) Converter inlet ratio valve.
(13) Differential valve.
(14) Slug.
(15) Slug.
(16) Modulating relief valve.
(17) Direction selection spool.
(18) Transmission oil filter.
(19) Second and fourth speed selector spool.
(20) Oil pump.
(21) Pressure differential valve..
(22) Load piston.
(23) Orifice.
(24) First and third speed selector spool.
(25) Screen.
(26) Reservoir.
(A) Pressure tap for lubrication..
(B) Pressure tap for converter outlet.
(C) Pressure tap for converter inlet [P3].
(D) Pressure tap for speed clutches [P1].
(E) Pressure tap for pump.
(F) Pressure tap for direction clutches [P2].

Checks During Operation

⚠ WARNING

Make Reference to the WARNING in the previous section Power Train Testing and Adjusting.

Start the engine and disengage the parking brake. Move the transmission control switches through all speeds and directions. The transmission must engage in all positions. The machine must not move in NEUTRAL.

With the engine running, engage the parking brake. Move the transmission direction switch to forward and then to reverse. The parking brake alert indicator light and the action light must come "ON" and the action alarm must sound. When the direction switch is moved to the neutral position the action alarm must stop and the action light must go "OFF".

NOTICE

With the parking brake ENGAGED, move the machine in case of necessity only. Fire and damage to the parking brake can be the result if the machine is moved too far.

Disengage the parking brake. Operate the machine in each direction and speed. Make note of all noises that are not normal and find their sources.

If the operation of the machine is not correct, make reference to the Troubleshooting section for "problems" and "probable causes".

Problem Checklist:

Transmission Problem List:

1. The transmission does not operate in any speed or slips in all speeds.
2. Transmission gets hot.
3. Pump noise not normal.
4. Noise in the transmission that is not normal.
5. Transmission operates in FORWARD only.
6. Transmission operates in REVERSE only.
7. Transmission does not operate in FIRST SPEED FORWARD or REVERSE.
8. Transmission does not operate in SECOND SPEED FORWARD or REVERSE.
9. Transmission does not operate in THIRD SPEED FORWARD or REVERSE.
10. Transmission does not operate in FOURTH SPEED FORWARD or REVERSE.
11. Low pressure at pressure taps for P1 (speed) and P2 (direction) clutches in all speeds and directions.
12. Low pressure at P2 clutch pressure tap in REVERSE speeds.
13. Low pressure at P2 clutch pressure tap in FORWARD speeds.
14. High pressure at pressure taps for P1 (speed) and P2 (direction) clutches in all speeds and directions.
15. Pressure differential between P1 and P2 not correct.
16. Clutch engagement is sudden (rough shifts).
17. Clutch engagement is slow (slow shifts-all gears).
18. Clutch engagement is slow (slow shifts-all FORWARD gears or all REVERSE gears or any one gear in both FORWARD and REVERSE).
19. Transmission engages but the machine does not move and the engine lugs down.
20. With the engine running and the parking brake "ENGAGED", the action alarm does not sound when the transmission selection lever is put into either a FORWARD or REVERSE direction.
21. Backup alarm does not sound when selection lever is put in REVERSE.

Torque Converter Problem List

22. Low stall speed.
23. High stall speed in both directions.
24. High stall speed in one speed or in one direction
25. High converter pressure.
26. Low converter pressure.
27. Torque converter gets hot.

Differential Problem List

28. Constant noise in the differential.
29. Noise at different intervals.
30. Noise on turns only.
31. Leakage of lubricant.
32. Drive wheels do not turn (universal joint turns).

NOTE: In the following troubleshooting, the numbers in parenthesis refer to the power train hydraulic system schematic.

NOTE: This machine is equipped with an Electronic Transmission Control. The electronic transmission control has built-in system diagnostics to detect faults in the transmission electronic system. The diagnostics are displayed on the Diagnostic display when the system is placed in the service mode.

For Systems Operation, Testing and Adjusting make reference to Service Manual, SENR5922, Electronic Transmission Control System.

Troubleshooting List

Transmission

Problem 1: The transmission does not operate in any speed or slips in all speeds.

Possible Causes:

1. Transmission shift fuse is open or blown.
2. Problem in the electrical circuit.
3. Low system voltage.
4. Low oil pressure caused by:
   a. Low oil level.
   b. Restriction in the oil flow circuit such as a dirty oil strainer.
   c. Oil pump failure.
   d. Air leaks on the inlet side of the pump.
   e. Leakage inside the transmission:
      Worn or damaged seals around the clutch piston.
   f. Modulating relief valve (16) stuck open.
5. Torque converter failure.
6. Mechanical failure in the transmission.
7. Clutch discs and plates are worn too much
8. Transmission neutralizer switch is open.

Problem 2: Transmission gets hot.

Possible Causes:

1. Low coolant level in the engine radiator.
2. Wrong application for the machine. There is too much torque converter slippage caused by too much load.
3. Incorrect transmission gear for load on machine. Shift to a lower gear.
4. Defective temperature gauge.
5. Incorrect (high or low) oil level.
6. Oil cooler or lines are restricted.
7. Clutch slips too much.
   a. Low oil pressure. See Problem: Transmission does not operate in any speed or slips in all speeds.
   b. Damaged clutch.
8. Low oil flow caused by pump wear or leakage in the hydraulic system.
9. Air mixed in the oil. Air leaks on the intake side of the pump.
10. Magnetic pump inlet screen plugged.
11. Torque converter inlet ratio valve (12) is stuck open, which causes low oil flow through the torque converter.
12. Clutch or clutches not fully released (drag).
    a. Warped plates or discs.
    b. Broken or weak return spring.

Problem 3: Pump noise not normal.

Possible Causes:

1. A loud sound at short time periods indicates that foreign material is in the transmission hydraulic system.
2. A constant loud noise indicates pump failure.
3. Air at the inlet side of the pump.

Problem 4: Noise in the transmission that is not normal.

Possible Causes:

1. Transmission components are worn or damaged:
   a. Damaged gears.
   b. Worn teeth of clutch plates and/or clutch discs.
   c. Slipping clutch plates and disc noise.
   d. Other component parts that are worn or damaged.

Problem 5: Transmission operates in FORWARD only.

Possible Causes:

1. Transmission REVERSE solenoid valve (6) is inoperative.
2. Problem in the electrical circuit.
3. REVERSE clutch not engaged (slips) because of:
   a. Low oil pressure because of leaking seals on piston.
   b. Discs and plates have too much wear.
   c. Broken components.
4. Selector spool (17) is stuck.

Problem 6: Transmission operates in REVERSE only.

Possible Causes:

1. Transmission FORWARD solenoid valve (1) is inoperative.
2. Problem in the electrical circuit.
3. FORWARD clutch not engaged (slips) because of:
   a. Low oil pressure because of leaking seals on piston.
   b. Discs and plates have too much wear.
   c. Broken components.
4. Selector spool (17) is stuck.

Problem 7: Transmission does not operate in FIRST SPEED FORWARD or REVERSE.

Possible Causes:

1. FIRST SPEED solenoid valve (5) is inoperative.
2. Problem in the electrical circuit.
3. FIRST SPEED clutch not engaged (slips) because of:
   a. Low oil pressure because of leaking seals on piston
   b. Discs and plates have too much wear.
   c. Broken components.
4. Selector spool (24) stuck.

Problem 8: Transmission does not operate in SECOND SPEED FORWARD or REVERSE.

Possible Causes:

1. SECOND SPEED solenoid (7) is inoperative.
2. Problem in the electrical circuit.
3. SECOND SPEED clutch not engaged (slips) because of:
   a. Low oil pressure because of leaking seals on piston.
   b. Discs and plates have too much wear.
   c. Broken components.
4. Selector spool (19) stuck.

Problem 9: Transmission does not operate in THIRD SPEED FORWARD or REVERSE.

Possible Causes:

1. THIRD SPEED solenoid (8) is inoperative.
2. Problem in the electrical circuit.
3. THIRD SPEED clutch not engaged (slips) because of:
   a. Low oil pressure because of leaking seals on piston.
   b. Discs and plates have too much wear.
   c. Broken components.
4. Selector spool (24) stuck.

Problem 10: Transmission does not operate in FOURTH SPEED FORWARD or REVERSE.

Possible Causes:

1. FOURTH SPEED solenoid (2) is inoperative.
2. Problem in the electrical circuit.
3. FOURTH SPEED clutch not engaged (slips) because of:
   a. Low oil pressure because of leaking seals on piston.
   b. Discs and plates have too much wear.
   c. Broken components.
4. Selector spool (19) is stuck.

Problem 11: Low pressure at pressure taps for P1 (speed) and P2 (direction) clutches in all speeds and directions.

Possible Causes:

1. Modulating relief valve (16) stuck.
2. Low oil pressure. See Problem: Transmission does not operate in any speed or slips in all speeds.
3. Load piston (22) springs weak, damaged or missing. Spacers missing.

Problem 12: Low pressure at P2 clutch pressure tap in REVERSE speeds.

Possible Causes:

Too much leakage in the REVERSE clutch piston seals.

Problem 13: Low pressure at P2 clutch pressure tap in FORWARD speeds.

Possible Causes:

Too much leakage in the FORWARD clutch piston seals.

Problem 14: High pressure at pressure taps for P1 (speed) and P2 (direction) clutches in all speeds and directions.

Possible Causes:

1. Operation of modulating relief valve (16) sticky
2. Load piston (22) stuck.
3. Wrong load piston springs Too many spacers
4. Worn slug (14) or worn modulating relief valve (16) bore.

Problem 15: Pressure differential between P1 and P2 not correct.

Possible Causes:

Operation of pressure differential valve (21) not correct.
   a. Weak, damaged or wrong spring.

Problem 16: Clutch engagement is sudden (rough shifts).

Possible Causes:

1. Operation of pressure differential valve (21) not correct.
   a. Weak, damaged or wrong spring.
2. Load piston (22) stuck.
3. Load piston springs are wrong or damaged.

Problem 17: Clutch engagement is slow (slow shifts-all gears).

Possible Causes:

1. Screen orifice for the load piston is dirty (plugged).
2. Low oil pressure. See Problem: Transmission does not operate in any speed or slips in all speeds
3. Load piston springs are weak or have damage.
4. Modulating relief valve (16) is stuck.

Problem 18: Clutch engagement is slow (slow shifts-all FORWARD gears or all REVERSE gears or any one gear in both FORWARD and REVERSE).

Possible Causes:

Low clutch pressure because of leaking seals on the piston for the affected gear.

Problem 19: Transmission engages but the machine does not move and the engine lugs down.

Possible Causes:

1. Machine brakes are locked up.
2. Parking brake not released or locked up.
3. Mechanical failure in a differential (front or rear).
4. Mechanical failure in a final drive.
5. Gears in transmission do not turn because of:
   a. Mechanical failure in transmission.
   b. Too many clutches engaged.

Problem 20: With the engine running and the parking brake ENGAGED, the action alarm does not sound when the transmission selection lever is put into either a FORWARD or REVERSE direction.

Possible Causes:

1. Failure of the action alarm.
2. Failure in the wiring.
   a. Loose or defective connector.
   b. Broken wire.
3. Transmission control group (lever) problem.

Problem 21: Backup alarm does not sound when selection lever is put in REVERSE.

Possible Causes:

1. Failure of backup alarm fuse.
2. Failure of backup alarm.
3. Failure in the wiring.
   a. Loose or defective connector.
   b. Broken wire.
4. Transmission control group (lever) problem.

Torque Converter

Problem 22: Low stall speed.

Possible Causes:

1. Engine performance is not correct.
2. Cold oil.

Problem 23: High stall speed in both directions.

Possible Causes:

1. Engine performance is not correct.
2. Low oil level.
3. Air in the oil.
4. Clutches are slipping.
5. Torque converter failure.

Problem 24: High stall speed in one speed or in one direction.

Possible Causes:

1. There is a leak in the clutch circuit.
2. There is a clutch failure in the speed or direction that there is high stall speed.

Problem 25: High converter pressure.

Possible Causes:

1. A restriction inside the converter.
2. A restricted oil passage or oil cooler.
3. Converter inlet ratio valve (12) is stuck closed.

Problem 26: Low converter pressure.

Possible Causes:

1. Converter inlet ratio valve (12) is stuck open.
2. Low pump flow or pressure. See Problem: Transmission does not operate in any speed or slips in all speeds.

Problem 27: Torque converter gets hot.

Possible Causes:

1. Wrong application for the machine. There is too much torque converter slippage caused by too much load.
2. Incorrect transmission gear for load on machine. Shift to a lower gear.
3. Incorrect (high or low) oil level in the transfer gear case.
4. Low water level in the engine radiator.
5. Restrictions in the oil cooler or lines.
6. Not enough oil to the converter because of:
   a. Converter inlet ratio valve (12) bypassing too much flow.
   b. Low pump flow or pressure. See Problem: Transmission does not operate in any speed or slips in all speeds.

Differential And Drive Axle

Problem 28: Constant noise in the differential.

Possible Causes:

1. Lubricant above or below the proper level.
2. Wrong type of lubricant.
3. Wheel bearings are out of adjustment or are defective.
4. The ring gear and pinion do not have correct tooth contact.
5. The ring gear and pinion are damaged or worn.
6. There is too much or too little pinion to gear backlash.
7. Loose or worn pinion bearings.
8. Loose or worn side bearings.

Problem 29: Noise at different intervals.

Possible Causes:

1. Ring gear does not run even:
   a. Bolts on the ring gear are not tight.
   b. The ring gear is warped.
2. Loose or broken differential bearings.

Problem 30: Noise on turns only.

Possible Causes:

1. The differential pinion gears are too tight on the retainer pins or the pinion shaft.
2. Side gears are too tight in the differential case.
3. Differential pinion or side gears are defective.
4. Thrust washers are worn or damaged.
5. Too much backlash between the side and pinion gears.

Problem 31: Leakage of lubricant.

Possible Causes:

1. Loss through axle shafts:
   a. Lubricant above the proper level.
   b. Wrong type of lubricant.
   c. Axle housing breather is restricted.
   d. Axle shaft oil seal is installed wrong or is damaged.
2. Loss at pinion shaft.
   a. Lubricant above the proper level.
   b. Wrong type of lubricant.
   c. Axle housing breather is restricted.
   d. Pinion oil seal worn or is not installed correctly.
   e. Universal joint flange loose on the pinion shaft.

Problem 32: Drive wheels do not turn (universal joint turns).

Possible Causes:

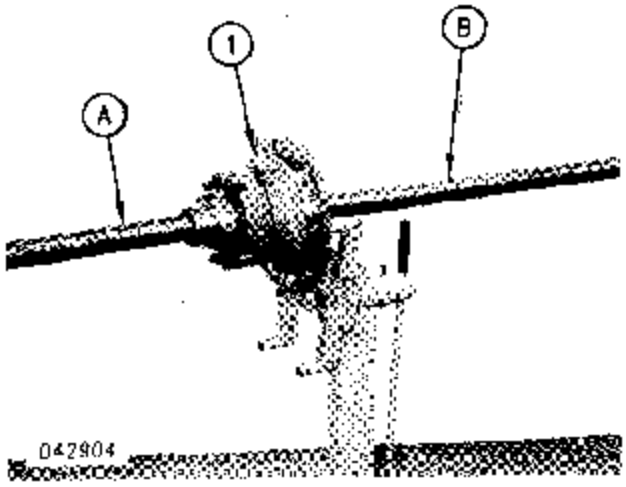
1. Broken axle shaft.
2. Ring gear teeth are damaged.
3. Side gear or differential pinion are broken.
4. Differential pinion shaft or retainer pin are broken.

NoSPIN Differential

NoSPIN Differential Test (Before Installation)

After the NoSPIN differential has been assembled and before it is installed in the machine, make a test of the operation of the differential as follows:

1. Install the NoSPIN differential in the case.
2. Put the case in a stand or a vise to keep it from rotating
3. Install both axles in the case.

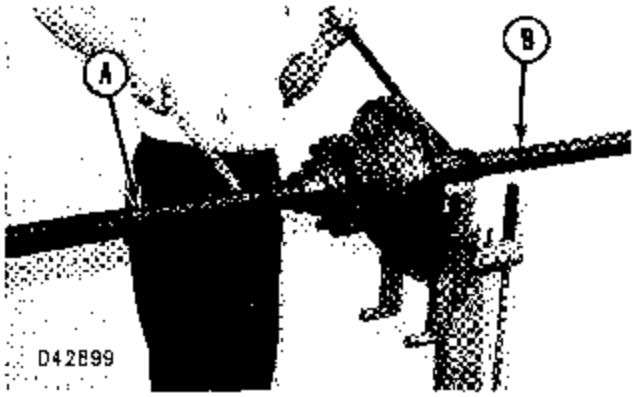


Test Procedure For NoSPIN Differential
(1) Case. (A) Axle. (B) Axle.

4. Put a force in a clockwise direction on both axles.
5. Keep the force on axle (A) and turn axle (B) in a counterclockwise direction. A small noise will be heard in the NoSPIN differential and axle (B) will turn freely.

NOTE: Make sure the force is kept on axle (A).

6. Keep the force on axle (A) and turn axle (B) in a clockwise direction. A small noise will be heard in the NoSPIN differential and axle (B) will not turn any farther.



NoSPIN Differential Test

7. Put a force in a counterclockwise direction on both axles.

8. Keep the force on axle (A) and turn axle (B) in a clockwise direction. A small noise will be heard in the NoSPIN differential and axle (B) will turn freely.

NOTE: Make sure the force is kept on axle (A).

9. Keep the force on axle (A) and turn axle (B) in a counterclockwise direction. A small noise will be heard in the NoSPIN differential and axle (B) will not turn any farther.

10. Perform Steps 4 through 9 again, except now hold axle (B) and turn axle (A).

If the NoSPIN differential does not have the correct action, inspect the components and check the assembly procedure.

CATERPILLAR®

SENR1309
February 1996

Testing & Adjusting

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Shift Transmission

814F	815F	816F	Transmission
9DM1-UP	1GN1-UP	5FN1-UP	1XY1-UP
			1YY1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Index

Testing And Adjusting

Power Shift Transmission 4
- Electronic Control Module 4
- Hydraulic Schematic 5
- Pressure Chart 7
- Pressure Tap Locations 6
- Spacer Chart 7
- Speed And Clutch Engagement Chart 7

Systems Operation

Reference: For Systems Operation, Testing and Adjusting make reference to SENR1308, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Train.

Specifications

Reference: For Specifications with illustrations, make reference to SENR1307, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Train Specifications. If the Specifications in SENR1307 are not the same as in the Systems Operation, Testing and Adjusting, look at the printing date on the cover of each book. Use the Specifications given in the book with the latest date.

Testing And Adjusting

Power Shift Transmission

⚠ WARNING

Sudden movement of the machine or release of oil under pressure can cause injury to persons on or near the machine.

To prevent possible injury, perform the procedure that follows before testing and adjusting the power shift transmission.

1. Move the machine to a smooth horizontal location. Move away from working machines and personnel.
2. Permit only one operator on the machine. Keep all other personnel either away from the machine or in view of the operator.
3. Put the transmission control lever in the NEUTRAL position and any speed position. Lock the control lever in neutral.
4. Lower the implement to the ground.
5. Put blocks in front of and behind the wheels.
6. Install the steering frame lock link.
7. Engage the parking brake.

NOTE: All tests and adjustments must be made with the oil in the transmission hydraulic control system at normal temperature of operation.

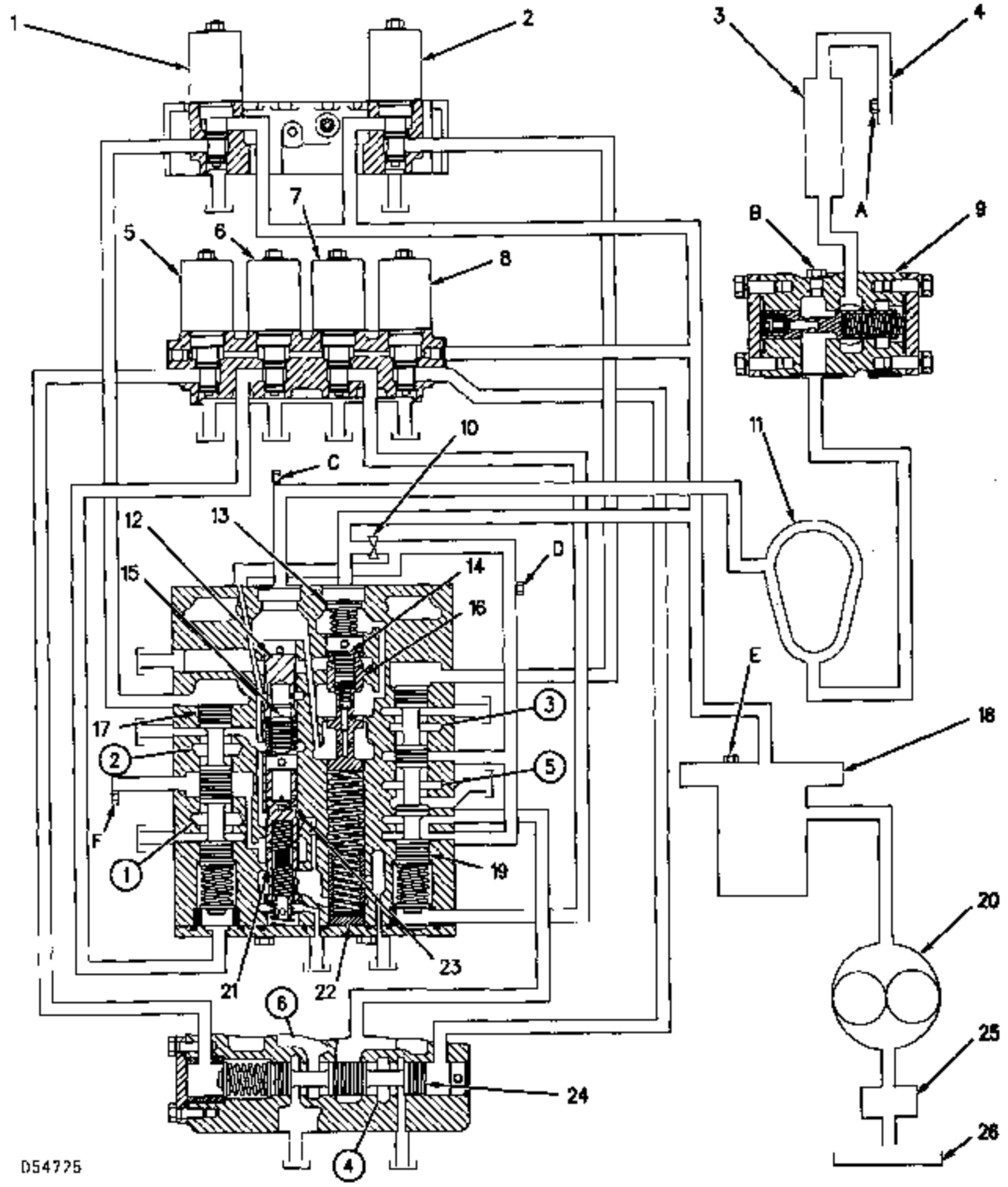
Transmission Electronic Control Module

The electronic control module for the transmission is located in the cab, behind the operator seat. The main function of the electronic control module is to shift the transmission. The electronic control module receives operator input from the transmission control group to shift the transmission to the desired speed and direction.

The electronic control module also controls engine starting and the back-up alarm. The electronic control module will not allow the engine to be started unless the direction control switch is in the neutral position. The back-up alarm is activated any time the direction control switch is in the reverse position.

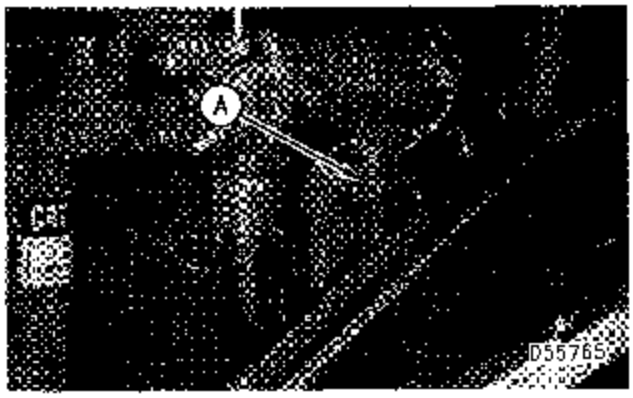
The electronic control module has built-in system diagnostics to detect faults in the transmission system. Always perform electronic diagnostics before performing hydraulic tests. For Systems Operation, Testing and Adjusting make reference to SENR5922, Electronic Transmission Control System.

Power Train Hydraulic System Schematic

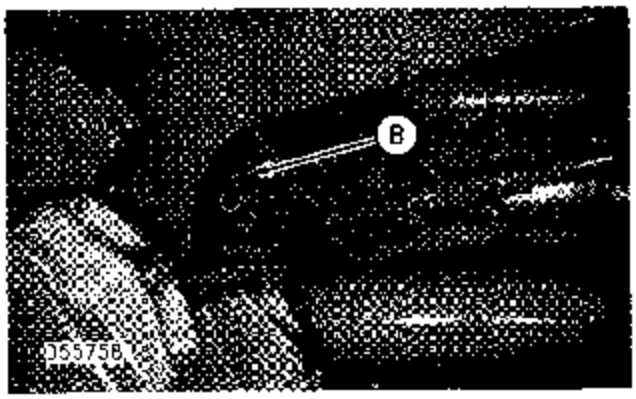


TRANSMISSION HYDRAULIC CONTROLS (NEUTRAL, ENGINE STOPPED): (1) No. 2 clutch solenoid. (2) No. 3 clutch solenoid. (3) Oil cooler. (4) Transmission lubrication passage. (5) No. 5 clutch solenoid. (6) No. 1 clutch solenoid. (7) No. 5 clutch solenoid. (8) No. 4 clutch solenoid. (9) Torque converter outlet relief valve. (10) Flow control orifice. (11) Torque converter. (12) Converter inlet ratio valve. (13) Differential valve. (14) Slug. (15) Slug. (16) Modulating relief valve. (17) Direction selection spool. (18) Transmission oil filter. (19) Second and fourth speed selector spool. (20) Oil pump. (21) Pressure differential valve. (22) Load piston. (23) Orifice. (24) First and third speed selector spool. (25) Screen. (26) Reservoir. (A) Pressure tap for lubrication. (B) Pressure tap for converter outlet. (C) Pressure tap for converter inlet [P3]. (D) Pressure tap for speed clutches [P1]. (E) Pressure tap for pump. (F) Pressure tap for direction clutches [P2].

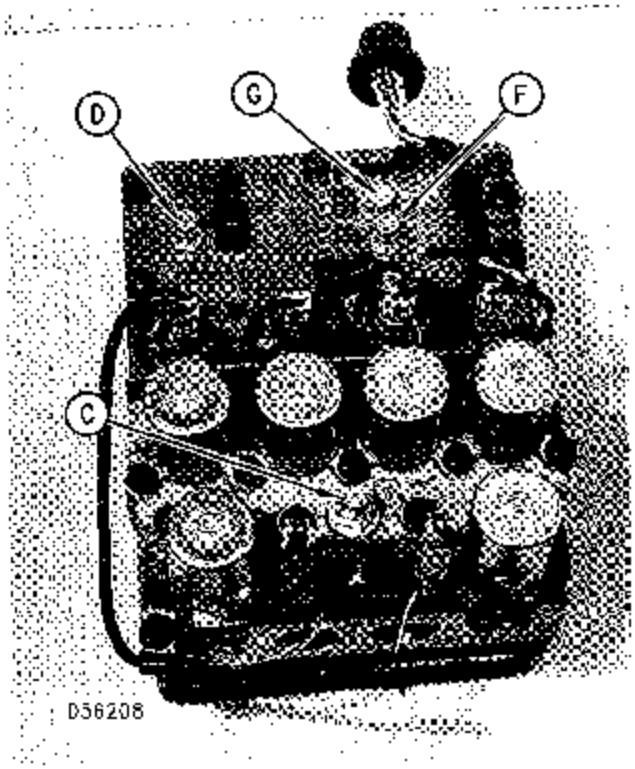
Pressure Tap Locations



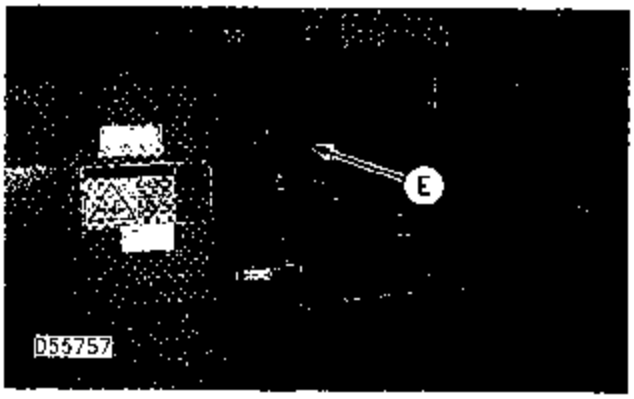
(A) Transmission Lubrication.



(B) Converter outlet



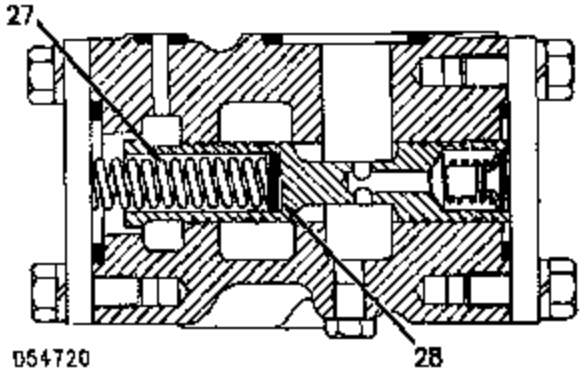
(C) Converter inlet (P3). (D) Speed clutch (P1). (F) Direction clutch (P2). (G) Plug for load piston (LP).



(E) Oil pump (on filter).

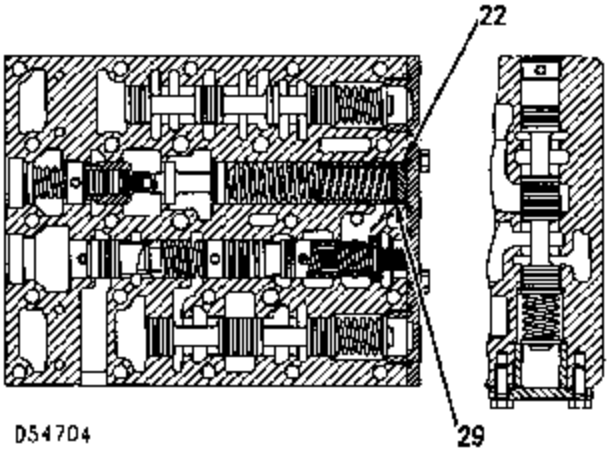
NOTE: Port (F) on the oil filter is an oil sampling valve. To connect a pressure gauge, the valve must be removed and a 6V-3965 Nipple installed.

NOTE: All tests and adjustments must be made with the oil in the transmission hydraulic control system at normal temperature of operation.



Torque Converter Outlet Relief Valve
(27) Relief valve for converter outlet. (28) Spacers.

TRANSMISSION PRESSURE CHARTS				
		Governor Control Lever At:		
Pressure	Pressure Tap	Low Idle	High Idle	Adjustment
Transmission Lubrication Oil	(A)	7 kPa (1 psi) Minimum.	70 to 140 kPa (10 to 20 psi)	None
Converter Outlet Pressure	(B)		415 kpa (60 psi) Minimum 550 kpa (80 psi) Maximum with engine speed at 2100 rpm and transmission in NEUTRAL.	Add or remove to the amount of spacers (28). See SPACER CHART.
Converter Inlet Pressure (P3)	(C)		980 kPa (142 psi) Maximum with cold oil.	None
Speed Clutch (P1) (Initial Pressure)	(D)	550 ± 35 kPa (80 ± 5 psi) with direction selector in NEUTRAL, speed selector in FIRST. Load piston plug (G) removed.		Add or remove to the amount of spacers (29). See SPACER CHART.
Speed Clutch (P1)	(D)	Must be 2206 kPa (320 psi) minimum, with selector lever in any FORWARD speed. Load piston plug (G) installed.	2620 ± 140 kPa (380 ± 20 psi) with selection lever in any FORWARD speed. Load piston plug (G) installed.	None
Oil Pump	(E)	2150 kPa (310 psi) Minimum.	2760 ± 115 kPa (400 ± 17 psi)	None
Direction Clutch (P2)	(F)	379 ± 55 kPa (55 ± 8 psi) less than the speed clutch pressure at tap (D). Load piston plug (G) installed.	379 ± 55 kPa (55 ± 8 psi) less than the speed clutch pressure at tap (D). Load piston plug (G) installed.	None



Transmission Selector And Pressure Control Valve
(22) Load piston. (29) Spacers.

SPACER CHART PRESSURE CHANGE TO THE VALVE BY REMOVAL OR ADDITION OF ONE SPACER			
Spacer Part No.	Thickness mm (in)	Change kPa (psi)	Where Used
(27) 4M1751 5S7001	0.41 (.016) 0.91 (.036)	19 (2.7) 40 (5.0)	Outlet relief valve (9)
(29) 5M9622 5M9623 5M9624	1.60 (.063) 0.90 (.035) 0.25 (.010)	98 (14.2) 56.5 (8.20) 15.8 (2.29)	Load Piston (22)

Transmission Selection	Clutches Engaged In Transmission
Neutral	3
First Speed Forward	2 and 6
Second Speed Forward	2 and 5
Third Speed Forward	2 and 4
Fourth Speed Forward	2 and 3
First Speed Reverse	1 and 6
Second Speed Reverse	1 and 5
Third Speed Reverse	1 and 4
Fourth Speed Reverse	1 and 3

CATERPILLAR®

SENR5922-02
February 1995

Service Manual

Electronic Transmission Control System

For Medium Wheel Loaders

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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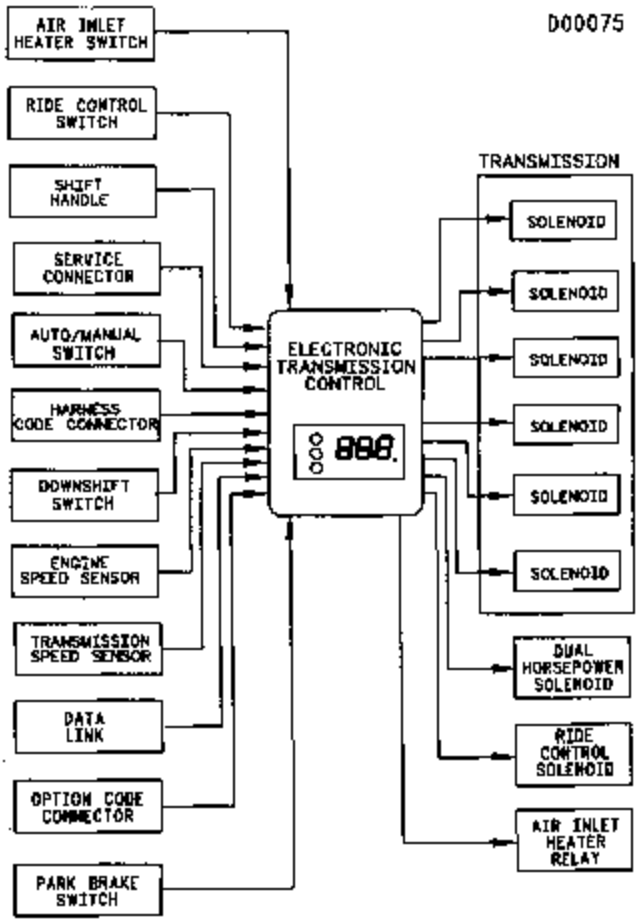
NOTE: A "C" in the left margin is an indication of a change from the former issue.

Systems Operation

Introduction



Electronic Transmission Control System Block Diagram (Shown With A Display)

C **NOTE:** The preceding illustration shows the control with a display. Some controls do not have a display. Both controls operate the same.

The electronic transmission control system electronically shifts the machine transmission by activating and deactivating the transmission solenoids. The control shifts the transmission based on engine speed, transmission speed and shift handle switch positions (gear and direction).

All the components shown in the Electronic Transmission Control Block Diagram illustration are not required for basic transmission shifting; see the topic Normal Operation. On certain models, other components are necessary for the control to perform additional functions; see the topic Additional Features.

Components Description

The same transmission control is used on a variety of models. All of the following electrical components are not present on every machine. The control recognizes the machine on which it is installed and knows which components are present. For the location of components see the Electrical System Schematic in the machine Service Manual.

Electronic Transmission Control

TRANSMISSION CONTROL CONNECTOR CONTACT DESCRIPTION		
No.	**Function**	**Type**
1	+Battery	Power
2	Ground	Ground
3	Park Brake SW (N/O)	Operational Input
4	Park Brake SW (N/C)[3]	Operational Input
5	Transmission Speed	Sensor Input
6	Engine Speed	Sensor Input
7	Air Inlet Heater SW	Operational Input
8	CAT Data Link +	Input/Output
9	CAT Data Link -	Input/Output
10	Ride Control Select 1 (+Battery)[1]	Operational Input
	Air Inlet Heater Relay[2]	Solenoid Output
11	Ride Control Select 2 (+Battery)[1]	Operational Input
	Unused[2]	
12	Forward Select (Ground)	Operational Input
13	Reverse Select (Ground)	Operational Input
14	First Gear Select (Ground)	Operational Input
15	Second Gear Select (Ground)	Operational Input
16	Third Gear Select (Ground)	Operational Input
17	Fourth Gear Select (Ground)	Operational Input
18	Forward Select (+Battery)	Operational Input
19	Reverse Select (+Battery)	Operational Input
20	Auto/Manual Select (N/C)	Operational Input
21	Auto/Manual Select (N/O)	Operational Input
22	Downshift Select (N/O)	Operational Input
23	Downshift Select (N/C)	Operational Input
24	Unused[1]	
	Ride Control Select 2 (Ground)[2]	Operational Input

TRANSMISSION CONTROL CONNECTOR CONTACT DESCRIPTION (Cont'd)		
No.	**Function**	**Type**
25	Option Code 0	Option Input
26	Ride Control Select 3 (Ground)	Operational Input
27	Option Code 1	Option Input
28	Service [4]	Service Input
29	Clear [4]	Service Input
30	Unused[1]	
	Option Code 2[2]	Option Input
31	Solenoid 1 (Reverse)	Solenoid Output
32	Solenoid 2 (Forward)	Solenoid Output
33	Solenoid 3 (Fourth Gear)	Solenoid Output
34	Solenoid 4 (Third Gear)	Solenoid Output
35	Solenoid 5 (Second Gear)	Solenoid Output
36	Solenoid 6 (First Gear)	Solenoid Output
37	Ride Control Solenoid	Solenoid Output
38	Dual Horsepower Solenoid	Solenoid Output
39	Solenoid Return	Solenoid Ground
40	Unused	

[1] For machines equipped with air over hydraulic brakes or machines not equipped with a control display.
[2] For all machines equipped with hydraulic over hydraulic brakes.
[3] For machines equipped with a control display.
[4] Not used on machines equipped with a control that has no display.

C NOTE: The preceding chart has been revised.

Electronic circuits within the control make shifting decisions and control the transmission solenoid valves. The control inputs and outputs are connected to the machine harness wiring through a 40 contact connector.

Input/Output

The CAT data link is bidirectional, allowing the control to receive and send information. The purpose of the data link is to communicate with the Computerized Monitoring System (CMS). The data link is not a visible component. It consists of internal control circuits and the connecting harness wiring.

The transmission control receives harness code information from CMS.

The transmission control sends engine speed, transmission speed, transmission gear, transmission direction and transmission control faults to CMS to be shown on the CMS display.

All electronic controls that use the data link have a module identifier (MID). The MID for this transmission control is the number 81.

Inputs

Several types of inputs provide information to the control.

Operational

The operational inputs provide information about operator requests to the control. These inputs receive information from the shift handle, downshift, ride control and auto/manual switches. These switches provide an open (floating), ground or battery signal, to the inputs of the control.

Option

The option inputs (connector contacts 25, 27 and 30) tell the control what options the machine is equipped with. These inputs are either open or grounded by the options code plug. For the option code of the machine being serviced, see the Option Code chart on the Electrical System Schematic in the machine Service Manual.

Service

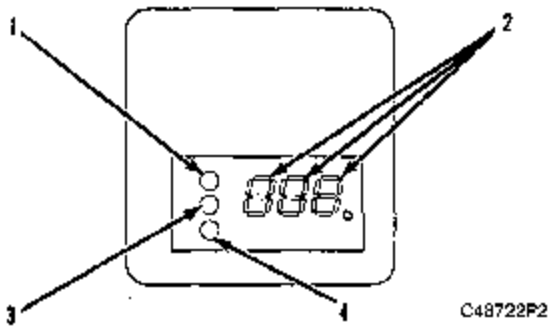
The service inputs (connector contacts 28 and 29) control the mode of operation and certain diagnostic functions. Grounding service input (connector contact 28) and clear input (connector contact 29) at the same time, initiates changing the control display mode. Removing ground from these two inputs locks the control in the selected mode. Other diagnostic functions are also performed when the service inputs are grounded and/or opened at the proper time. For more information, see the topic Display Modes in the Systems Operation section

Sensor

At each sensor input, an AC signal is present which represents the transmission speed (connector contact 5) and engine speed (connector contact 6). The control measures the frequency (Hz) of the AC signals to determine the transmission and engine speed. The control uses this speed information to make shifting decisions.

Outputs

Display



Electronic Transmission Control Display Area
(1) Power indicator (green). (2) Readout (component identifier and failure mode identifier). (3) Service mode indicator (yellow). (4) Fault present indicator (red).

The display shows the operating status of the electronic transmission control system and diagnostic information.

Solenoid

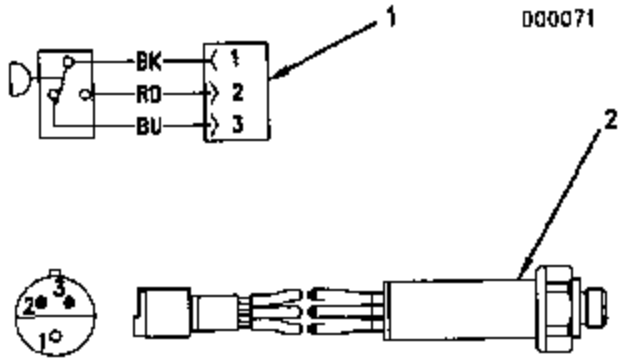
The control sends a voltage to the solenoid outputs to energize solenoids that control various machine functions. These functions are transmission gear selection, ride control activation, engine horsepower selection and air inlet heater activation (using a relay).

Switches

Switches provide information (input) to the control. Switches are two state devices. The two states are:

- Closed – the switch closes a circuit to the control input.
- Open – the switch opens a circuit to the control input.

Park Brake Switch (If Equipped)

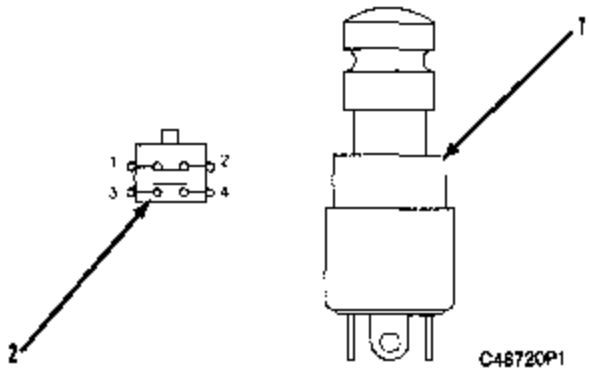


Park Brake Switch
(1) Schematic symbol. (2) Switch.

The purpose of park brake switch (2) is to tell the control when the park brake is engaged. The control also sends this information to the Computerized Monitoring System (CMS). Park brake switch (2) has two input connections to the control; park brake N/C at connector contact 4 and downshift N/O at connector contact 3. When the park brake is engaged, the park brake N/C circuit is open and the park brake N/O circuit is closed to ground. When the switch is not activated, the park brake N/C circuit is closed to ground and the park brake N/O circuit is open.

NOTE: A two pole switch is used for diagnostic purposes. If the two poles are ever in the same state (open or grounded), the control knows a circuit failure is present.

Downshift Switch

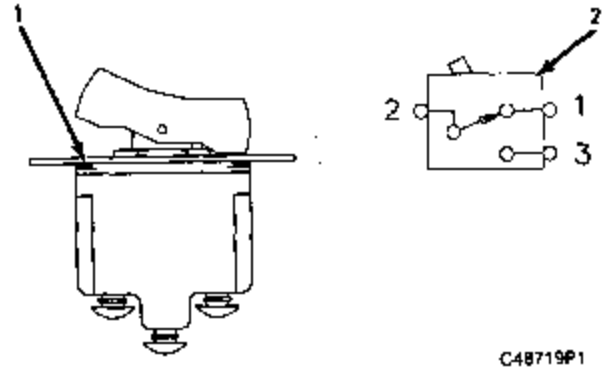


Downshift Switch
(1) Switch. (2) Schematic symbol.

The purpose of downshift switch (1) is to tell the control that the operator wants the transmission to downshift one gear. Downshift switch (1) has two input connections to the control; downshift N/C at connector contact 23 and downshift N/O at connector contact 22. When the operator presses downshift switch (1), the downshift N/C circuit is open and the downshift N/O circuit is closed to ground. When the switch is not activated, the downshift N/C circuit is closed to ground and the downshift N/O circuit is open.

NOTE: A two pole switch is used for diagnostic purposes. If the two poles are ever in the same state (open or grounded), the control knows a circuit failure is present. This fault is then shown on the diagnostic indicator; see Diagnostic Indicator Operation.

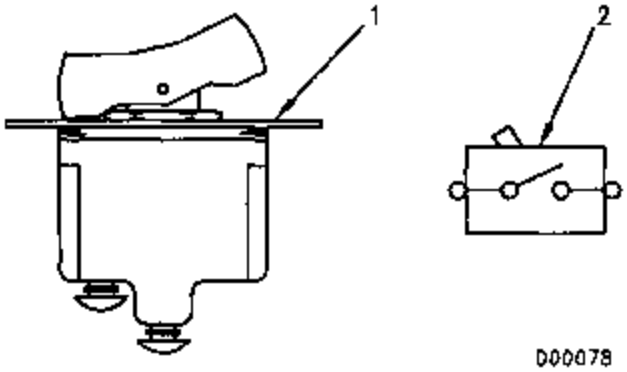
Auto/Manual Switch



Auto/Manual Switch
(1) Switch. (2) Schematic symbol.

The purpose of auto/manual switch (1) is to tell the control which shift mode the operator wants the control to operate in. Auto/manual switch (1) has two input connections to the control: auto/manual N/C at connector contact 20 and auto/manual N/O at connector contact 21. When the operator selects AUTO mode, the auto/manual N/O circuit is open and the auto/manual N/C circuit is closed to ground. When MANUAL mode is selected, the auto/manual N/O circuit is closed to ground and the auto/manual N/C circuit is open.

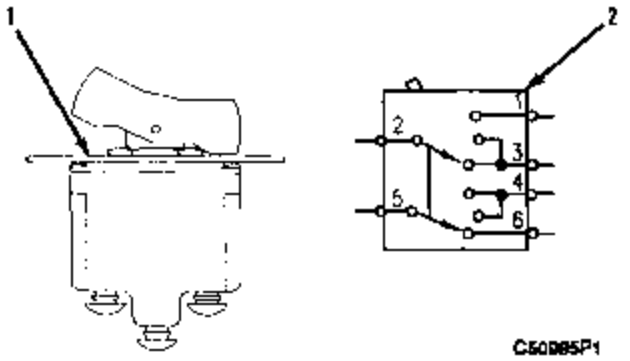
Air Inlet Heater Switch (If Equipped)



Air Inlet Heater Switch
(1) Switch. (2) Schematic symbol.

The purpose of air inlet heater switch (1) is to tell the control that the operator wants to continue to heat the inlet air. Air inlet heater switch (1) has one input connection to the control at connector contact 7. When the operator holds the switch in the heat position, the input to the control is closed to ground. With the switch in the OFF position, the input to the control is open.

Ride Control Switch (If Equipped)



Ride Switch
(1) Switch. (2) Schematic symbol.

Machines With Air Over Hydraulic Brakes

The purpose of ride control switch (1) is to tell the control which ride mode (AUTO/ON/OFF) the operator wants the control to operate in. Ride control switch (1) has three input connections to the control: input 1 at connector contact 10, input 2 at connector contact 11 and input 3 at connector contact 26. When the operator selects AUTO mode, input 2 is open, input 1 is closed to +battery and input 3 is closed to ground. When ON mode is selected, input 2 is closed to +battery, input 1 is open and input 3 is open. When OFF is selected, input 2 is open, input 1 is closed to +battery and input 3 is closed to ground.

RIDE CONTROL SWITCH STATUS			
Mode	D744-WH Circuit (Input 2)	D743-GN Circuit (Input 1)	E701-PK Circuit (Input 3)
ON	Closed[1]	Open	Open
OFF	Open	Closed[1]	Open
AUTO	Open	Closed[1]	Closed[2]

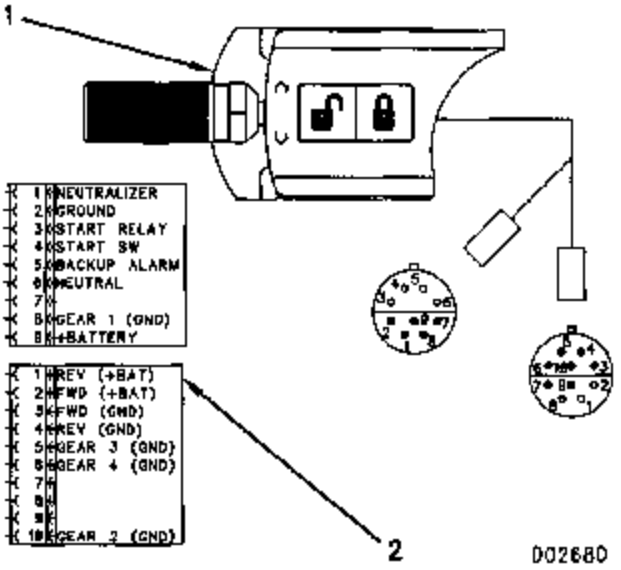
1 Closed to +battery.
2 Closed to ground.

Machines With Hydraulic Over Hydraulic Brakes

The purpose of ride control switch (1) is to tell the control which ride mode (AUTO/ON/OFF) the operator wants the control to operate in. Ride control switch (1) has two input connections to the control: input 2 at connector contact 24 and input 3 at connector contact 26. When the operator selects AUTO mode, input 2 is closed to ground and input 3 is open. When ON mode is selected, input 2 is open and input 3 is closed to ground. When OFF is selected, input 2 and input 3 are closed to ground.

RIDE CONTROL SWITCH STATUS			
Mode	Switch Position	D743-GN Circuit (Input 2)	D744-WH Circuit (Input 3)
ON	Up	Open	Closed
OFF	Center	Closed	Closed
AUTO	Down	Closed	Open

Shift Handle Switches

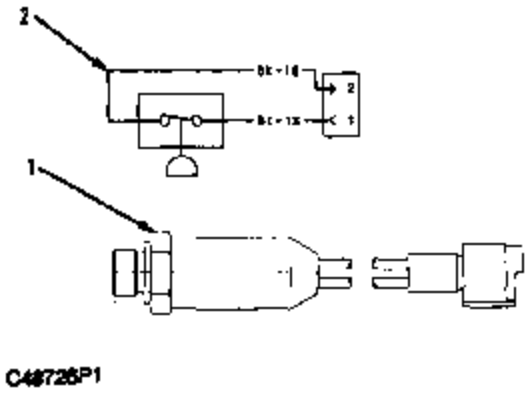


Shift Handle
(1) Handle. (2) Schematic symbol.

The shift handle switches are inputs to the control and connect to contacts 12 through 19. The purpose of the switches is to tell the control what gear and direction the operator has selected with the shift handle.

The shift handle switches close gear and direction inputs on the control to ground and +battery. The gear and direction selected are the only closed switches; the other direction and gear switches are open.

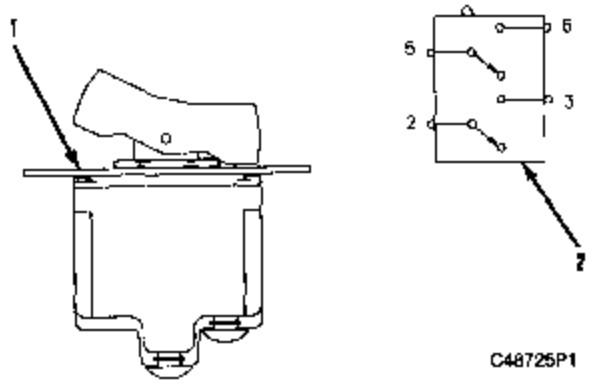
Neutralizer Switch



Neutralizer Switch
(1) Switch. (2) Schematic symbol.

During normal operation, neutralizer switch (1) closes the neutralizer input of the shift handle (9 contact connector - contact 1) to battery voltage. Depressing the brake pedal increases the brake oil pressure and opens the neutralizer input line. With this line open, the shift handle cannot close either direction solenoid input of the control (connector contacts 18 and 19) to battery voltage. Without battery voltage at one of these inputs the control neutralizes the transmission. With the transmission neutralized, the direction solenoids are not activated.

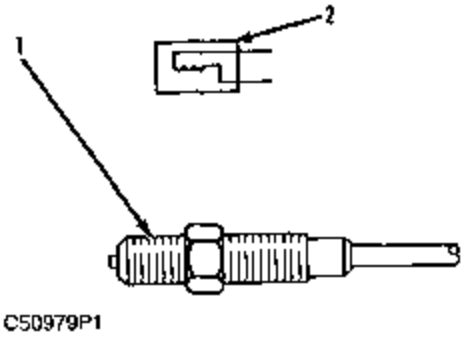
Neutralizer Override Switch



Neutralizer Override Switch
(1) Switch. (2) Schematic symbol.

When activated, neutralizer override switch (1) closes the neutralizer input of the shift handle (9 contact connector - contact 1) to battery voltage whether the brakes are applied or not. This switch is used to disable the neutralizer switch when neutralizing the transmission during braking is not desired.

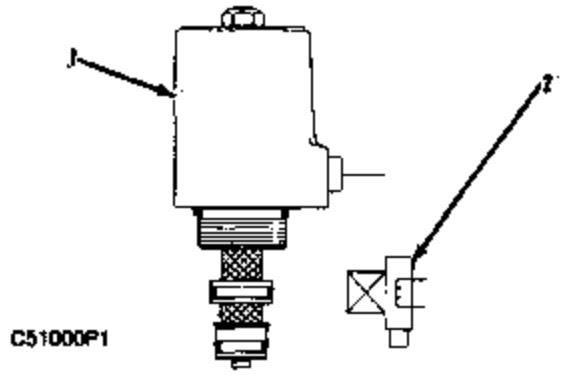
Sensors



Sensor (Typical Example)
(1) Sensor. (2) Schematic symbol.

The engine and transmission speed sensors are located on the flywheel housing and the transmission housing respectively. As gear teeth pass the end of each sensor, an AC voltage is produced. The frequency of the voltage is proportional to the speed of the passing gear teeth. The control uses these signals to make shifting decisions.

Solenoids



Transmission Solenoids
(1) Solenoid. (2) Schematic symbol.

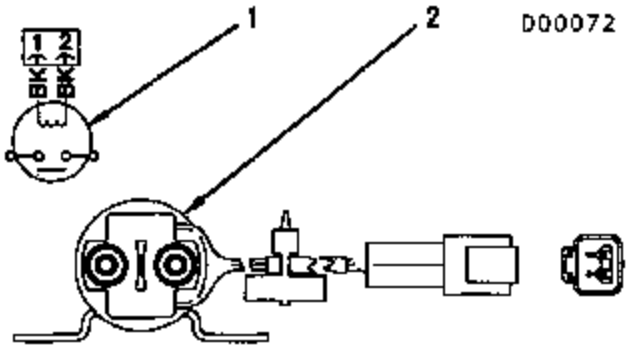
The purpose of the transmission solenoids is to turn on and off the oil flow to the clutches in the transmission. When a direction and gear are selected by the operator or the control, the control activates the appropriate solenoids. For movement of the machine two solenoids are activated; one for direction and one for gear. When activated, a solenoid receives voltage from the control. When in neutral, the 4th gear (solenoid 3) is activated.

The purpose of the ride control solenoid is to turn on and off the hydraulic oil flow to and from the load dampening system.

The dual horsepower/engine shutdown solenoid is one solenoid with two coils, one for each function. The purpose of the dual horsepower portion is to limit the engine rack movement. When high horsepower is activated the control energizes the dual horsepower coil of the solenoid. This allows the engine rack to open more and allows greater fuel flow, increasing the engine horsepower.

The solenoids have a connector with two contacts. One contact receives power from the corresponding connector contact (31 through 38) of the control. The other contact of all the solenoids join together and return to connector contact 39 of the control.

Air Inlet Heater Relay

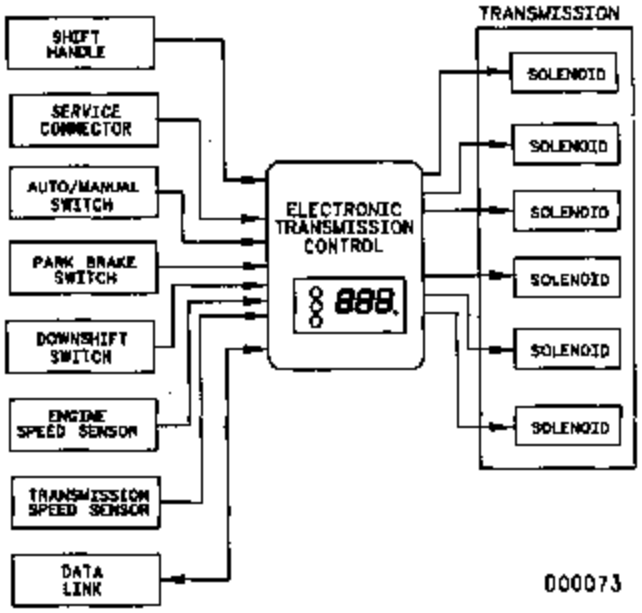


Air Inlet Heater Relay
(1) Schematic symbol. (2) Relay.

The purpose of the air inlet heater relay is to turn on and off the current flow to the air inlet heater. When the control determines that the air inlet heater should be engaged, the control activates the air inlet heater relay output (connector contact 7), which energizes the air inlet heater relay.

The relay has a connector with two contacts. One contact receives power from the control (connector contact 7). The other contact returns to connector contact 39 of the control.

Normal Operation



Normal Operation Block Diagram

C NOTE: The preceding illustration shows the control with a display. Some controls do not have a display. Both controls operate the same.

The electronic transmission control shifts the machine based on engine speed, transmission speed and shift handle switch positions (gear and direction).

The electronic transmission control system consists of a shift handle, a control, a downshift switch, a neutralizer override switch, a neutralizer switch, an auto/manual switch, a transmission speed sensor, an engine speed sensor and transmission solenoids. The control gets input from the switches and sensors, processes this information and activates the appropriate transmission solenoids.

The shift handle contains switches that tell the control what direction and transmission gear the operator has selected.

NOTE: The shift handle should be in the neutral position when the key is turned to ON. If it is not, the shift handle must be returned to the neutral position before a direction can be selected.

The neutralizer switch is actuated when the brake pedal is depressed. Actuation of this switch tells the control to neutralize the transmission. With the transmission neutralized, the direction solenoids are not activated. The brake pedal neutralizer switch can be disabled by actuating the neutralizer override switch. When the neutralizer override switch is actuated the neutralizer override lamp is ON.

Manual Operation

When the auto/manual switch is in the MANUAL position, the control operation is manual. The control shifts the transmission to the gear selected by the operator.

Pressing the downshift switch tells the control to downshift the transmission. A downshift is only possible if gear 2 is selected with the shift handle. After a downshift, the control will shift the transmission back to gear 2 when there is a direction change. The control will also shift the transmission out of gear 1 and into gears 3 or 4, if gears 3 or 4 are selected with the shift handle. The control will shift the transmission as above except for certain conditions. see the topic Exceptions.

Automatic Operation

When the auto/manual switch is in the AUTO position, the control automatically upshifts and downshifts the transmission. Automatic upshifts are not possible to a gear higher than selected by the operator. There is no automatic downshift from gear 2 to gear 1. To downshift from gear 2, the downshift switch must be pressed or gear 1 selected with the shift handle.

Momentarily pressing the downshift switch tells the control to downshift the transmission one gear. Pressing and holding the downshift switch tells the control to continue to downshift the transmission as the machine speed decreases. After the downshift switch is released the control waits three seconds before resuming automatic shifting. The control will shift the transmission as above except for certain conditions, see the topic Exceptions.

Exceptions

These are the exceptions to normal shifting as previously described in the Normal Operation section.

If the park brake is engaged (park brake switch closed) when the transmission is in neutral, the control will not shift out of neutral into first forward or first reverse on the initial attempt. Returning the shift handle to neutral then back to first forward or first reverse will allow the transmission to shift out of neutral.

If the park brake is engaged (park brake switch closed) when the transmission is in first forward or first reverse, the control shifts the transmission into neutral. When the park brake is disengaged (park brake switch open), the control keeps the transmission in neutral until the shift handle is placed in the neutral position.

NOTE: On machines equipped with air over hydraulic brakes, the park brake switch status information is sent to the transmission control via the CAT data link from the Computerized Monitoring System (CMS). On machines equipped with hydraulic over hydraulic brakes, the park brake switch is an input to the transmission control. The transmission control then sends park brake switch status information to CMS.

Additional Features

These are features that the electronic transmission control performs in addition to shifting the transmission as described in the Normal Operation section.

Air Inlet Heater (If Equipped)

The operation of the air inlet heater system varies depending on the temperature of the machine engine coolant. The engine coolant temperature is monitored by another electronic control on the machine. The control sends the engine coolant information to the transmission control via the CAT data link.

The air inlet heater works in three different stages. The stages are: preheat (heat before starting the engine), cranking heat (heat during starting the engine) and postheat (heat after the engine has started). An air inlet heater alert indicator is turned ON whenever the air inlet heater is ON.

The preheat stage begins when the key start switch is turned to the ON position and the engine coolant temperature is 7°C (44°F) or less. The preheat stage ends when the preheat time has elapsed or when the key start switch is turned from the ON position to the START position. The transmission control adjusts the preheat time (10 to 30 seconds) based on the engine coolant temperature. During the preheat stage the air inlet heater alert indicator is turned ON. When the preheat stage ends the alert indicator is turned OFF.

The cranking heat stage begins when the key start switch is turned to the START position and the machine engine coolant temperature is 14°C (57°F) or less. The cranking heat stage ends when the key start switch is turned to the ON or OFF positions. The air inlet heater alert indicator is ON during this stage.

The postheat stage begins when the engine starts and the engine coolant temperature is 14°C (57°F) or less. The postheat stage ends when the postheat time has elapsed or when the key start switch is turned to the OFF position. The transmission control adjusts the postheat time (0 to 120 seconds) based on the engine coolant temperature. During the postheat stage the air inlet heater alert indicator is turned ON. When the postheat stage ends the alert indicator is turned OFF. The postheat stage can be extended by momentarily pushing the air inlet heater switch. When the switch is pushed the air inlet heater is turned ON for an additional 30 seconds and the alert indicator is turned ON.

Ride Control (If Equipped)

The ride control feature is enabled when the operator places the ride control switch in the ON or AUTO positions. In the ON position, ride control is activated all the time and the transmission control energizes the ride control solenoid continuously. In the AUTO position, ride control is activated and deactivated depending on the machine ground speed. When the ground speed increases above approximately 6 mph, ride control is activated. When the ground speed decreases below approximately 5.5 mph, ride control is deactivated. As ride control is activated and deactivated the ride control solenoid is energized and deenergized.

Dual Horsepower (If Equipped)

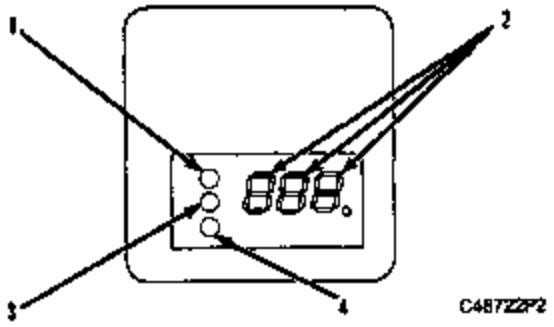
The dual horsepower feature allows the transmission control to select one of two different engine horsepower modes for the engine to operate in. The transmission control selects which horsepower mode the engine should operate in. This is based on which transmission gear is activated and the engine speed. Low horsepower can only be activated when the transmission is in first gear. If the transmission is in first gear, low horsepower mode is activated when the engine speed is above 2000 rpm. When the engine speed falls below 1800 rpm, high horsepower is activated. The transmission control energizes the dual horsepower solenoid when high horsepower mode is activated.

c Diagnostic Operation (Control Without A Display)

When a fault is detected in the transmission control system, the control sends diagnostic information to the monitoring system. The monitoring system is used to display diagnostic information for the transmission control. For information about displaying diagnostic information on the monitoring system see Caterpillar Monitoring System, Form No. SENR6717 or the Computerized Monitoring System (CMS), Form No. SENR5247. The monitoring system service manual should only be used to display the transmission control faults. Use the Testing And Adjusting portion of this manual to troubleshoot the faults for the transmission control.

Diagnostic Operation (Control With A Display)

Display Modes



Electronic Transmission Control Display
(1) Power indicator (green). (2) Readout (component identifier and failure mode identifier). (3) Service mode indicator (yellow). (4) Fault present indicator (red).

The control has three different display modes. The three display modes are:

- Normal Mode (Mode 0)
- Service Mode (Mode 1)
- Test Mode (Mode 2)

When power is applied, the control enters normal mode. To enter the other modes, the service and clear inputs are grounded at the same time. This causes the mode numbers (0 through 2) to scroll on readout (2). When ground is removed from the service and clear inputs, the control enters the mode which corresponds to the number that is presently shown. For example: removing ground when mode number "– 1 –." is shown on readout (2), causes the control to enter service mode.

NOTE: Each time "– 0 –." is shown, the scrolling stops. The service and clear contacts must be opened from ground, then closed to ground, to scroll the modes again.

The service connector, located within the operator compartment, provides access to the service and clear inputs. Connector contact 1 is the service input and contact 2 is the clear input. Connector contacts 3 and 4 are both ground. The easiest way to ground these inputs is with a service tool. See the topic Service Tool in the Testing And Adjusting section for more information.

Normal Mode (Mode 0)

Normal Mode is used during normal machine operation. When in normal mode, the control display area shows the operator

- Whether the control is operating properly. Whenever the key switch is turned to the ON position, the display performs a self test. See the topic Self Test in the Testing And Adjusting section. Power indicator (1) remains ON to show that power is applied to the control.
- Whether a system fault exists. The control continuously checks for faults in the electronic transmission control system. When an electronic transmission control system fault is detected, the fault information is shown. See Service Mode.

The control enters normal mode when it is powered-up (key switch turned on).

Service Mode (Mode 1)

The control detects faults that occur in switches, sensors, solenoids and the related harness circuits, while in normal mode. A fault is detected when the signal (at the control connector) is outside a valid range. The control records the fault and displays it as a fault code.

The presence of fault information on the display, while in normal mode, means that a fault was detected and that diagnostic information is available in service mode.

Service mode allows service personnel to see and clear the faults that the control has detected. When in service mode, service mode indicator (3) is ON.

When placed in service mode, the diagnostics of the control are available to assist with the troubleshooting of detected faults. Two identifiers are used to specify each detected fault. These identifiers are alternately shown on the readout. The identifiers are:

- Component Identifier (CID) – The CID tells which component or system is faulty. For example; the engine speed sensor or transmission speed sensor. The CID is a three digit code. A complete CID list for this control is shown in the chart below.

Component Identifier (CID)	
CID No.	**Component**
168	Electrical System
190	Engine Speed Sensor
248	CAT Data Link
362	Ride Control Solenoid
368	Auto/Manual Switch
617	Air Inlet Heater Relay
621	Downshift Switch
627	Park Brake Switch
631	Solenoid 1 (Reverse)
632	Solenoid 2 (Forward)
633	Solenoid 3 (Gear 4)
634	Solenoid 4 (Gear 3)
635	Solenoid 5 (Gear 2)
636	Solenoid 6 (Gear 1)
650	Harness Code
668	Shift Handle
671	Transmission Speed Sensor
680	Ride Control Switch
685	Service Identification Code
687	Options Identification Code
688	Dual Horsepower Solenoid

- Failure Mode Identifier (FMI) – The FMI tells what type of failure has occurred. For example; voltage above normal, current below normal or abnormal frequency. FMI is a two digit code preceded by an "F". For a list of FMI codes that this control uses, see the Detected Faults chart under the topic Faults Detected By The Control in the Testing And Adjusting section.

Upon entering service mode; the diagnostic code for the first available fault is shown. At this time, the fault shown is on-hold. When a fault is on-hold, the fault is shown continuously. The readout alternates showing the CID then the FMI. This is maintained as long as the service and clear inputs remain open. Troubleshooting and clearing may be performed while the fault is being displayed.

Scrolling the faults shows all detected faults one at a time. Grounding the service input, while in service mode, causes the faults to scroll. Removing ground from the service input, when the desired fault is shown, stops the scrolling. The fault shown is now on-hold.

Fault present indicator (4) ON, means the displayed fault is currently present. Fault present indicator (4) OFF, means the displayed fault is not present at this time, but occurred previously. This can aid in troubleshooting of intermittent system problems. When the displayed fault changes status from not present to present, fault present indicator (4) also changes respectively from OFF to ON.

Clearing a fault removes it from the memory of the control. When a fault is corrected, it is necessary to remove the fault from the memory of the control. When the fault is on-hold, momentarily grounding the clear input removes the fault from memory. The control does not allow clearing of a fault that is present. After the fault is cleared, the next available fault is shown on the display.

The control leaves service mode when the service and clear inputs are grounded at the same time. For more information on changing modes, see the beginning of the topic Display Modes under the subject Diagnostic Operation.

Diagnostic Example

Fault information is displayed on the readout and the fault present indicator is ON. The CID and FMI are being shown alternately on the readout.

- CID = "190". Component identifier code "190" means that the fault is in the engine speed sensor circuit. For a list of CID codes for the electronic transmission control system, see the Detected Faults chart in the Faults Detected By The Control section.

- FMI = "F08". Failure mode identifier "F08" means that erratic, intermittent or incorrect data is being received concerning CID "190". For a list of FMI codes for the electronic transmission control system, see the Detected Faults chart in the Faults Detected By The Control section.

- Fault present indicator = ON. Therefore the "190" CID fault is present now.

Test Mode (Mode 2)

Test mode is used to test the shift handle and harness wiring. When in test mode the control display alternately shows the control connector contact numbers for shift handle inputs.

When the shift handle is moved through each direction and speed position, the control can determine which shift handle position circuits work properly. After the shift handle is moved through each position, the numbers still shown on the display are the connector contact numbers of the shift handle circuits that did NOT work properly.

NOTE: The shift handle must remain in each position for at least one second.

NOTE: The neutralizer switch must not be activated during this test.

Testing And Adjusting

Introduction

TROUBLESHOOTING QUICK REFERENCE
Go to the section Faults Detected By The Control for faults related to:
Electrical System Voltage - CID 168 Procedure
Engine Speed Sensor - CID 190 Procedure
CAT Data Link - CID 248 Procedure
Ride Control Solenoid - CID 362 Procedure
Auto/Manual Transmission Switch - CID 368 Procedure
Air Inlet Heater Relay - CID 617 Procedure
Downshift Switch - CID 621 Procedure
Park Brake Switch - CID 627 Procedure
Solenoid 1 (Reverse) - CID 631 Procedure
Solenoid 2 (Forward)- CID 632 Procedure
Solenoid 3 (Gear 4) - CID 633 Procedure
Solenoid 4 (Gear 3)- CID 634 Procedure
Solenoid 5 (Gear 2) - CID 635 Procedure
Solenoid 6 (Gear 1) - CID 636 Procedure
Harness Code [1] - CID 650 Procedure
Shift Handle And Neutralizer Switch - CID 666 Procedure
Transmission Speed Sensor - CID 671 Procedure
Ride Control Switch - CID 680 Procedure
Service Identification Code - CID 685 Procedure
Options Identification Code - CID 687 Procedure
Dual Horsepower Solenoid - CID 688 Procedure
Go to the section Faults Not Detected By The Control for faults related to:
Blank Control Display Area
No Automatic Shifting, no faults shown

[1] Harness code and machine code are similar terms used to describe the particular machine that the control is installed on. Harness code is the status of the three harness code inputs.

Troubleshooting the electronic transmission control system requires additional information from the machine Service Manual. The Electrical System Schematic and the Operation & Maintenance Manual are required support material.

As a guide, a simplified electronic transmission control schematic is at the end of this manual. For a complete schematic, see the Electrical System Schematic in the machine Service Manual.

If wire insulation is punctured during troubleshooting, repair after probing. Seal the punctures with 8T-0065 Adhesive. Cover the adhesive with two layers of 1P-0810 Tape. Remove the harness connector from the control using the single screw in the center of the connector.

When the troubleshooting procedure instructs to REPAIR THE HARNESS, use the Electrical System Schematic in the machine Service Manual to trace the circuit. Perform continuity checks at connectors to locate harness failures. At component connectors, always check the ground circuit. Less than five ohms of resistance is required between the connector ground contacts and frame ground. Excessive ground resistance, greater than five ohms, can cause incorrect diagnosing of problems.

During troubleshooting, inspect all component and harness connections before any component is replaced. If these connections are not clean and tight they can cause electrical problems, either permanent or intermittent (come and go). Make sure the connections are tight before other tests are made.

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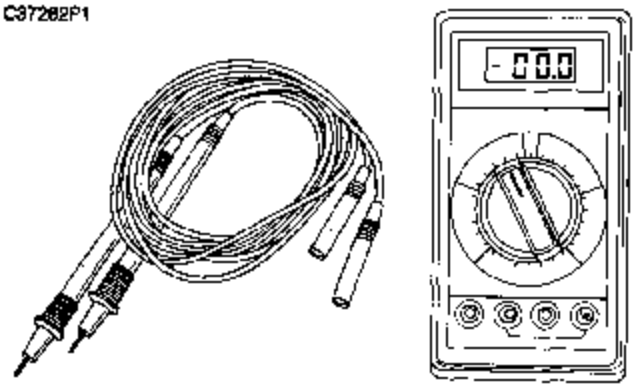


Caterpillar Digital Multimeter

Use the 6V-7070 Digital Multimeter or equivalent for making continuity checks, resistance measurements or voltage measurements. The optional 8T-3224 Needle Tip Group for the 6V-7070, is useful during troubleshooting. For instruction on use of the 6V-7070 see Special Instruction SEHS7734.

NOTE: Except for harness tests, continuity testers (such as 8T-0500), or voltage testers (such as 5P-7277) are not recommended for use on present-day Caterpillar electrical circuits.

c Troubleshooting Using The Display On The Control (If Equipped)

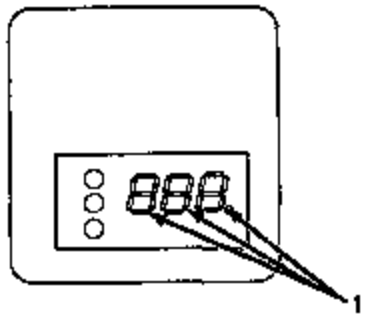
The service connector provides access to the service and clear inputs. Connector contact 1 is the service input and contact 2 is the clear input. The service connector is part of the cab harness and is located near the control. For a more exact service connector location and connector requirements, see the Electrical System Schematic in the machine Service Manual.

Various diagnostic functions require the grounding and/or opening of the service and clear contacts at the service connector. During troubleshooting, it is necessary for the service person to make the proper electrical connections between the contacts of the service code connector. These electrical connections may be made with two jumpers. Also see the topic Service Box in the Testing And Adjusting section.

Changing Modes

ACTIVATION OF DISPLAY OPERATIONS (Quick Reference)		
Display Operation	**Service Contact [1]**	**Clear Contact [1]**
Changing Modes:		
To Scroll	Ground	Ground
To Hold	Open	Open
Service Mode (Mode 1):		
To Scroll	Ground	Open
To Hold	Open [2]	Open
To Clear [3]	Open	Ground

[1] Of the service connector.
[2] Open when the desired information is shown during scrolling.
[3] A fault is cleared only while it is on-hold. A fault that is currently present cannot be cleared.



Control Display Area
(1) Readout.

The control has three display modes. The different modes are identified by the mode number which is shown on readout (1). The three display modes and the corresponding mode numbers are:

Normal Mode – "– 0 –." is shown on mode readout (1).

Service Mode – "– 1 –." is shown on mode readout (1).

Test Mode – "– 2 –." is shown on mode readout (1).

Procedure

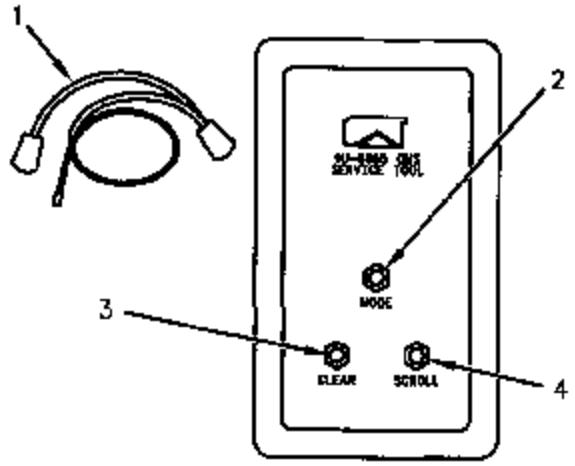
1. Turn key switch ON. Wait for the Self Test to finish; approximately seven seconds.

2. At the same time, ground the service and clear contacts of the service connector or actuate the mode switch on the service box. This causes the mode numbers ("– 0 –." through "– 2 –.") to scroll on mode readout (1).

NOTE: Each time "– 0 –." is shown, the scrolling stops. The service and clear contacts must be opened from ground, then closed to ground, to scroll the modes again.

3. When the desired mode number is shown on mode readout (1), remove ground from (open) the service and clear contacts.

c Service Tool



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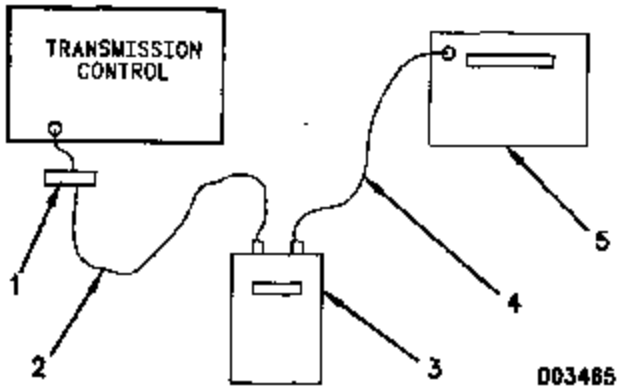
9U-6665 Service Tool
(1) Adapter cable. (2) Mode select switch. (3) Clear switch.
(4) Scroll switch.

The 9U-6665 Service Tool is helpful for the service person to make the proper electrical connections at the service connector during troubleshooting. The service tool and wiring adapter is shown in the Service Tool illustration. Adapter cable (1) has two connectors that are wired in parallel so that the service tool is usable on the different types of machine harnesses.

Actuating mode switch (2) scrolls through the three display modes. Actuating scroll switch (4) scrolls the display with the control in the service or test mode. Actuating clear switch (3) clears the fault being continuously displayed in the service mode. To use the service tool, refer to the Tool Operating Manual, Form No. NEHS0586.

c Troubleshooting Using The Electronic Control Analyzer Programmer (ECAP)



ECAP Connections
(1) Service connector.
(2) 7X-1570 Cable.
(3) 7X-1700 Communication Adapter (with NEXG4523 Communication Adapter Software installed).
(4): 7X-1851 Cable for 8T-8697-A ECAP later
or 7X-1420 Cable for 8T-8697 ECAP earlier.
(5): 8T-8697-A ECAP later (with NEXG4521 Machine Functions Dual SPM installed)
or 8T-8697 ECAP earlier (with NEXG4521 Machine Functions Dual SPM installed).

Optional (not shown): 8C-9995 Mounting Bracket and 7X-1703 Plate Group.

The ECAP service tool is not needed to determine or clear system faults, but it makes the tasks easier and faster. The ECAP can also display the status of certain system parameters. This feature along with the ability to display system fault history information, make the ECAP a useful troubleshooting tool.

The ECAP connects to the service connector (if equipped) located next to the harness code connector in the cab. To use the ECAP service tool, see SEHS9343 Tool Operating Manual. The Tool Operating Manual contains all the instructions and information needed to use the ECAP to troubleshoot the electronic transmission control system. After determining the system faults with the ECAP, see the topic Faults Detected By The Control in the Testing And Adjusting section.

c Troubleshooting Using The Caterpillar Monitoring System Or The Computerized Monitoring System (CMS)

Transmission control diagnostic information can be shown on the monitoring system display. When using the monitoring system for troubleshooting, all faults associated with the transmission control have a MID of 81. For more information about use of the Caterpillar Monitoring System, see service manual SENR6717. For more information about use of the Computerized Monitoring System (CMS), see service manual SENR5247.

Faults Detected By The Control

DETECTED FAULTS For troubleshooting, see the procedure with the same CID And FMI No.	
CID No. / FMI No.	**Description**
CID 168 - Electrical System:	
FMI F03	System voltage above normal.
FMI F04	System voltage below normal
CID 190 - Engine Speed Sensor:	
FMI F08	Signal not valid.
CID 248 - CAT Data Link:	
FMI F02	Signal not correct.
CID 362 - Ride Control Solenoid:	
FMI F03	Short to +battery.
FMI F05	Open circuit.
FMI F06	Short to ground.
FMI F12	Internal malfunction.
CID 368 - Auto/Manual Switch:	
FMI F02	Signal not correct.
CID 617 - Air Inlet Heater Relay:	
FMI F03	Short to +battery.
FMI F05	Open circuit.
FMI F06	Short to ground.
FMI F12	Internal malfunction.
CID 621 - Downshift Switch:	
FMI F02	Signal not correct.
CID 627 - Park Brake Switch:	
FMI F02	Signal not correct.
CID 631 - Solenoid 1 (reverse):	
FMI F03	Short to +battery.
FMI F05	Open circuit.
FMI F06	Short to ground.
FMI F12	Internal malfunction.

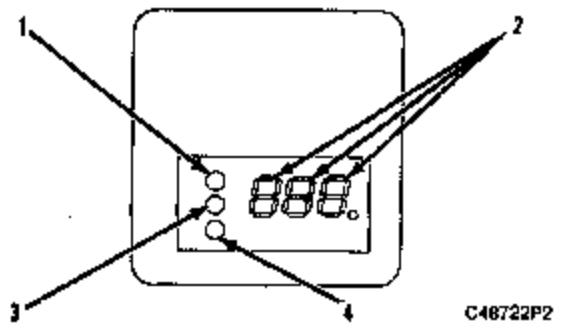
DETECTED FAULTS For troubleshooting, see the procedure with the same CID And FMI No.	
CID No. / FMI No.	**Description**
CID 632 - Solenoid 2 (forward):	
FMI F03	Short to +battery.
FMI F05	Open circuit.
FMI F06	Short to ground.
FMI F12	Internal malfunction.
CID 633 - Solenoid 3 (speed 4):	
FMI F03	Short to +battery.
FMI F05	Open circuit.
FMI F06	Short to ground.
FMI F12	Internal malfunction.
CID 634 - Solenoid 4 (speed 3):	
FMI F03	Short to +battery.
FMI F05	Open circuit.
FMI F06	Short to ground.
FMI F12	Internal malfunction.
CID 635 - Solenoid 5 (speed 2):	
FMI F03	Short to +battery.
FMI F05	Open circuit.
FMI F06	Short to ground.
FMI F12	Internal malfunction.
CID 636 - Solenoid 6 (speed 1):	
FMI F03	Short to battery.
FMI F05	Open circuit.
FMI F06	Short to ground.
FMI F12	Internal malfunction.
CID 650 - Harness Code:	
FMI F02	Invalid code.
CID 656 - Shift Handle:	
FMI F02	Signal not correct.
CID 671 - Transmission Speed Sensor:	
FMI F08	Signal not valid.
CID 680 - Ride Control Switch:	
FMI F02	Signal not correct.
CID 685 - Service Identification Code:	
FMI F02	Signal not correct.
CID 687 - Options Identification Code:	
FMI F02	Signal not correct.
CID 688 - Dual Horsepower Solenoid:	
FMI F03	Short to battery.
FMI F05	Open circuit.
FMI F06	Short to ground.
FMI F12	Internal malfunction.

When the control detects a fault while in normal mode, the fault is shown on the display, if equipped, or the operator monitor. Service mode shows the fault and is used to clear the fault from the control memory. For detailed information, see Service Mode (Mode 1) under the topic Diagnostic Operation located in the Systems Operation section.

TRANSMISSION CONTROL CONNECTOR CONTACT DESCRIPTION		
No.	Function	Type
1	+Battery	Power
2	Ground	Ground
3	Park Brake SW (N/O)	Operational Input
4	Park Brake SW (N/C)[3]	Operational Input
5	Transmission Speed	Sensor Input
6	Engine Speed	Sensor Input
7	Air Inlet Heater SW	Operational Input
8	CAT Data Link +	Input/Output
9	CAT Data Link -	Input/Output
10	Ride Control Select 1 (+Battery)[1]	Operational Input
	Air Inlet Heater Relay[2]	Solenoid Output
11	Ride Control Select 2 (+Battery)[1]	Operational Input
	Unused[2]	
12	Forward Select (Ground)	Operational Input
13	Reverse Select (Ground)	Operational Input
14	First Gear Select (Ground)	Operational Input
15	Second Gear Select (Ground)	Operational Input
16	Third Gear Select (Ground)	Operational Input
17	Fourth Gear Select (Ground)	Operational Input
18	Forward Select (+Battery)	Operational Input
19	Reverse Select (+Battery)	Operational Input
20	Auto/Manual Select (N/C)	Operational Input
21	Auto/Manual Select (N/O)	Operational Input
22	Downshift Select (N/O)	Operational Input
23	Downshift Select (N/C)	Operational Input
24	Unused[1]	
	Ride Control Select 2 (Ground)[2]	Operational Input
25	Option Code 0	Option Input
26	Ride Control Select 3 (Ground)	Operational Input
27	Option Code 1	Option Input
28	Service [4]	Service Input
29	Clear [4]	Service Input
30	Unused[1]	
	Option Code 2[2]	Option Input
31	Solenoid 1 (Reverse)	Solenoid Output
32	Solenoid 2 (Forward)	Solenoid Output
33	Solenoid 3 (Fourth Gear)	Solenoid Output
34	Solenoid 4 (Third Gear)	Solenoid Output
35	Solenoid 5 (Second Gear)	Solenoid Output
36	Solenoid 6 (First Gear)	Solenoid Output
37	Ride Control Solenoid	Solenoid Output
38	Dual Horsepower Solenoid	Solenoid Output
39	Solenoid Return	Solenoid Ground
40	Unused	

[1] For machines equipped with air over hydraulic brakes or machines not equipped with a control display.
[2] For all machines equipped with hydraulic over hydraulic brakes.
[3] For machines equipped with a control display.
[4] Not used on machines equipped with a control that has no display.

Initial Troubleshooting Procedure For A Control With A Display



Control Display Area
(1) Power indicator. (2) Readout (component identifier and failure mode identifier). (3) Service mode indicator. (4) Fault present indicator.

Use the following procedure when a fault is detected. When a fault is detected, the readout will show the fault.

1. Enter service mode (mode 1).
2. A single fault is shown and is on-hold at this time. When no fault has occurred, the display shows "- - -.".
3. To see all detected faults, scroll the faults. To do so, ground the service contact of the service connector.
4. Place the desired fault on-hold (stop the scrolling). To do so, remove ground from the service contact of the service connector when the desired fault is shown.
5. Observe fault present indicator (4):

- If fault present indicator (4) is ON, the fault shown is currently present.
- If fault present indicator (4) is OFF, the fault shown is not present at this time. The fault has occurred and then went away, sometime in the past (intermittent).

6. To troubleshoot the fault, go to the procedure with that OID and FMI.
7. After a fault is corrected, clear the fault. To do so, momentarily ground the clear contact of the service connector while the fault is on-hold. After clearing, the display advances to the next fault if there is one.
8. Repeat Steps 2 through 8 for any remaining faults. Return to normal mode when finished.

Initial Troubleshooting Procedure For A Control Without A Display

If the machine is equipped with the Caterpillar Monitoring System or the Computerized Monitoring System (CMS) a detected transmission control fault will be displayed in the readout area. Use the following procedure when a fault is detected. When a fault is detected, the service code indicator shows "SERV CODE" while in normal mode.

NOTE: For more information about use of the Caterpillar Monitoring System, see service manual SENR6717. For more information about use of the Computerized Monitoring System (CMS), see service manual SENR5247.

1. Enter service mode.

NOTE: Diagnostic Scrolling Mode may be entered to see the detected faults, but The faults can be more easily diagnosed using Service Mode. Service Mode allows faults to be placed on-hold for further investigation and to be cleared when the problem has been fixed.

2. A single fault is shown and is on-hold at this time. The display toggles between the MID, the CID, and the FMI. When no fault is available; the MID shows "- - -". The display does not toggle to show the CID, FMI information.

3. To see all detected faults, scroll the faults. To do so, ground the service contact of the service connector. The display momentarily shows the MID then CID and FMI for each fault. The MID shows "End" after the last fault has been shown.

4. Place the desired fault on-hold (stop the scrolling). To do so, remove ground from the service contact of the service connector when the desired fault is shown.

5. Make sure that the MID is "81".

6. Observe the fault present indicator:

- If the fault present indicator shows "SERV CODE", then the fault shown is currently present.

- If the fault present indicator is OFF, then the fault shown is not present at this time. The fault has occurred and then went away, sometime in the past (intermittent).

7. To troubleshoot the fault, go to the procedure with the same CID and FMI.

8. After a fault is corrected or it is no longer needed, clear the fault. To do so, momentarily ground the clear contact of the service connector while the fault is on-hold. After clearing, the display advances to the next available fault.

9. Repeat Steps 2 through 8 for the remaining faults. Return to normal mode when finished.

Troubleshooting Procedures:

Go to the procedure which corresponds to the CID and FMI shown on the control display. Use the operator monitor to show the CID and FMI if the control has no display.

NOTE: Repair wiring after probing. Seal the punctures with 8T-0065 Adhesive. Cover the adhesive with two layers of 1P-0810 Tape.

CID 168 Procedure (Electrical System Voltage)

The diagnostic circuit in the control identifies a system voltage that is either below 21.3 DCV or above 32.5 DCV.

Ensure that the fault is being displayed.

FMI F03

This fault should only be displayed with the fault present indicator ON and the engine running. If this occurs, the charging system is charging at an excessive voltage. Check the charging system. See Starting And Charging System module, SENR2947 in the machine Service Manual.

If this fault is displayed, with the fault present indicator ON, the engine stopped and no battery charger connected, replace the control. See the topic Control Replacement in the Testing And Adjusting section.

FMI F04

STEP 1. CHECK BATTERY VOLTAGE – Start the engine and run at high idle for several minutes. Measure the battery voltage at the battery posts.

- Voltage is at or above 21.3 DCV; battery voltage is correct. Go to Step 2.

- Voltage is below 21.3 DCV; the charging system is not correct. Check the charging system. See Starting And Charging System module, SENR2947 in the machine Service Manual.

STEP 2. CHECK SYSTEM VOLTAGE AT CONTROL – Using sharp meter test leads, puncture the wire insulation near the control connector. Measure the system voltage between wires 164-WH and 202-BK at contacts 1 and 2 of the harness connector. The engine must be running at high idle.

- Voltage is below 21.3 DCV; harness is not correct. Repair or replace the harness.
- Voltage is at or above 21.3 DCV; system voltage is correct. Check to make sure CID 168 and FMI F04 are still displayed and that the fault present indicator is ON. Disconnect the control harness connector and inspect contacts 1 and 2. Connect harness connector to the control. If fault still exists, with the fault present indicator ON, replace the control. See the topic Control Replacement in the Testing And Adjusting section.

CID 190 Procedure (Engine Speed Sensor)

Service Notes: Ensure that fault being analyzed is on-hold. Ensure that the fault present indicator is ON.

The engine RPM input is a frequency type sensor input. The engine speed signal is at contact 6 of the control connector.

FMI F08

STEP 1. CHECK SENSOR RESISTANCE – Disconnect the machine harness from the sensor. At the sensor connector, measure the resistance between the two contacts.

C • Resistance is NOT between 100 and 500 Ω; the speed sensor is faulty. Replace the sensor. Adjust the speed sensor properly when installing it. See Speed Sensor Adjustment. Clear the fault code.

C • Resistance is between 100 and 500 Ω; the speed sensor resistance is correct. Go to Step 2

STEP 2. CHECK SENSOR VOLTAGE – Reconnect the sensor to the machine harness. Disconnect the machine harness from the control. Start the engine and run at low idle. At the machine harness connector, for the control, measure the voltage (ACV) between contact 2 (ground) and contact 6.

- Voltage is greater than 3.0 ACV; the speed sensor voltage is correct. Replace the control; see Control Replacement.
- Voltage is less than 3.0 ACV; the speed sensor voltage is NOT correct. Go to Step 3.

STEP 3. CHECK SENSOR – Remove the sensor and check for foreign material on sensor tip. Install the speed sensor and adjust correctly, see the topic Speed Sensor Adjustment in the Testing And Adjusting section. Check the sensor voltage in the same manner as in Step 2.

- Voltage remains less than 3.0 ACV; there is a defect. Go to Step 4.
- Voltage is now greater than 3.0 ACV. Problem is NOT present; adjustment of the speed sensor corrected the problem. Clear the fault code.

STEP 4. CHECK HARNESS – Connect the sensor to the machine harness. The control remains disconnected from the machine harness. At the machine harness connector, for the control, measure the resistance between contact 2 (ground) and contact 6.

C • Resistance is between 100 and 500 Ω; the machine harness resistance is correct. Replace the sensor. Adjust the speed sensor properly when installing it. See the topic Speed Sensor Adjustment in the Testing And Adjusting section. Clear the fault code.

C • Resistance is NOT between 100 and 500 Ω; the machine harness is shorted or open. Repair or replace the harness. Clear the fault code.

CID 248 Procedure (Data Link)

FMI F02

This fault is recorded when the control does not receive expected information from the data link (wire 944-OR or 945-BR).

Service Notes: Ensure that the CID 248/FMI F02 fault is on-hold and that the fault present indicator is ON.

STEP 1. INSPECT HARNESS CONNECTORS – Inspect the machine harness connections related to the data link. Make sure that connectors are clean and tight. If necessary, repair or replace the machine harness. Check to see if the fault present indicator remains ON for the CID 248/FMI F02 fault.

- Fault present indicator is OFF; a machine harness connection was faulty. The fault is not present now. Possibly an intermittent connection exists in the data link circuits of the machine harness. Watch for a recurrence of this fault.
- Fault present indicator is ON; the fault remains present. Go to Step 2.

STEP 2. CHECK FOR SHORTED HARNESS – Disconnect the machine harness from the transmission control and CMS. At the machine harness connector for the transmission control, measure the resistance between contacts 8 and 9.

- Resistance is less than 5000 Ω (continuity); the machine harness is faulty. There is a short between frame ground and the data link circuit in the machine harness. Repair or replace the machine harness.
- Resistance is greater than 5000 Ω (no continuity); harness circuit resistance is correct. Go to Step 3.

STEP 3. CHECK FOR OPEN HARNESS – The transmission control and CMS remain disconnected from the machine harness. Check the continuity of the data link circuit in the machine harness. Place a jumper between contacts 23 and 24 of the machine harness connector for CMS. Check for continuity between contacts 8 and 9 of the machine harness connector for the transmission control.

- There is NO continuity; the machine harness is faulty. The data link circuit (wire 944-OR or 945-BR) is open in the machine harness. Repair or replace the machine harness.
- There is continuity; this circuit is not the cause of the fault. Go to Step 4.

STEP 4. CHECK FOR OPEN HARNESS – The transmission control and CMS remain disconnected from the machine harness. Remove the jumper of the previous Step. Check the continuity of the data link circuit in the machine harness. Place a jumper between contacts 8 and 9 of the machine harness connector for the transmission control. Check for continuity between contacts 23 and 24 of the machine harness connector for CMS.

- There is NO continuity; the machine harness is faulty. The data link circuit (wire 944-OR or 945-BR) is open in the machine harness. Repair or replace the machine harness.
- There is continuity; the data link circuit in the machine harness is correct. It is unlikely that an electronic control is faulty. Perform the previous Steps again. If the cause is not found, replace the controls one at a time to determine which control is the cause of the fault. See the subject Control Replacement.

CID 368 Procedure (Auto/Manual Transmission Switch)
CID 627 Procedure (Park Brake Switch)
CID 621 Procedure (Downshift Switch)

Service Notes: Ensure that fault being analyzed is on-hold. Ensure that the fault present indicator is ON.

FMI F02

These faults are recorded when the control reads improper signals from the auto/manual transmission switch, the downshift switch or the park brake switch.

The control detects the status of the switch circuits. The status is correct, when one circuit is open and one is grounded. The status is wrong, when both circuits are open or grounded at the same time. Connector contacts 20 and 21 are for the auto/manual switch. Connector contacts 22 and 23 are for the downshift switch. Connector contacts 3 and 4 are for the park brake switch.

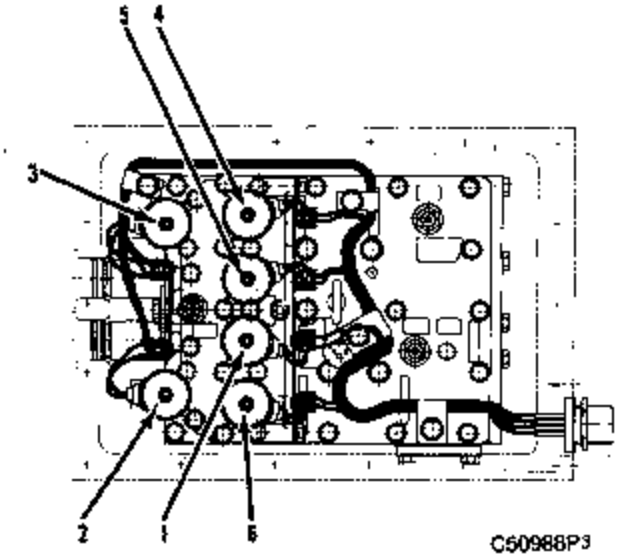
STEP 1. CHECK CIRCUIT FOR PROPER OPERATION – Disconnect the harness connector from the control. At the harness connector, check for continuity from contact 2 (ground) to the switch input circuits with the faults. One input for the circuit should have continuity and one should not. Place the switch in the other position and the status of each input should change.

- Operation is correct; switch and switch harness circuitry is correct. Inspect harness connector contacts. Connect harness connector to control and check control for the same fault, with the fault present indicator ON. If present, the control is faulty. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.
- Operation is not correct; switch or switch harness circuitry is not correct. Go to Step 2.

STEP 2. CHECK SWITCH – At the switch, check for the same operation as in Step 1.

- Operation is not correct; switch is faulty. Repair or replace the switch.
- Operation is correct; harness is faulty. Repair or replace the harness.

CID 362 (Ride Control Solenoid)
CID 631 Procedure (Solenoid 1 - Reverse)
CID 632 Procedure (Solenoid 2 - Forward)
CID 633 Procedure (Solenoid 3 - Gear 4)
CID 634 Procedure (Solenoid 4 - Gear 3)
CID 635 Procedure (Solenoid 5 - Gear 2)
CID 636 Procedure (Solenoid 6 - Gear 1)
CID 686 Procedure (Dual Horsepower Solenoid)



Transmission Solenoid Location
(1) Solenoid 1 - Reverse. (2) Solenoid 2 - Forward. (3) Solenoid 3 - Gear 4. (4) Solenoid 4 - Gear 3. (5) Solenoid 5 - Gear 2. (6) Solenoid 6 - Gear 1.

Service Notes: Ensure that the fault being analyzed is on-hold. Ensure that the fault present indicator is ON. The auto/manual switch should be in the manual position while troubleshooting solenoid circuit problems.

The following chart shows which transmission solenoids are energized in each position of the shift handle. An easy check of the solenoids can be done by placing a steel washer next to the solenoid that should be energized. When the solenoid is energized it becomes magnetic. The washer should be attracted to the energized solenoid. The same check can be done on the ride control and dual horsepower solenoids.

TRANSMISSION SOLENOID INFORMATION	
Shift Handle Position	**Solenoid Energized**
Neutral	Solenoid 3
Forward 1	2 and 6
Forward 2	2 and 5
Forward 3	2 and 4
Forward 4	2 and 3
Reverse 1	1 and 6
Reverse 2	1 and 5
Reverse 3	1 and 4

FMI F03

This fault is recorded when the control senses there is a short to +battery in the solenoid circuit.

STEP 1. CHECK FOR SHORT TO +BATTERY – Disconnect the machine harness connector from the control. Check for continuity from the faulty solenoid output circuit to +battery (contact 1). The connector contacts are: Reverse – 31, Forward – 32, Gear 4 – 33, Gear 3 – 34, Gear 2 – 35, Gear 1 – 36, Ride Control – 37 and Dual Horsepower – 38. Turn the various power circuits (headlights, heater etc.) OFF and ON during this test to check for short from these circuits to the solenoid output circuit.

- There is NOT continuity; solenoid harness is not shorted to +battery. Go to Step 2.
- There is continuity; the solenoid harness is shorted to +battery. Repair or replace harness.

STEP 2. CHECK FOR SHORT TO OTHER SOLENOID OUTPUTS – Check for continuity from the faulty solenoid output to the other solenoid outputs. The connector contacts are: Reverse – 31, Forward – 32, Gear 4 – 33, Gear 3 – 34, Gear 2 – 35, Gear 1 – 36, Ride Control – 37 and Dual Horsepower – 38.

- There is NOT continuity; solenoid harness circuitry is correct. Inspect harness connector contacts. Connect harness connector to control and check control for the same fault, with the fault present indicator ON. If present, the control is faulty. Replace the control, see Control Replacement.
- There is continuity; the solenoid harness is shorted. Repair or replace harness.

FMI F05

This fault is recorded when the control senses there is not a complete electrical circuit for this solenoid.

CHECK FOR OPEN HARNESS – Disconnect the machine harness connector from the control. Measure the resistance from the faulty solenoid output circuit to solenoid return (contact 39). The connector contacts are: Reverse – 31, Forward – 32, Gear 4 – 33, Gear 3 – 34, Gear 2 – 35, Gear 1 – 36, Ride Control – 37 and Dual Horsepower – 38.

- Resistance is 9 to 65 Ω; solenoid circuitry resistance is correct. Inspect harness connector contacts. Connect harness connector to control and check control for the same fault, with the fault present indicator ON. If present, the control is faulty. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.

- Resistance is NOT 9 to 65 Ω; the solenoid or solenoid harness circuitry is faulty. Repair or replace harness and/or solenoid.

FMI F06

This fault is recorded when the control senses there is a short to ground in the solenoid circuit.

CHECK FOR SHORT TO GROUND – Disconnect the machine harness connector from the control. Check for continuity from the faulty solenoid output circuit to ground (contact 2). The connector contacts are: Reverse – 31, Forward – 32, Gear 4 – 33, Gear 3 – 34, Gear 2 – 35, Gear 1 – 36, Ride Control – 37 and Dual Horsepower – 38.

- There is NOT continuity; solenoid harness circuitry is correct. Inspect harness connector contacts. Connect harness connector to control and check control for the same fault. If present, the control is faulty. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.

- There is continuity; the solenoid or solenoid harness is shorted to ground. Repair or replace harness and/or solenoid.

FMI F12

This fault is recorded when the control senses an internal fault. If this fault is present, replace the control. See the topic Control Replacement in the Testing And Adjusting section.

CID 617 (Air Inlet Heater Relay)

Service Notes: Ensure that the fault being analyzed is on-hold. Ensure that the fault present indicator is ON.

FMI F03

This fault is recorded when the control senses there is a short to +battery in the relay circuit

STEP 1. CHECK FOR SHORT TO +BATTERY – Disconnect the machine harness connector from the control. Check for continuity from connector contact 10 to contact 1 (+battery). Turn the various power circuits (headlights, heater etc.) OFF and ON during this test to check for short from these circuits to the output circuit.

- There is NOT continuity; relay harness is not shorted to +battery. Go to Step 2.

- There is continuity; the relay harness is shorted to +battery. Repair or replace harness.

STEP 2. CHECK FOR SHORT TO OTHER SOLENOID OUTPUTS – Check for continuity from connector contact 10 to the other solenoid outputs. The connector contacts are: Reverse – 31, Forward – 32, Gear 4 – 33, Gear 3 – 34, Gear 2 – 35, Gear 1 – 36, Ride Control – 37 and Dual Horsepower – 38.

- There is NOT continuity; relay harness circuitry is correct. Inspect harness connector contacts. Connect harness connector to control and check control for the same fault, with the fault present indicator ON. If present, the control is faulty. Replace the control, see Control Replacement.

- There is continuity; the relay harness is shorted. Repair or replace harness.

FMI F05

This fault is recorded when the control senses there is not a complete electrical circuit for this relay.

CHECK FOR OPEN HARNESS – Disconnect the machine harness connector from the control. Measure the resistance from connector contact 10 to contact 39 (solenoid return).

- Resistance is 15 to 65 Ω; relay circuitry resistance is correct. Inspect harness connector contacts. Connect harness connector to control and check control for the same fault, with the fault present indicator ON. If present, the control is faulty. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.

- Resistance is NOT 15 to 65 Ω; the relay or relay harness circuitry is faulty. Repair or replace harness and/or relay.

FMI F06

This fault is recorded when the control senses there is a short to ground in the solenoid circuit.

CHECK FOR SHORT TO GROUND – Disconnect the machine harness connector from the control. Check for continuity from connector contact 10 to contact 2 (ground).

- There is NOT continuity; relay harness circuitry is correct. Inspect harness connector contacts. Connect harness connector to control and check control for the same fault. If present, the control is faulty. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.
- There is continuity; the relay or relay harness is shorted to ground. Repair or replace harness and/or relay.

FMI F12

This fault is recorded when the control senses an internal fault. If this fault is present, replace the control. See the topic Control Replacement in the Testing And Adjusting section.

CID 650 Procedure (Harness Code)

NOTE: Check to see if a data link fault (CID 248/FMI F02) exists. If a data link fault is present, correct it prior to performing these procedures.

Service Notes: Ensure that the fault being analyzed is on-hold. Ensure that the fault is present.

FMI F02

This fault is recorded when the control does not recognize the harness code received from CMS on the data link (wires 944-OR and 945-BR).

STEP 1. CHECK CMS – The transmission control receives harness code information from CMS. Check CMS for a related CMS fault. See service manual SENR5247 Computerized Monitoring System (CMS) With VFD Circular Gauges.

- CMS has a related fault; correct the related fault per the CMS service manual. Then go to Step 2.
- CMS does not have a related fault; check the data link. Perform the troubleshooting procedure for a data link fault (CID 248/FMI F02).

STEP 2. RECHECK FOR FAULT – Check the transmission control to see if the fault present indicator remains ON for this fault (CID 650/FMI F02).

- Fault present indicator is ON; check the data link. Perform the troubleshooting procedure for a data link fault (CID 248/FMI F02).
- Fault present indicator is OFF; the fault is corrected. Clear the fault. Watch for a recurrence of this fault.

CID 668 Procedure (Shift Handle) (Control Without a Display)

Disconnect the shift handle harness connectors. At the 9 contact machine harness connector check for battery voltage between contact 2 (ground) and contact 1. Neutralizer switch must NOT be activated. If not correct, repair or replace harness or switch. If correct turn the disconnect switch to OFF position. Use the machine Electrical System Schematic to check the wiring harness from the shift handle to the control. Check for shorts and continuity of the harness circuits.

- Harness is NOT correct: repair or replace the harness.
- Harness is correct; check all connector contacts. Check for shift handle fault codes. If still present replace the shift handle. If the problem is still present replace the transmission control.

CID 668 Procedure (Shift Handle) (Control With a Display)

Service Notes: Ensure that the fault being analyzed is on-hold.

NOTE: The procedure that follows is used with 105-0154 and 106-4804 Shift Handle Control Group. Use the previous procedure "CID 668 Procedure (Shift Handle) (Control Without a Display)" to test the 107-6219 Shift Handle Control Group.

Use test mode (mode 2) to find the area of the shift handle or shift handle harness with the fault. In test mode the control detects faults that occur in the shift handle switches and related harness circuits.

NOTE: The neutralizer switch must NOT be activated during this test.

STEP 1. Put control into test mode (mode 2).

STEP 2. Move the shift handle through neutral and all gear and direction positions, pausing for one second in each position. After moving the shift handle through all positions the display shows "– – –," if no faults exist. If a fault does exist, the display shows the control connector contact number(s) that corresponds to the faulty shift handle circuits.

- Display shows number(s) "18" and/or "19"; shift handle and/or neutralizer switch circuits are not correct. Go to Step 4.

- Display shows number(s) "12" through "17"; shift handle switch and/or ground circuits not correct. Go to Step 3.

- Display shows "- - -."; shift handle circuit fault no longer exists. Check harness and harness connections for damage and poor connections. Clear the fault. Move the shift handle through each position several times. Wiggle the shift handle To find intermittent problems in the handle. Check the control for the same fault (CID 668). If the control detected the fault, replace the shift handle.

STEP 3. CHECK SHIFT HANDLE GROUND CIRCUIT – Turn the disconnect switch to OFF position. Disconnect the 9 and 10 contact shift handle connectors. At the 9 contact machine harness connector for the shift handle, check for continuity from ground to contact 2.

- There is continuity; the shift handle ground circuit is correct. Go to Step 5.

- There is NO continuity; the shift handle ground circuit in the harness has a fault. Repair or replace the harness.

STEP 4. CHECK SHIFT HANDLE POWER CIRCUITS – Disconnect the 9 and 10 contact shift handle connectors. At the 9 contact machine harness connector for the shift handle, check for battery voltage between contact 2 (ground) and contacts 1 and 9. Neutralizer switch must NOT be activated.

- Battery voltage measured; the shift handle power circuits are correct. Go to Step 5.

- Battery voltage is NOT measured; the power circuit harness or neutralizer switch is not correct. Repair or replace the harness and/or switch.

STEP 5. CHECK SHIFT HANDLE – See the topic Shift Handle Test in the Testing And Adjusting section.

- Shift handle is correct; harness or harness connector problem. Go to Step 6.

- Shift handle NOT correct; there is a fault in the shift handle. Replace the shift handle.

STEP 6. CHECK HARNESS FROM SHIFT HANDLE TO CONTROL – Use the machine Electrical System Schematic to check for shorts and continuity of the harness circuits that correspond to the connector contacts shown on the control display.

- Harness is NOT correct; repair or replace the harness.

- Harness is correct; Check all connector contacts. Change the control to test mode and check shift handle again. If numbers are still shown, replace the control. See the topic Control Replacement in the Testing And Adjusting section.

CID 671 Procedure (Transmission Speed Sensor)

Service Notes: Ensure that fault being analyzed is on-hold.

The transmission RPM input is a frequency type sensor input. The transmission speed signal is at contact 5 of the control connector.

FMI **F08**

STEP 1. CHECK SENSOR – Remove the sensor and check for foreign material on sensor tip. Install the speed sensor and adjust correctly, see the topic Speed Sensor Adjustment in the Testing And Adjusting section. Clear the fault and test machine operation. Check the control for the same fault (CID 671).

- Fault is shown; the speed sensor or harness is not correct. Go to Step 2.

- Fault is NOT shown; adjustment of the speed sensor or cleaning speed sensor tip corrected the problem. Clear the fault code.

STEP 2. CHECK HARNESS – Connect the sensor to the machine harness. The control remains disconnected from the machine harness. At the machine harness connector, for the control, measure the resistance between contact 2 (ground) and contact 5.

- Resistance is between 100 and 500 Ω; the machine harness resistance is correct. Replace the sensor. Adjust the speed sensor properly when installing it. See the topic Speed Sensor Adjustment in the Testing And Adjusting section. Clear the fault code.

- Resistance is NOT between 100 and 500 Ω; the machine harness is shorted or open. Repair or replace the harness. Clear the fault code.

CID 680 Procedure (Ride Control Switch)

Service Notes: Ensure that fault being analyzed is on-hold. Ensure that the fault present indicator is ON.

FMI F02 (Machines With Air Over Hydraulic Brakes)

These faults are recorded when the control reads improper signals from the ride control switch.

The control detects the status of the ride control switch circuits. The status is correct. when the ride switch control inputs are as specified in one of the following charts. If the status is wrong a fault is recorded.

STEP 1. CHECK CIRCUIT FOR PROPER OPERATION – Disconnect the harness connector from the control. At the harness connector, check for continuity from contact 2 (ground) to the auto (contact 26) switch input circuit and from contact 1 (+battery) to the N/C (contact 11) and N/O (contact 10) switch input circuits. Use the following chart to check the status of each input for all three switch positions.

RIDE CONTROL SWITCH STATUS (Machines With Air Over Hydraulic Brakes)			
Switch Position	D744-WH Circuit (Input 2)	D743-GN Circuit (Input 1)	E701-PK Circuit (Input 3)
ON	Closed[1]	Open	Open
OFF	Open	Closed[1]	Open
AUTO	Open	Closed[1]	Closed[2]

1 Closed to +battery.
2 Closed to ground.

- Operation is correct; switch and switch harness circuitry is correct. Inspect harness connector contacts. Connect harness connector to control and check control for the same fault, with the fault present indicator ON. If present, the control is faulty. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.
- Operation is not correct; switch or switch harness circuitry is not correct. Go to Step 2.

STEP 2. CHECK SWITCH – At the switch, check for the same operation as in Step 1.

- Operation is not correct; switch is faulty. Repair or replace the switch.
- Operation is correct; harness is faulty. Repair or replace the harness.

FMI F02 (Machines With Hydraulic Over Hydraulic Brakes)

These faults are recorded when the control reads improper signals from the ride control switch.

The control detects the status of the ride control switch circuits. The status is correct, when the ride switch control inputs are as specified in one of the following charts. If the status is wrong a fault is recorded.

STEP 1. CHECK CIRCUIT FOR PROPER OPERATION – Disconnect the harness connector from the control. At the harness connector, check for continuity from contact 2 (ground) to the ride control switch inputs (contacts 24 and 26). Use the following chart to check the status of each input for all three switch positions.

RIDE CONTROL SWITCH STATUS (Machines With Hydraulic Over Hydraulic Brakes)			
Mode	Switch Position	D743-GN Circuit (Input 2)	D744-WH Circuit (Input 3)
ON	Up	Open	Closed
OFF	Center	Closed	Closed
AUTO	Down	Closed	Open

- Operation is correct; switch and switch harness circuitry is correct. Inspect harness connector contacts. Connect harness connector to control and check control for the same fault, with the fault present indicator ON. If present, the control is faulty. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.
- Operation is not correct; switch or switch harness circuitry is not correct. Go to Step 2.

STEP 2. CHECK SWITCH – At the switch, check for the same operation as in Step 1.

- Operation is not correct; switch is faulty. Repair or replace the switch.
- Operation is correct; harness is faulty. Repair or replace the harness.

CID 685 Procedure (Service Identification Code)

Service Notes: It may be impossible to change modes or clear faults if this fault is present. If this fault is present, fault codes may not be displayed properly.

FMI F02

CHECK HARNESS – Turn the disconnect switch to the OFF position. Disconnect the machine harness from the control. Check the harness between the control connector and the service connector. Check for short to ground, short between service inputs and open circuits.

- Harness is correct: the control has a fault. Inspect the contacts on the machine harness connector and connect to the control. Check for presence of fault code 685. If fault is still present, replace the control. See the topic Control Replacement in the Testing And Adjusting section.
- Harness is NOT correct: the harness has a fault. Repair or replace the harness.

CID 687 (Option Identification Code)

Service Notes: Ensure that the fault being analyzed is on-hold. Ensure that the fault is ACTIVE.

FMI F02

When turned ON, the control looks at the option code contacts, if the contacts do not represent a valid option code, this fault is recorded. See the Options Code Configuration chart on the Electrical System Schematic for the machine being serviced.

CHECK OPTION CODE – Disconnect the machine harness from the control. At the machine harness connector for the control, check for proper option code. The proper option code can be found in the Options Code Configuration chart on the Electrical System Schematic.

- Option code is correct; option code circuitry is correct. Inspect harness connector contacts. Connect harness to control. Clear the fault. Turn the key switch OFF then back ON to recheck the control. If the same fault is active, replace the control. See the topic Control Replacement in the Testing And Adjusting section.
- Option code is NOT correct; option code circuitry is faulty. Repair the option code circuits or replace the harness. Clear the fault.

Faults Not Detected By The Control

Transmission Does Not Shift Automatically

CHECK AUTO/MANUAL SWITCH INPUT – If the transmission does not shift automatically while in AUTO mode and there is no fault code displayed, verify that the control is getting the proper signals from the AUTO/MANUAL switch. See machine Electrical System Schematic for proper operation of switch.

- If the control has the proper signals for automatic operation, follow the procedure for fault codes CID 190 and CID 671.
- If the control does not have the proper signals follow the procedure for fault codes CID 368 and CID 621.

Control Display Area Is Blank (For Machines Equipped With A Control That Has A Display)

STEP 1. CHECK FOR BATTERY VOLTAGE AT THE CONTROL – Battery voltage is the voltage measured at the battery posts. Voltage at the control must not vary more than .5 volt from battery voltage. Using sharp meter test leads, puncture the wire insulation and measure the system voltage between contacts 1 and 2 of the control at the harness connector. Key switch must be in the ON position.

- Voltage measured does NOT vary from battery voltage more than .5 DCV; system voltage is correct. Disconnect connector and inspect connector contacts. Connect harness connector to control. If the display is still blank, the control is faulty. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.
- Voltage measured does vary from battery voltage more than .5 DCV; system voltage is incorrect. Go to Step 2.

STEP 2. CHECK FOR OPEN TRANSMISSION CONTROL FUSE – Check machine fuse panel for an open transmission control fuse.

- Fuse is open; fuse is faulty. Go to Step 3.
- Fuse is NOT open: the harness is faulty. There is an open circuit in the battery and/or ground circuits or the connector contacts are dirty. Inspect connector contacts. Repair or replace harness.

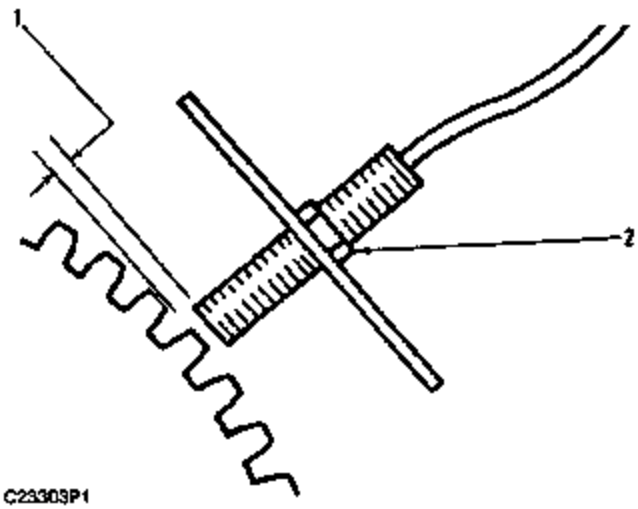
STEP 3. CHECK FOR SHORTED HARNESS – Disconnect the machine harness connector from the control. Measure the resistance from connector contacts 1 and 2 on the harness connector.

- There is NO continuity; the harness circuit resistance is correct. Go to Step 4.
- There is continuity; the harness is not correct. There is a short between the +battery and frame ground or between wires in the harness. Repair or replace the harness.

STEP 4. CHECK CONTROL – Measure the resistance from harness connector contacts 1 and 2 on the control.

- Resistance is less than 100 Ω; the control is not correct. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.
- Resistance is greater than 100 Ω; the harness is not correct. There is an intermittent short between +battery and frame ground. Repair or replace the harness.

Speed Sensor Adjustment



Speed Sensor
(1) Air gap. (2) Locknut.

1. Remove the speed sensor. Align a gear tooth directly in the center of the threaded sensor opening.
2. By hand, screw the sensor into the hole until the end of the sensor just makes contact with the gear tooth.
3. Turn the sensor back out ½ turn (180° in the counterclockwise direction). This sets air gap (1) to 0.89 mm (.035 in).
4. Tighten locknut (2) to 25 ± 5 N•m (18 ± 4 lb ft).

NOTE: Do not allow the sensor to turn as locknut (2) is tightened.

Shift Handle Test

Test For The 105-0154 And The 106-4804 Control Groups

Use the charts below to check the shift handle switches. Use a 6V-7070 Digital Multimeter on the diode scale for these tests. The polarity of the meter leads is important for these tests. If the shift handle switches operate according to the charts, the shift handle is good.

SHIFT HANDLE TEST (Red Meter Lead On Contact 1[2])									
	Shift Handle Position								
Contact	1F	2F	3F	4F	N	1R	2R	3R	4R
1[1]	O	O	O	O	O	X	X	X	X
2[1]	X	X	X	X	O	O	O	O	O
7[1]	O	O	O	O	O	O	O	O	O

[1] These contacts are in the 10 contact shift handle connector.
[2] This contact is in the 9 contact shift handle connector.
O No voltage measured (OL).
X Less than 1 DCV measured.
NOTES: There should be no continuity in any shift handle position from contact 1 of the 9 contact connector, to any shift handle connector contacts not listed in the chart.

SHIFT HANDLE TEST (Black Meter Lead On Contact 2[2])									
	Shift Handle Position								
Contact	1F	2F	3F	4F	N	1R	2R	3R	4R
3[1]	X	X	X	X	O	O	O	O	O
4[1]	O	O	O	O	O	X	X	X	X
5[1]	O	O	X	O	O	O	O	X	O
6[1]	O	O	O	X	O	O	O	O	X
10[1]	O	X	O	O	O	O	X	O	O
5[2]	O	O	O	O	O	X	X	X	X
6[2]	O	O	O	O	X	O	O	O	O
8[2]	X	O	O	O	O	X	O	O	O

[1] These contacts are in the 10 contact shift handle connector.
[2] These contacts are in the 9 contact shift handle connector.
O No voltage measured (OL).
X Less than 1 DCV measured.
NOTES: There should be no continuity in any shift handle position from contact 2 of the 9 contact connector, to any shift handle connector contacts not listed in the chart.

SHIFT HANDLE TEST (Red Meter Lead On Contact 9[2])									
	Shift Handle Position								
Contact	1F	2F	3F	4F	N	1R	2R	3R	4R
7[1]	O	O	O	X	X	O	O	O	X
8[1]	O	O	X	O	O	O	O	X	O
9[1]	O	X	O	O	O	O	X	O	O
7[2]	X	O	O	O	O	X	O	O	O

[1] These contacts are in the 10 contact shift handle connector.
[2] These contacts are in the 9 contact shift handle connector.
O No voltage measured (OL).
X Less than 1 DCV measured.
NOTES: There should be no continuity in any shift handle position from contact 9 of the 9 contact connector, to any shift handle connector contacts not listed in the chart.

Use a 6V-7070 Digital Multimeter on the 200 Ω scale for the following chart. If the shift handle switch operates according to the chart, the shift handle is good.

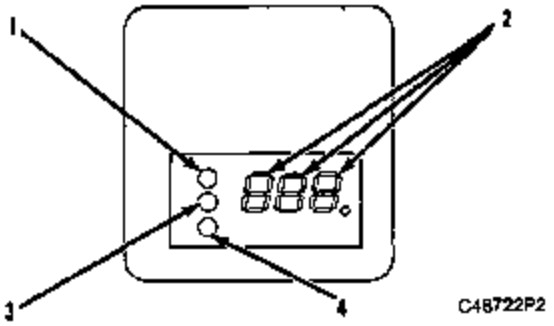
SHIFT HANDLE TEST (Meter Lead On Contact 3[2])									
	Shift Handle Position								
Contact	1F	2F	3F	4F	N	1R	2R	3R	4R
4[2]	O	O	O	O	X	O	O	O	O

[2] These contacts are in the 9 contact shift handle connector.
O Open (no continuity).
X Closed (continuity).
NOTES: There should be no continuity in any shift handle position from contact 3 of the 9 contact connector, to any shift handle connector contacts not listed in the chart.

C Test For The 107-6219 Control Group

The 107-6219 Control Group contains electronic circuitry and cannot be tested using the 6V-7070 Digital Multimeter. If the electronic transmission control indicates a shift circuit fault, check the associated wiring harness, before replacing the 107-6219 Control Group.

Self Test (For Controls With A Display)



Control Display Area
(1) Power indicator. (2) Readout (component identifier and failure mode identifier). (3) Service mode indicator. (4) Fault present indicator.

The self test verifies that the control is operating properly. The control performs an automatic self test each time the key switch is turned from the OFF to the ON position.

The internal circuits and the display are automatically checked. The operator must observe the display to determine whether or not the control is operating properly.

During the self test, the tests follow this sequence:

1. All three indicators are ON and the digital display shows "888.". The dot in the upper left corner is shown for one half second and "888." is shown for two seconds.
2. The red and yellow indicators turn OFF. The digital display shows the one digit options identification code and the two digit machine identification code for two seconds. The left most digit is the options identification code and the right two digits are the machine code. The machine code is a two digit representation of the harness code received from CMS via the data link. For the machine code of the machine being serviced, see the Operation And Maintenance Manual for that machine.
3. The digital display shows the software version. This number identifies the software which is used within the control.
4. The digital display shows "– 0 –." for two seconds. This indicates that the control is in normal mode (mode 0).
5. The green indicator remains ON and the digital display shows "– – –." if there are no faults. If a fault has occurred the display will show the component identifier (CID) and the failure mode identifier (FMI) codes. If the fault is present, the fault present indicator will be ON. If the fault is not present, the fault present indicator will be OFF.

- If the control operates as described; the control is operating properly.
- If the control does not operate as described; there is a harness code problem or the control is faulty. Check the harness code, follow the troubleshooting procedure for the harness code fault CID 650. If the fault present indicator flashes and the display is blank, the control is faulty. Replace the control, see the topic Control Replacement in the Testing And Adjusting section.

Control Replacement

Prior to replacement of the control, ensure that replacement is absolutely necessary. Rarely is the control the cause of a fault. Always check that power is available to the control; battery voltage is required between control connector contacts 1 and 2 of the machine harness.

Procedure

STEP 1. Turn the key switch to the OFF position. Disconnect the machine harness from the control.

STEP 2. Remove the control.

STEP 3. Make sure the replacement control has the correct part number.

STEP 4. Connect the machine harness to the control.

STEP 5. Install the replacement control.

STEP 6. Turn the disconnect and key switches to the ON position. Make sure the control successfully completes the self test; see Self Test.

Glossary

+Battery – +Battery refers to any of the harness wiring which is part of the circuit that connects to the positive battery post.

+V – +V is a constant voltage that is supplied to a component to provide electrical power for its operation. +V is provided by an electronic control module or the battery.

Abnormal – Abnormal refers to a machine condition or signal that is not normal. The presence of an abnormal condition or signal means a problem exists and warning operation is activated which notifies the operator.

CID (Component Identifier) – The CID is a diagnostic code that tells which component or system is faulty. For example; auto/manual switch, speed sensor, or shift handle. The CID is a three digit code that is located in the digital readout area when in normal or service mode.

Clear – Clear refers to removing diagnostic information from the memory of the control. Before clearing information, it is necessary that the information is on-hold and that the control is in service mode.

Connector Contact – A connector contact is the component of a harness connector that actually makes the electrical connection. Connector contacts are either pins or sockets.

Detected Fault – A detected fault is a fault that has been found by the control. The fault is recorded and diagnostic information is available when in service mode

Diagnostic – Diagnostic refers to the showing, monitoring and/or recording of information other than normal. Diagnostic information is available from service, test or normal mode.

Display – Display refers to the indicators or digital readouts within the control display area.

Fault – A fault is a failure of a component of the system. For example; open or shorted harness, faulty switch, sensor or control.

FMI (Failure Mode Identifier) – The FMI is a diagnostic code that tells what type of failure has occurred. For example; voltage above normal, current below normal or abnormal frequency. The FMI is a two digit code preceded by the letter "F". This code is located in the digital readout area when in service mode.

Hard Wired – Hard wired refers to electrical connections made within the harness that are permanent. These soldered or crimped connections are not meant to be altered.

Hold or On-Hold – Hold or On-hold refers to holding (or locking) a set of diagnostic information that is shown in the digital display area when in service mode. It is necessary to hold the set of diagnostic information before troubleshooting or clearing.

Jumper – A jumper is a piece of wire used to make an electrical connection during troubleshooting.

Option Code – Option code refers to the grounded or open condition of the two option code inputs (connector contacts 25, 27 and 30). The option code tells the control what options are installed on the machine.

Scroll – Scrolling is the process of showing (within the digital display area) all available sets of diagnostic information one set at a time. A set of diagnostic information is shown briefly and then the display automatically advances to the next set. After all sets are shown the sets are repeated.

Show – Show refers to information within the control display area that is viewed by the operator or service person.

Signal Wire – The signal wire is the harness wire which connects the sensor or switch to the control.

Switch Input – A switch input is any input of the control which is expecting only an open (floating) or grounded signal.

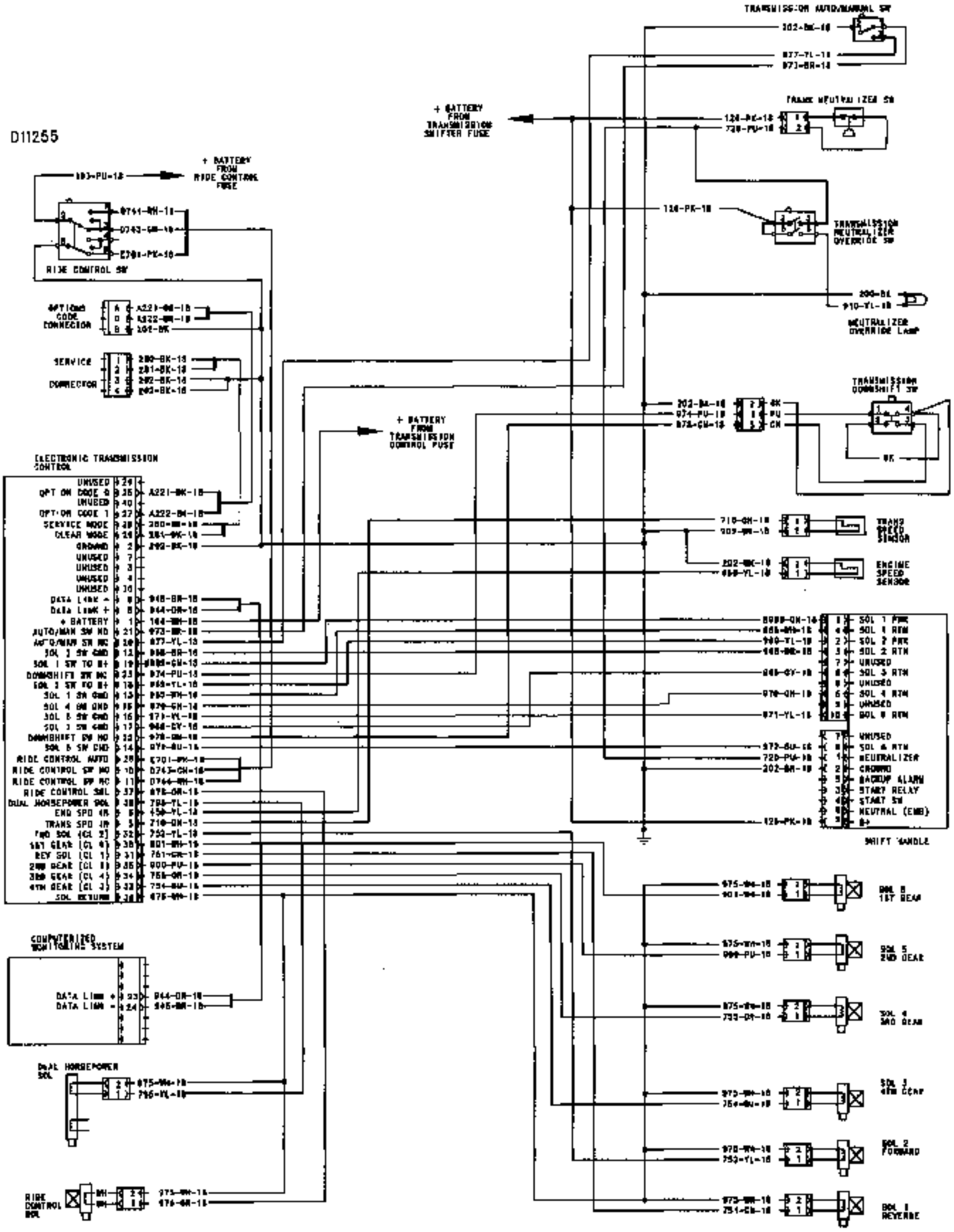
System Voltage – System voltage is the actual voltage that exists between the positive battery post and frame ground. System voltage is also referred to as +battery voltage.

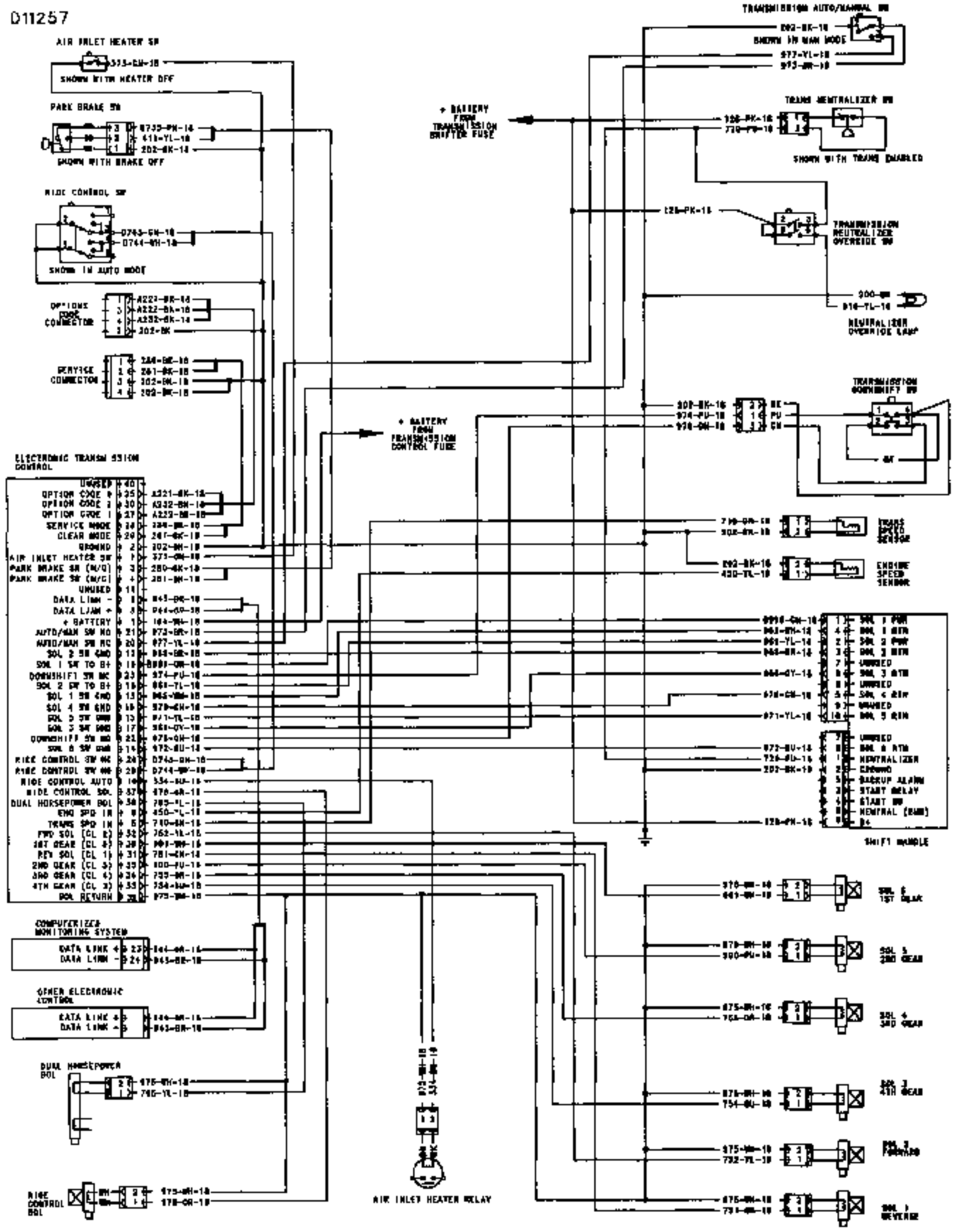
Undetected Fault – An undetected fault is a fault that exists and is not found by the control but is found by the operator or service person.

Machine Code – The machine code is a two digit number that has been assigned to a particular harness code for a particular machine. The machine code is shown on the control display during the Self Test. Each sales model has a specific harness code and therefore also a specific machine code.

C Electronic Transmission Control System Schematics

NOTE: The simplified system schematics that follow are for controls with a display. These schematics are electrically correct, but do not show all the possible harness connectors. For a complete electrical system schematic, always see the Electrical System Schematic module in the machine Service Manual.


D11255
+ BATTERY FROM RIDE CONTROL FUSE
RIDE CONTROL SW
OPTIONAL CODE CONNECTOR
SERVICE CONNECTOR
+ BATTERY FROM TRANSMISSION CONTROL FUSE
ELECTRONIC TRANSMISSION CONTROL
+ BATTERY FROM TRANSMISSION SHIFTER FUSE
TRANSMISSION AUTO/MANUAL SW
FRAME NEUTRALIZER SW
TRANSMISSION NEUTRALIZER OVERRIDE SW
NEUTRALIZER OVERRIDE LAMP
TRANSMISSION DOWNSHIFT SW
TRANS SPEED SENSOR
ENGINE SPEED SENSOR
SHIFT HANDLE
COMPUTERIZED MONITORING SYSTEM
DUAL HORSEPOWER SOL
RIDE CONTROL SOL
SOL 5 2ND GEAR
SOL 4 3RD GEAR
SOL 3 4TH GEAR
SOL 2 FORWARD
SOL 1 REVERSE


D11257
AIR INLET HEATER SW
SHOWN WITH HEATER OFF
PARK BRAKE SW
SHOWN WITH BRAKE OFF
RIDE CONTROL SW
SHOWN IN AUTO MODE
OPTIONS CODE CONNECTOR
SERVICE CONNECTOR
ELECTRONIC TRANSMISSION CONTROL
+ BATTERY FROM TRANSMISSION BRAKE FUSE
+ BATTERY FROM TRANSMISSION CONTROL FUSE
TRANS NEUTRALIZER SW
SHOWN WITH TRANS ENABLED
TRANSMISSION NEUTRALIZER OVERRIDE SW
NEUTRALIZER OVERRIDE LAMP
TRANSMISSION DOWNSHIFT SW
TRANS SPEED SENSOR
ENGINE SPEED SENSOR
SHIFT HANDLE
COMPUTERIZED MONITORING SYSTEM
OTHER ELECTRONIC CONTROL
DUAL HORSEPOWER SOL
RIDE CONTROL SOL
AIR INLET HEATER RELAY

CATERPILLAR®

GOV #2
September 1996

Disassembly & Assembly

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Power Train

814F:	815F:	816F:
9DM1-UP	1GN1-UP	5FN1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety Is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operation that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warning in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139Γ.

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⚠ WARNING

Disconnect batteries before performance of any service work.

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

NOTE: Special care and cleanliness are essential for correct disassembly and assembly of the transmission, differential and other gear components. Failure to follow these procedures may result in early hour wear and failure. Thoroughly clean the exterior of the transmission and differential prior to any disassembly. Any exterior dirt which would enter the transmission or differential could cause damage and failure of the unit. Disassemble and assemble the unit in as clean an area as possible. It is essential to replace all parts which have become defective along with all O-rings and seals. All machined parts showing signs of scratches or other wear must be replaced. The cavities of the housing, especially the corners, must be carefully cleaned and rinsed. If the disassembly and assembly is a result of a serious breakdown, it is essential that all portions of the unit be cleaned and flushed to eliminate any broken parts or metal particles. Carefully lubricate all parts during reassembly.Cover all faces of housings and covers, which must be oil tight towards the outside, with the proper sealing compound, gasket or O-ring. Prior to operation, insure that the unit has been filled with the proper lubricant. Consult the Operation And Maintenance Manual for the proper levels.

Disassembly & Assembly

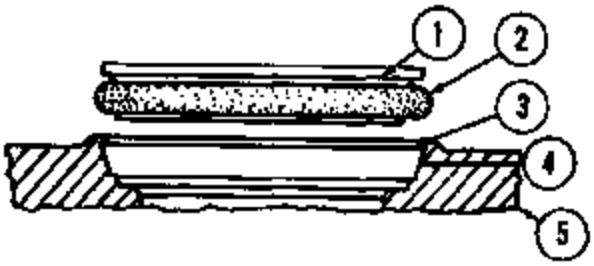
Duo-Cone Seals

Assembly And Installation Of Conventional Duo-Cone Seals 7561-016,012

Introduction

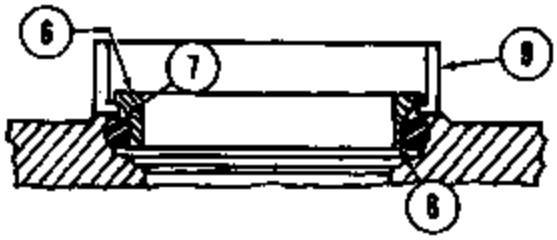
This instruction gives the procedure for installing Conventional Duo-Cone Seals.

It is most important that correct assembly and installation procedures be followed.



C20391P1

(1) Seal (2) Rubber Toric Ring (3) Housing Retaining Lip (4) Housing Ramp (5) Seal Ring Housing



C20392P1

(6) Seal Ring Face (7) Seal Ring Ramp (8) Seal Ring Retaining Lip (9) Installation Tool.

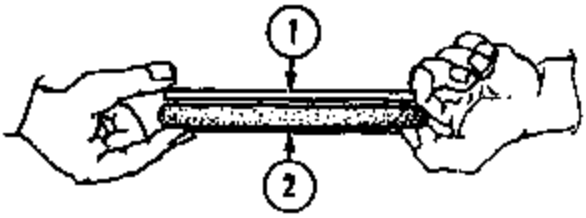
1. Remove any oil film, dust or other foreign matter from toric rubber rings (2) and from ramps (4) and (7) and lips (3) and (8) of both seal rings (1) and housings (5). Use Isopropyl Alcohol and clean cloth or paper towels for wiping.

NOTICE

Never permit oil to get on the toric rings or ramps before both seal rings are put together in their final assembled position (Step 10).

⚠ WARNING

Avoid prolonged skin contact with Isopropyl alcohol. Avoid breathing the vapors in enclosed areas without adequate ventilation and do not smoke. Do not use near open flame or welding operations or other heated surfaces exceeding 482° C (900° F).



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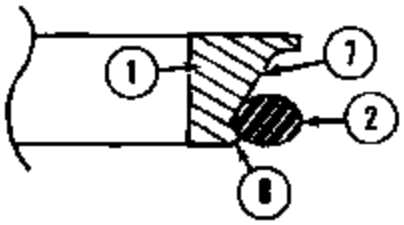
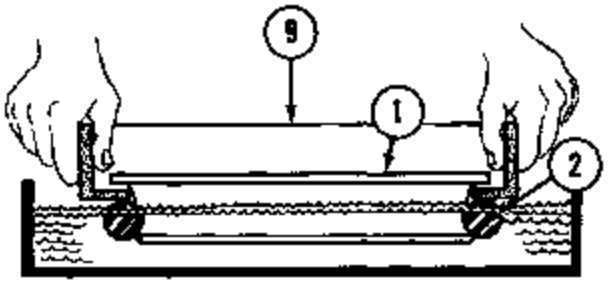


C20394P1*

2. Put toric ring (2) on seal ring (1), at the bottom of seal ring ramp (7) and against retaining lip (8).

NOTICE

Make sure that toric ring (2) is straight on seal ring (1) and is not twisted. Be careful when you work on the rubber toric ring. Nicks, cuts and scratches can cause leaks.

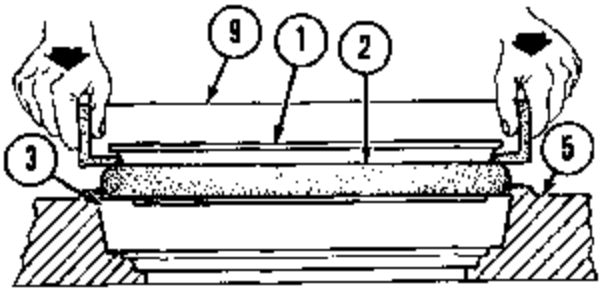


C20395P1*

3. Put installation tool (9) onto seal ring (1) with toric ring (2). Lower the rings into a container with Isopropyl alcohol until all surfaces of toric ring (2) are wet.

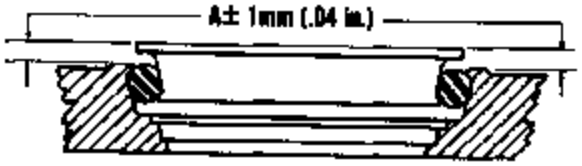
NOTICE

Do not use Stanisol or any other liquid that leaves an oil film or does not evaporate quickly.



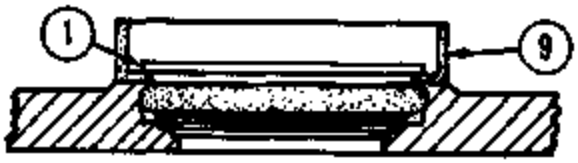
C20396P1*

4. With all surfaces of toric ring (2) wet, use installation tool (9) to position seal ring (1) and toric ring (2) squarely against housing (5) as shown. Use sudden and even pressure to pop (push) toric ring (2) under retaining lip (3) of housing (5).



C20397P1*

5. Check assembled height (A) in at least four places, **90 degrees apart.** The difference in height around the ring must not be more than **1 mm (.04")**.



C20398P1*

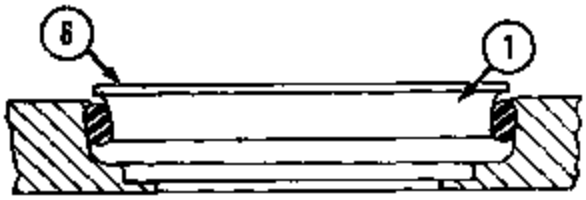
6. If small adjustments are necessary, do not push directly on seal ring (1); use installation tool (9).

7. Toric ring (2) can twist if it is not wet all around during installation or if there are burrs or fins on retaining lip (3) of housing (5).

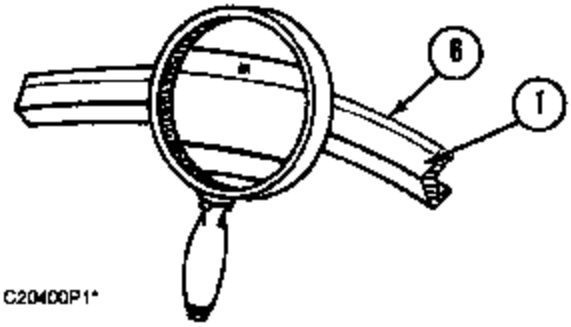
NOTICE

Misalignment, twists and bulges of the toric ring will cause Duo-Cone Seal failures. If correct installation is not obvious, remove seal from housing and repeat steps 3 thru 6.

IMPORTANT: Toric rings (2) must never slip on the ramps of either seal rings (1) or seal ring housings (5). To prevent slippage, wait a minimum of two minutes to let the Isopropyl alcohol evaporate before further assembly. Once correctly in place, the toric ring must roll on the ramps only.

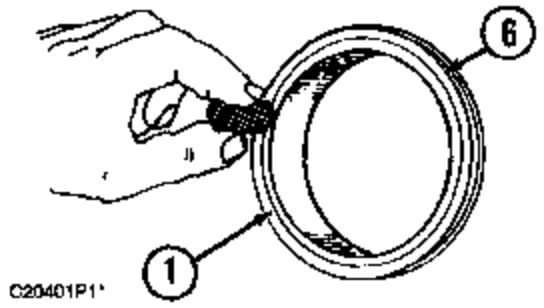


C20399P1*

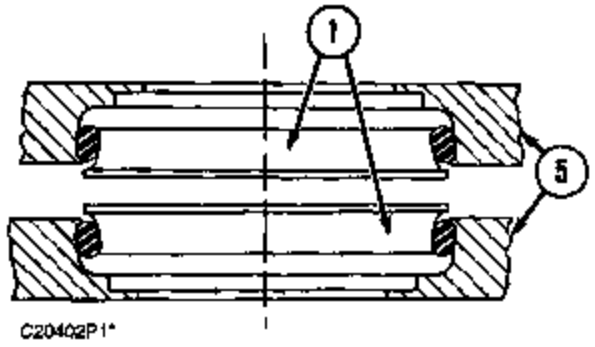


C20400P1*

8. Wipe seal faces (6) of seal rings (1) clean. Use a lint free cloth or paper towel. No particles of any kind are permissible on the sealing surfaces. Even a small piece from a paper towel can hold the seal faces apart and cause leakage.



9. Put a thin film of clean oil on the seal faces. Use an applicator, a disposable tissue or a clean finger to distribute the oil evenly. Be careful not to get any oil on the rubber toric rings.



10. Make sure both housings (5) are in correct alignment and are concentric. Move the parts slowly and carefully toward each other.

NOTICE

Do not slam seals together. High impact can scratch or break the seal components.

11. Once in place, fasten all parts tightly.

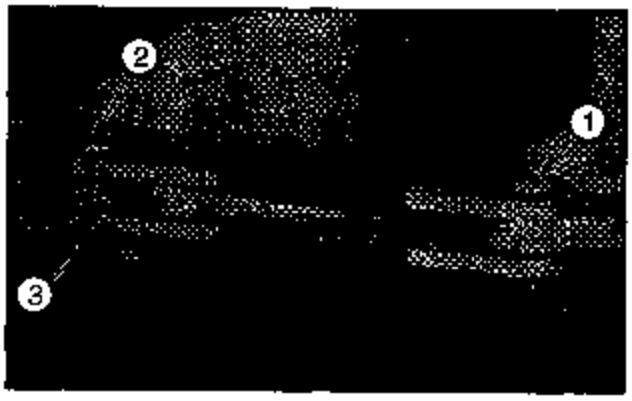
Steering Frame Lock Link

Separate & Connect Steering Frame Lock Link 7506-029

⚠ WARNING

There is no clearance for a person in the area between the front and rear frames of the machine when turning the vehicle. When a machine is to be lifted, transported on another vehicle or service work is being preformed near the center of the machine, connect the steering frame lock link between the front and rear frames to keep the machine in a straight ahead position. Before operation and when operating, be sure the steering frame lock link, located near lower center of machine, is disconnected and pinned to the retaining plates.

1. To connect the steering frame lock link, first put the machine in a straight ahead position.



3. Remove lock pin and pin from the trunnion on the front frame in the stored position.

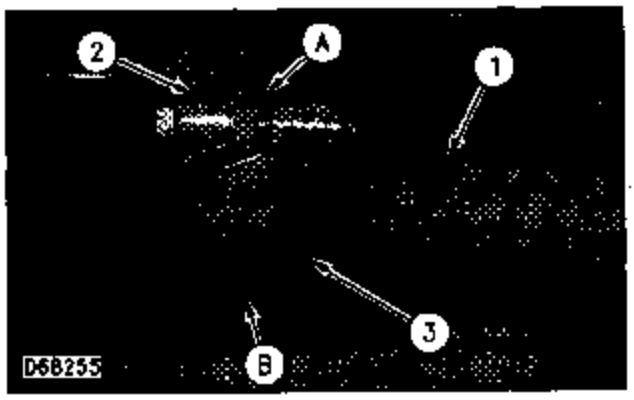
4. Move steering frame lock link (1) to the engine end frame. Install pin (2) and lock pin (3) that hold steering frame lock link (1) in place.

5. Reinstall pin (2) back in lock link (1) as shown, and install spring pin (3) to hold it in place.

NOTE: **Install steering frame lock link in reverse order.**

Shimming Procedure (Typical)

Remove & Install Shims



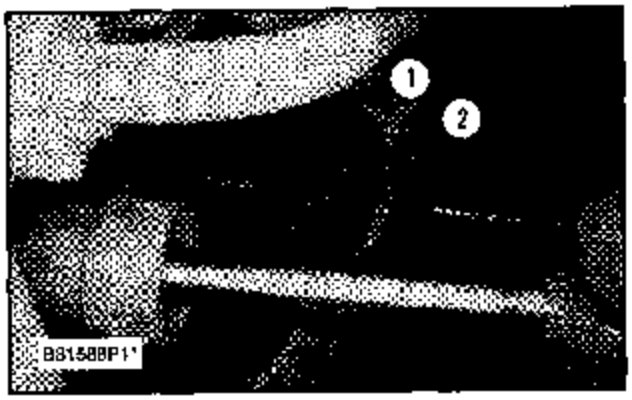
Typical Example

1. Remove all shims from assembly (1)
2. Install assembly (1) and cap (2) on trunnion (3) without the shims. Tighten the bolts, maintaining equal distance on both sides of the cap.
3. Insert as many shims as possible into spaces (A) and (B) between the cap and the assembly.
4. Add two additional shims to the total shims used.
5. Install half the shims at (A) and the other half at (B). Tighten the bolts to the proper torque.
6. This allows the assembly to move on the trunnion freely and within the specified tolerance.

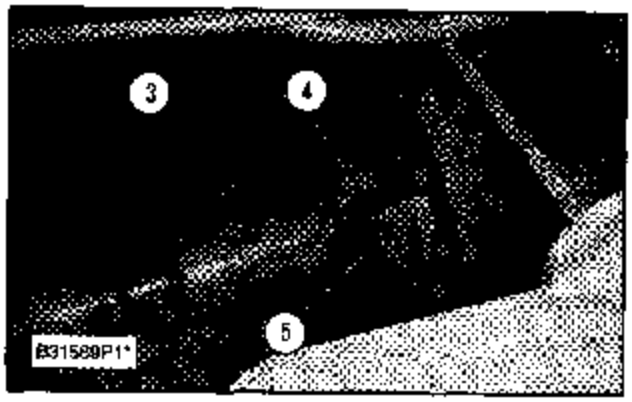
Center Drive Shaft

Remove & Install Center Drive Shaft 3253-CE-010

1. Connect the steering frame lock link. See the topic, "Separate & Connect Steering Frame Lock Link" in this module.
2. Be sure the parking brake is released so the drive shaft can be turned. Put block in front of and behind the tires of the machine so it can not roll.



3. Remove four bolts (1) and two straps (2) to disconnect the center drive shaft from the yoke on the transfer gear case.



4. Remove four bolts (4) and two straps (5) to disconnect the center drive shaft from the yoke on the parking brake.

5. Remove center drive shaft (3) from the machine.

NOTE: The following steps are for the installation of the center drive shaft.

NOTICE

NOTE: Be sure the drive shaft yokes are positioned on the same center line with the center drive shaft.

6. Put center drive shaft (3) in position. Install straps (2) and (5) and bolts (1) and (4).

7. Tighten bolts (1) and (4) to a torque of **135 ± 15 N•m (100 ± 11 lb ft).**

8. Separate the steering frame lock link. See the topic, "Separate Steering Frame Lock Link" in this module.

Front Drive Shaft Carrier Bearing

Remove & Install Front Drive Shaft Carrier Bearing 3267-FR-010

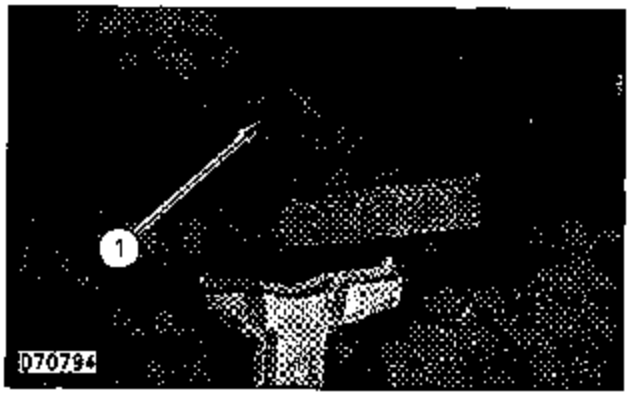
Tools Needed		A	B
1P-2321	Puller Group	1	
9S-9153	Jaw	3	
8B-7561	Plate		1
1B-1422	Bolt		1
FT-1408	Spacer		2
6V-3009	H-Bar		1

Tools Needed		A	B	C
1P-2321	Puller Group	1		
9S-9153	Jaw	3		
1P-0520	Driver Group		1	
8b-7561	Plate			1
1B-1422	Bolt			1
FT-1408	Spacer			2
6V-3009	H-Bar			1

Start By:

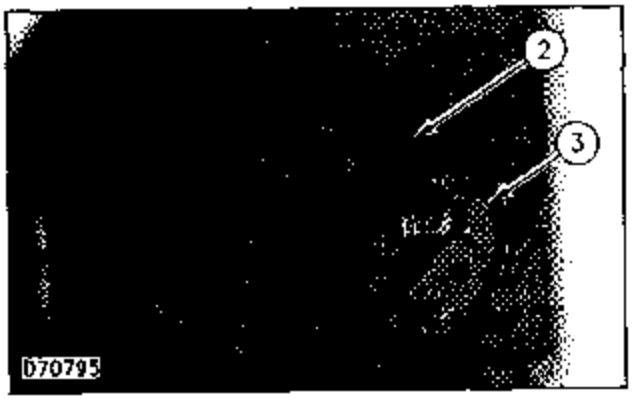
a. remove parking brake *

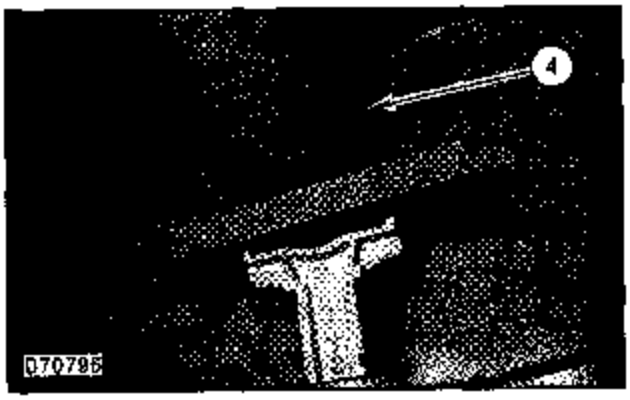
* This operation is in the 815F Compactor Machine Systems Disassembly & Assembly module, Form No. SENR1318.



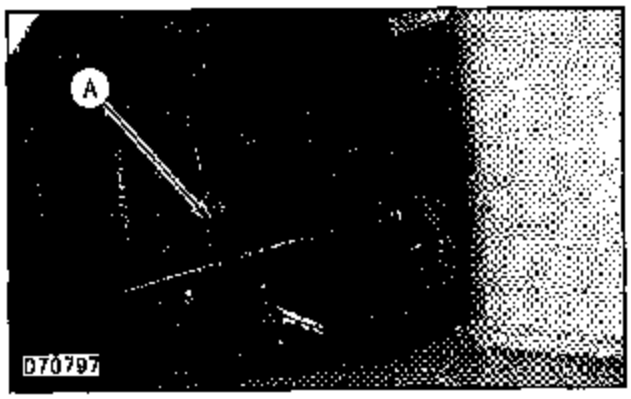
1. Support front drive shaft (2) with a suitable stand to prevent damage to the drive shaft splines.

2. Disconnect grease tube assembly (3) from fitting (2).

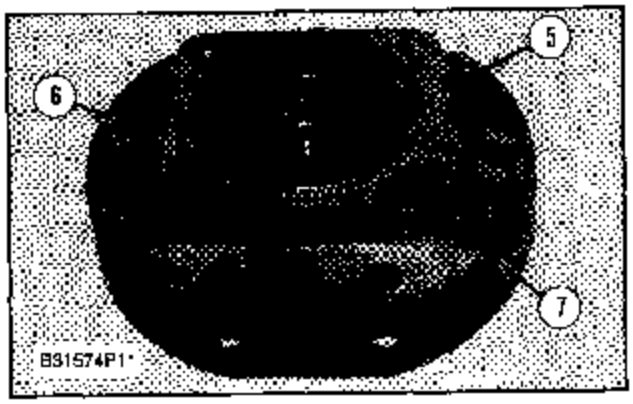




3. Remove six bolts (4) and the washers that hold the carrier bearing housings to the frame of the machine.

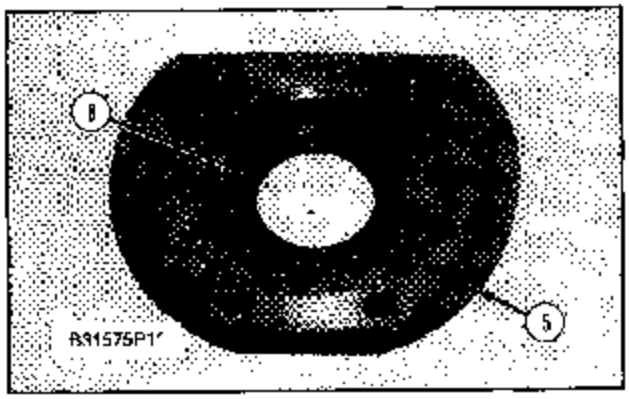


4. Using tooling (A), pull the carrier bearing housings off of the front drive shaft, and remove the unit from the machine.

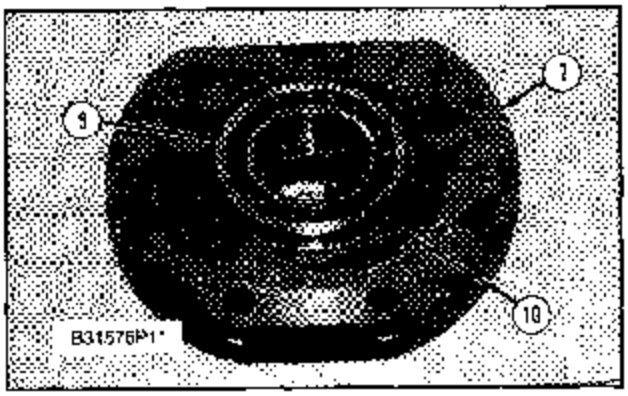


5. Remove bolts (6) that hold carrier bearing housings (5) and (7) together.

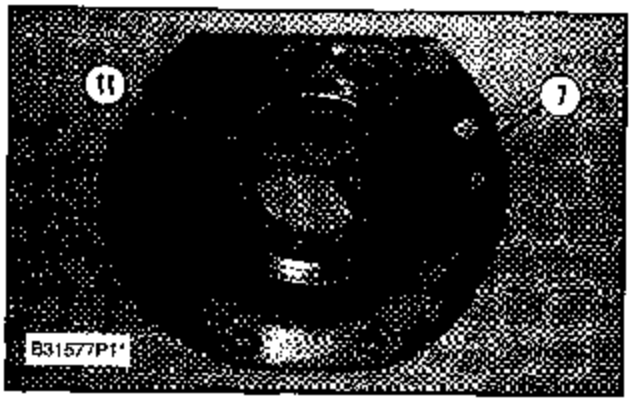
6. Separate carrier bearing housing (5) from carrier bearing housing (7). If necessary, use **two 5/8" - 11 NC X 1 3/4 " bolts** as forcing screws to separate the carrier bearing housings.



7. Remove lip seal (8) from carrier bearing housing (5).



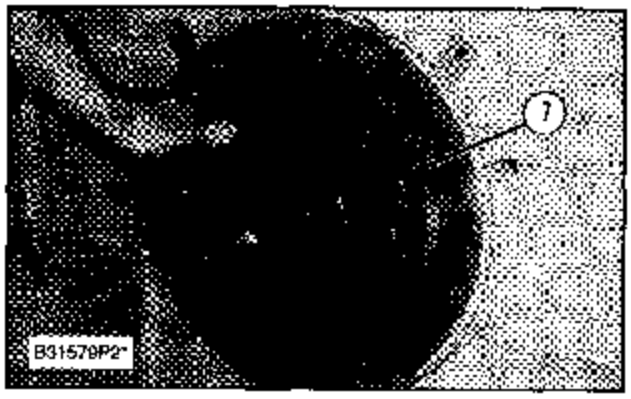
8. Remove O-ring seal (10) and bearing (9) from carrier bearing housing (7).



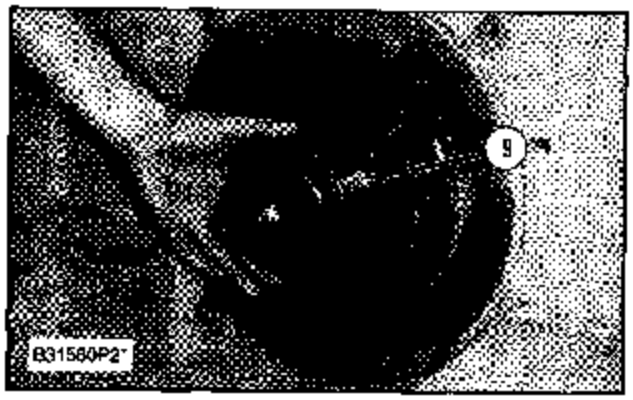
9. Remove lip seal (11) from carrier bearing housing (7).

NOTE: Install the front drive shaft carrier bearing in the following manner.

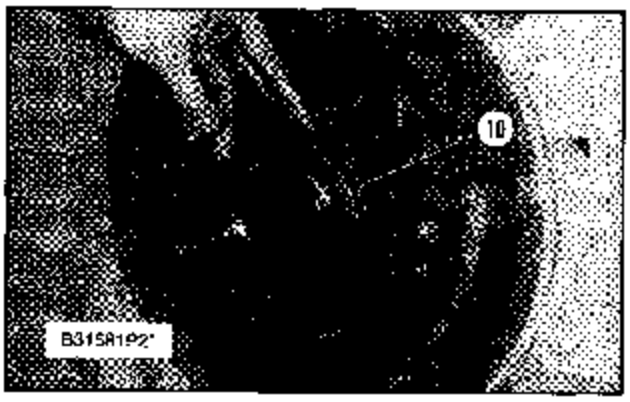
10. Use tool (B) to install the lip seal in carrier bearing housings (5) and (7). Be sure the seal makes contact with the counterbore in thecarrier bearing housing.



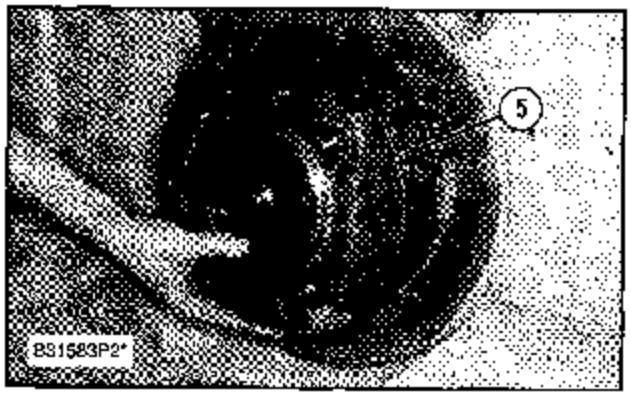
2. Put **5P0960 Multipurpose Grease** on the lip of the seal in carrier bearing housing (7). Install the carrier bearing housing over the front drive shaft.



3. Install bearing (9) on the end of the front drive shaft.

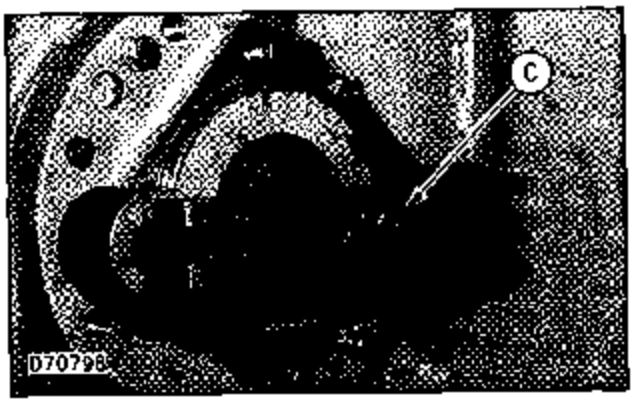


4. Install O-ring seal (10) in carrier bearing housing (7).



5. Put **5P0960 Multipurpose Grease** on the lip of the seal in carrier bearing housing (5). Install carrier bearing housing (5) over the end of the front drive shaft. Install the bolts and washers that hold the two carrier bearing housings together.

NOTE: It may be necessary to lower the temperature of the front splinedportion of the front drive shaft to allow easy installation of the carrier bearing.



6. Use tooling (C) to pull shaft into housing and seat bearing.

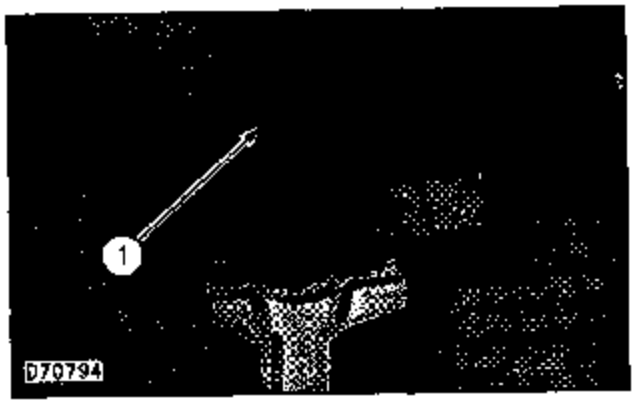
7. Install bolts (4) to hold the carrier bearing housings to the frame of the machine.

8. Connect grease tube assembly (1) to the carrier bearing housing.

9. Reinstall yoke (12) for the center drive shaft. Temporarily install the O-ring seal, the retainer and the bolt that holds it in position.

10. Fill the carrier bearing housings with **5P0960 Multipurpose Grease**, and be sure no grease comes out between the lip seal and yoke into the area of the parking brake mounting. If there is leakage, a replacement of the lip seal must be made.

11. Remove yoke (12).



12. Remove the stand from front drive shaft (1).

End By:

a. install parking brake *

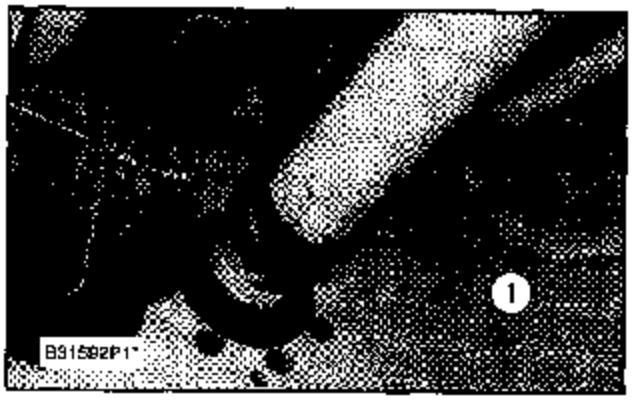
* This operation is in the 815F Compactor Machine Systems Disassembly & Assembly module, Form No. SENR1318.

Front Drive Shaft

Remove Front Drive Shaft 3253-FR-011

Start By:

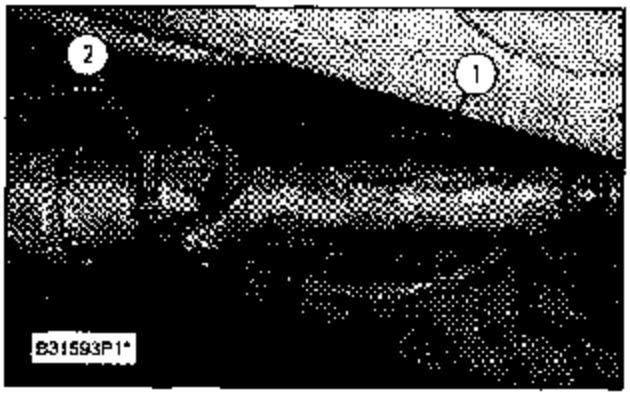
a. remove front drive shaft carrier bearing



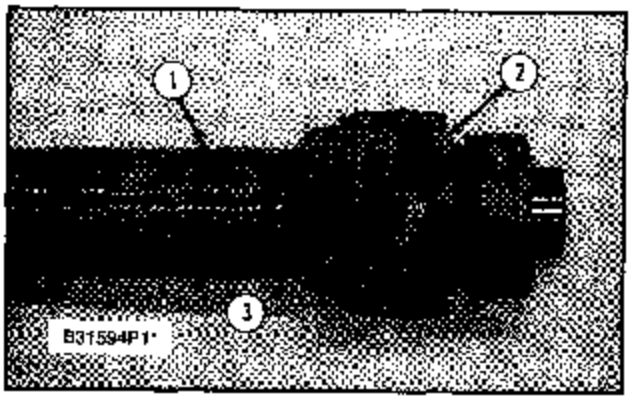
NOTICE

Be careful not to damage the carrier bearing surface on front drive shaft (1) when the front drive shaft is being lowered.

1. Lower the end of front drive shaft (1) that is supported with the nylon lifting strap.



2. Use two persons to pull front drive shaft (1) and yoke (2) from the differential pinion shaft, and lower the unit from the machine. The weight of the front drive shaft and yoke is **25 kg (55 lb)**.

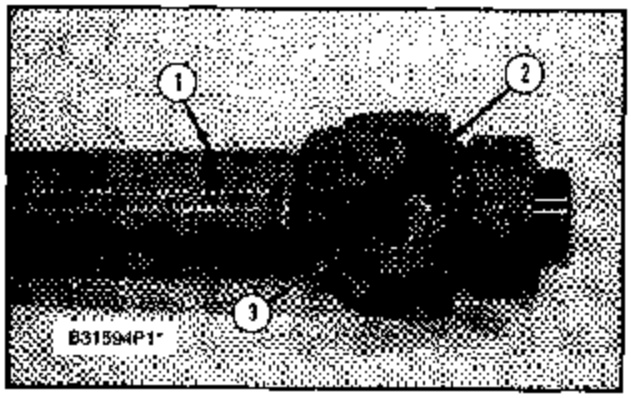


3. Remove the bolts and straps to remove yoke (2) from the universal joint and front drive shaft (1).

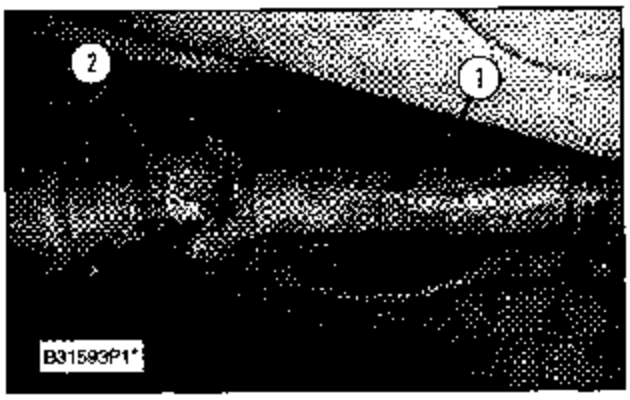
Install Front Drive Shaft 3253-FR-012

NOTICE

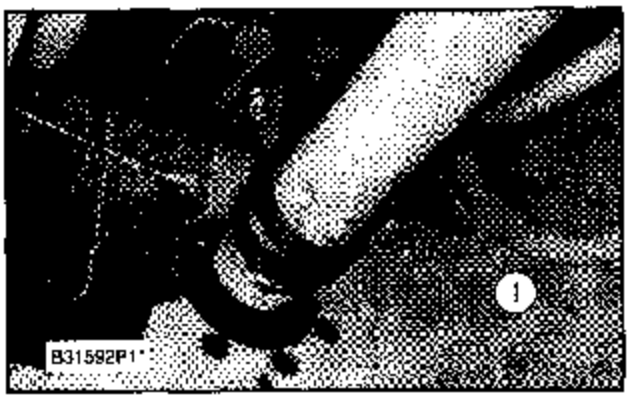
Be sure the drive shaft yokes are in alignment prior to installation of the front drive shaft or unusual vibration may result during machine operation.



1. Connect yoke (2) to the universal joint and front drive shaft (1) with the straps and bolts (3). Tighten bolts (3) to a torque of **135 ± 15 N•m (100 ± 11 lb ft)**.



2. Using two persons, put front drive shaft (1) and yoke (2) in position, and slide the yoke on the differential pinion shaft.



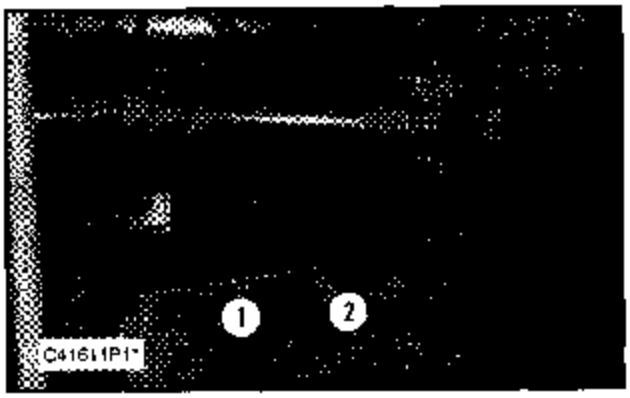
3. Fasten a nylon lifting strap to the unsupported end of front drive shaft (1) to hold it in position for the installation of the front drive shaft carrier bearing.

End By:

a. Install front drive shaft carrier bearing

Rear Drive Shaft

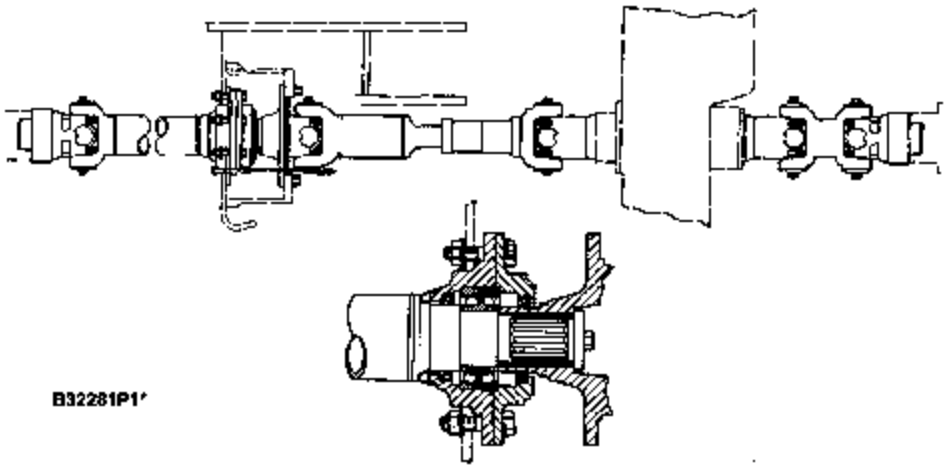
Remove & Install Rear Drive Shaft 3253-RE-010



1. Remove eight bolts (1) and the four straps that hold the rear drive shaft to the universal joints.

2. Remove rear drive shaft (2).

NOTE: The following steps are for the installation of the rear drive shaft.



3. Be sure the universal joints are positioned on the same center line with the rear drive shaft.

4. Put rear drive shaft (2) in position on the universal joints.

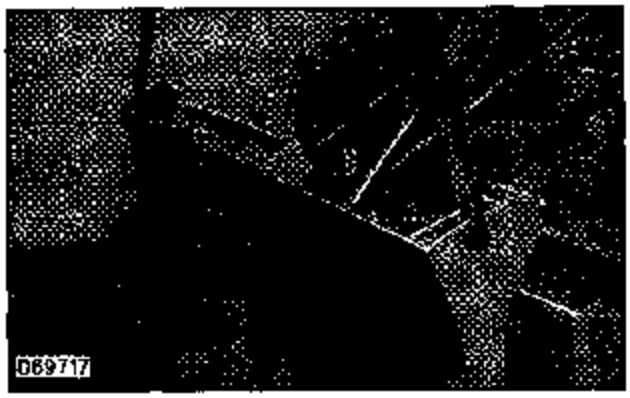
5. Install the four straps and eight bolts (1) that hold the rear drive shaft in position. Tighten bolts (2) to a torque of **135 ± 15 N•m (100 ± 11 lb ft)**.

Front Axle Housing Group (Fixed)

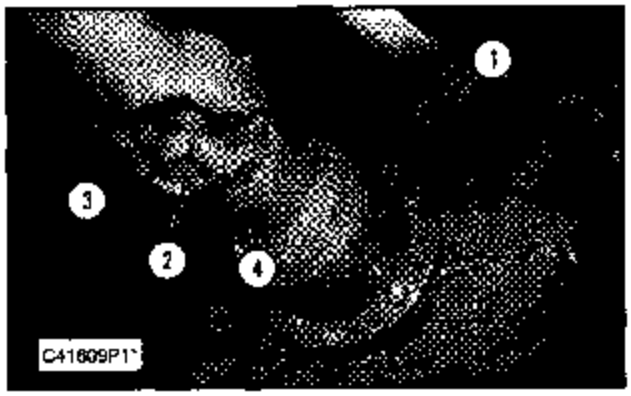
Remove & Install Front Axle Housing Group (Fixed) 3278-010

Start By:

a. remove front tire and rim assemblies

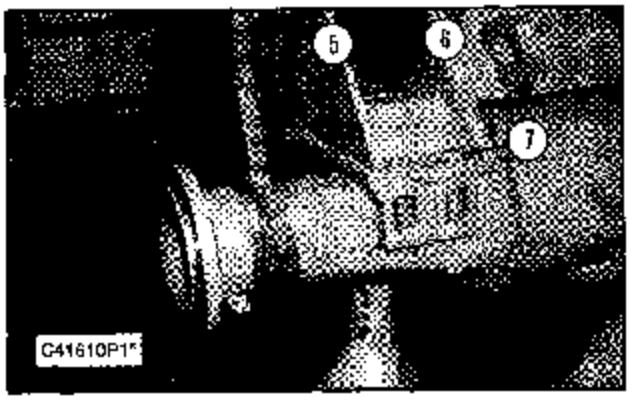


1. Start the machine. Lift the blade and lift arms, and put wood blocks in position under the lift arms for support. Lower the weight of the blade and lift arms onto the wood blocks. Shut the machine off.



2. Disconnect hose and tube assembly (1) from the front axle housing group.

3. Remove four bolts (2) and the two straps, and disconnect front drive shaft (3) from differential pinion yoke (4).



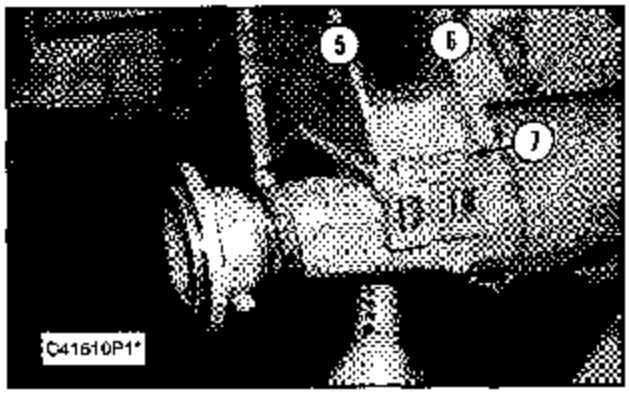
4. Fasten a nylon lifting strap to each side of the front axle housing group as shown. Fasten a hoist to both nylon lifting straps.

5. Remove two bolts (5), the washers and plate (6) from each side of the front axle housing group.

6. Remove eight bolts (7) and the washers that hold the front axle housing group to the front loader frame. Lower the front axle housing group from the machine. The weight of the front axle housing group is **1225 kg (2700 lb)**.

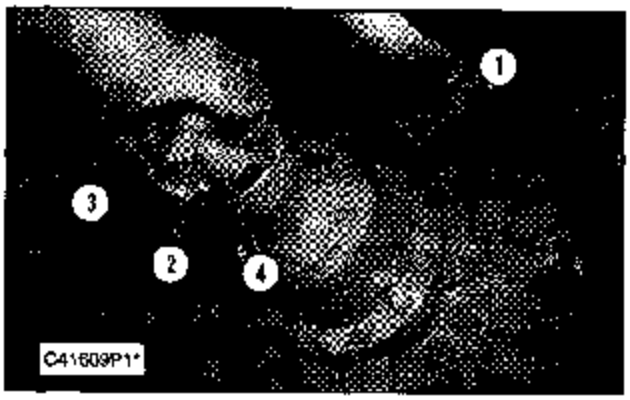
NOTE: The following steps are for the installation of the front axle housing group.

7. Be sure the mounting surfaces on the front axle housing group and the front loader frame are clean and free of dirt and debris prior to installation of the front axle housing group.



8. Fasten nylon lifting straps and a hoist to both ends of the front axle housing group. Raise the front axle housing group into position against the front loader frame. Install eight bolts (7) and the washers that hold it. Tighten the bolts to a torque of **1800 ± 200 N•m (1320 ± 150 lb ft)**.

9. Install plate (6), the two washers and bolts (5) which hold it.



10. Put front drive shaft (3) in position in differential pinion yoke (4). Install the two straps and four bolts (2). Tighten four bolts (2) to a torque of **135 ± 15 N•m (100 ± 11 lb ft)**.

11. Connect the hose and tube assembly (1) to the front axle housing group.

12. Start the machine, and raise the lift arms and blade. Remove wood blocks, and lower the blade to the ground.

13. After installing the front tires and rim assemblies, remove (bleed) the air from the brake system. See the topic, "Remove Air From Brake System (Bleed The Brakes)" in Systems Operation Testing & Adjusting, 815F Compactor Systems Operation publication, Form No. SENR1336.

End By:

a. install front tire and rim assemblies

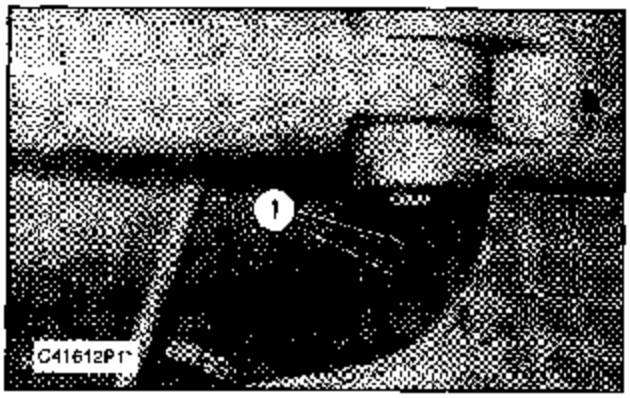
Rear Axle Housing Group (Oscillating)

Remove & Install Rear Axle Housing Group (Oscillating) 3278-010

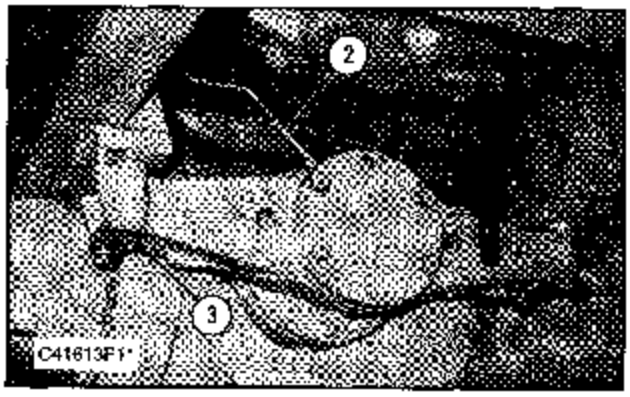
Start By:

a. remove rear tire and rim assemblies

b. remove rear drive shaft

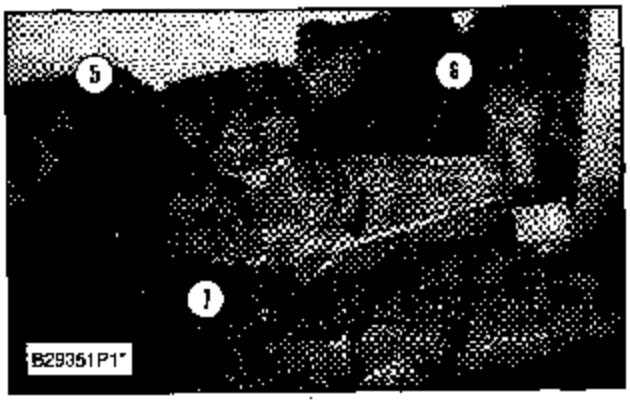


1. Disconnect hose and tube assembly (1) from the top of the rear axle housing group.



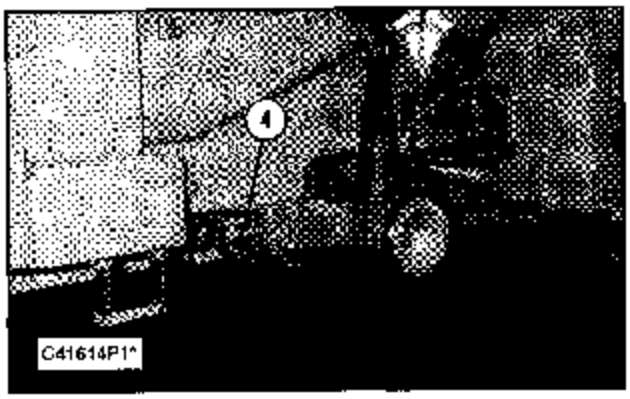
2. Fasten a nylon lifting straps to each side of the rear axle housing group. Fasten a hoist to both nylon lifting straps.

3. Disconnect tube (2) from the rear axle housing group. Remove four bolts (3) and the nuts that hold the rear support to the frame of the machine.



Typical Example

4. Fasten a chain around the axle, front support (6) and yoke (5) to prevent the support and the yoke from falling as the axle is removed. Remove four bolts (7) and the nuts that hold front support (6) to the frame of the machine.



5. Lower the rear axle housing group evenly, so that dowel (4) does not bind and prevent lowering of the rear axle housing group. The weight of the rear axle housing group is **1225 kg (2700 lb)**.

NOTE: The following steps are for the installation of the rear axle housing group.

6. Fasten a chain to support the front support and yoke. Raise the rear axle housing group into position. Install four bolts (7) and four bolts (3) that hold the front and rear supports for the rear axle housing group to the frame. Tighten the bolts to a torque of **475 ± 60 N•m (350 ± 45 lb ft)**.

7. Connect tube (2) to the rear axle housing group. Connect hose and tube assembly (1) to the top of the rear axle housing group.

8. Lubricate the front and rear supports for the rear axle housing group. See the Operation & Maintenance Manual for the correct lubricating procedure.

9. After installing the rear tire and rim assemblies and the rear drive shaft, remove (bleed) the air from the brake system. See the topic, "Remove Air From Brake System (Bleed The Brakes)" in Systems Operation Testing & Adjusting, 815F Compactor Systems Operation, Form No. SENR1336.

End By:

a. install rear drive shaft

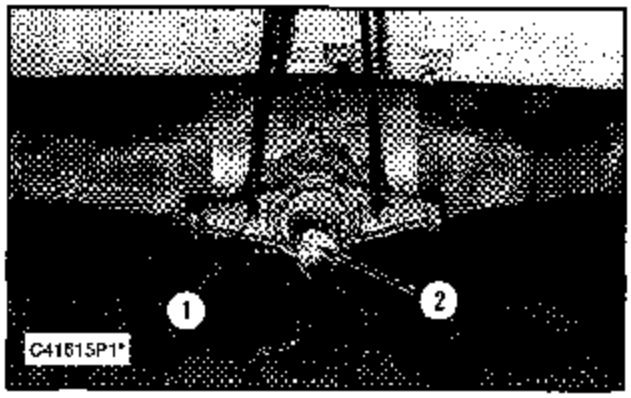
b. install rear tire and rim assemblies

Front Support (Rear Axle Housing Group)

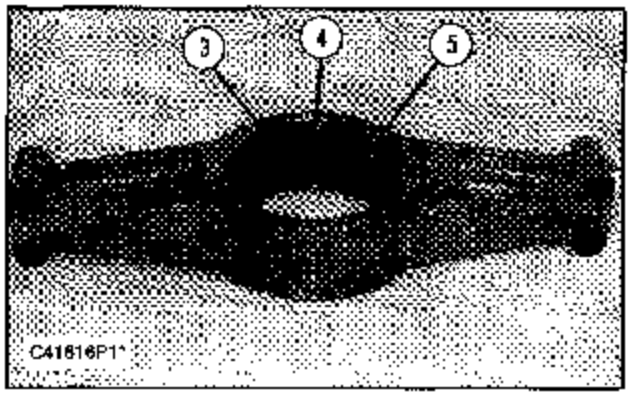
Remove Front Support (Rear Axle Housing Group) 3268-FR-011

Start By:

a. remove rear axle housing group (oscillating)



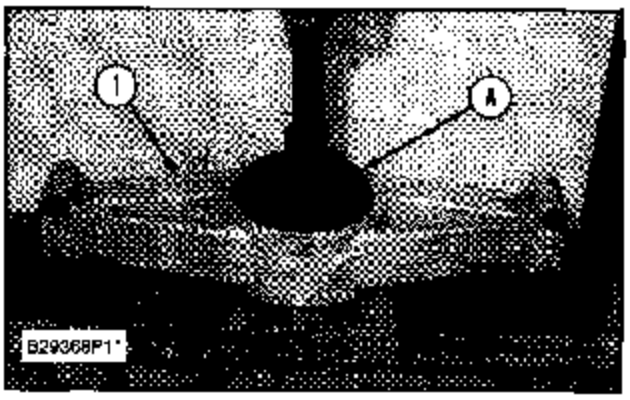
1. Remove yoke (2) from the differential pinion shaft.
2. Fasten a hoist to front support (1), and slide the front support off of the rear axle housing. The weight of the front support is **34 kg (75 lb)**.



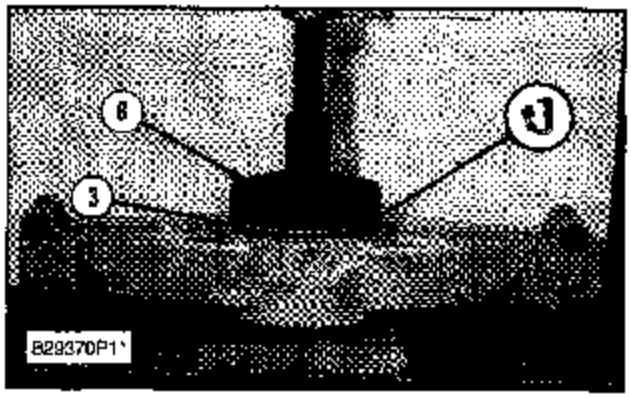
3. Remove lip seal (3) from the front support. Remove ring (4) that holds bearing (5) in the front support.
4. Turn the front support over, and remove the other lip seal. Using a press, remove bearing (5) from the front support.

Install Front Support (Rear Axle Housing Group) 3268-FR-012

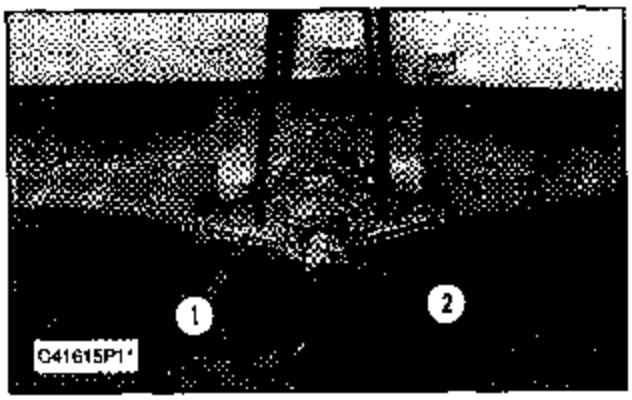
Tools Needed	A
1P0520 Driver Group	1



1. Use a press and tool (A) to install the bearing in front support (1) until it makes contact with the counterbore in the support.
2. Install the retaining ring that holds the bearing in the front support.



3. Use a press and tool (A) to install lip seal (3) in both sides of the front support. Install the seals until they make contact with the counterbores in the front support and with the lip of each seal facing toward the outside of the front support as shown.



4. Put **5P0960 Multipurpose Grease** on the lips of seals (3).

5. Fasten a hoist to front support (1), and install it on the rear axle housing group.

6. Install yoke (2) on the differential pinion shaft.

End By:

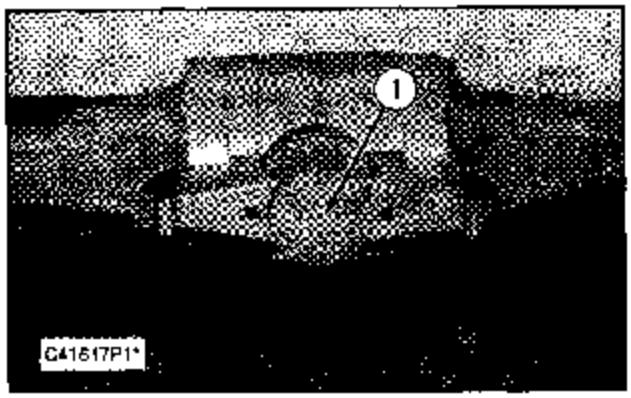
a. install rear axle housing group (oscillating)

Rear Support (Rear Axle Housing Group)

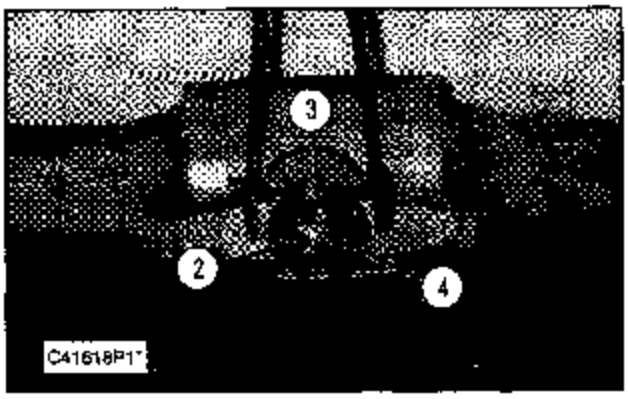
Remove Rear Support (Rear Axle Housing Group) 3268-RE-011

Start By:

a. remove rear axle housing group (oscillating)



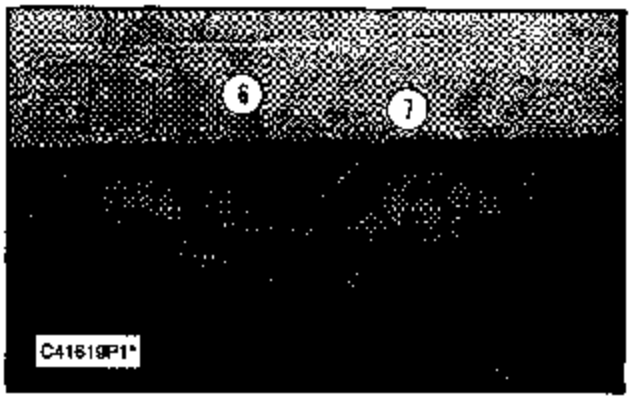
1. Remove the bolts and washers that hold cover (1) to the rear support. Remove the cover.



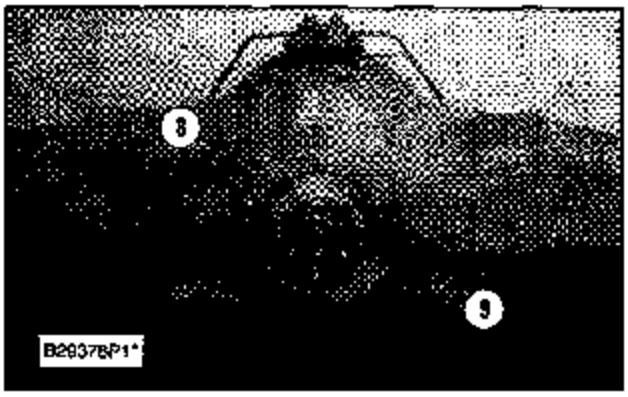
2. Fasten a hoist to the rear support.

3. Remove four bolts (2), the washers, thrust washer (3) and plate (4). Remove the thrust washer that is behind plate (4).

4. Remove the rear support. The weight of the rear support is **45 kg (100 lb)**.



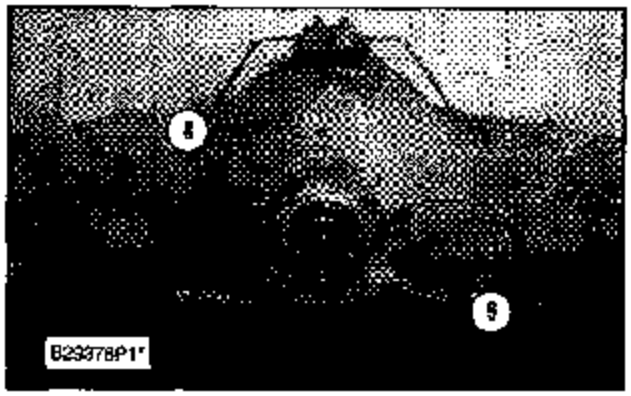
5. Remove lip seal (6) and sleeve bearing (7) from the rear support.



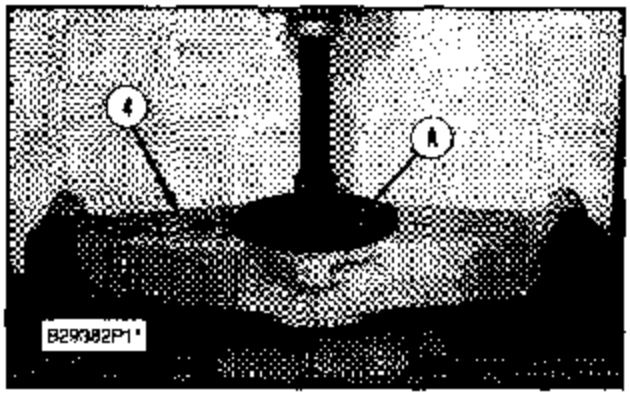
6. Remove bolts (8), the washers and trunnion (9). The weight of the trunnion is **20 kg (45 lb).**

Install Rear Support (Rear Axle Housing) 3268-012

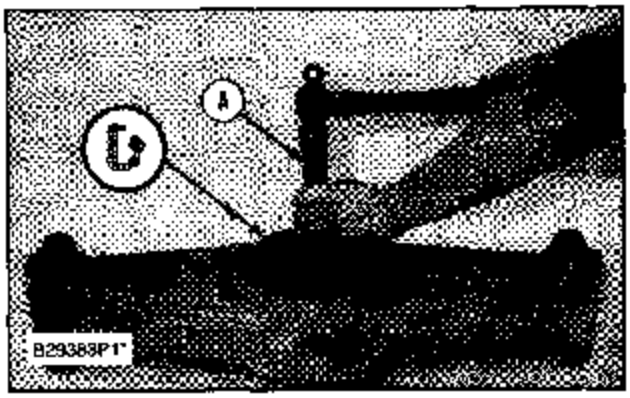
Tools Needed		A
1P0520	Driver Group	1



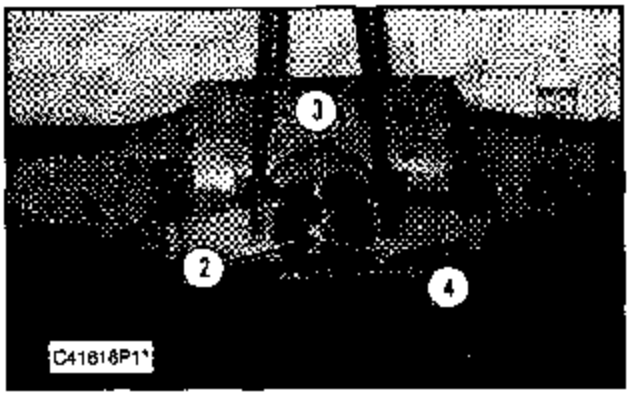
1. Put **6V6640 Gasket Maker** on the mating surface of trunnion (9) and the oscillating housing assembly. Put the trunnion in position on the oscillating housing assembly, and install bolts (8) and the washers which hold it. Tighten the bolts to a torque of **300 ± 40 N•m (220 ± 30 lb ft)**.



2. Use tool (A) and a press to install the sleeve bearing in the rear support.



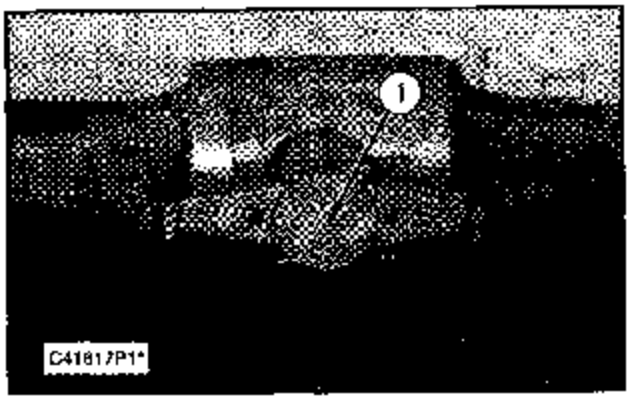
3. Use tool (A) to install the lip seal in the support. Be sure the lip is facing toward the outside of the rear support as shown.



4. Fasten nylon lifting straps and a hoist to the rear support. Put the rear support in position on the trunnion.

5. Put **5P0960 Multi-Purpose Grease** on the two thrust washers.

6. Install a thrust washer, plate (4), washers (3) and four bolts (2). Tighten four bolts (2) to a torque of **570 ± 80 N•m (420 ± 60 lb ft)**.



7. Install cover (1). Tighten the bolts that hold it to a torque of **270 ± 40 N•m (200 ± 30 lb ft)**.

End By:

a. install rear axle housing group (oscillating)

Axle Shaft Assemblies

Disassemble & Assemble Axle Shaft Assemblies 3260-017

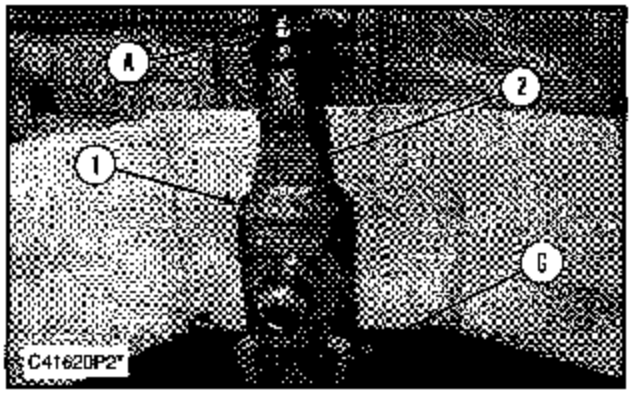
Tools Needed		A	B	C	D	E	F	G
6V2157	Link Bracket	2						
1P1863	Pliers		1					
6V2156	Link Bracket			3				
6V7820	Torque Multiplier				1			
4C8500	Spanner Wrench Assembly				1			
FT1183	Plate					1		
1U6436	Installer						1	
1P2420	Transmission Repair Stand							1

Start By:

a. remove front axle housing group (fixed)

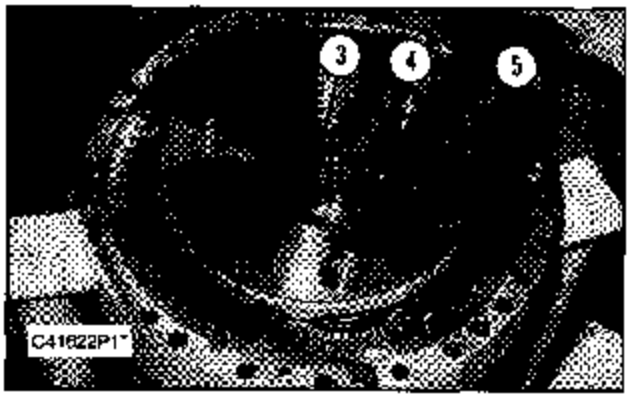
b. remove rear axle housing group (oscillating)

NOTE: The axle shaft assemblies used in the front and rear axle housing groups are similar. The removal, disassembly, assembly and installation procedures are the same for both axle groups.



1. Install the axle housing group on tool (G) in a vertical position as shown.

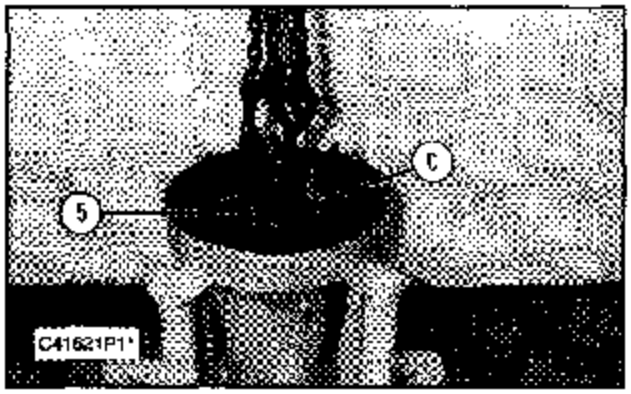
2. Fasten tool (A) and a hoist to the rim flange of the axle shaft as shown. Remove twenty six bolts (1) and the washers that hold axle shaft assembly (2) to the differential housing. Carefully remove the axle shaft assembly. The weight of the axle shaft assembly is **295 kg (650 lb).**



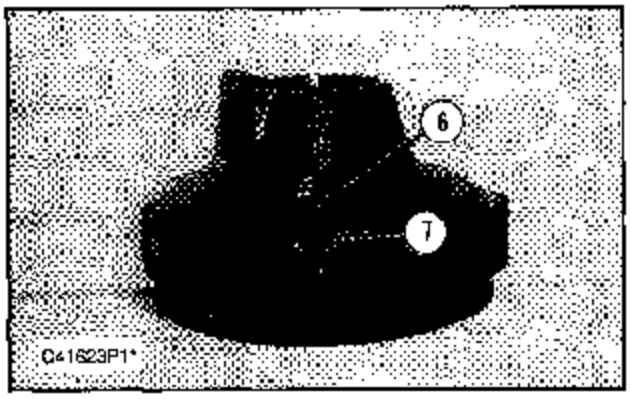
3. Remove the bottom half of the axle housing group from tool (G). Install axle shaft assembly (2) on tool (G) with planetary carrier assembly (5) facing up as shown.

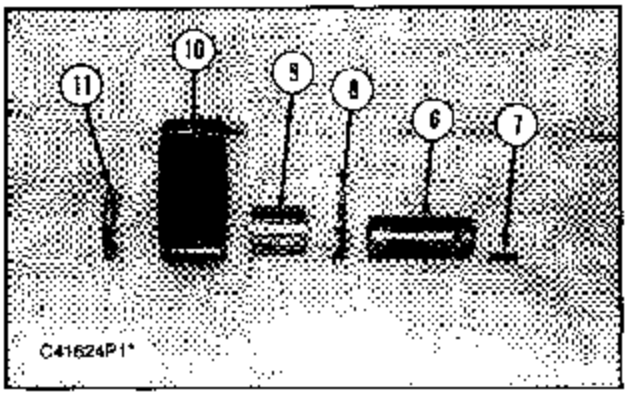
NOTE: To completely remove retaining ring (3) from the axle shaft assembly, planetary carrier assembly (5) must be removed and disassembled.

4. Use tool (B) to remove retaining ring (3) from the groove in the end of axle shaft (4). Position the retaining ring in the planetary carrier.



5. Fasten tool (C) and a hoist to planetary carrier assembly (5) as shown. Remove the planetary carrier assembly from the axle shaft housing. The weight of the planetary carrier assembly is **60 kg (175 lb).**





6. Disassemble planetary carrier assembly (5) as follows:

   a. Using a hammer and punch, push spring pin (7) all the way into shaft (6).

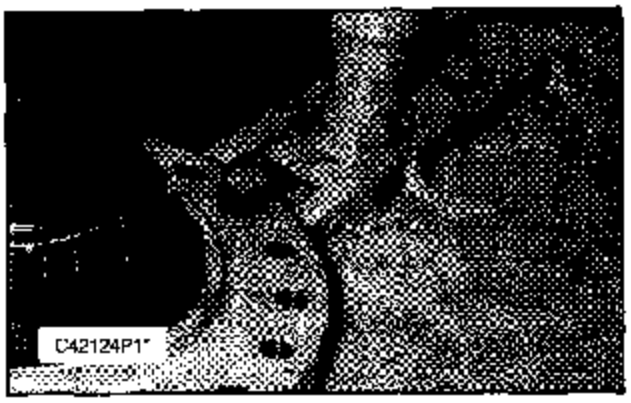
   b. Remove shaft (6), thrust washers (11) and (8) and planetary gear (10) from the carrier.

   c. Remove bearing (9) from planetary gear (10).

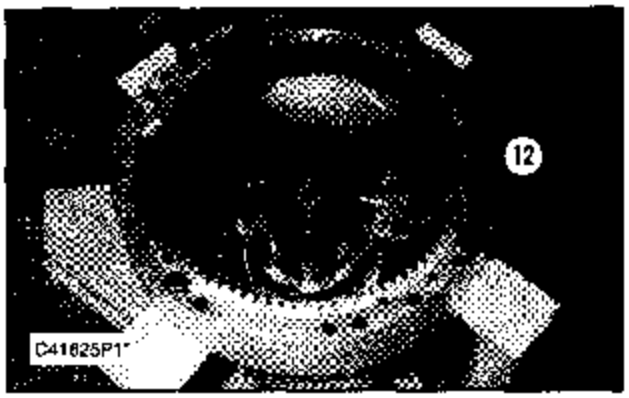
   d. Remove spring pin (7) from shaft (6) with a hammer and punch.

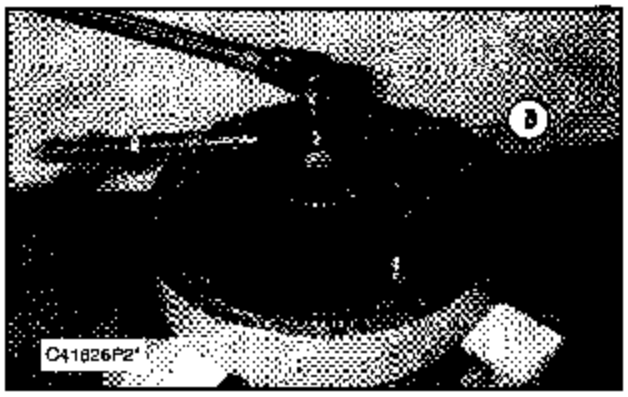
   e. Remove the other two planetary gears (10) from the carrier as in Steps 6a through 6d.

   f. Remove retaining ring (3) from the carrier.

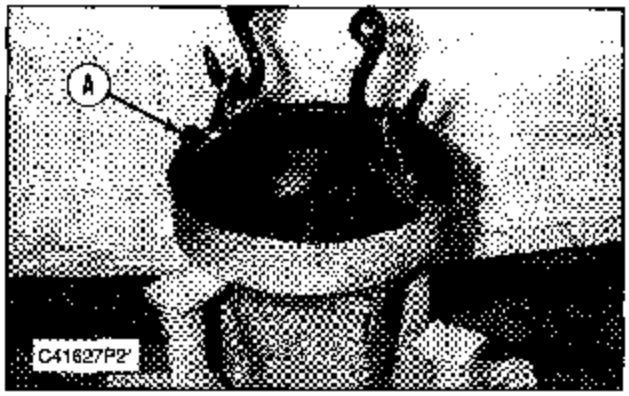


The axle shaft housing has been removed from the axle shaft for better photo illustration of mounting the axle shaft to tool (G).





7. Fasten the rim flange of the axle shaft to tool (G) with suitable size bolts as shown in above photo. Installation of the bolt will prevent the axle shaft from turning when bearing nut (12) is removed. Use tooling (D) to remove bearing nut (12) from the axle shaft.

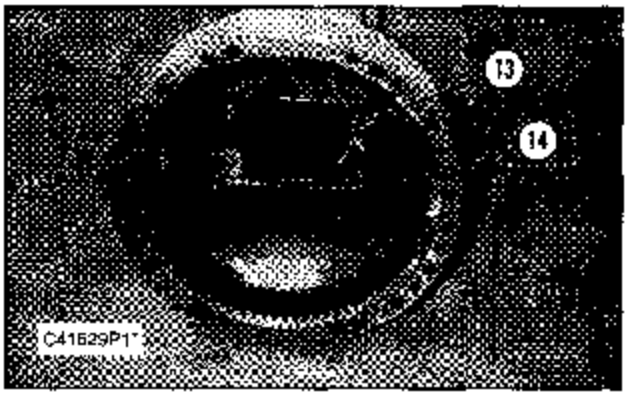


8. Fasten tooling (A) and a hoist to the axle shaft housing as shown. Put slight lifting tension on the axle shaft housing.

NOTE: The bearing cone, which is located under bearing nut (12), will be removed at the same time that the axle shaft housing is being removed from the axle shaft.

9. Fasten tool (E) to the axle shaft housing as shown. Put a hand operated hydraulic jack between tool (E) and the end of the axle shaft as shown. Operate the hydraulic jack to push the axle shaft housing and inner bearing cone off of the axle shaft. Remove the axle shaft housing and inner bearing cone from the axle shaft. The weight of the axle shaft housing is **105 kg (231 lb)**.

10. Remove the inner bearing cone from the axle shaft housing.

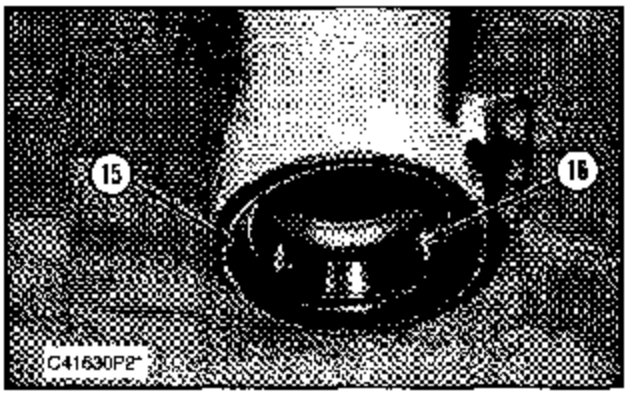


11. Remove inner bearing cup (13) from the axle shaft housing.

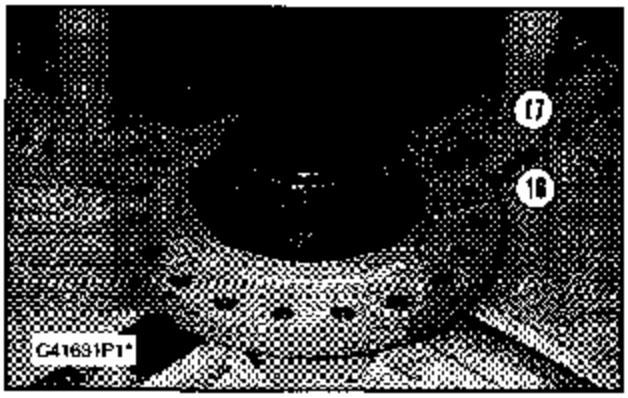
NOTICE

Ring gear (14) will be destroyed when it is removed from the axle shaft housing.

12. Remove ring gear (14) from the axle shaft housing. Using a torch, cut the ring gear in two places **180 degrees apart**. Cut the ring gear at the position of the locating dowels in the axle shaft housing. An alternate method is to make three welds equally spaced around the circumference of the ring gear to cause it to shrink. Remove the four locating dowels for ring gear (14).

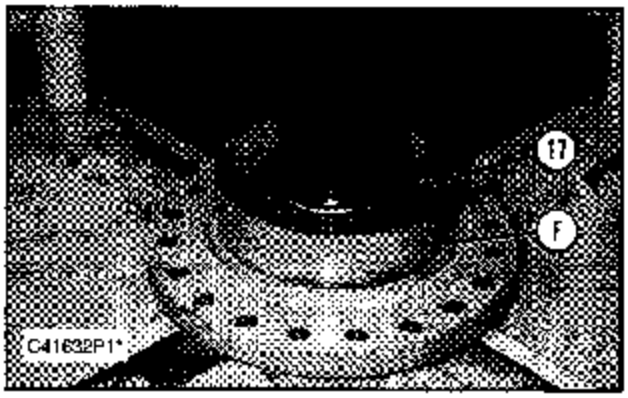


13. Remove Duo-Cone seal (15) and outer bearing cup (16) from the opposite end of the axle shaft housing.



14. Remove Duo-Cone seal (18) and outer bearing cone (17) from the axle shaft.

NOTE: The following steps are for the assembly of the axle shaft assemblies.



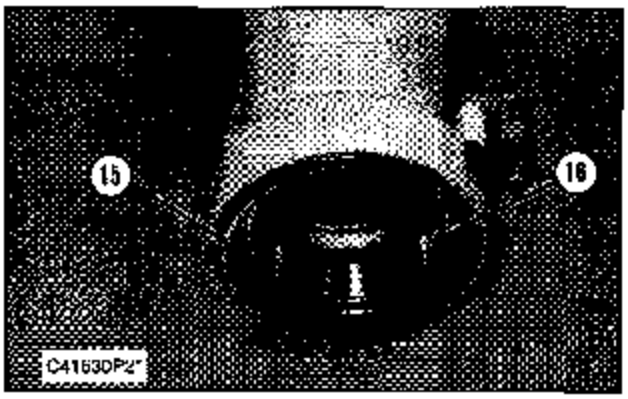
15. Fasten the rim flange of the axle shaft to tool (G) with suitable size bolts as shown. Heat outer bearing cone (17) to a maximum temperature of **135°C (275°F)**, and install the bearing cone on the axle shaft as shown. Be sure the bearing cone is seated against the shoulder on the end of the axle shaft. Allow the bearing cone and shaft to cool.

NOTICE

See, "Assembly And Installation Of Conventional Duo-Cone Seals" in this module.

NOTE: The rubber seals and all surfaces that make contact with the seals must be clean and dry. After installation of the seals, put clean **SAE 30 oil** on the contact surfaces of the metal seals.

16. Use tool (F) to install the Duo-Cone seal in the end of the axle shaft.



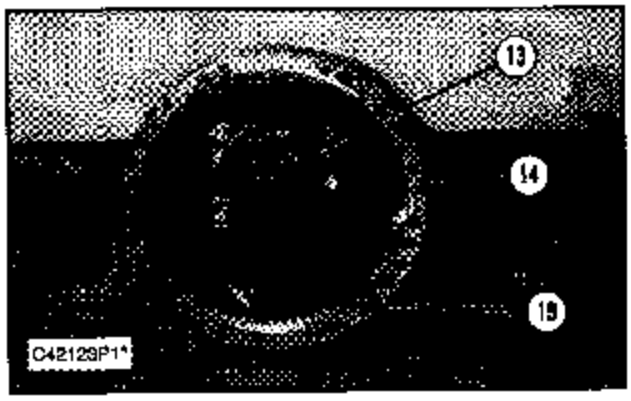
17. Lower the temperature of outer bearing cup (16), and install it in the end of the axle shaft housing as shown. Be sure the bearing cup is seated all the way down in the axle shaft housing.

NOTICE

See, "Assembly And Installation Of Conventional Duo-Cone Seals" in this module.

NOTE: The rubber seals and all surfaces that make contact with the seals must be clean and dry. After installation of the seals, put clean SAE 30 oil on the contact surfaces of the metal seals.

18. Use tool (F) to install the Duo-Cone seal in the end of the axle shaft housing.



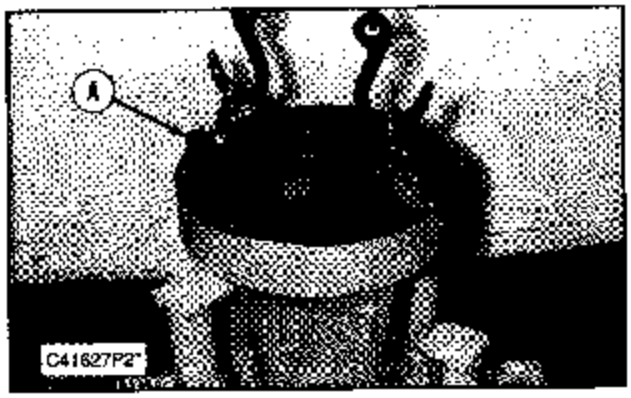
19. Lower the temperature of inner bearing cup (13), and install it in the opposite end of axle shaft housing as shown. Be sure the bearing cup is seated all the way down against the shoulder in the axle shaft housing.

NOTE: Four dowels (19) are used to locate and hold ring gear (14) in position in the axle shaft housing. The four dowels are not equally spaced.

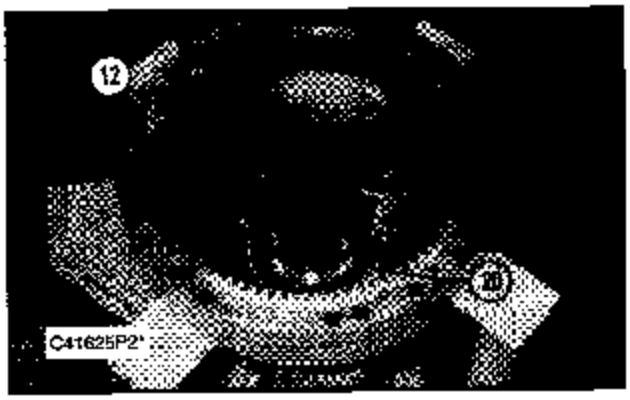
20. Locate the position of the ring gear in relation to the axle shaft housing by aligning the half holes for the four dowel. Put alignment marks on the ring gear and axle shaft housing to ensure correct installation.

21. Lower the temperature of ring gear (14) to a temperature of **-38°C (-36°F).** Install four dowels (19) in the half holes on the outside diameter of the ring gear. Use an O-ring seal or rubber band to hold the four dowels in position.

22. Using a press, install ring gear (14) in the axle shaft housing. Install the ring gear with the chamfered side down. As the ring gear is being pressed into the axle shaft housing, it will be necessary to tap four dowels (19) down along with the ring gear. After installation, the ring gear should be even or slightly below the machined surface of the axle shaft housing. The four dowels must be flush with the ring gear.



23. Put a thin coat of clean **SAE 30 oil** on the outer bearing cone on the end of the axle shaft and on the contact surfaces of the Duo-Cone seal on the end of the axle shaft and in the axle shaft housing. Fasten tool (A) and a hoist to the axle shaft housing as shown. Lower the axle shaft housing on to the axle shaft.



24. Heat inner bearing cone (20) to a maximum temperature of **135°C (275°F).** Install the inner bearing cone on the axle shaft with slight end play remaining. After the inner bearing cone cools, lubricate it with clean **SAE 30 oil.**

NOTICE

The adjusting nut (12) must be installed with side that has the part number facing away from inner bearing cone (20).

25. Put clean **SAE 30 oil** on bearing nut (12). Install bearing nut (12) on the axle shaft. Tighten the nut until only a small amount of end play remains in the axle shaft assembly.

26. Measure the torque required (also called "Seal Drag Torque" or SDT) to rotate the axle housing as follows:

a. Install a nut and bolt through one of the outer mounting bolt holes in the axle housing.

b. Install a **203 mm (8 in)** torque wrench on the bolt installed in Step 26a so that it is in line with the center of the axle shaft.

c. While turning the axle housing with the torque wrench, note the reading on the torque wrench, and calculate the actual seal drag torque with the following formula:

$$SDT = \frac{C \times (B + A)}{B}$$

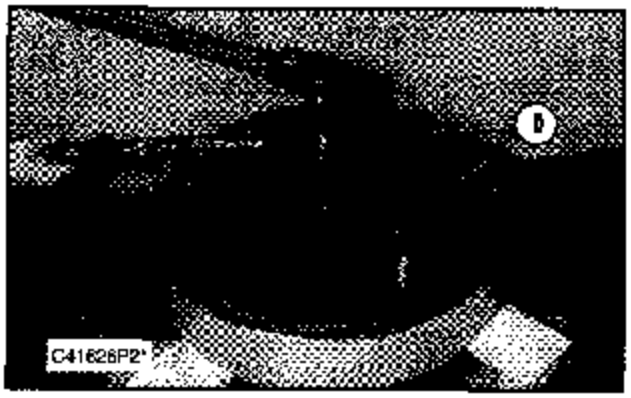
Where:

"SDT" is the actual seal drag torque (in N•m)

"C" is the reading on the torque wrench (in N•m).

"B" is the length of the torque wrench (in meters).

"A" is the bolt circle radius of the axle housing in meters and is equal to **.234 m (9.213 in)**.



27. While turning the axle housing with the torque wrench, tighten bearing nut (12) until the torque wrench reading calculated with the following formula is reached:

$$C = \frac{(T + SDT) \times B}{(B+A)}$$

Where:

"C" is the reading on the torque wrench (in N•m).

"B" is the length of the torque wrench (in meters).

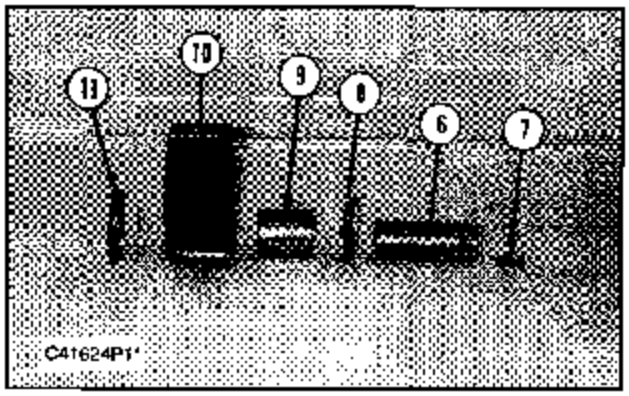
"A" is the bolt circle radius of the axle housing in meters and is equal to **.234 m (9.213 in)**.

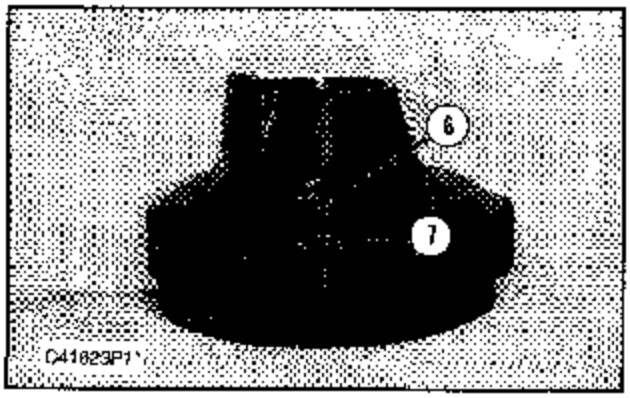
"T" is the rolling torque specification for axle bearing preload which is **10.4 to 11.6 N•m (92 to 103 lb in)**.

"SDT" is the actual seal drag torque (in N•m) from Step 26.

28. Check to be sure there is zero end play in the axle shaft.

29. If the axle bearing preload rolling torque exceeds the specification, back off bearing nut (12) by 1/8 turn, and reseat the bearing against the bearing nut. Perform Step 27 again.





30. Assemble planetary carrier assembly (5) as follows:

a. Install retaining ring (3) in the carrier.

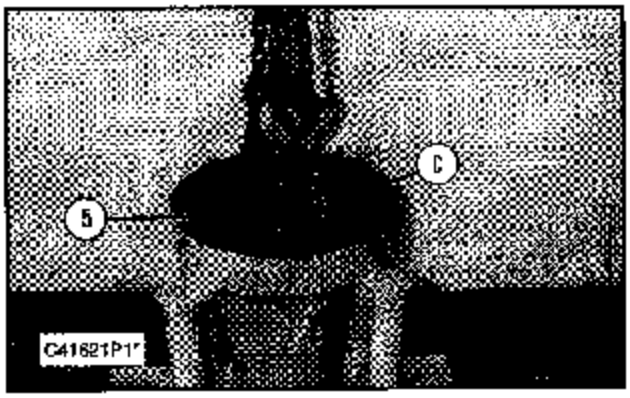
b. Put clean **SAE 30 oil** on all parts of planetary carrier assembly (5).

c. Install bearing (9) in planetary gear (10).

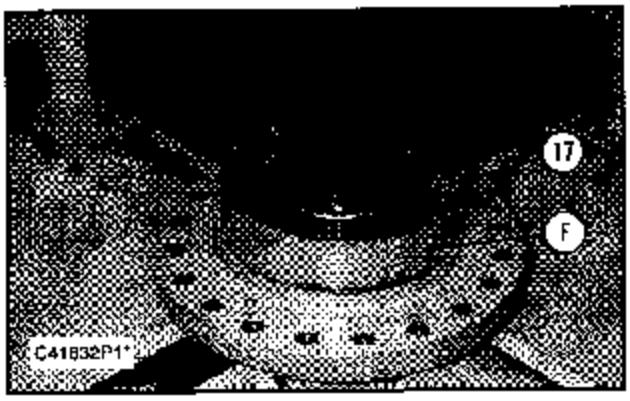
d. Put thrust washers (11) and (8) on each side of planetary gear (10), and install the planetary gear in the carrier.

e. Install shaft (6) in the carrier. Be sure the spring pin hole in the shaft is in alignment with the spring pin hole in the carrier. Install a new spring pin in the carrier and shaft. Install the spring pin slightly below the outside surface of the carrier.

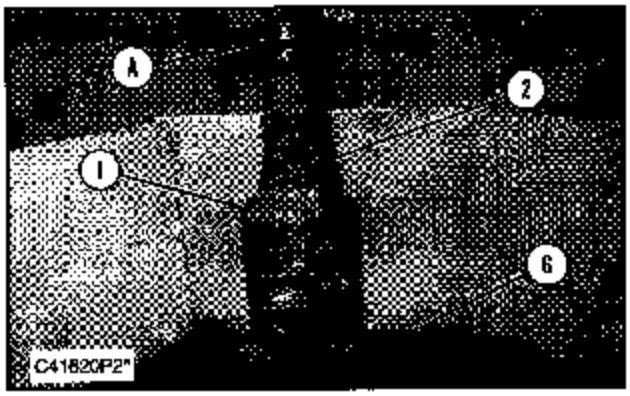
f. Install the other two planetary gears in the carrier as in Steps 30a through 30e.



31. Fasten tool (C) and a hoist to planetary carrier assembly (5). Lower the planetary carrier assembly into the axle housing. As the planetary carrier assembly is being lowered into position, align the flat on the hub of the planetary carrier assembly with the flat on bearing nut (12).



32. Use tool (B) to install retaining ring (3). Check to be sure the that the retaining ring is fully seated in the groove in the axle shaft.



33. Remove axle shaft assembly (2) from tool (G). Reinstall the bottom half of the axle housing group on tool (G).

34. Put **6V6640 Gasket Maker** on the machined surface of the axle shaft housing and on the intermediate housing assembly. Fasten tool (A) and a hoist to the rim flange on the axle shaft. Put axle shaft assembly (2) in position on the differential housing. Install twenty six washers and bolts (1) that hold it. Tighten the bolts to a torque of **300 ± 40 N•m (220 ± 30 lb ft)**.

End By:

a. install rear axle housing group (oscillating)

b. install front axle housing group (fixed)

Brake Groups

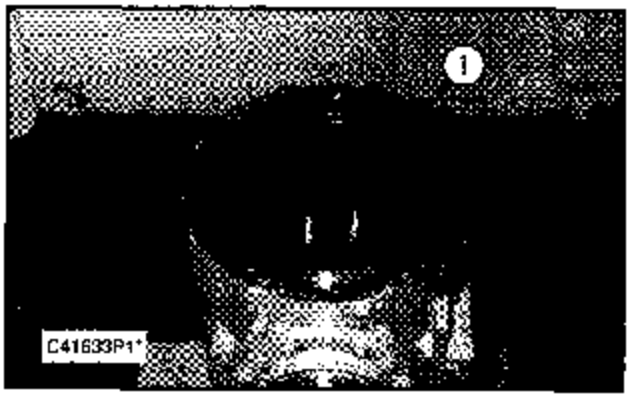
Remove & Install Brake Groups 4250-010

Start By:

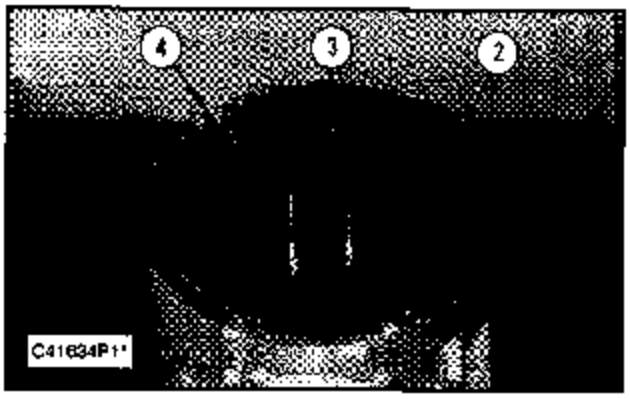
a. remove front axle housing group (fixed)

NOTE: There are only front brakes on the 815F. The rear oscillating axle is not equipped with brakes.

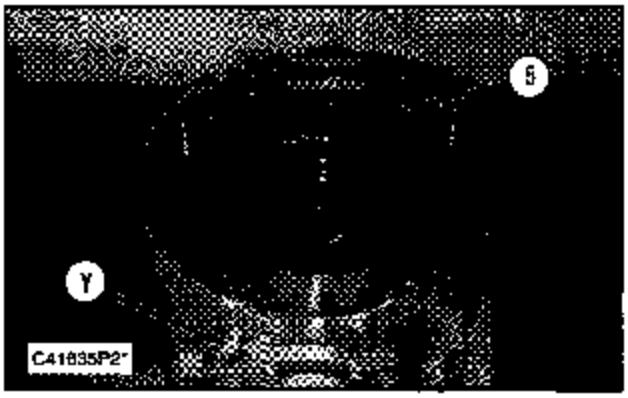
1. Remove the axle shaft assembly. See "Disassemble & Assemble Axle Shaft Assemblies" in this module.



2. Remove reaction plate (1).



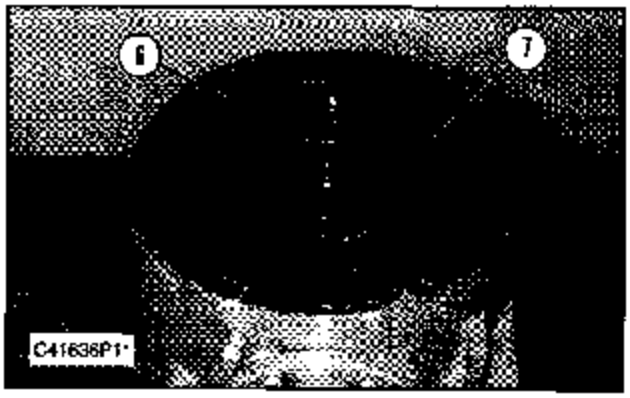
3. Remove three springs (2), sun gear (3) and friction disc (4).



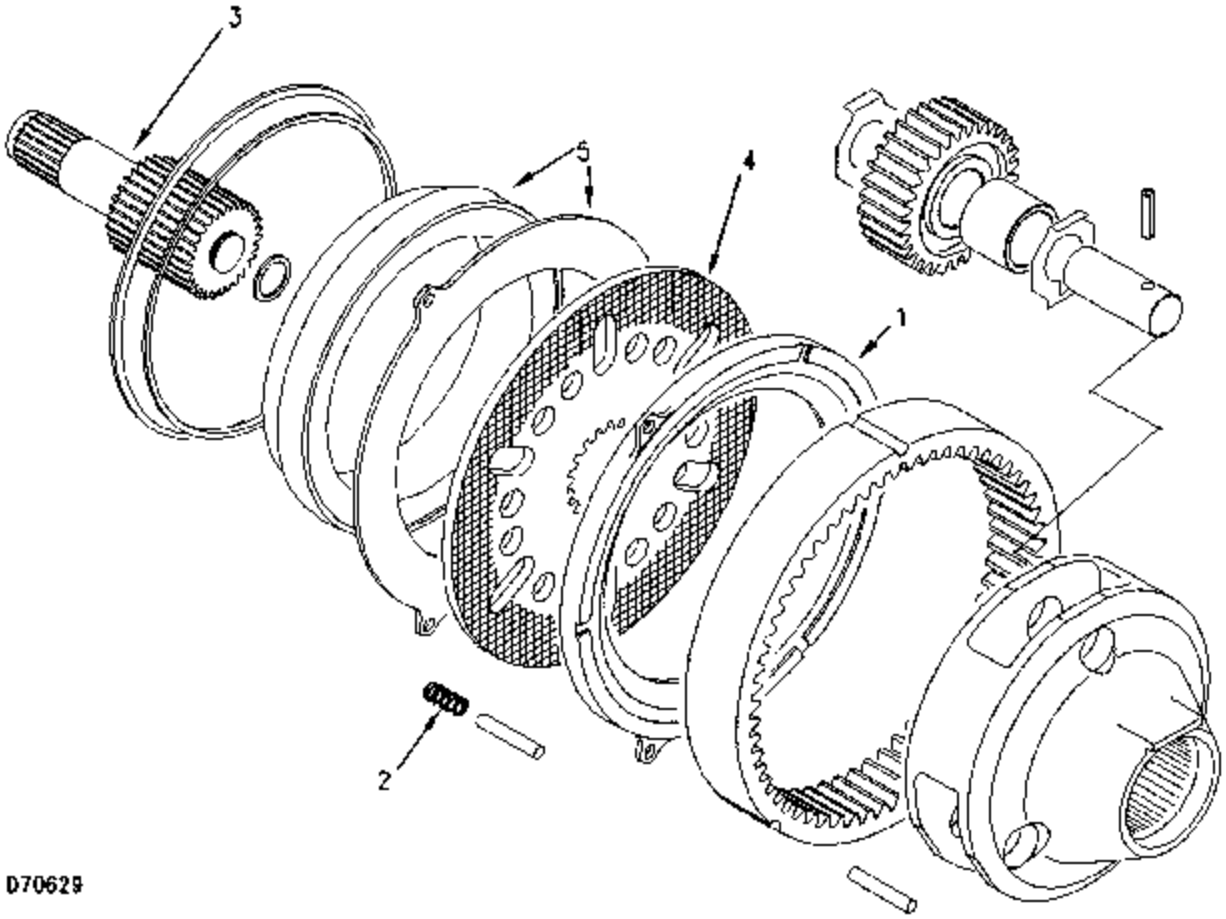
⚠ WARNING

Brake piston (5) must be removed from the intermediate housing assembly with shop air pressure. The brake piston can come out of the intermediate housing assembly with force during the removal procedure. To prevent possible personal injury, the brake piston must be retained in the intermediate housing assembly when applying shop air pressure.

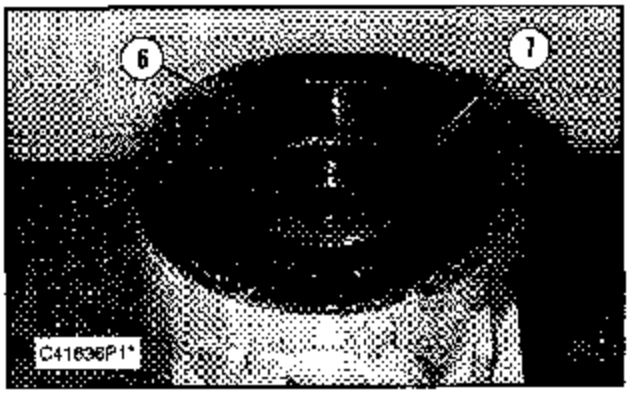
4. While retaining the brake piston, apply shop air pressure (free of water) of **approximately 525 kPa (75 psi)** to fitting (Y). Brake piston (5) will move up and out of the intermediate housing assembly.



5. Remove seal (6) and seal assembly (7) with the back-up ring.



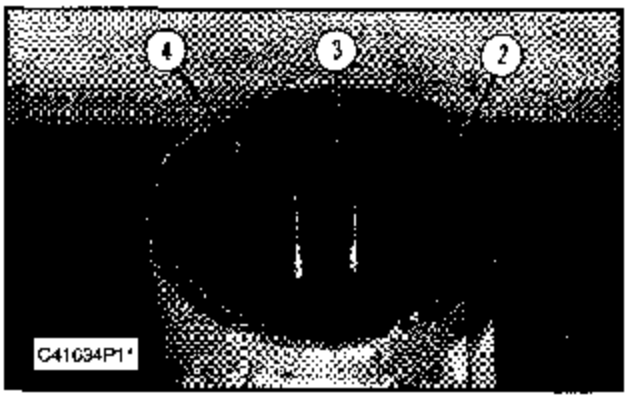
NOTE: The following steps are for the installation of the brake group.



NOTE: Lubricate all seals with **SAE 30 oil**.

6. Install seal (6) and seal assembly (7) with the back-up ring. Seal assembly (7) consists of an L-shaped seal and a back-up ring. Put the L-shaped seal with the flat side towards the differential. Put the back up ring in position away from the differential.

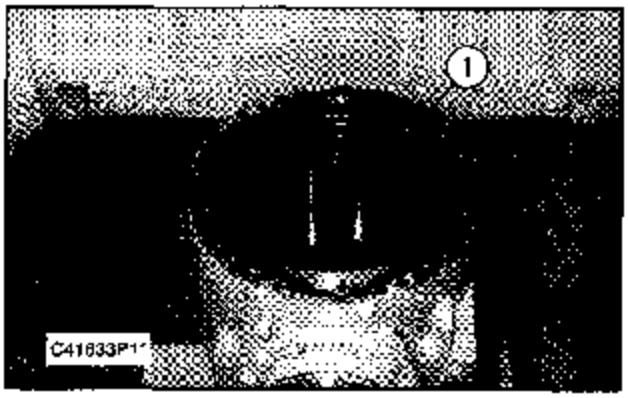
7. Install piston (5) in the intermediate housing assembly.



NOTICE

The continued use of the friction disc with **7.65 mm (.301 in) or less** of friction material (depth of oil groove) will result in accelerated wear. Do not use the disc color as an indication for wear, the overall thickness and groove depth are more important.

8. Inspect friction disc (4) for wear. Replace the friction disc if the friction material thickness is **7.65 mm (.301 in) or less**. Immerse the friction disc in clean **SAE 30 oil.** Install friction disc (4), sun gear (3) and three springs (2).



9. Install reaction plate (1).

10. Install the axle shaft assemoly. See "Disassemble & Assemble Axle shaft Assemb-ies" in this module.

End By:

a. install rear axle housing group (oscillating)

b. install front axle housing group (fixed)

Differentials & Pinion Assemblies

Remove & Install Differentials & Pinion Assemblies 3280-010

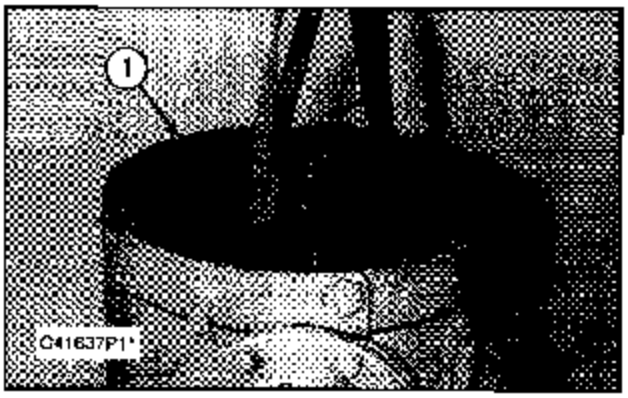
Tools Needed		A	B	C	D	E	F
6V2156	Link Bracket	2					
6V2157	Link Bracket		2				
8B7551	Puller Assembly			1			
5F7343	Puller Assembly				1		
4C8348	Wrench Assembly					1	
4C8349	Wrench Assembly						1

Start By:

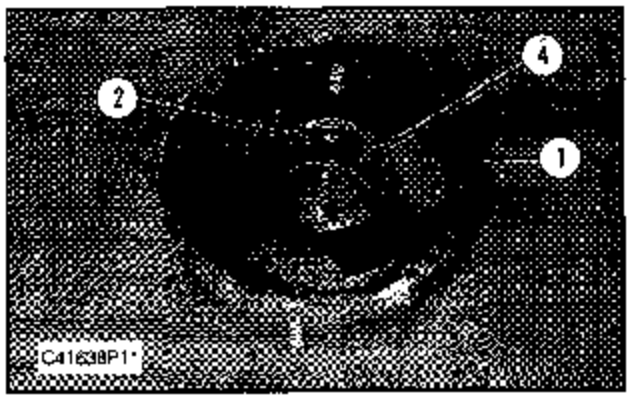
a. remove front axle housing group (fixed)

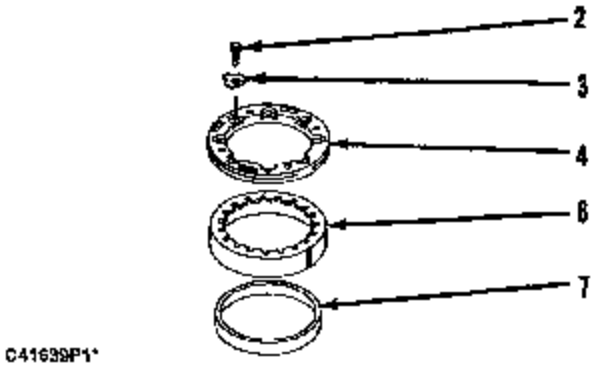
b. remove rear axle housing group (oscillating)

1. Remove one of the brake groups from the axle housing group. See the topic, "Remove & Install Brake Groups" in this module.



2. Faston a hoist to intermediate housing assembly (1) as shown. Remove the four bolts that hold intermediate housing assembly (1) to the differential center housing. Remove the intermediate housing assembly. The weight of the intermediate housing assembly is **57 kg (125 lb)**.

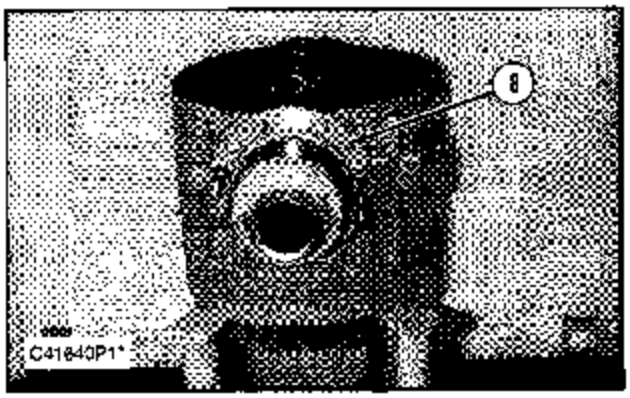




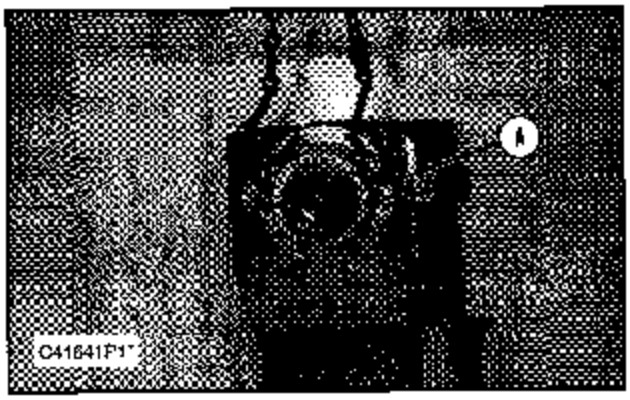
3. Remove bolt (2) and washer (3).

NOTE: Two different size adjusting nuts are used in the bevel gear group. Use tool (E) or (F) to remove the appropriate size adjusting nuts.

4. Use appropriate tool, tool (E) or (F), to remove adjusting nut (4). Remove the pin, sleeve (6) and bearing cup (7) from intermediate housing assembly (1).

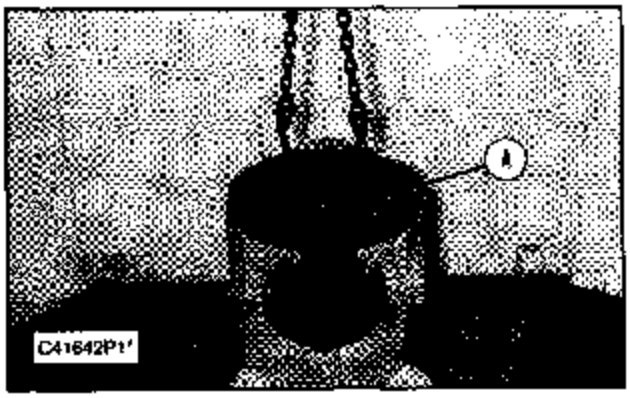


5. Remove two of the bolts (8), located **180 degrees apart** from each other, that hold the pinion assembly to the differential center housing. Install two suitable size guide bolts that are approximately **152.4 mm (6.00 in) long** in the bolt holes as shown.

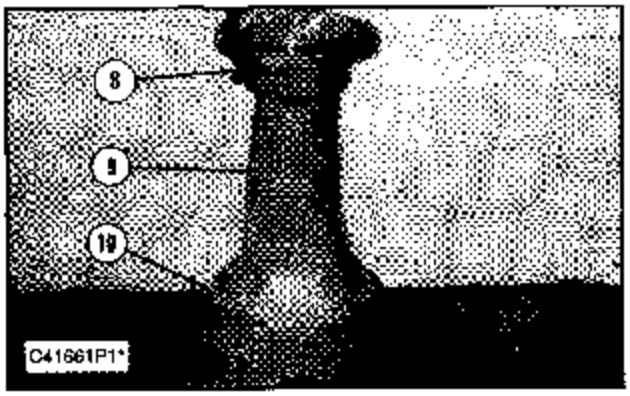


6. Remove the remaining bolts (8) that hold the pinion assembly to the differential center housing. Slide the pinion out on the guide bolts far enough to install tool (A). Fasten a hoist to the pinion assembly as shown.

7. Remove the pinion assembly from the differential center housing. The weight of the pinion assembly is **66 kg (145 lb)**. Remove the shims and O-ring seal from the pinion housing.



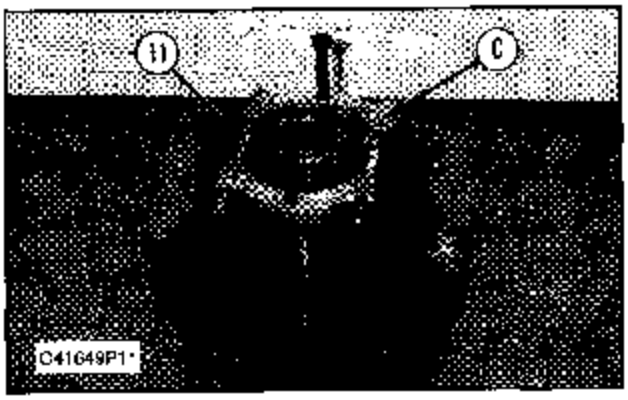
8. Fasten tool (A) and a hoist to the differential as shown. Carefully lift the differential out of the differential center housing. The weight of the differential is **109 kg (240 lb)**.



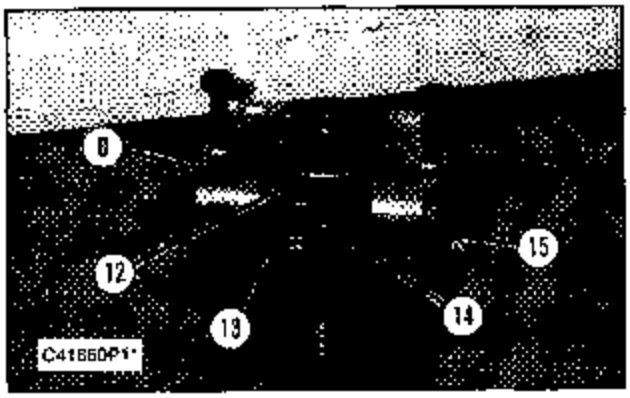
9. Turn the remainder of the axle housing group over, and fasten it to the transmission repair stand. Fasten tool (B) and a hoist to the rim flange on axle shaft assembly (9) as shown. Remove twenty six bolts (10) and the washers that hold the axle shaft assembly to the differential center housing. Remove the axle shaft assembly. The weight of the axle shaft assembly is **295 kg (650 lb)**.

10. Remove the brake group from the differential center housing. See "Remove & Install Brake Groups" in this module.

11. Repeat Steps 2 through 4 to remove and disassemble the other intermediate housing assembly (1) that is on the differential center housing.



12. Remove bearing cone (11) from the differential with tool (C).

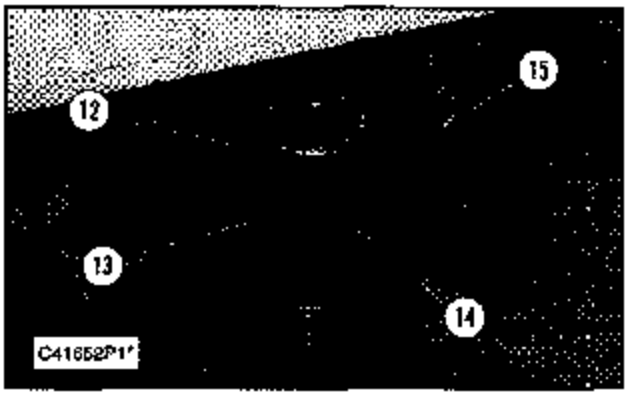


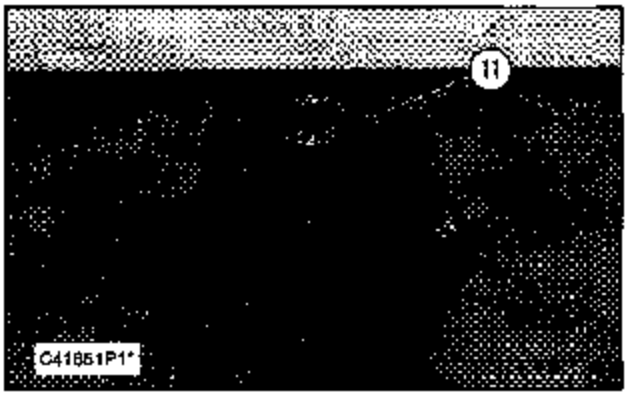
13. Turn the differential over, and remove bearing cone (12) with tool (D).

14. Use a press to remove the four large spring pins and four small spring pins (13) from the differential.

15. Remove sixteen bolts (14) that hold bevel gear (15) in position. Using a press, remove bevel gear (15) from the differential.

NOTE: The following procedure is for the installation of the differential and pinion assembly. Also, the following procedure controls bearing preload and gives the same results for new or used bearings.



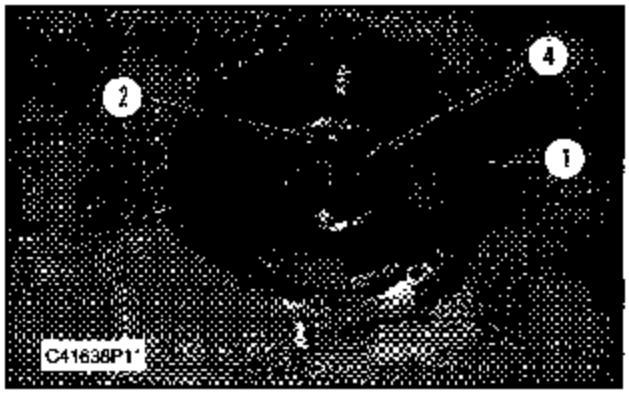


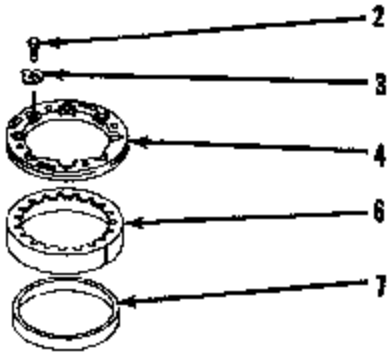
16. Heat bevel gear (15) to a temperature of **135°C (275°F) for a maximum of four hours**. Install the bevel gear on the differential.

17. Install four large pins (13) partially into bevel gear (15). Install four small pins (13) into the larger pins. Press the pins into bevel gear (15) until they are even with the outside surface of the bevel gear. Install sixteen bolts (14) that hold the bevel gear to the differential. Tighten bolts (14) to a torque of **285 ± 40 N•m (210 ± 30 lb ft)**. Tighten each bolt an additional **120 degrees ± 5 degrees.** Check to be sure the bevel gear is seated on the differential group shoulder.

18. Press bearing cone (11) and bearing cone (12) on the differential case. Check for full seating of the bearing cones.

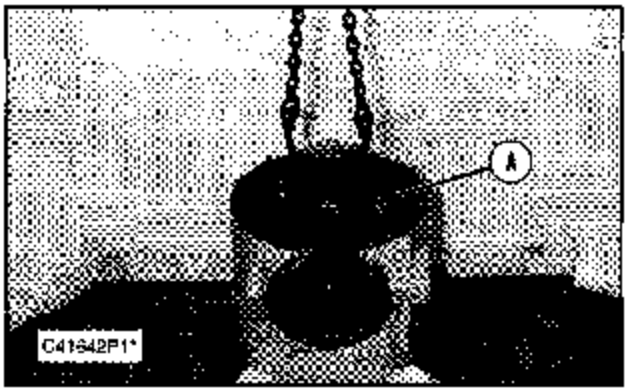
NOTE: Cup freezing or cone heating may be used if cups or cones are reset with a driver or press after the parts have reached a uniform temperature. Limit cone heating to **135°C (275°F) maximum for a maximum of 4 hours**. Lubricate the bearings after they have cooled to prevent rusting.



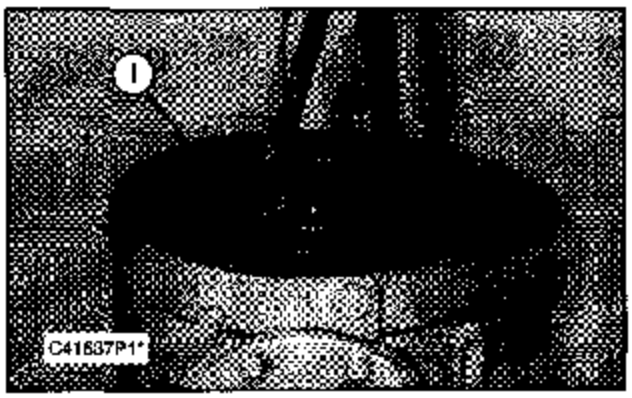


19. Install bearing cup (7), sleeve (6) and the pin in the intermediate housing. Lubricate the threads on adjusting nut (4), and install it in intermediate housing assembly (1).

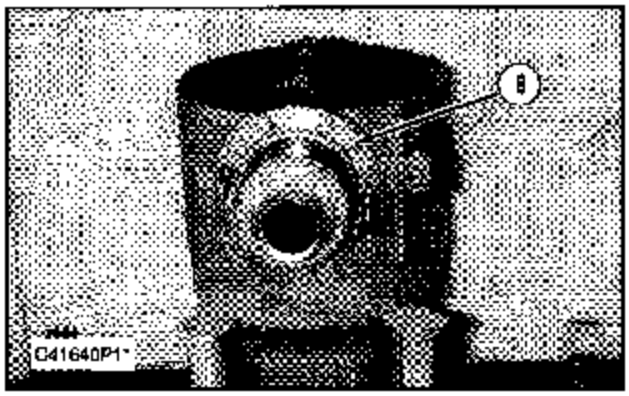
20. Assembly the other intermediate housing (1) as in Step 19.

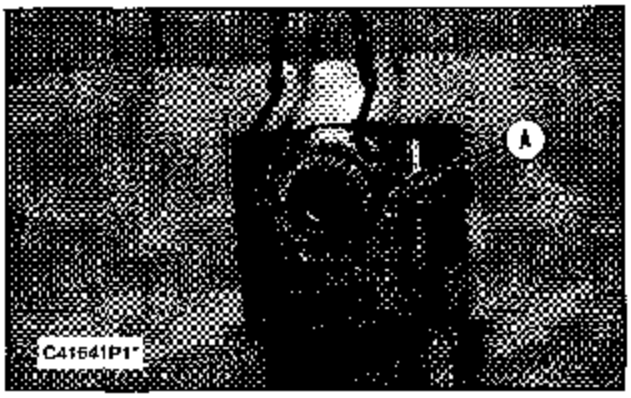


21. Position the differential center housing on a transmission repair stand with the open side facing upward. Fasten tool (A) and a hoist to the differential, and lower it on to the three dowels in the differential center housing.



22. Fasten a hoist to intermediate housing assembly (1). Install the intermediate housing assembly on the differential center housing. Install and tighten the four bolts that hold it.



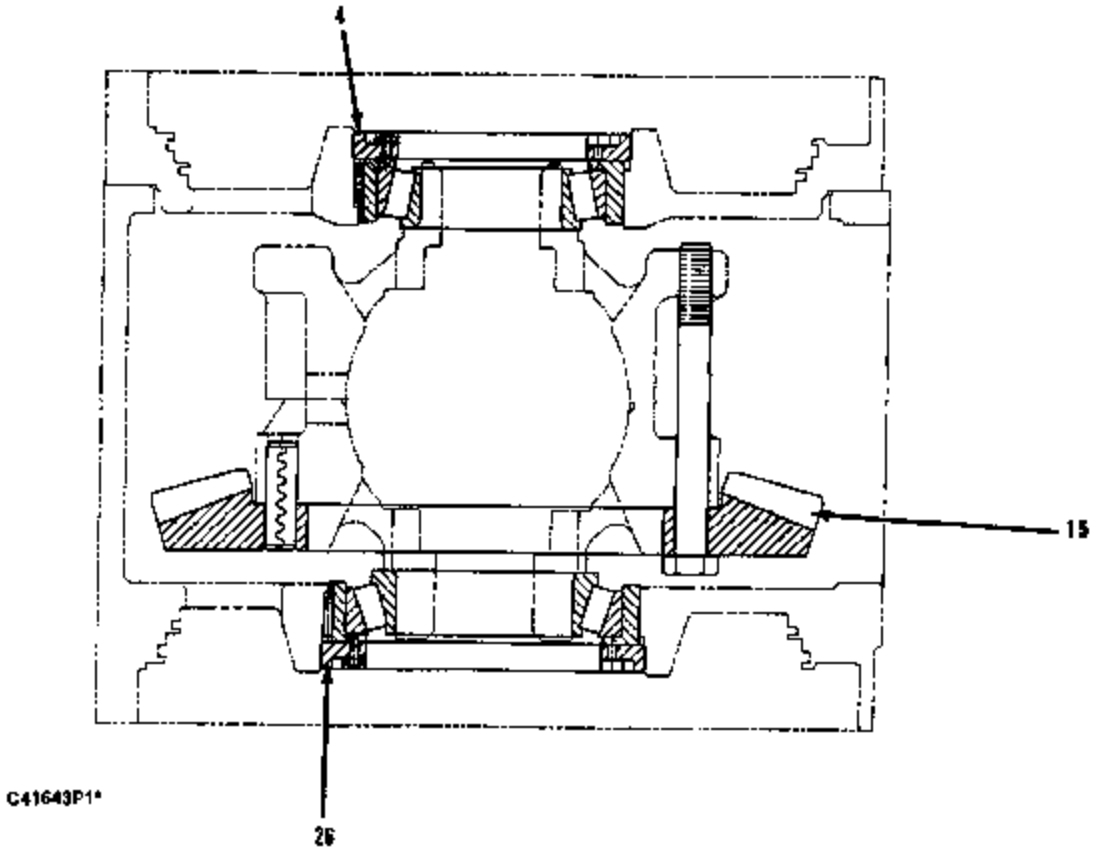


NOTE: Use the original thickness of shims or a new shim pack measured to the same thickness as the original pack. If the original shim pack is not available, use 70% of a new shim pack.

23. Lubricate and install the O-ring seal used on the pinion housing. Install the original shim pack on the pinion housing. Install the two guide bolts in the differential center housing. Fasten tool (A) and a hoist to the pinion assembly, and install it in the differential center housing. Install twelve bolts (B) that hold the pinion assembly in position. Tighten the bolts to a torque of **300 ± 40 N•m (220 ± 30 lb ft)**.

NOTE: The shim pack thickness may have to be changed when adjusting the tooth contact pattern between the bevel gear and pinion shaft.

24. Reposition the differential center housing on the transmission repair stand so the differential center housing and the pinion assembly are horizontal (the same position as they are in the vehicle).



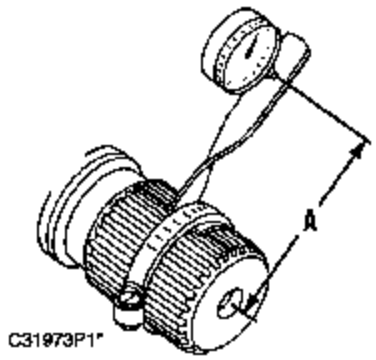
25. Tighten adjusting nuts (4) and (26) with tool (E) and (F) to a position that maintains gear backlash (but not tight gear mesh) and a slight bearing end play.

26. Measure the torque required to rotate the pinion shaft. Record the measured torque. Use a **1U6690 Socket** on the pinion shaft nut for this measurement.

27. While rotating the pinion shaft back and forth, tighten adjusting nut (26) to zero backlash position. Then back off adjusting nut (26) **20 degrees plus the increment to the nearest lock position**.

28. Tighten adjusting nut (4) while rotating the pinion shaft. Tighten nut (4) until a torque increase of **0.2 to 0.6 N•m (2.0 to 5.0 lb in)** over the torque recorded in Step 26 is measured. This is the seated position.

29. Tighten adjusting nut (4) **60 degrees plus the increment to the nearest lock position.**



Pinion Shaft Spline (backlash measurement)
(A) Distance of dial indicator from pinion centerline.

NOTE: As a check for correct assembly and adjustment, the rolling torque of the bevel gear group measured at the pinion shaft should be **1.8 to 3.6 N•m (16 to 32 lb in)** for new bearings and **0.9 to 1.8 N•m (8 to 16 lb in)** for used bearings.

30. Measure the backlash between bevel gear (15) and the pinion shaft. The backlash must be **0.30 + 0.12 - 0.10 mm (.011 + .005 -.004 in).** Do this by placing a dial indicator (as shown) tangent to the spline, being sure the yoke or spline adapter is tight to the spline.

31. The following chart gives examples of backlash at the pinion shaft, by showing the different distances from the pinion centerline to the dial indicator:

EXAMPLES OF BACKLASH AT PINION SHAFT			
Dimension (A) mm (in)	Nominal Backlash mm (in)	Maxium Backlash mm (in)	Minimum Backlash mm (in)
50 (2)	0.28 (.011)	0.40 (.016)	0.18 (.007)
100 (4)	0.55 (.022)	0.80 (.032)	0.35 (.014)
150 (6)	0.83 (.033)	1.20 (.047)	0.53 (.021)
200 (8)	1.10 (.043)	1.60 (.063)	0.70 (.028)

32. If the backlash does not meet specifications, loosen one adjusting nut the same amount as the opposite adjusting nut is tightened. This will maintain the bearing preload.

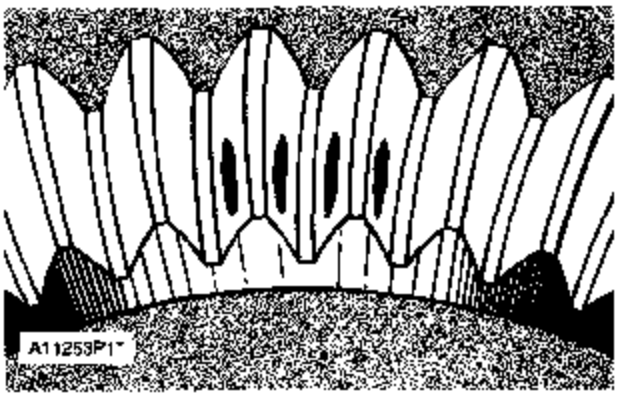


Illustration A

33. After the backlash and preload adjustments have been made, the tooth contact between pinion shaft and bevel gear (15) must then be checked. Do the procedure that follows:

a. Put a small amount of Prussian blue, red lead or paint on three or four adjacent teeth of bevel gear (15).

b. Rotate the pinion shaft several revolutions in one direction and then several revolutions in the opposite direction. Then turn pinion shaft in one direction until the marked teeth can be seen.

c. The correct area of tooth contact starts near the inside end of the teeth of bevel gear (15) and goes a maximum of 50% of the length of the teeth. See Illustration A for an example of the correct area of tooth contact.

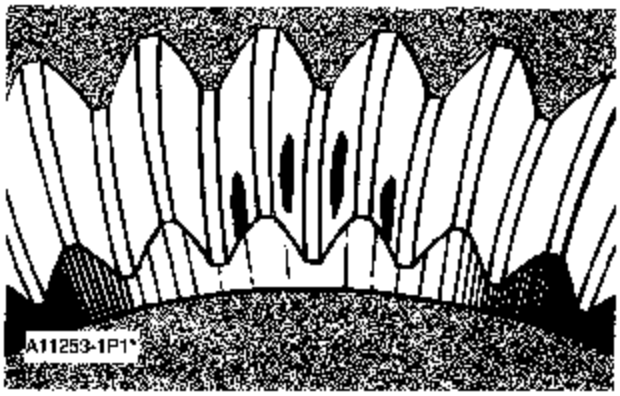


Illustration B

34. If the tooth contact looks like the marks in Illustration B, do the procedure that follows:

a. Remove some of shims from behind the pinion housing.

b. Do Steps 29, 30 and 31 for the backlash adjustment procedure again.

c. Do Step 32 again.

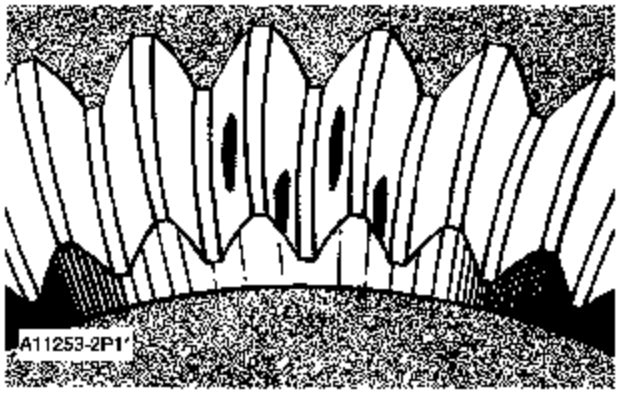


Illustration C

35. If the tooth contact looks like the marks in Illustration C, do the procedure that follows:

a. Add shims behind the pinion housing.

b. Do Steps 29, 30 and 31 again.

c. Do Step 32 again.

NOTE: Always be sure the backlash adjustment is correct before an adjustment is made to the area of tooth contact. Several adjustments to the backlash and tooth contact may be necessary to get the correct adjustments. Always remember that a change to gear clearance (backlash) will also change the gear contact. A change in gear contact will also change gear clearance (backlash).

36. After adjustments are made, remove the Prussian blue, red lead or paint from the gears.

37. Install one bolt and lock (2) in each adjusting nut (4) and (26), tighten both bolts and bend the locks.

38. Install the brake groups and the axle shaft assemblies on the differential center housing. See the topic, "Remove & Install Brake Groups" and "Disassemble & Assemble Axle Shaft Assemblies" in this module.

End By:

a. install rear axle housing group (oscillating)

b. install front axle housing group (fixed)

Pinion Assemblies

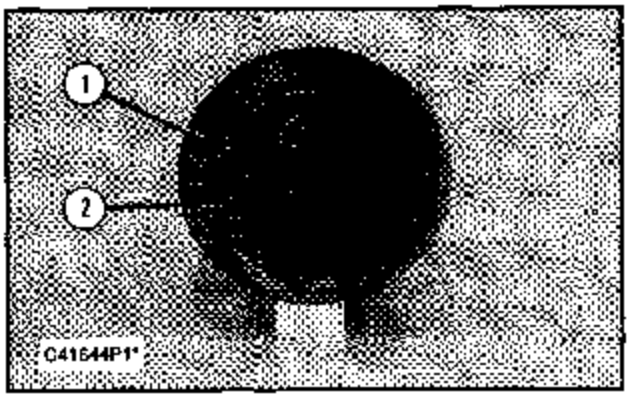
Disassemble Pinion Assemblies 3254-015

Tools Needed	A
1U6690 Socket	1

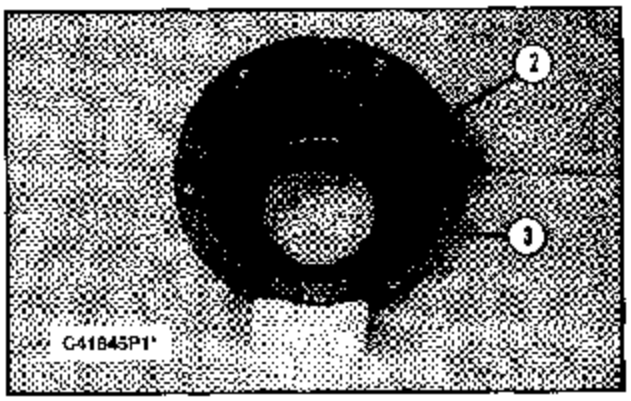
Start By:

a. remove differentials and pinion assemblies.

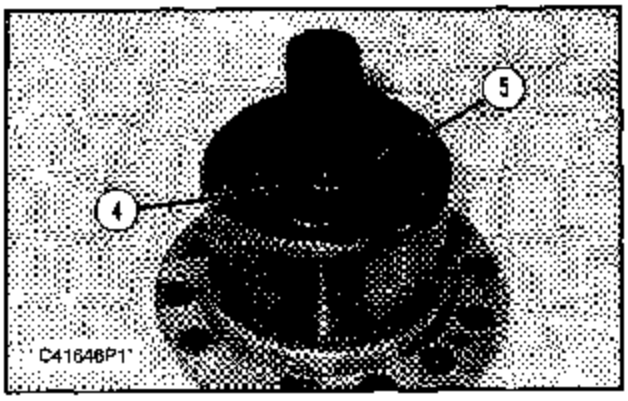
NOTE: The disassembly procedure is the same for the front and rear pinion assemblies.

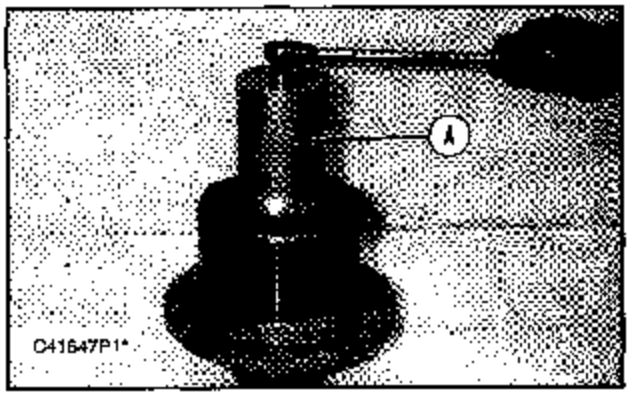


1. Remove six bolts (1) and the washers that hold retainer (2) to the pinion housing. Remove the retainer.



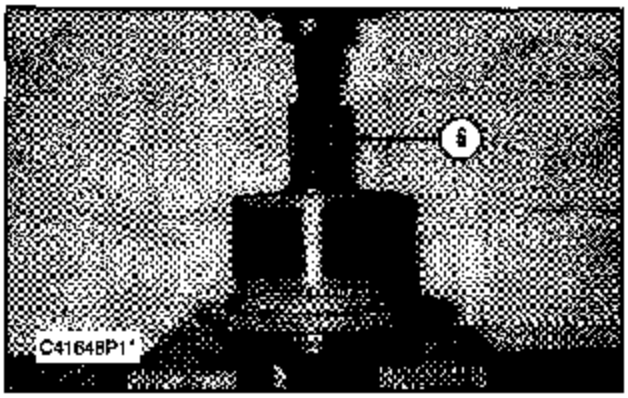
2. Remove lip seal (3) from retainer (2).



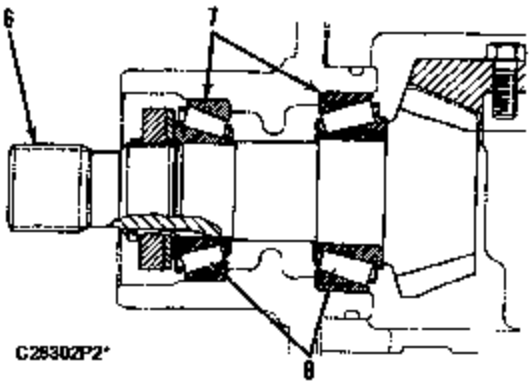


3. Bend crimp (4) away from the slot in the pinion shaft with a hammer and punch.

4. Use tool (A) to remove nut (5) from the pinion shaft.



5. Using a press, remove pinion shaft (6) from the pinion housing.

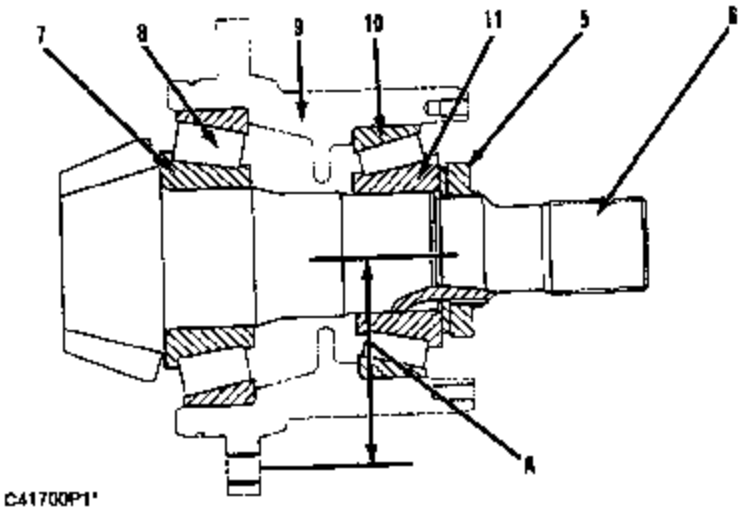


6. Remove bearing cones (8) and bearing cups (7) from the pinion housing.

Assemble Pinion Assemblies 3254-016

Tools Needed	A
1U6690 Socket	1

NOTE: The same assembly is used for both the front and rear pinion assemblies.



NOTE: Cup freezing or cone heating may be used if cups or cones are reset with a driver or press after parts have reached a uniform temperature. Limit cone heating to **135°C (275°F) maximum for a maximum of 4 hours**. Lubricate bearings after they have cooled to prevent rusting.

1. Install bearing cups (8) and (10) in pinion housing (9). The bearing cups must be seated against the shoulders in pinion housing (9).
2. Install bearing cone (7) on pinion (6). Bearing cone (7) must be against (seated) the shoulder on pinion (6). Lubricate bearing cone (7).
3. Install pinion (6) in housing (9). Press bearing cone (11) into place leaving a small amount of end play. Lubricate bearing cone (11). Lubricate and install the washer and nut (5).
4. Position the assembly vertically in a soft jawed vise. Tighten the vise against the teeth on pinion shaft (6). Install an appropriate size bolt and nut through an outer mounting bolt hole in pinion housing (9).
5. Place a **203 mm (8.0 in)** torque wrench on this bolt so that it is in line with the center of pinion shaft (6).
6. While turning pinion housing (9) with the torque wrench, tighten nut (5) until the torque wrench reading in the following chart is reached.

PINION ROLLING TORQUE		
	Actual Torque At The Pinion	Torque Wrench Reading
New Bearings	0.9-18 N•m (8-16lb in)	0.5-1.1 N•m (5-10 lb in)
Used Bearings	0.45-0.90 N•m (4-8 lb in)	0.25-0.55 N•m (2.5-5.0 lb in)

*When using a 203 mm (8.0 in) torque wrench.

Check to be sure that there is zero end play of pinion shaft (6).

7. If pinion rolling torque exceeds the specification, back off nut (5) ⅛ turn, and reseat bearing cone (11) and the washer against nut (5). Perform Steps 5 and 6 again.

NOTE: If any other length torque wrench is used, find the torque wrench reading by using the following formula:

$$C = \frac{B \times T}{B + A}$$

Where:

"C" is the reading on the torque wrench (in N•m).

"B" is the length of the torque wrench (in meters).

"A" is the bolt circle radius of pinion housing (9) in meters and is equal to **0.135 m (5.31 in).**

"T" is the rolling torque specification for pinion bearing preload which is **0.9 to 1.8 N•m (8 to 16 lb in).**

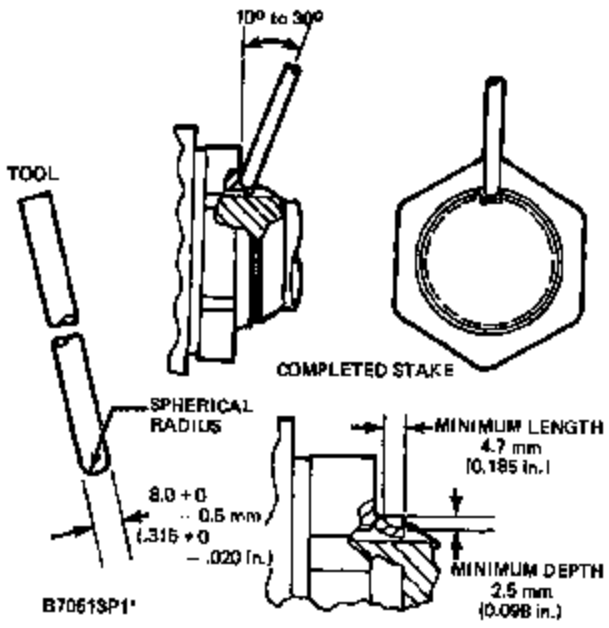
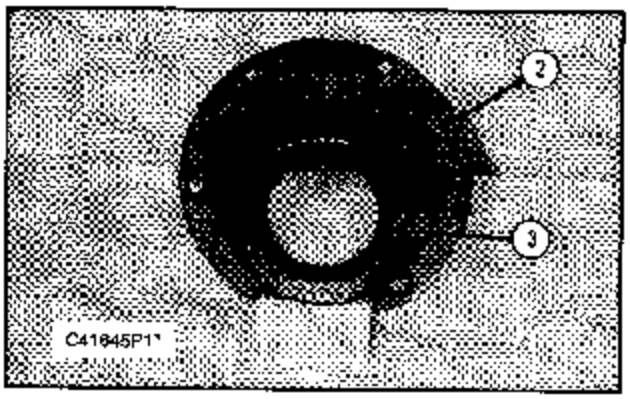


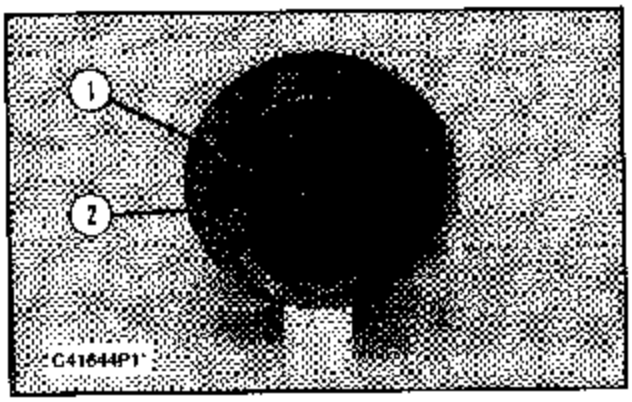
Illustration A

8. When the torque needed to turn the pinion is correct, stake nut (5) by peening the collar on the nut into the key slot in pinion shaft (6). See Illustration A for the correct tooling and dimensions.

NOTE: The nut may be reused if the collar is not cracked during removal or restaking.



9. Install lip seal (3) in retainer (2) with the lip of the seal facing toward the outside of the pinion housing.



10. Put retainer (2) in position on the pinion housing, and install six bolts (1) and the washers which hold it.

End By:

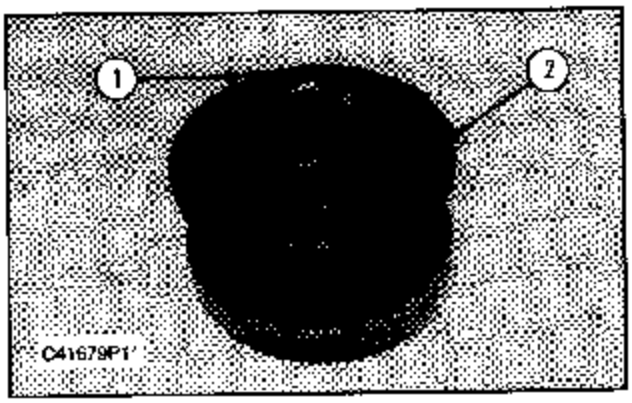
a. Install differentials and pinion assemblies

Differential (Standard)

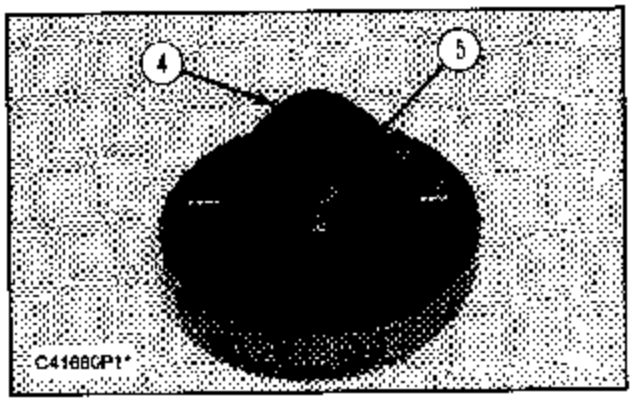
Disassemble Differential (Standard) 3258-015

Start By:

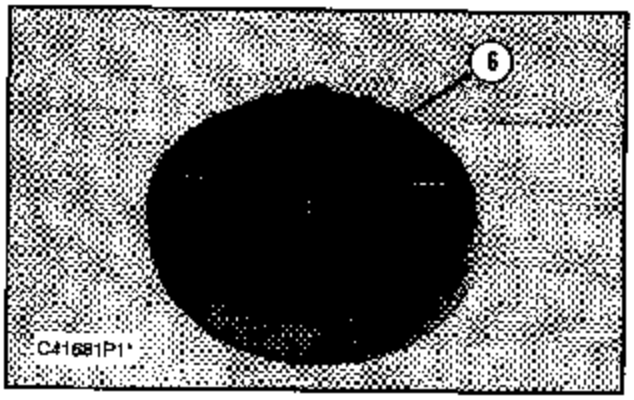
a. remove differentials and pinion assemblies



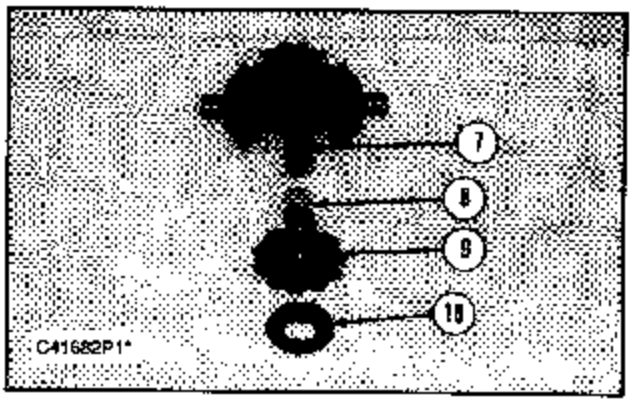
1. Remove four bolts (1) and the washers that hold case assembly (2). Remove the case assembly.



2. Remove thrust washer (5) and bevel gear (4).

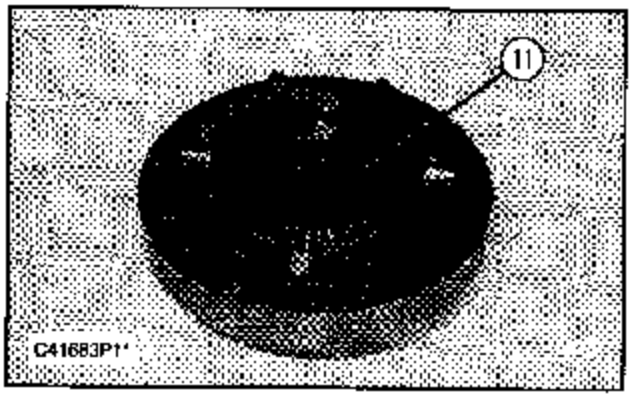


3. Remove spider and gear assembly (6).

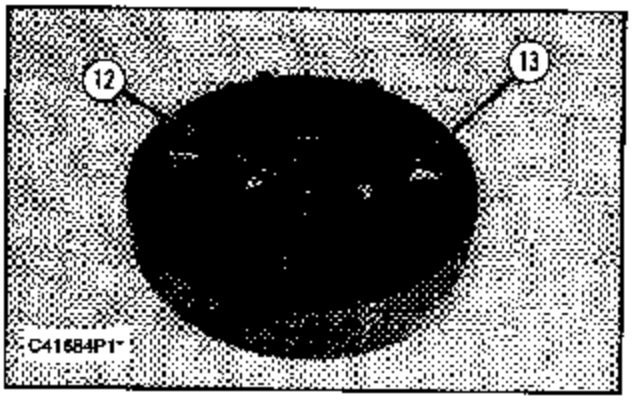


4. Disassemble the spider and gear assembly. Remove thrust washer (10), bevel pinion (9) and sleeve bearing (8) from spider (7).

5. Disassemble the remainder of the spider and gear assembly as in Step 5.

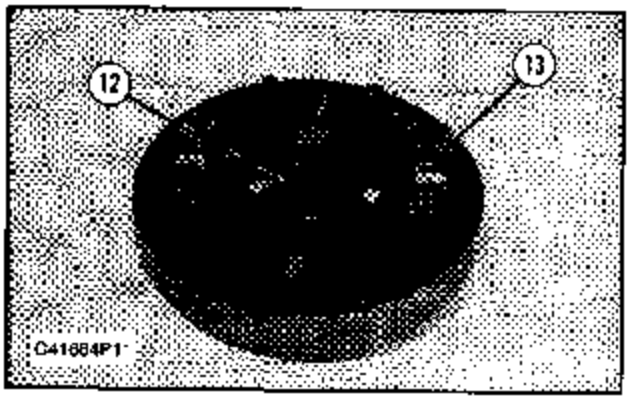


6. Remove bevel gear (11) from the case assembly.

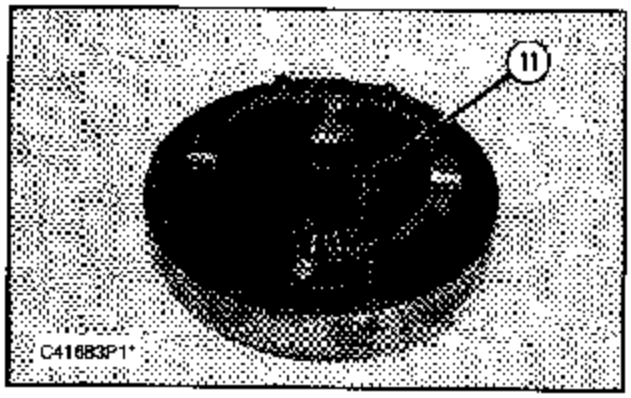


7. Remove thrust washer (12) from case assembly (13).

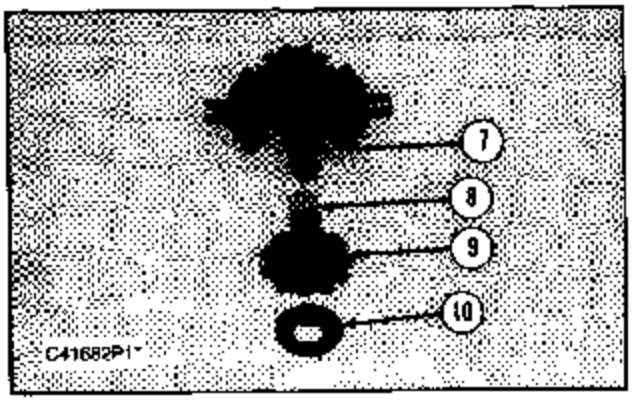
Assemble Differential (Standard) 3258-016



1. Install thrust washer (12) in case assembly (13).

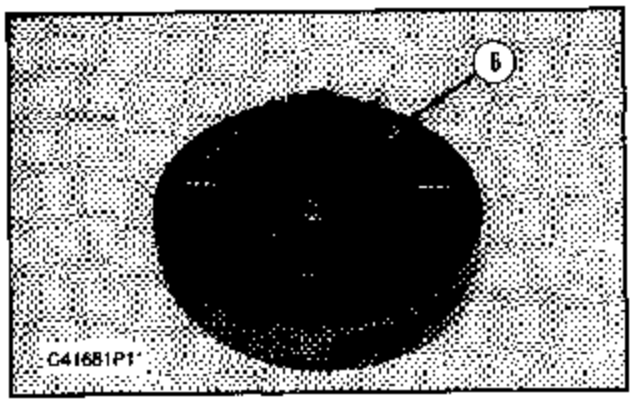


2. Install bevel gear (11) in the case assembly.

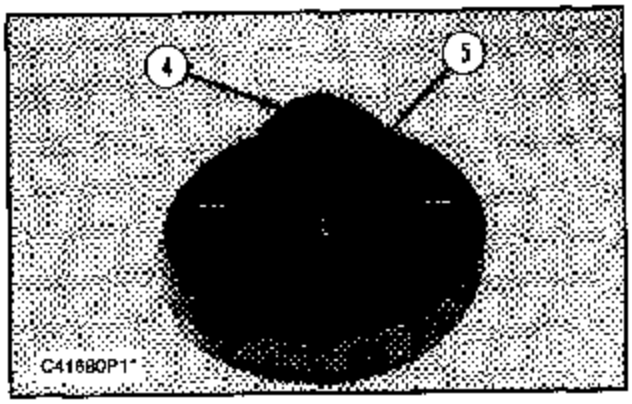


3. Assemble the spider and gear assembly. Install sleeve bearing (8), bevel pinion (9) and thrust washer (10) on spider (7).

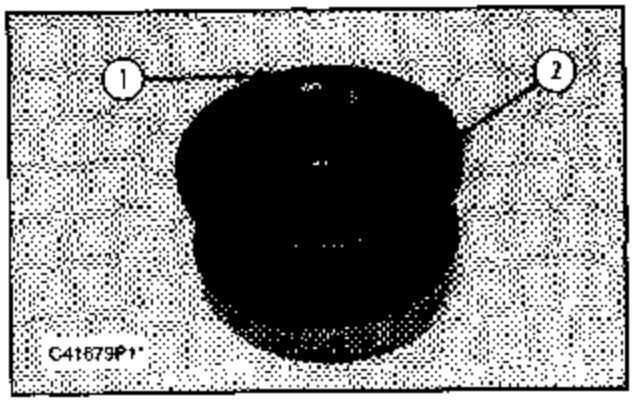
4. Assemble the remainder of the spider and gear assembly as in Step 3.



5. Install spider and gear assembly (6) in the case assembly.



6. Install bevel gear (4) and thrust washer (5) in the case assembly.



7. Put case assembly (2) in position, and install four bolts (1) and the washers that hold it.

End By:

a. install differentials and pinion assemblies

Transmission Oil Filter

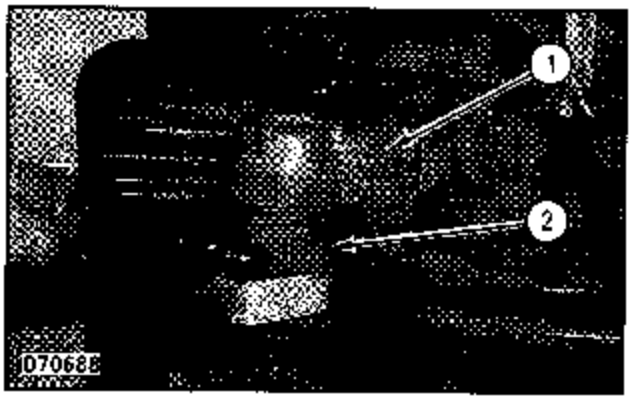
Remove & Install Transmission Oil Filter 3179-010

Tools Needed	A
2P8250 Strap Wrench Assembly	1

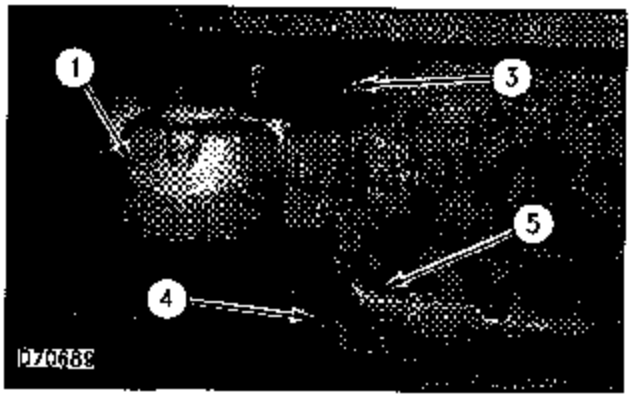
NOTE: If only the transmission oil filter element is to be serviced, see the Operation & Maintenance Manual.

NOTICE

Do not remove or install the transmission oil filter housing with an air wrench. See the Operation & Maintenance Manual for the correct service intervals for the transmission oil filter.



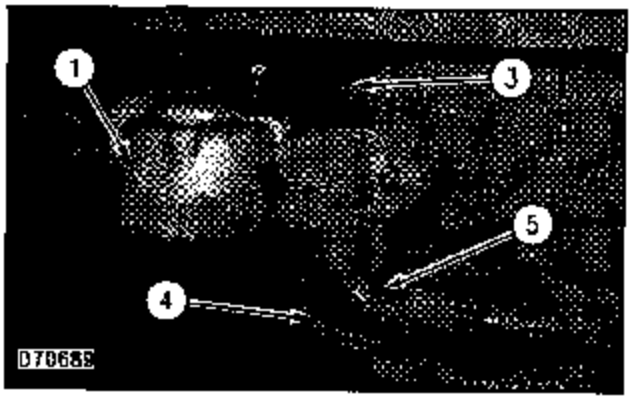
1. Using tool (A), remove filter housing (2) from filter base (1). Remove the filter element from the filter housing.



2. Disconnect hose assemblies (4) and (5) from filter base (1).

3. Remove three bolts (3) and the washers. Remove filter base (1) from its mounting base.

NOTE: The following steps are for the installation of the transmission oil filter.



4. Check the condition of the O-ring seal in filter base (1). If the seal is worn or damaged, use a new part for replacement. Put filter base (1) in position on its mounting base, and install three bolts (3) and the washers which hold it.

5. Check the condition of the O-ring seals in the ends of hoses (4) and (5). If the seals are worn or damaged, use new parts for replacement.

6. Connect hose assemblies (4) and (5) to filter base (1).

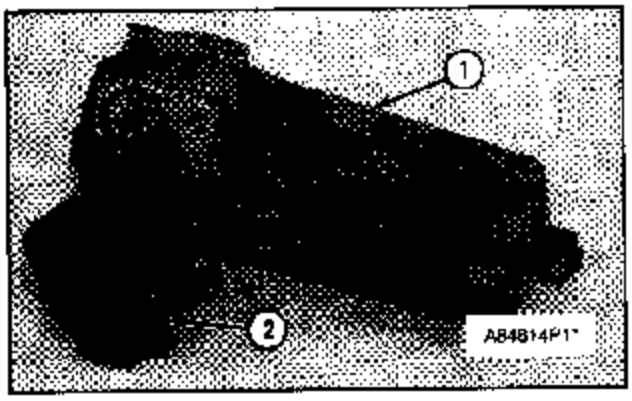
7. Install a new filter element in the filter housing. Install the filter housing on the filter base. Be sure the filter housing is seated against the filter base.

8. Check the fluid level of the transmission. See the Operation & Maintenance Manual for the correct filling procedure.

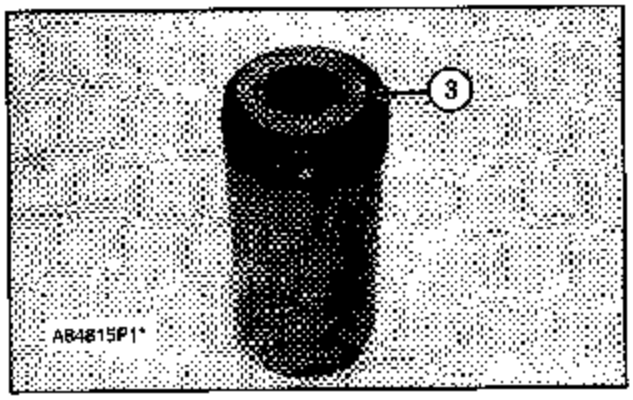
Disassemble & Assemble Transmission Oil Filter 3179-017

Start By:

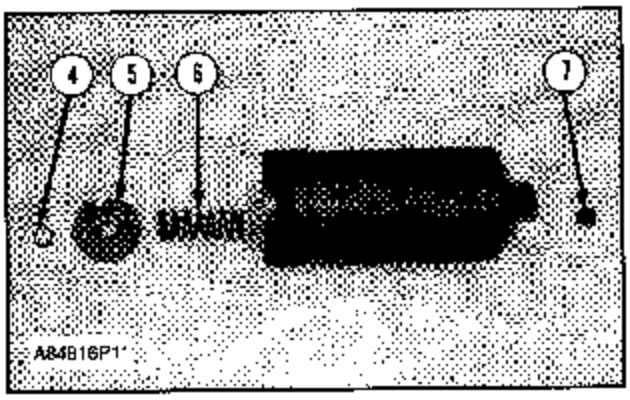
a. remove transmission oil filter



1. Remove filter housing (1) from filter base (2).



2. Remove filter element (3) from the filter housing. Remove the O-ring seal from the filter base.

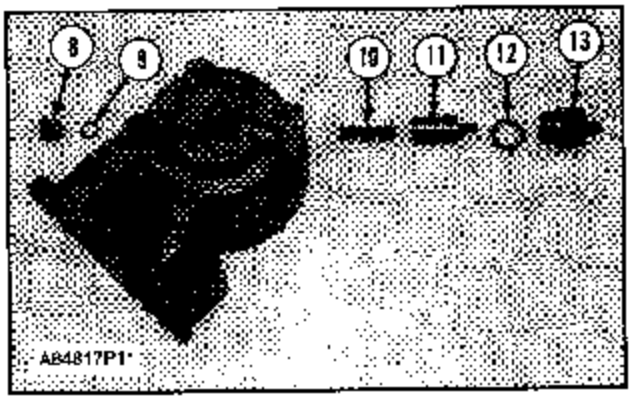


3. Remove plug (7) from the bottom of the filter housing. Remove the O-ring seal from plug (7).

⚠ WARNING

There is spring force against retaining ring (4) and retainer (5). When retaining ring (4) is removed, the spring force will be released. To prevent possible personal injury, retainer (5) must be held in position when retaining ring (4) is removed.

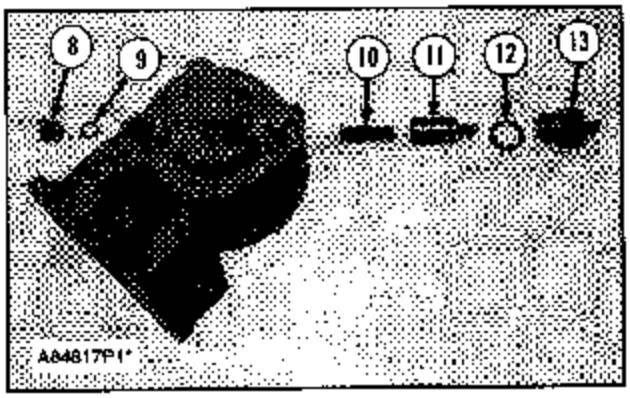
4. While holding retainer (5) in position, remove retaining ring (4). Remove retainer (5) and spring (6) from the filter housing.



5. Remove plug (8) from the filter base. Remove O-ring seal (9) from the plug.

6. Remove switch (13), spool (11) and spring (10) from the filter base. Remove O-ring seal (12) from the switch.

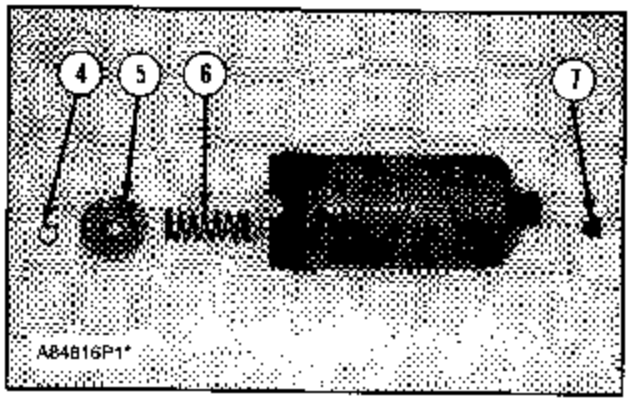
NOTE: The following steps are for the assembly of the transmission oil filter.



7. Check the condition of all O-ring seals used in the transmission oil filter. If any of the seals are worn or damaged, use new parts for replacement.

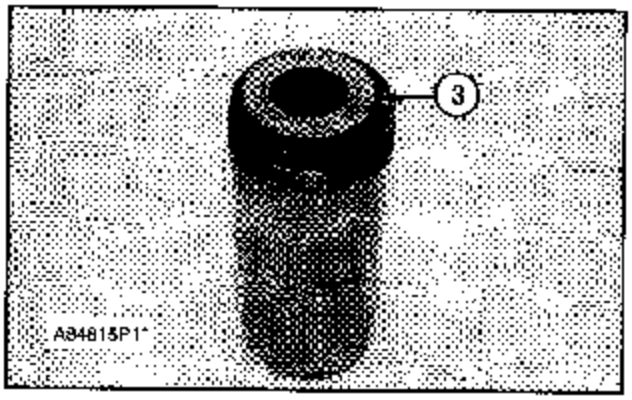
8. Install O-ring seal (9) and plug (8) in the filter base.

9. Install spring (10), spool (11), O ring seal (12) and switch (13) in the filter base.

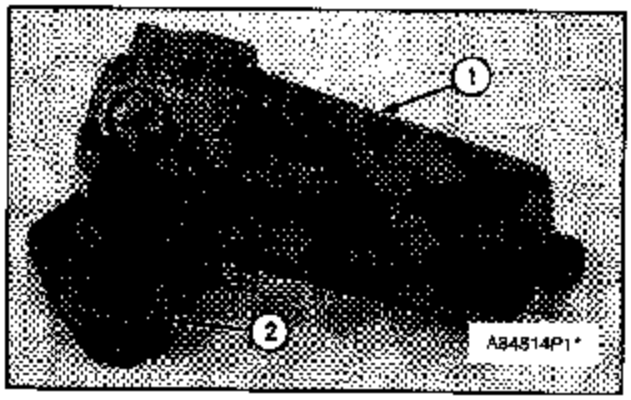


10. Install the O-ring seal and plug (7) in the bottom of the filter housing.

11. Put spring (6) and retainer (5) in position in the filter housing. Compress the spring with the retainer, and install retaining ring (4).



12. Put filter element (3) in the filter housing.



13. Install the O-ring seal in the filter base. Install filter housing (1) on filter base (2).

End By:

a. install transmission oil filter

Transmission Oil Pump

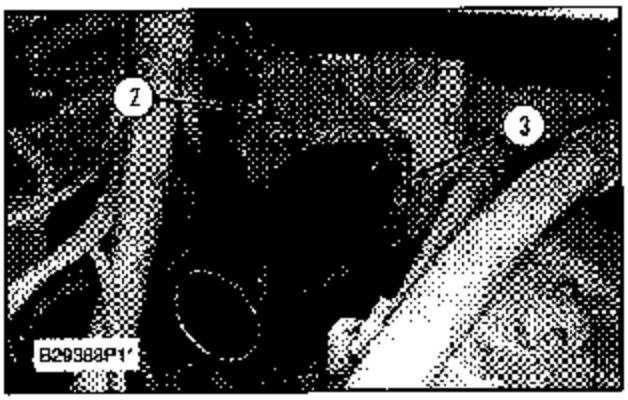
Remove & Install Transmission Oil Pump 3153-010

Start By:

a. remove implement, steering & pilot systems oil pump *

* This operation is in the 815F Compactor Machine Systems Disassembly & Assembly module, Form No. SENR1318.

1. Disconnect hose assembly (1) from the transmission oil pump.



2. Remove seven bolts (2) and transmission oil pump (3) from the torque converter housing. Remove the two O-ring seals from the transmission oil pump.

NOTE: The following steps are for the installation of the transmission oil pump.

3. Check the condition of the O-ring seals used on the body of the transmission oil pump and in the end of hose assembly (1). If the seals are worn or damaged, use new parts for replacement.

4. Put the two O-ring seals in position on the body of the transmission oil pump. Put clean oil on the O-ring seals.

5. Put transmission pump (3) in position on the torque converter housing. Install seven bolts (2) that hold it.

6. Install the O-ring seal in the end of hose assembly (1). Connect the hose assembly to the transmission oil pump.

End By:

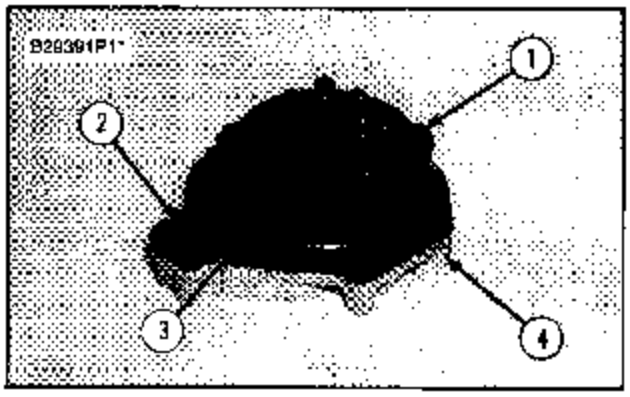
a. * install implement, steering & pilot systems oil pump

* This operation is in the 915F Compactor Machine Systems Disassembly & Assembly module, Form No. SENR1316.

Disassemble Transmission Oil Pump 3153-015

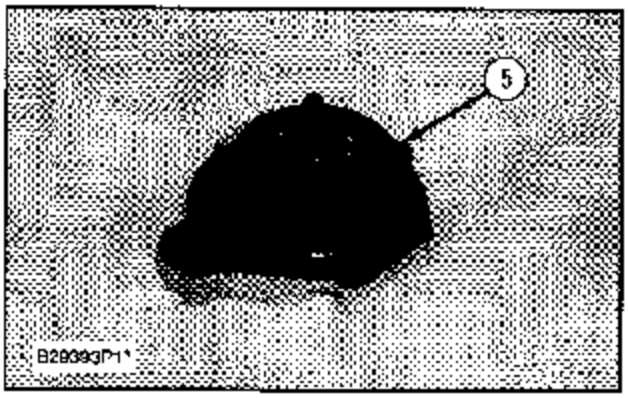
Start By:

a. remove transmission oil pump

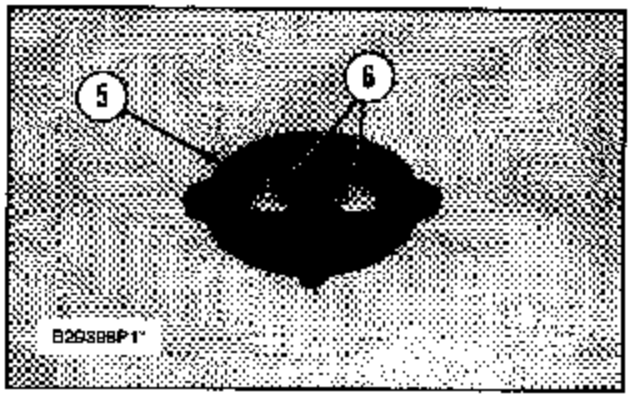


1. Remove O-ring seals (2) and (3) from manifold (4).

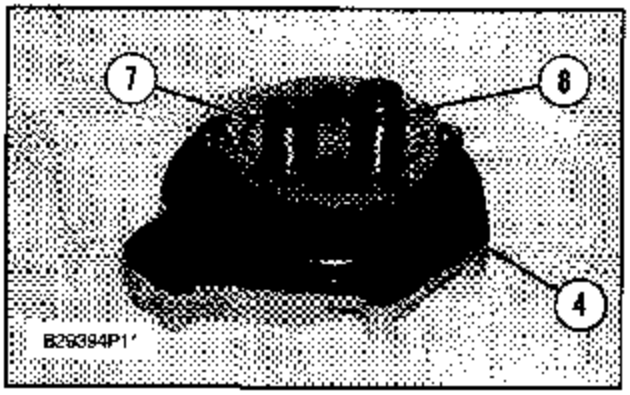
2. Remove six bolts (1).



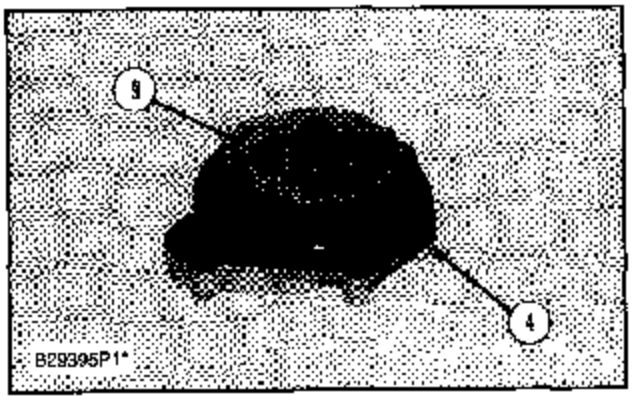
3. Remove cover (5) from the pump body.



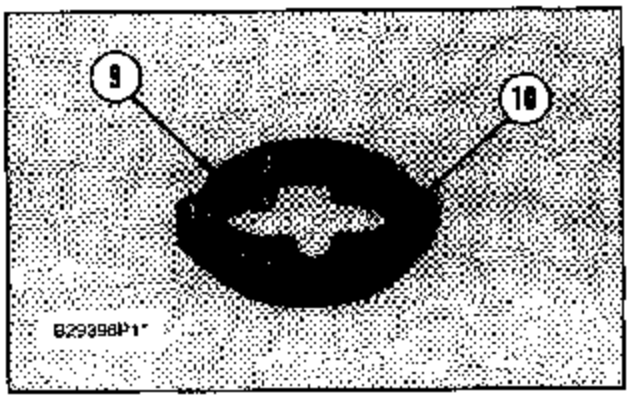
4. Remove bearings (6) from cover (5).



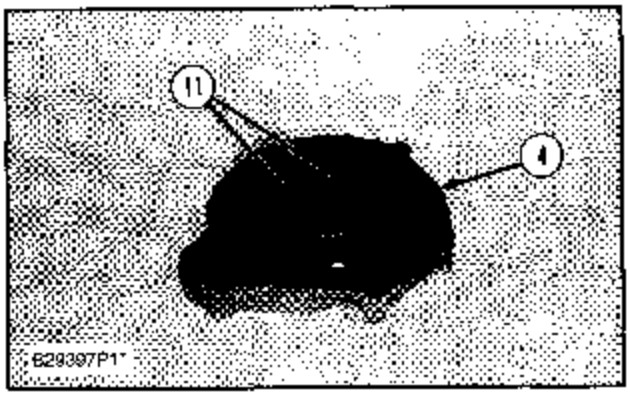
5. Remove gears (7) and (8) from manifold (4).



6. Remove body (9) from manifold (4).



7. Remove four dowels (10) from body (9).

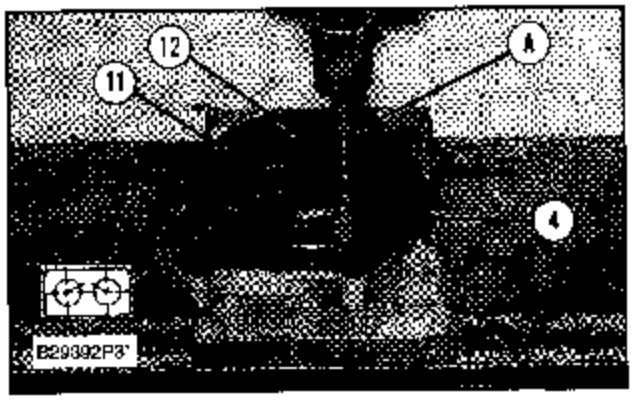


8. Remove bearings (11) from manifold (4).

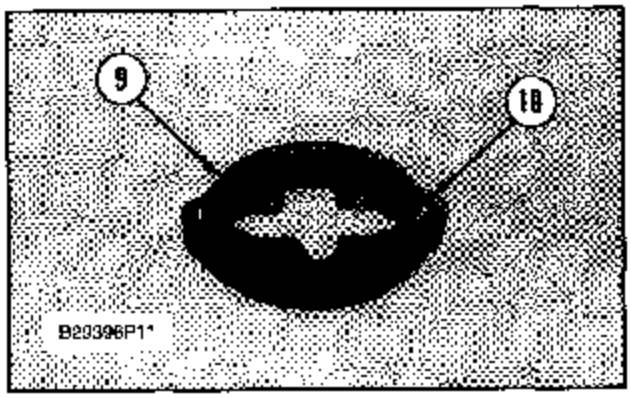
Assemble Transmission Oil Pump 3153-016

Tools Needed	A
1P0510 Driver Group	1

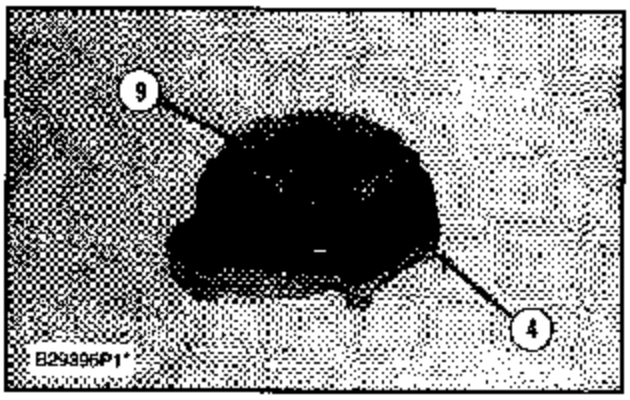
1. Check the condition of all O-ring seals used in the transmission oil pump. If the seals are worn or damaged, use new parts for replacement. Put clean oil on all parts of the transmission oil pump during assembly.



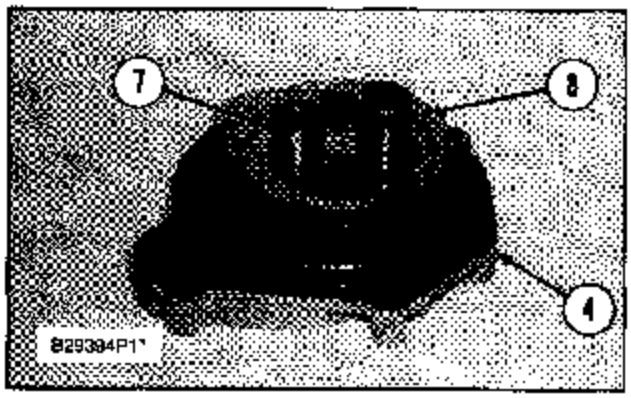
2. Use tool (A) and a press to install bearings (11) in manifold (4). Install the bearings until they are **1.5 ± .05 mm (.059 ± .020 in)** below the machined surface of manifold (4). Be sure the bearing joints are **30 degrees ± 15 degrees** from the centerline toward oil passage (12) as shown.



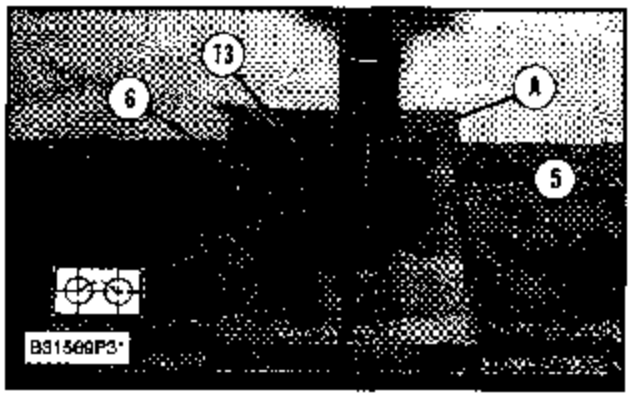
3. Install four dowels (10) in body (9). Dowels (10) must extend **5.0 ± 0.5 mm (.197 ± .020 in)** above the surface of the body.



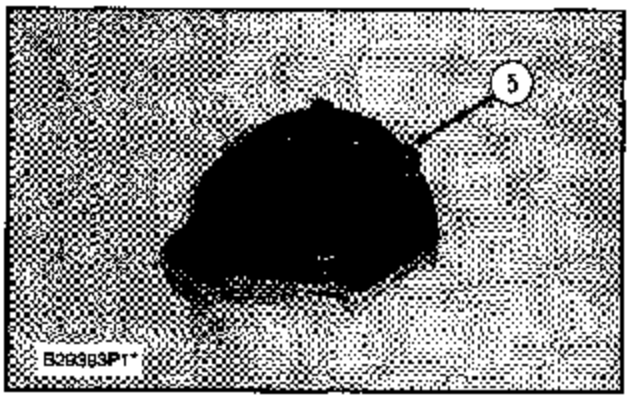
4. Install body (9) on manifold (4).



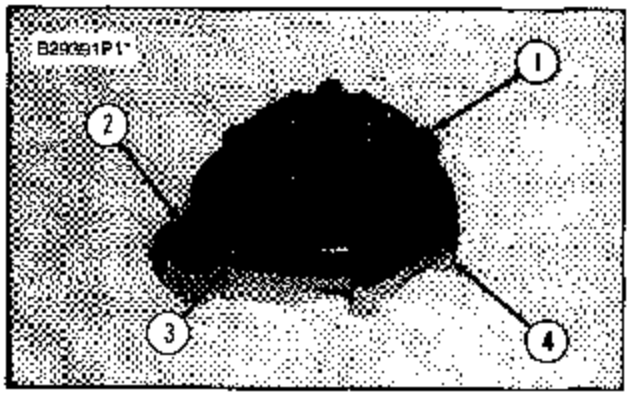
5. Put clean oil on the bearings, and install gears (7) and (8) in manifold (4).



6. Use tool (A) and a press to install bearings (6) in cover (5). Bearings (6) must be **1.5 ± 0.5 mm (.059 ± .020 in)** below the surface of cover (5). Be sure the bearing joints are **30 degrees ± 15 degrees** from the centerline towards oil passage (13) as shown.



7. Install cover (5) on the pump body.



8. Install bolts (1). Install O ring seals (2) and (3) on manifold (4).

9. Be sure the transmission oil pump rotates freely by hand after assembly.

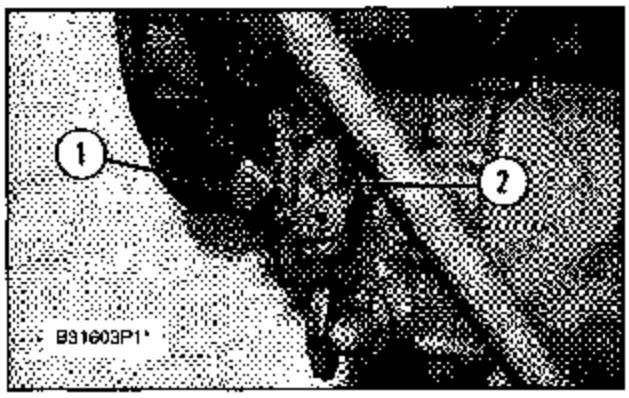
End By:

a. install transmission oil pump

Torque Converter Outlet Relief Valve

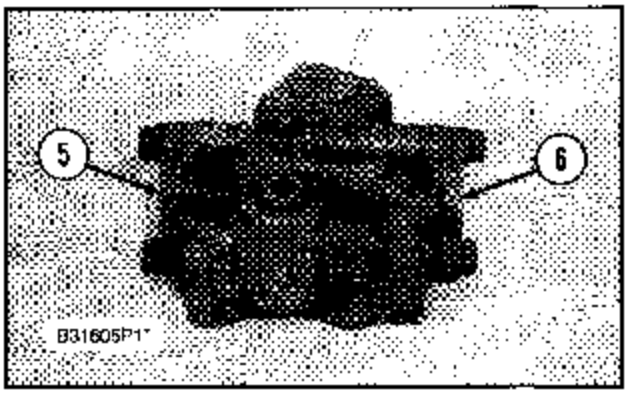
Remove Torque Converter Outlet Relief Valve 3133-011

NOTE: The torque converter and transmission are removed from the machine only for better photo illustration of the torque converter outlet relief valve. The torque converter and transmission do not have to be removed to service the torque converter outlet relief valve.

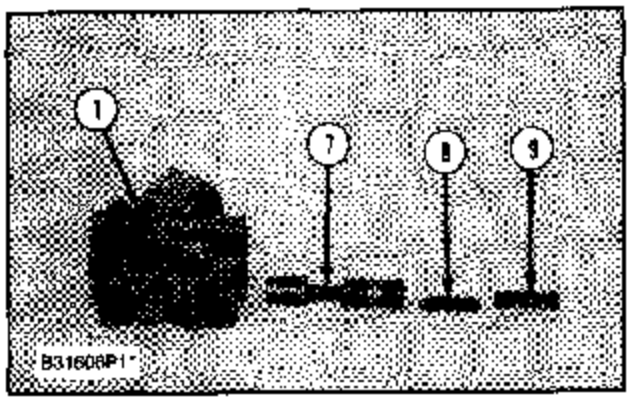


1. Disconnect the oil cooler tube assembly from torque converter outlet relief valve (1).

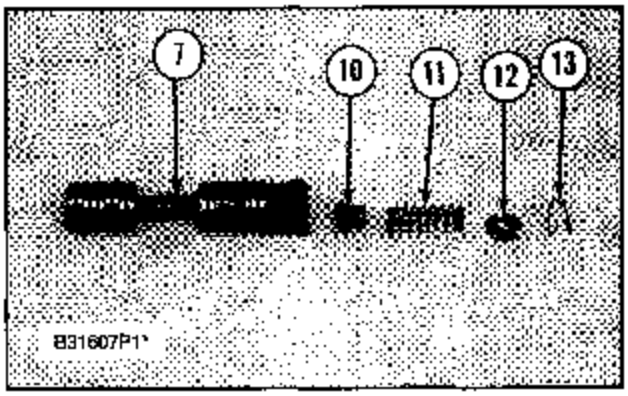
2. Remove three bolts (2) and torque converter outlet relief valve (1). Remove the two O-ring seals from the torque converter outlet relief valve.



3. Remove the bolts and washers that hold covers (5) and (6). Remove the covers. Remove the O-ring seals from the covers.



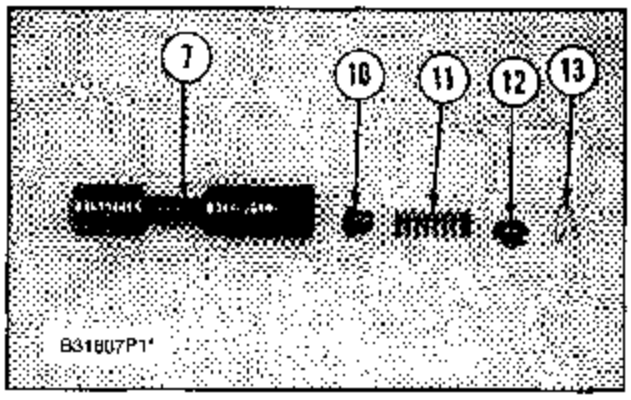
4. Remove spring (9), spacers (8) and valve spool (7) from valve body (1).



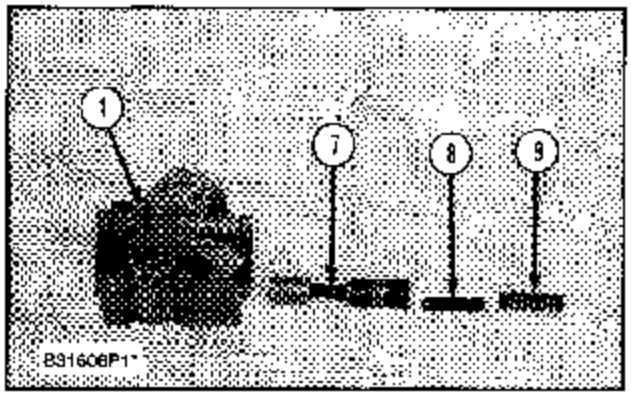
5. Disassemble the valve spool. Remove retaining ring (13), retainer (12), spring (11) and poppet (10) from valve spool (7).

Install Torque Converter Outlet Relief Valve 3133-012

NOTE: Before assembly, be sure all parts of the torque converter outlet relief valve are thoroughly clean and free of dirt and debris. Apply a coat of clean oil to all parts.

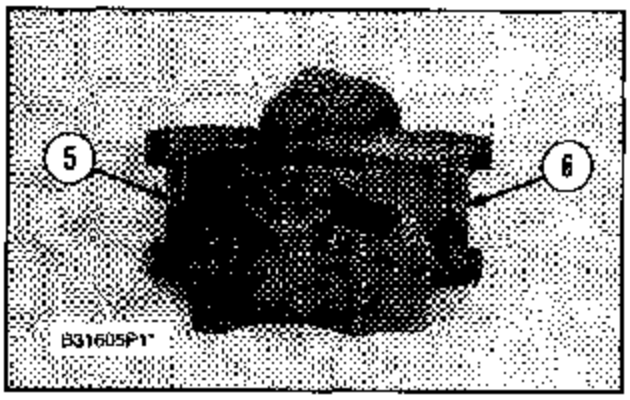


1. Assemble the valve spool. Install poppet (10), spring (11), retainer (12) and retaining ring (13) in valve spool (7).



NOTE: Spacers (8) are used to adjust the pressure needed to open the torque converter outlet relief valve. Refer to the topic "Pressure Chart" in Testing & Adjusting, 815F Compactor Power Shift Transmission, Form No. SENR1336 for the correct procedure to adjust the pressure of the torque converter outlet relief valve.

2. Install spool (7), spacers (8) and spring (9) in valve body (1).



3. Put the O-ring seals in position in covers (5) and (6). Installcovers (5) and (6) on the valve body. Tighten the bolts that hold covers (5) and (6) to a torque of **48 ± 7 N•m (35 ± 5 lb ft).**

4. Put the two O-ring seals in position on the valve body. Put torque converter outlet relief valve (1) in position on the torque converter housing. Install three bolts (2) and the washers which hold it.

5. Connect the oil cooler tube assembly to torque converter outlet relief valve (1).

6. Fill the transmission with oil to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

Torque Converter, Transmission And Transfer Gears

Remove Torque Converter, Transmission And Transfer Gears 3003-011

Tools Needed		A	B	C	D
6V2156	Link Bracket	2			
FT1584	Engine Support Bracket		2		
	Forcing Screw (5/8 - 18NF x 6" long)		2		
6V2157	Link Bracket			2	
8S9906	Ratchet Puller				1

Start By:

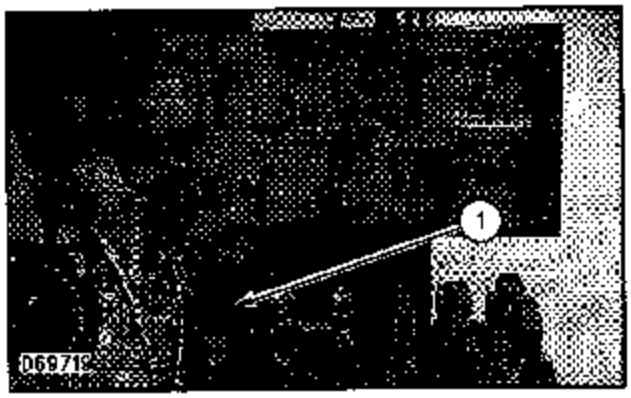
a. remove rear drive shaft

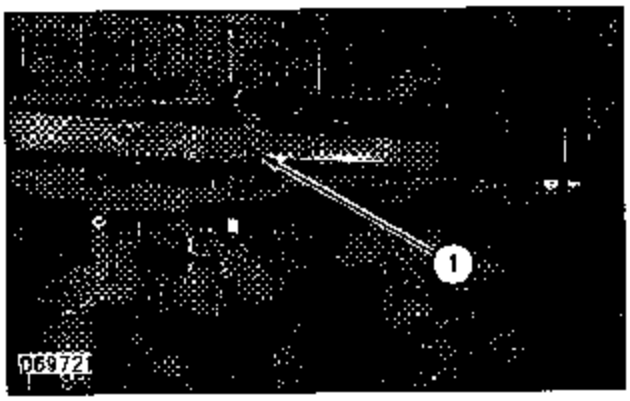
b. remove cab *

c. remove hood **

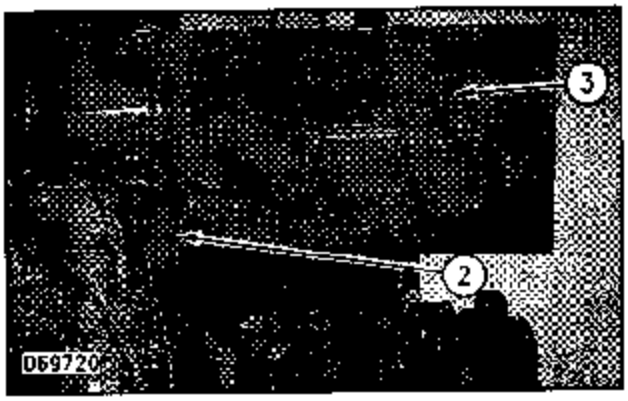
* This operation is in the 815F Compactor Machine Systems Disassembly & Assembly module, Form No. SENR1318.

** This operation is in the 3306 Engine Supplement For 815F Compactor Disassembly & Assembly module, Form No. SENR1306.

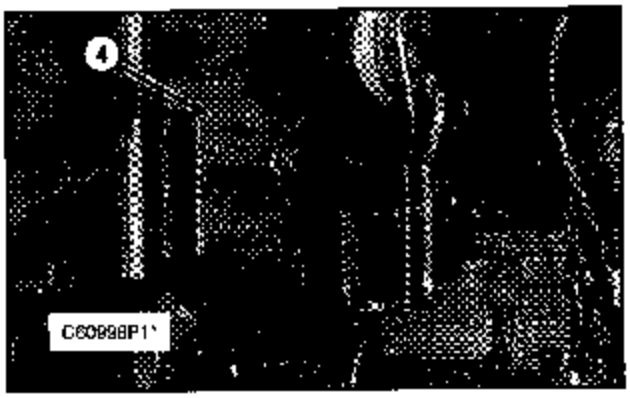




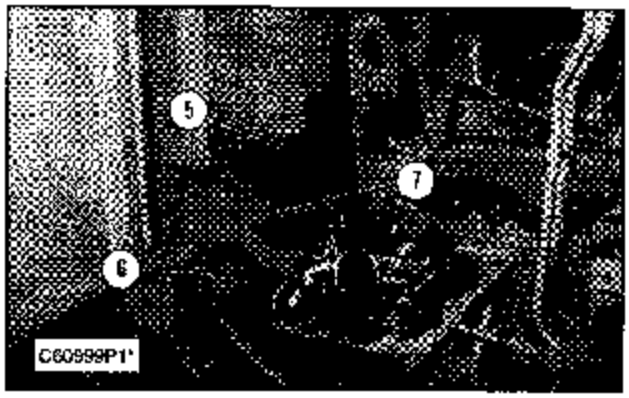
1. Remove two bolts from both ends of support assembly (1). Remove the support assembly from both sides of the machine.



2. Fasten nylon lifting straps and a hoist to door (3). Remove the bolts from hinge (2). Remove both right and left hard doors. The weight of the door is **41 kg (90 lb).**

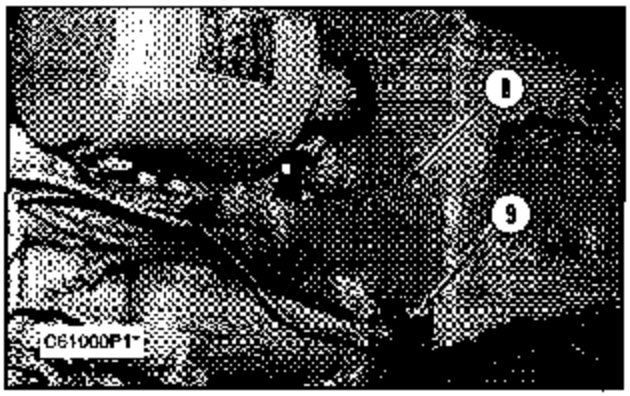


3. Remove four bolts from electrical box cover (4) and lay the cover aside.



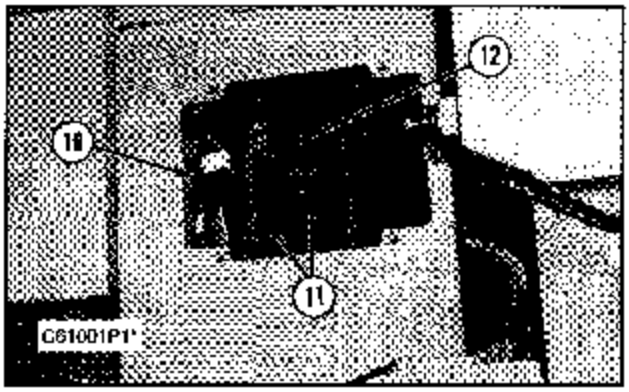
4. Disconnect electrical connectors (5) and (6).

5. Remove the clips that hold wiring harness (7).



6. Disconnect line (8).

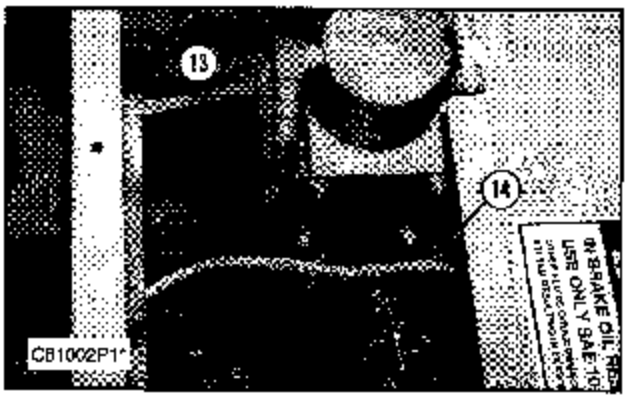
7. Remove the remaining clips from wiring harness (9).



8. Disconnect heater element connector (10) from the air dryer.

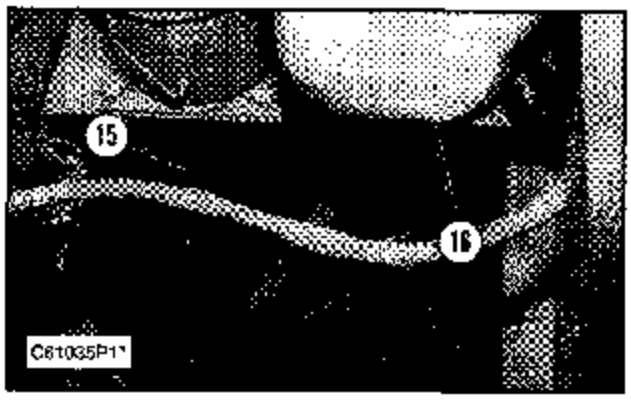
9. Disconnect hoses (11) from the air dryer.

10. Disconnect electrical connector (12).



11. Disconnect two air lines (13) from the air dryer.

12. Remove the support clips from wire (14).



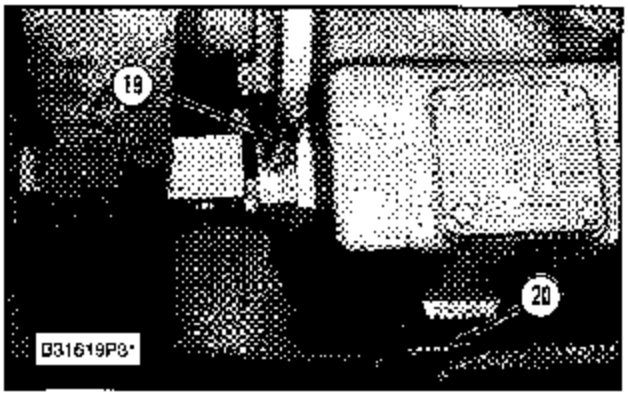
13. Disconnect two hoses (15) from brake reservoirs. Drain brake fluid in a suitable container.

14. Remove support clips from hoses (15) that are attached to the fire wall.

15. Disconnect the wire and fluid hose from windshield washer reservoir (16).

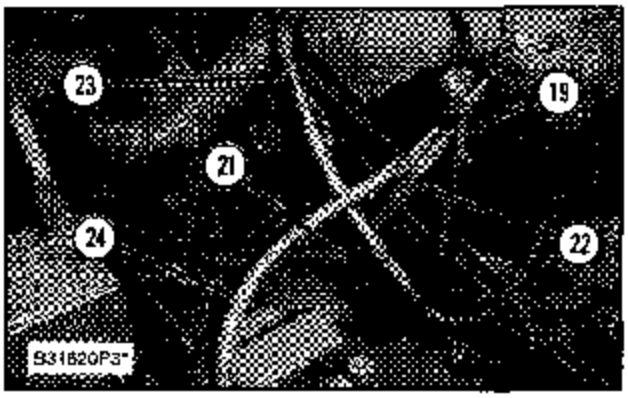
16. Fasten tooling (A) and a hoist to firewall group (17) as shown.

17. Remove eight bolts (18) and washers. Remove firewall group (17). The weight of the firewall group is **114kg (250 lb).**



18. Remove plug (20) and drain oil from the transmission and transfer gears into a suitable container. The capacity of the system is **46 liter (12 U.S. gal).**

19. Remove the bolts, and disconnect oil level gauge (19) from the bottom of the transfer gear case.

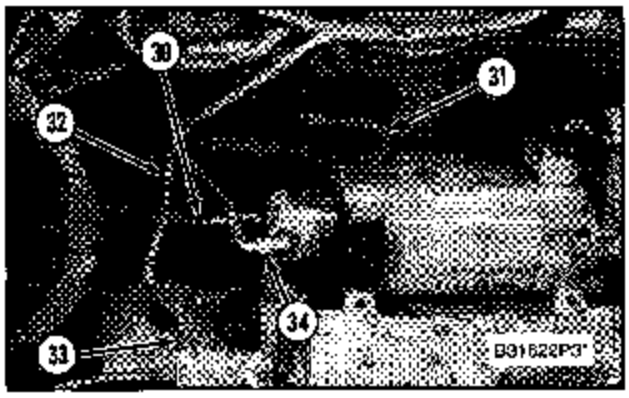


20. Remove the bolts to disconnect heater hose clip (21). Remove oil filler tube (22) and oil level gauge (19) from the machine.

21. Remove oil filter hoses (23) and (24).

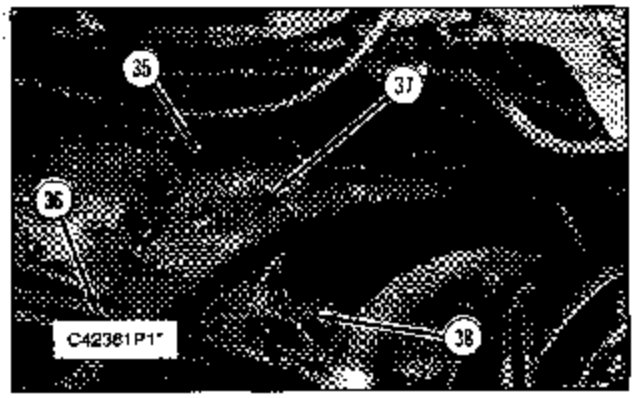
22. Remove four bolts (29) and the washers. Disconnect wire (28). Move the elbow and the hose out of the way.

23. Remove two hoses (25). Remove bolts (27) and the washers. Move hose (26) out of the way.



24. Disconnect wiring assembly (33) from wiring harness (32).

25. Disconnect hose assemblies (30), (31) and (34) from the pilot and hydraulic pump.



26. Remove the bolts and clips (35) from the transmission.

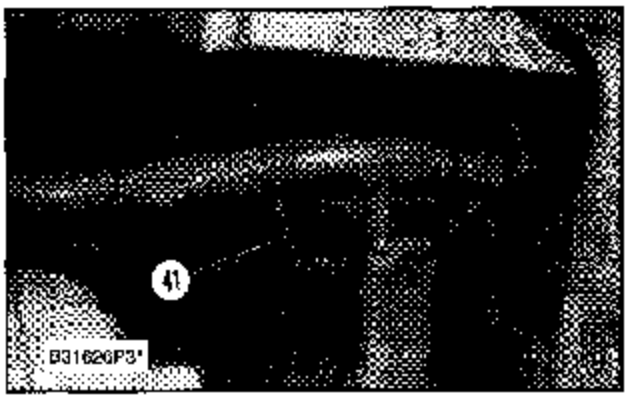
27. Move hose group (36) out of the way.

28. Disconnect transmission control electrical connector (37). Remove the support clips from this harness on transmission.

29. Remove the bolt, and move the hose assembly and clip (38) out of the way.

30. Drain the oil from the hydraulic tank into a suitable container. The capacity of the hydraulic tank is **140 liter (37 U.S. gal)**.

31. Loosen the clamps, and move hose (39) down on tube assembly (40) to disconnect the hydraulic oil pump elbow from the hydraulic tank.



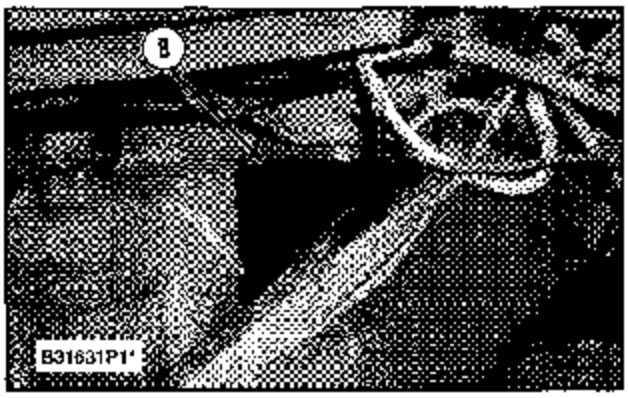
View From Under Machine.

32. Disconnect wires (41) from the sending unit on the transmission. (Right side of machine).

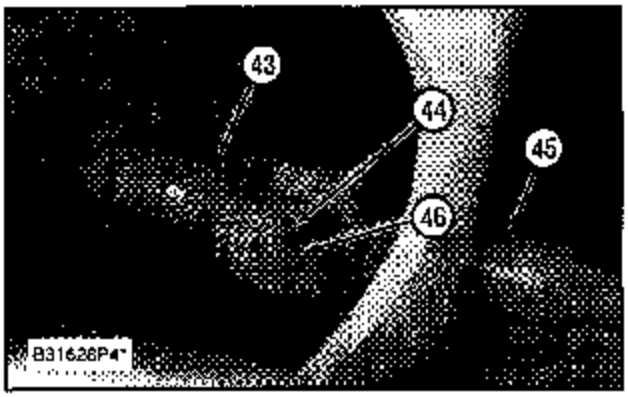
Typical Example

33. Remove two hoses (42) from the transmission oil cooler.

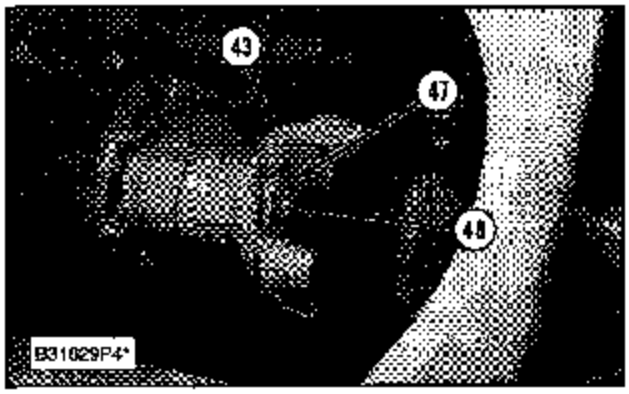
34. Remove the two lower side panels (one from each side of the machine).



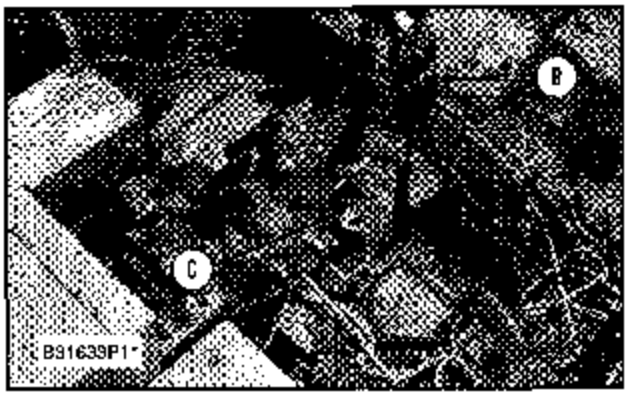
35. Install tool (B) on both sides of the engine flywheel housing as shown.



36. Remove bolts (44) and straps (46) to disconnect center drive shaft (45) from yoke (43) on the transfer gear case.

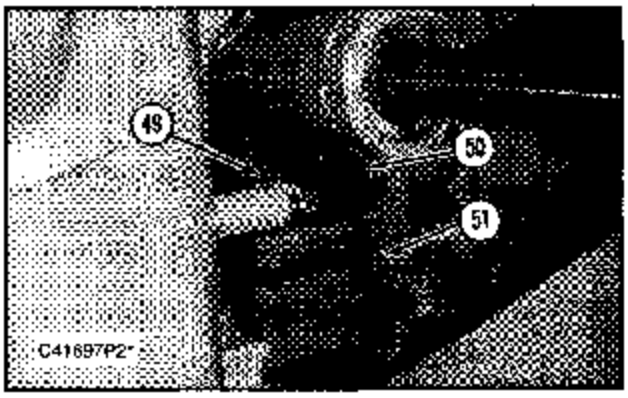


37. Remove bolt (48), retainer (47) and the O-ring seal from the end of the transfer gear shaft. Pull yoke (43) off the shaft.

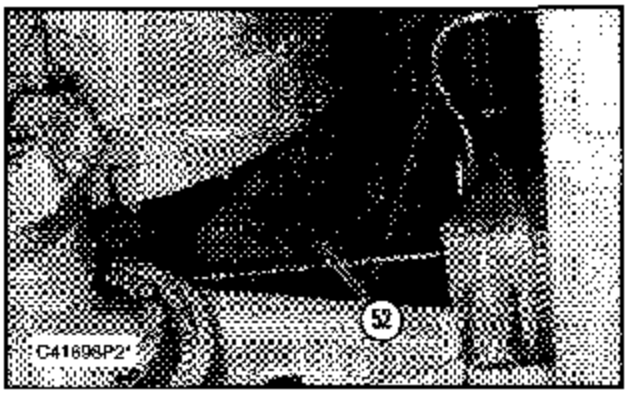


Typical Example

38. Fasten a hoist to the torque converter and transmission with tooling (C) as shown. Use tool (D) to keep the unit level.



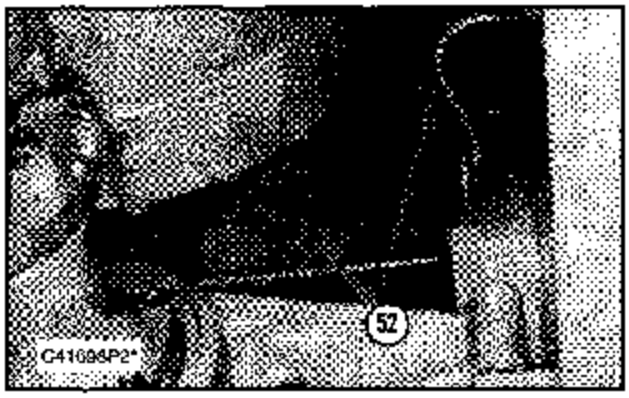
39. Remove bolts (49) and the washers from both sides of the machine. Remove four bolts (50) and the washers and brackets (51) from both sides of the machine.



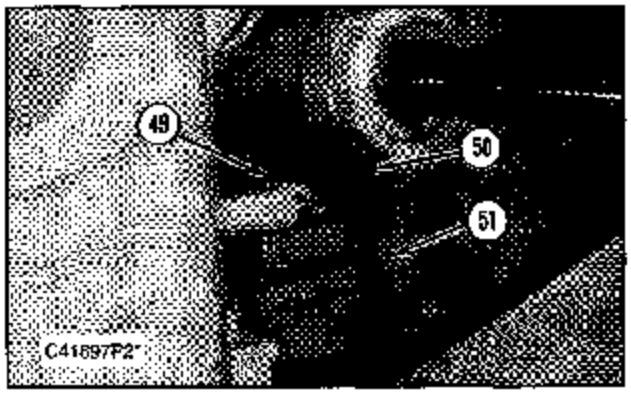
40. Remove twelve bolts (52) and the washers that hold the torque converter to the engine. Move the torque converter away from the flywheel housing, and remove the torque converter, transmission and transfer gears. The weight of the unit is **1020 kg (2250 lb)**.

Install Torque Converter, Transmission And Transfer Gears 3003-012

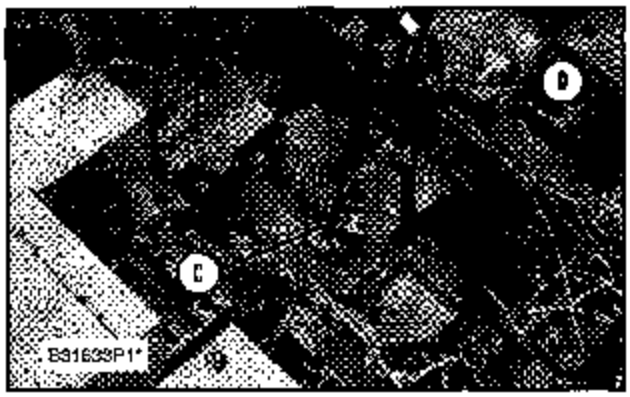
Tools Needed		A	B	C	D
6V2156	Link Bracket	2			
FT1584	Engine Support Bracket		2		
	Forcing Screw (5/8 - 18NF x 6" long)		2		
6V2157	Link Bracket			2	
8S9906	Ratchet Puller				1



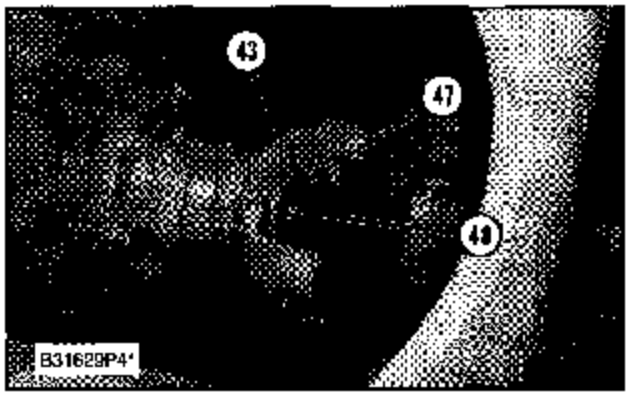
1. Using tool (C) and (D), put the torque converter, transmission and transfer gears in position in the machine. Install twelve bolts (52) and the washers that hold the torque converter to the engine.



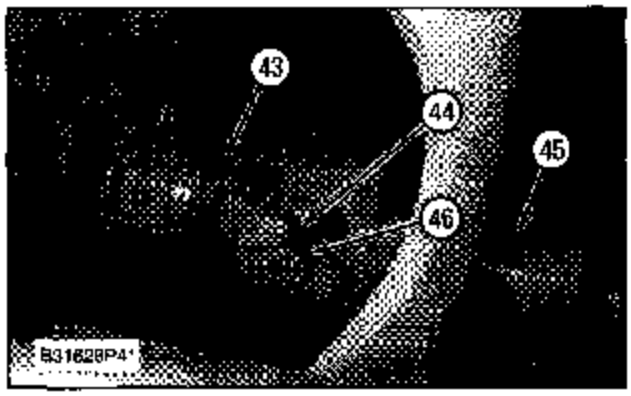
2. Install brackets (51) on both sides of the machine. Use bolts (49), the washers and four bolts (50) and the washers to hold the brackets in place.



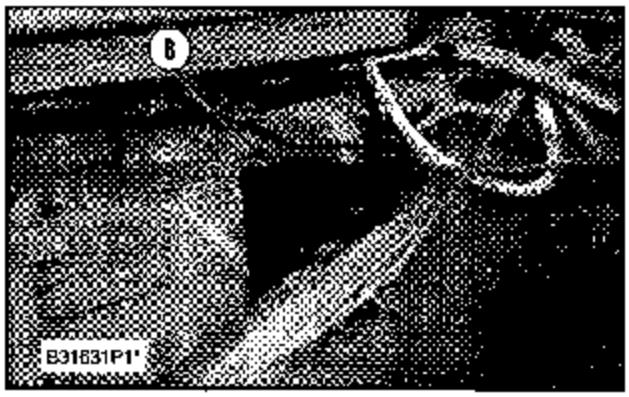
3. Remove tooling (C) and (D).



4. Put yoke (43) on the shaft in the transfer gears. Install the O-ring seal, retainer (47) and bolt (48) that holds the yoke in place. Tighten bolt (48) to a torque of **115 ± 7 N•m (85 ± 5 lb ft)**.



5. Put center drive shaft (45) in position on yoke (43). Install straps (46) and bolts (44) to hold it. Tighten bolts (44) to a torque of **135 ± 15 N•m (100 ± 10 lb ft)**.

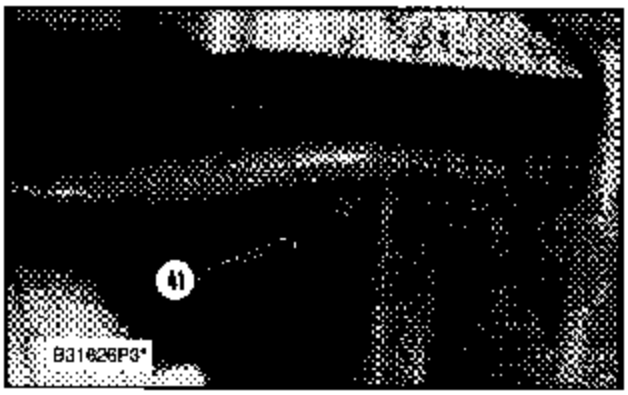


6. Remove tool (B) from both sides of the engine flywheel housing.

Typical Example

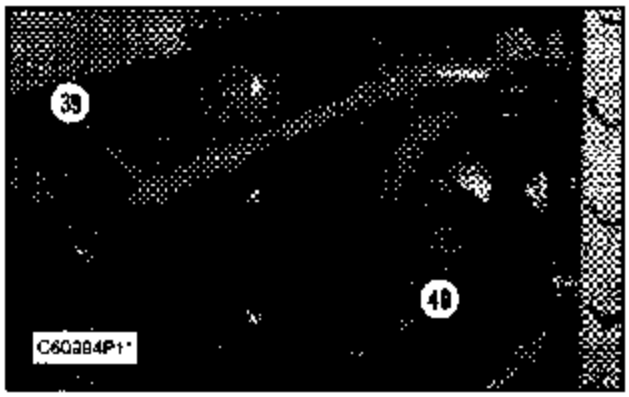
7. Connect two hoses (42) to the transmission oil cooler.

8. Install the lower side panels (one on each side of the machine).

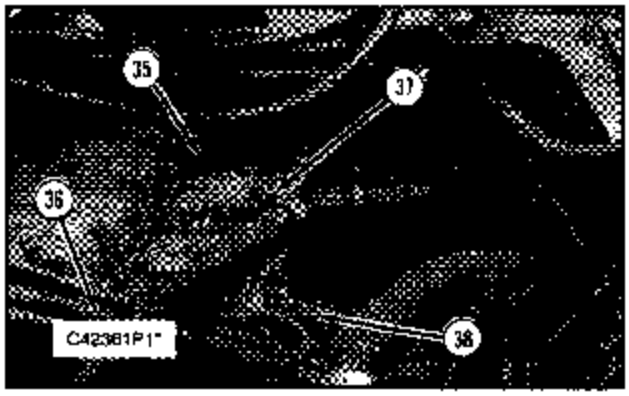


View From Under Machine.

9. Connect wires (41) to the sending unit on the right side of the transmission.



10. Put nose (39) in position, and install the clamps that hold it.

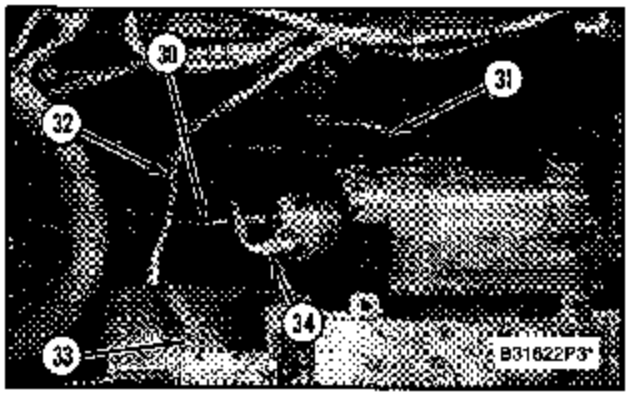


11. Install clips (35) on the transmission.

12. Position hose group (36).

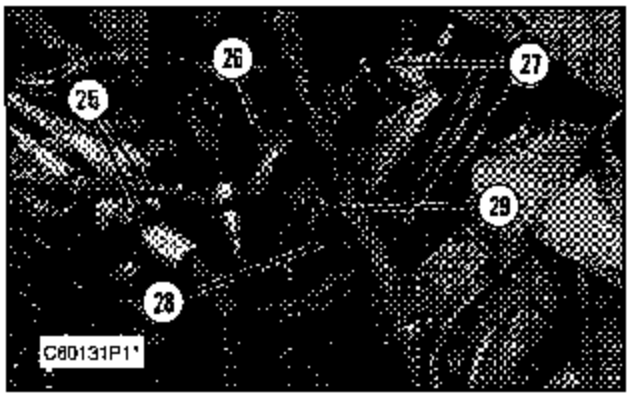
13. Connect transmission control connector (37).

14. Connect hose assembly and clip (38) to the transmission.



15. Connect wiring assembly (33) to wiring harness (32).

16. Connect hose assemblies (30), (31) and (34) to the pilot and hydraulic pump.

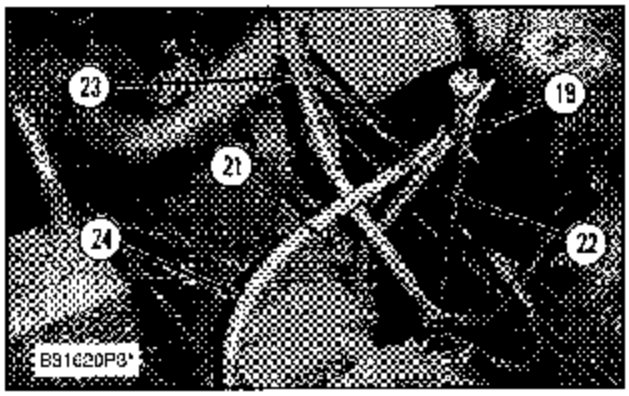


17. Install four bolts (29) and washers. Connect wire (28).

18. Connect the hose assembly, and install bolts (27).

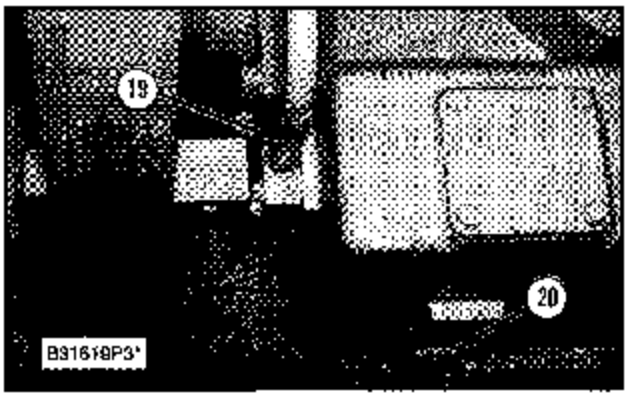
19. Connect hose (26).

20. Connect hoses (25).



21. Install the bolts to connect heater hose clip (21). Install oil filler tube (22) and oil level gauge (19).

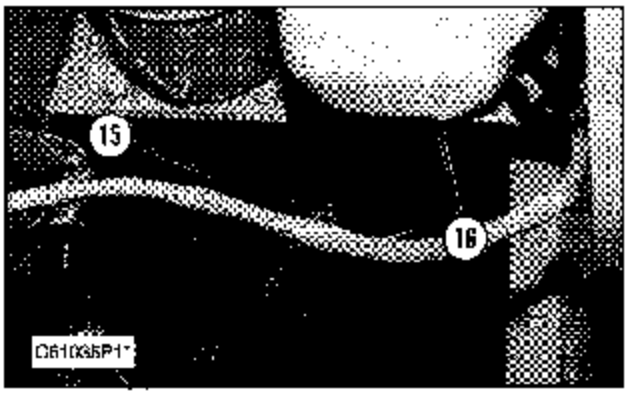
22. Install oil filter lines (23) and (24).



23. Install plug (20).

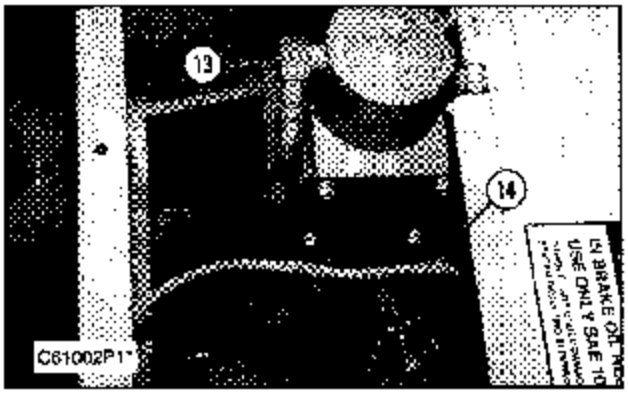
24. Install the bolts that connect oil level gauge (19) to the bottom of the transfer gear case.

25. Use a hoist and tooling (A) to position firewall group (17), and install eight bolts (18) and the washers that hold it. The weight of the fire wall is **1020 kg (2250 lb).** Connect wire.



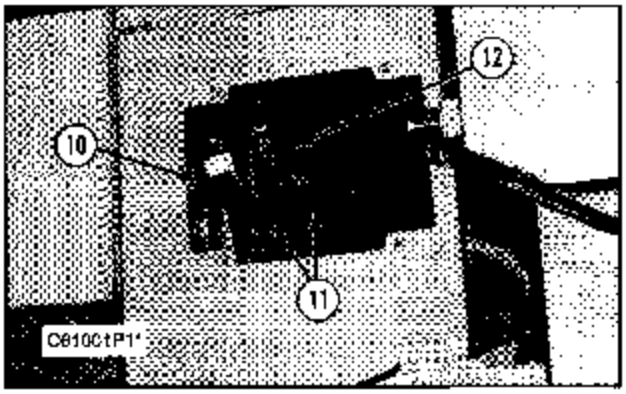
26. Connect two hoses (15) to the brake reservoirs. Install the clips that fasten hose (15) to the firewall.

27. Connect the wire and hoses to windshield washer reservoir (16).



28. Connect air lines (13) to the air dryer.

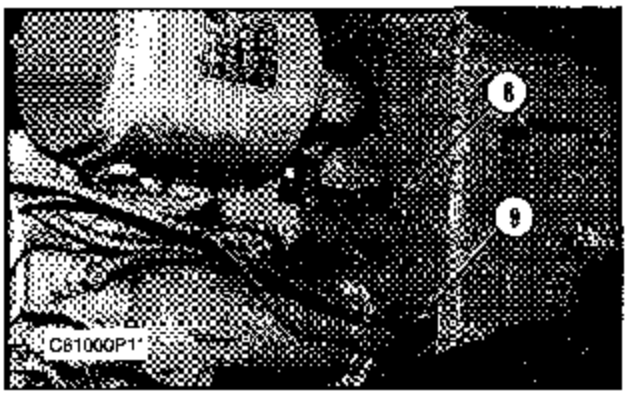
29. Install the support clips to wire (14).



30. Connect heater element wire (10) to the air dryer.

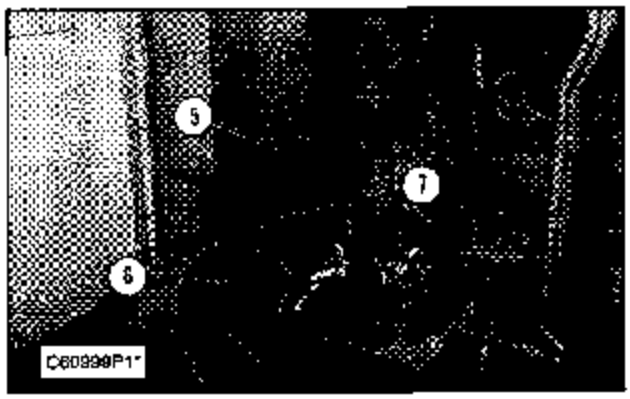
31. Connect air lines (11) to the air dryer.

32. Connect electrical connector (12).



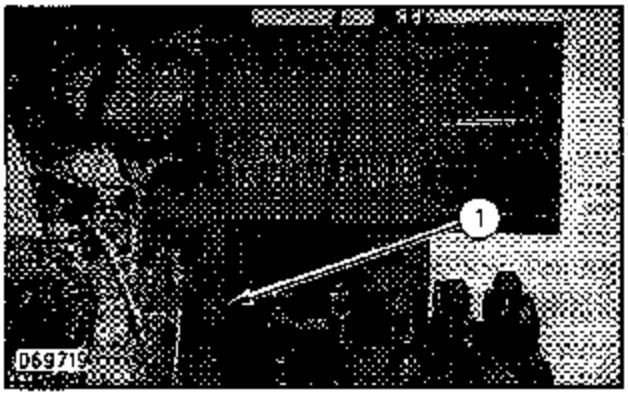
33. Connect line (8).

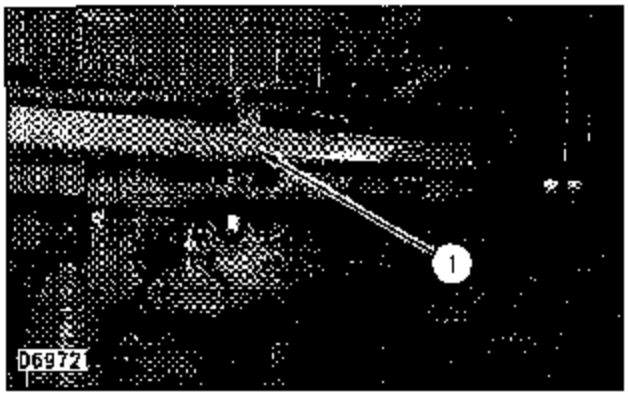
34. Install the clips on wiring harness (9).



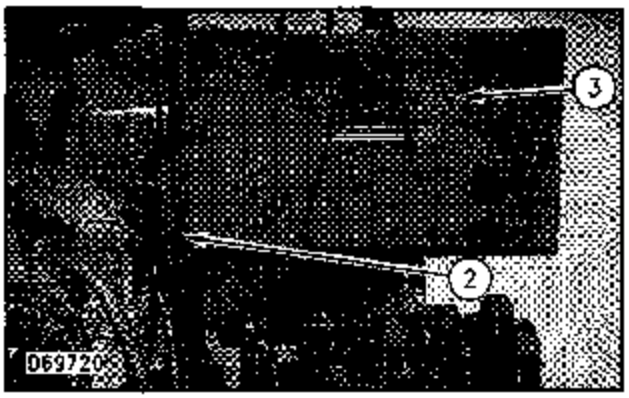
35. Install the clips on wiring harness (7).

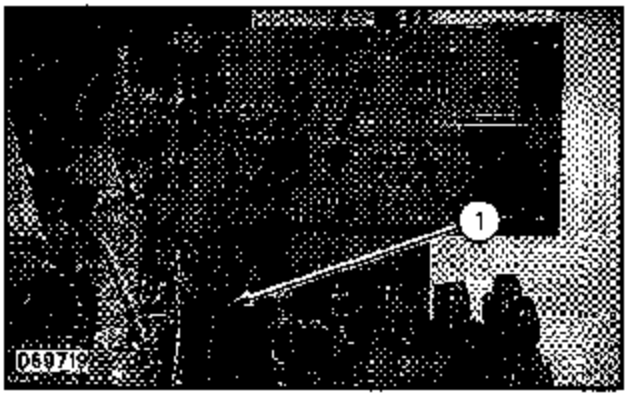
36. Connect electrical connectors (5) and (6).





37. Install cover (4) and the four bolts that hold it.





38. Use a hoist and a lifting strap to position door (3). Install bolts (2) to secure the door. The weight of the door is 41kg (90lb). Use same procedure to install the door on the opposite side of the machine.

39. Position support assembly (1). Install the two bolts at both ends of the support assembly. Use same procedure to install the support assembly on the opposite side of the machine.

40. Fill the hydraulic tank with oil to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

41. Check the fluid levels in the torque converter, transmission and transfer gears. See the Operation & Maintenance Manual.

42. Fill the brake oil reservoirs to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

End By:

a. install cab *

b. install hood **

c. install rear drive shaft

* This operation is in the 815F Compactor Machine Systems Disassembly & Assembly module. Form No. SENR1318.

** This operation is in the 3306 Engine Supplement For 815F Compactor Disassembly & Assembly module, Form No. SENR1306.

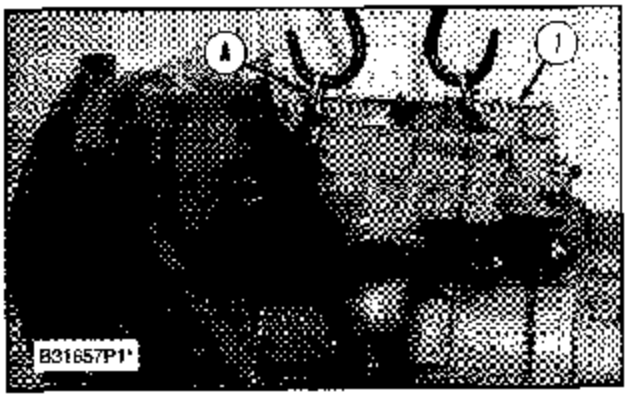
Torque Converter

Separate Torque Converter From Transmission 3001-076

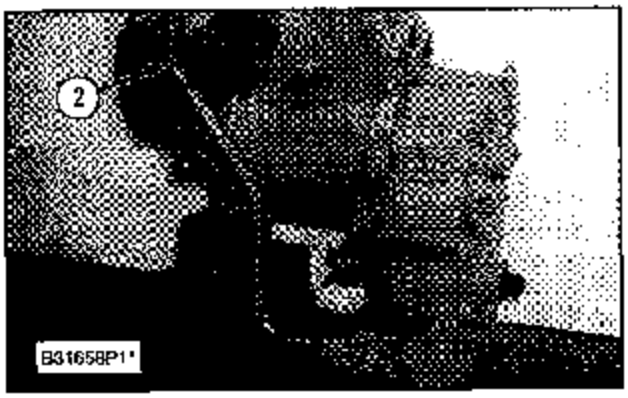
Tools Needed		A	B
5P9736	Link Bracket	2	
2P8312	Pliers		1

Start By:

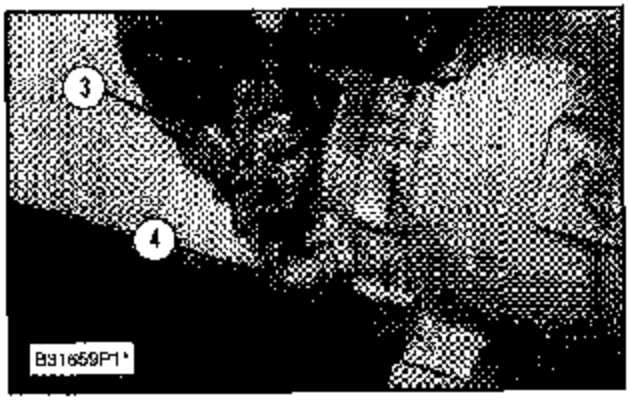
a. remove torque converter, transmission and transfer gears



1. Fasten tool (A) and a hoist to pilot and hydraulic pump (1). Remove the mounting bolts, and remove pilot and hydraulic pump (1). The weight of the pump is **68 kg (150 lb).**

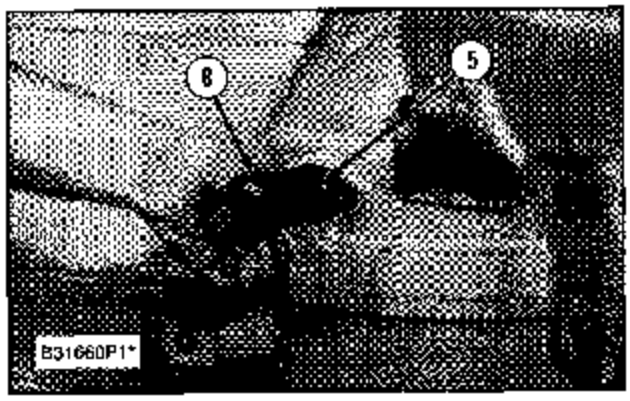


2. Remove tube assembly (2).

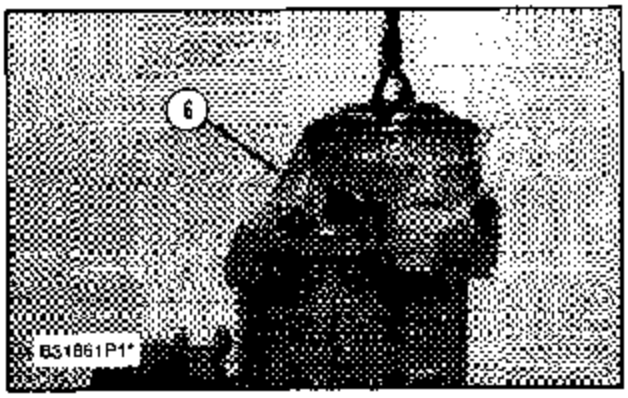


3. Remove elbow (4) and torque converter outlet relief valve (3).

4. Fasten a hoist to the torque converter, transmission and transfer gears. Put the unit in a vertical position with the torque converter facing up.



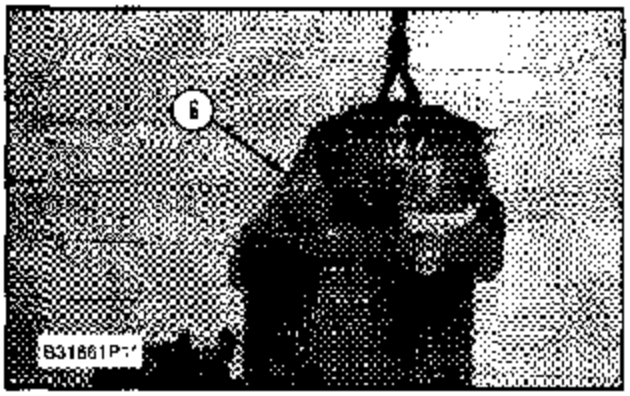
5. Use tool (B) to pull sleeve (5) and the O-ring seals from the torque converter housing.



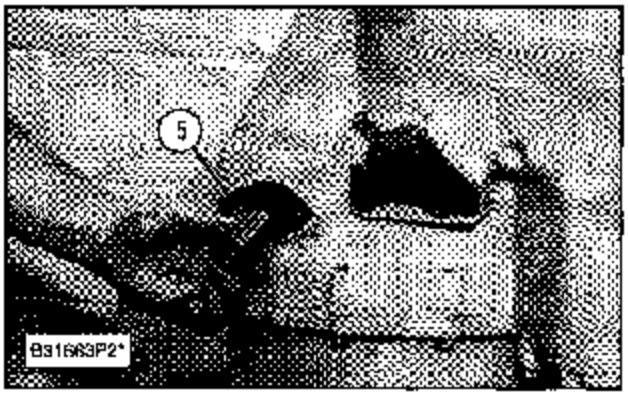
6. Fasten a hoist to torque converter (6) as shown. Remove the mounting bolts that hold the torque converter to the transmission. Remove the torque converter from the transmission. The weight of the torque converter is **180 kg (400 lb)**.

Connect Torque Converter To Transmission 3001-077

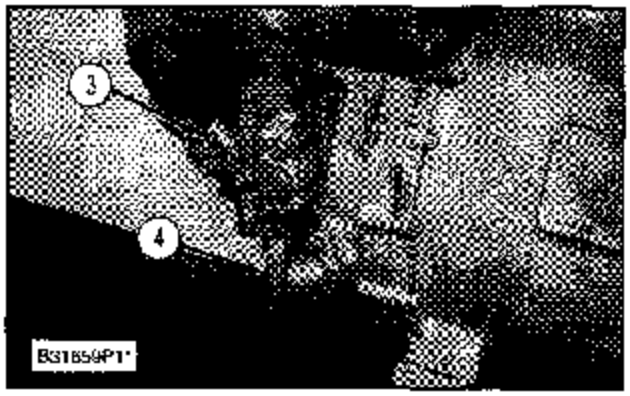
Tools Needed	A
5P9736 Link Bracket	2



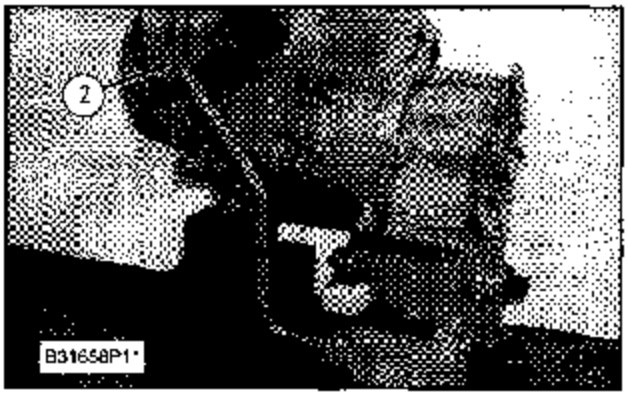
1. Fasten a hoist to the torque converter, and put it in position on the transmission. Be sure the O-ring seal is in position on the transmission case. Install the mounting bolts that hold the torque converter to the transmission.



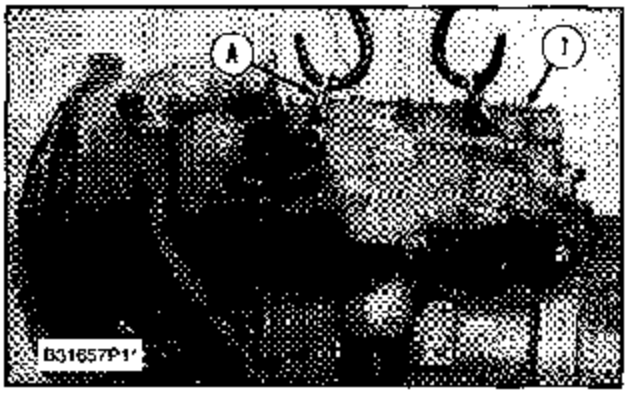
2. Install the O-ring seals on sleeve (5). Put clean oil on them. Install sleeve (5) in the torque converter housing.



3. Install the O-ring seals on the torque converter outlet relief valve and the elbow. Put clean oil on the seals. Install torque converter outlet relief valve (3) and elbow (4).



4. Install tube assembly (2).



5. Fasten tool (A) and a hoist to pilot and hydraulic pump (1). Put the pilot and hydraulic pump in position in the torque converter housing, and install the bolts and washers that hold it.

End By:

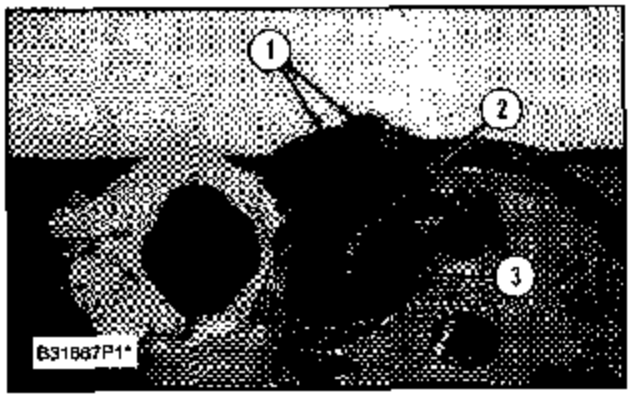
a. install torque converter, transmission and transfer gears

Disassemble Torque Converter 3101-015

Tools Needed		A	B	C
6V2156	Link Bracket	2		
1P0510	Driver Group		1	
2P8312	Pliers			1

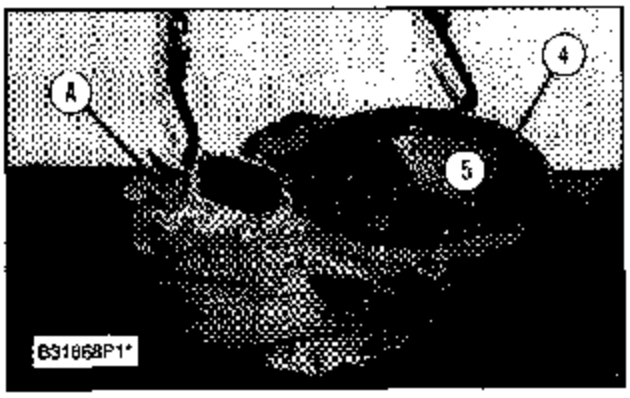
Start By:

a. separate torque converter from transmission

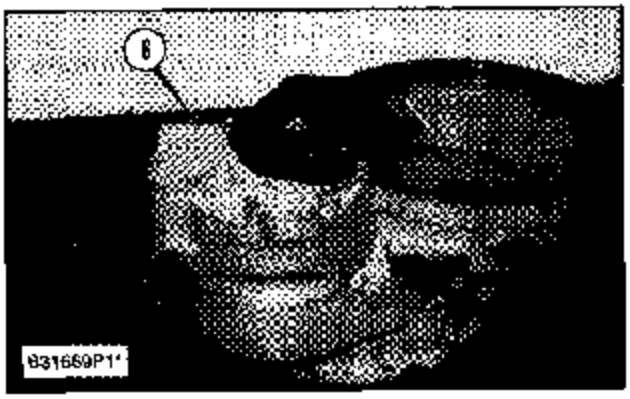


1. Remove O-ring seals (1) from the torque converter housing.

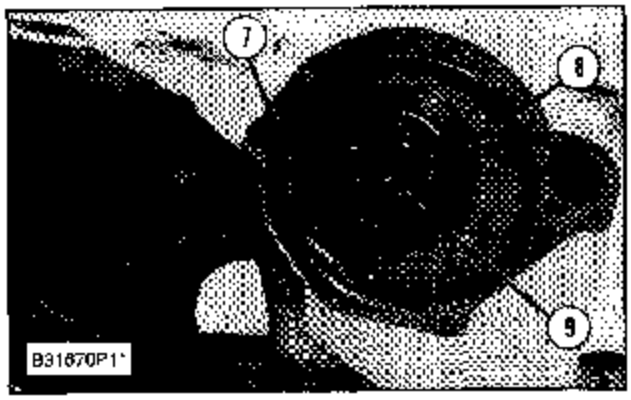
2. Remove the bolt, retainer (2) and gear (3) from the output shaft.



3. Fasten tool (A) and a hoist to torque converter housing (4) as shown. Remove eight bolts (5) and torque converter housing (4). The weight of the torque converter housing is **113 kg (250 lb).**



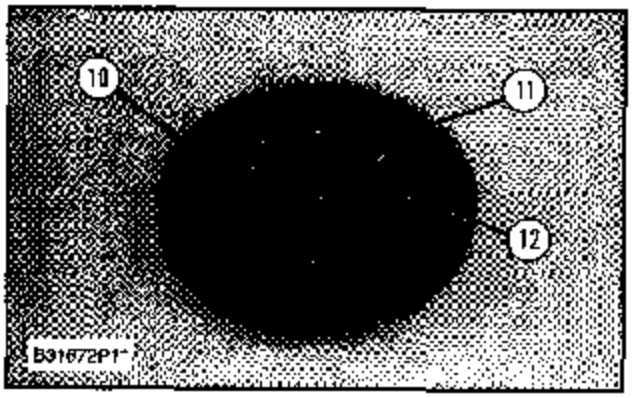
4. Remove the bolts and transmission oil pump (6) from the torque converter housing.



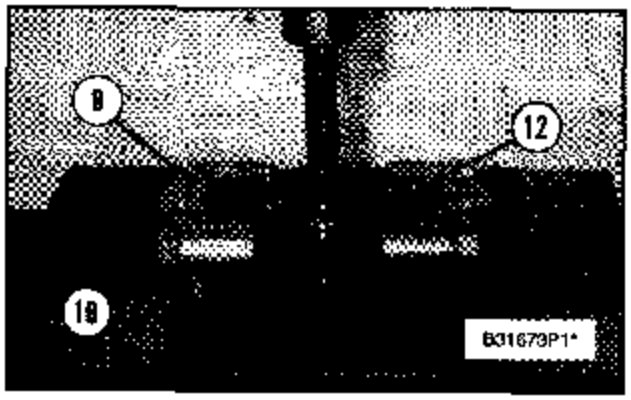
5. Pull shaft (9) out of the oil pump drive gear.

6. Remove bolts (8) and tube assembly (7) from the housing.

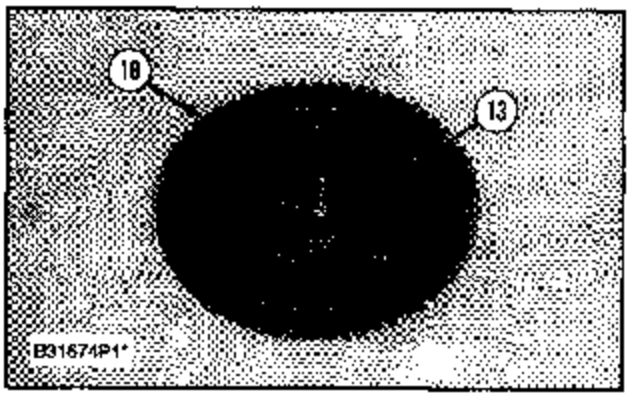
7. Remove transmission oil pump drive gear (10) from the other side of the torque converter housing.



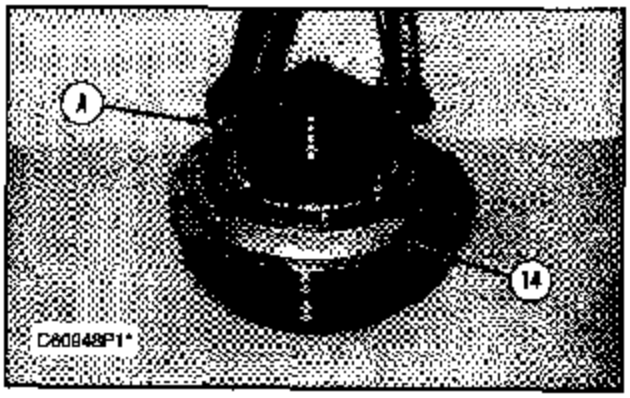
8. Remove retaining ring (11) that holds bearing (12) on gear (10).



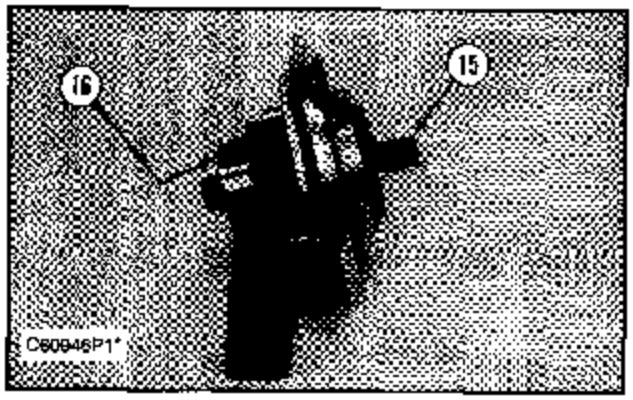
9. Use tool (B) and a press to push gear (10) out of bearing (12).



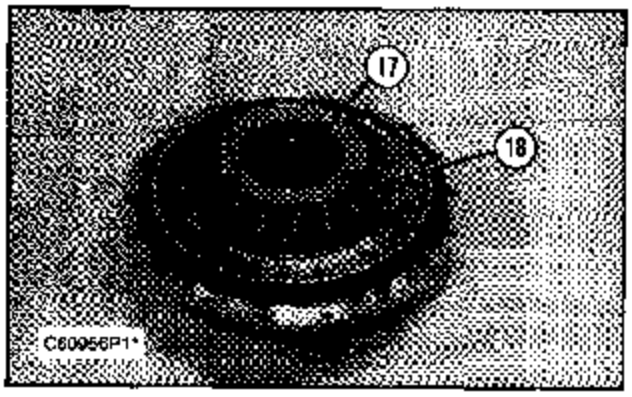
10. Remove bearing retainer (13) from gear (10).



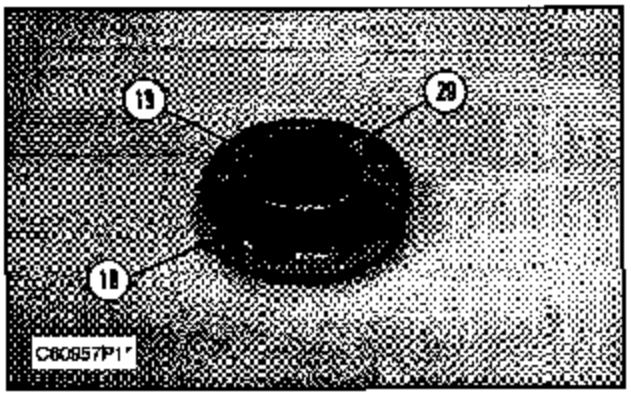
11. Fasten tool (A) and a hoist to the carrier assembly as shown. Remove the 18 bolts that fasten the impeller to the housing. Use two **M10 X 1.50 Metric** forcing screws (14) to loosen the impeller from the housing. Remove the impeller and carrier assembly from the housing. The weight of the unit is **36 kg (80 lb)**.



12. Remove retaining ring (16) from the carrier assembly. Remove the bearing and shaft (15).



13. Remove retaining ring (17) from the end of the carrier assembly, and remove stator (18).

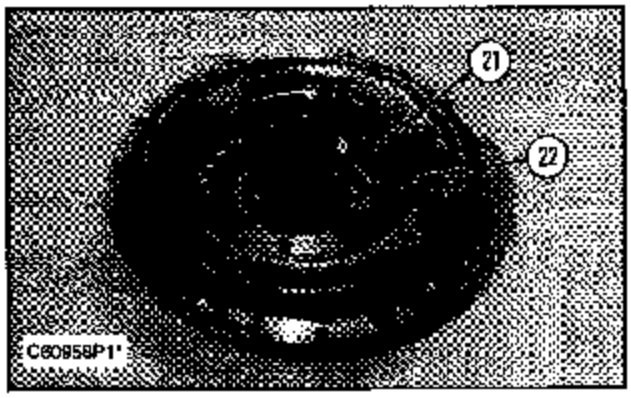


NOTICE

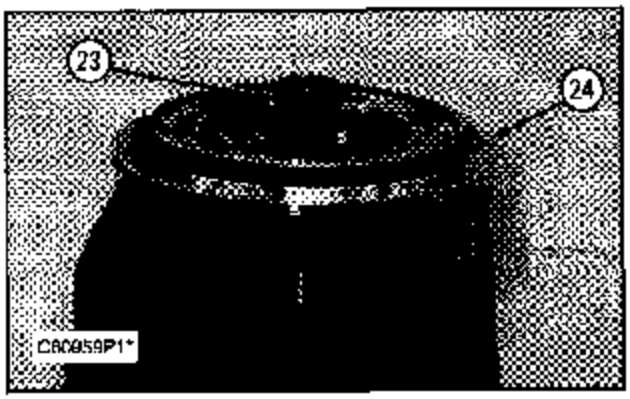
To prevent possible damage, do **not** remove splined adaptor (20) from the stator unless necessary. For part reusability refer to" Guideline For Reusable Parts" Form No. SEBF 8087.

14. Remove retaining rings (19) from each side of stator (18).

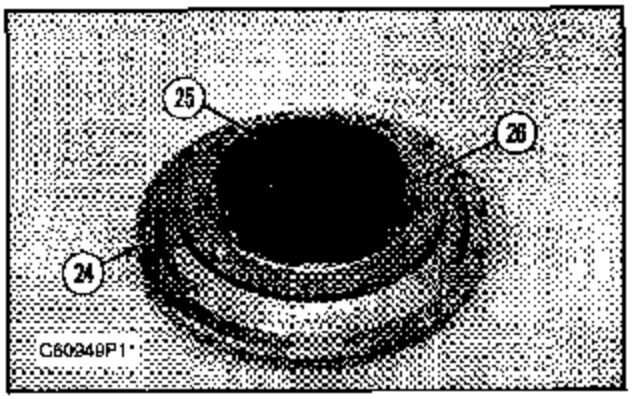
15. Heat stator (18) to a temperature of **121°C (250°F) for one hour**. Then remove splined adapter (20) from stator (18).



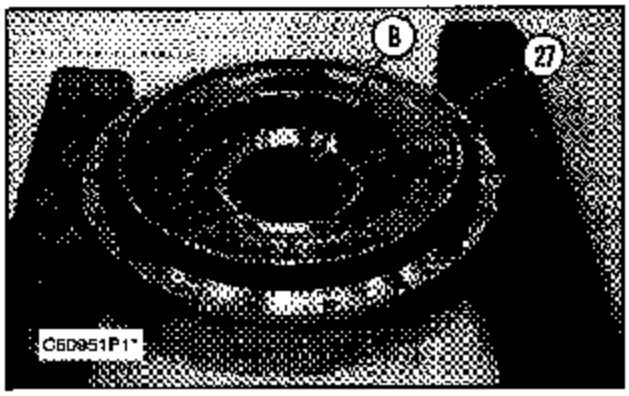
16. Use tool (C) to remove retaining ring (21). Remove spacer (22).



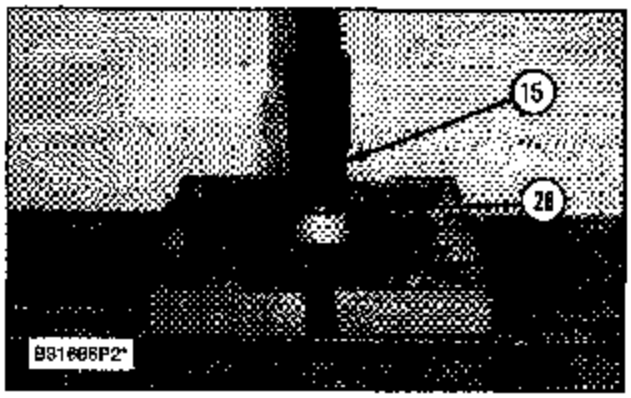
17. Support the carrier assembly, and drive carrier assemply (23) out with a soft hammer from impeller (24). Remove the seal ring from carrier assembly (23).



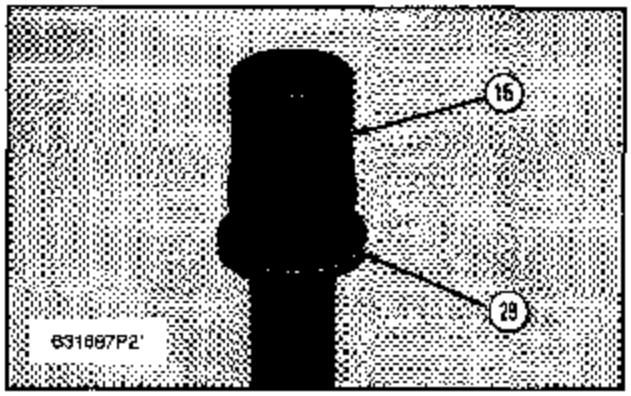
18. Turn impeller (24) over. Remove bolts (25) and gear (26).



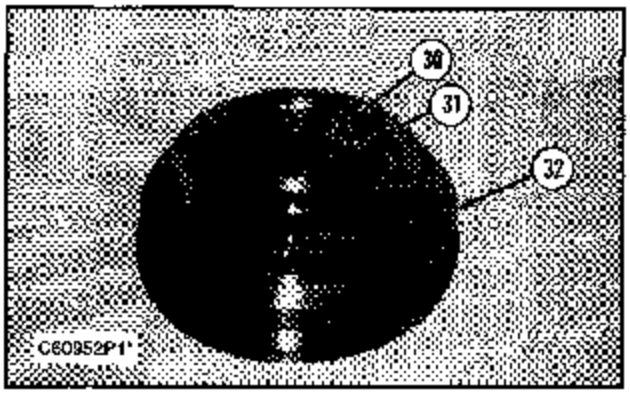
19. Position the impeller on blocks as shown. Use tooling (B) to remove bearing (27).



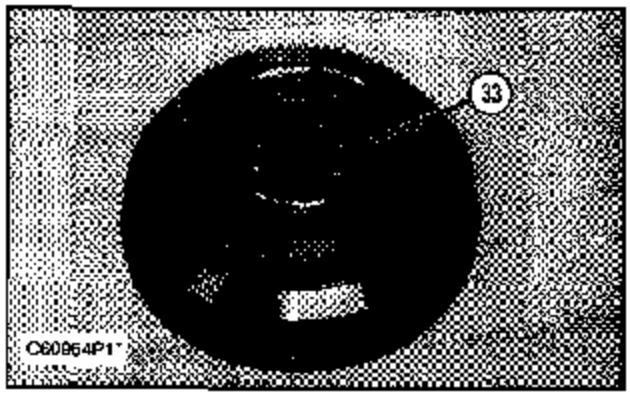
20. Use a press to push output shaft (15) out of bearing (28).



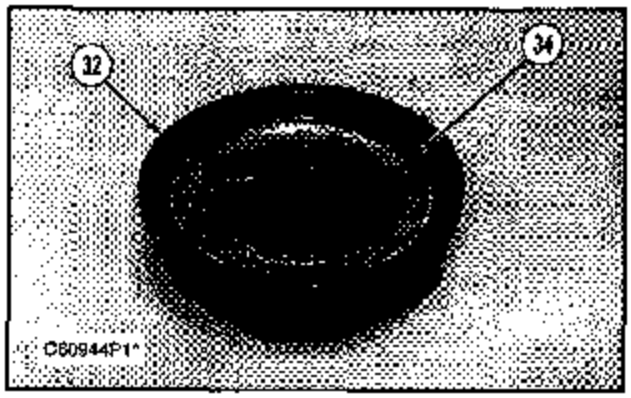
21. Remove piston ring (29) from shaft (15).



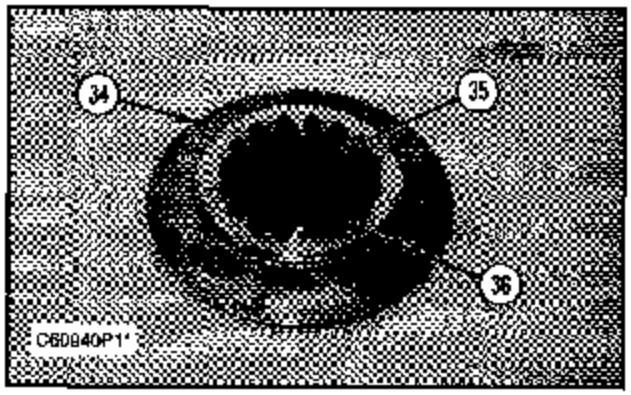
22. Remove retaining ring (30) and cap (31) from housing (32).



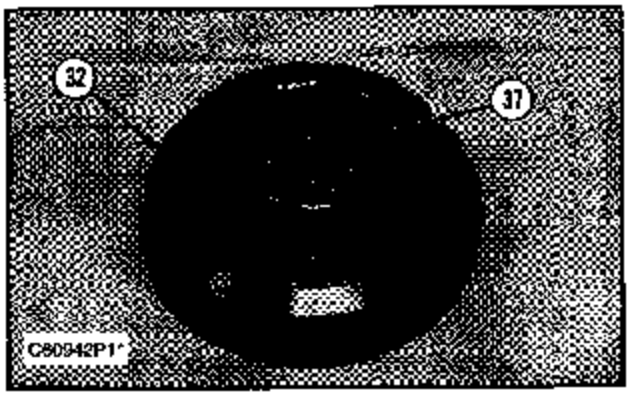
23. Remove retaining ring (33) with tooling (C).



24. Turn the housing over, and remove turbine (34) from housing (32).



25. Remove bolts (36), and remove hub (35) from turbine (34).

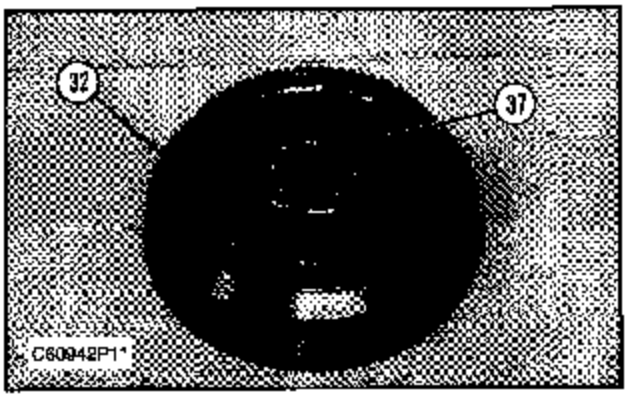


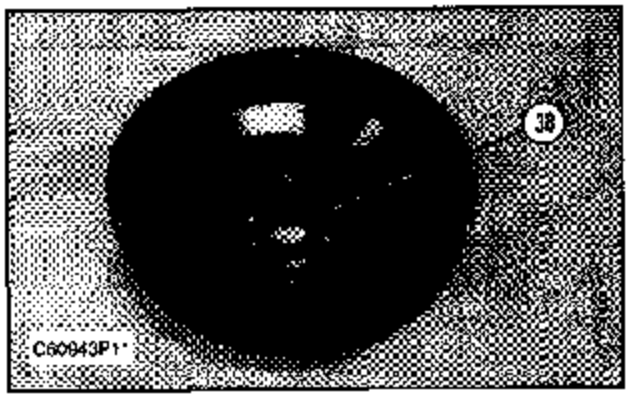
26. Remove bearing (37) from housing (32).

Assemble Torque Converter 3101-016

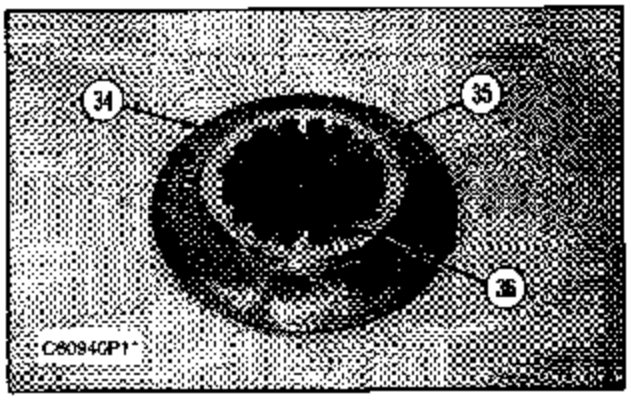
Tools Needed		A	B	C
1P0510	Driver Group	1		
2P8312	Pliers		1	
6V2156	Link Bracket			1

NOTE: Prior to fully assembling the torque converter, check the clearance between the stator and turbine and the stator and impeller. Refer to the topic "Torque Converter" in Specifications, 815F Compactor in this publication.

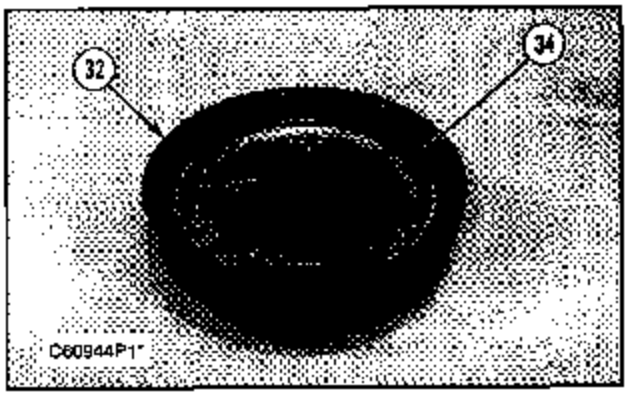




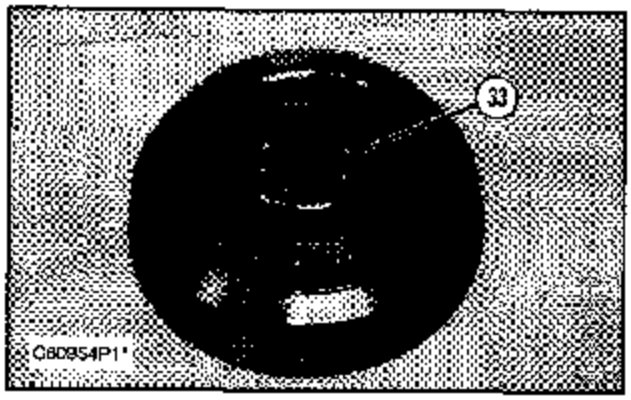
1. Use tool (A) and a press to install the bearing (37) in housing (32). Install the bearing with groove (38) toward the inside of the housing.



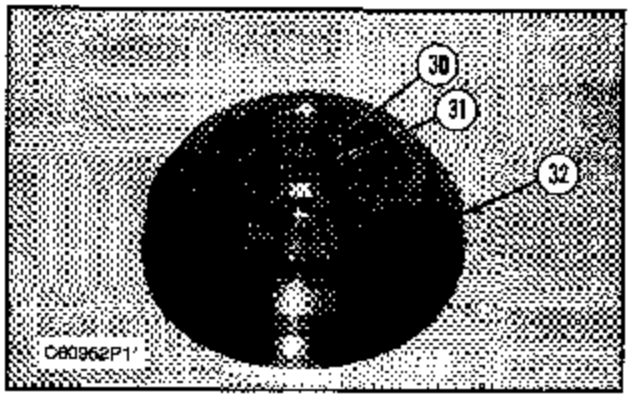
2. Position hub (35) in turbine (34), and install bolts (36). Tighten the bolts to a torque of **60 ± 7 N•m (44 ± 5 lb ft)**.



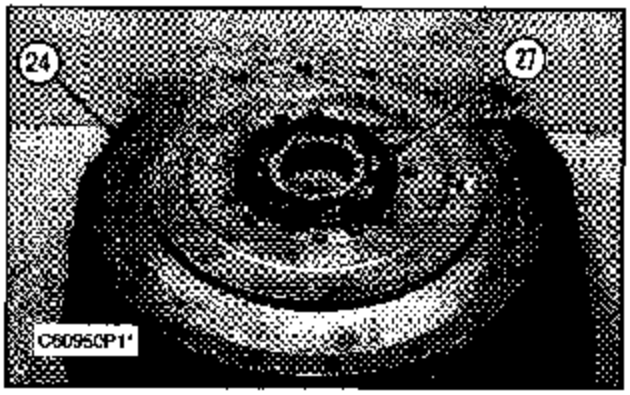
3. Install turbine (34) in housing (32). Align the ball in the hub with groove (38).

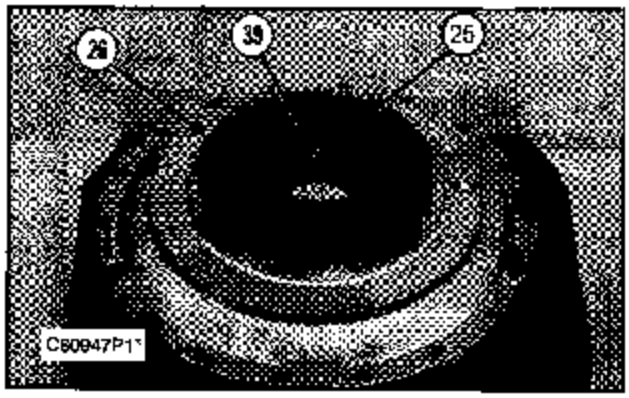


4. Hold the turbine in position, and turn the housing over. Install retaining ring (33) with tool (B).



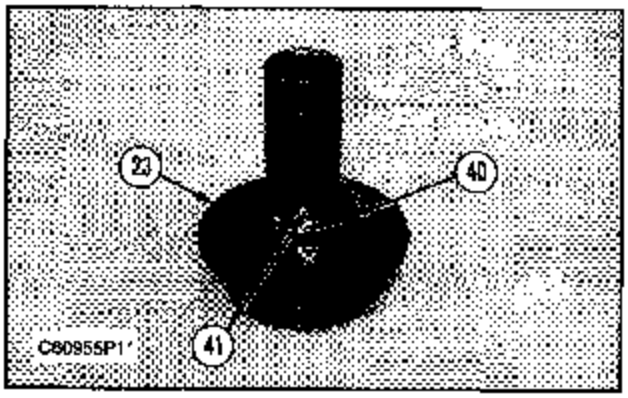
5. Install cap (31) and retaining ring (30) on housing (32).

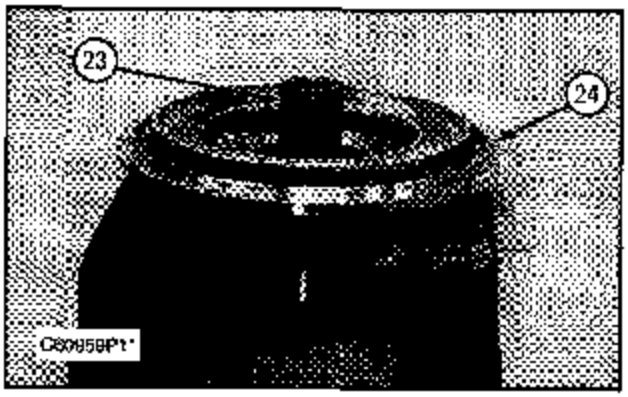




6. Lower the temperature of bearing (27) and install it in impeller (24). Install the bearing with notch (39) toward gear (26).

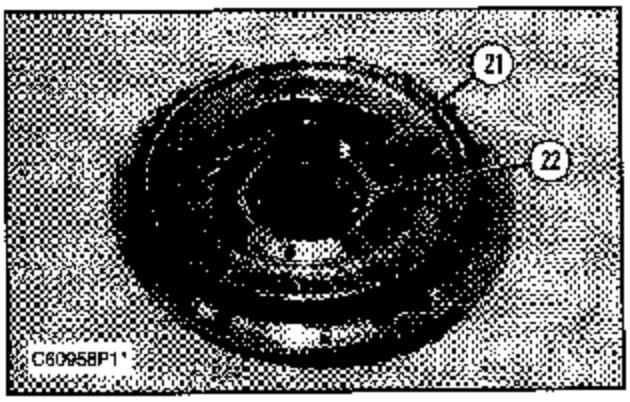
7. Position gear (26) on impeller (24), and install bolts (25). Tighten the bolts to a torque of **105 ± 15 N•m (75 ± 11 lb ft)**.



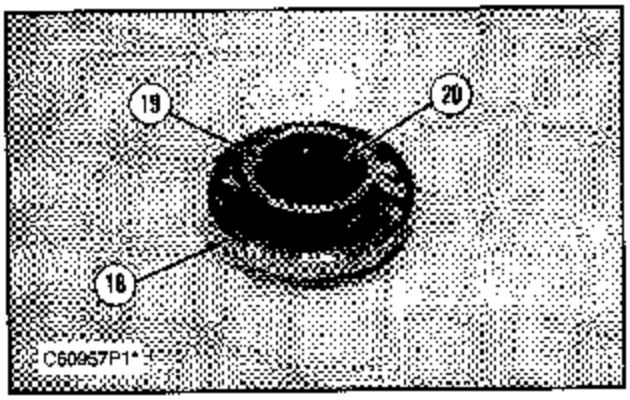


8. Install seal ring (40) on carrier assembly (23). Put clean oil on the seal ring.

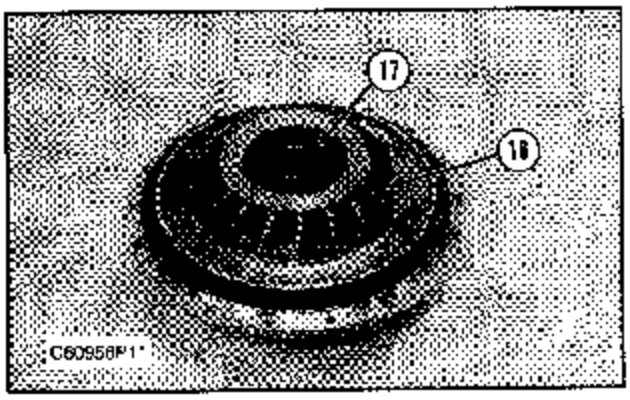
9. Align ball (41) with groove (39), and install carrier assembly (23) in impeller (24).



10. Install spacer (22) and use tool (B) to install retaining ring (21).

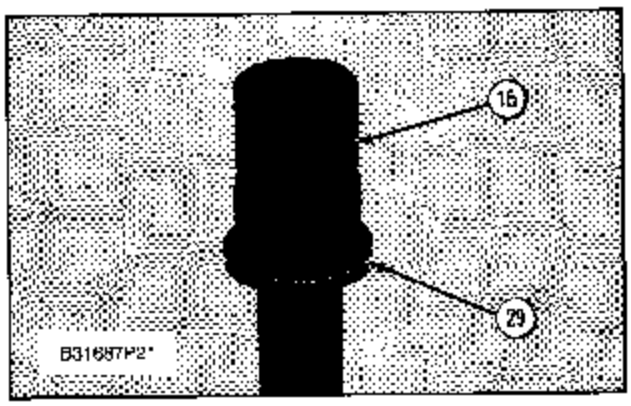


11. Heat stator (18) to a temperature of **121°C (250°F) for one hour**. Install splined adapter (20) in stator (18) before it is allowed to cool. Install retaining rings (19) on both sides of stator to hold the unit together.

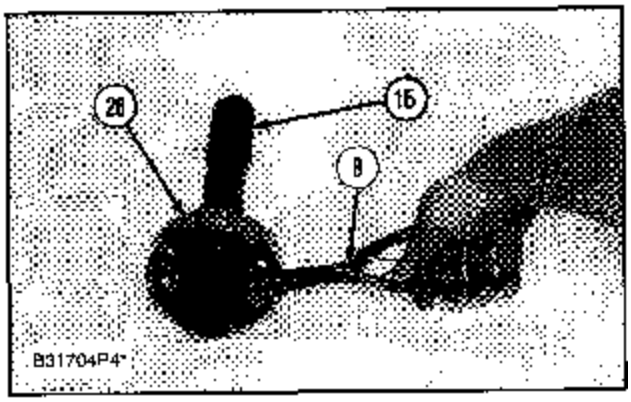


12. Install stator (18) on the impeller.

13. Use tool (B) to install retaining ring (17) on the carrier assembly to hold stator (18) in position.



14. Install seal ring (29) on shaft (15).

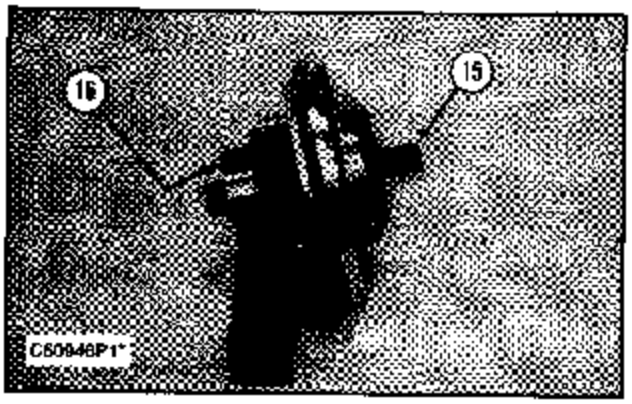


NOTICE

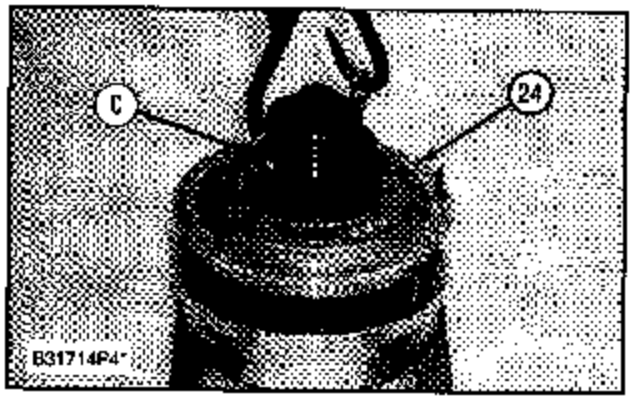
Bearing (28) must be installed on shaft (15) with the closed side of the non-metallic cage toward the torque converter wheels. This will prevent the cage from coming off the balls and ensure maximum bearing life.

15. Install bearing (28) on shaft (15).

16. Use tool (B) to install the retaining ring that holds bearing (28) on shaft (15).

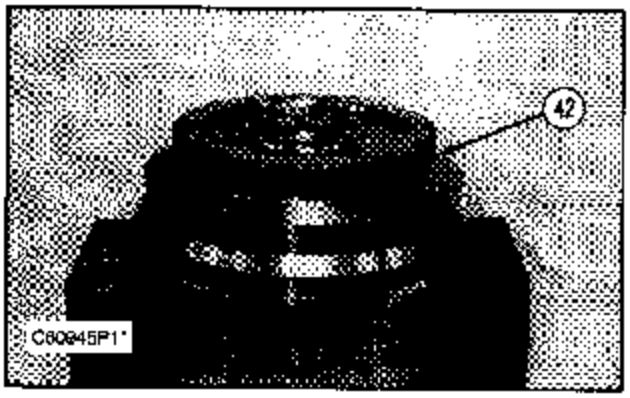


17. Install shaft (15) in the carrier assembly. Install retaining ring (16).

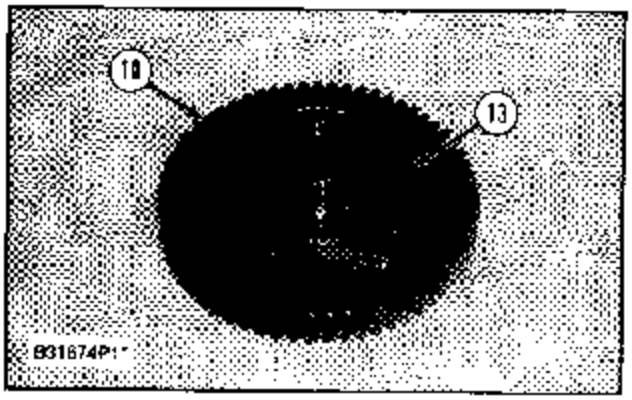


18. Install two **M10 X 1.50 Metric** guide bolts in the housing.

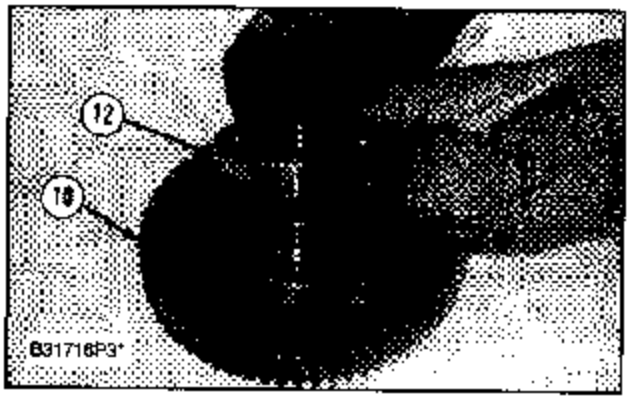
19. Use tool (C) and a hoist to put impeller (24) in position on the housing. Install the eighteen bolts that hold the unit together. Tighten the bolts to a torque of **60 ± 7 N•m (44 ± 5 lb ft)**.



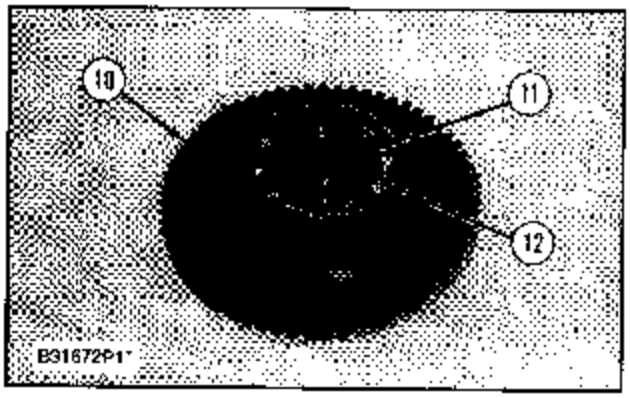
20. Install O-ring seal (42) on the torque converter. Put clean oil on the O-ring seal.



21. Install retainer (13) on gear (10).

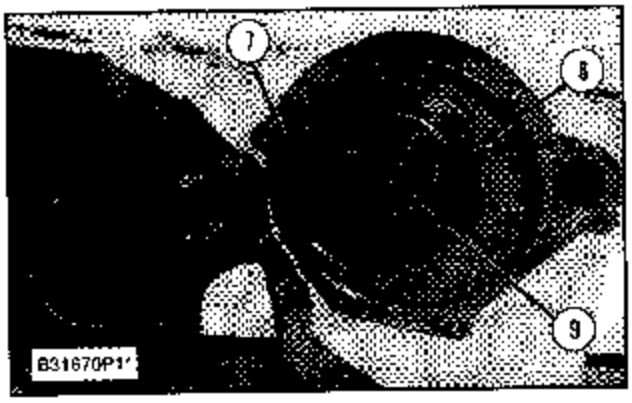


22. Install the retaining ring on bearing (12). Heat bearing (12) to a maximum temperature of **135°C (275°F)**, and install the bearing on gear (10).

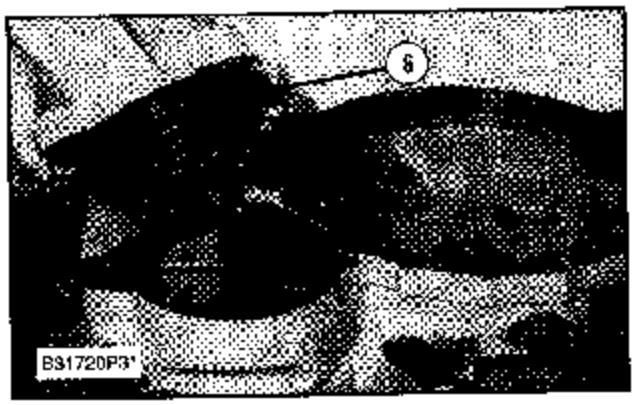


23. Install retaining ring (11) that holds bearing (12) on gear (10).

24. Install gear (10) in the torque converter housing.

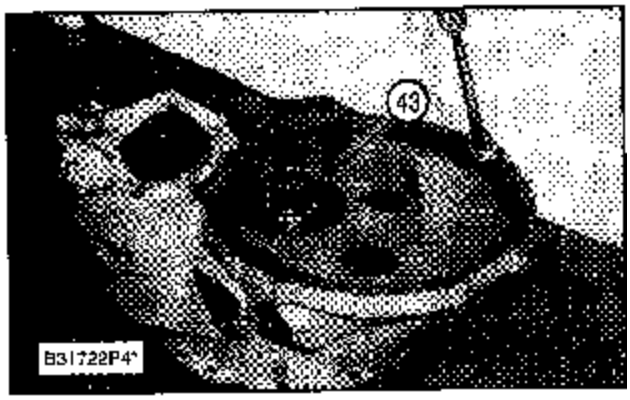


25. Install tube assembly (7). Install bolts (8) through the housing and into the retainer to hold the gear in position. Tighten bolts (8) to a torque of **50 ± 7 N•m (37 ± 5 lb ft)**. Install shaft (9) into the gear.

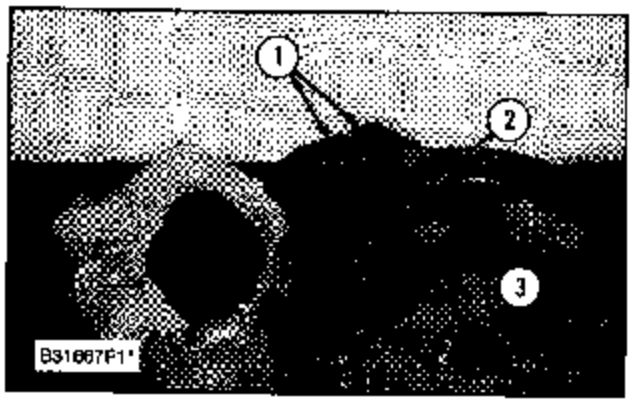


26. Put clean oil on the O-ring seal, and install transmission oil pump (6) in the torque converter housing.

27. Fasten tool (C) and a hoist to torque converter housing (4). Put the torque converter housing in position on the torque converter.



28. Install guide bolts (43) as shown. Align the bolt holes in the carrier and housing. Install the bolts through the housing into the carrier. Tighten the bolts to a torque of **50 ± 7 N•m (37 ± 5 lb ft)**.



29. Position gear (3) on the output shaft. Install retainer (2) and the bolt to hold it. Tighten the bolt to a torque of **120 ± 15 N•m (90 ± 11 lb ft)**.

30. Put clean oil on O-ring seals (1). Install the seals on the torque converter housing.

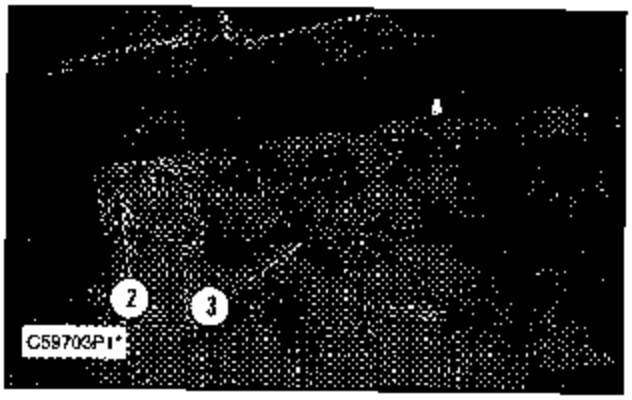
End By:

a. connect torque converter to transmission

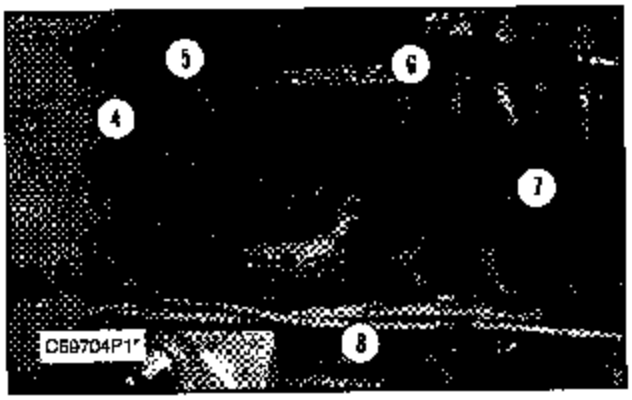
Transmission Hydraulic Control Valve

Remove & Install Transmission Hydraulic Control Valve 3152-010

1. Remove the six bolts and washers that hold seat assembly (1) in position. Using two persons, remove the seat assembly from the cab. The weight of the seat assembly is **approximately 23 kg (50 lb)**.



2. Remove bolts (2) and access plate (3) from the cab.



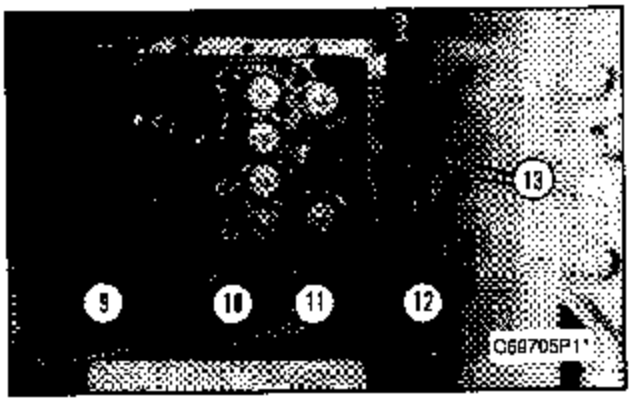
Typical Example

NOTE: In the following steps, the cab has been removed for better photo illustration of the transmission hydraulic control valve.

3. Remove ten bolts (4), the washers and cover (5).

4. Remove nuts (6), the washers and cover (7). Remove the gasket for cover (7).

5. Remove the bolts, washers and cover (8).



Typical Example

6. Disconnect the wiring harness from connector (9). Remove the nut from connector (9).

NOTICE

Before removing transmission hydraulic control valve (10), be sure sleeves (13) are positioned into the torque converter, clear of the transmission hydraulic control valve. Move the wiring harness and connector (9) clear of the transmission housing before removing the transmission hydraulic control valve.

7. Remove bolt (12) and the washer holding sleeves (13) in position.

8. Push sleeves (13) into the torque converter housing and clear of the transmission housing.

9. Move the wiring harness and connector (9) clear of the transmission housing.

NOTE: The transmission hydraulic control valve is held in to the transmission with four bolts (11). Bolts (11) are marked with an "X" in Previous photo.

10. Remove four bolts (11) from the transmission hydraulic control valve.

Typical Example

11. Fasten a lifting strap and a hoist to the existing lifting eye in the transmission hydraulic control valve. Carefully remove transmission hydraulic control valve (10) from the transmission. The weight of the transmission hydraulic control valve is approximately **43 kg (95 lb).**

NOTE: The following steps are for the installation of the transmission hydraulic control valve.

12. Be sure the mating surfaces of the planetary group and the transmission hydraulic control valve are thoroughly clean.

13. Check the condition of the gaskets used with the covers for the transmission hydraulic control valve. If the gaskets are worn or damaged, use new parts for replacement.

14. Install the transmission hydraulic control valve in the reverse order of removal. Tighten four bolts (11) marked with the "X" that hold the transmission hydraulic control valve to the planetary housing to a torque of **48 ± 4 N•m (35 ± 3 lb ft)**.

15. Fill the transmission with oil to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

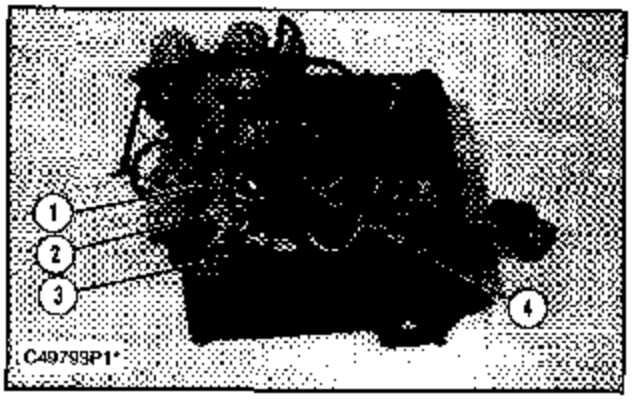
Disassemble & Assemble Transmission Hydraulic Control Valve 3152-017

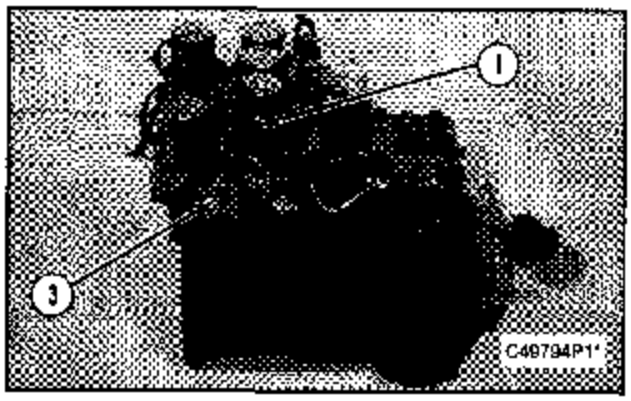
Start By:

a. remove transmission hydraulic control valve

NOTICE

Put identification marks on all sections of the transmission hydraulic control valve to ensure proper assembly.





1. Remove the solenoid valve from the transmission hydraulic control valve assembly as follows:

   a. Remove electrical connector (4) from the support clip.

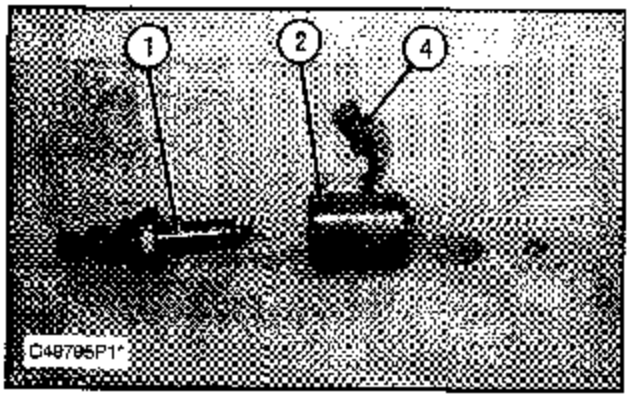
   b. Remove the nut, washer and coil assembly (2) from cartridge (1). For assembly purposes, the torque for the nut holding coil assembly (2) is **4.5 to 5.5 N•m (40 to 48 lb in)**.

   c. Remove cartridge (1) from manifold (3). For assembly purposes, the torque for cartridges (1) is **108 ± 7 N•m (80 ± 5 lb ft)**.

   d. Repeat Steps 1a through 1c for the remaining solenoid valves.

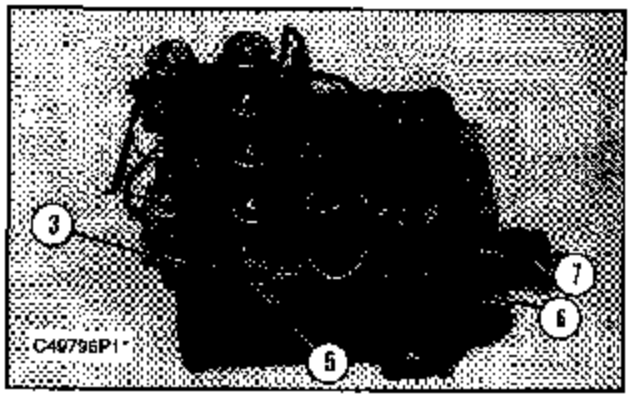
NOTICE

The six solenoid valves can be reassembled and installed on manifold (3) after the O-ring seals on cartridges (1) have been inspected and replaces as needed.



2. Check the condition of the three O-ring seals on each cartridge (1). Replace the O-ring seals if needed.

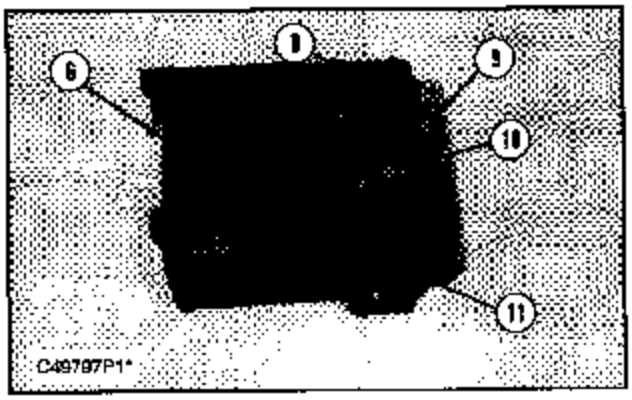
3. Reverse the procedures in Steps 1 and 2 to reinstall cartridges (1) into manifold (3). Be sure each electrical connector (4) is positioned into the correct support clip.



4. Remove the bolts from the support clamps holding wiring harness (7).

5. Remove bolts (5) from manifold (3).

6. Remove manifold (3) and wiring harness (7) from manifold (6).



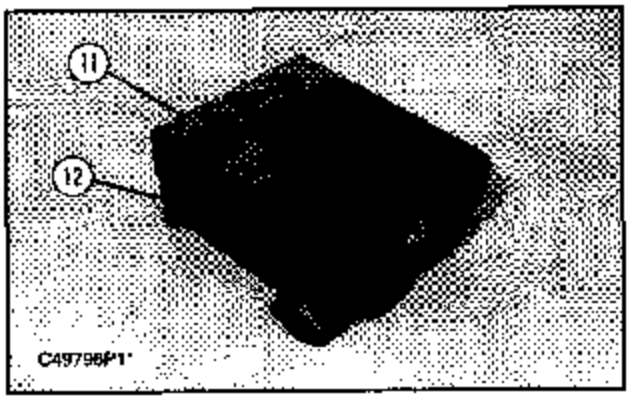
7. Remove two connectors (8) from manifold (6). Check the condition of the O-ring seals on connectors (8). Replace the O-ring seals if needed.

8. Remove plug (10) from manifold (6).

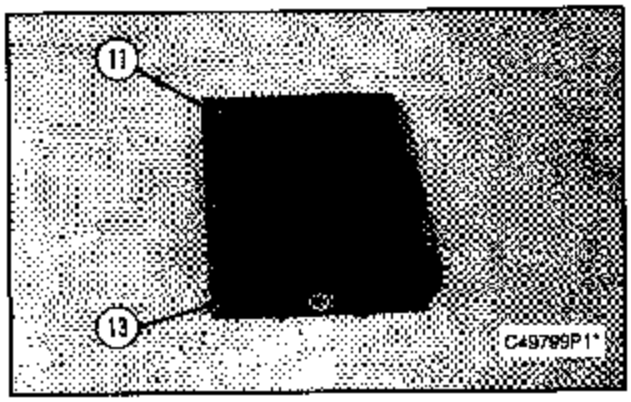
9. Check the condition of the O-ring seal on plug (10). Replace the O-ring seal if needed.

10. Remove twenty one bolts (9) from manifold (6).

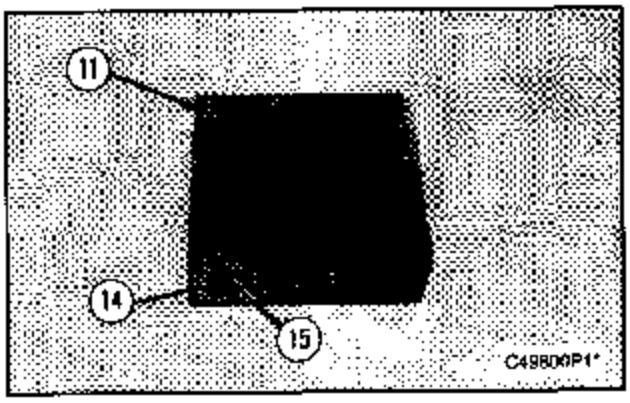
11. Remove manifold (6) from valve (11).



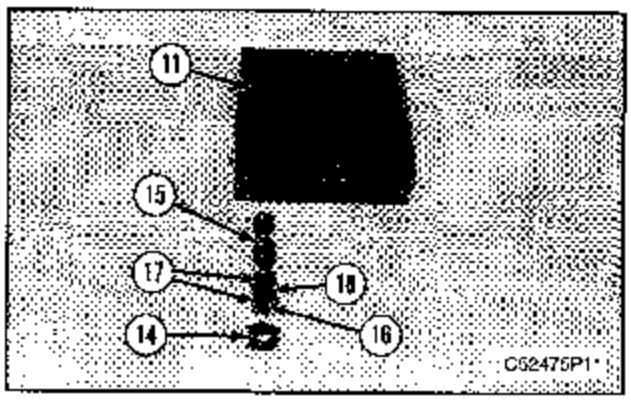
12. Remove valve (11) from plate (12).

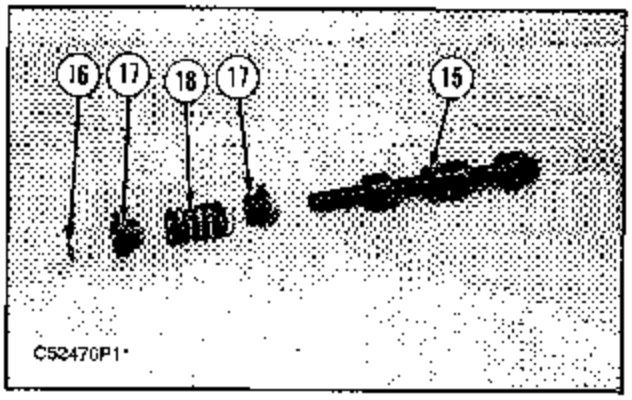


13. Remove the bolts and cover (13) from valve (11). Check the condition of the O-ring seals beneath cover (13). Replace the O-ring seals if needed.



14. Remove stop (14) and spool (15) from valve (11).

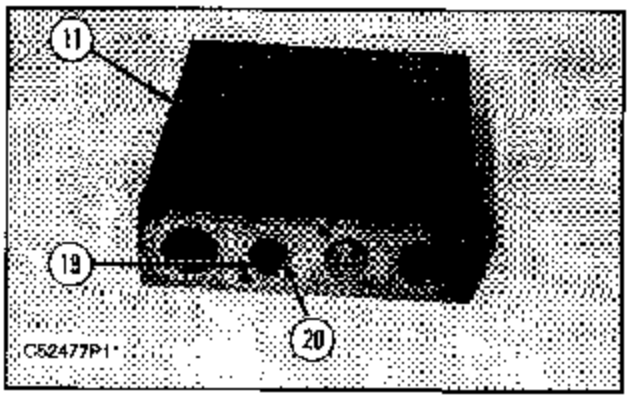


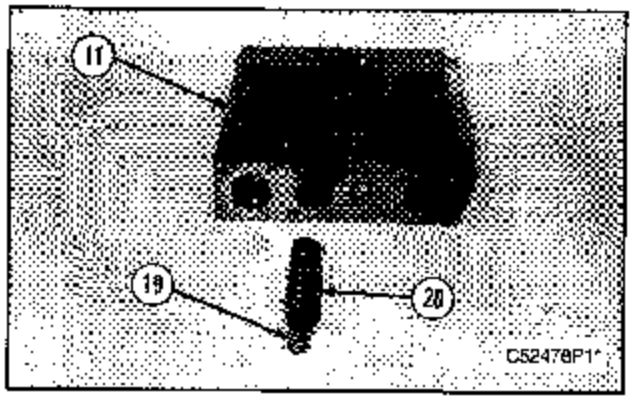


⚠ WARNING

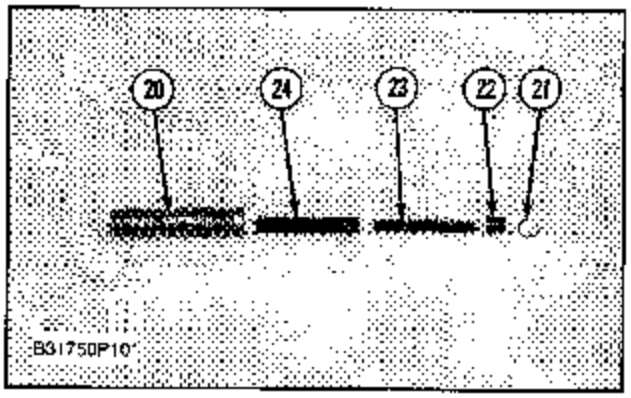
There is spring force against retaining ring (16). When retaining ring (16) is removed, the spring force will be released. To prevent possible personal injury, support retainers (17) and spring (18) while removing retaining ring (16).

15. Remove retaining ring (16), two retainers (17) and spring (18) from spool (15).





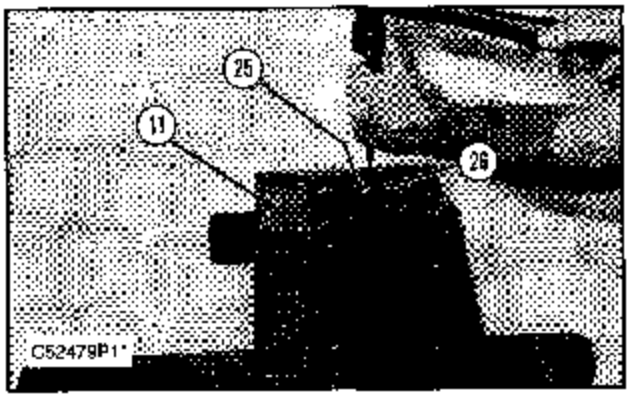
16. Remove spring (19) and spool (20) from valve (11).

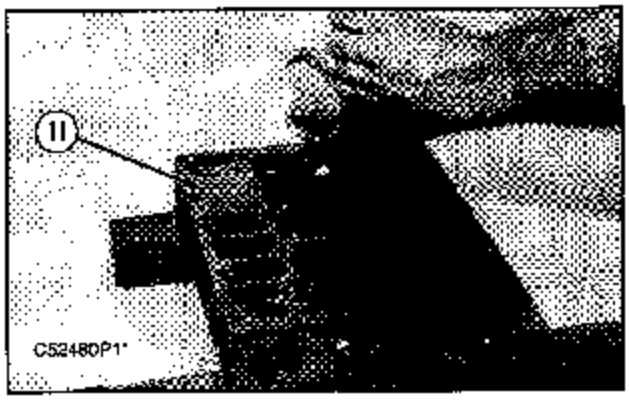


⚠ WARNING

There is spring force against retainer (22) and retaining ring (21). When retaining ring (21) is removed, the spring force will be released. To prevent possible personal injury, support retainer (22) and spool (20) while removing retaining ring (21).

17. Remove retaining ring (21), retainer (22), spring (23) and spring (24) from spool (20).





NOTE: Spool (20) and spool (25) are located in the same bore of valve (11). Spool (25) must be removed from the end opposite spool (20).

⚠ WARNING

There is spring force against pin (26) and spool (25). When pin (26) is removed, the spring force will be released. To prevent flying parts and possible personal injury, be sure to follow the procedure in Steps 18a through 18f.

18. Remove spool (25) from valve (11) as follows:

a. Turn valve (11) over. Position valve (11) on wood blocks as shown.

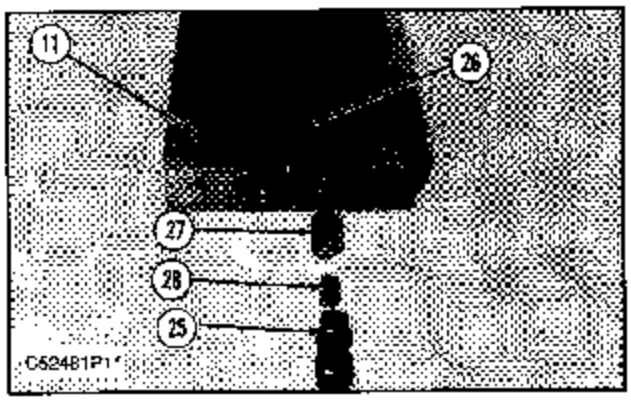
b. Use a punch to drive pin (26) into valve (11) until pin (26) is clear of spool (25). **Do not** remove the punch at this time.

c. Use a screwdriver to slightly depress spool (25).

d. Remove the punch from the hole for pin (26).

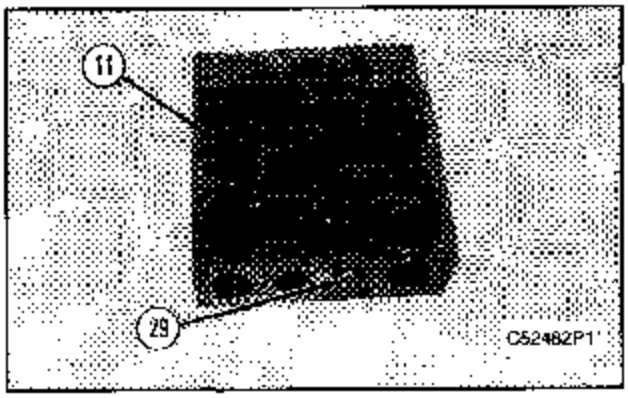
e. Slowly remove the screwdriver depressing spool (25). This will relieve the spring force against spool (25).

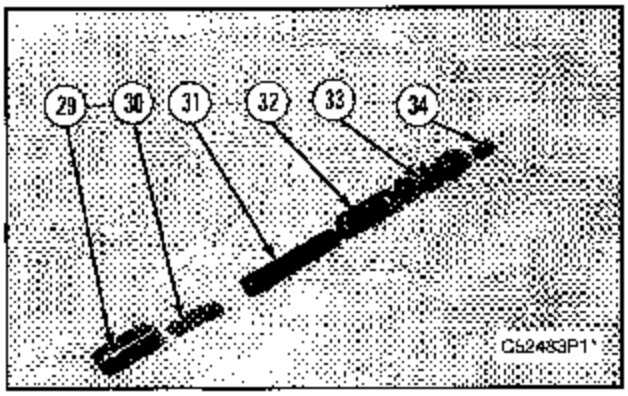
f. Remove spool (25) from valve (11).



19. Remove spring (27) from valve (11).

20. Remove slug (28) from spool (25).





21. Reposition valve (11) on a bench as shown.

22. Remove piston (29) from valve (11).

23. Remove spacers (30) from the inside diameter of piston (29).

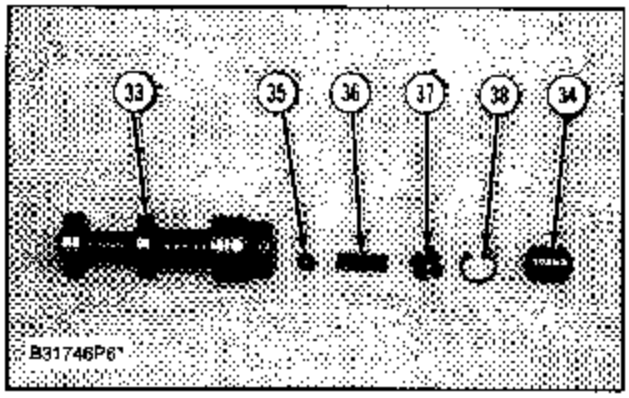
24. Remove spring (31) and (32) from valve (11).

NOTICE

When removing spool (33), use a punch or screwdriver to keep the outside diameters of the spool aligned with the bore of valve (11). Avoid damaging or scratching the highly finished surfaces of spool (33) and the bore of valve (11).

25. Remove spool (33) from valve (11).

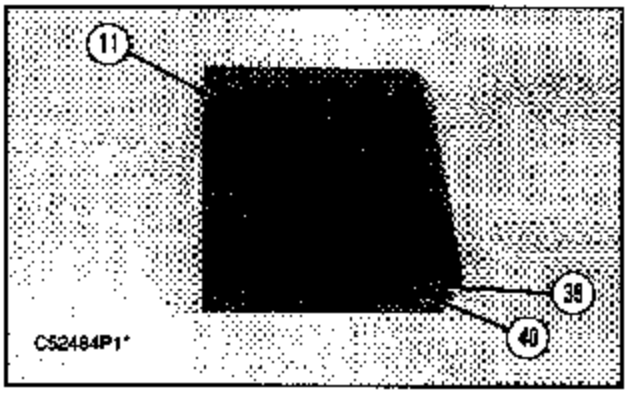
26. Remove slug (34) from spool (33).



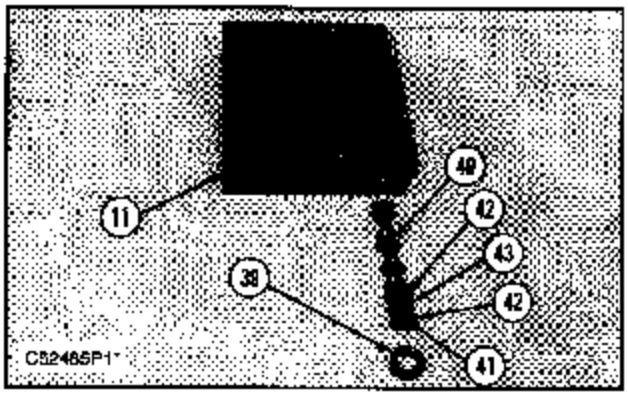
⚠ WARNING

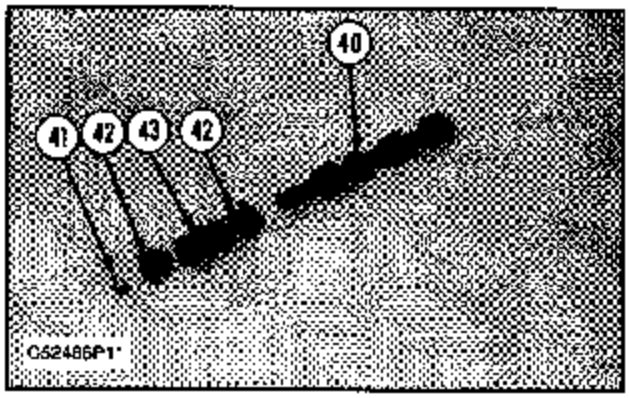
There is spring force against retaining ring (38). When retaining ring (38) is removed, the spring force will be released. Release the compression of the spring slowly. Sudden release of the spring could result in personal injury.

27. Remove retaining ring (38), retainer (37), spring (36) and ball (35) from spool (33).



28. Remove stop (39) and spool (40) from valve (11).

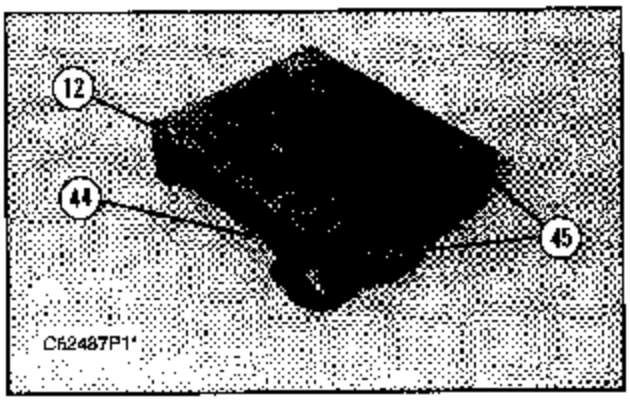




⚠ WARNING

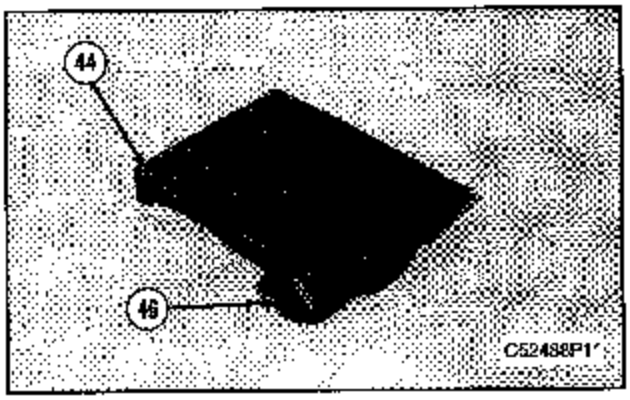
There is spring force against retaining ring (41). When retaining ring (41) is removed, the spring force will be released. To prevent possible personal injury, support retainers (42) and spring (43) while removing retaining ring (41).

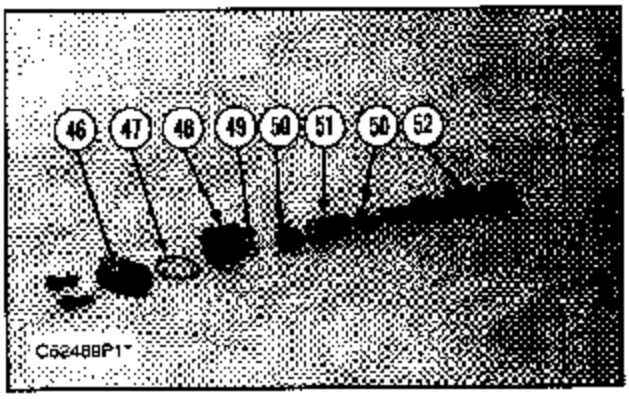
29. Remove retaining ring (41), two retainers (42) and spring (43) from spool (40).



30. Remove plate (12) from valve (44).

31. Remove two plugs (45) from plate (12). Check the condition of the O-ring seal on each plug (45). Replace the O-ring seals if needed.





32. Remove the bolts and cover (46) from valve (44). Check the condition of O-ring seal (47) located beneath cover (46). Replace O-ring seal (47) if needed.

33. Remove stop (48) from valve (44).

34. Remove spool (52) from valve (44).

⚠ WARNING

There is spring force against retaining ring (49). When retaining ring (49) is removed, the spring force will be released. To prevent possible personal injury, support retainers (50) and spring (51) while removing retaining ring (49).

35. Remove retaining ring (49), two retainers (50) and spring (51) from spool (52).

NOTE: The following steps are for the assembly of the transmission hydraulic control valve.

36. Thoroughly clean and inspect all parts of the transmission hydraulic control valve prior to assembly. Put a clean oil on all parts of the valve prior to assembly.

37. Assemble the components into valve (43) as follows:

    a. Install retainers (50), spring (51) and retaining ring (49) onto spool (52).

    b. Install spool (52), stop (48), O-ring seal (47) and cover (46) ontovalve (44). Tighten the bolts holding cover (46) to a torque of **30 ± 7 N•m (22 ± 5 lb ft)**.

38. Install the O-ring seals and two plugs (45) into plate (12).

39. Install two retainers (42), spring (43) and retaining ring (41) onto spool (40).

40. Install two retainers (17), spring (18) and retaining ring (16) onto spool (15).

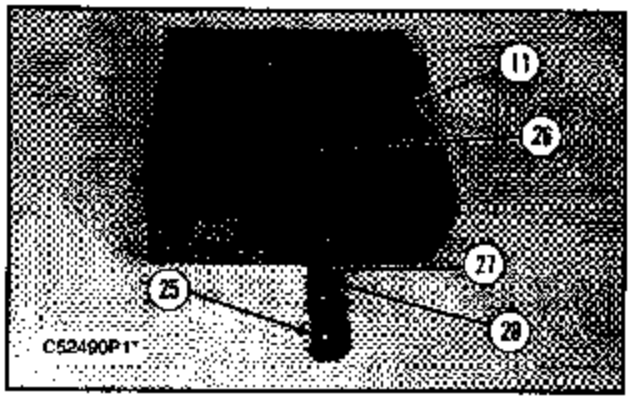
41. Install ball (35), spring (36), retainer (37) and retaining ring (38) into spool (33).

42. Install slug (34) into spool (33).

43. Install spring (24), spring (23), retainer (22) and retaining ring (21) onto spool (20).

44. Install slug (28) and spring (27) onto spool (25).

45. Assemble the components into valve (11) as follows:



Slug (28) is not visible in photo.

a. Position valve (11) and pin (26) on a bench as shown. Be sure pin (26) is clear of the bore for spool (25).

b. Install slug (28), spring (27) and spool (25) into valve (11).

c. Use a screwdriver to depress spool (25) into the bore of valve (11). Drive pin (26) into valve (11) with a soft faced hammer. Remove the screwdriver depressing spool (25).

d. Install spacers (30) into piston (29).

e. Install slug (34), spool (33), spring (32), spring (31), piston (29) and spacers (30) into their original locations in the bore of valve (11).

f. Install assembled spools (15) and (40) into their original locations in valve (11).

g. Install stops (14) and (39) into their original locations in valve (11).

h. Install spool (20) and spring (19) into their original locations in valve (11).

46. Install the O-ring seals and cover (13) onto valve (11). Tighten the bolts holding cover (13) to a torque of **30 ± 7 N•m (22 ± 5 lb ft)**.

47. Install plate (12), valve (11) and manifold (6) into their original locations on valve (44).

48. Install bolts (9). Tighten the bolts to a torque of **48 ± 4 N•m (42 ± 3lb ft)**.

49. Install manifold (3) and wiring harness (7) onto manifold (6). Tighten bolts (5) holding manifold (3) to a torque of **30 ± 4 N•m (22 ± 3 lb ft)**.

50. Install the bolts for the support clamps and wiring harness (7).

End By:

a. Install transmission hydraulic control valve

Transmission

Disassemble Transmission 3150-015

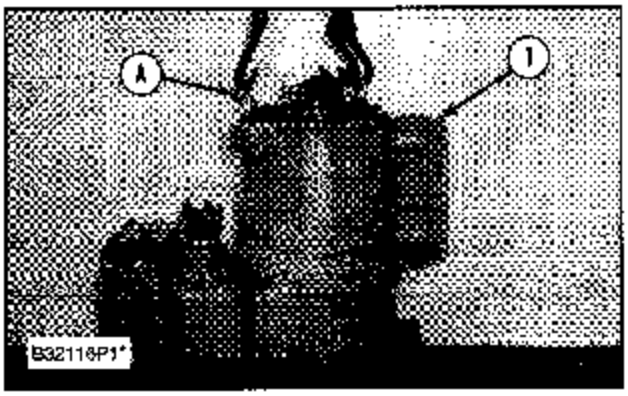
Tools Needed		A	B	C	D	E	F	G
5P9736	Link Bracket	3						
6V2156	Link Bracket		3					
FT0833	Clamp			2				
1P1863	Pliers				1			
5P4758	Pliers					1		
2P8312	Pliers						1	
FT0947	Clamp							2

Tools Needed		H	J	K	L
1P0520	Driver Group	1			
1P1862	Pliers		1		
8H0663	Bearing Puller Attachment			1	
1P1861	Pliers				1

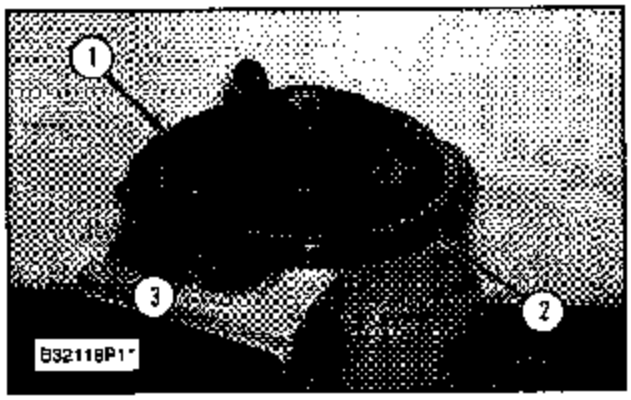
Start By:

a. remove transmission hydraulic control valve

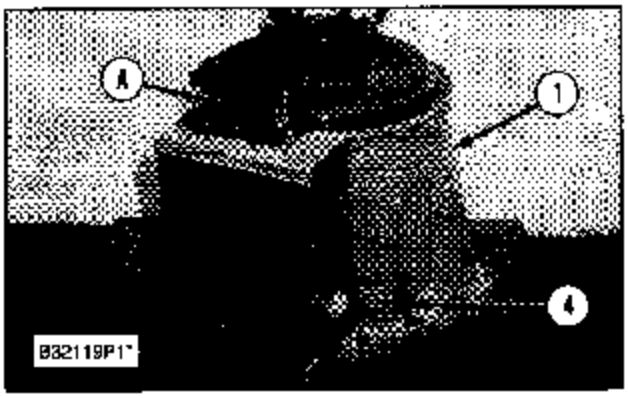
b. separate torque converter from transmission



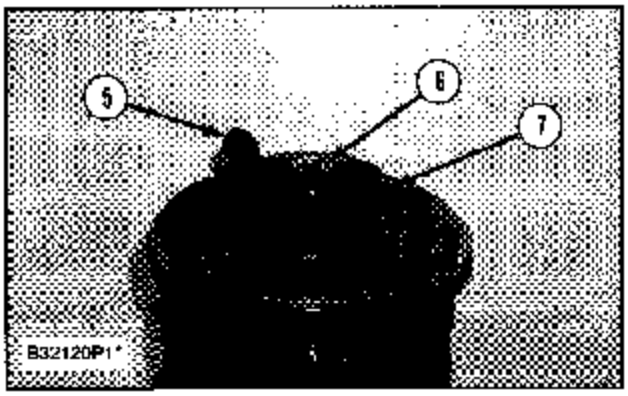
1. Fasten tool (A) and a hoist to the reverse clutch housing as shown. Remove the bolts that hold the transmission and case (1) to the transfer gear case. Use two **3/8" - 16 NC** forcing screws to separate the transmission from the transfer gear case. The weight of the unit is **540 kg (1200 lb)**.



2. Remove O-ring seals (2) and (3) from case (1).

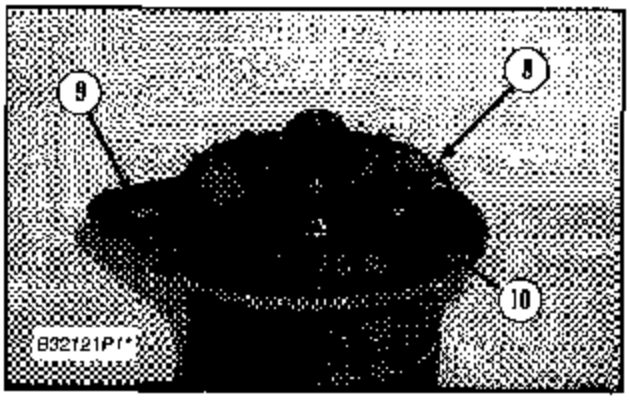


3. Fasten tool (A) and a hoist to case (1) as shown. Remove the bolts that hold case (1) to the transmission manifold assembly. Use two 3/8" - 16 NC forcing screws to separate case (1) from the manifold. Remove case (1) from the transmission. The weight of the case is **90 kg (200 lb)**.



4. Remove elbow (5) and the O-ring seal from the reverse clutch housing.

5. Remove the bolt, retainer (6) and gear (7) from the transmission input shaft.



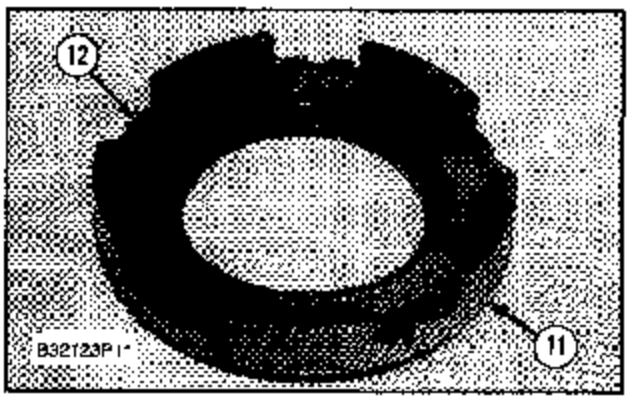
6. Turn the transmission over with a hoist, so the No. 6 (first speed) clutch housing is up. The weight of the transmission is **450 kg (1000 lb)**.

7. Remove O-ring seal (10) and both O-ring seals (9) from the manifold assembly.

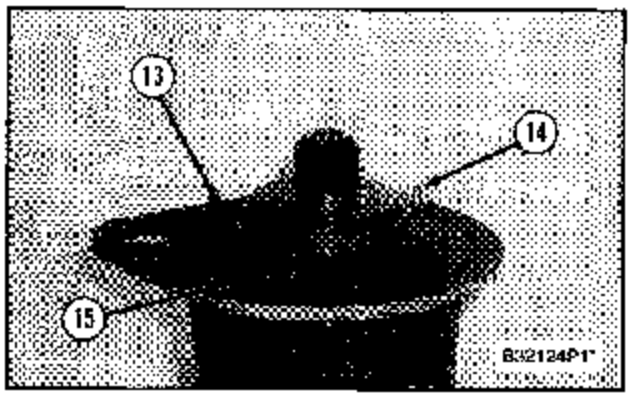
NOTE: Put an alignment marks across the clutch housings for the correct alignment at assembly.

8. Install tool (C) to hold the piston in the No. 6 clutch housing.

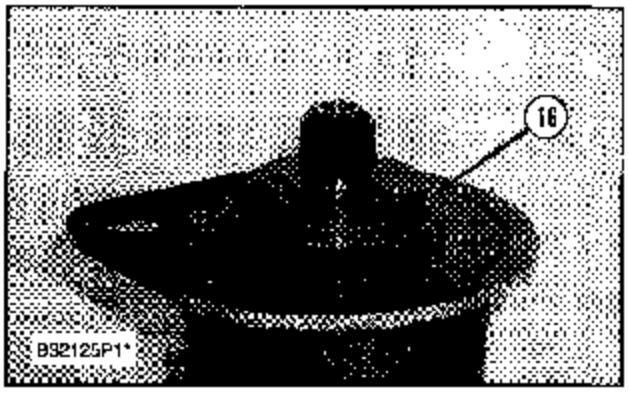
9. Fasten tool (B) and a hoist to clutch housing (11). Remove bolts (8). Remove the clutch piston and clutch housing (11) from the transmission. The weight of clutch piston and clutch housing (11) is **27 kg (60 lb)**.



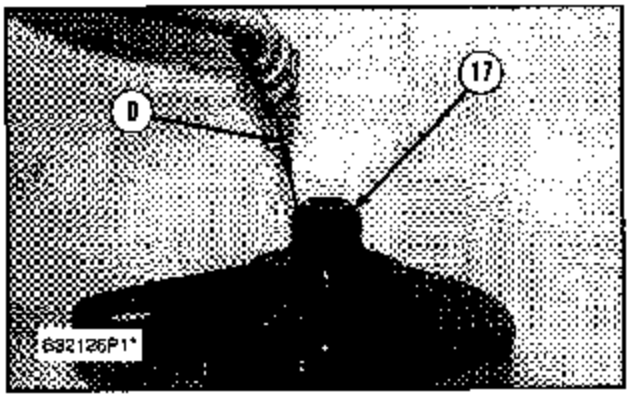
10. Remove clutch piston (12) from clutch housing (11). Remove the seal rings from the clutch piston.



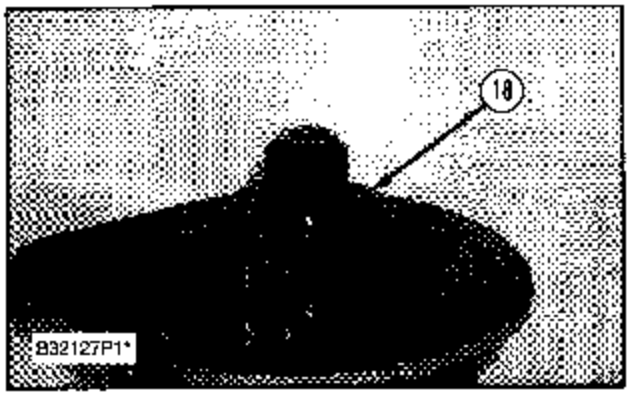
11. Remove reaction dowels (14), springs (15), three friction discs (13) and the two clutch plates from the manifold.

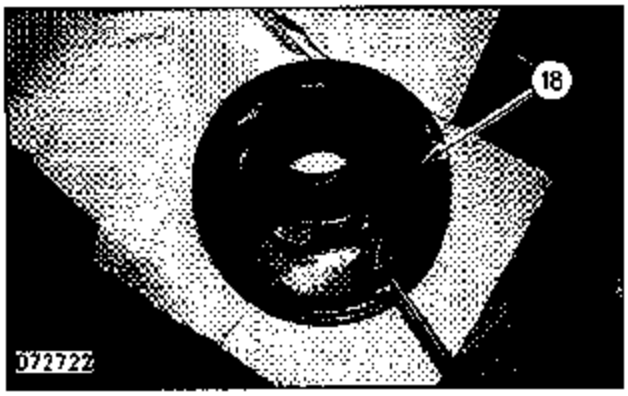


12. Remove ring gear (16) from the carrier.

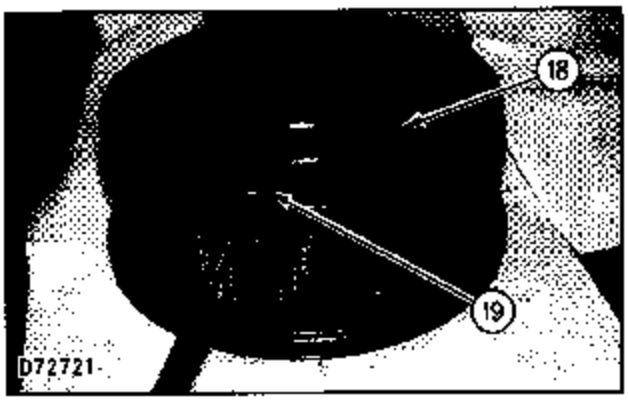


13. Use tool (D) to remove retaining ring (17) from the transmission shaft.





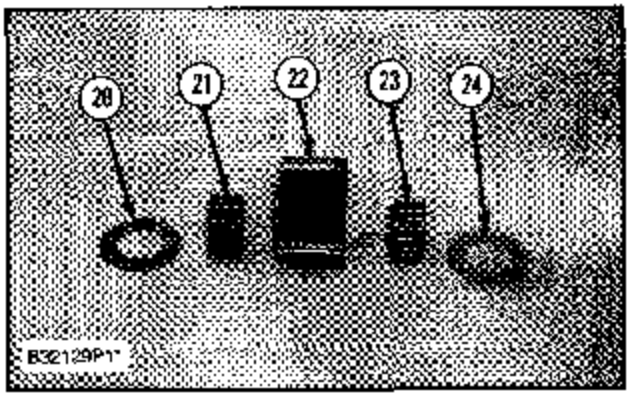
14. Remove carrier assembly (18) from the manifold assembly.



15. Disassemble carrier assembly (18) as follows:

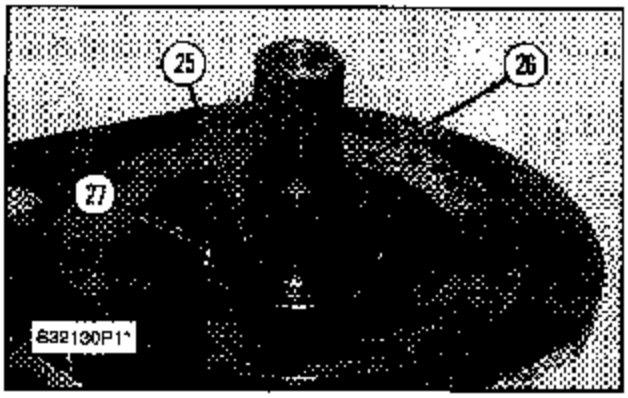
a. Remove the ring seal from the outside of the carrier assembly.

b. Use a hammer and a punch to push the spring pin through carrier (18) into planetary shaft (19). Remove planetary shaft (19) from carrier (18).



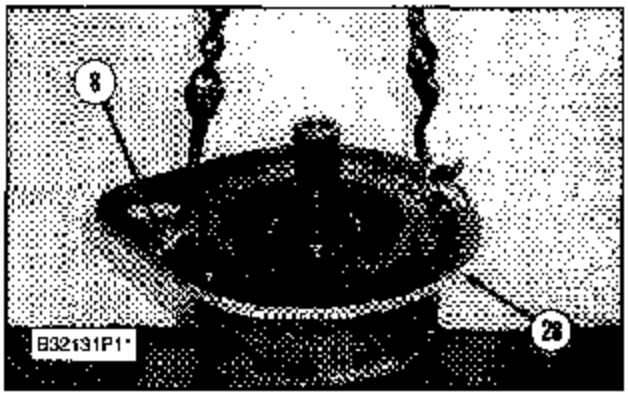
c. Remove thrust discs (20) and (24), bearings (21) and (23) and planetary gear (22) from carrier (18).

d. Remove the other two planetary gears from the carrier as in Steps 15b and 15c.

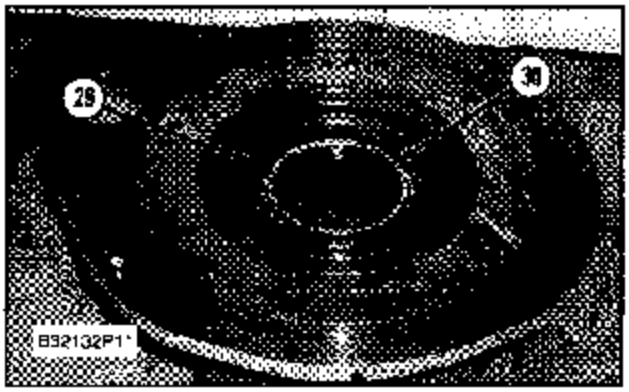


16. Remove retaining ring (25) and sun gear (26) from the output shaft.

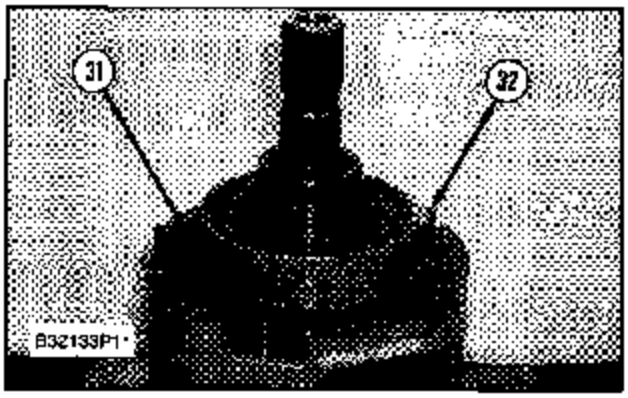
17. Use tool (D) to remove retaining ring (27) from the housing.



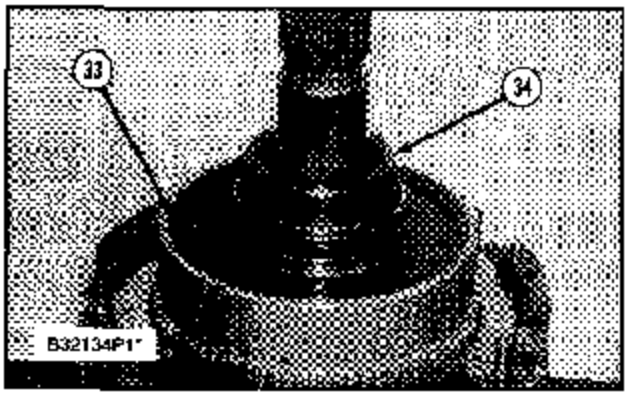
18. Fasten tool (B) and a hoist to manifold assembly (28) as shown. Remove manifold assembly (28) from the transmission. The weight of manifold assembly (28) is **64 kg (140 lb).** Remove the large O-ring seal from the manifold assembly.



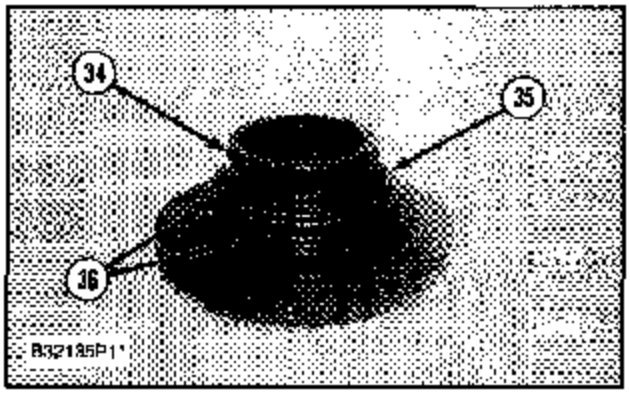
19. Use tool (E) to remove retaining ring (29) from the manifold. Remove bearing (30) from the manifold.



20. Remove springs (32), two friction discs (31) and one clutch plate from the No. 3 and No. 4 clutch housing.

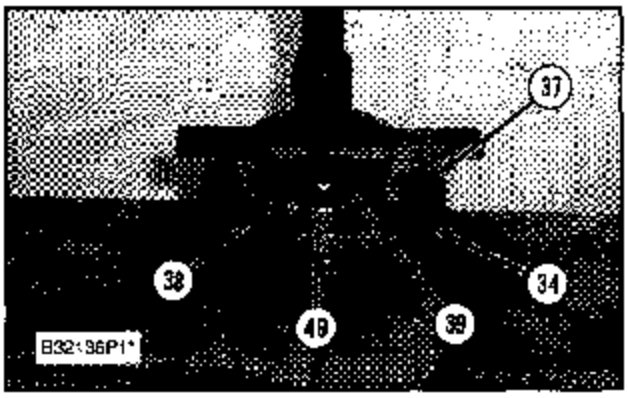


21. Remove retaining ring (33) and housing assembly (34) from the ring gear for the No. 4 clutch.



22. Remove seal rings (36) from ring carrier (35).

23. Do not remove ring carrier (35) from housing (34) unless it is worn or damaged. Use a hammer and chisel to break the ring carrier, and remove it. After ring carrier (35) is removed, remove the spring pin that holds the carrier in position on housing (34).

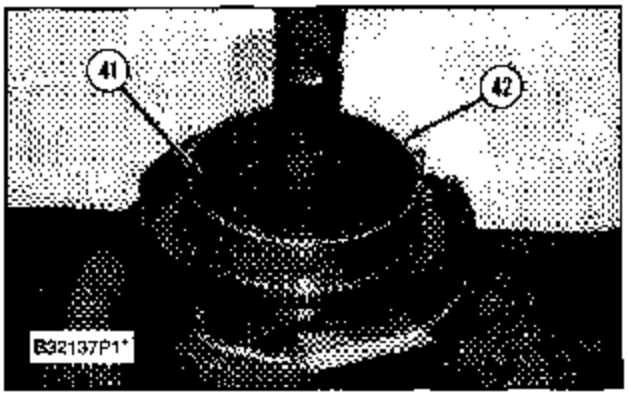


24. Use steel spacers, as necessary, and a press to push on retainer plate (38) to put three disc springs (40) under compression.

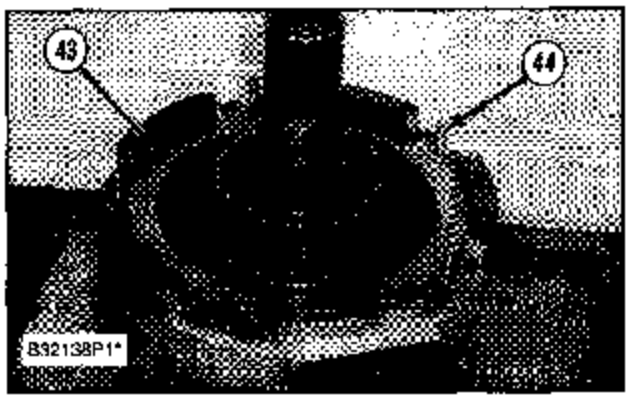
NOTE: Prior to removing three disc springs (40) from housing (34), note their installed positions for assembly purposes.

25. Use tool (F) to remove retaining ring (39) from housing (34). Release the pressure on plate (38), and remove the retainer plate, three disc springs (40) and No. 5 piston (37) from housing (34).

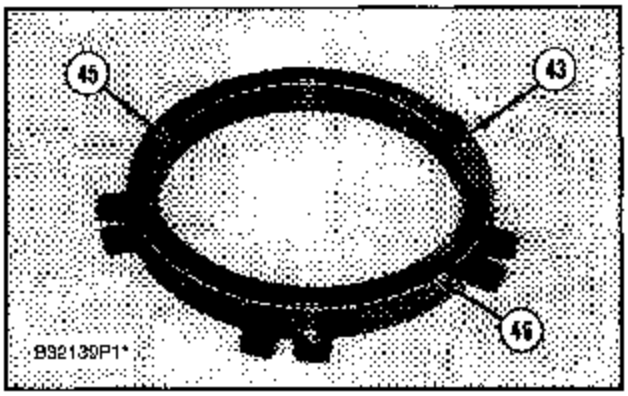
26. Remove the two seal rings from piston (37).



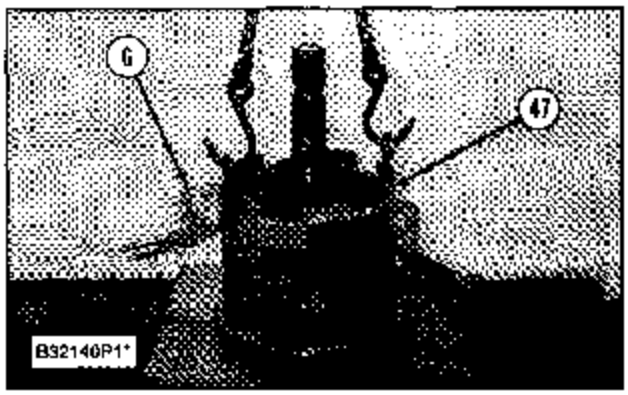
27. Remove ring gear (42) from the No. 3 and 4 clutch housing. Remove four friction discs (41) and three clutch plates from ring gear (42). Remove the clutch plate from the ring gear.



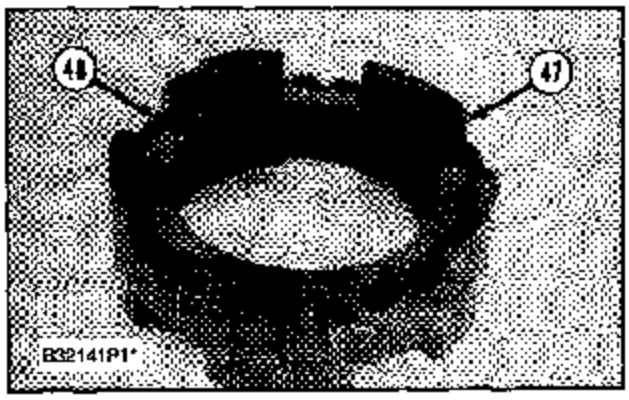
28. Remove No. 4 (third speed) clutch piston (43) and reaction dowels (44) from the clutch housing.



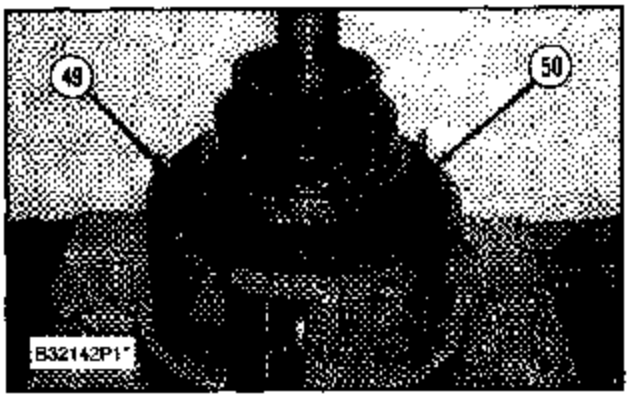
29. Remove seal rings (45) and (46) from clutch piston (43).



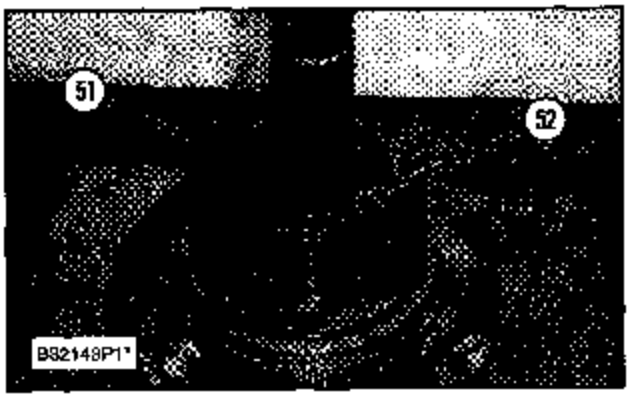
30. Install tool (G) to hold No. 3 (fourth speed) clutch piston in clutch housing assembly (47). Install two **5/8" - 11 NC** forged eyebolts in clutch housing assembly (47) as shown. Fasten a hoist to the eyebolts. Remove clutch housing assembly (47) and the clutch piston. The weight of the unit is **41 kg (90 lb).**



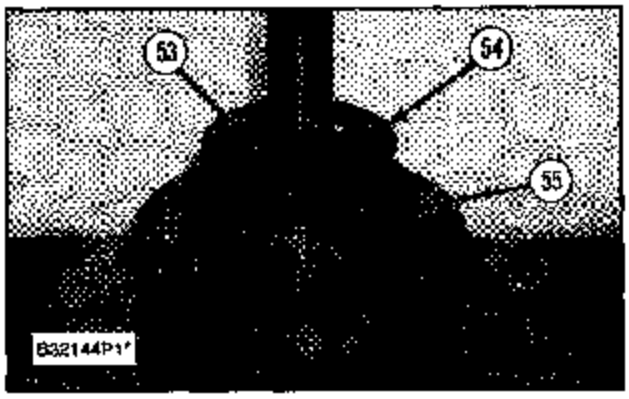
31. Remove clutch piston (48) from clutch housing assembly (47). Remove the seal rings from clutch piston (48).



32. Remove springs (49), three friction discs (50) and the two clutch plates from the No. 2 (forward) clutch housing.



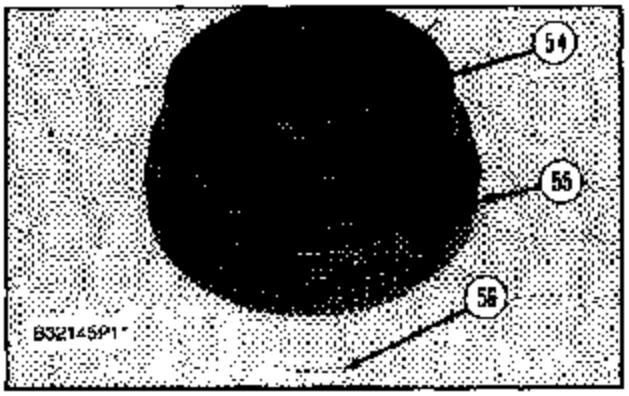
33. Use tool (D) to remove retaining ring (52). Remove clutch hub (51).



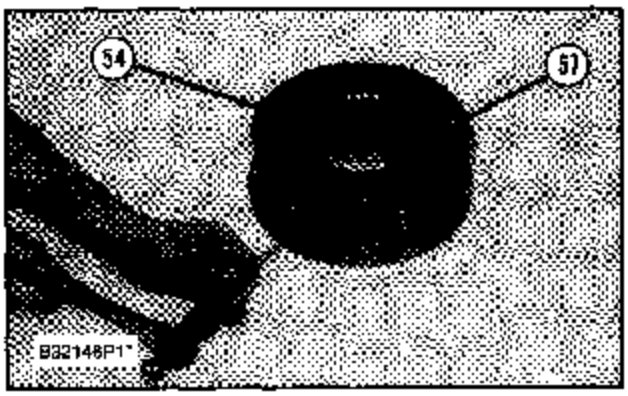
34. Lift sun gear (53), carrier assembly (54) and ring gear (55) from the transmission shaft as a unit.

35. Remove sun gear (53) from carrier assembly (54).

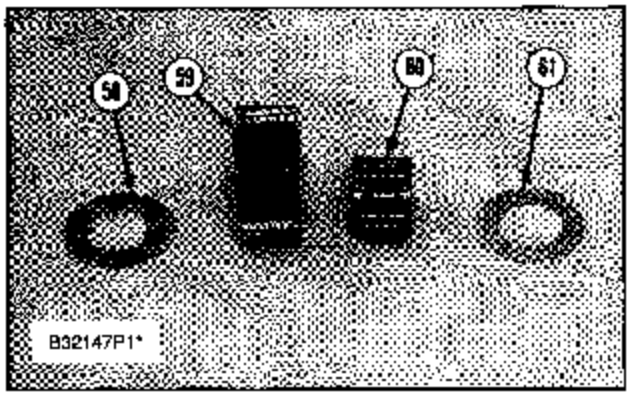
36. Disassemble carrier assembly (54) as follows:



a. Put the lock ring under compression, and remove carrier assembly (54) from ring gear (55). Several short lengths of **3.175 mm (.125 in)** rod (56) with a point ground on one end can be used to put the ring under compression.

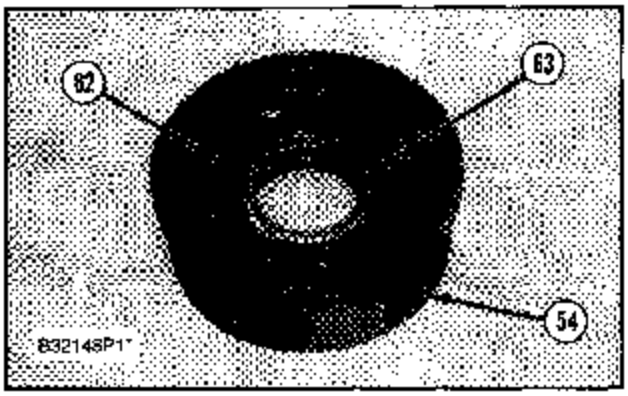


b. Use a hammer and a punch to push the spring pin through carrier (54) into planetary shaft (57). Remove planetary shaft (57) from carrier (54).

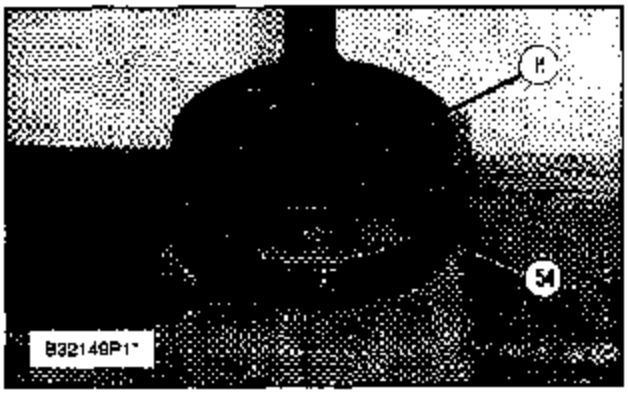


c. Remove thrust discs (58) and (61), bearing (60) and planetary gear (59) from carrier (54).

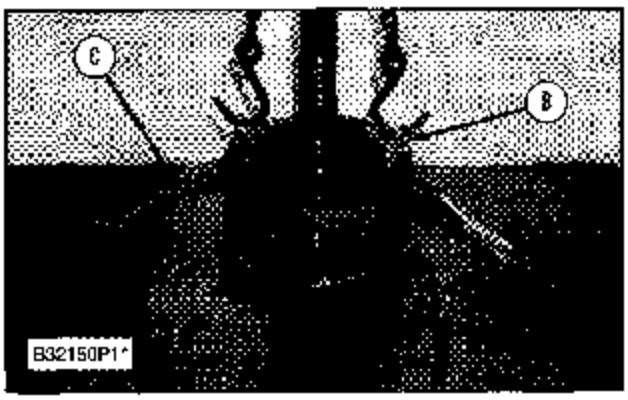
d. Remove the other two planetary gears from the carrier as in Steps 36b and 36c.



e. Remove retaining ring (62) that holds bearing (63) in carrier (54).

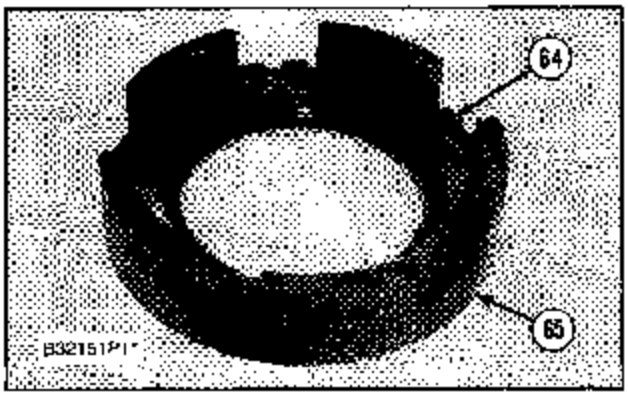


f. Use tool (H) and a press to push bearing (63) out of carrier (54).

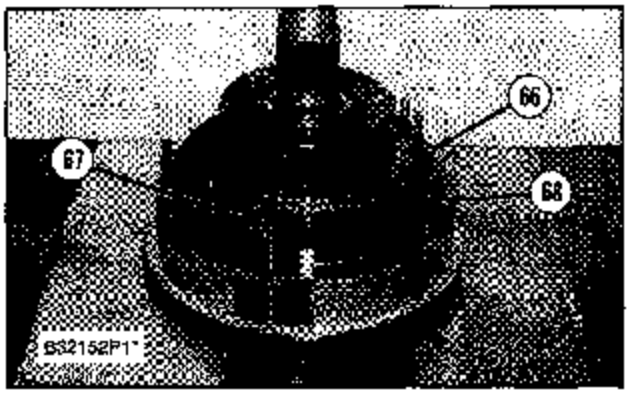


37. Install tool (C) to hold the forward clutch piston in the clutch housing.

38. Fasten tool (B) and a hoist to the No. 2 (forward) clutch housing. Remove the bolts and the clutch housing with the clutch piston. The weight of the unit is **27 kg (60 lb)**.

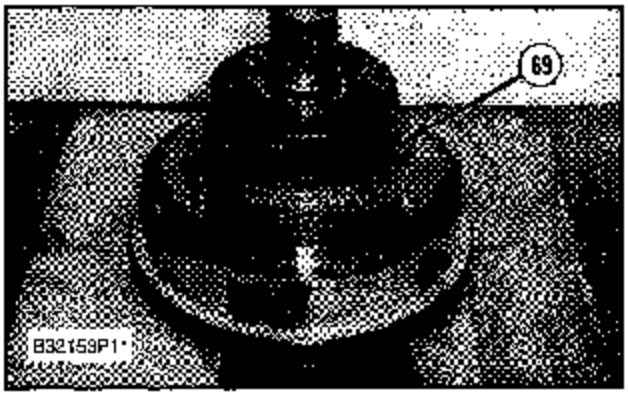


39. Remove clutch piston (64) from the No. 2 (forward) clutch housing (65). Remove the seal rings from clutch piston (64).

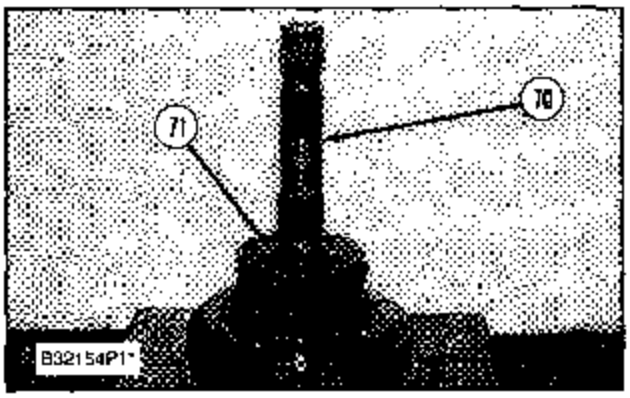


40. Remove springs (68) and reaction dowels (67).

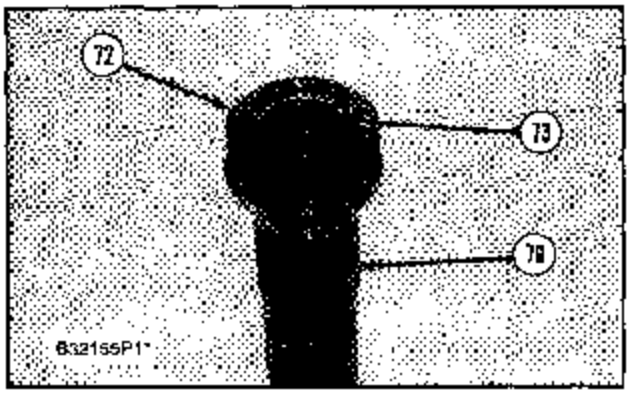
41. Remove three friction discs (66) and the two clutch plates.



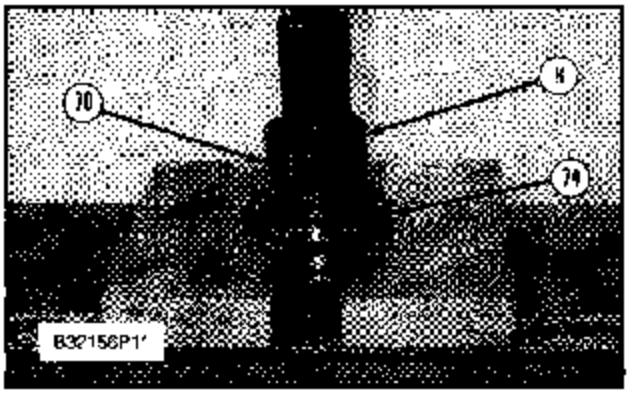
42. Remove ring gear (69) from the carrier assembly and shaft.



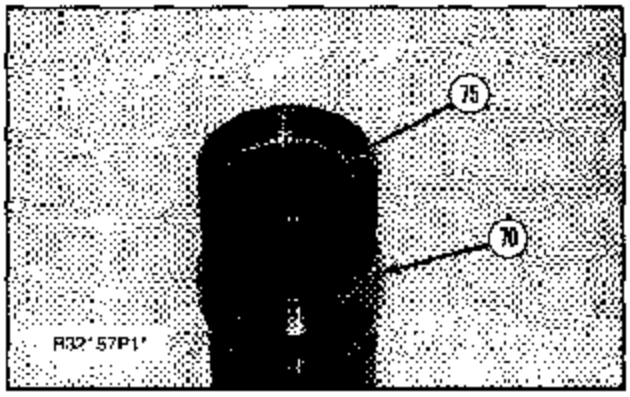
43. Remove retaining ring (71) that holds the bearing in the carrier assembly. Remove shaft (70) from the carrier assembly and the inner shaft.

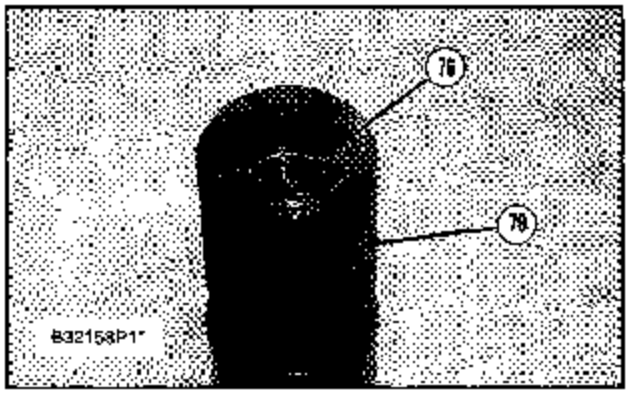


44. Use tool (D) to remove retaining ring (73) from the end of shaft (70). Remove gear (72) from shaft (70).

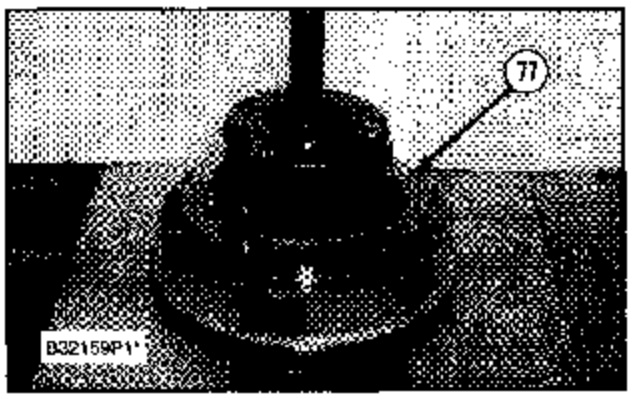


45. Use tool (H) and a press to push shaft (70) out of bearing (74) as shown.

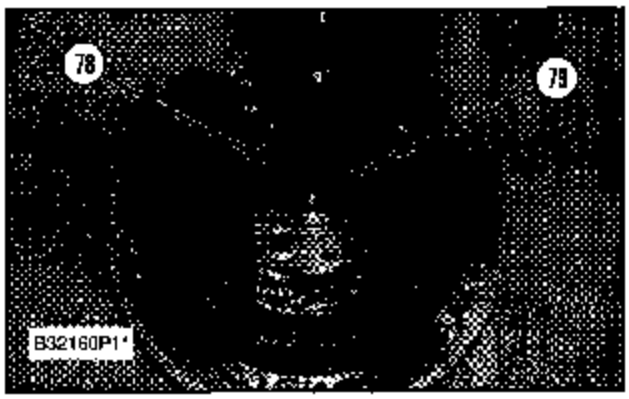




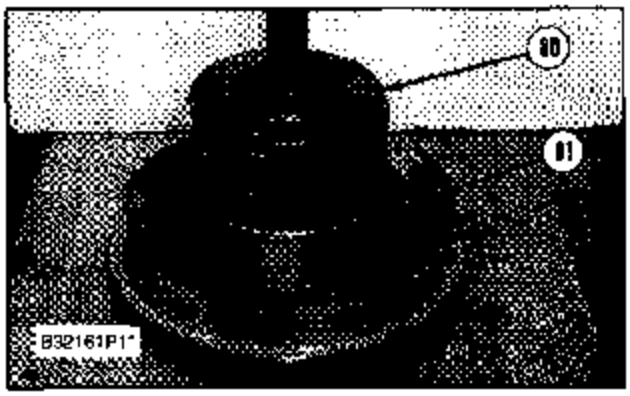
46. Remove bearings (75) and (76) from the ends of shaft (70).



47. Remove plate assembly (77) from the reverse clutch housing.

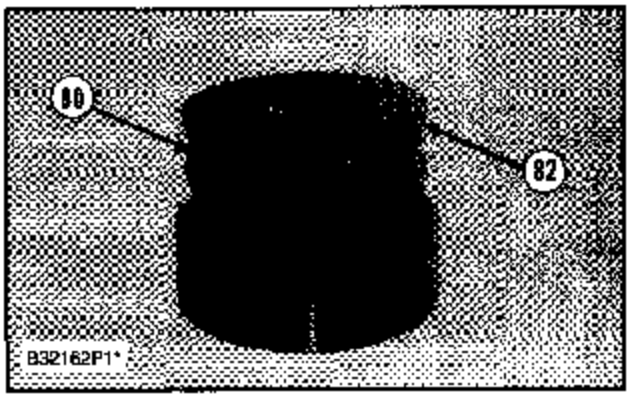


48. Use tool (J) to remove retaining ring (79) that holds sun gear (78).



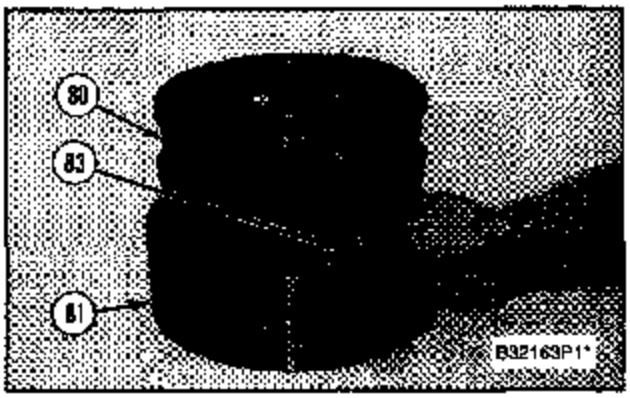
49. Remove carrier assembly (80) and ring gear (81) from the shaft.

50. Disassemble carrier assembly (80) as follows:

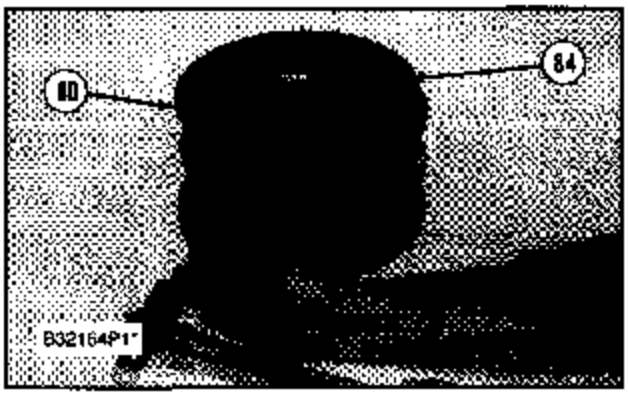


a. Remove the sun gear from carrier assembly (80).

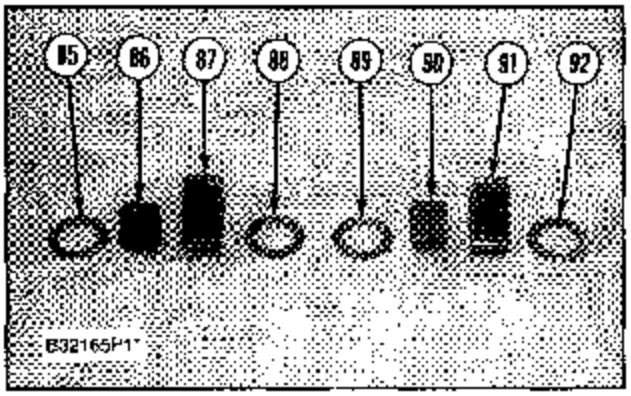
b. Remove seal ring (82) from carrier assembly (80).



c. Put the retaining ring under compression, and remove carrier assembly (80) from ring gear (81). Several short lengths of **3.175 mm (.125 in)** rod (83) with a point ground on one end can be used to put the ring under compression.

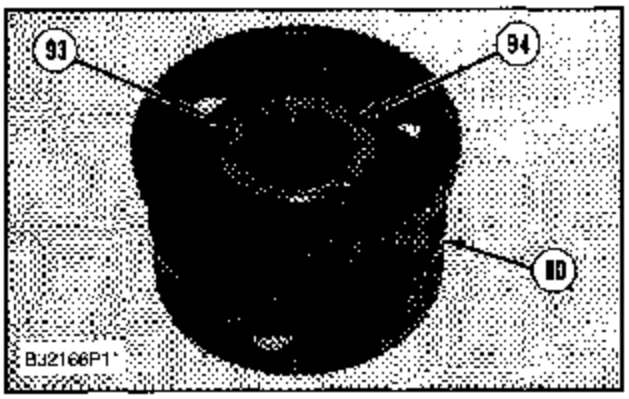


d. Use a hammer and a punch to push the spring pins through carrier (80) and into planetary shafts (84). Remove planetary shafts (84) from carrier (80).

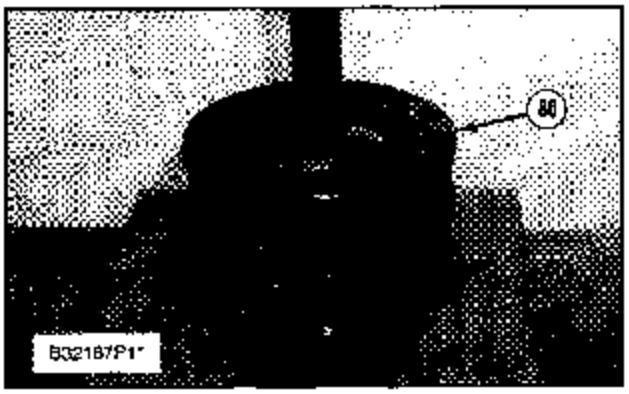


e. Remove thrust disc (85), bearing (86), planetary gear (87), thrust disc (88), thrust disc (89), bearing (90), planetary gear (91) and thrust disc (92) from the carrier.

f. Remove the other planetary gears (87) and (91) from carrier (80) as in Step 50e.

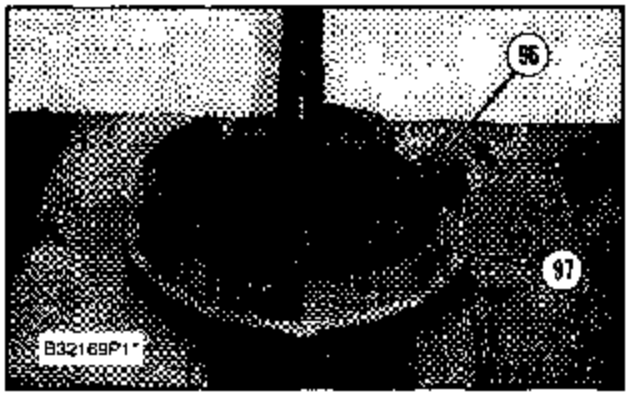


g. Remove retaining ring (93) that holds bearing (94) in carrier (80).

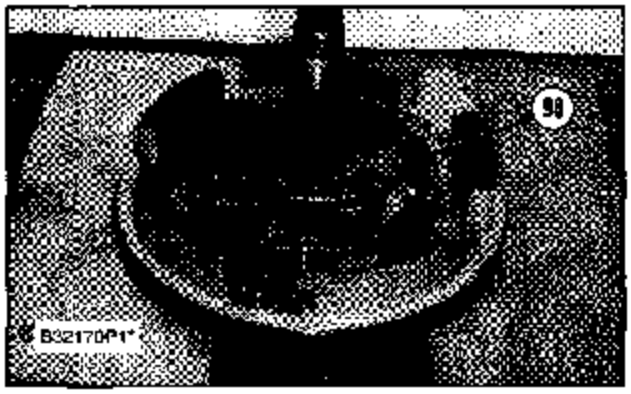


h. Use tool (H) and a press to push bearing (94) out of carrier (80).

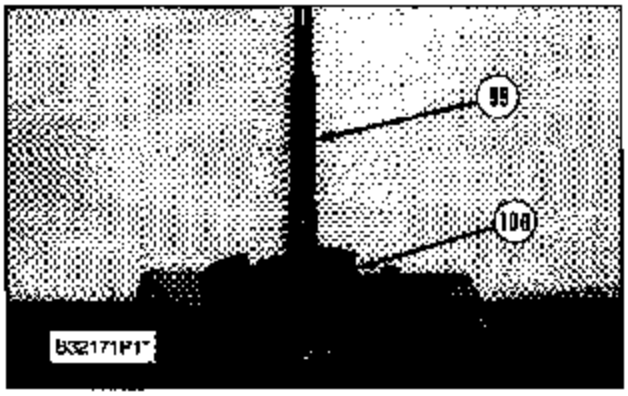
51. Remove sun gear (95) from the shaft and carrier.



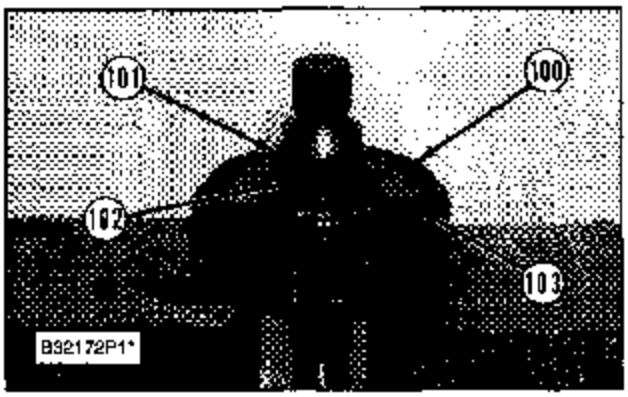
52. Remove three friction discs (96) and two clutch plates (97) from the No. 6 (reverse) clutch housing.



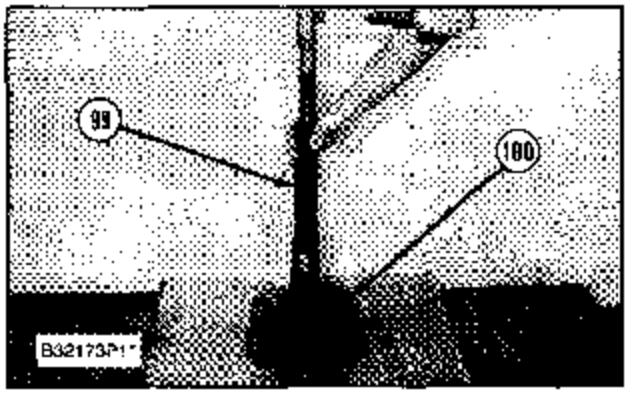
53. Remove ring gear (98).



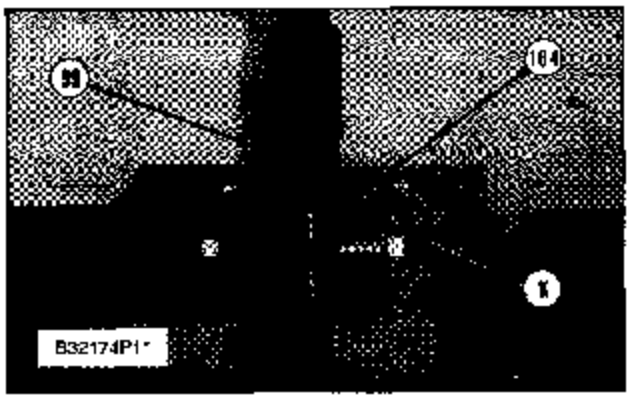
54. Use a hoist to remove shaft (99) and carrier assembly (100) from the clutch housing. The weight of the shaft and carrier assembly is **25 kg (55 lb)**.



55. Remove seal ring (103) from carrier assembly (100). Remove seal rings (101) and (102) from the seal carrier.



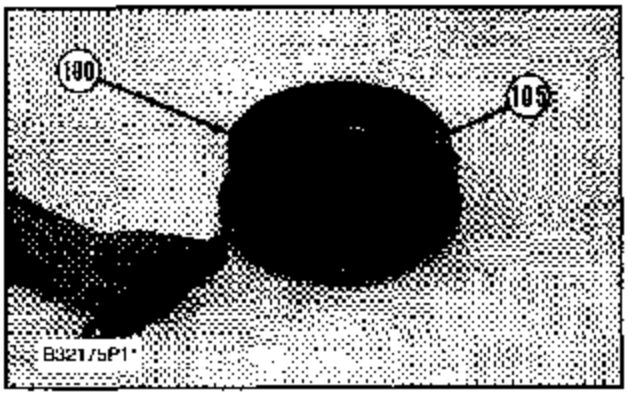
56. Use a soft faced hammer to push shaft (99) out of the bearing in carrier assembly (100) as shown.



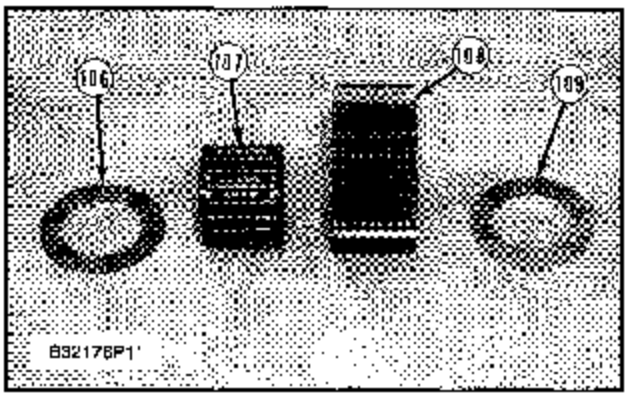
57. Do not remove inner bearing race (104) from shaft (99) unless it is necessary. Use a hammer and chisel to break the seal carrier, and remove it fromshaft (99). Remove the pin that holds the seal carrier on shaft (99).

58. Use a press and tool (K) to push shaft (99) out of bearing race (104).

59. Disassemble carrier assembly (100) as follows:

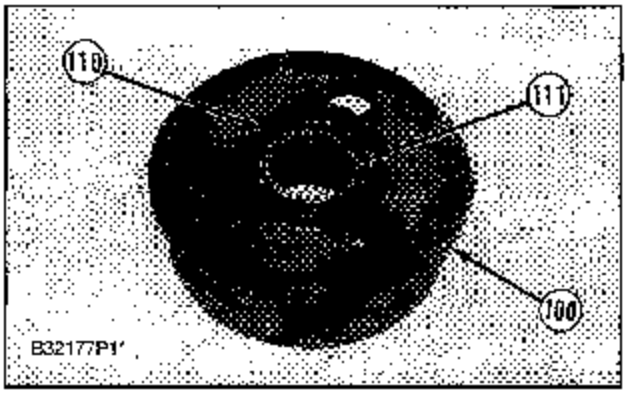


a. Use a hammer and a punch to push the spring pins through carrier (100) and into planetary shaft (105). Remove planetary shaft (105) from carrier (100).

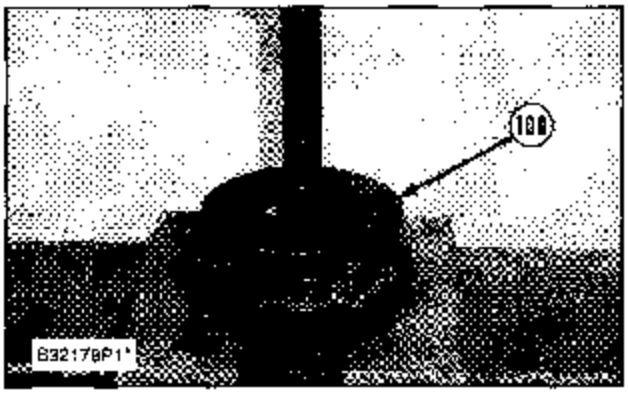


b. Remove thrust disc (106), bearing (107), planetary gear (108) and thrust disc (109) from the carrier.

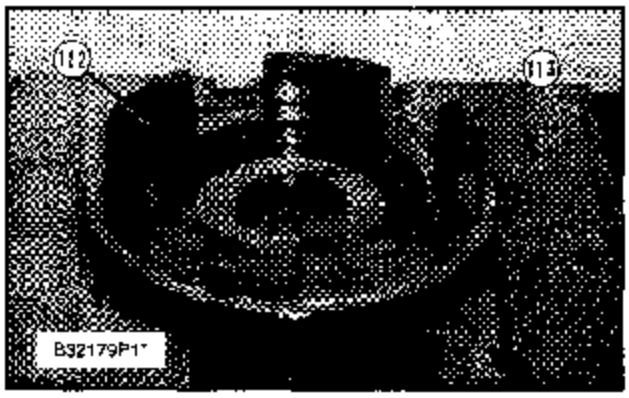
c. Remove the other two planetary gears (108) from carrier (100) as in Step 59b.



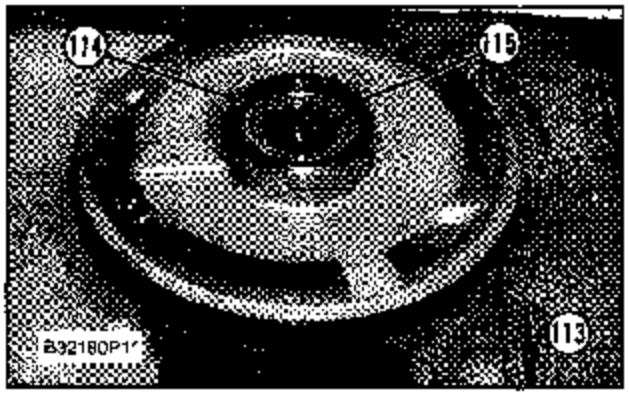
d. Use tool (L) to remove retaining ring (110) that holds bearing (111) in carrier (100).



e. Use tool (H) and a press to push bearing (111) out of carrier (100) as shown.

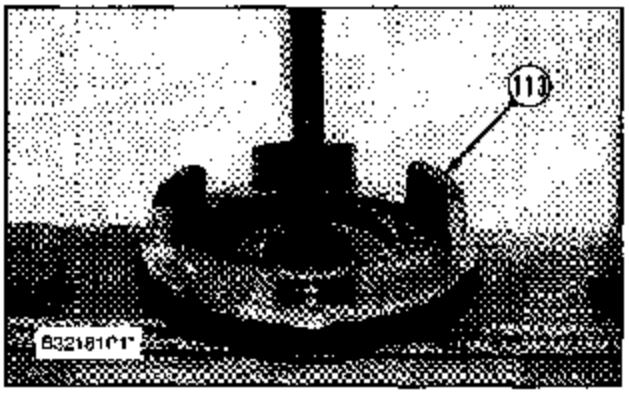


60. Remove clutch piston (112) from No. 6 (reverse) clutch housing (113). Remove the seal rings from clutch piston (112).



61. Use a hoist to turn housing (113) over. The weight of housing (113) is **43 kg (95 lb)**.

62. Use tool (E) to remove retaining ring (114) that holds bearing (115) in housing (113).



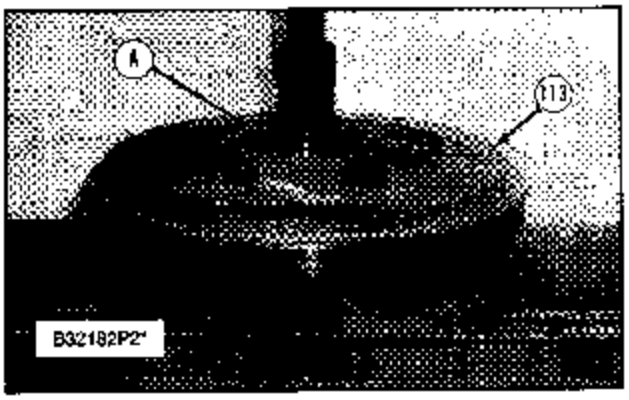
63. Use a press and tool (H) to push the bearing out of housing (113) as shown.

Assemble Transmission 3150-016

Tools Needed		A	B	C	D	E	F	G
1P0520	Driver Group	1						
5P4758	Pliers		1					
1P1861	Pliers			1				
1P1862	Pliers				1			
1P0510	Driver Group					1		
1P1863	Pliers						1	
FT0833	Clamp							2

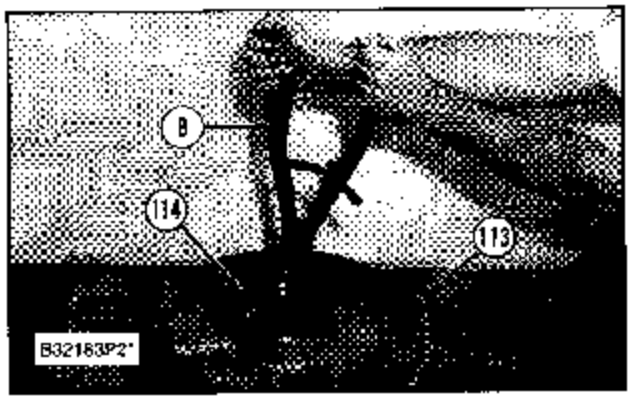
Tools Needed		H	J	K	L	M	N
6V2156	Link Bracket	2			3		
FT0947	Clamp		2				
2P8312	Pliers			1			
FT0834	Clutch Test Nozzle					1	
5P9736	Link Bracket						3

NOTE: Check all parts of the transmission for wear or damage. If any parts are worn or damaged, use new parts for replacement. During assembly, put clean transmission oil on all parts.

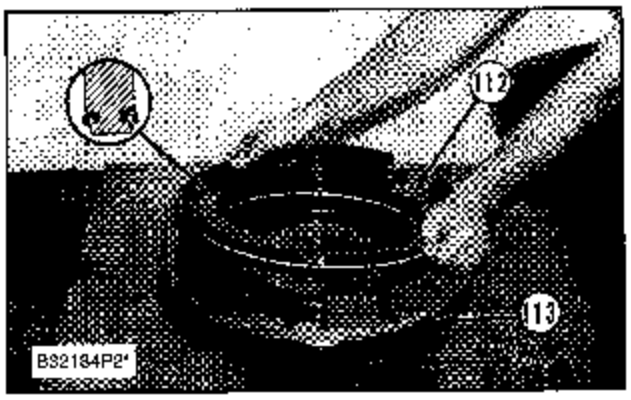


1. Be sure the small plug in the bottom of the bearing bore in No. 6 (reverse) clutch housing (113) is installed **1.25 ± 0.25 mm (.049 ± .010 in)** below the surface of the bearing bore.

2. Use tool (A) and a press to install the bearing in No. 6 (reverse) clutch housing (113) as shown.



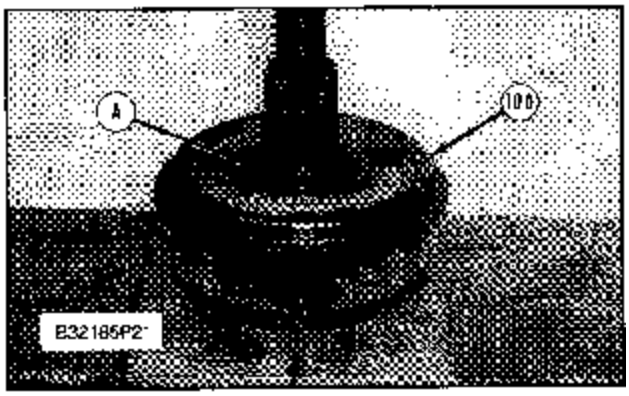
3. Use tool (B) to install retaining ring (114) in clutch housing (113).



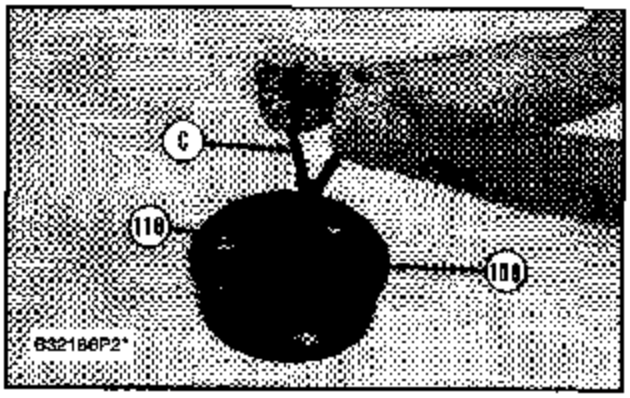
4. Install the seal rings on clutch piston (112). Be sure the lips on the seal rings are facing toward the clutch housing as shown.

5. Put clean transmission oil on the seal rings, and install clutch piston (112) in clutch housing (113).

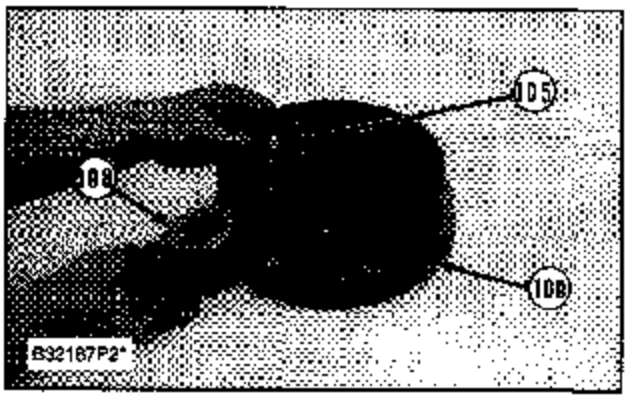
6. Assemble carrier assembly (100) as follows:



a. Put bearing (111) in position on carrier (100) with notch in the inner race up (toward the outside). Use tool (A) and a press to install the bearing in carrier (100).



b. Use tool (C) to install retaining ring (110) in carrier (100).



NOTICE

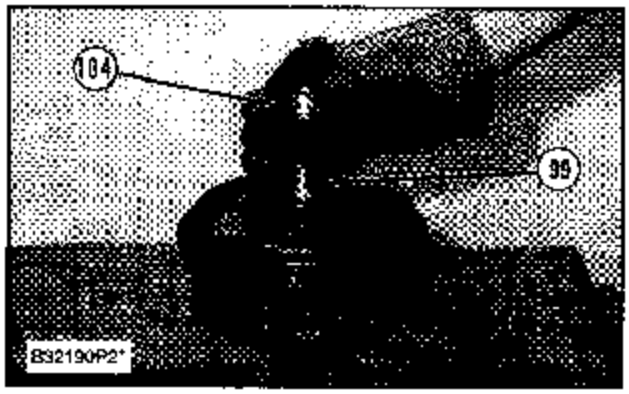
Be sure the rubber in the spring pins that hold planetary shafts (105) in carrier (100) is not damaged. If the rubber is damaged, replace the spring pins with new parts.

c. Install the bearing in planetary gear (108). Install planetary gear (108) in carrier (100) with a thrust disc on each side of the planetary gear as shown. Install planetary shaft (105) in carrier (100) and through the bearing and planetary gear (108). Be sure the spring pin hole in the carrier is in alignment with the spring pin hole in the planetary shaft. Install the spring pin to hold the planetary shaft in position.

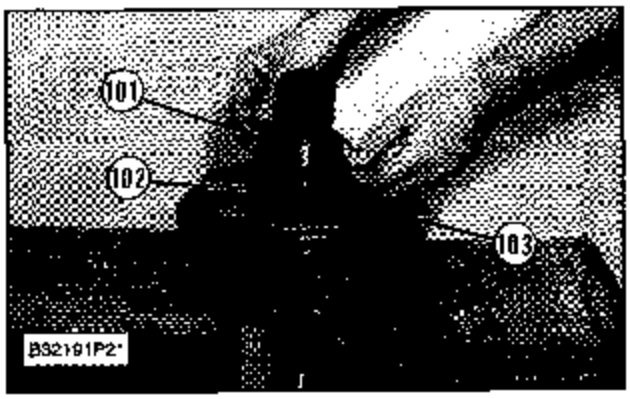
d. Install the other two planetary gears (108) in carrier (100) as in Step 6c.

7. Install shaft (99) in carrier assembly (100) as shown. Be sure the dowel in shaft (99) engages in the notch of the carrier bearing.

8. Put seal carrier (102) in position on shaft (99), and install the pin to hold the seal carrier in place.

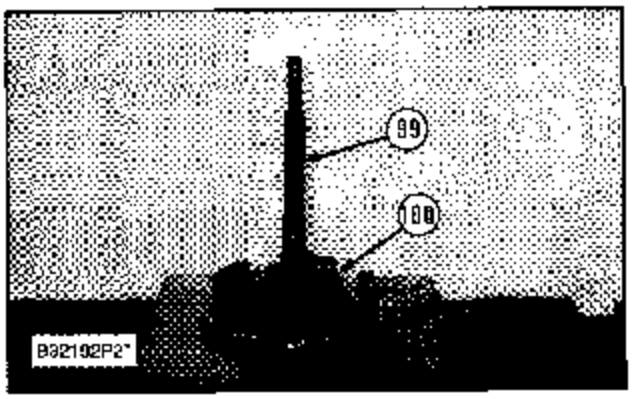


9. Heat inner bearing race (104) to a maximum temperature of **135°C (275°F).** Install it on shaft (99).

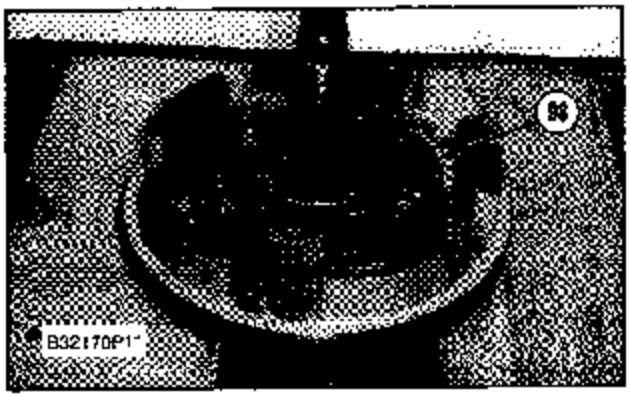


10. Install seal ring (103) on the carrier assembly (100).

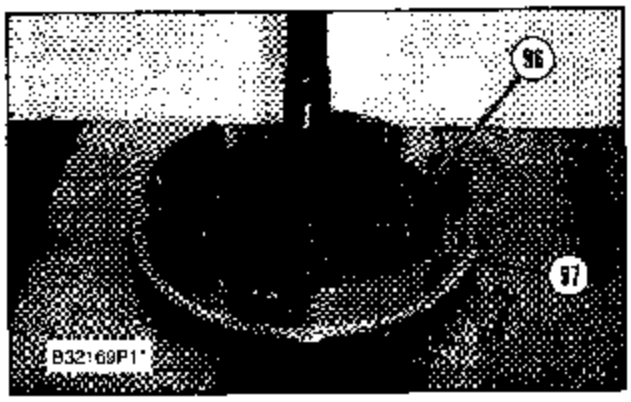
11. Install seal rings (101) in the grooves of seal carrier (102).



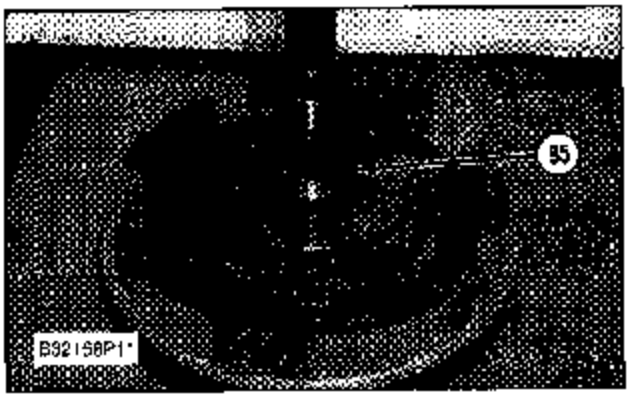
12. Use a hoist to install carrier assembly (100) and shaft (99) in the No. 6 (reverse) clutch housing as shown. The weight of the unit is **25 kg (55 lb)**.



13. Install ring gear (98) in the No. 6 (reverse) clutch housing.

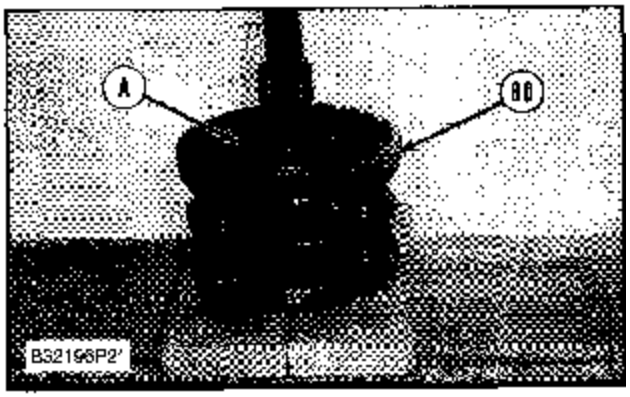


14. Install three friction discs (96) and the two clutch plates in the clutch housing in alternating order. Start with a friction disc, and end with a friction disc.

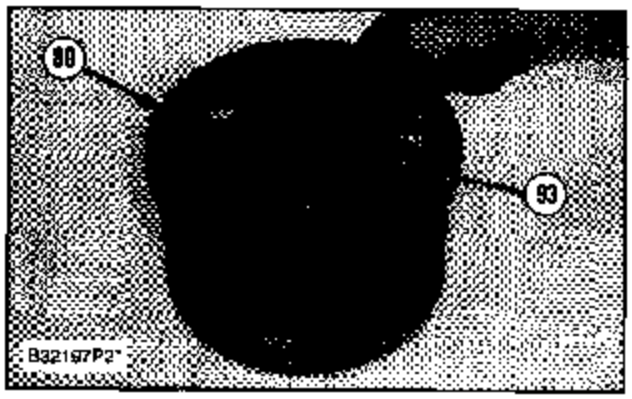


15. Install sun gear (95) in the carrier assembly as shown.

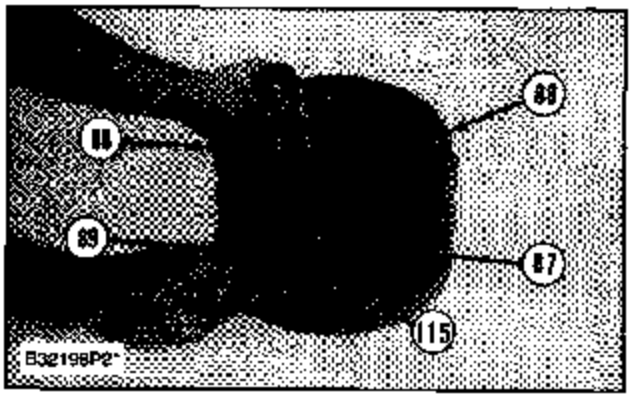
16. Assemble carrier assembly (80) as follows:



a. Put bearing (94) in position on carrier (80) with the notch in the inner race up (toward the outside). Use tool (A) and a press to install the bearing in the carrier.



b. Install retaining ring (93) to hold the bearing in carrier (80).

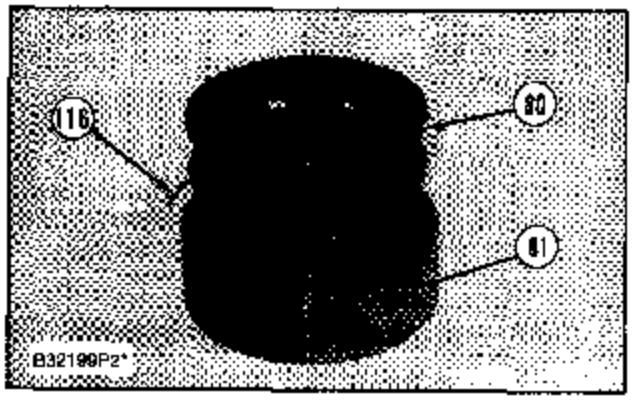


NOTICE

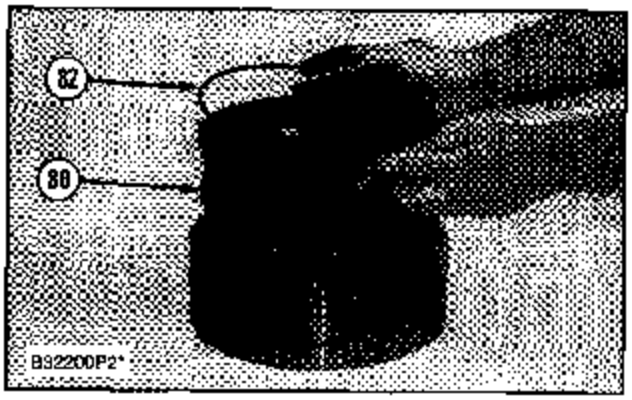
Be sure the rubber in spring pins (115) is not damaged. If the rubber is damaged, replace the spring pins with new parts.

c. Install bearings (86) in planetary gears (87). Install planetary gears (87) in carrier (80) with a thrust disc (89) on each side of the planetary gear as shown. Install planetary shaft (84) in carrier (80) and through the bearings and planetary gears (87) as shown. Be sure the spring pin hole in the planetary shaft is in alignment with the spring pin hole in the carrier. Install spring pin (115) to hold planetary shaft (84) in position.

d. Install the remainder of the planetary gears in carrier (80) as in Step 16c.

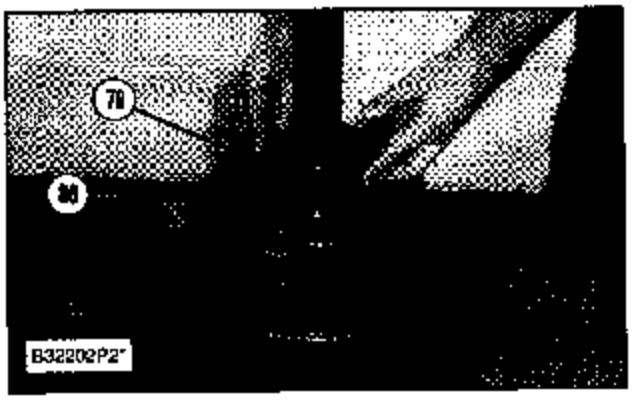


17. Install retaining ring (116) in the groove of carrier (80). Install carrier assembly (80) in ring gear (81) until retaining ring (116) fits in the groove of ring gear (81) to hold the unit together.



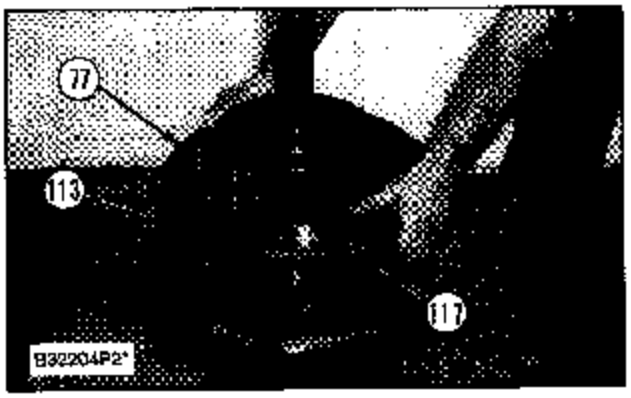
18. Install seal ring (82) in the groove of carrier assembly (80).

19. Install ring gear (81) and carrier assembly (80) over the transmission shaft as shown. Be sure the notch in the carrier engages with the dowel in the gear assembly on the shaft.

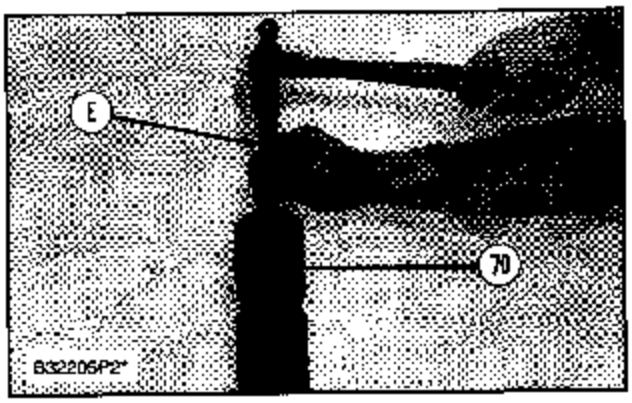


20. Install sun gear (78) on the transmission shaft. Be sure the gear teeth are correctly engaged with the lower set of planetary gears in carrier assembly (80).

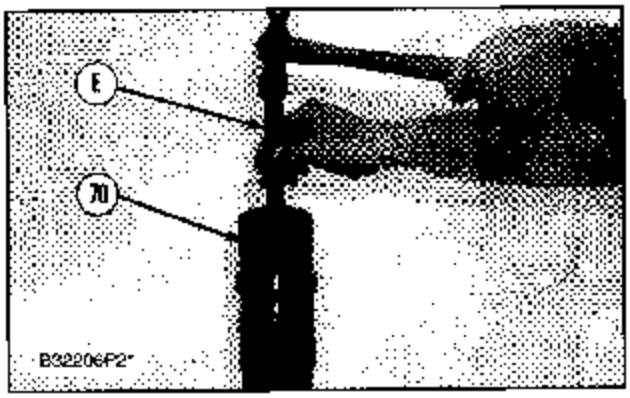
21. Use tool (D) to install retaining ring (79) on the shaft to hold the sun gear in position.



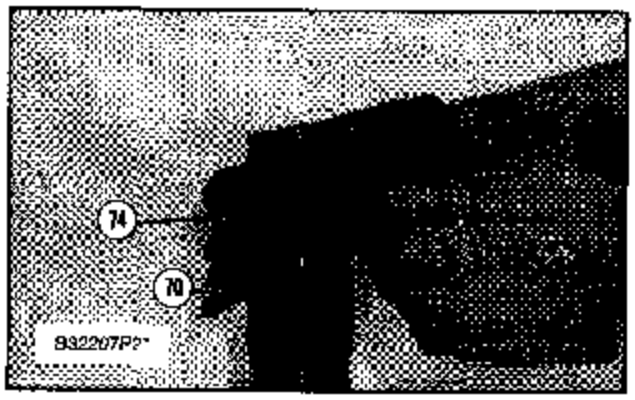
22. Install plate assembly (77) on No. 6 (reverse) clutch housing (113). Be sure the pins in plate assembly (77) are correctly fitted into their bores in clutch housing (113). Also one of the two oil passages (117) for the clutch piston must be in alignment with the passage in clutch housing (113).



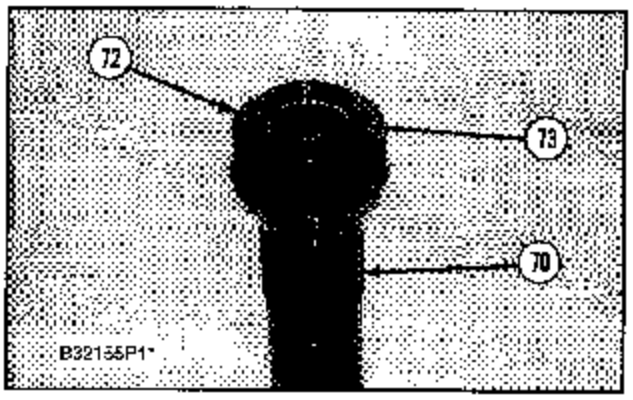
23. Lower the temperature of the small bearing, and put it in position in the end of output shaft (70).Use tool (F) to install the bearing until it is **25.50 ± 0.25 mm (1.004 ± .010 in)** below the end of the shaft. The inside diameter of the bearing must be **35.629 ± 0.039 mm (1.4027 ± .0015 in)** after assembly.



24. Lower the temperature of the large bearing, and put it in position in the end of output shaft (70). Use tool (A) to install the bearing until it is **13.00 ± 0.25 mm (.512 ± .010 in)** from the end of the shaft. The inside diameter of the bearing must be **56.650 ± 0.061 mm (2.2303 ± .0024 in)** after assembly.

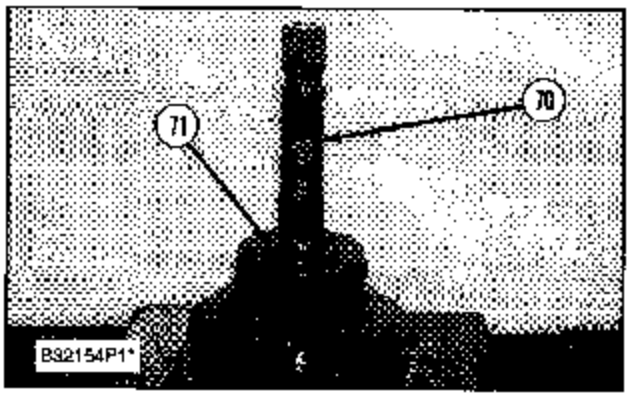


25. Heat bearing (74) to a maximum temperature of **135°C (275°F)**, and install it on shaft (70). Be sure the shoulder is toward the end of the shaft as shown.



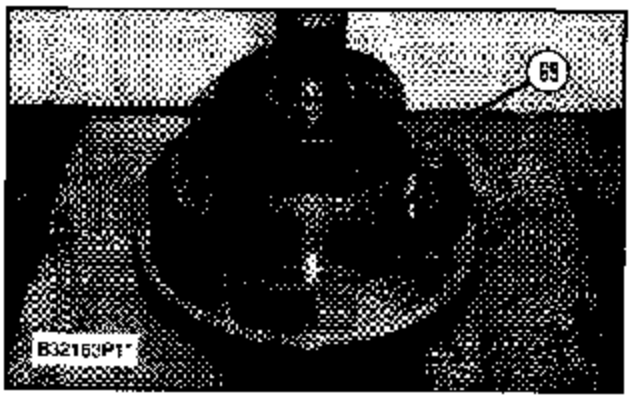
26. Install gear (72) on shaft (70) next to the bearing.

27. Use tool (F) to install retaining ring (73) in the groove of shaft (70).

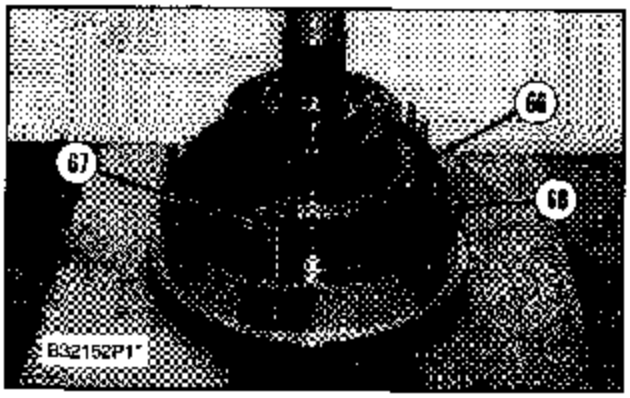


28. Install output shaft (70) over the input shaft.

29. Install retaining ring (71) to hold the bearing in the carrier assembly.

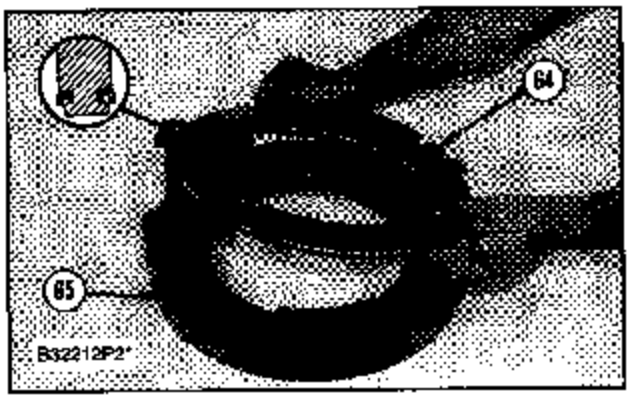


30. Install ring gear (69) over the transmission shafts and carrier assembly.



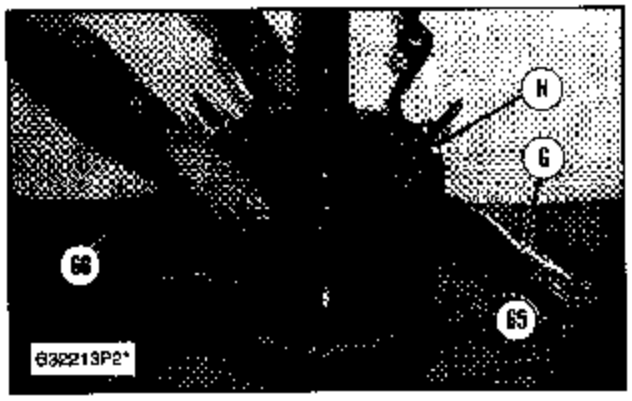
31. Install springs (68) and reaction dowels (67) through the plate assembly and into the No. 6 (reverse) clutch housing.

32. Install three friction discs (66) and the two clutch plates on top of the plate assembly in alternating order. Start with a friction disc and stop with a friction disc.



33. Install the seal rings on clutch piston (64). Be sure the lips of the seal rings are toward the housing as shown.

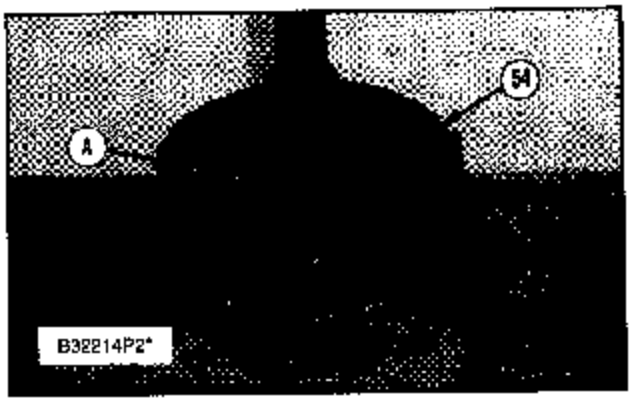
34. Put clean transmission oil on the seal rings, and install clutch piston (64) in the No. 5 (forward) clutch housing (65).



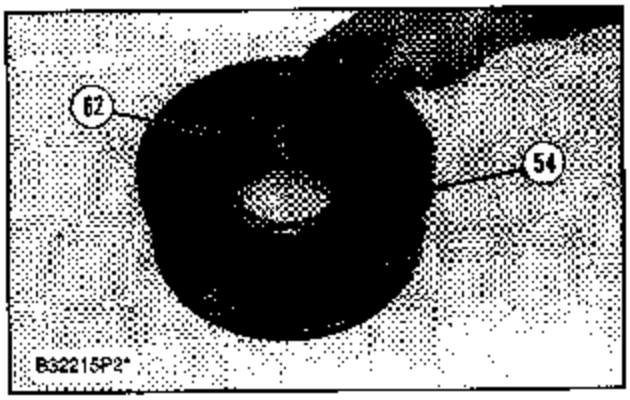
35. Use tool (G) to hold the clutch piston in clutch housing (65). Fasten tool (H) and a hoist to clutch housing (65). Put the clutch housing in position on the plate assembly as shown.

36. Be sure springs (68) fit correctly in the clutch pistons, and remove tool (G) and tool (H). Install the two bolts that hold the clutch housings and plate assembly together.

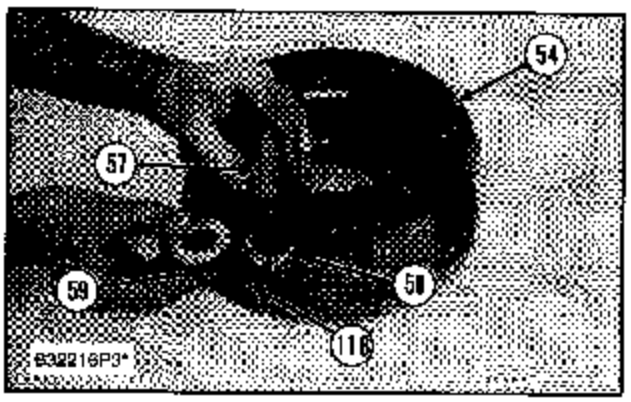
37. Assemble carrier assembly (54) as follows:



a. Put the bearing in position in carrier (54) with the notch in the inner race up (toward the outside). Use tool (A) and a press to install the bearing in carrier (54).



b. Install retaining ring (62) to hold the bearing in carrier (54).

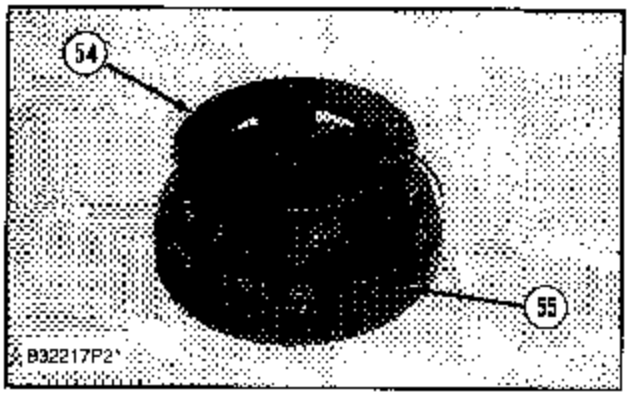


NOTICE

Be sure the rubber in spring pins (118) is not damaged. If the rubber is damaged, replace the spring pins with new parts.

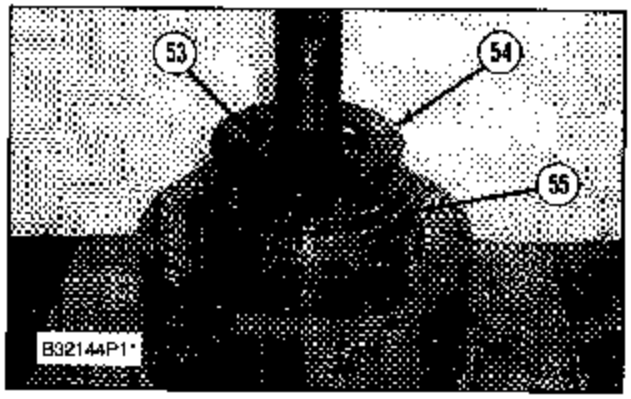
c. Install the bearing in planetary gear (59). Install planetary gear (59) in carrier (54) with a thrust disc (58) on each side of the planetary gear as shown. Install planetary shaft (57) in carrier (54) through the bearing and planetary gear (59) as shown. Be sure the spring pin hole in the carrier is in alignment with the spring pin hole in the planetary shaft. Install spring pin (118) to hold planetary shaft (57) in position.

d. Install the other two planetary gears in carrier (54) as in Step 37c.

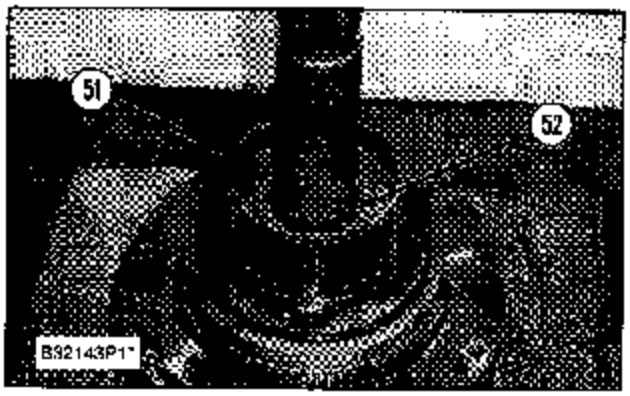


38. Install the retaining ring in the groove of carrier assembly (54). Install carrier assembly (54) in ring gear (55) until the retaining ring fits in the groove of ring gear (55) to hold the unit together.

39. Install carrier assembly (54) and ring gear (55) over the transmission shafts and planet carrier as shown. Be sure the notch in the carrier bearing engages with the dowel in the output shaft.

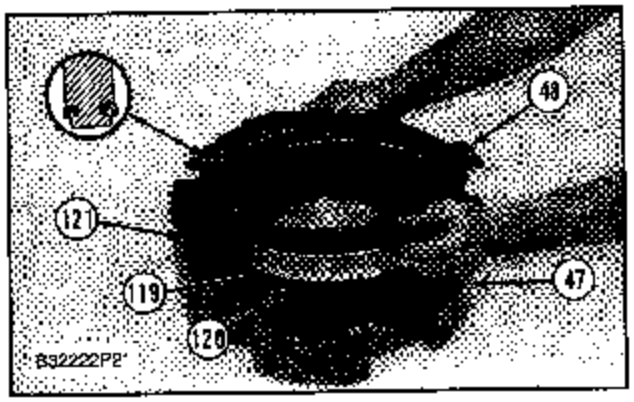


40. Install sun gear (53) in carrier assembly (54).



41. Install clutch hub (57). Use tool (F) to install retaining ring (52) to hold the clutch hub in position.

42. Install three friction discs (50) and the two clutch plates in alternating order. Start with a friction disc, and stop with a friction disc.

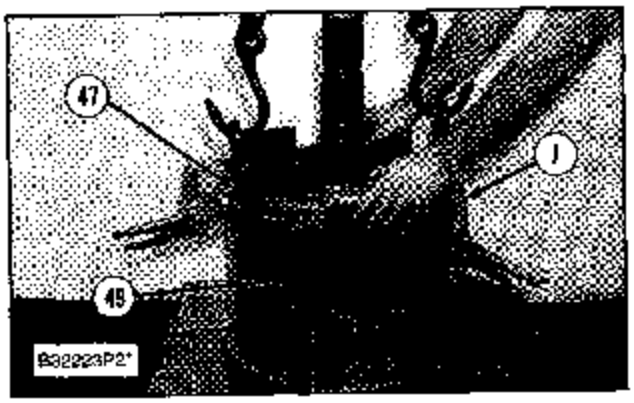


43. Install the ten dampers in bolt holes (119) of the No. 3 (fourth speed) clutch housing (47). Install the two dampers in bolt holes (120) on the No. 4 (third speed) clutch side of clutch housing (47).

44. Be sure four dowels (121) extend **11.0 ± 0.5 mm (.43 ± .02 in)** above the surface of clutch housing (47).

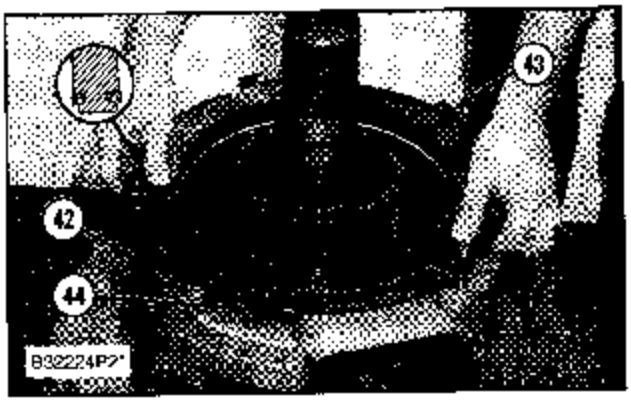
45. Install the seal rings on No. 3 (fourth speed) clutch piston (48). Be sure the lips of the seal rings are toward the housing as shown.

46. Put clean transmission oil on the seal rings, and install clutch piston (48) in the No. 3 and 4 clutch housing (47).



47. Install tool (J) to hold the No. 3 (fourth speed) clutch piston in clutch housing (47). Install two **5/8" - 11 NC** forged eyebolts in clutch housing (47), and fasten a hoist to it.

48. Put springs (49) in position, and install the clutch piston and clutch housing (47) as shown. Be sure the springs are engaged correctly with the clutch piston and forward clutch housing. Remove tool (J) and the hoist.

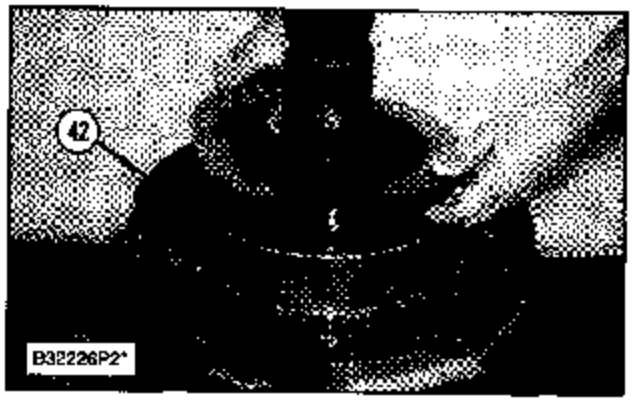


49. Install reaction dowels (44) in clutch housing (47).

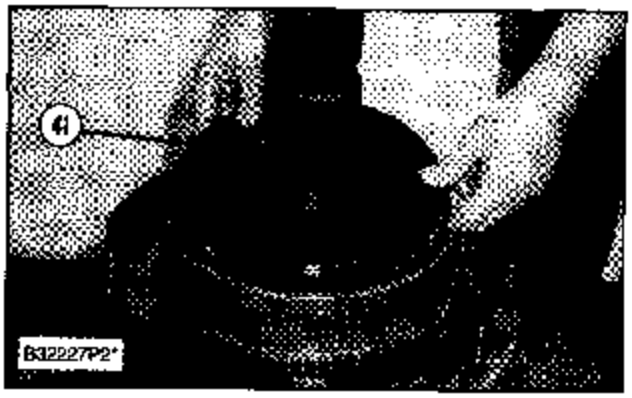
50. Install the seal rings on No. 4 (third speed) clutch piston (43). Be sure the lips of the seals are toward the housing as shown.

51. Put clean transmission oil on the seal rings, and install clutch piston (43) in clutch housing (47).

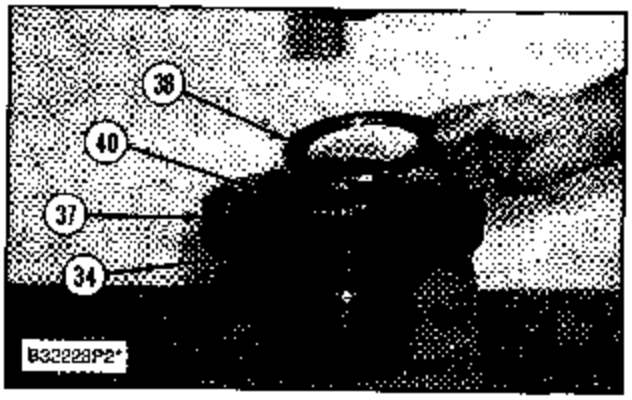
52. Install ring gear (42) in the clutch housing.



53. Install the clutch plate in ring gear (42).

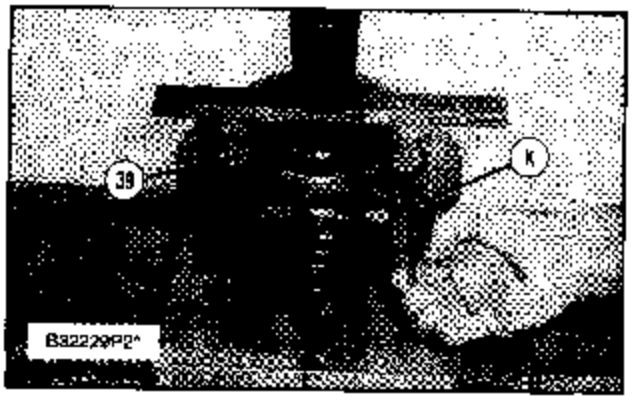


54. Install four friction discs (41) and the clutch three plates in the ring gear in alternating order. Start with a friction disc and stop with a friction disc.

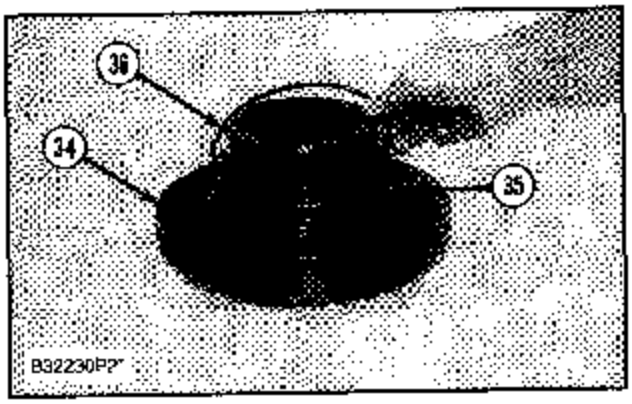


55. Install the two seal rings on piston (37). Be sure the lips of the seal ring are toward housing (34). Put clean transmission oil on the seal rings. Install piston (37) in housing (34).

56. Install three disc springs (40) on housing (34) in their original positions. Put plate (38) in position on the disc springs with the shoulder for the retaining ring up as shown.



57. Use steel spacers and a press to put the plate and three disc springs under compression. Use tool (K) to install retaining ring (39).



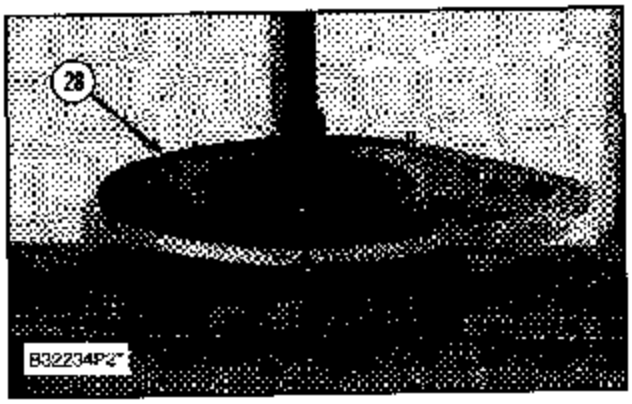
58. Heat ring carrier (35) to a temperature of **127° to 166°C (260° to 330°F)** for a maximum of ten minutes. Install the ring carrier on housing (34) so the part number can be seen. Install the pin to hold ring carrier (35).

59. Install seal rings (36) on carrier (35).

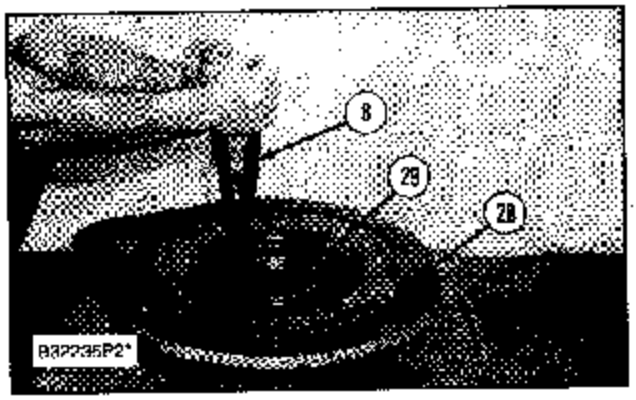
60. Install housing assembly (34) in the ring gear as shown.

61. Install retaining ring (33) to hold housing assembly (34) in the ring gear.

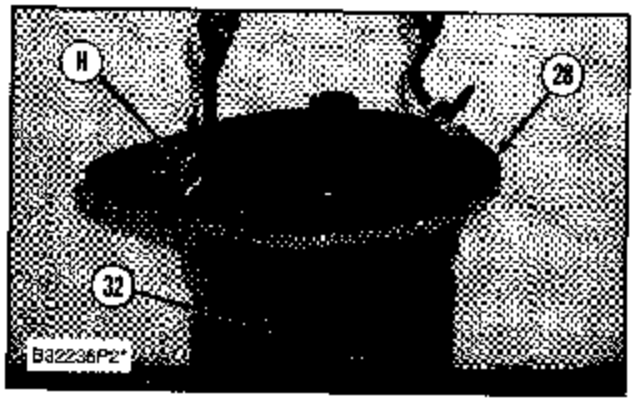
62. Install two friction discs (31) and the clutch plate on the No. 4 (third speed) clutch piston. Be sure the clutch plate is between the two friction discs.



63. Use a press to install the bearing in manifold assembly (28). Be sure the notch in the inner bearing race is down (toward the inside) before the bearing is installed.

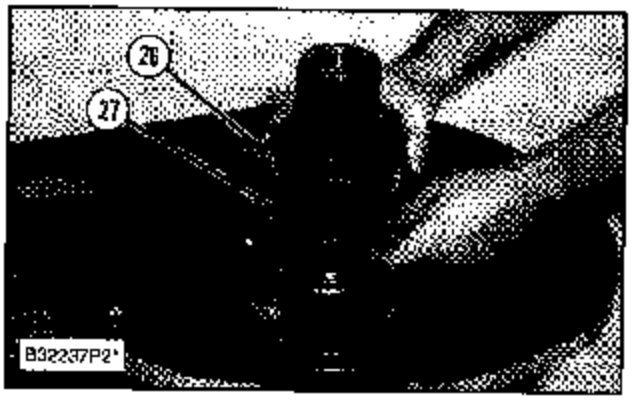


64. Use tool (B) to install retaining ring (29) that holds the bearing in manifold assembly (28).

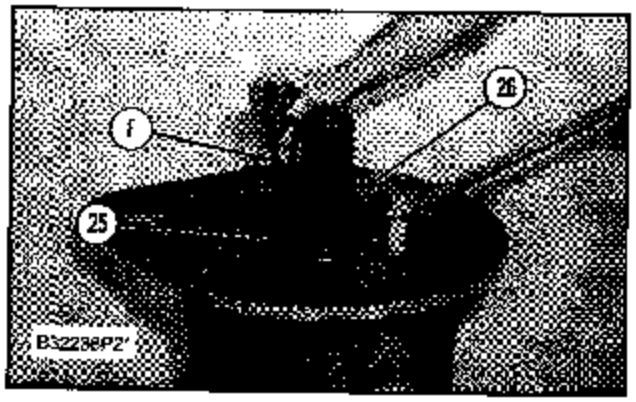


65. Put springs (32) in position on the No. 4 (third speed) piston.

66. Fasten tool (H) and a hoist to manifold assembly (28). Put the manifold assembly in position on the clutch housing. Be sure the springs are fitted correctly in the manifold assembly and clutch piston. Also, be sure the notch in the bearing engages with the dowel in the No. 5 (second speed) clutch housing. Install the two bolts that hold manifold assembly (28). Remove the hoist and tool (H) from the manifold assembly.

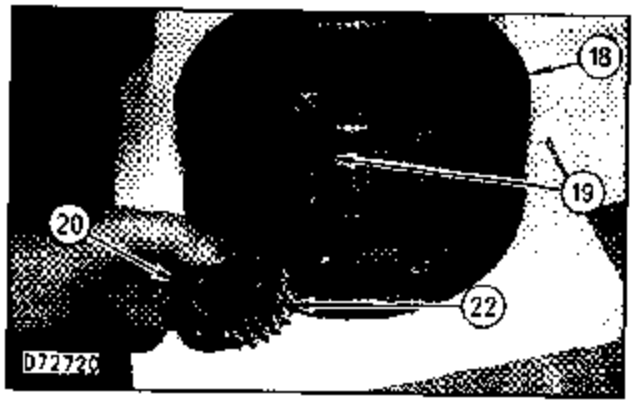


67. Put sun gear (26) in position, and install retaining ring (27) to hold it on the transmission output shaft.



68. Pull up on sun gear (26) to move the No. 5 (second speed) piston housing, and use tool (F) to install retaining ring (25).

69. Assemble carrier assembly (18) as follows:



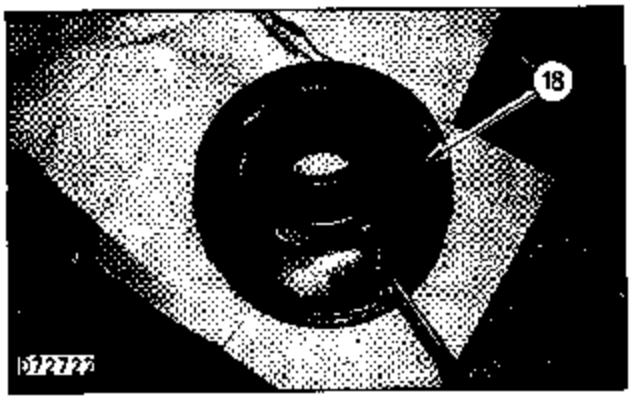
NOTICE

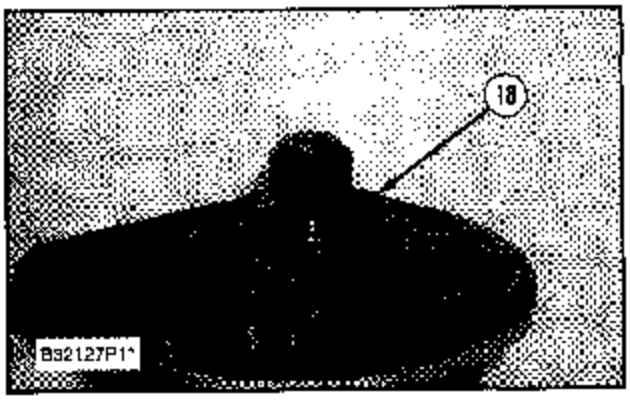
Be sure the rubber in the spring pins is not damaged. If the rubber is damaged, replace the spring pins with new parts.

a. Install the bearing in planetary gear (22). Install planetary gear (22) in carrier (18) with a thrust disc (20) on each side of the planetary gear as shown. Install planetary shaft (19) in carrier (18) through the bearing and planetary gear (22) as shown. Be sure the spring pin hole in the carrier is in alignment with the spring pin hole in the planetary shaft. Install spring pin (118) to hold planetary shaft (19) in position.

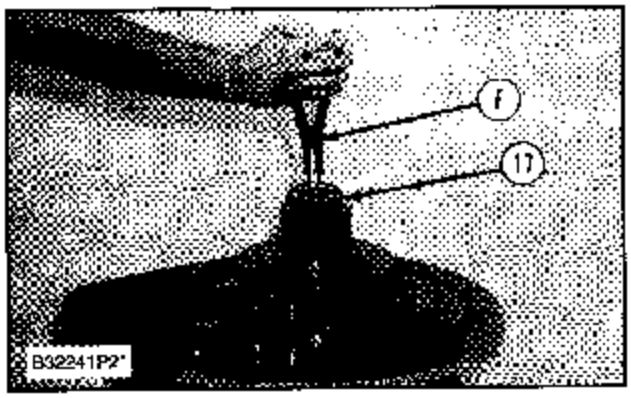
b. Install the other two planetary gears in carrier (18) as in Step 69a.

c. Install the ring seal on carrier assemoly (18).

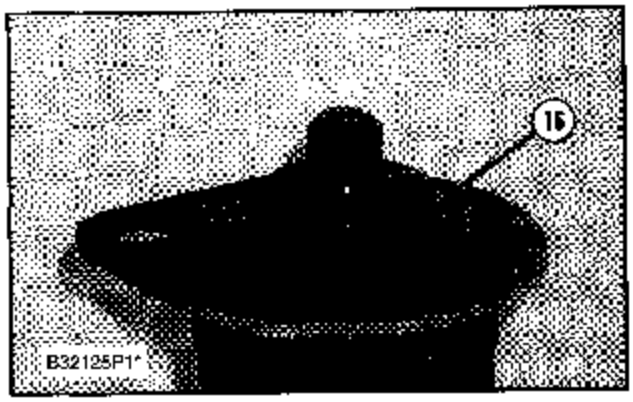




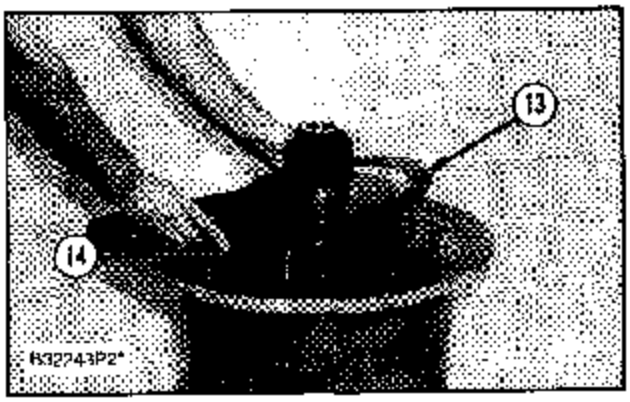
70. Install carrier assembly (18).



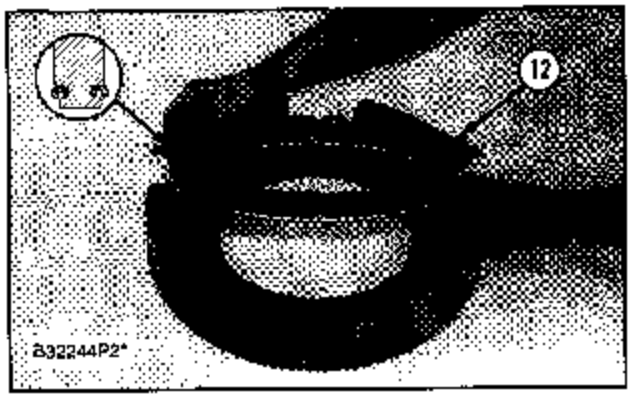
71. Use tool (F) to install retaining ring (17).



72. Install ring gear (16).



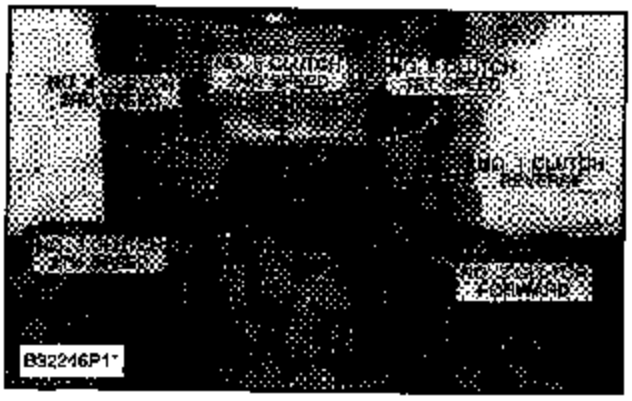
73. Install reaction dowels (14). Install three friction discs (13) and the two clutch plates in alternating order. Start with a friction disc and end with a friction disc.



74. Install the seal rings on clutch piston (12). Be sure the lips of the seal rings are toward the housing as shown.

75. Put clean transmission oil on the seal rings, and install clutch piston (12) in No. 6 (first speed) clutch housing (11).

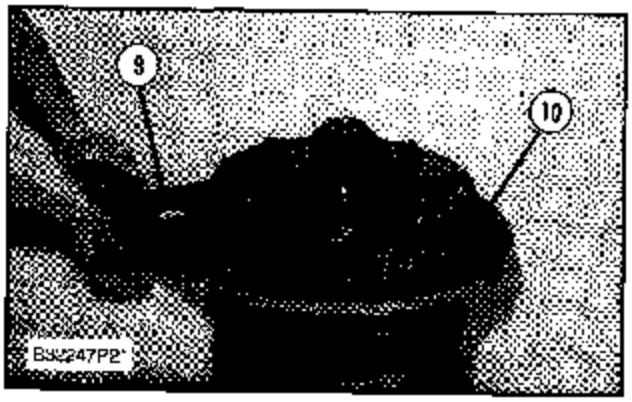
76. Install tool (G) to hold the clutch piston in position in clutch housing (11). Fasten tool (L) and a hoist to clutch housing (11). Install springs (15) in the manifold assembly, and put clutch housing (11) in position. Be sure the springs are engaged correctly in the manifold assembly and the clutch piston. Remove tool (G), the hoist and tool (L). Install the bolts to hold the clutch housings together. Tighten the bolts to a torque of **115 ± 7 N•m (85 ± 5 lb ft).**



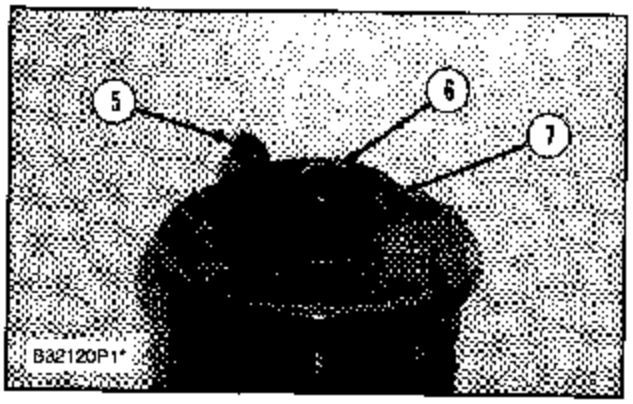
77. Check to be sure the clutch pistons are free in their clutch housings with Nozzle (M), as follows:

a. Put air free of water under a pressure of **690 to 1030 kPa (100 to 150 psi)** into each of the six oil passages.

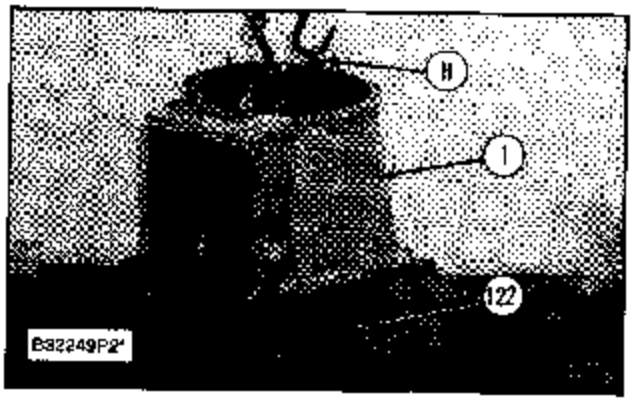
b. If the clutch pistons do not move, put a small amount of clean SAE 30 oil into each passage. Check for movement again. If the clutch pistons still do not move, the transmission must be disassembled to check the clutch pistons and seal rings.



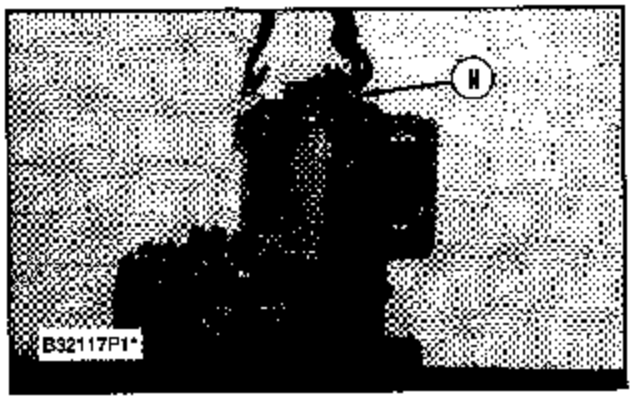
78. Install O-ring seals (9) and (10) on the manifold assembly.



79. Use a hoist to turn the transmission over. Install the O-ring seal and elbow (5). Install gear (7), retainer (6) and the bolt on the transmission input shaft.

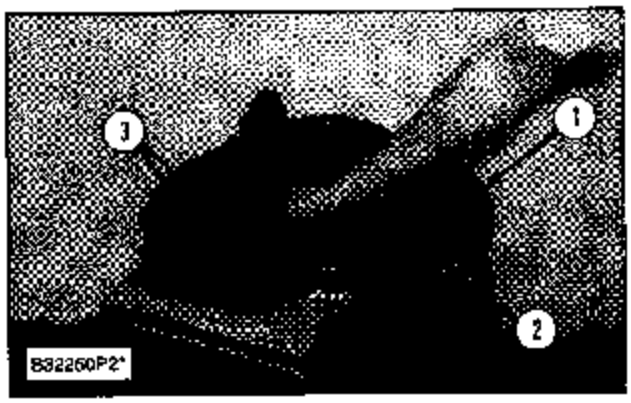


80. Install O-ring seal (122) on the manifold assembly. Fasten tool (A) and a hoist to case (1). Install the case on the transmission. Install the bolts that hold case (1) to the manifold assemoly.



81. Fasten tool (N) and a hoist to the reverse clutch housing, and put the transmission in position on the transfer gear case. Two 1/2" - 13 NC guide bolts may be used to keep the components in alignment.

82. Install the bolts to hold the transmission and transfer gears together.

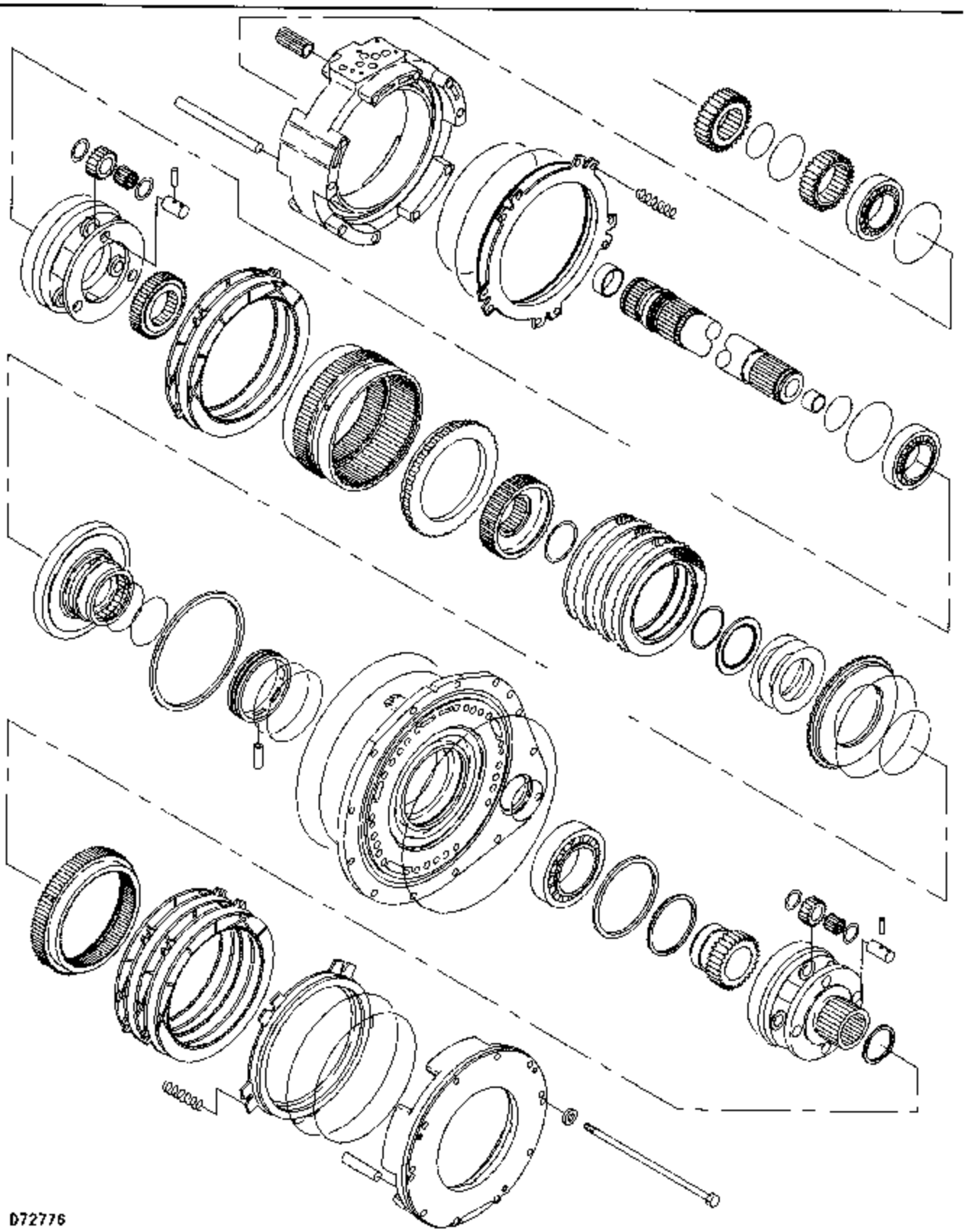


83. Install O-ring seals (3) and (2) on case (1).

End By:

a. connect torque converter to transmission

b. install transmission hydraulic control valve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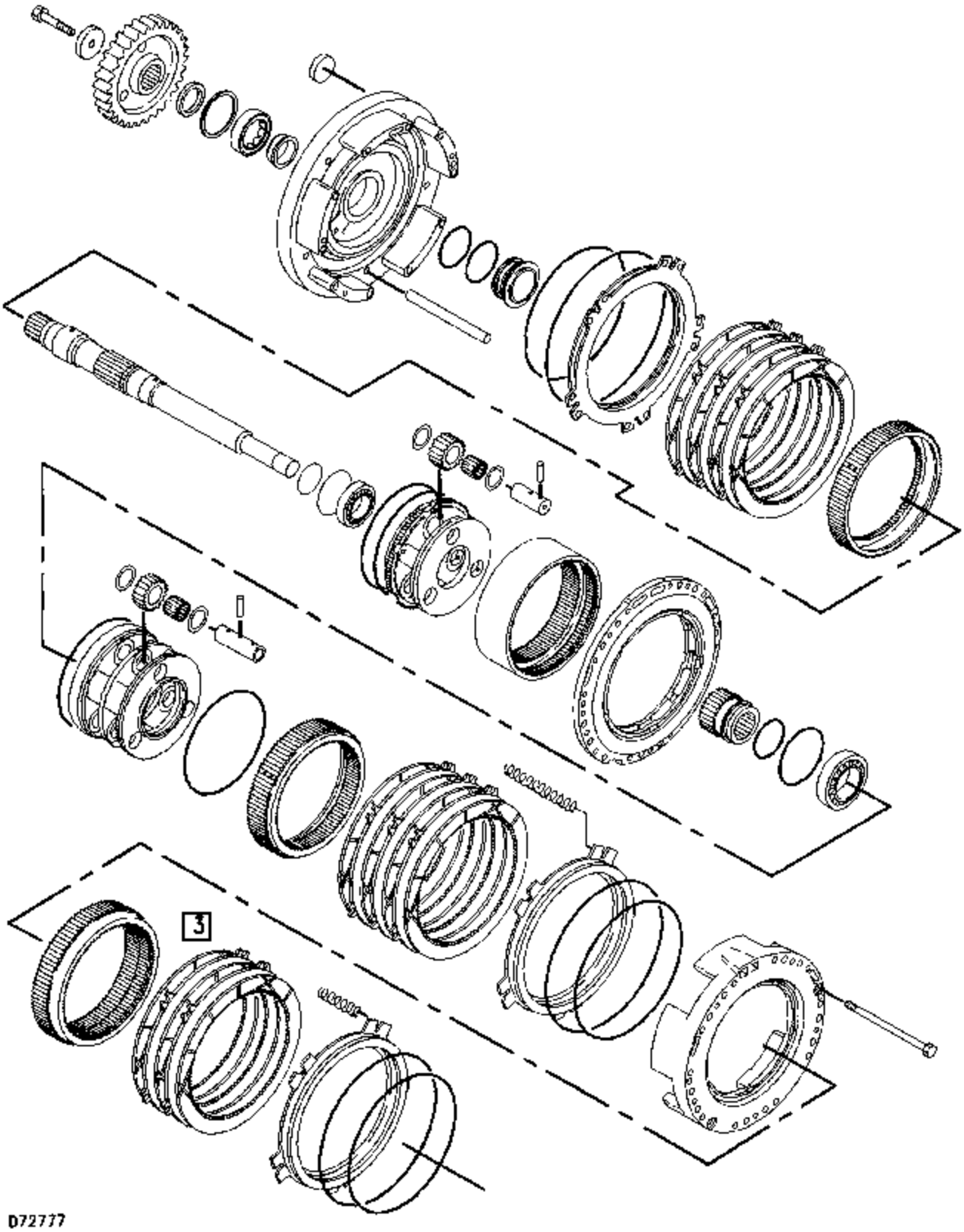
3
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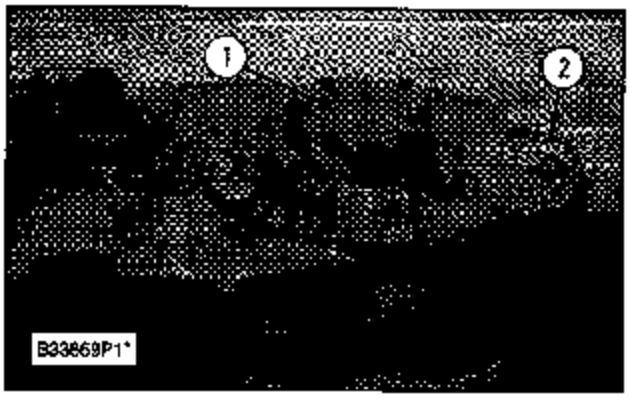
Transfer Gears

Disassemble Transfer Gears 3159-015

Tools Needed		A	B
1H3107	Puller Assembly	1	
1H3110	Bearing Pulling Attachment	1	
1P0520	Driver Group	1	1

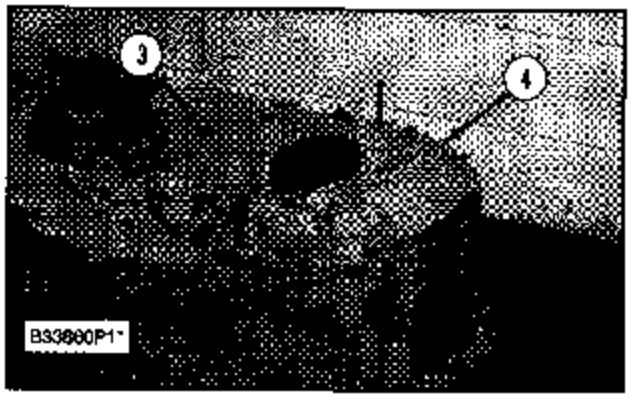
1. Remove the transfer gears from the transmission. See the topic "Disassemble Transmission" in this module.

2. Loosen the jam nut, and remove the speed sensor from the top of the transfer gear case.

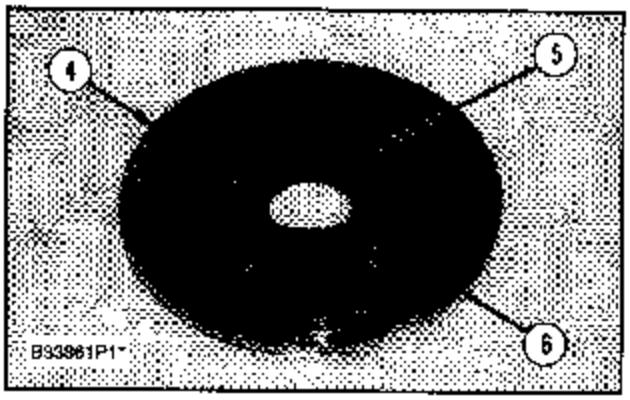


3. Use a hoist to put the transfer gears on wood blocks with the rear of the unit facing up as shown. The weight of the transfer gears is **245 kg (540 lb)**.

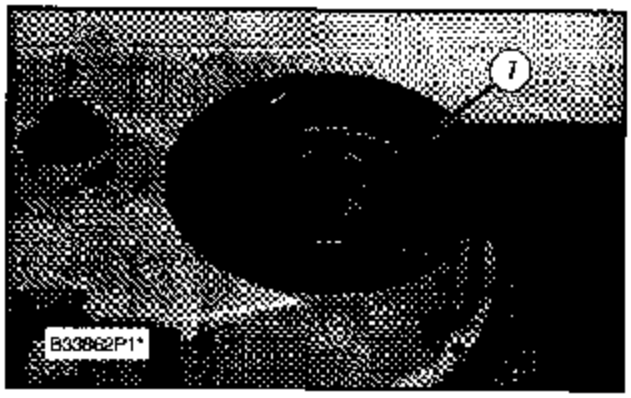
4. Remove cover (1) and eye plate (2) from the back of the bearing cage.



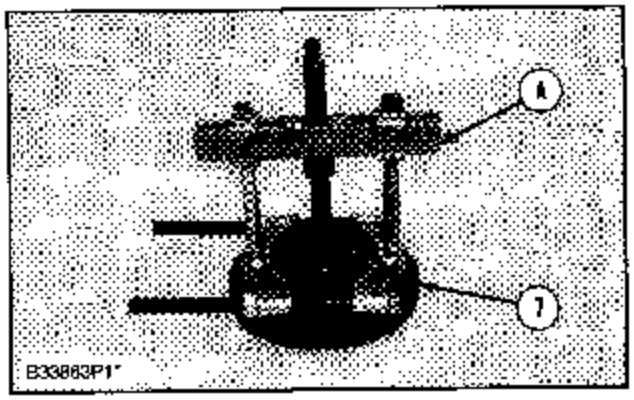
5. Remove bolts (3). Use two 3/8" - 16 NC forcing screws to loosen bearing cage (4). Remove the bearing cage with the shims. Keep the shims together for assembly purposes. Remove the O-ring seal from cage (4).



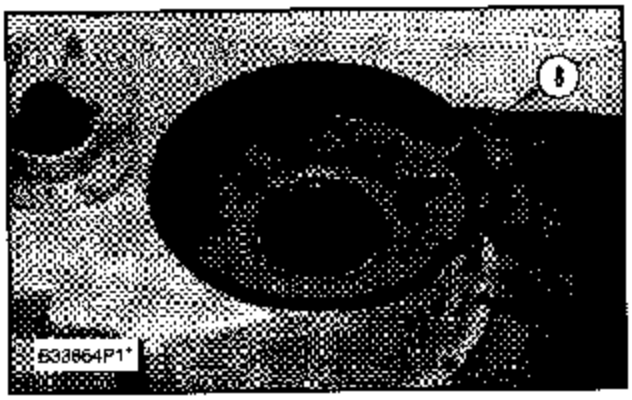
6. Remove O-ring seal (6) and bearing cup (5) from bearing cage (4).



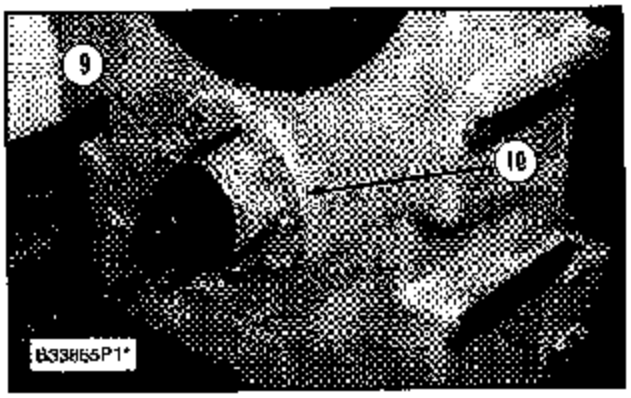
7. Use a hoist to remove transfer gear (7) with the bearing cones. The weight of the transfer gear and bearing cones is **27 kg (60 lb)**.



8. Use tool (A) to remove the bearing cone from each side of transfer gear (7).



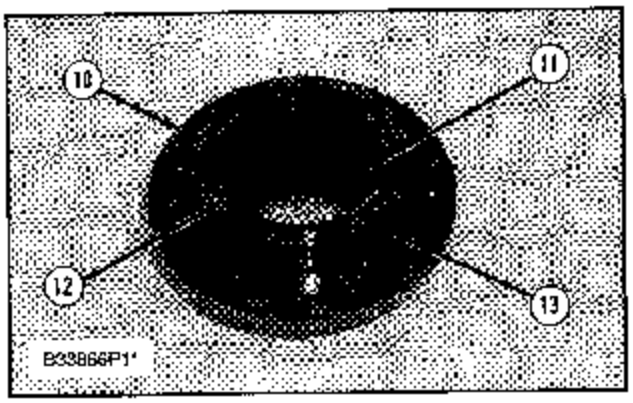
9. Remove bearing cup (8) from the case.



Typical Example

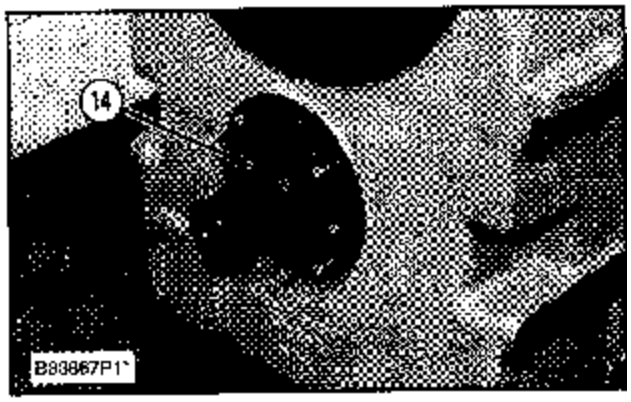
10. Fasten a hoist to the transfer gear case in a vertical position as shown. The weight of the unit is **193 kg (425 lb)**.

11. Remove nuts (9) and the washers. Use two **3/8" - 16 NC** forcing screws to loosen bearing cage (10). Remove bearing cage (10).



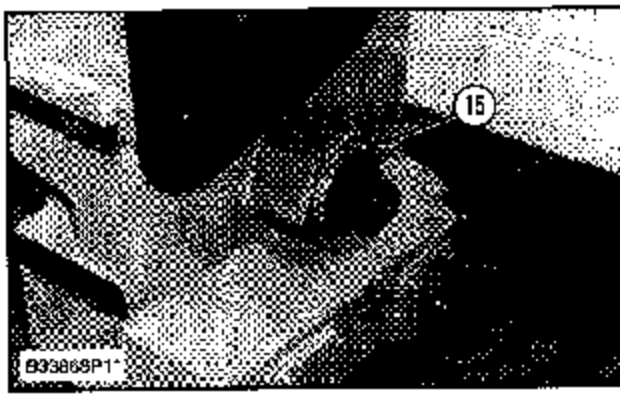
Typical Example

12. Remove O-ring seal (13), lip seal (11) and outer bearing race (12) from cage (10).



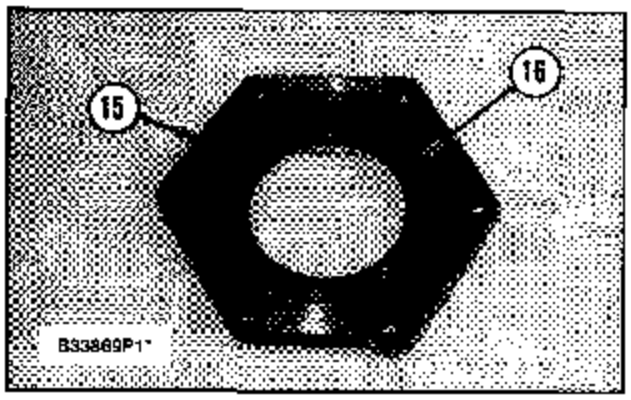
Typical Example

13. Remove spacer (14) from the end of the output shaft.



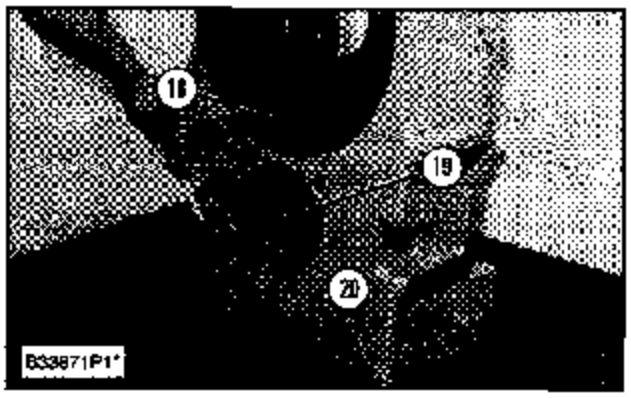
14. Remove the bolt, retainer, O-ring seal and yoke from the end of the output shaft. Remove the dirt guard from the output shaft.

15. Remove bearing retainer (15).

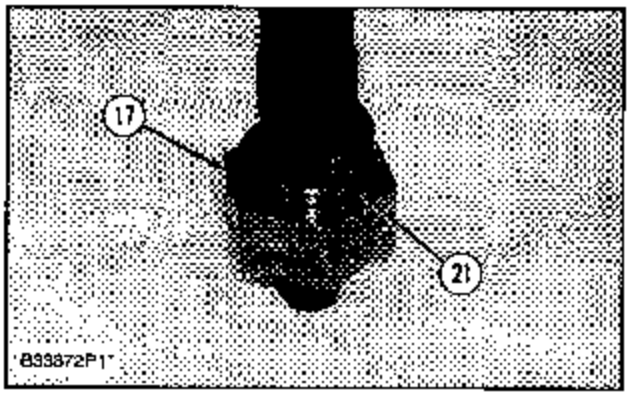


16. Remove lip seal (16) from bearing retainer (15).

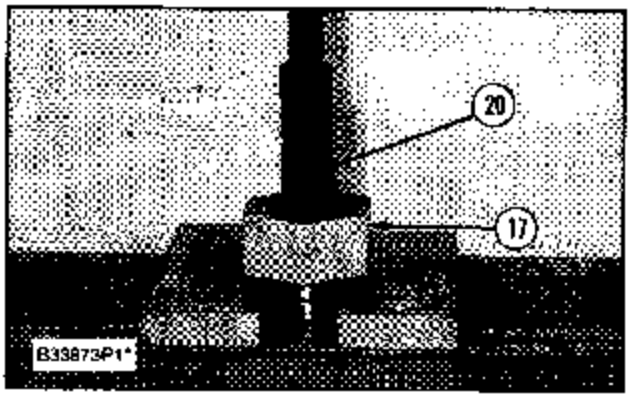
17. Install two **3/8" - 16 NC** guide bolts in the case through bearing cage (17) as shown.



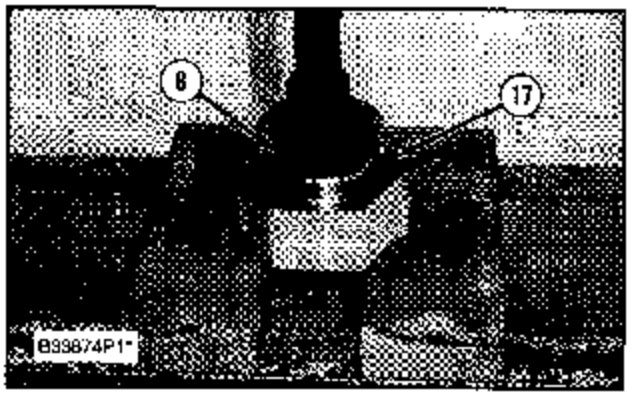
18. Fasten a nylon lifting strap and a hoist to transfer gear (18) to hold it in position as shown. Use a soft faced hammer, and push output shaft (20) out of transfer gear (18) and the bearing cage. Remove bearing (19). Remove output shaft (20) and bearing cage (17), as a, unit from the opposite side of the transfer gear case.



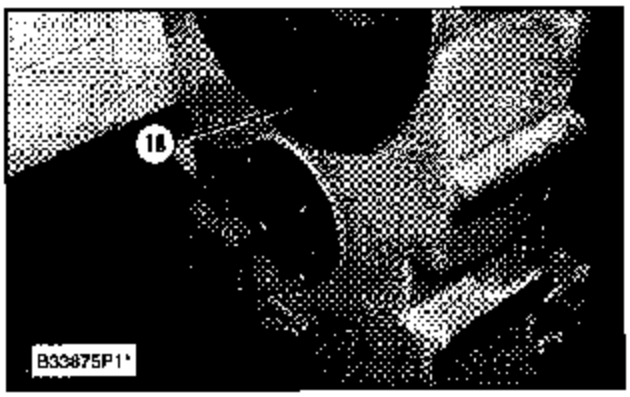
19. Remove O-ring seal (21) from bearing cage (17).



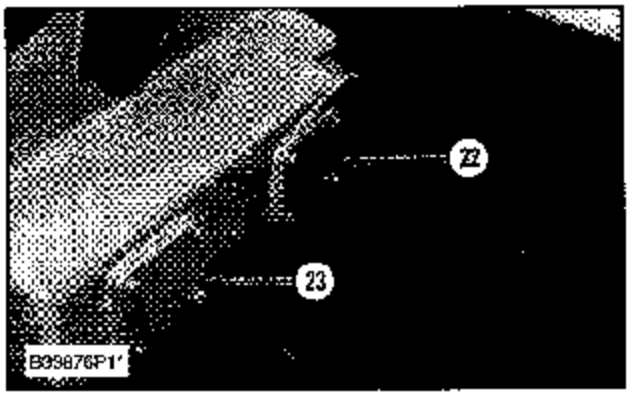
20. Use a press to push output shaft (20) out of bearing cage (17).



21. Use tool (B) and a press to push the bearings out of cage (17).

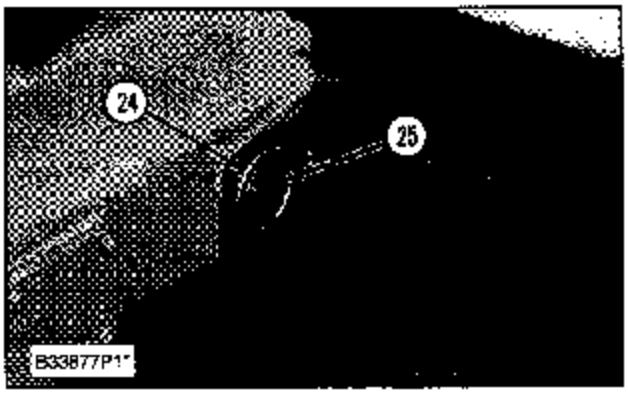


22. Remove transfer gear (18) from the transfer gear case.



23. Remove covers (23) and the gaskets from both sides of the transfer gear case.

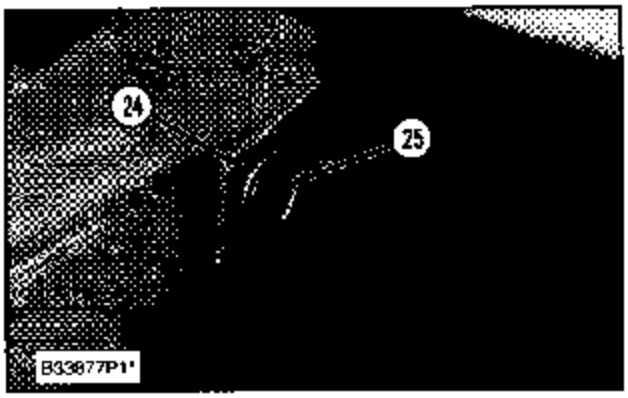
24. Remove cover (22) and the gasket from the transfer gear case.



25. Remove screen tube assembly (25) and screen (24).

Assemble Transfer Gears 3159-016

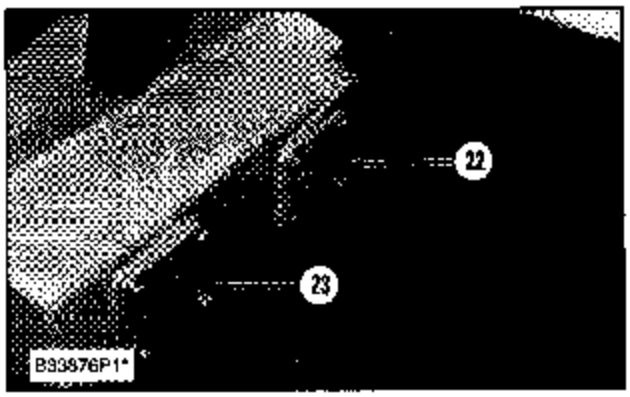
Tools Needed		A	B
1P0520	Driver Group	1	
8S2328	Dial Indicator Group		1



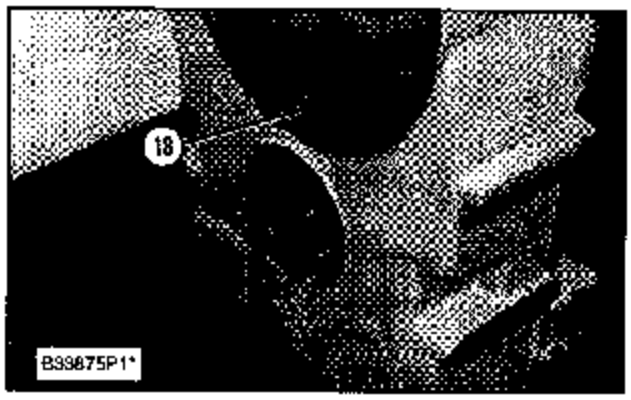
NOTICE

Be sure the magnets on screen tube assembly (25) and screen (24) are clean and free of dirt and debris prior to installation.

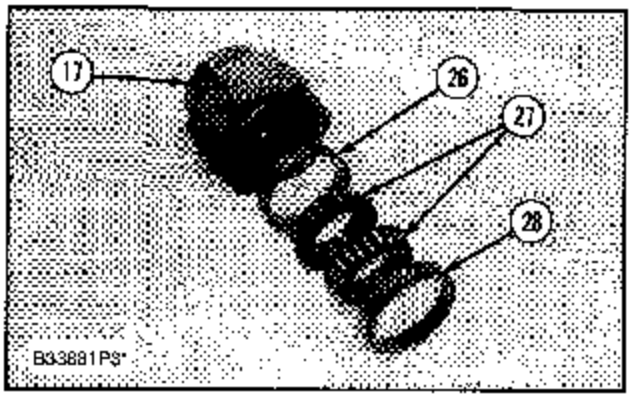
1. Install screen tube assembly (25) and screen (24).



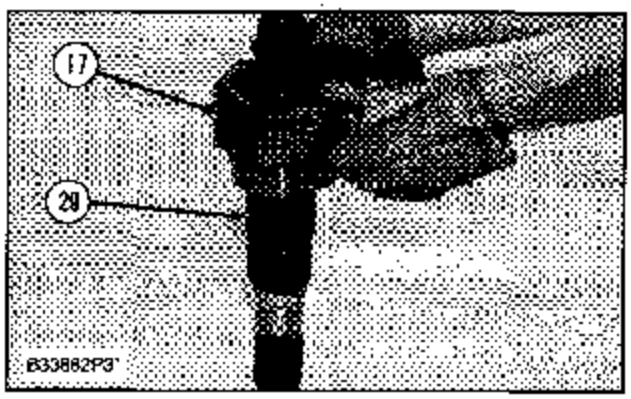
2. Coat the O-ring seal with clean oil, and install the O-ring seal on cover (22). Install cover (22). Install covers (23) and the gaskets.



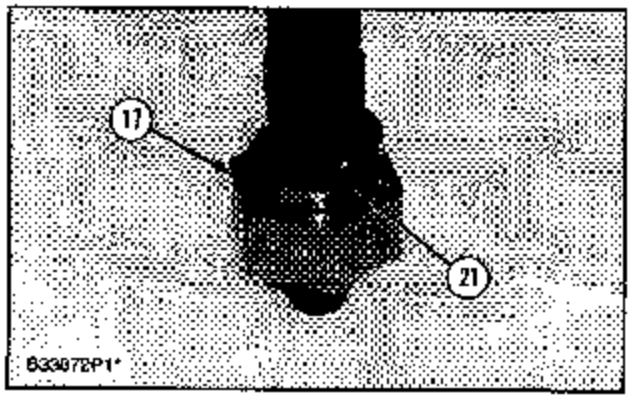
3. Install transfer gear (18). Use a hoist to hold the transfer gear in position.



4. Lower the temperature of bearing cups (26) and (28). Install the bearing cups and cones in bearing cage (17) as shown.

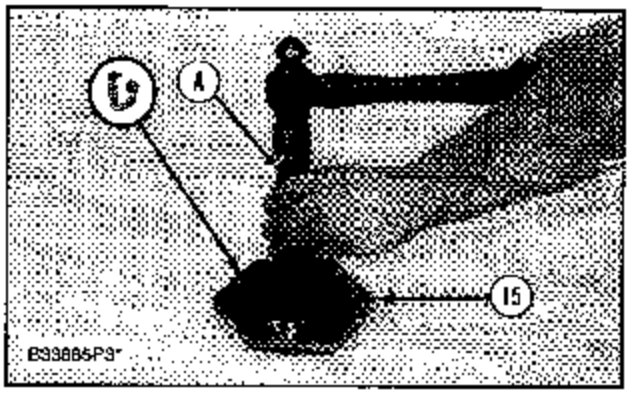


5. Heat bearing cage (17) and the bearings to a temperature of **149°C (250°F)**. Install the unit on output shaft (20) as shown.

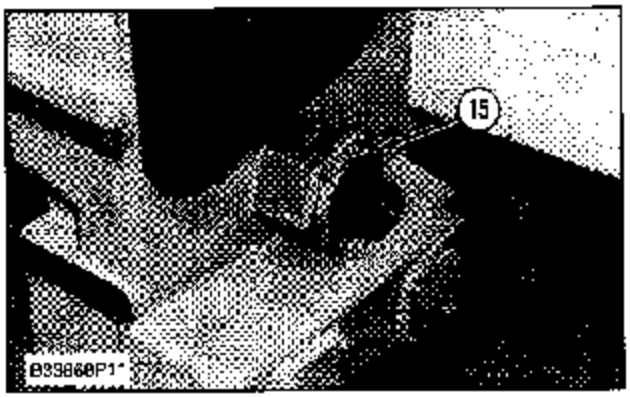


6. Coat O-ring seal (21) with clean oil, and install the O-ring seal on bearing cage (17).

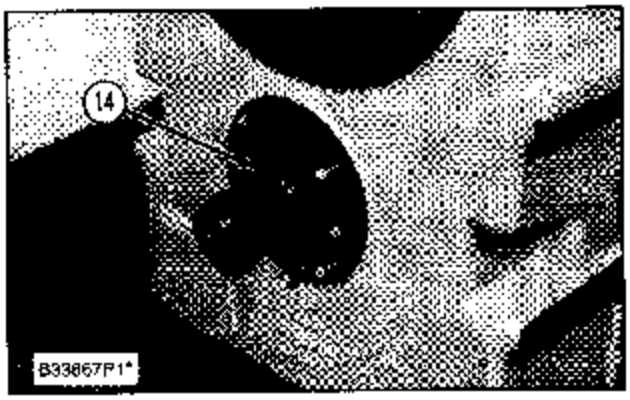
7. Install two 3/8" - 16 NC guide bolts in the transfer gear case. Install bearing cage (17) and the output shaft.



8. Apply **7M7260 Liquid Gasket Material** to the bore of bearing retainer (15), and let it dry. Do not put the gasket material on the seal case. Use tool (A) to install the lip seal in bearing retainer (15). Install the lip seal with the sealing lip facing in as shown.



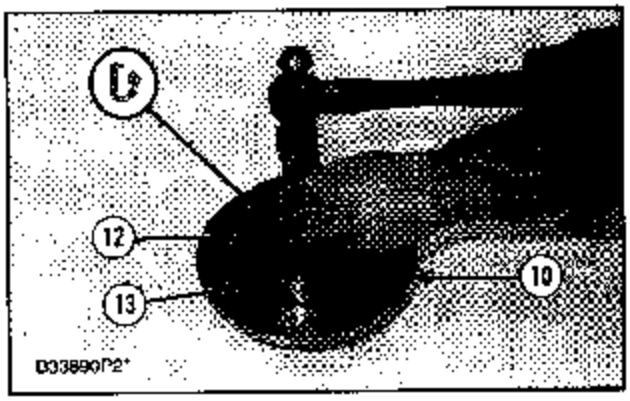
9. Put clean oil on the O-ring seal and the lip of the lip seal in bearing retainer (15). Install the O-ring seal and bearing retainer (15). Install the bolts that hold the bearing retainer in place.



Typical Example

10. Heat the bearing to a maximum temperature of **135°C (275°F)**, and install it on the output shaft.

11. Install spacer (14) on the output shaft.

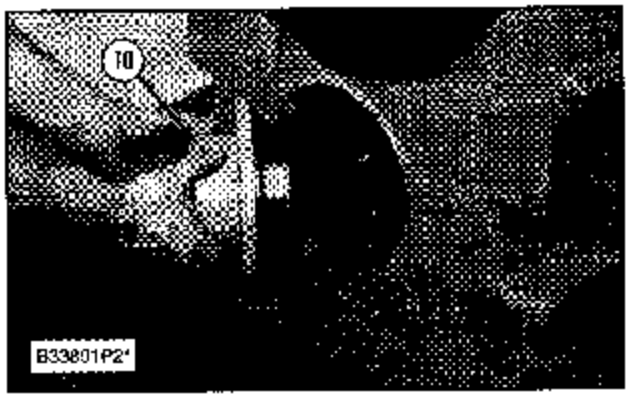


Typical Example

12. Apply **7M7260 Liquid Gasket Material** on the bore of cage (10), and allow it to dry. Do not put the gasket material on the seal case. Use tool (A) to install the lip seal in cage (10). Install the lip seal with the sealing lip facing in as shown.

13. Lower the temperature of outer bearing race (12), and install it in cage (10). Be sure the shoulder of the outer bearing race is facing the lip seal.

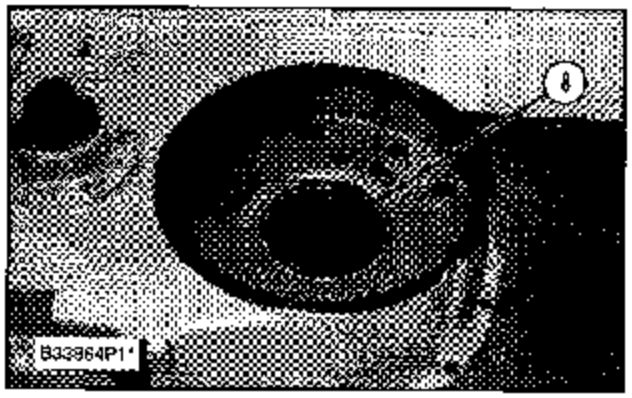
14. Install O-ring seal (13) on cage (10). Put clean oil on the O-ring seal and the lip of the lip seal in cage (10).



Typical Example

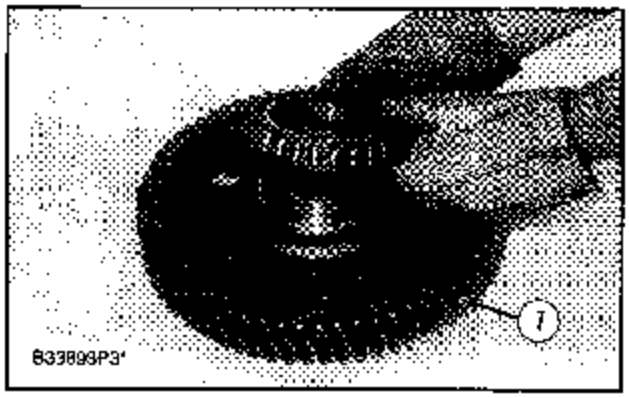
15. Be sure the studs in the transfer gear case are tightened to a torque of **55 ± 10 N•m (41 ± 7 lb ft)**.

16. Put cage (10) in the transfer gear case. Install the washers and nuts that hold it.

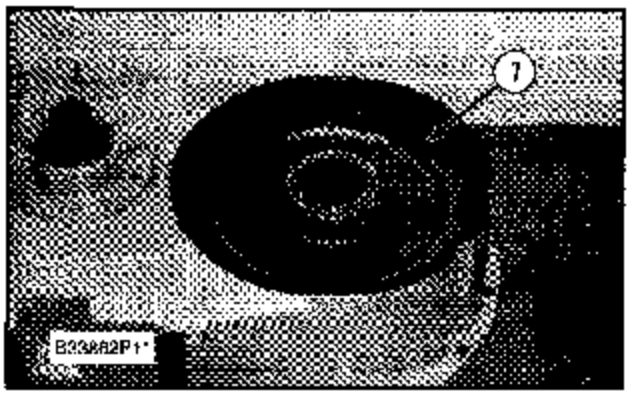


17. Use a hoist to put the transfer gear case in a horizontal position as shown.

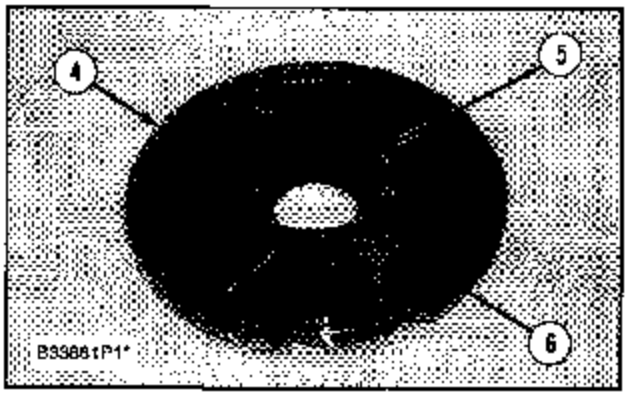
18. Lower the temperature of bearing cup (8), and install it in the transfer gear case.



19. Heat the two bearing cones to a maximum temperature of **135°C (275°F)**. Install the bearings on transfer gear (7) as shown.

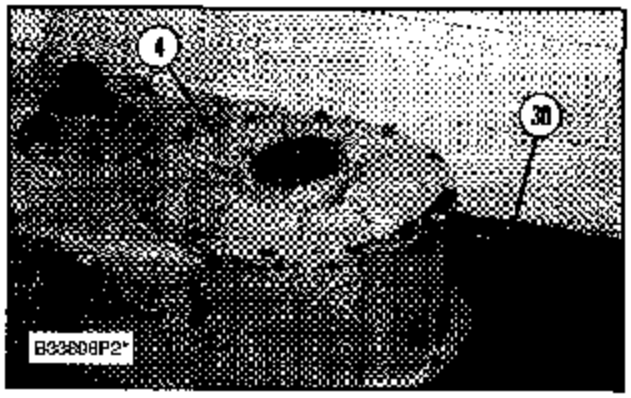


20. Use a hoist to install transfer gear (7) in the transfer gear case.



21. Lower the temperature of bearing cup (5), and install it in bearing cage (4).

22. Do not install O-ring seal (6) at this time. The bearing end play must be checked before the O-ring seal is installed.



23. Put bearing cage (4) in position on the transfer gear case. Install the bolts that hold it. Tighten the bolts evenly.

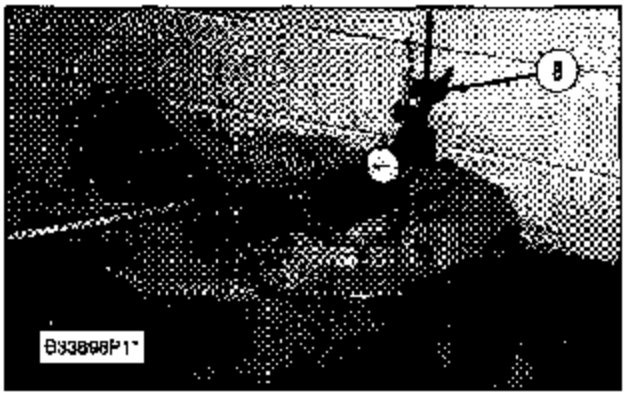
24. Put the transfer gear case in a vertical position.

25. Rotate transfer gear (7) back and forth several times to seat the bearings.

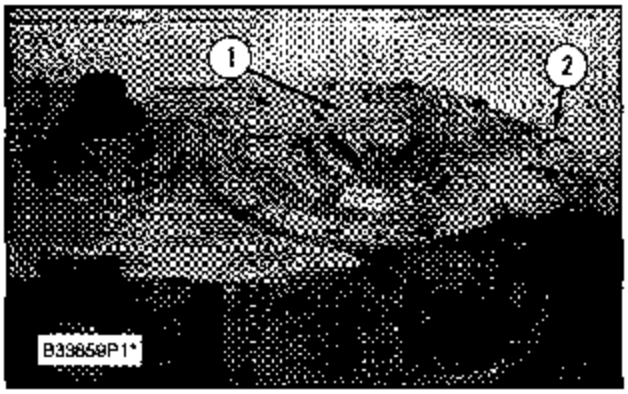
26. Use feeler gauge (30) to measure the gap between the transfer gear case and bearing cage (4).

27. Add shims between bearing cage (4) and the transfer gear case to obtain **0.10 ± 0.05mm (.004 ± .002 in)** end play.

28. Install the O-ring seal on bearing cage (4), and put clean oil on it. Reinstall bearing cage (4), and tighten the bolts that hold it evenly.



29. Use tool (B) to check the bearing end play again. If the end play is less than **0.05 mm (.002 in)**, add shims. If the end play is greater than **0.15 mm (.006 in)**, remove shims.



30. Install plate (2). Put **6V5765 Sealant** on the mating surfaces of cover (1) and the bearing cage. Install cover (1) on the bearing cage.

31. Install the yoke assembly, the O-ring seal, the retainer and bolt on the output shaft. Tighten the bolt to a torque of **115 ± 7 N•m (85 ± 5 lb ft)**.

32. Install the speed sensor in the transfer gear case. See to topic "Speed Sensors" in the Electronic Transmission Control System manual, Form No. SENR5922 for the correct procedure.

33. Install the transfer gears on the transmission. See the topic "Assemble Transmission" in this module.

Wheels (815F & 816F)

Remove Wheels (815F & 816F) 4206-011

Tools Needed	A
8S-7640 Jack Stands	2

Start By:

a. connection of steering frame lock link

b. remove cleaner assembly

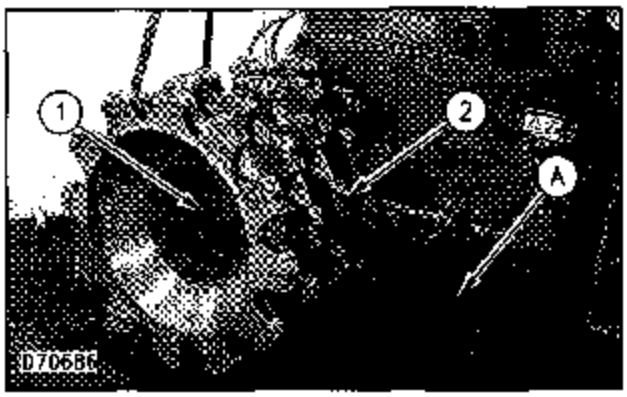
c. remove bulldozer group (front only)*

*This operation location is in Machine System Disassembly And Assembly section.

NOTE: Connect the steering frame lock link prior to lifting machine.

1. Put blocks in front of and behind the wheels that are not to be removed.

2. For the removal of the rear wheels put wood blocks between axle and frame.

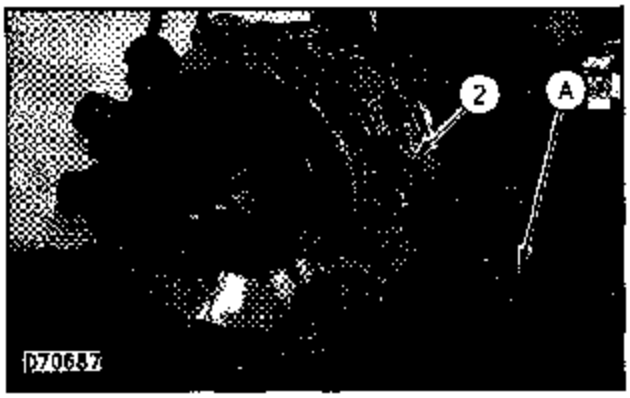


3. Put tooling (A) in position as shown. Lift the machine high enough to remove the wheel.

4. Fasten cables and a hoist to wheel (2).

5. Remove nuts (1) and remove the wheel. The weight of the empty wheel is **1058 kg (2350 lb)**. (815F only).

Install Wheels (815F & 816F) 4206-012



1. Fasten a cable and hoist to wheel (2) and put into position on the machine.

NOTE: NOTE: Make sure when the wheel is installed that the chevron pattern is as shown on next page with plugs on the outside.

2. Install the nut that holds the wheel to the machine. Tighten the nuts to a torque of **570 + 80 N m (420 + 60 lb.ft.) (815F), 570 + 80 N m (420 + 60 lb.ft.)** (816F). Lower the machine and remove the floor jacks.

End By:

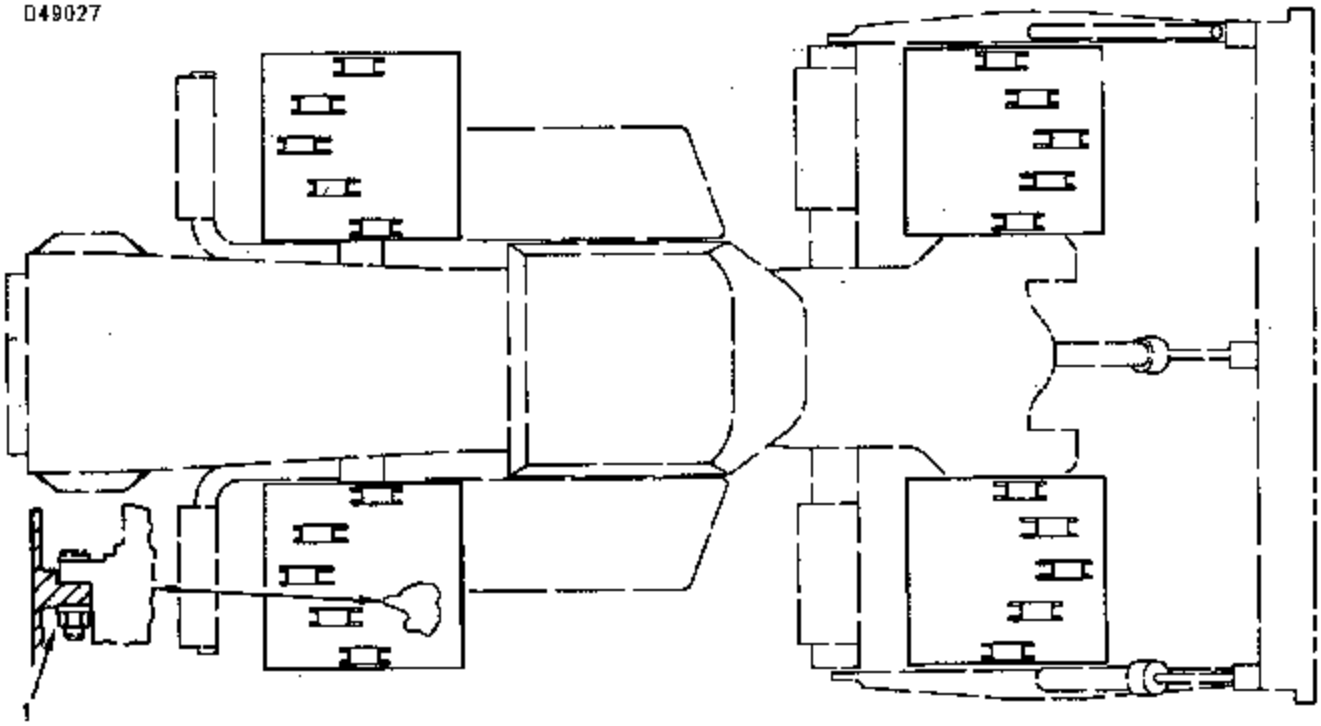
a. separation of steering frame lock link

b. install cleaner assembly

c. install bulldozer group (front only)*

*This operation location is in Machine Systems Disassembly And Assembly section.

NOTE: The following two pages display correct wheel installation of tamping foot wheel or chopper wheel.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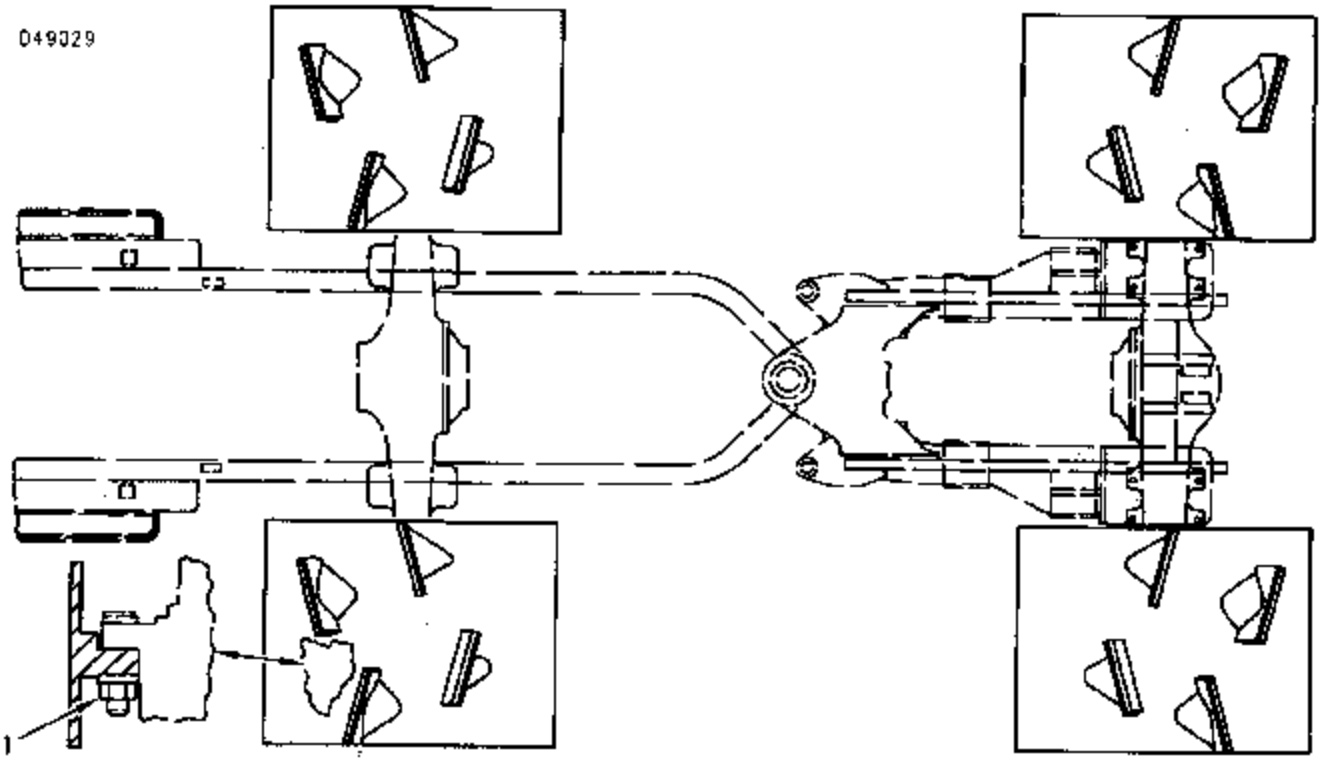
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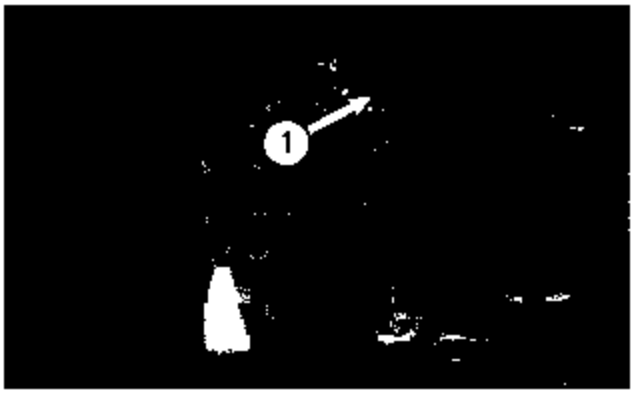
Transmission Oil Sampling Valve

Remove and Install Transmission Oil Sampling Valve

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance oil inspection, maintenance, testing, adjusting, and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to " TOOLS AND SHOP PRODUCT GUIDE NENG2500" for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose of fluids according to local regulations and mandates.



1. Disconnect transmission oil sampling valve (1) from transmission fluid filter.

NOTE: The following steps are for the installation of the transmission oil sampling valve.

2. Connect transmission oil sampling valve to transmission fluid filter.
3. Start the machine and check for leaks.

CATERPILLAR®

SENR1311
February 1996

Specifications

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Steering System

814F	815F	816F
9DM1-UP	1GN1-UP	5FN1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

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Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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Introduction

When the words 'use again' are in the description, the specification given can be used to determine if a part can be used again. If the part is equal to or within the specification given, use the part again.

When the word 'permissible' is in the description, the specification given is the 'maximum or minimum' tolerance permitted before adjustment, repair and/or new parts are needed.

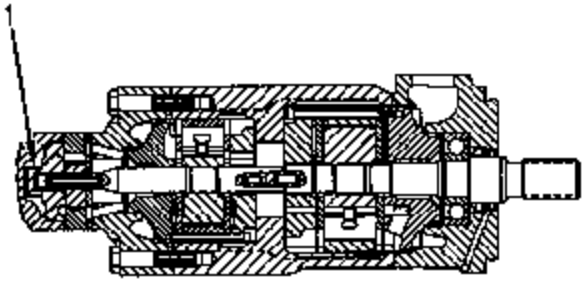
A comparison can be made between the measurements of a worn part and the specifications of a new part to find the amount of wear. A part that is worn can be used if an estimate of the remainder of its service life is good. If a short service life is expected, replace the part.

REFERENCE: For Systems Operation and Testing and Adjusting make reference to SENR1312, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Steering System.

Specifications

814F & 816F Implement, Steering And Pilot Systems Hydraulic Pump

121-3409



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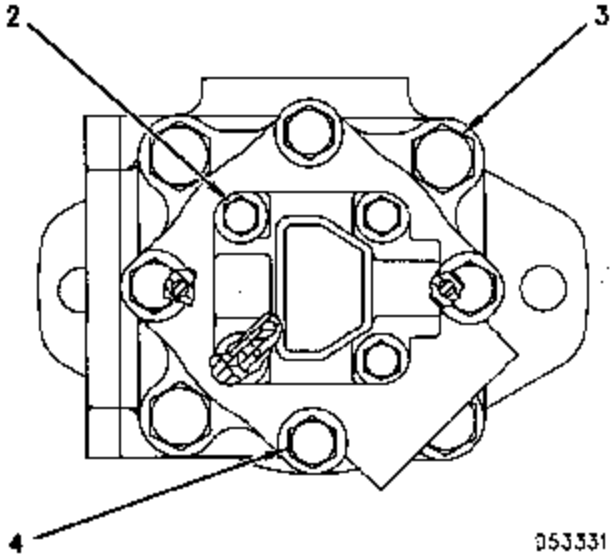


D53331

Rotation is counterclockwise when seen from drive end.

Type of pump: Vane

For test, use SAE 10W oil at 65°C (150°F).

(1) 1U-2816 Spring:
- Length under test force ..... 14.7 mm (.579 in)
- Test force ..... 192 ± 14 N (43.1 ± 3.1 lb)
- Free length after test ..... 29.7 mm (1.170 in)
- Outside diameter ..... 29.65 ± 0.52 mm (1.167 ± .020 in)

(2) Torque for four bolts ..... 55 ± 7 N•m (40 ± 5 lb ft)

(3) Torque for four bolts ..... 203 ± 14 N•m (150 ± 10 lb ft)

(4) Torque for four bolts ..... 95 ± 7 N•m (70 ± 5 lb ft)

Drive End Section (Implement)

Test at Full Speed:

Output ..... 144 liter/min (38 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Output ..... 130 liter/min (34 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 72 liter/min (19 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Output ..... 65 liter/min (17 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Center Section (Steering)

Test at Full Speed:

Output ..... 112 liter/min (29 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Output ..... 101 liter/min (26 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 56 liter/min (15 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Output ..... 50 liter/min (13 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Cover End Section (Pilot)

Test at Full Speed:

Output ..... 24 liter/min (6.5 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 21 liter/min (5.5 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

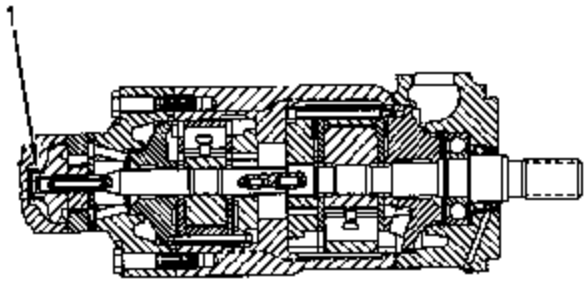
Output ..... 12 liter/min (3 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 10 liter/min (2.6 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

NOTE: Discharge and drain flows must be teed together to measure flow correctly.

815F Implement, Steering And Pilot Systems Hydraulic Pump

123-6765



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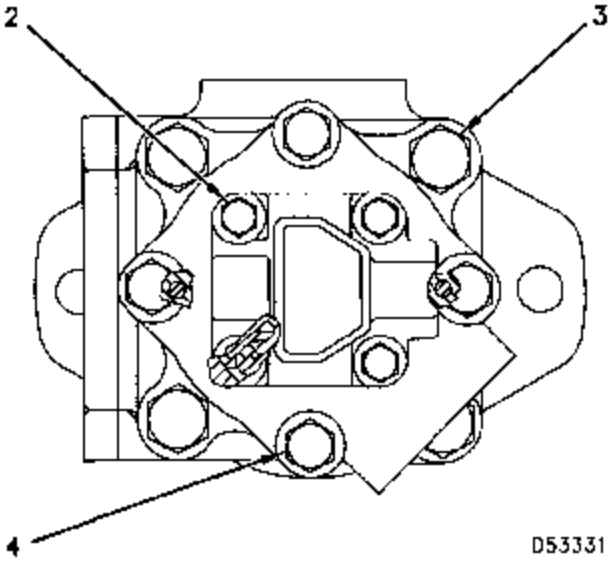

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With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 130 liter/min (34 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 72 liter/min (19 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 65 liter/min (17 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Center Section (Steering)

Test at Full Speed:

Output ..... 76 liter/min (20 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 68 liter/min (18 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 38 liter/min (10 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 34 liter/min (9 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Cover End Section (Pilot)

Test at Full Speed:

Output ..... 24 liter/min (6.5 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 21 liter/min (5.5 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

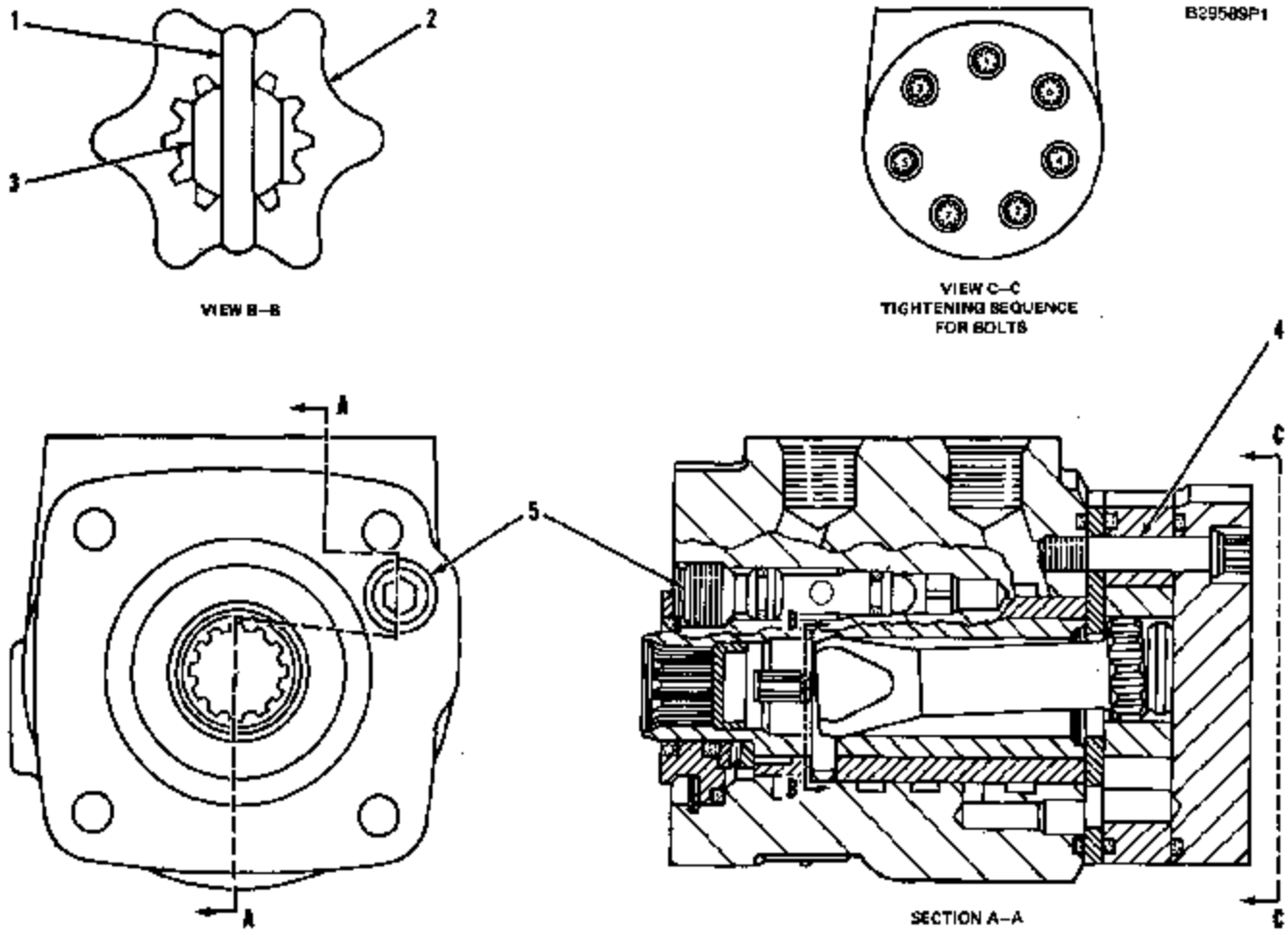
Output ..... 12 liter/min (3 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 10 liter/min (2.6 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

NOTE: Discharge and drain flows must be teed together to measure flow correctly.

Metering Pump (Steering)

8E-6406



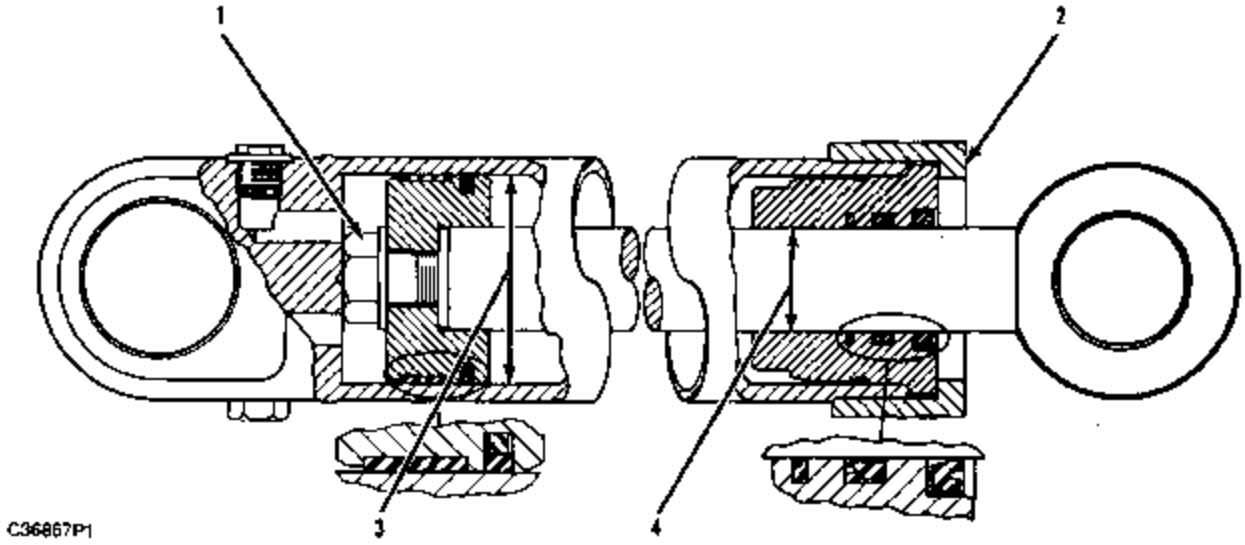
Pin (1) in the body must be aligned with internal pump gear (gerotor) (2) and drive (3) as shown.

(4) Tighten bolts in sequence shown.
Tighten to a first torque of ..... 14.1 ± 2.8 N•m (125 ± 25 lb in)
Tighten to a final torque of ..... 28.2 ± 2.8 N•m (250 ± 25 lb in)

(5) Torque for plug ..... 11.3 N•m (100 lb in)
Plug to be flush (even) with or below mounting surface.

Steering Cylinders

4T-1574



(1) Torque for bolt with lubricant on the threads ..... 1050 ± 150 N•m (775 ± 110 lb ft)

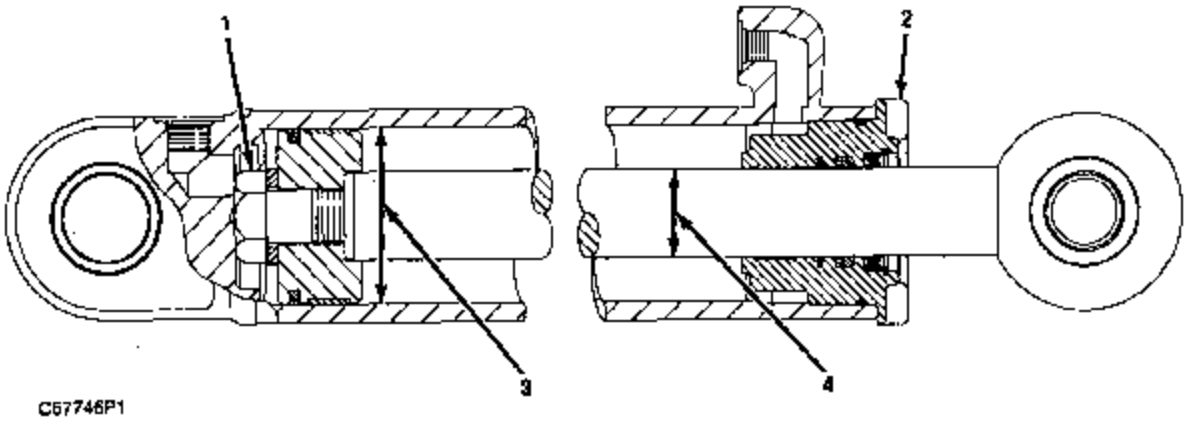
(2) Put lubricant on head and crown. Tighten crown to ..... 475 + 270 - 00 N•m (350 + 200 - 000 lb ft)

(3) Bore of cylinder (new) ..... 101.60 + 0.13 - 0.05 mm (4.000 + .005 - .002 in)

(4) Bore of head (new) .... 51.08 ± 0.03 mm (2.011 ± .001 in)

Diameter of rod (new) ..... 50.749 ± 0.038 mm (1.9980 ± .0015 in)

NOTE: Lubricate sealing lips with a small amount of oil being sealed.



(1) Torque for bolt with lubricant on the threads ..... 1800 ± 200 N•m (1325 ± 150 lb ft)

(2) Put lubricant on head and crown. Tighten crown to ..... 600 ± 130 N•m (440 ± 95 lb ft)

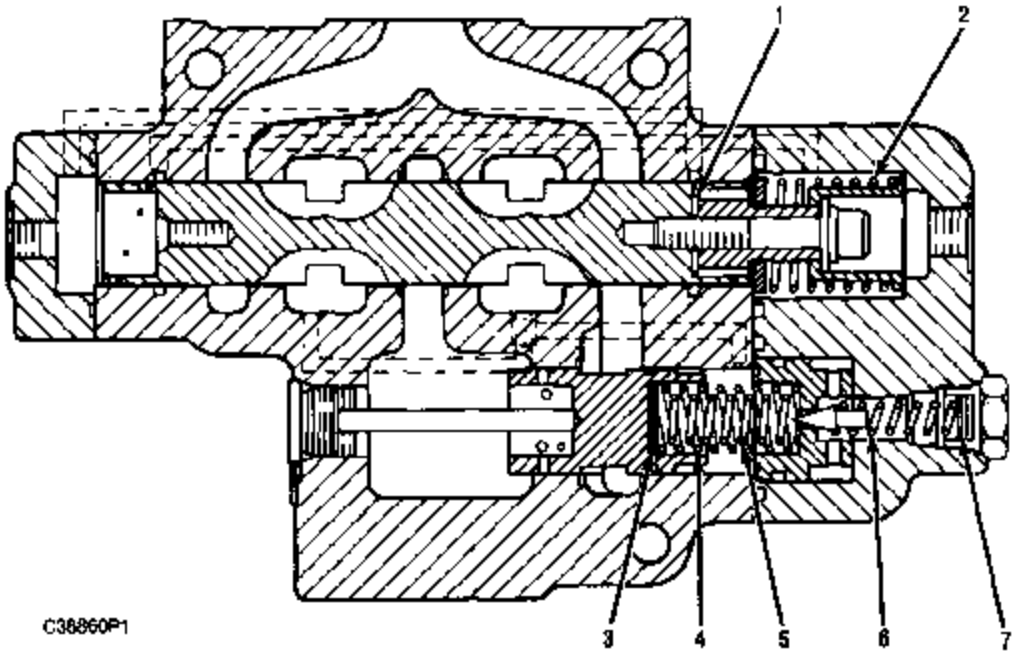
(3) Bore of cylinder (new) ..... 101.6 ± .08 mm (4.000 ± .003 in)

(4) Bore of head (new) .... 51.13 ± 0.03 mm (2.013 ± .001 in)

Diameter of rod (new) ..... 50.750 ± 0.038 mm (2.0000 ± .0010 in)

Steering Control Valve

9J-9330



Torque for three bolts that hold valve in place .... 50 ± 3 N•m (37 ± 2 lb ft)

(1) Flow balance shims:

5J-4776 Shim thickness ..... 0.12 mm (.005 in)

Two 5J-4776 Shims will change the steering time at high idle by approximately ..... .05 second

4J-8224 Shim thickness ..... 0.25 mm (.010 in)

Two 4J-8224 Shims will change the steering time at high idle by approximately ..... .1 second

NOTE: The addition of shims will cause a faster right turn (stop to stop) and a slower left turn. The result is opposite when shims are removed.

(2) 9J-5714 Spring for valve spool:

Length under test force ..... 40.6 mm (1.60 in)
Test force ..... 56 ± 6 N (12.6 ± 1.4 lb)
Free length after test ..... 55.4 mm (2.18 in)
Outside diameter ..... 36.6 mm (1.44 in)

(3) Shims for flow control valve:

4J-6806 Shim thickness ..... 1.22 mm (.048 in)

One shim will change the steering time (stop to stop) at high idle by approximately ..... .1 second

(4) 2J-6086 Spring (outer) for flow control valve:

Length under test force ..... 38.7 mm (1.52 in)
Test force ..... 98.1 ± 5 N (22 ± 1.1 lb)
Free length after test ..... 59.5 mm (2.34 in)
Outside diameter ..... 20.62 mm (.812 in)

(5) 4J-7490 Spring (inner) for flow control valve:

Length under test force ..... 41.4 mm (1.63 in)
Test force ..... 59 ± 3 N (13.3 ± .7 lb)
Free length after test ..... 50.8 mm (2.00 in)
Outside diameter ..... 15.24 mm (.600 in)

(6) 2J-6089 Spring for pilot valve:

Color code ..... yellow stripe
Length under test force ..... 36.3 mm (1.43 in)
Test force ..... 278 ± 14 N (62.5 ± 3.1 lb)
Free length after test ..... 44.1 mm (1.74 in)
Outside diameter ..... 12.50 mm (.492 in)

(7) Pressure relief setting for steering system ..... 17 250 ± 345 kPa (2500 ± 50 psi)

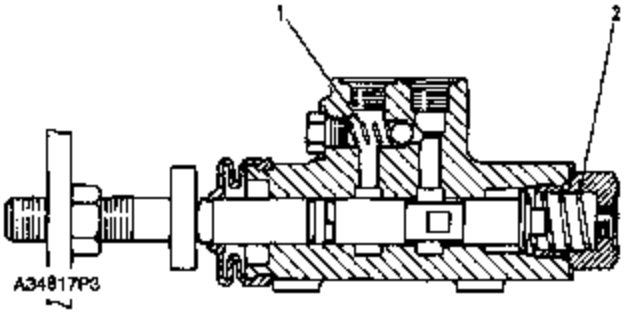
Shims for pilot valve spring:

3H-2549 Shim thickness ..... 0.25 mm (.010 in)

One 3H-2549 Shim will change the relief pressure by approximately ..... 340 kPa (50 psi)

Neutralizer Valves

8J-1553



(1) 1A-8096 Spring for ball check valve:
Length under test force ..... 14.2 mm (.56 in)
Test force ..... 18 ± 1 N (4.0 ± .3 lb)
Free length after test ..... 23.9 mm (.94 in)
Outside diameter ..... 8.1 mm (.32 in)

(2) 7B-8194 Spring for stem:
Length under test force ..... 27.9 mm (1.1 in)
Test force ..... 134 ± 11 N (30.0 ± 2.4 lb)
Free length after test ..... 55.1 mm (2.17 in)
Outside diameter ..... 20.6 mm (.81 in)

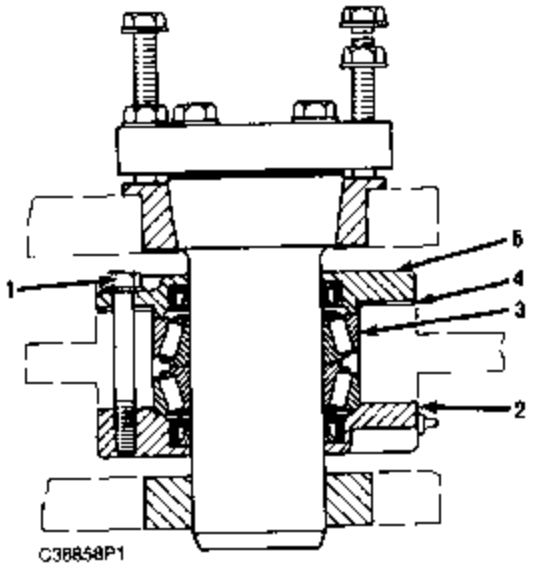
To check the striker adjustment:

(a) Put a 12.7 mm (.50 in) ball of putty (or similar material) on the front frame stops
(b) Raise an empty bucket about 300 mm (12 in) and release the brakes.
(c) With the engine at high idle, steer rapidly into both stops.
(d) The thickness of the putty must then be 6.4 ± 3.0 mm (.25 ± .12 in) after the turns.
(e) If necessary, adjust the strikers until this dimension is correct.

Articulated Hitch Groups

9V-8537

Upper Hitch Assembly Instructions



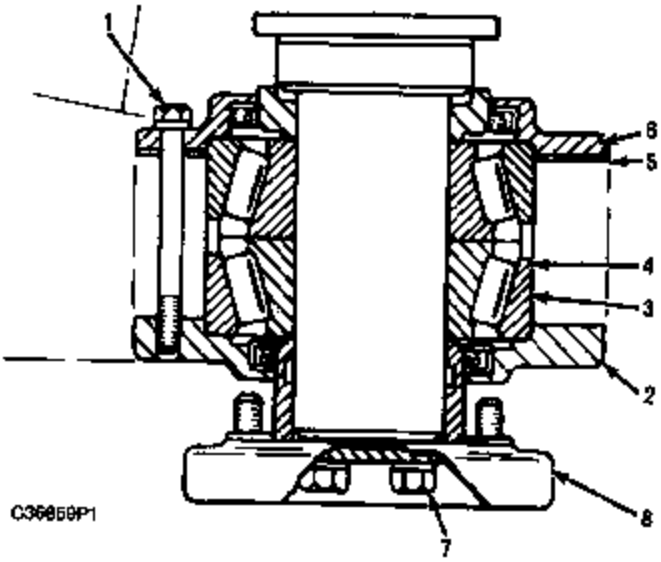
Upper Hitch Assembly

1. Coat bores with 5P-0960 Lubricant.
2. Install three bolts (1), equally spaced around lower cap (2).
3. Cool bearing cups down to -75° ± 5°C (-103° ± 9°F) and install lower cup (3), in bearing housing.
4. Drive down to ensure contact with cap (2).
5. Lubricate cones with oil and install.
6. Install cooled top cup (3), and drive down to ensure light contact pressure on cones.
7. Install shim (4), upper cap (5), three bolts (1) and tighten.
8. Install torquing bolt assembly and tighten.
9. Apply torque wrench to torquing bolt and read torque necessary to rotate cones.
10. If torque is within range of 2.3 to 13.6 N•m (1.70 to 10.06 lb ft), install remaining bolts and tighten
11. If torque is less than 2.3 N•m (1.70 lb ft) or greater than 13.6 N•m (10.06 lb ft), remove or add shims to obtain correct rotating torque.

Upper Hitch Tightening Procedure

1. Tighten two diagonally opposite bolts an equal amount.
2. Tighten the two remaining bolts an equal amount.
3. Repeat procedure until all bolts are tight.

Lower Hitch Assembly Instructions



Lower Hitch Assembly

1. Coat bores with 5P-0960 Lubricant.
2. Install four bolts (1), equally spaced around lower cap (2).
3. Cool bearing cups down to -75° ± 5° C (103° ± 9° F) and install lower cup (3) in bearing housing.
4. Drive down to ensure contact with cap (2).
5. Lubricate cones (4) with oil and install.
6. Install cooled top cup (3), and drive down to ensure light contact pressure on cones.
7. Install shim (5), upper cap (6), four bolts (1), and tighten diagonally opposite bolts an equal amount.
8. Install torquing bolt assembly and tighten.
9. Apply torque wrench to torquing bolt and read torque necessary to rotate cones.
10. If torque is within a range of 7.9 to 22.6 N•m (5.85 to 16.72 lb ft), install remaining bolts and tighten.
11. If torque is less than 7.9 N•m (5.85 lb ft) or greater than 22.6 N•m (16.72 lb ft), remove or add shims to provide correct rotating torque.

Lower Hitch Tightening Procedure

1. Install two bolts (7), 180° apart, tighten to 68 N•m (50 lb ft).
2. Measure gap 360° around between frame and plate (8).
3. Install shim of minimum measurement minus 0.25 mm (.001 in) under plate.
4. Install all bolts and tighten.

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CATERPILLAR®

SENR1312
February 1996

Systems Operation Testing & Adjusting

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Steering System

814F	815F	816F
9DM1-UP	1GN1-UP	5FN1-UP

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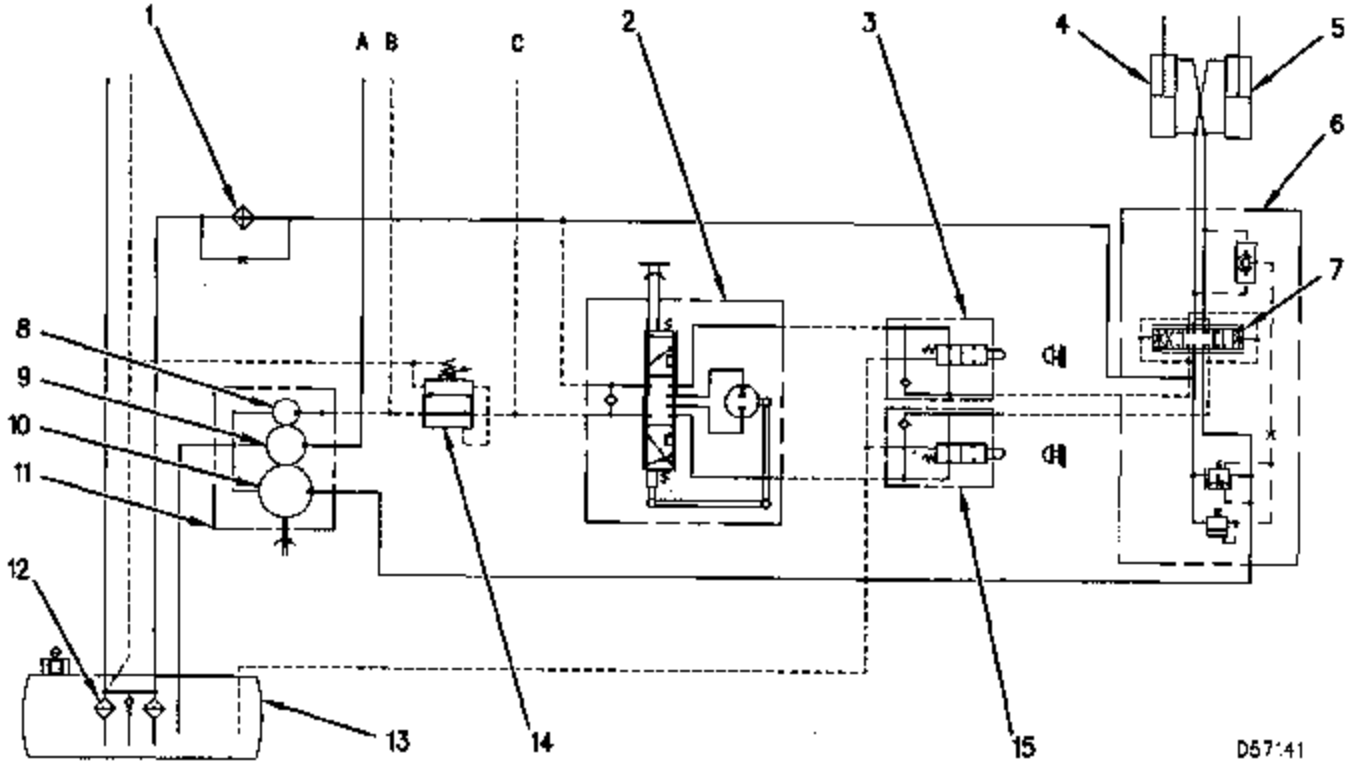
REFERENCE: For Specifications with illustrations, make reference to SENR1311, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Steering Systems Specifications. If the Specifications in SENR1311 are not the same as in the Systems Operation and the Testing and Adjusting, look at the printing date on the cover of each book. Use the Specification in the book with the latest date.

Systems Operation

Introduction



Steering Hydraulic System Schematic.
(1) Oil cooler. (2) Metering pump (steering). (3) Left neutralizer valve. (4) Left steering cylinder. (5) Right steering cylinder. (6) Steering control valve. (7) Valve spool. (8) Pilot section of pump. (9) Implement section of pump. (10) Steering section of pump. (11) Pump group. (12) Filter group. (13) Hydraulic tank group. (14) Pressure reducing valve. (15) Right neutralizer valve. (A) To implement system. (B) To brake system. (C) To implement pilot system.

The steering hydraulic system is made up of two basic circuits: the pilot circuit and the high pressure circuit. The oil for both systems comes from hydraulic pump group (11) that has three sections. Pilot section (8) provides oil for the steering and implement pilot systems and for the brake system. Steering section (10) provides oil for the steering high pressure circuit. Implement section (9) provides oil for the implement hydraulics system.

The pilot system controls the movement of spool (7) in the steering control valve (6). The components of the pilot system are pilot pump section (8), pressure reducing valve (14), metering pump (2), and left and right neutralizer valves (3) and (15.

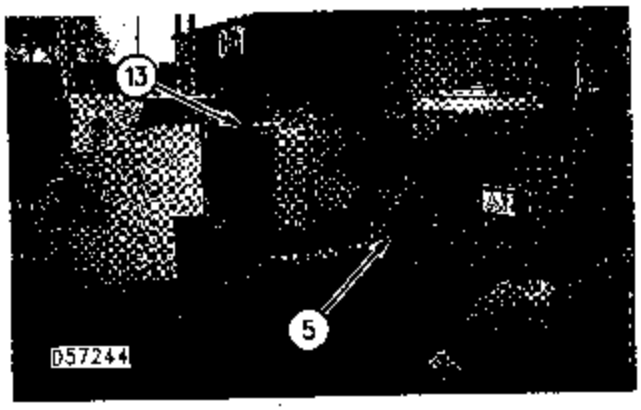
Pump oil from pilot section (8) flows through pressure reducing valve (14) and is always available at metering pump (2). The metering pump is a small hydraulic pump that is used as a metering and directional valve. The metering pump directs oil through one of the neutralizer valves when the steering wheel is turned.

The neutralizer valve stops the flow of pilot oil to the steering control valve when the machine is turned completely to the right or left. If the machine is not turned completely, the pilot oil will flow through the neutralizer valve to one end of steering control valve spool (7).The oil then flows across the metering orifices in the spool. The oil flow across the orifice causes the spool to move.

The high pressure steering circuit components are steering pump section (10), steering control valve (6), steering cylinders (4) and (5), hydraulic oil cooler (1), hydraulic tank (13), and filters (12). These components work together to provide the force needed to turn the machine.

The oil for the steering system flows from steering pump section (10) to steering control valve (6). If the pilot oil has moved the steering control valve spool to either the right or left turn position, the pump oil will flow to the steering cylinders. The pressure of this oil moves the cylinder rods and causes the machine to turn.

Component Locations

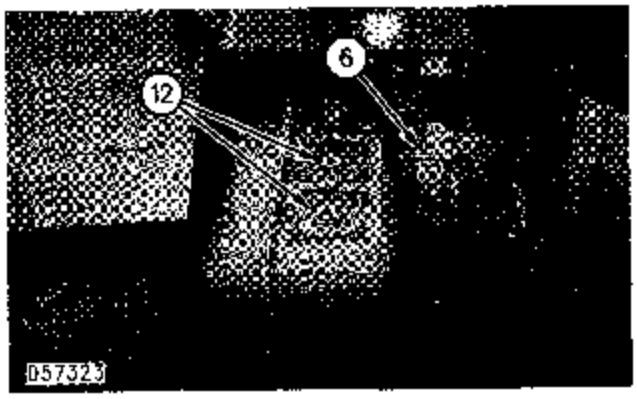


Hydraulic Tank And Right Side Steering Cylinder Location
(5) Right side steering cylinder. (13) Hydraulic tank.

Hydraulic tank (13) is located in the middle of the right side of the machine. Steering cylinder (5) is located behind the hydraulic tank.

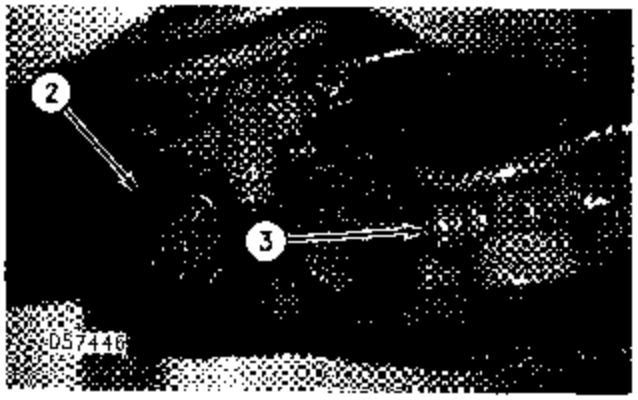
Pilot pump (8), steering pump (10) and implement pump (9) are part of pump group (11). The pump group is located under the operator's station on the left side of the machine. The pumps are mounted on the pump drive on the flywheel end of the engine.

NOTE: For more information on the implement system pump section of pump group (11), see SENR1315, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Hydraulic Systems Specifications and SENR1316, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Hydraulic System Operation, Testing And Adjusting.



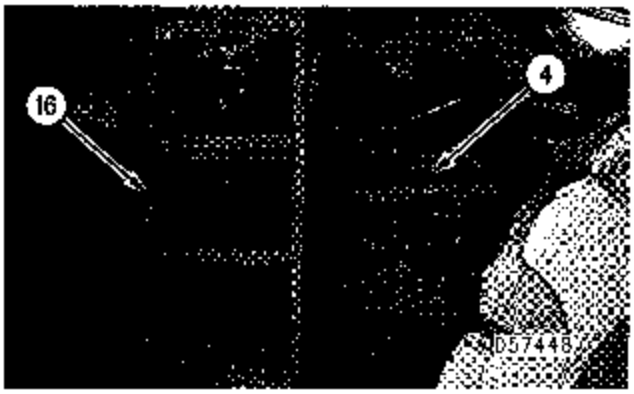
Steering Control Valve And Hydraulic Oil Filters Location
(6) Steering control valve. (12) Hydraulic oil filter group.

Hydraulic oil filter group (12) is mounted in the top of hydraulic tank (13). Steering control valve (6) is also mounted on the hydraulic tank.



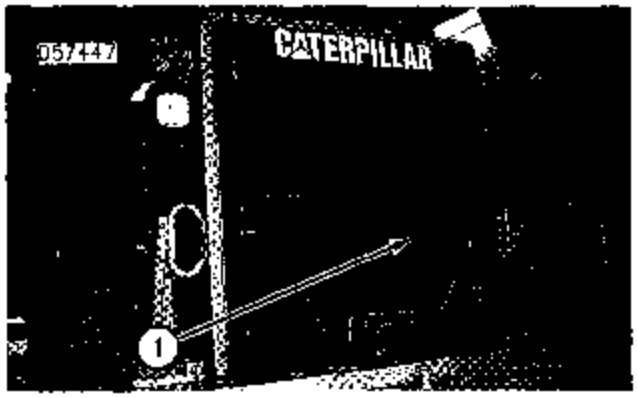
Metering Pump And Neutralizer Valves Location
(2) Metering pump. (3) Left neutralizer valve.

Metering pump (2) is mounted on the bottom of the steering column and located under the floor of the operator's station. Left neutralizer valve (4) and right neutralizer valve (15) (not visible) are located on the rear frame under the operator's station. The neutralizer valves can be accessed from the opening under the front of the cab.



Left Steering Cylinder Location
(4) Left steering cylinder. (16) Ladder.

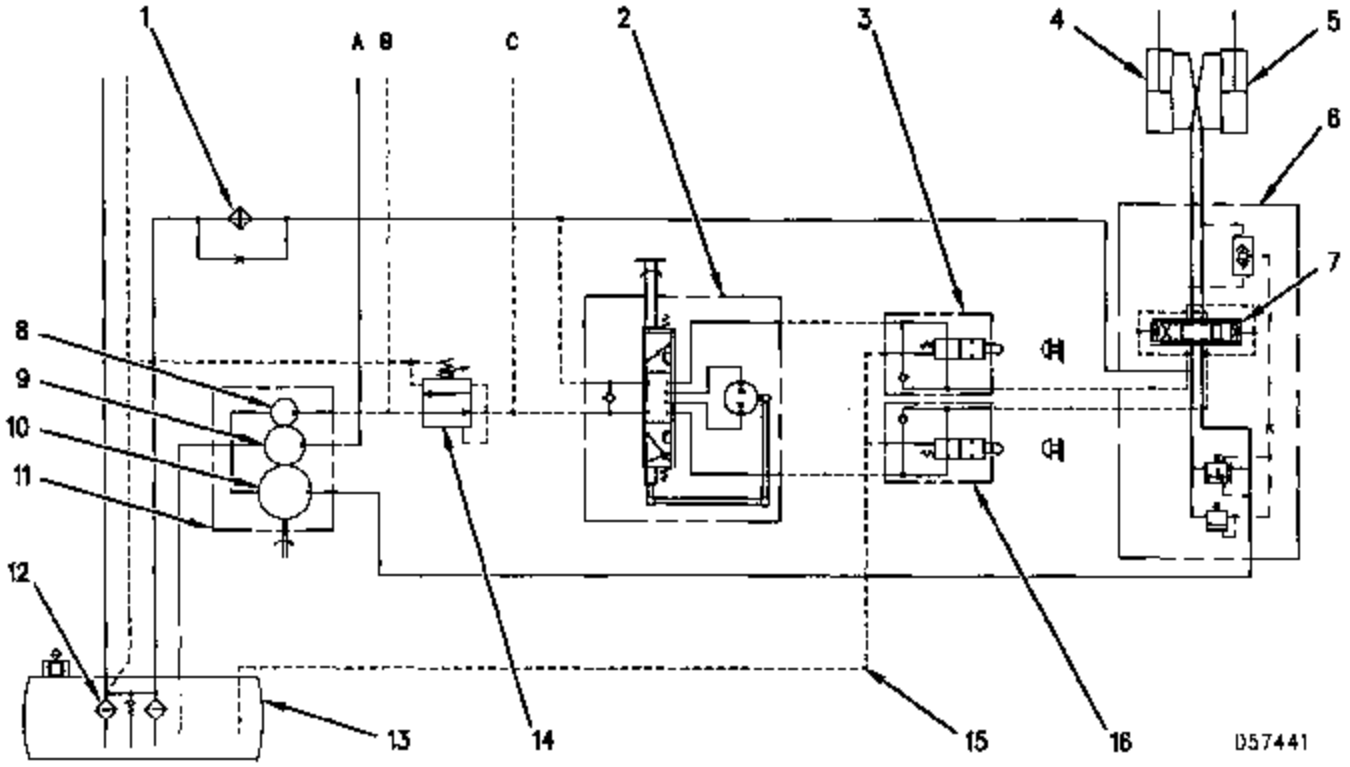
Left steering cylinder (4) is in the middle of the machine, to the inside of ladder (16).



Oil Cooler Location
(1) Oil cooler.

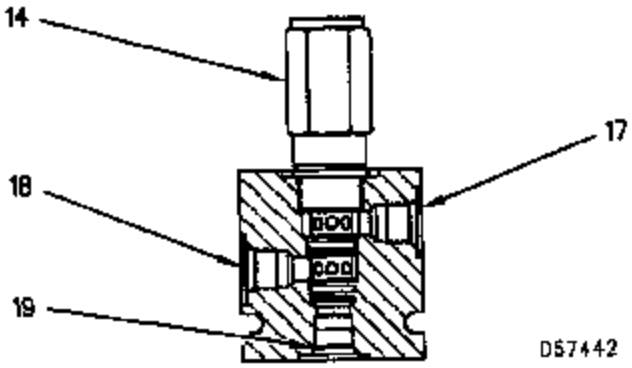
Oil cooler (1) is mounted on the outside of the radiator. Access is gained by opening the guard on the rear of the machine.

Pilot Oil Circuit



Steering Hydraulic System Schematic
(1) Oil cooler. (2) Metering pump (steering). (3) Left neutralizer valve. (4) Left steering cylinder. (5) Right steering cylinder. (6) Steering control valve. (7) Valve spool. (8) Pilot section of pump. (9) Implement section of pump. (10) Steering section of pump. (11) Pump group. (12) Filter group. (13) Hydraulic tank group. (14) Pressure reducing valve. (15) Pilot return oil line. (16) Right neutralizer valve. (A) To implement system. (B) To brake system. (C) To implement pilot system.

Pressure Reducing Valve



Pilot System Pressure Reducing Valve
(14) Valve. (17) Drain outlet. (18) Inlet. (19) Reduced pressure outlet.

A part of the oil from pilot pump (8) flows to the brake system. The rest of the oil flows into inlet (18) of pressure reducing valve (14).

Oil flows through inlet (18) into reducing valve (14). Reducing valve (14) is a cartridge valve that reduces pilot pressure to the pilot and steering circuits at 2410 ± 140 kPa (350 ± 20 psi).

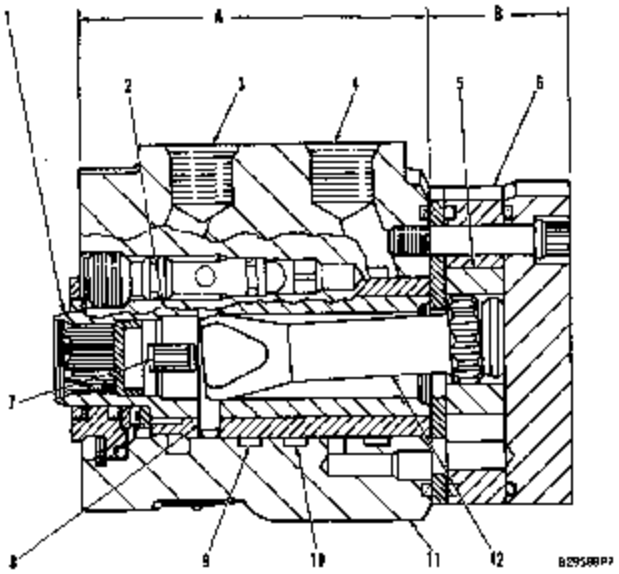
Reduced pressure oil flows through outlet (19) to the pressure control and selector valve for the implement system and to steering metering pump (2). Excess oil returns to the hydraulic tank through outlet (17).

Oil flows from the pressure reducing valve into metering pump (2). The metering pump is attached to the steering wheel. When the steering wheel is turned to either turn direction, the pilot oil control valve in the metering pump routes pilot oil to either left (3) or right (16) neutralizer valves, depending on which direction the steering wheel is turned.

Pilot oil flows from the neutralizer valves into steering control valve (6). The pilot oil acts on one side or the other of control valve spool (7) causing the spool to move. When the spool moves, high pressure oil from steering pump (10) flows to steering cylinders (4) and (5).

Return pilot oil from the steering control valve and the neutralizer valves flows through line (15) back to hydraulic tank (13).

Metering Pump (Steering)



Metering Pump (Steering)
(1) Spool. (2) Sleeve. (3) Outlet (to tank). (4) Inlet (for pump oil). (5) Internal pump gear. (6) External pump gear. (7) Centering springs. (8) Pin (9) Left turn port. (10) Right turn port. (11) Body. (12) Drive. (A) Control section. (B) Metering section.

The metering pump has two main sections: control section (A), and pump or metering section (B). These two sections work together to send pilot oil to the steering control valve. The steering wheel is connected to spool (1) by a shaft assembly and splines.

Oil from the pilot pump flows through inlet (4) into the control section of the metering pump. When the steering wheel is turned, the control section sends the oil to and from the metering section and also to and from the steering control valve.

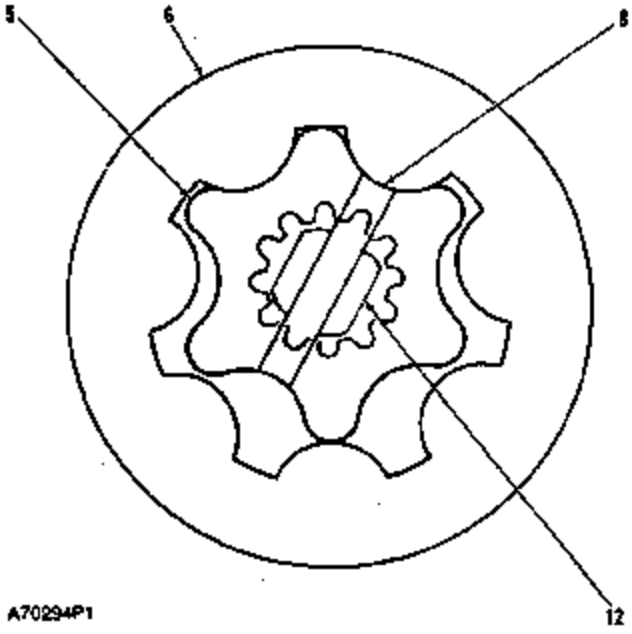
The metering section is a small hydraulic pump. It controls the pilot oil that flows to the steering control valve. As the steering wheel is turned faster, there is an increase in the flow of pilot oil to the steering control valve.

The increased flow causes the steering control valve spool to move farther. As the spool moves farther, more oil can flow from the steering pump to the steering cylinders. This results in a faster turn.

Oil Flow

The control section of the metering pump is a closed center valve. When the steering wheel is centered (neutral), oil flow is blocked by spool (1). Pump oil can not flow through inlet (4) until the steering wheel is turned.

When the steering wheel is turned, spool (1) turns a small amount and springs (7) are compressed. As springs (7) compress, sleeve (2) starts to turn. As long as the steering wheel is turned, the spool and sleeve both turn as a unit, but they turn a few degrees apart.



Pump Gears In Metering Section
(5) Internal pump gear. (6) External pump gear. (8) Pin. (12) Drive.

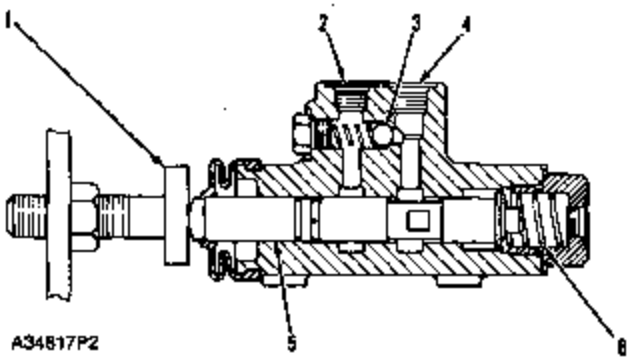
When the spool and sleeve are a few degrees apart, oil passages are opened between them. This allows the pump oil from inlet (4) flow through passages in body (11) to the metering section.

When the steering wheel is turned, pin (8) turns with the sleeve and causes drive (12) to turn also. The drive causes gear (5) rotate to inside gear (6). This rotation of the gear sends a metered flow of pilot oil back through body (11).

This oil flows to either port (9) or (10) and then on to the neutralizer valve. The other port (9) or (10) that is not used for pilot oil, is used for the return oil from the other neutralizer valve.

When steering wheel rotation is stopped, springs (7) move sleeve (2) back in alignment with spool (1) to the neutral position. This will close passages between the metering section and control section and the metering pump will be in the neutral position.

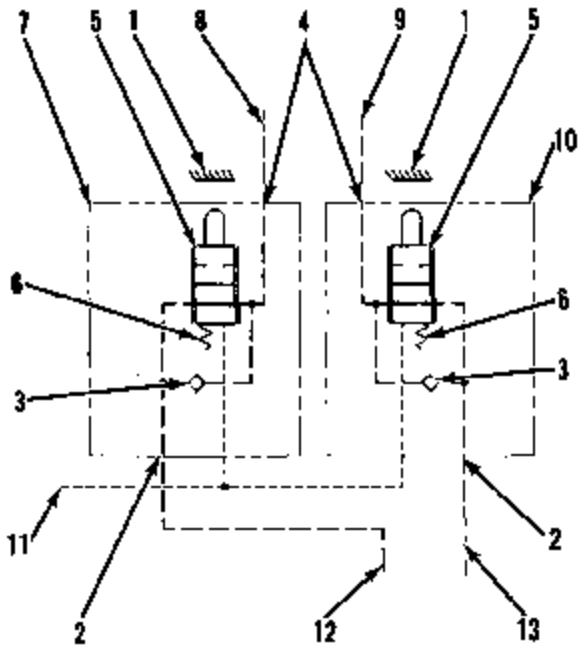
Neutralizer Valves



Neutralizer Valve In Closed Position
(1) Striker. (2) Inlet. (3) Ball check valve. (4) Outlet. (5) Stem. (6) Spring.

The neutralizer valve stops the flow of pilot oil to the steering control valve at the end of a complete turn. This stops the steering action before the machine turns against the frame stops.

Striker (1) for each valve is mounted on the front frame. Both of the neutralizer valves are mounted on the rear frame. The right and left neutralizer valves and strikers are identical.



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Neutralizer Valves Schematic
(1) Striker. (2) Inlet. (3) Ball check valve. (4) Outlet. (5) Stem. (6) Spring. (7) Left neutralizer valve. (8) Oil line. (9) Oil line. (10) Right neutralizer valve. (11) Drain line. (12) Pilot oil line. (13) Pilot oil line.

Pilot oil flows from the metering pump to either the right or left neutralizer valve before flowing to the steering control valve. Oil flows from the metering pump through line (12) or (13) into neutralizer valve (7) or (10) through inlet port (2). Then the oil flows around stem (5) and through outlet port (4) into line (8) or (9). Then the oil flows to the steering control valve.

When the steering wheel is turned to the right turn position, and the machine is turned as far right as it can turn, striker (1) comes in contact with stem (5) of the right neutralizer valve. The striker forces the stem to compress spring (6) and moves the stem until pilot oil can not flow from port (2) to port (4). This stops the flow of pilot oil through line (9).

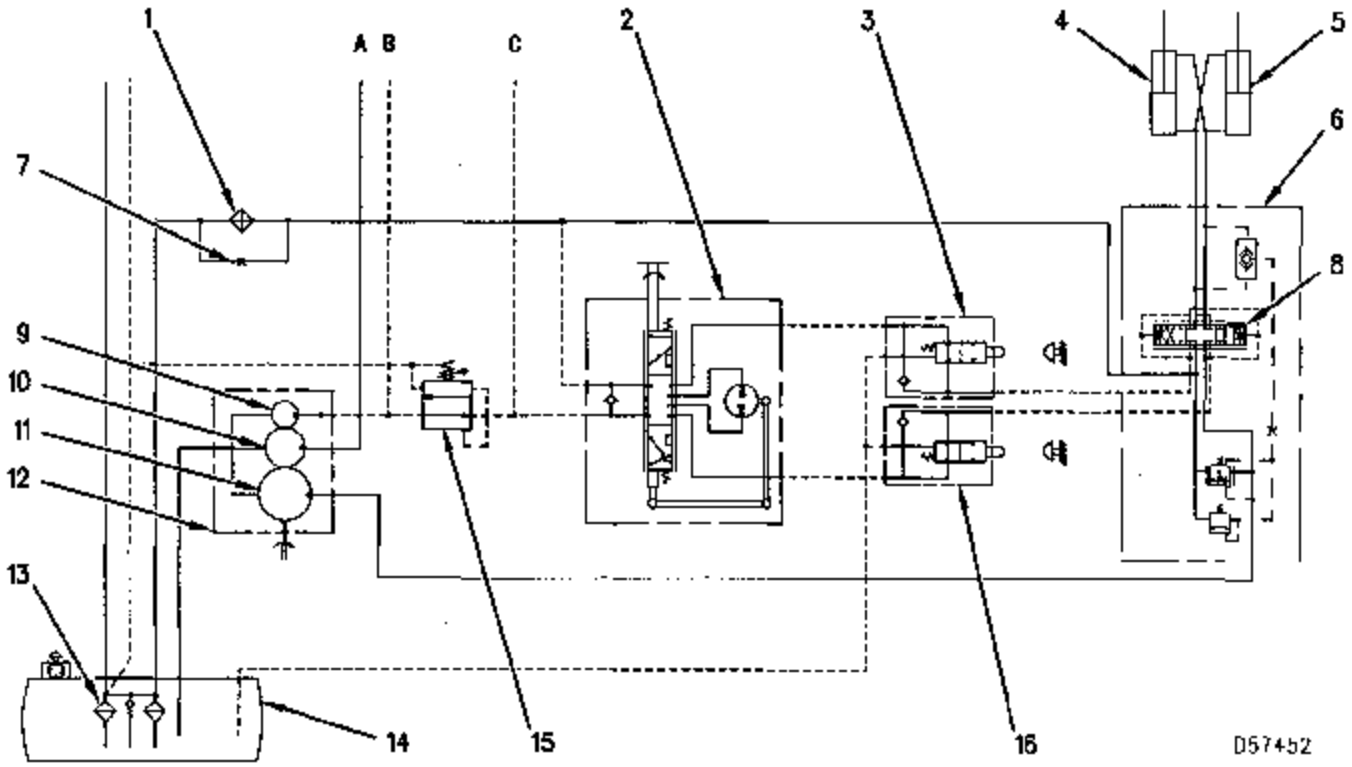
When the flow of pilot oil stops acting on the spool in the steering control valve, oil stops flowing across the metering orifices in the valve spool. The valve spool will then return to neutral, and the steering action of the machine stops.

When the steering wheel is turned back to the left, return oil from the end of the steering control valve spool flows through line (9) into port (4) of the right neutralizer valve. Because stem (5) has oil flow from port (2) to port (4) blocked, the oil forces ball check (3) to the right. The oil now flows out port (2) through line (13) back to the pilot control valve. This allows the steering control valve spool to move and the machine begins to turn to the left.

As the machine moves to the left a small amount, striker (1) will move away from stem (5). Spring (6) tension acts against stem (5) and moves it back into the open position. This allows the pilot oil to flow around the stem again, and ball check valve (3) closes.

The left neutralizer valve operates in exactly the same manner as the right side valve.

Steering Oil Circuit



Steering Hydraulic System Schematic.
(1) Oil cooler. (2) Metering pump (steering). (3) Left neutralizer valve. (4) Left steering cylinder. (5) Right steering cylinder. (6) Steering control valve. (7) Orifice. (8) Valve spool. (9) Pilot section of pump (10) Implement section of pump. (11) Steering section of pump. (12) Pump group (13) Filter group. (14) Hydraulic tank group. (15) Pressure reducing valve. (16) Right neutralizer valve. (A) To implement system. (B) To brake system. (C) To implement pilot system.

With the engine running, oil flows from hydraulic tank (14) to pump group (12). The three section vane pump has individual pump sections for the steering circuit, implement circuits and pilot circuits.

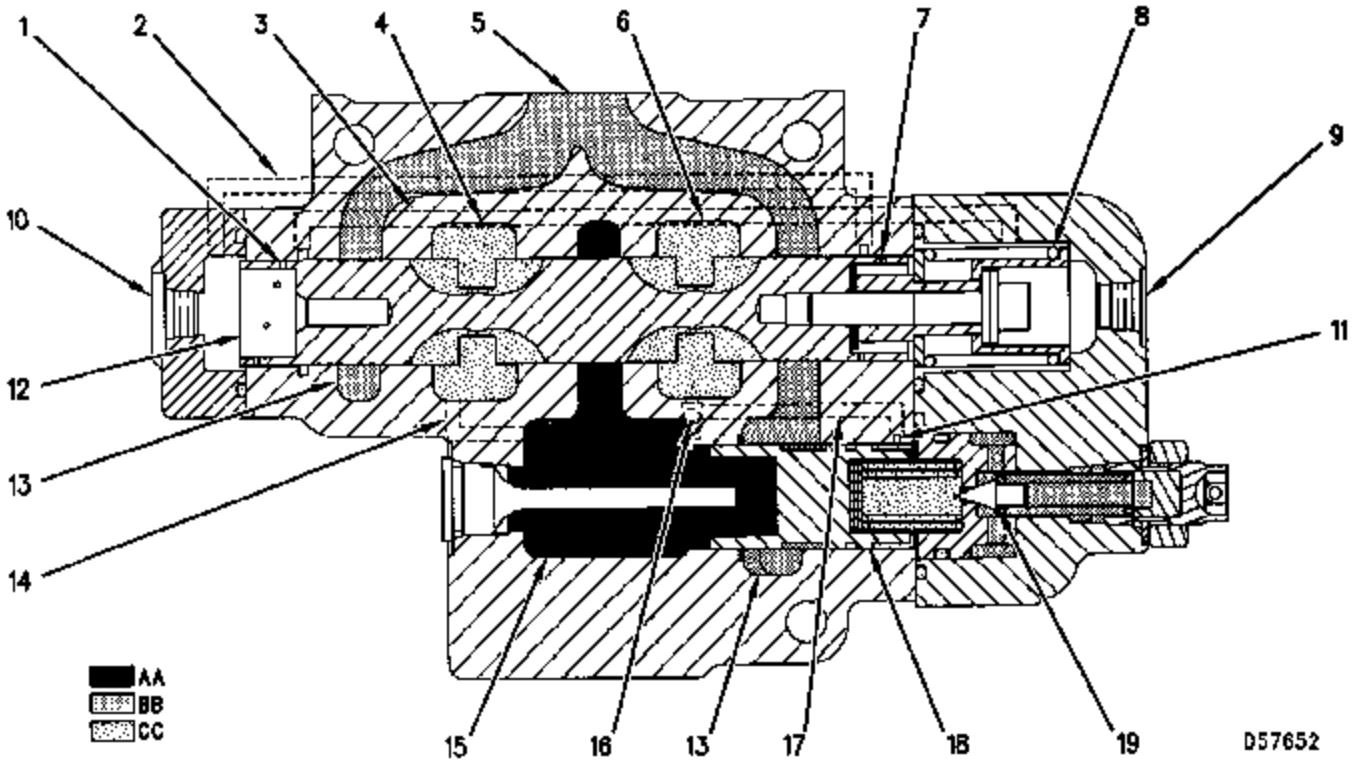
The steering pump sends the oil to steering control valve (6). Oil flows through valve spool (8) in steering control valve (6) to steering cylinders (4) and (5). The oil returning from the cylinders flows through the control valve to oil cooler (1). Then the oil flows through oil cooler (1) and returns to the hydraulic tank.

Bypass orifice (7) allows a small amount of oil to flow from the control valve, around the oil cooler, to the hydraulic tank.

Under normal operating oil temperature, most of the oil flows through oil cooler (1) and back to hydraulic tank (14).

Steering Control Valve

Neutral Position



Steering Control Valve In Neutral
(1) Metering orifices. (2) Passage. (3) Passage. (4) Outlet for left turn. (5) Outlet to tank. (6) Outlet for right turn. (7) Metering orifices. (8) Spring. (9) Inlet (from right neutralizer valve). (10) Inlet (from left neutralizer valve). (11) Orifice. (12) Spool. (13) Return passage. (14) Passage. (15) Inlet (from steering pump section). (16) Ball resolver valve. (17) Passage. (18) Flow control valve. (19) Relief valve. (AA) Pressure Oil. (BB) Return Oil. (CC) Blocked Oil.

The flow of pilot oil to either end of valve spool (12) is stopped when; (a) rotation of steering wheel is stopped, or (b) the neutralizer valve stops the flow after a complete turn has been made. With no pilot oil flow against either end of the valve spool, spring (8) will keep the spool in its neutral position.

When the steering control valve is in its neutral position no pilot oil flows to either inlet (9) or (10). Spring (8) centers spool (12) and blocks the oil flowing from the steering pump.

Because the oil is blocked by the spool, oil pressure increases in inlet passage (15). This pressure increase causes flow control valve (18) to move to the right. When the flow control valve moves, oil can flow through the orifices in it to outlet (5).

When the valve spool is in the neutral position, it also blocks the oil in the lines to the cylinders. This holds the machine in the turning radius it was in when steering wheel movement was stopped.

The pressure of the oil in blocked outlet (4) or (6) is felt through ball resolver valve (16) and against pilot relief valve (19). If an outside force tries to turn the machine when the valve spool is in the neutral position, the increase in pressure in outlet (4) or (6) will open relief valve (19). The pressure in the lines will not go higher than the relief valve setting [17 225 ± 340 kPa (2500 ± 50 psi)].

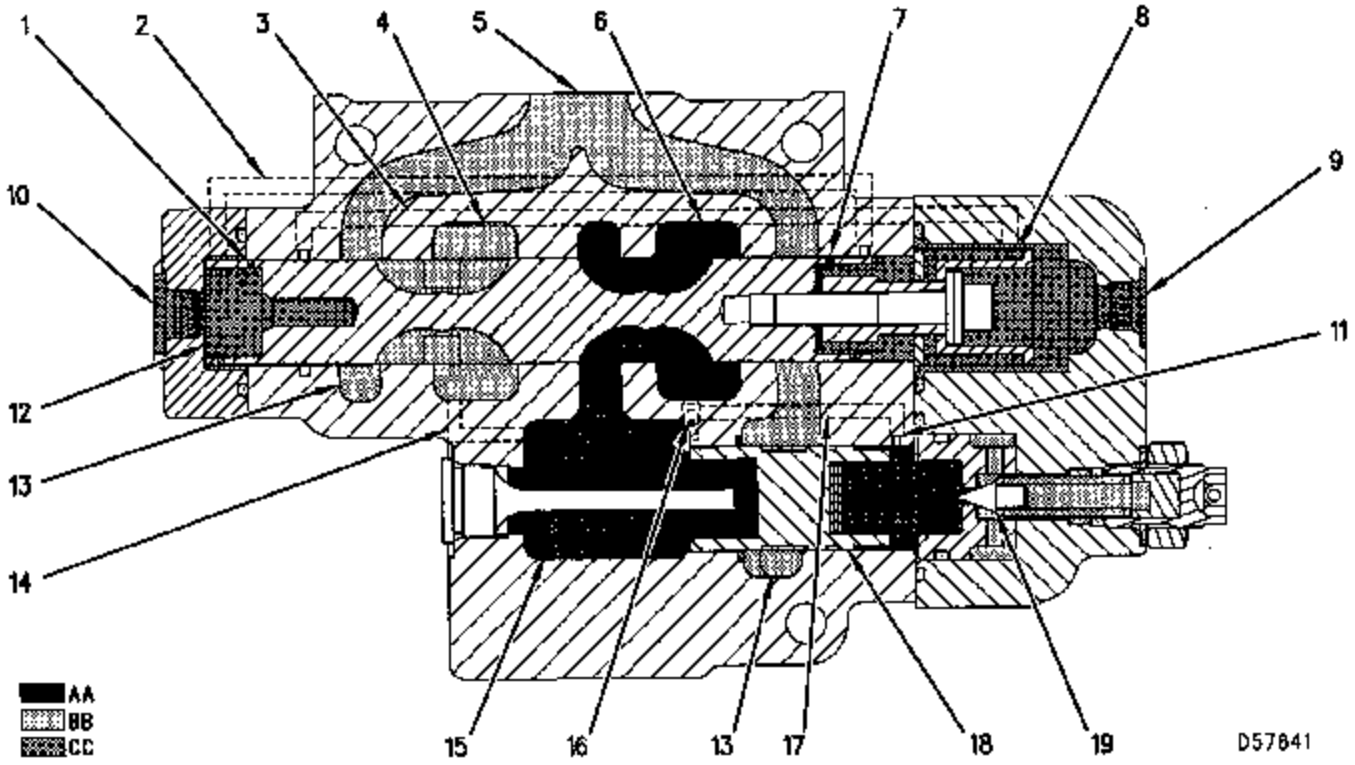
When the pilot flow to one end of the spool stops, part of the oil on that end of the spool must be removed before the valve spool can return to the neutral position. To do this, part of the oil is pushed, by the force of centering spring (8), to the opposite end of the spool. The spool can then move to its neutral position.

As an example, a left turn is made and pilot oil flows through inlet (10). The pressure of the oil from inlet (10) causes spool (12) to move to the right.

When pilot oil flow stops, part of the oil from the left end of the spool must be removed so that the spool can move to the neutral position. The force of spring (8) causes the spool to move to the left. As the spool moves, oil that is pushed from the left end of the spool flows through metering orifices (1).

The oil flows through passage (3) to the spring end of spool (12). The spool movement continues until the orifices are blocked and flow through them is stopped. This movement of the spool stops the flow of pressure oil to the steering cylinders.

Right Turn Position



Steering Control Valve In Right Turn Position
(1) Metering orifices. (2) Passage. (3) Passage. (4) Outlet for left turn. (5) Outlet to tank. (6) Outlet for right turn. (7) Metering orifices. (8) Spring. (9) Inlet (from right neutralizer valve). (10) Inlet (from left neutralizer valve). (11) Orifice. (12) Spool. (13) Return passage. (14) Passage. (15) Inlet (from steering pump). (16) Ball resolver valve. (17) Passage. (18) Flow control valve. (19) Relief valve. (AA) Pressure Oil. (BB) Return Oil. (CC) Pilot Oil.

When the steering wheel is turned to the right, pilot oil is sent through the right neutralizer valve to inlet (9). The oil flows through inlet (9) into the chamber for spring (8).

Pilot oil enters inlet (9), overcomes the force of spring (8) and causes spool (7) to move to the left. The amount of spool movement is controlled by the rotation of the steering wheel. If the steering wheel is moved slowly there will be a low volume of pilot oil and less spool movement. A slow turn is the result.

If the steering wheel is moved faster there will be a larger volume of pilot oil and more spool movement. This results in a faster turn.

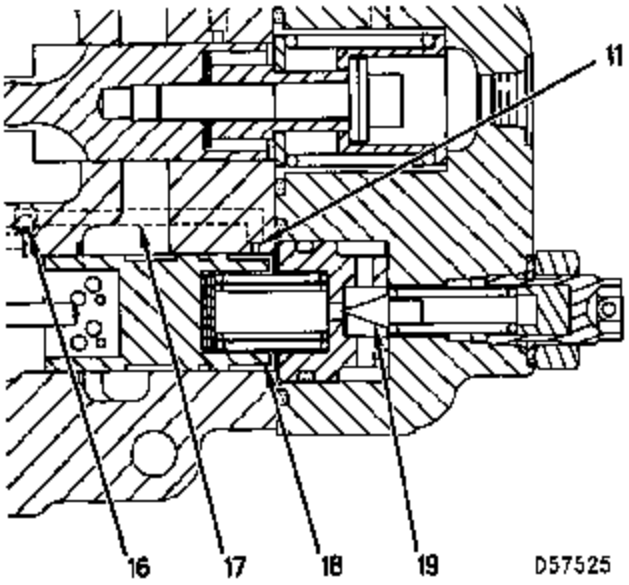
Pilot oil flows from the spring chamber across metering orifices (7). This oil flows through passage (2) to the left end of the spool. Then the oil flows through inlet passage (10), through the left neutralizer valve to the metering pump. The metering pump routes the oil back to the hydraulic tank.

With the spool moved to the left, oil from the steering pump can flow from inlet (15), through slots in the spool, into outlet (6). This oil flows to the head end of the left steering cylinder, and the rod end of the right steering cylinder.

The pressure of the oil in the cylinders extends the left cylinder rod and retracts the right cylinder rod. This causes the machine to turn to the right.

When pressure oil enters outlet (6), the pressure moves ball resolver valve (16). The pressure of the oil in the cylinders is felt through passage (17), against relief valve (19) and flow control valve (18).

If an outside force prevents the machine from turning, the pressure in outlet (6) will increase. This pressure increase is also felt against flow control valve (18) and relief valve (19).



Steering Control Valve With Relief Valve Open
(11) Orifice. (16) Ball resolver valve. (17) Passage. (18) Flow control valve. (19) Relief valve.

The pressure acts against the flow control valve and causes it to move to the left. This increases oil pressure to the cylinders. If the pressure rises above the relief valve setting, the relief valve will move to the right and open.

When the relief valve opens, oil flows through passage (17) and past the relief valve. The flow of oil past orifice (11) causes a lower pressure in the chamber for the flow control spring. This allows pressure oil in inlet passage (15) to move flow control valve (18) to the right.

Oil from inlet (15) can now flow through the holes in the flow control valve, which now acts as a dump valve. This releases the extra pressure from the circuit. When the outside force is removed and the pressure is reduced, the springs for flow control valve and relief valve return the valves to their normal positions.

Return oil from the cylinders enters outlet (4). It flows into return passage (13) and then through outlet (5).

Left Turn Position

The control valve operation for a left turn is similar to that for a right turn. Pilot oil enters inlet passage (10), overcomes the force of spring (8) and causes spool (12) to move to the right.

When the spool moves, pump oil from inlet (15) flows through the slots in the spool to outlet (4). This oil flows to the head end of the right steering cylinder and to the rod end of the left steering cylinder.

The pressure of the oil in the cylinders extends the right cylinder rod and retracts the left cylinder rod. This causes the machine to turn to the left.

When the valve spool is in the left turn position, the pressure of the oil to the cylinders is felt through passage (14) and across the ball resolver valve. This same pressure is felt through passage (17) and at relief valve (19). The remainder of the relief valve operation is the same for the left turn position and the right turn position.

Testing And Adjusting

Steering System

⚠ WARNING

Personal injury or death can result from improperly checking for a leak.

Always use a board or cardboard when checking for a leak. Escaping fluid under pressure, even a pin-hole size leak, can penetrate body tissue, causing serious injury, and possible death. If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.

⚠ WARNING

Sudden movement of the machine or release of oil under pressure can cause injury to persons on or near the machine.
To prevent possible injury, perform the procedure that follows before testing and adjusting the hydraulic system.

1. Move the machine to a smooth horizontal location. Move away from working machines and personnel. Stop the engine.
2. Permit only one operator on the machine. Keep all other personnel either away from the machine or in view of the operator.
3. Engage the parking brake. Lower the bucket to the ground. Stop the engine. Put blocks in front of and behind the wheels.
4. Push on the brake pedal many times until there is no more brake oil pressure. When the pressure has been removed from the brake circuit, there will be no pressure in the hydraulic circuit.
5. Make sure all hydraulic pressure is released before any fitting, hose or component is loosened, tightened, removed or adjusted.

When any test is made to the steering hydraulic system, the hydraulic oil must be at the normal temperature for operation. To increase the oil temperature, start the engine, lift the implement and turn the machine in both directions.

Visual Checks

The 8T-5320 and 4C-4890 Hydraulic Test Groups, or 1U-5481 Pressure Gauge Group are used to make the pressure tests of the steering system. Before any tests are made, visually inspect the complete steering system for leakage of oil and for parts that have damage. For some of the tests, a magnet and a measuring rule (either for inches or millimeters) are usable tools.

Visual checks and measurements are the first step when troubleshooting a possible problem. Then perform the operation checks and last the instrument tests. Lower the implement to the ground and stop the engine. To remove the hydraulic tank fill cap, slowly turn the fill cap until it is loose. If oil comes out, allow the tank pressure to lower before the fill cap is removed.

Before any operation checks are made to the steering system, visually inspect the complete system as follows:

1. Measure the oil level.
2. Check for cracks or wear in hoses and lines.
3. Check for restriction of flow; like sharp bends, clamps that are not installed correctly, and damage to hoses and lines.
4. Check for loose connections.
5. Check for damage to components.

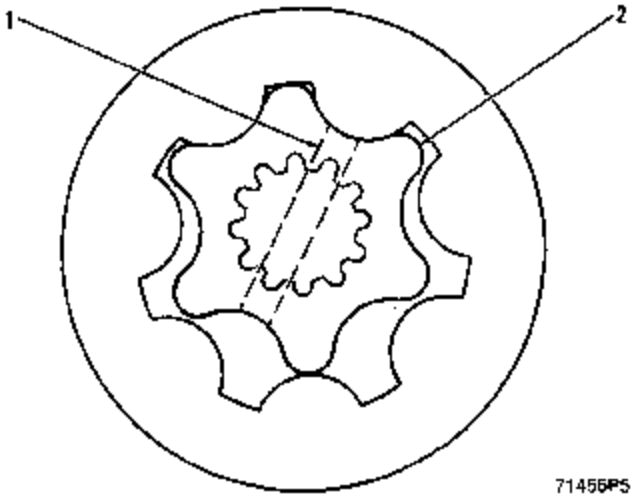
Performance Tests

Performance tests of the steering system can be used for a diagnosis of poor performance and to find the source of internal and external oil leakage in the hydraulic system.

Problem: Steering wheel is hard to turn.

Probable Cause:

1. Oil is cold.
2. Restriction in metering pump pilot lines.
3. Pilot lines to metering pump are not connected to proper ports
4. Steering pump pressure is low.
5. Bolts are too tight for metering section of metering pump.



Timing Of Metering Pump Drive
(1) Pin. (2) Internal pump gear.

6. Timing of metering pump drive is not correct [pin (1) must align with valley of internal pump gear (2)].

Problem: Steering wheel is hard to turn when steering quickly away from a full turn.

Probable Cause:

Not enough clearance between ball check and plug assembly in neutralizer valve.

Problem: Steering wheel can be turned when the machine is at full turn.

Probable Cause:

1. Adjustment of striker (stud assembly) for neutralizer valve is not correct.
2. Seat for the neutralizer ball check has a defect.
3. Relief valve opens before striker moves the neutralizer valve stem.

Problem: Machine does not turn smoothly.

Probable Cause:

Flow control valve does not move freely.

Problem: Machine turns too slow in both directions.

Probable Cause:

1. Springs for flow control valve are not adjusted correctly.
2. Not enough flow from primary steering pump section.
3. Main control spool does not move all the way.

Problem: Machine turns too slow in one direction.

Probable Cause:

Flow balance adjustment of main control spool is not correct. (See Steering Time Check in Testing and Adjusting).

Problem: Machine turns correctly when moving, but is slow in both directions when the machine turns against a load (high resistance).

Probable Cause:

1. Leakage past relief valve seat or seals.
2. Leakage past both ball resolver seats.
3. The fit of the flow control valve in the bore is not correct.

Problem: Machine turns correctly when moving, but is slow in one direction when the machine turns against a load (high resistance).

Probable Cause:

1. Right turn: leakage past upper ball resolver seat or seal.
2. Left turn: leakage past lower ball resolver seat or seal.

Problem: Machine does not turn when steering wheel is turned.

Probable Cause:

1. Flow control valve will not move from the open position.
2. A defect in the pilot relief valve or seat.
3. Failure of the seal around the seat for the pilot relief valve at higher system pressures.

NOTE: Some steering "slip" is normal. See Steering Slip Check in Testing and Adjusting.

Problem: Machine turns by itself (operator does not turn the steering wheel).

Probable Cause:

1. Spool in steering valve does not return to neutral correctly.
2. The mounting bolts for the steering control valve are too tight.
3. The bolts are too tight for the end covers of the steering control valve.
4. Manufacturing tolerances on spool in steering control valve do not permit spool to go back to neutral.

NOTE: This may be corrected by turning the spool in steering control valve around in its bore (turn end for end). To do this, the spring, retainer, and shims must be installed on the opposite end of the spool. An adjustment may be necessary for the steering times.

5. Steering wheel turns without operator turning it.
   a. Foreign material causes sleeve valves in metering pump to stick.
   b. Metering pump centering (leaf) springs are broken or damaged.

Problem: Machine turns too fast to make small steering corrections when the machine moves at fast speeds.

Probable Cause:

1. Flow control valve adjustment is not correct. (See Steering Time Check in Testing and Adjusting).
2. Main control spool does not move freely.
3. Metering orifices on main control spool are filled with foreign material or were not drilled correctly.

Problem: Pump makes noise and the steering cylinder rod does not move smoothly.

Probable Cause:

1. Air in the steering hydraulic circuit.
2. The pump has too much wear.
3. Loose connection of the oil line on the inlet side of the pump.
4. The viscosity of the oil is incorrect.
5. The relief valve opens at a low pressure.
6. The oil level in the tank is low.

Pump Efficiency Check

For any pump test at a given rpm, the pump flow at 690 kPa (100 psi) will be larger than the pump flow at 6900 kPa (1000 psi). The difference between the pump flow of the two operating pressures is the flow loss.

Method of finding flow loss:

Pump flow at 100 psi	57.5 gpm (liter/min)*
Pump flow at 1000 psi	−52.0 gpm (liter/min)*
Flow loss.....	5.5 gpm (liter/min)*

Flow loss when expressed as a percent of pump flow is used as a measure of pump performance.

Example of finding percent of flow loss:

$$\frac{\text{gpm flow loss}}{\text{Pump flow @ 100 psi}} \times 100 = \text{Percent of flow loss}$$

$$\text{or } \frac{*5.5}{*57.5} \times 100 = 9.5\%$$

If the percent of flow loss is more than 10%, pump performance is not good enough.

*Numbers in examples are for illustration and are not values for any specific pump or pump condition. See Specifications for pump flow of a new pump at 690 kPa (100 psi) and 6900 kPa (1000 psi).

Machine Test

Install a Flow Meter. For Formula I, measure pump flow at 690 kPa (100 psi) and at 6900 kPa (1000 psi) with the engine at high idle rpm.

Formula I:

$$\frac{\text{gpm @ 100 psi} - \text{gpm @ 1000 psi}}{\text{gpm @ 100 psi}} \times 100 = \text{Percent of flow loss}$$

Bench Test

If the test bench can be run at 6900 kPa (1000 psi) and at full pump rpm, find the percent of flow loss using Formula I.

If the test bench cannot be run at 6900 kPa (1000 psi) and at full pump rpm, run the pump shaft at 1000 rpm. Measure the pump flow at 690 kPa (100 psi) and at 6900 kPa (1000 psi). Use these values in the top part of Formula II. For the bottom part of the formula, run the pump shaft at 2000 rpm. Measure the pump flow at 690 kPa (100 psi).

Formula II:

$$\frac{\text{gpm @ 100 psi} - \text{gpm @ 1000 psi}}{\text{gpm @ 100 psi @ 2000 rpm}} \times 100 = \text{Percent of flow loss}$$

Steering Force Check

Check the force needed to turn the steering wheel very slowly.

(a) Torque to turn the steering wheel when the engine is stopped ..... 4.0 to 4.5 N•m (35 to 40 lb in)

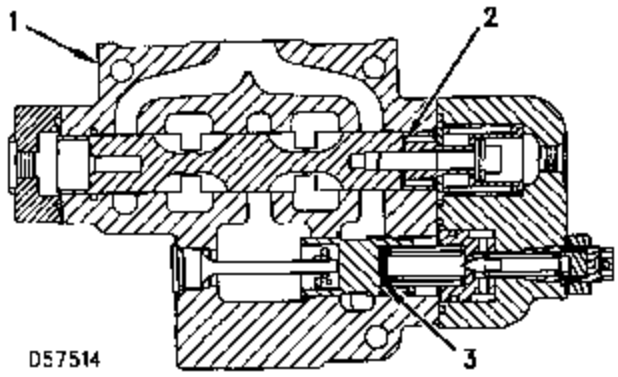
(b) Torque to turn the steering wheel when the engine is at low idle ..... 2.3 to 2.8 N•m (20 to 25 lb in)

Steering Time Check

To check the steering time, put the machine on a dry, hard surface. With the engine at high idle, the time for a full turn, from stop to stop, must not be more than 2.8 ± .3 seconds.

The difference between the time for a right turn and the time for a left turn must not be more than .3 second. With the brakes activated, the time must not increase more than .2 second.

If the difference between the times for a full right turn and a full left turn is more than .3 second:



Steering Control Valve
(1) Control valve. (2) Flow balance shims. (3) Cylinder flow shims.

1. Remove the end cover from steering control valve (1).
2. Add flow balance shims (2) to decrease the right turn time (steer faster) and increase the left turn time (steer slower). If the flow balance shims are removed, the result is opposite.
3. Shims (2) are available in two thicknesses.
   5J4776 Shims are 0.13 mm (.005 in) thick. Two 5J4776 Shims will change the steering time high idle by approximately .05 second. 4J8224 Shims are 0.25 mm (.010 in) thick. Two 4J8224 Shims will change the steering time at high idle by approximately .1 second.

Example: A check of the steering times shows that the right turn time is .4 second more than the left turn time. Shims (2) must be added to decrease the difference between the times. The addition of four 4J8224 Shims will decrease the right turn time by approximately .2 second and increase the left turn time approximately .2 second. This will make the right and left turn times approximately the same.

4. Replace the end cover on the control valve.

If both steering times (right and left) are slow, cylinder flow shims (3) must be added.

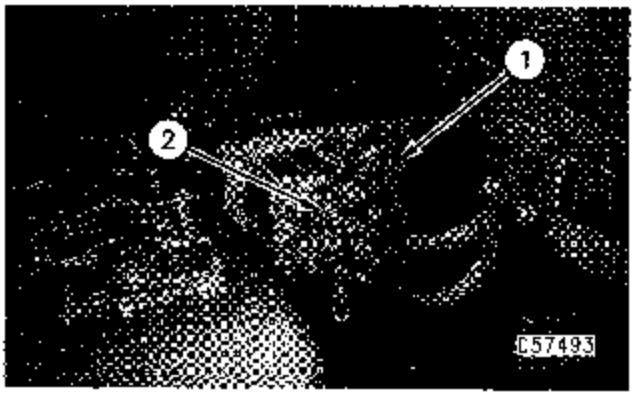
4J6806 Shim thickness ..... 1.22 mm (.048 in)
One shim will change the steering times at high idle by approximately .1 second.

Steering System Pressure Test

⚠ WARNING

To prevent personal injury, make reference to WARNING on first page of Testing And Adjusting section.

Main Relief Valve



Steering Control Valve
(1) Steering system pressure Tap. (2) Steering relief valve adjustment screw.

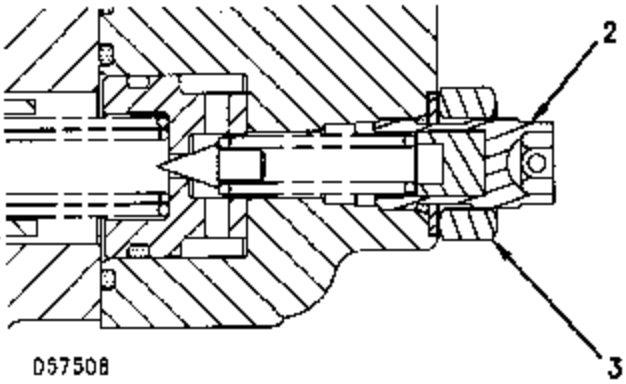
Steering Frame Lock Link Installed

1. Install the steering frame lock link so the machine can not turn.

2. Assemble the necessary hoses and install a pressure gauge (0 to 28 000 kPa or 0 to 4000 psi) to pressure tap (1).

3. Start the engine and operate it at high idle.

4. Turn the steering wheel in both directions until the relief valve opens. Note the indication on the gauge. The correct relief pressure setting is 17 225 ± 340 kPa (2500 ± 50 psi).



Steering Control Valve
(2) Adjustment screw. (3) Locknut.

5. If the pressure is not the same in both directions, there is a problem in the shuttle valve. If the pressure is the same in both directions, but the pressure is not correct, adjust the main relief valve.

6. Stop the engine.

7. Loosen locknut (3).

8. Turn adjustment screw (2) clockwise to increase the pressure setting or turn counterclockwise to decrease the pressure setting. Tighten the locknut.

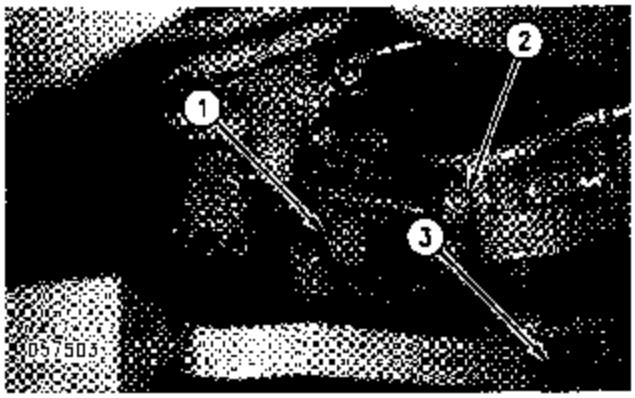
9. Start the engine and operate it at high idle.

10. Turn the steering wheel in both directions until the relief valve opens. Note the indication on the gauge. The correct relief pressure setting is 17 225 ± 340 kPa (2500 ± 50 psi).

11. After correct pressure setting is made, stop the engine. Remove the pressure gauge from the pressure tap.

12. Remove the steering frame lock link.

Neutralizer Valve



Neutralizer Valve
(1) Striker. (2) Neutralizer valve. (3) Front frame upper hitch.

To check the adjustment of striker (1):

1. Put a 12.7 mm (.50 in) ball of putty (or similar material) on front frame upper hitch at position (3).
2. Start the engine and operate it at high idle.
3. Raise an the implement about 305 mm (12 in) and release the brakes.
4. With the engine at high idle, steer rapidly into both stops.
5. Stop the engine. Engage the parking brake.
6. Thickness of the putty must be 6.4 ± 3.0 mm (.25 ± .12 in) after the turns. This is the clearance between the frame stops when a full turn is made.
7. If the clearance is not correct adjust the strikers until the dimension is correct.
8. Repeat steps 1 through 6 until correct clearance is obtained.

CATERPILLAR®

SENR1313
February 1996

Specifications

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Brake System

814F	815F	816F
9DM1-UP	1GN1-UP	5FN1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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Introduction

When the words "use again" are in the description, the specification given can be used to determine if a part can be used again. If the part is equal to or within the specification given, use the part again.

When the word "permissible" is in the description, the specification given is the "maximum or minimum" tolerance permitted before adjustment, repair and/or new parts are needed.

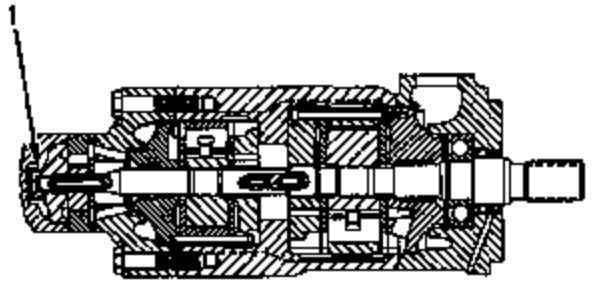
A comparison can be made between the measurements of a worn part and the specifications of a new part to find the amount of wear. A part that is worn can be used again if an estimate of the remainder of its service life is good. If a short service life is expected, replace the part.

Reference: For Systems Operation and Testing and Adjusting, make reference to SENR1314, 814F Wheel Tractor, 815F Soil Compactor, & 816F Landfill Compactor Brake System.

Specifications

814F & 816F Implement, Steering And Pilot Systems Hydraulic Pump

121-3409



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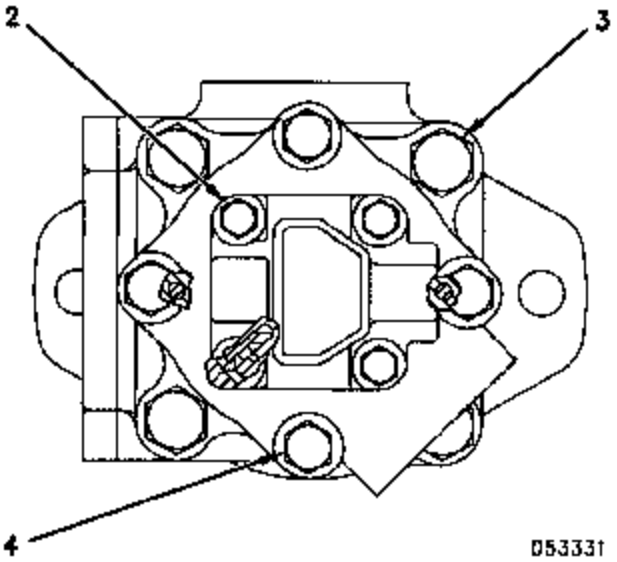


D53331

Rotation is counterclockwise when seen from drive end.

Type of pump: Vane

For test, use SAE 10W oil at 65°C (150°F).

(1) 1U-2816 Spring:
- Length under test force ..... 14.7 mm (.579 in)
- Test force ..... 192 ± 14 N (43.1 ± 3.1 lb)
- Free length after test ..... 29.7 mm (1.170 in)
- Outside diameter ..... 29.65 ± 0.52 mm (1.167 ± .020 in)

(2) Torque for four bolts ..... 55 ± 7 N•m (40 ± 5 lb ft)

(3) Torque for four bolts ..... 203 ± 14 N•m (150 ± 10 lb ft)

(4) Torque for four bolts ..... 95 ± 7 N•m (70 ± 5 lb ft)

Drive End Section (Steering)

Test at Full Speed:

Output ..... 144 liter/min (38 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Output ..... 130 liter/min (34 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 72 liter/min (19 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Output ..... 65 liter/min (17 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Center Section (Implement)

Test at Full Speed:

Output ..... 112 liter/min (29 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Output ..... 101 liter/min (26 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 56 liter/min (15 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Output ..... 50 liter/min (13 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Cover End Section (Pilot)

Test at Full Speed:

Output ..... 24 liter/min (6.5 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 21 liter/min (5.5 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

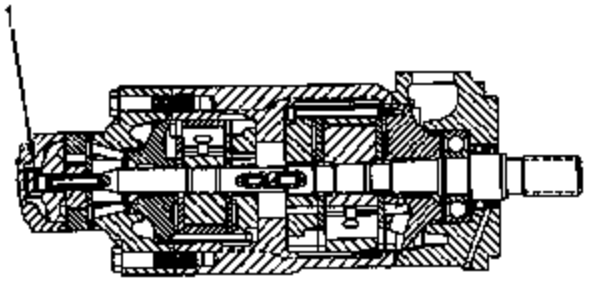
Output ..... 12 liter/min (3 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 10 liter/min (2.6 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

NOTE: Discharge and drain flows must be feed together to measure flow correctly.

815F Implement, Steering And Pilot Systems Hydraulic Pump

123-6765



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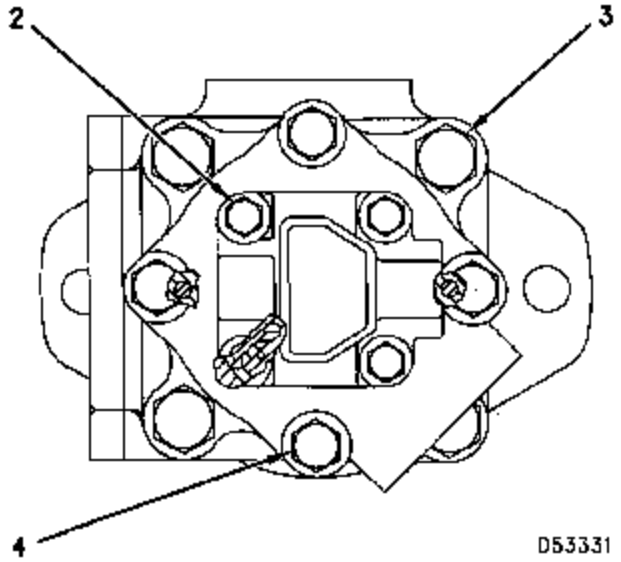


D53331

Rotation is counterclockwise when seen from drive end.

Type of pump: Vane

For test, use SAE 10W oil at 65°C (150°F).

(1) 1U-2816 Spring:
Length under test force ..... 14.7 mm (.579 in)
Test force ..... 192 ± 14 N (43.1 ± 3.1 lb)
Free length after test ..... 29.7 mm (1.170 in)
Outside diameter ..... 29.65 ± 0.52 mm (1.167 ± .020 in)

(2) Torque for four bolts ..... 55 ± 7 N•m (40 ± 5 lb ft)

(3) Torque for four bolts ..... 203 ± 14 N•m (150 ± 10 lb ft)

(4) Torque for four bolts ..... 95 ± 7 N•m (70 ± 5 lb ft)

Drive End Section (Steering)

Test at Full Speed:

Output ..... 144 liter/min (38 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 130 liter/min (34 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 72 liter/min (19 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 65 liter/min (17 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Center Section (Implement)

Test at Full Speed:

Output ..... 76 liter/min (20 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 68 liter/min (18 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 38 liter/min (10 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 34 liter/min (9 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Cover End Section (Pilot)

Test at Full Speed:

Output ..... 24 liter/min (6.5 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 21 liter/min (5.5 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

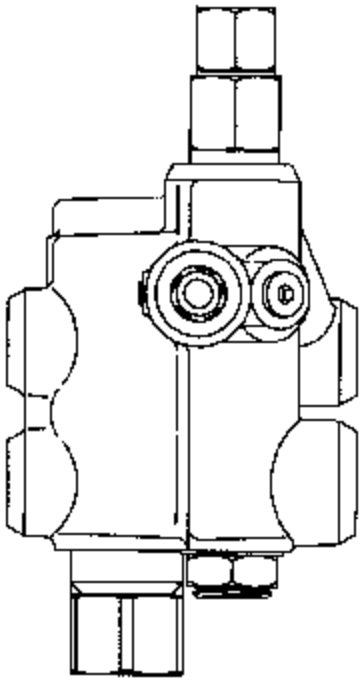
Output ..... 12 liter/min (3 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 10 liter/min (2.6 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

NOTE: Discharge and drain flows must be teed together to measure flow correctly.

Accumulator Charging Valve

8R-5603



D40181

Accumulator charging limits:
Cut-in ..... 11 725 ± 345 kPa (1700 ± 50 psi)
Cutout ..... 14 485 ± 345 kPa (2100 ± 50 psi)

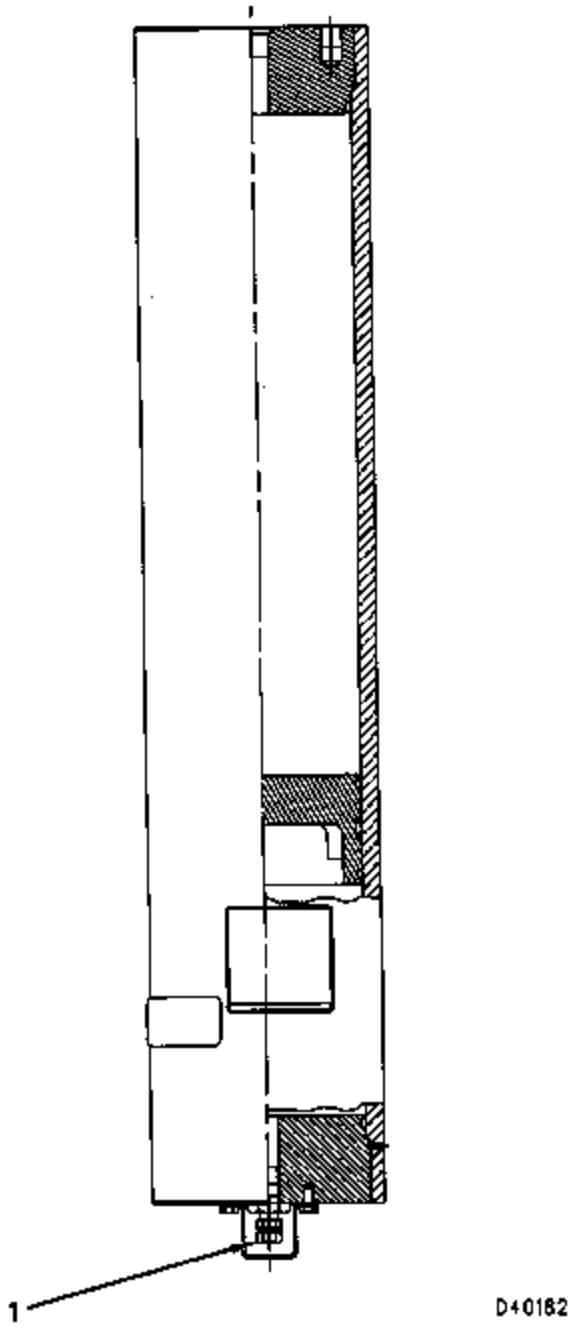
Standby pressure ..... 2900 ± 140 kPa (420 ± 20 psi)

Relief valve pressure set at ..... 16 550 ± 690 kPa (2400 ± 100 psi)

Accumulator charge rate ..... 15.1 L/min (4.00 U.S. gpm) at 6900 kPa (1000 psi)

Accumulators

114-1151



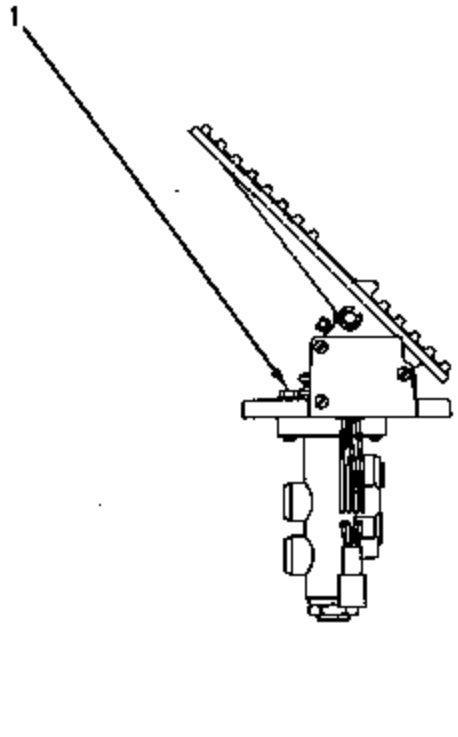
Pressure of nitrogen (precharge) ..... 6890 kPa (1000 psi)

Internal volume of gas compartment ..... 0.615 L (.7 qt)

(1) Tighten cap to a torque of ..... 1.6 ± 0.1 N•m (14.16 ± .88 lb in)

Service Brake Control Group

106-4842

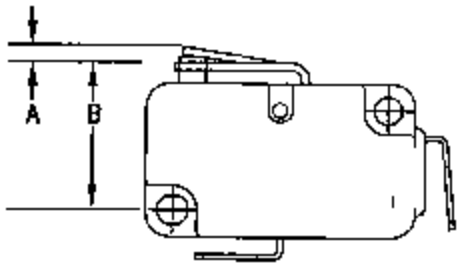


(1) Tightening torque for two bolts ..... 30 ± 5 N•m (22 ± 4 lb ft)

Output pressure of top brake port is approximately 350 kPa (50 psi) higher than output of bottom port. Both brake ports (not shown in this view) are located on the back side of the valve.

Transmission Neutralizer Switch

105-6117



D56900

Contacts normally closed

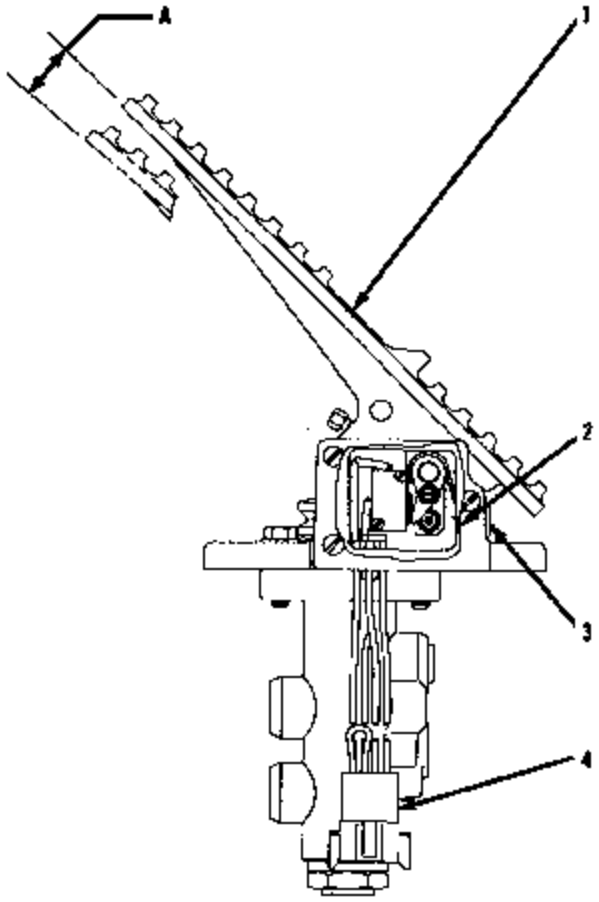
Actuating force ..... 1.16 N (.261 lb)

Maximum pretravel dimension (A) ..... 1.52 mm (.060 in)

Operating dimension (B) .... 15.24 ± 0.51 mm (.600 ± .020 in)

Minimum overtravel ..... 0.89 mm (.035 in)

Neutralizer Switch Assembly Adjustment



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NOTE: The adjustment for the neutralizer switch assembly has been correctly preset at assembly. However, the following procedure should be used if the switch assembly requires service.

NOTE: Both the neutralizer switch assembly and the stop lamp switch assembly are positioned immediately next to each other in the left pedal assembly. Both switch assemblies share the same mounting screws and therefore, both switch assemblies must be installed when making an adjustment to either switch. The neutralizer switch assembly is located toward the center of the pedal assembly.

1. Disconnect receptacle assembly (4) from the attached wire harness assembly (not shown).
2. Connect an ohmmeter (or continuity tester) to Pin 5 and Pin 6 of receptacle assembly (4). With pedal assembly (1) in the retracted position (fully released), the ohmmeter should indicate a closed (shorted) circuit condition.
3. With pedal assembly (1) in the retracted position (fully released), depress the pedal assembly until dimension (A) is obtained. Dimension (A) equals approximately 6.0 mm (.24 in).

4. The ohmmeter should now indicate an open (infinite) circuit condition, and an audible "click" should be heard which indicates the switch has been actuated.

NOTE: Do NOT make the mistake of only listening for the audible "click" sound because both the transmission neutralizer and stop lamp switch assemblies make the same sound, and should be set to actuate at approximately the same time.

If the previous steps do not indicate an open circuit, proceed with the following steps.

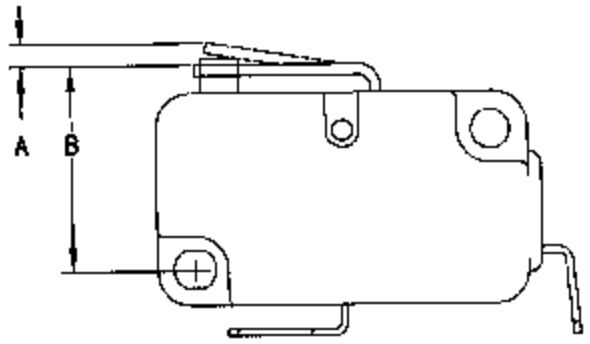
5. Remove plug (3), and insert a 3.18 mm (.125 in) hex wrench in screw (2).
6. Rotate the wrench in one-quarter turn increments and repeat Steps 3 and 4 until the desired result is obtained.

NOTE: Rotating screw (2) clockwise increases the value of dimension (A). Rotating screw (2) counterclockwise decreases the value of dimension (A).

7. Install plug (3).

Stop Lamp Limit Switch

105-6118



040741

Normally open contacts

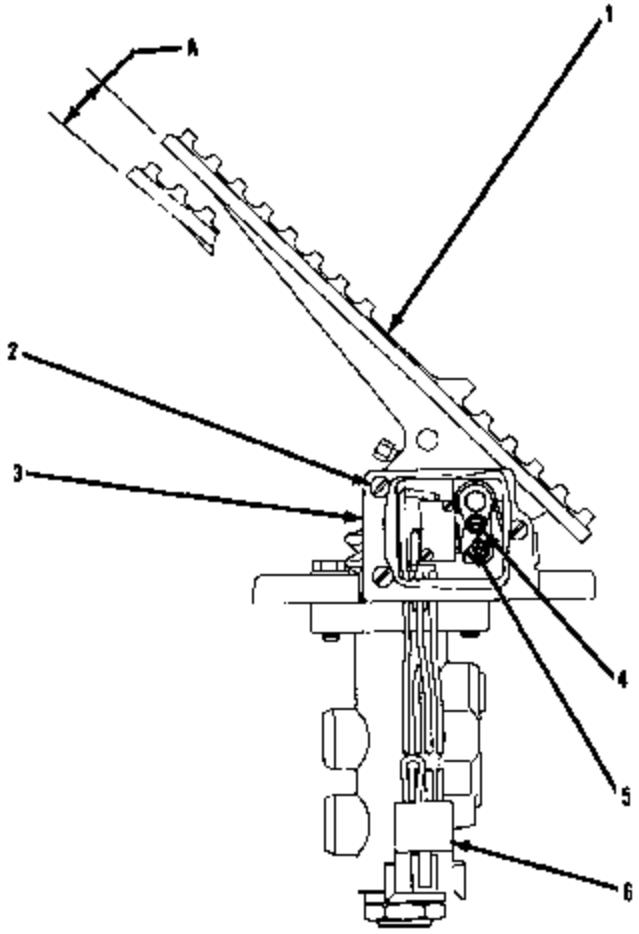
Actuating force ..... 1.16 N (.261 lb)

Maximum pretravel distance equals dimension (A). Dimension (A) equals ..... 1.52 mm (.060 in)

Operating position distance equals dimension (B). Dimension (B) equals ..... 15.24 ± 0.51 mm (.600 ± .020 in)

Minimum over-travel equals ..... 0.89 mm (.035 in)

Stop Lamp Limit Switch Adjustment



C57349P2

NOTE: The adjustment for the stop lamp switch assembly has been correctly preset at assembly. However, the following procedure should be used if the switch assembly requires service.

NOTE: Both the neutralizer switch assembly and the stop lamp switch assembly are positioned immediately next to each other in the left pedal assembly. Both switch assemblies share the same mounting screws and therefore, both switch assemblies must be installed when making an adjustment to either switch. The stop lamp switch assembly is located near cover (3).

1. Disconnect receptacle assembly (6) from the wire harness assembly.
2. Connect an ohmmeter (or continuity tester) to Pin 7 and Pin 8 of receptacle assembly (6). With pedal assembly (1) in the retracted position (fully released), the ohmmeter should indicate an open (infinite) circuit condition.
3. With pedal assembly (1) in the retracted position (fully released), depress the pedal assembly until dimension (A) is obtained. Dimension (A) equals approximately 6.0 mm (.24 in).

4. The ohmmeter should now indicate a closed (shorted) circuit condition, and an audible "click" should be heard which indicates the switch has been actuated.

NOTE: Do NOT make the mistake of only listening for the audible "click" sound because both the transmission neutralizer and stop lamp switch assemblies make the same sound, and should be set to actuate at approximately the same time.

If the previous steps do not indicate a closed circuit, proceed with the following steps.

5. Remove three screws (2) and cover (3).
6. Loosen screw (4) and rotate cam (5) approximately one-half degree, and retighten screw (4).

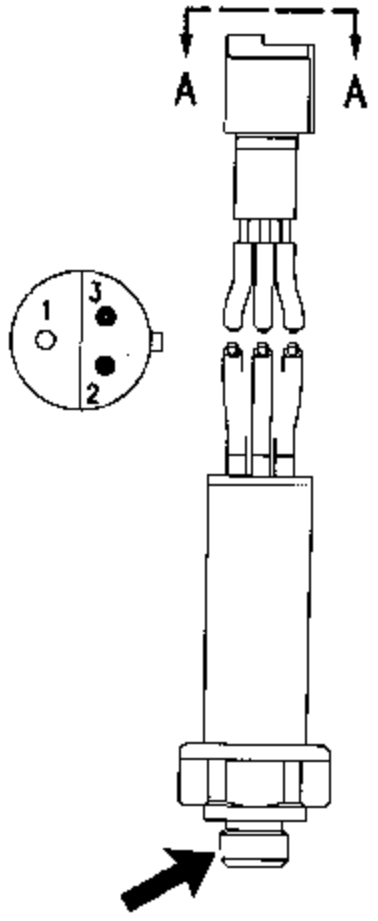
NOTE: Rotating cam (5) clockwise increases dimension (A). Rotating cam (5) counterclockwise decreases dimension (A).

7. Repeat Steps 3, 4, and 6, until the desired result is obtained.
8. Replace cover (3) and three screws (2).

Hydraulic Pressure Switches

Parking Brake Switch Assembly

9W-2653



Actuation pressure at −40 to +121°C (−40° to +250°F) ..... 8270 kPa (1200 psi) maximum

Deactuation pressure at −40 to +121°C (−40° to +250°F) ..... 6890 ± 345 kPa (1000 ± 50 psi)

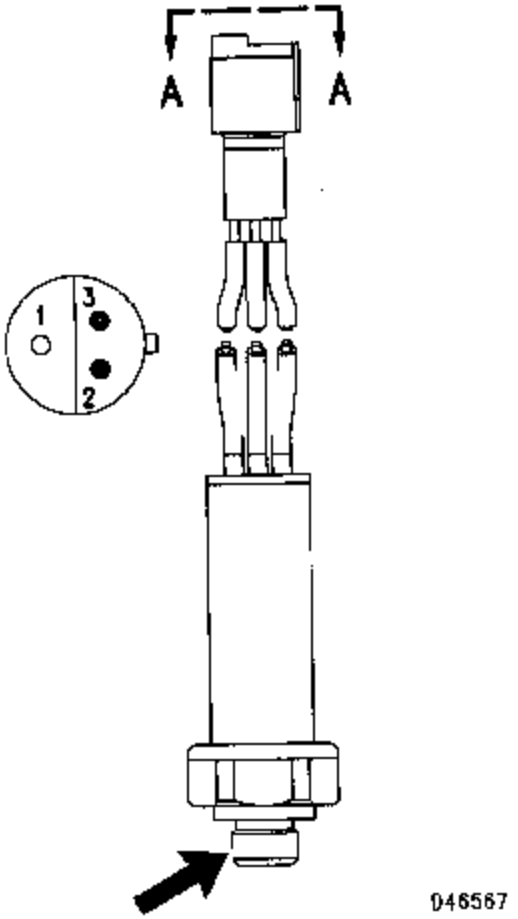
Contacts 1 and 2 normally open below deactuation pressure

Contacts 1 and 3 normally closed below deactuation pressure

Tightening torque to install switch .... 35 ± 3 N•m (25 ± 2 lb ft)

Low Brake Pressure Switch Assembly

9X-9643



Actuation pressure at −40 to +121°C (−40° to +250°F) ..... 10 700 kPa (1555 psi) maximum

Deactuation pressure at −40 to +121°C (−40°to +250°F) ..... 8960 ± 345 kPa (1300 ± 50 psi)

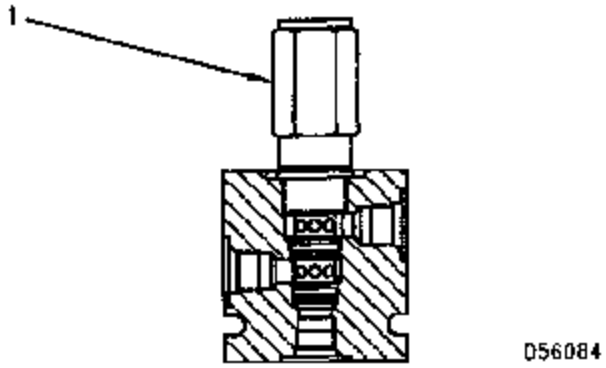
Contacts 1 and 2 normally open below 8600 kPa (1250 psi)

Contacts 1 and 3 normally closed below 8600 kPa (1250 psi)

Tightening torque to install switch .... 40 ± 5 N•m (30 ± 4 lb ft)

Pressure Reducing Valve

9U-3346



(1) Torque for valve to body ..... 50 ± 3 N•m (37 ± 2 lb ft)

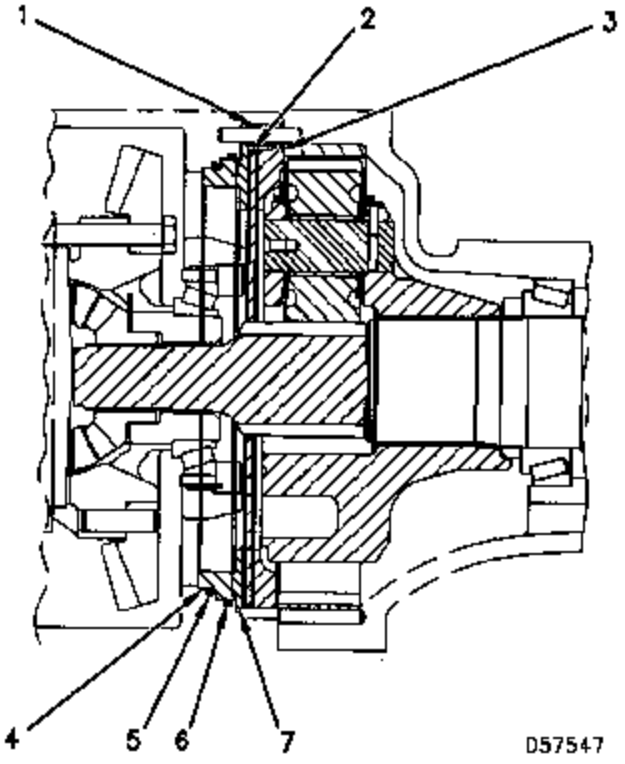
Output ..... 11.4 liter/min (3 U.S. gpm)

At a reduced pressure of ..... 2410 ± 140 kPa (350 ± 20 psi)

814F, 815F, 816F Service (Wheel) Brake Group

Front Axle Brakes

9U-2788



(1) 8R-0923 Spring for disengaging service brake:
Length under test force ..... 27.3 mm (1.07 in)
Test force ..... 334.8 N (75.24 lb)
Free length after test ..... 37.24 mm (1.466 in)
Outside diameter ..... 21.84 mm (.860 in)

(2) Thickness of new 6I-8030 Friction Disc ..... 9.10 ± 0.13 mm (.358 ± .005 in)
Minimum average permissible friction material thickness ..... 7.65 mm (.301 in)
Minimum depth of oil groove ..... 0.32 mm (.012 in)

(3) Thickness of new 8R-0942 plate ..... 23.37 mm (.920 in)

(4) Thickness of new 100-3596 piston ..... 33 mm (1.6 in)

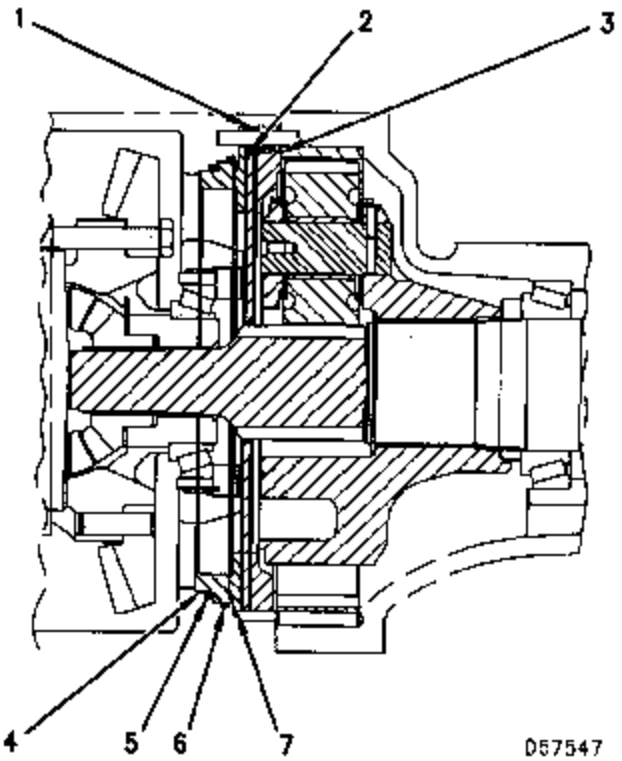
(7) Thickness of new 100-3597 plate ..... 10 mm (.393 in)

Note: When brake service is required, replace friction disc (2) and piston o-ring seals (5) and (6). Lubricate plates (3,7) and disc (2).

814F Service (Wheel) Brake Group

Rear Axle Brakes

9C-8185



(1) 8R-0923 Spring for disengaging service brake:
Length under test force ..... 27.3 mm (1.07 in)
Test force ..... 334.8 N (75.24 lb)
Free length after test ..... 37.24 mm (1.466 in)
Outside diameter ..... 21.84 mm (.860 in)

(2) Thickness of new 6I-8030 Friction Disc ..... 9.10 ± 0.13 mm (.358 ± .005 in)
Minimum average permissible friction material thickness ..... 7.65 mm (.301 in)
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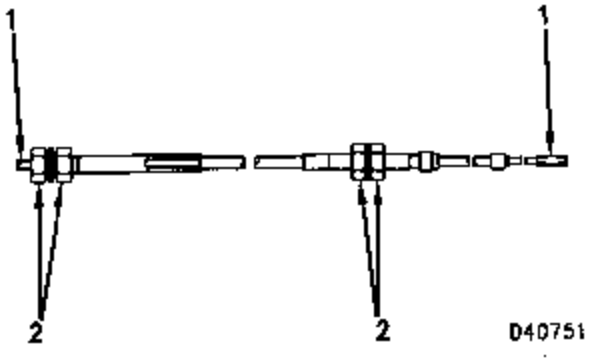
(4) Thickness of new 100-3596 piston ..... 33 mm (1.6 in)

(7) Thickness of new 100-3597 plate ..... 10 mm (.393 in)

Note: When brake service is required, replace friction disc (2) and piston o-ring seals (5) and (6). Lubricate plates (3,7) and disc (2).

Parking Brake Control Cable

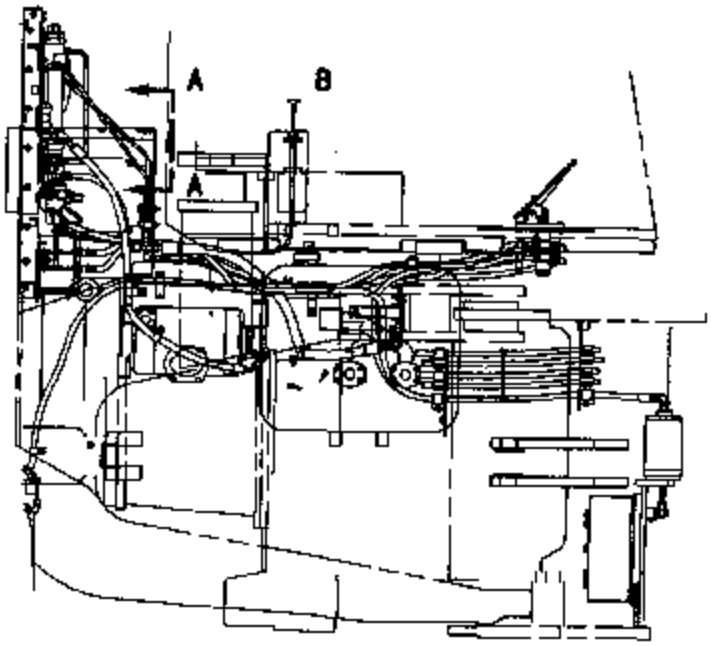
108-8100



(1) Final installation tightening torque for nuts or fittings (both ends) ..... 8 ± 3 N•m (6 ± 2 lb ft)

(2) Final installation tightening torque ..... 38 ± 7 N•m (28 ± 5 lb ft)

NOTE: Bulkhead nuts must clear the seals without causing damage to the seals.



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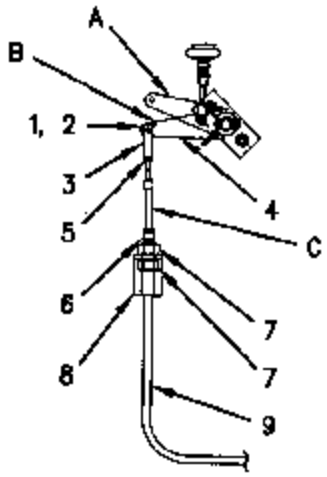

A–A

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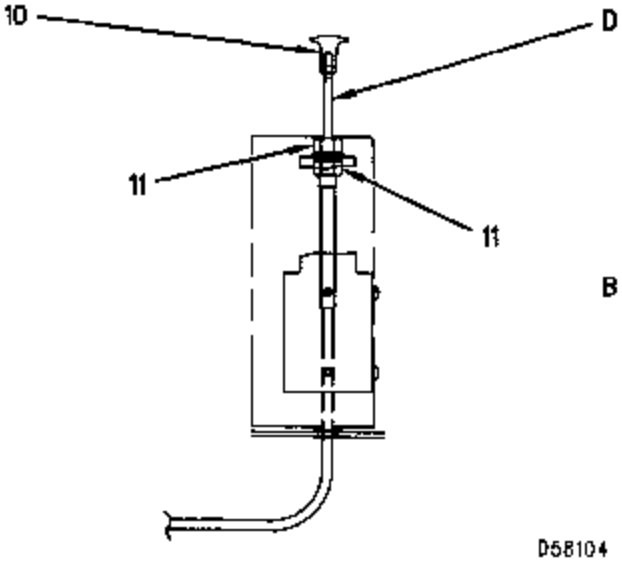


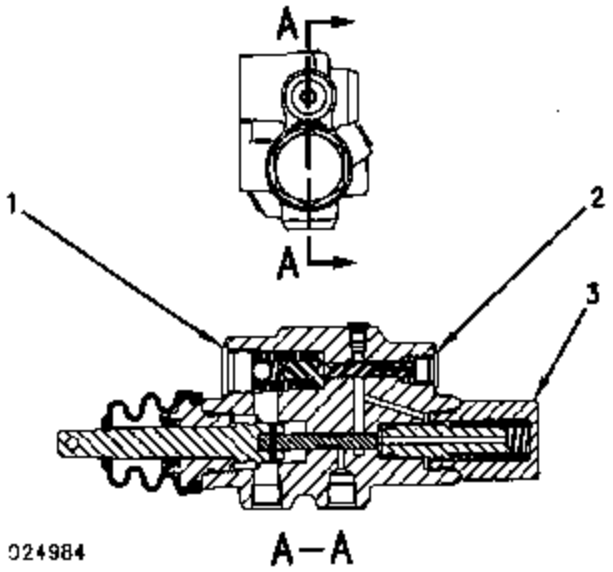
B

D58104

1. Center parking brake cable assembly bulkhead (6) on swivel end (C) of cable, on firewall bracket (8). Tighten bulkhead nuts (7) to a torque of 38 ± 7 N•m (28 ± 5 lb ft).
2. Extend cable completely to end (D), and maintain cable assembly in this position during Steps 3 and 4. Tighten nuts (11) to a torque of 38 ± 7 N•m (28 ± 5 lb ft).
3. With the parking brake valve and linkage in the brake ENGAGED position (A), thread rod end (3) onto cable end (C) until the hole in rod end (3) is in aligned with the hole in lever assembly (4).
4. Thread rod end (3) onto cable assembly (9) towards end (D) an additional ten full turns approximately 8.0 mm (.31 in).
5. If necessary, reposition cable bulkhead (6) on firewall bracket (8) to achieve the correct positioning of rod end (3) as described in Step 3.
6. Tighten jamnut (5) onto rod end (3) to a torque of 8 ± 3 N•m (6 ± 2 lb ft).
7. Install clevis pin (1) and cotter (2). Install knob (10).

Parking Brake Control Valve

100-8941



NOTE: Valve shown in the brake ENGAGED position.

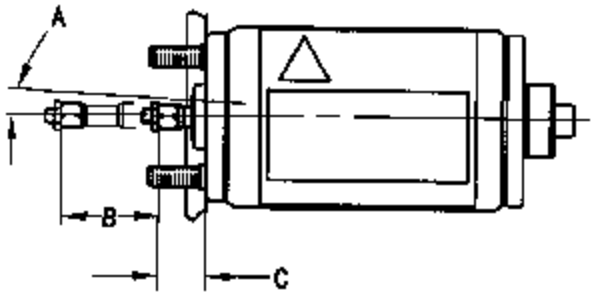
(1) Tighten plug to a torque of ..... 50 ± 7 N•m (37 ± 5 lb ft)

(2) Tighten plug to a torque of ..... 75 ± 7 N•m (55 ± 5 lb ft)

(3) Tighten end cap to a torque of ..... 75 ± 7 N•m (55 ± 5 lb ft)

Parking Brake Actuator Assembly

BR-8545



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(A) Maximum pull rod angle in any direction ..... 3°

(B) Length of actuator rod fully extended ..... 57.15 mm (2.250 in)

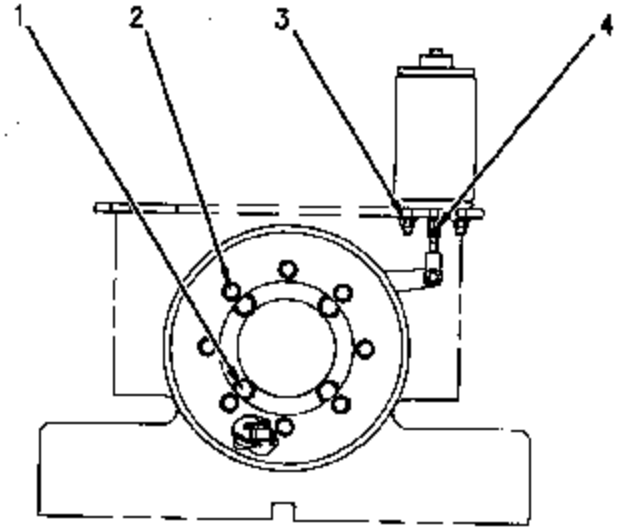
(C) Length of actuator rod fully retracted ... 29.9 mm (1.18 in)

Minimum actuation pressure ... 6035 ± 515 kPa (875 ± 75 psi)

Maximum working pressure ..... 20 700 kPa (3005 psi)

Parking Brake Group

121-3176



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(1) Tighten four bolts to a torque of ..... 215 ± 40 N•m (160 ± 30 lb ft)

(2) Tighten eight bolts to a torque of .... 105 ± 20 N•m (75 ± 15 lb ft)

(3) Tighten two nuts to a torque of .... 70 ± 15 N•m (50 ± 10 lb ft)

(4) Tighten lock nut to a torque of .... 55 ± 10 N•m (40 ± 7 lb ft)

Parking Brake Group Adjustment

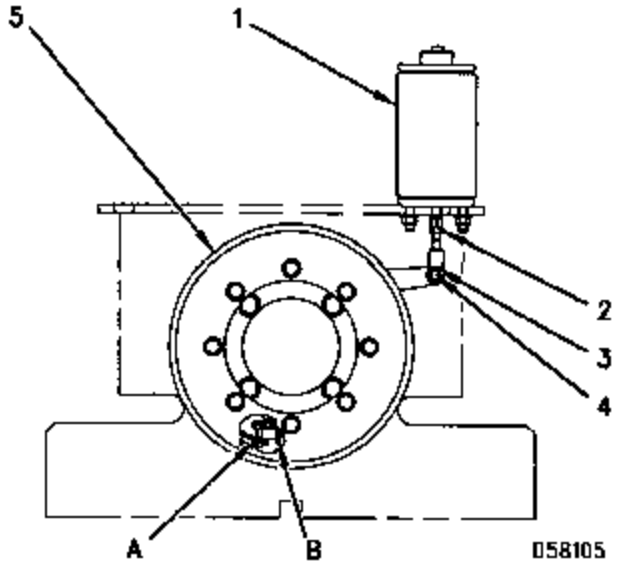
⚠ WARNING

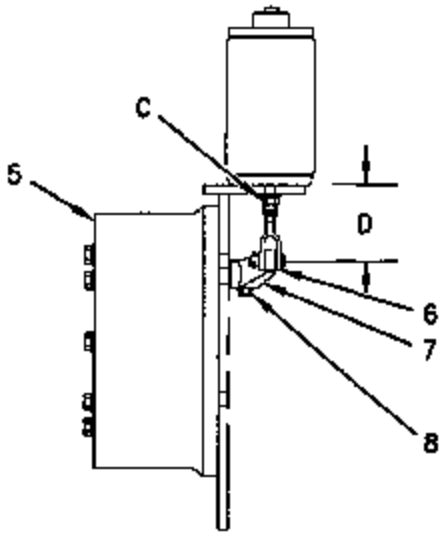
Personal injury or death can result from improperly adjusting the parking brake due to brake accumulator pressure.

Sudden movement of the machine or release of oil under pressure can cause injury to persons on or near the machine. To prevent possible injury, perform the procedure that follows before testing and adjusting the parking brake system.

1. Move the machine to a smooth horizontal location, away from working machines and personnel. Lower the bucket to the ground. Stop the engine.
2. Permit only one operator on the machine. Keep all other personnel either away from the machine or in view of the operator.
3. Engage the parking brake. Put blocks in front of and behind the wheels.
4. Install the steering frame lock link so the machine can not turn.
5. Move the hydraulic control levers to all positions to release any pilot/brake pressure in the hydraulic system.
6. Operate the brake pedal until pilot/brake pressure has been released from the brake accumulators.
7. Carefully loosen the fill cap on the hydraulic tank to release the pressure in the tank.
8. Tighten the fill cap on the hydraulic tank.

Parking Brake Group Adjustment Procedure





1. Insert a 0.50 mm (.020 in) feeler gauge between parking brake shoe lining (A), and brake drum (5). Rotate star wheel (B) until there is a snug fit using the feeler gauge between the shoe lining and the brake drum.
2. With no hydraulic pressure supplied to actuator (1), assemble rod end (6) to actuator shaft (C), to obtain dimension (D). Dimension (D) equals 87.0 mm (3.43 in). Tighten locknut (2) against actuator shaft.
3. Pressurize actuator (1) with a minimum of 8760 kPa (1270 psi). This will extend actuator shaft (C).
4. Position lever (7) on the splined end of the camshaft to obtain approximate hole alignment for clevis pin (4). Manually rotate lever as necessary and install clevis pin (4) through rod end (6) and lever (7). Secure lever on camshaft with bolt (8).
5. Install cotter pin (3) in clevis pin (4).
6. Engage the parking brake by releasing the hydraulic oil pressure in the actuator. If the total stroke of actuator exceeds 19.0 mm (.75 in), repeat Steps 1, 3, 4, and 5.
7. The secondary/parking brake should provide a minimum machine deceleration rate of 2.45 m/sec (0.25 G) during actual braking of the machine from maximum speed in fourth FORWARD or REVERSE.
8. For manufacturing purposes, the secondary/parking brake should be adjusted according to Step 1 through 7. This is to prevent machine movement in second REVERSE range, when the engine is slowly accelerated to full power.

CATERPILLAR®

SENR1314
March 1996

Systems Operation Testing & Adjusting

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Brake System

814F	815F	816F
9DM1-UP	1GN1-UP	5FN1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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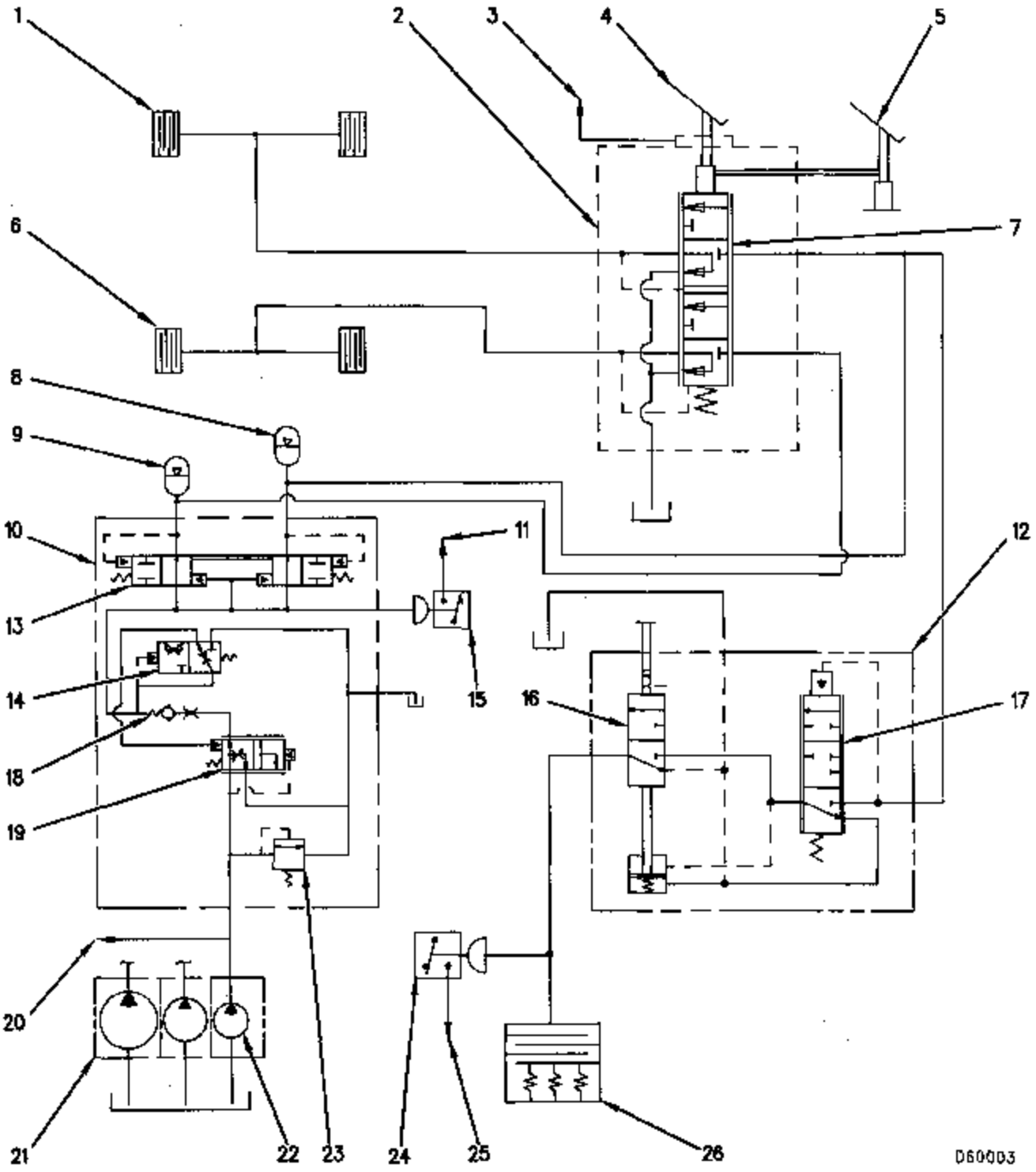
General Information

Specifications

NOTE: For specifications with illustrations, make reference to SENR1313, Specifications For 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Brake System. If the specifications in SENR1313 are not the same as in the Systems Operation, Testing And Adjusting module, look at the printing date on the back cover of each book. Use the specifications in the book with the latest date.

Schematics

NOTE: For hydraulic and electrical systems schematics, make reference to:
SENR1317, 814F Wheel Tractor, 815F Soil Compactor and 816F Landfill Compactor Hydraulic System Schematic.
SENR1319, 814F Wheel Tractor, 815F Soil Compactor and 816F Landfill Compactor Electrical System Schematic.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Brake System Hydraulic Schematic

(1) Rear service brakes.
(2) Service brake control valve.
(3) Wire to stop lamps.
(4) Left service brake pedal assembly.
(5) Right service brake pedal assembly.
(6) Front service brakes.
(7) Tandem spool assembly.
(8) Accumulator for the rear service brakes and parking brake.
(9) Accumulator for the front service brakes.
(10) Accumulator charging valve.
(11) Wire to low service brake oil pressure alert indicator.
(12) Parking brake control valve.
(13) Inverse shuttle check valve.
(14) Load sensing spool.
(15) Service brake low oil pressure switch.
(16) Manually operated spool for the parking brake.
(17) Pressure spool for the parking brake.
(18) Check valve.
(19) Flow control valve spool.
(20) Line to implement pilot oil system.
(21) Tandem pumps - Steering, implement, brake/pilot.
(22) Brake/pilot oil hydraulic pump.
(23) Pressure relief valve.
(24) Pressure switch for transmission control module.
(25) Wire to transmission control module.
(26) Parking brake.

Hydraulic oil pump (22) provides oil flow for both the implement pilot oil system, and the service brakes. Oil flows from brake pump (22) and branches off to flow to implement pilot circuit (20) before flowing to accumulator charging valve (10).

Accumulator charging valve (10) controls the amount of oil that flows to brake system accumulators (8) and (9). Accumulator charging valve (10) contains inverse shuttle check valve (13), load sensing spool (14), check valve (18), flow control valve (19), and relief valve (23).

Pressure oil flows through inverse shuttle check valve (13), to accumulators (8) and (9) during oil charge, but keeps the oil flow between the two accumulators separate. This valve is designed to charge each accumulator as it falls below the pressure set by the charge control for the accumulators.

Check valve (18) in accumulator charging valve (10), prevents oil from flowing back through the charging valve and to the pump.

A third port in the inverse shuttle valve section is used to connect low service brake oil pressure switch (15). This pressure switch alerts the operator when there is inadequate pressure available to charge accumulators (8) and (9).

Pressure oil then flows from inverse shuttle check valve (13) in accumulator charging valve (10), to the oil end of the two piston accumulators. Accumulator for the rear service brakes (8), and accumulator for the front service brakes (9), contain a precharge of dry nitrogen of approximately 6890 kPa (1000 psi).

As pressure oil flows into each accumulator, the pressure oil compresses against the piston. This puts compression on the dry nitrogen until the oil pressure reaches 14 485 ± 345 kPa (2100 ± 50 psi). The oil also flows to service brake control valve (2).

Each brake application removes some oil from the accumulators. The piston in each accumulator moves toward the oil end of the accumulator until there is a decrease in oil pressure of approximately 2760 kPa (400 psi). The accumulator charging valve then permits oil from the hydraulic pump to flow to accumulators (8) and (9) until the pressure again rises to 14 485 ± 345 kPa (2100 ± 50 psi).

Service brake control valve (2) is for rear service brakes (1), and front service brakes (6). This valve is in the line from the accumulators to the service brakes. When a brake pedal is pushed, oil from each accumulator flows to apply the service brakes.

When service brake control valve (2) is released, the lines from the accumulators are blocked, and the brake lines are connected to the drain port. This allows the service brakes to release, and dump the supply oil back to the hydraulic oil tank.

The left and right service brake pedal assemblies are connected together by a mechanical linkage. Pressing down on either brake pedal will apply the service brakes located at each wheel.

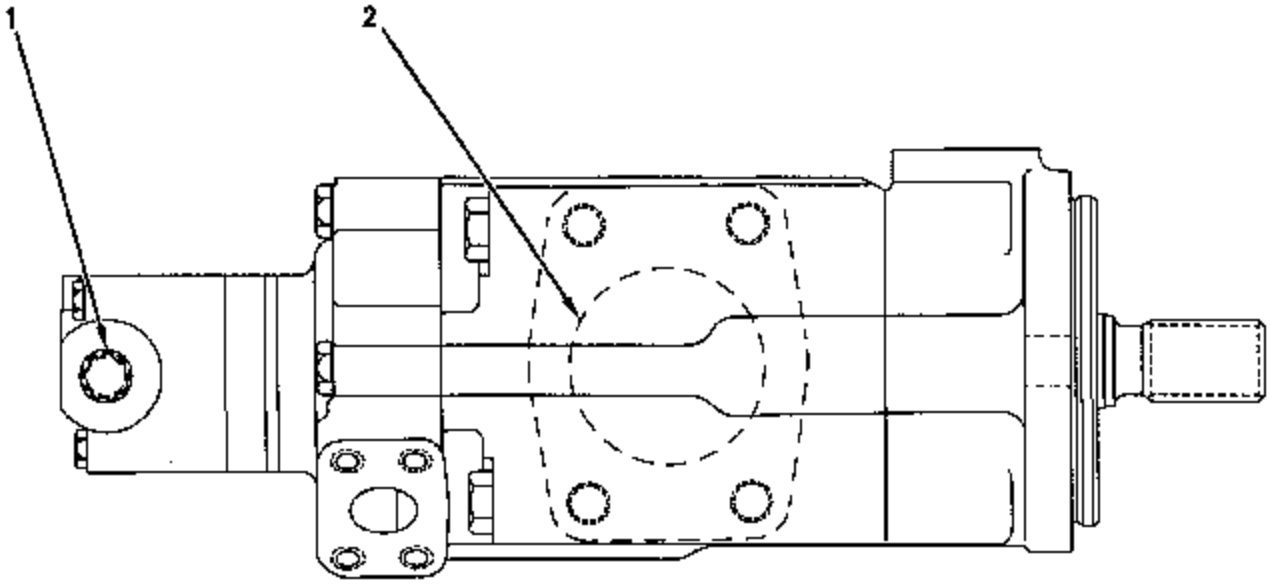
When either service brake pedal assembly is depressed, the enclosed wet multiple disc service brakes in each spindle are applied. This causes tandem spool (7) in brake control valve (2) to move, and allow oil from accumulators (8) and (9) to flow to the disc service brakes in each spindle. The heat from the friction of the brakes is removed by the oil in the axle housings.

Parking brake control valve (12) has manually operated spool (16), and parking brake pressure switch (24). Spool (16) controls the flow of oil pressure to parking brake actuator (26).

Pressure switch (24) is used to signal the transmission control module (TCM) when the parking brake is engaged. Whenever the parking brake engages, the transmission automatically shifts into neutral.

Hydraulic Pump

Brake Hydraulic Oil Pump Location (Arrow)
The operator's platform and cab has been removed for clarity



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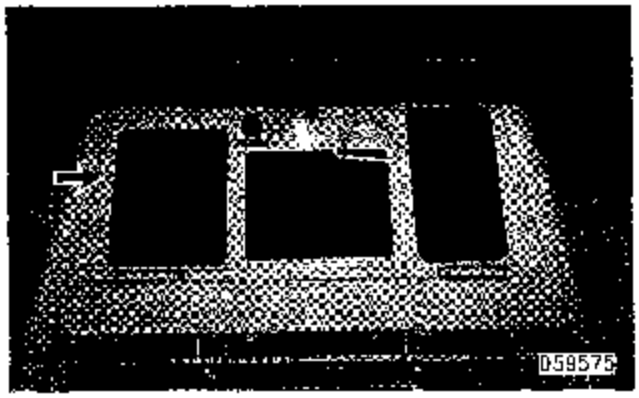
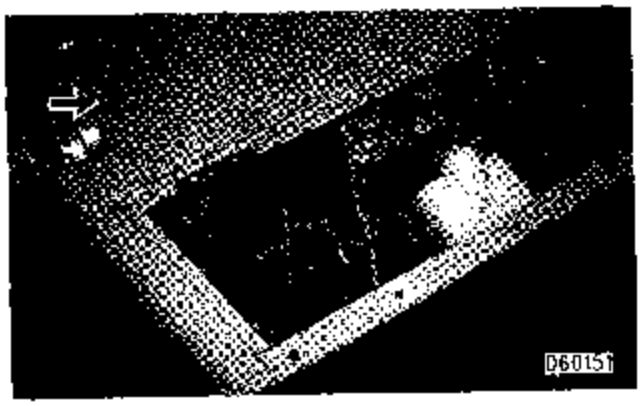
Side View Of Brake Hydraulic Oil Pump
(1) Pressure port (outlet to implement pilot oil circuit and service brake accumulator charging valve). (2) Tank port (inlet from hydraulic oil reservoir).

The hydraulic pump for the pilot and brake system is a fixed displacement pump. The pump is bolted to the implement pump, which is bolted to the steering pump. All three pumps are located under the floor of the operator's cab on the upper left side of the torque converter housing.

Accumulator Charging Valve

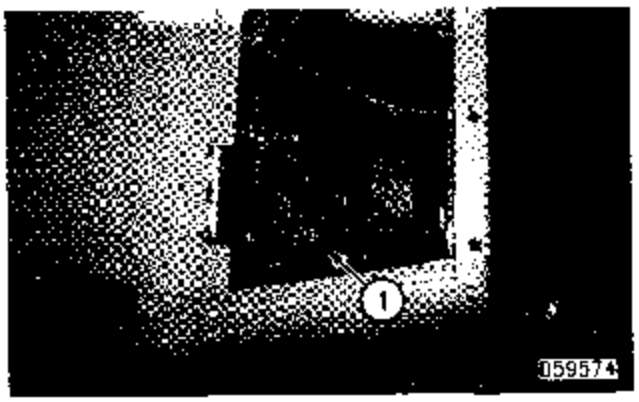


Top View
Location Of Brake System Component Access Panel (Arrow)

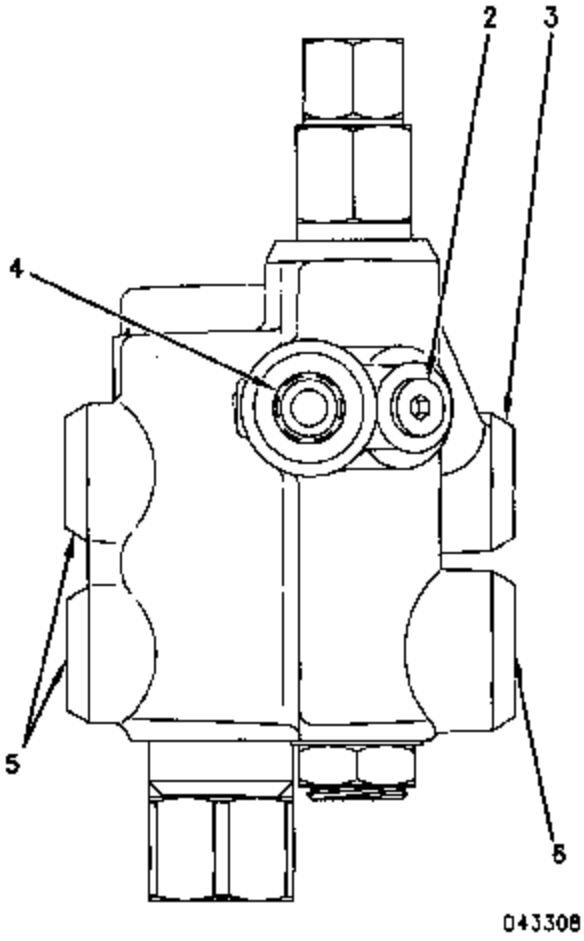


Open the Access Panel (Arrow) To Gain Access To The Brake Component Panel

The major brake system components are located on the engine end frame of the machine to the rear of the operator's platform. The two accumulators for the service brakes and parking brake, accumulator charging valve, parking brake valve, brake pressure switches, parking brake linkage, and pressure reducing valve are all located on a brake component plate on the engine end frame behind the operator's platform. The major brake system components are positioned opposite of the windshield washer solution container under an access panel.



Accumulator Charging Valve Location
(1) Accumulator charging valve.



Accumulator Charging Valve Port Identification
(2) Plug. (3) Outlet to hydraulic tank. (4) Inlet from pump.
(5) Accumulator ports. (6) Low brake oil pressure switch port.

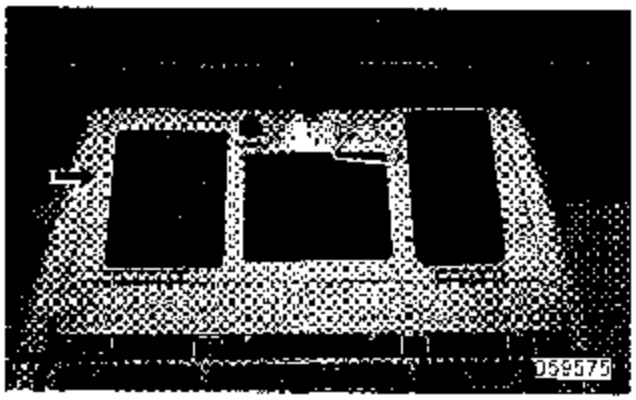
The pilot/brake pump is used to supply hydraulic oil flow for both the implement and steering pilot oil circuit, and the service brake circuit. In the service brake circuit, the oil first flows to accumulator charging valve.

The function of the accumulator charging valve is to keep the pressure in the two service brake accumulators at a constant range while the engine is running.

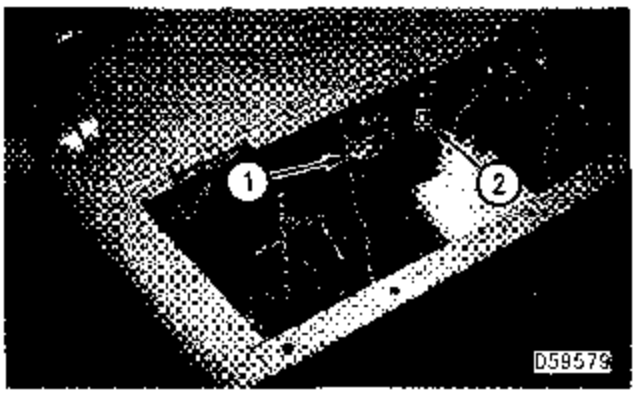
The accumulator charging valve senses the ower of the two accumulator pressures, and moves a spool to allow the hydraulic oil from the pump. to flow to one or both accumulators.

A valve assembly in the pressure port of the accumulator charging valve, maintains a standby pressure of 2900 ± 140 kPa (420 ± 20 psi). Oil supplied by the pilot and brake pump which is not required for the brake system is diverted to the implement pilot circuit before returning back to the hydraulic tank.

Accumulators

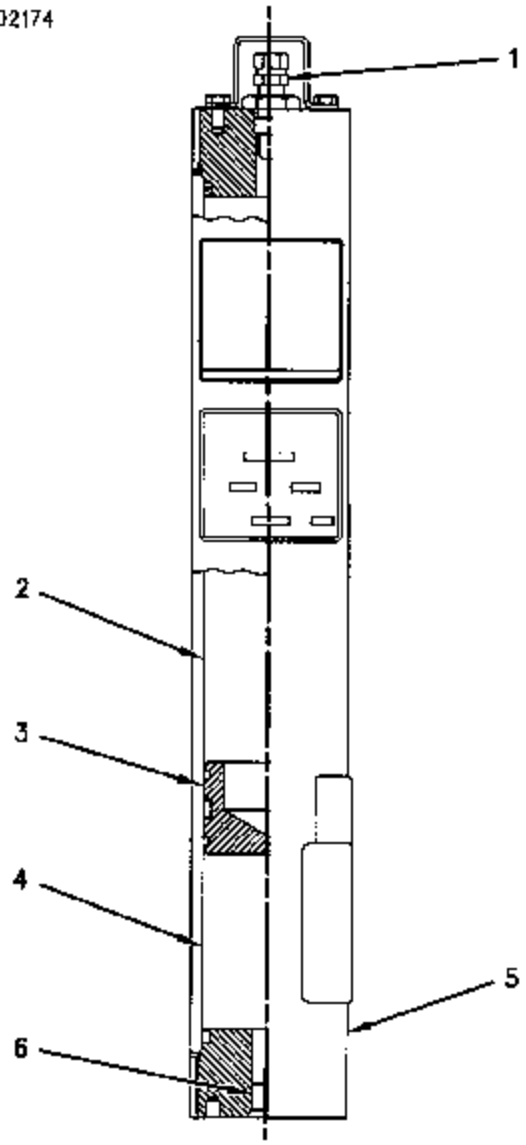


Top View
Location Of Brake Component Access Panel (Arrow)



Accumulator Location
(1) Accumulator for the front service brakes. (2) Accumulator for the rear service brakes and parking brake.

The two accumulators for the service brakes and parking brake are located to the rear of the operator compartment under an access panel.

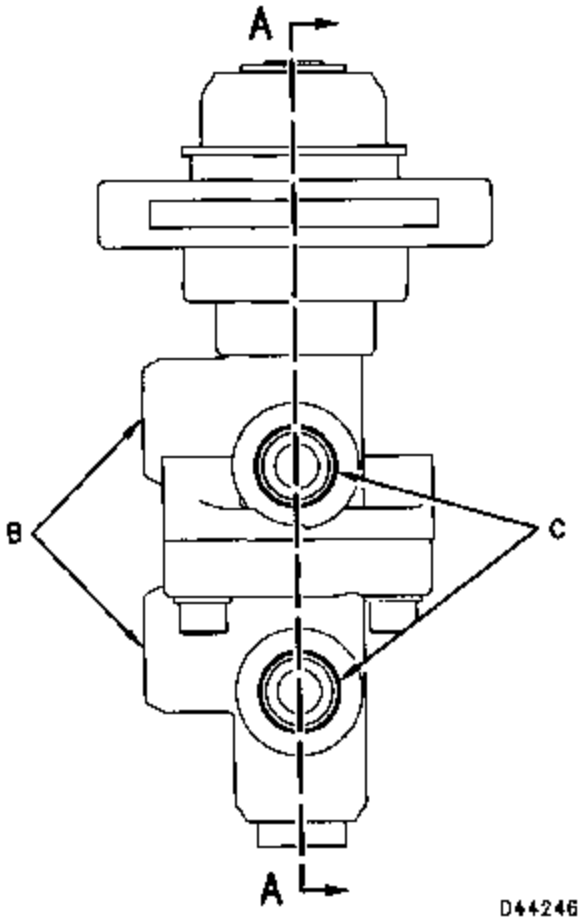


Accumulator Components
(1) Nitrogen charging valve. (2) Nitrogen gas chamber. (3) Piston. (4) Pressure oil chamber. (5) Accumulator. (6) Outlet to brake control valve.

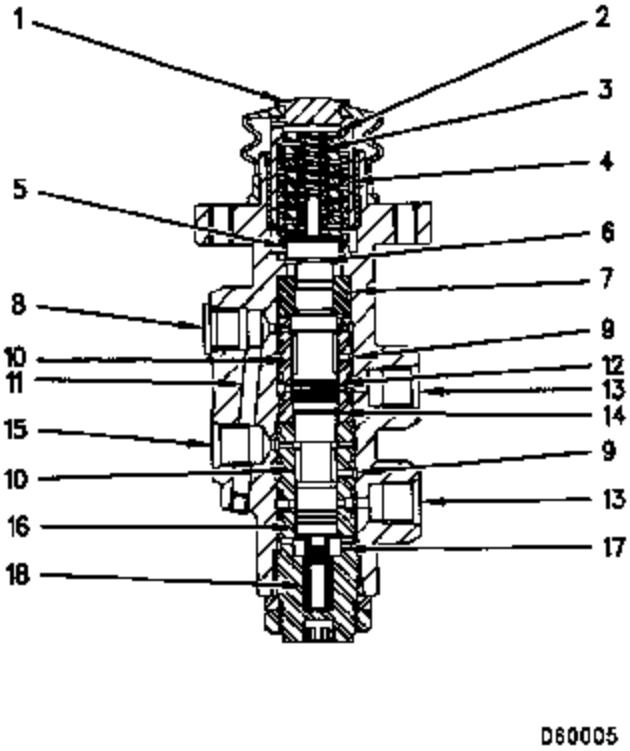
The accumulators have a sealed piston (3) that moves back and forth inside the bore of each accumulator. Nitrogen gas chamber (2), located above piston (3), has a charge of approximately 6890 kPa (1000 psi) of dry nitrogen gas. The dry nitrogen gas is put into the accumulator through nitrogen charging valve (1).

Oil from the accumulator charging valve flows in through port (6), and into accumulator chamber (4). This oil pushes piston (3) and causes the dry nitrogen gas to compress. When the pressure in the accumulator reaches 14 485 ± 345 kPa (2100 ± 50 psi), the supply of oil is stopped by the accumulator charging valve. When either brake pedal is pushed, oil from chamber (4) flows out of port (6). From port (6), the oil flows to the brake control valve and applies the service brakes.

Service Brake Control Valve



Service Brake Control Valve Located On Brake Pedal Assembly
(B) Service braka ports. (C) Pressure (accumulator) ports.



Service Brake Control Valve
(1) Piston. (2) Spring. (3) Spring. (4) Spring. (5) Retainer. (6) Ball. (7) Spacer. (8) Plug. (9) Outlet to service brakes. (10) Passage. (11) Drain port to tank. (12) Upper valve spool. (13) Supply from accumulator. (14) Cavity. (15) Outlet to tank. (16) Lower valve spool. (17) Cavity. (18) Spring.

The brake control valve assembly is a dual pressure reducing valve with two independent output pressures. The valve is actuated by either foot pedal assembly, however, the left brake pedal assembly can also actuate the transmission neutralizer.

Modulation of high pressure oil in the accumulators to the service brakes is controlled by the brake control valve. The position of either brake pedal causes a specific pressure at the service brakes. As the position of the pedal changes, the pressure at the service brakes also change.

When a brake pedal assembly is depressed, the roller on the pedal assembly pushes downward on piston (1). Piston (1) puts a force on springs (2), (3), and (4). The force of springs (2) and (3) moves retainer (5), and ball (6). Movement of retainer (5) and ball (6) causes upper valve spool (12) to move away from its seat in spacer (7).

The movement of upper valve spool (12) causes movement of lower valve spool (16) and the compression of spring (18). When valve spools (12) and (16) move, oil flow through passages (10) and (11) to tank is blocked.

This allows pressure oil from accumulator ports (13) to flow through passages (10) and through passages (9) to engage the service brakes. At the same time, pressure oil flows into cavities (14) and (17) by way of interior passages in the valve spools. The oil pressure at the service brakes is at the same pressure as the oil in cavities (14) and (17).

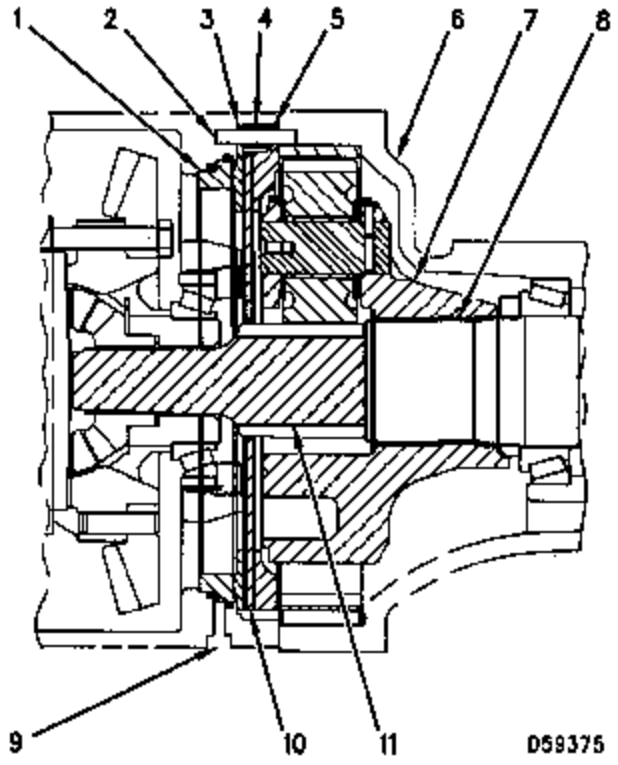
Oil pressure in cavity (17), together with the force of spring (18), act to balance lower valve spool (16) against the force created by pressure in cavity (14). In the same manner, pressure in cavity (14) creates a force against the bottom of upper valve spool (12), which is balanced by the force of springs (2) and (3), at the top of the spool.

The force of springs (2), (3), and (4), is balanced by the force applied to the pedal. Upward movement of valve spools (12) and (16) causes accumulator ports (13) to be covered. In this way, the level of pressure in the independent valve sections create a feedback force which allows the operator to modulate pressure to the brakes.

Upper valve spool (12), and lower valve spool (16), balances between their respective tank port and brake port. This is done as required to maintain brake pressure until the pedal position changes, calling for more or less brake pressure. If piston (1) is moved down to put more compression on springs (2) and (3), valve spools (12) and (16) will move to permit more pressure to outlets (9) to the service brakes. This results in a higher oil pressure in cavities (14) and (17) which is required to keep valve spools (12) and (16) in balance.

The internal metering passages reduce oil pressure to each axle to approximately 6900 ± 350 kPa (1000 ± 50 psi). The brake control valve meters oil to the rear brakes approximately 350 kPa (50 psi) higher than the front brakes.

Service Brakes



Service Brake Components
(1) Piston. (2) Dowel. (3) Plate. (4) Spring. (5) Plate. (6) Axle housing. (7) Planet Carrier. (8) Axle. (9) Chamber. (10) Disc. (11) Sun gear.

The service brakes are located in the axle housing next to the differential. There is one brake on each side of the differential. The service brakes are in both the front and rear axle housings on the 814F Wheel Tractor. The 815F Soil Compactor and 816F Landfill Compactor have service brakes in the front axle housings only.

Each service brake consists of piston (1), disc (10), plate (3), plate (5), dowels (2), and springs (4). The disc has splines on the inside diameter that fit on the splines of the sun gear (11). The disc turns with the sun gear (11).

The plates (3) and (5), are held stationary by dowels in the axle housing.

When a service brake pedal is pushed, oil under pressure flows from the brake control valve and into chamber (9), which is located behind piston (1). Oil in chamber (9) pushes piston (1) against the plates and disc. This causes friction between plates (3) and (5), which are held stationary by axle housing (6), and disc (10), which turns with the rotation of the wheels. This friction causes the wheels to turn slower or to stop. The amount of brake application is determined by the position of the brake pedal.

Grooves are cut in the faces of the disc which permit the passage of cooling oil between the plates and disc in either the engaged or disengaged position. Cooling oil will constantly flow between the disc and plates, even in the full application position, provided there is adequate groove depth in the friction disc.

When the brake pedal is released, oil from chamber (9) flows back through the brake control valve and to the tank. The spring force of the three springs (4) pull piston (1) away from the plates (3) and (5). The flow of oil between the plates and the disc helps to separate the stack as the service brakes are released.

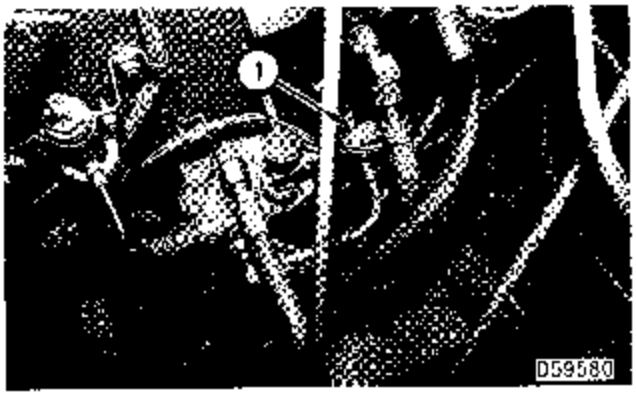
The service brakes can be actuated by either the left or right brake pedal. The left brake pedal will apply the service brakes, while at the same time, disengage the output of the transmission. This allows full engine power to be used in the hydraulic system.

For additional information on the transmission neutralizer function, see the section "Transmission Neutralizer", in this manual.

In the event the machine loses power or the hydraulic pump fails, the service brakes can still be applied for a short period of time. The pressure in the nitrogen charged brake accumulators will allow for several applications of the brake pedals in order to stop or slow the machine enough to engage the parking brake.

In the event the service brakes become inoperative, the parking brake should be engaged.

Service Brake Low Oil Pressure Switch

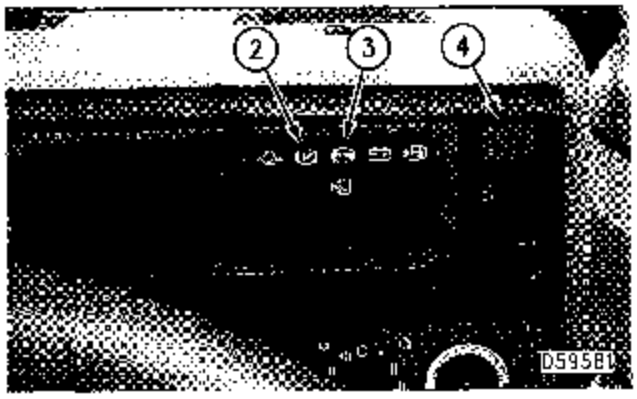


Service Brake Low Oil Pressure Switch Location
(1) Service brake low oil pressure switch.

The service brake low oil pressure switch is located next to the pressure tap on the accumulator charging valve.

The service brake low pressure switch is normally closed when the oil pressure in the service brake system falls below 8960 ± 345 kPa (1300 ± 50 psi). When the switch contacts change state, the low oil pressure alert indicator is turned on. Descending further to 6900 ± 350 kPa (1000 ± 50 psi) will cause the parking brake to engage.

If the operator selects a forward or reverse speed while the parking brake is engaged, the Caterpillar Monitoring System will produce a Category 3 warning.

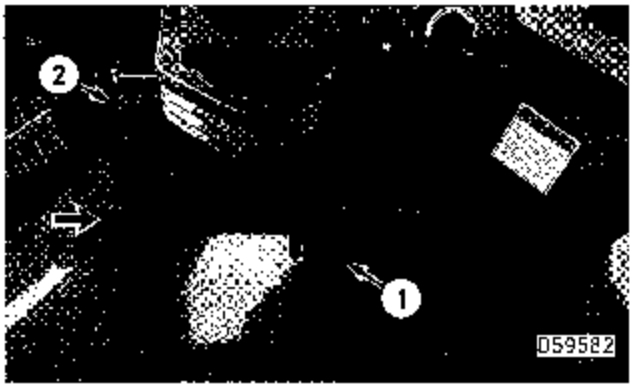


Alert Indicator And Master Action Light Locations
(2) Parking brake alert indicator. (3) Low oil pressure alert indicator. (4) Master action light.

When the switch contacts change state, the warning indications are: Parking brake alert indicator (2), service brake low oil pressure alert indicator (3), and master action light (4) on the Caterpillar Monitoring System panel flash. The action alarm will also sound. This indicates a loss of oil pressure to the service brakes.

When the service brake system pressure becomes greater than 10 700 kPa (1555 psi), the contacts on the pressure switch change state, and the low oil pressure alert indicator turns off.

Transmission Neutralizer



Service Brake Pedal And Transmission Neutralizer Limit Switch Location
(1) Right service brake pedal. (2) Left service brake pedal.
Large arrow indicates location of neutralizer limit switch (and stop lamp limit switch).

A normally closed limit switch is used in the left brake pedal assembly to activate the transmission neutralizer.

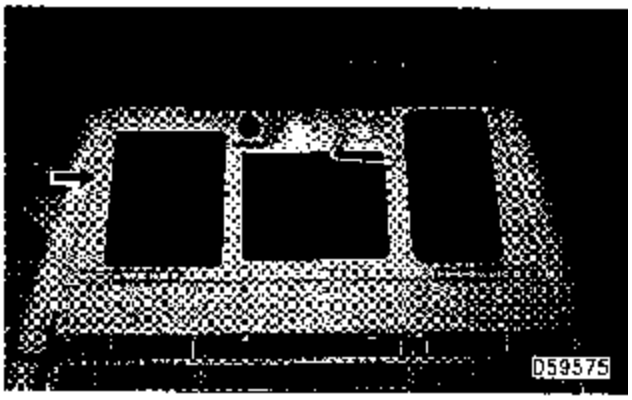
The transmission neutralizer function operates when the left brake pedal is depressed. At this time the transmission shifts into neutral and the service brakes are applied.

Also at this time, the engine rpm will increase due to a no-load condition from the transmission. This will allow full hydraulic power for dozer blade operation.

The transmission is neutralized by de-energizing the direction clutch solenoid, while leaving the speed clutch solenoid energized. This allows full engine power to be used in the hydraulic system.

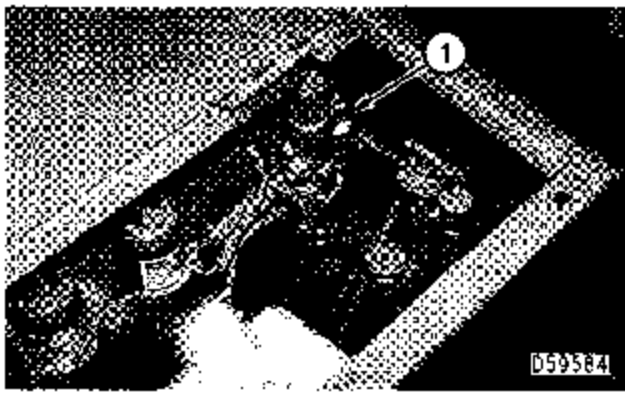
NOTE: For information on how to adjust the transmission neutralizer limit switch, refer to the section Transmission Neutralizer Switch Adjustment in SENR1313, 814F Wheel Loader, 815F Soil Compactor and 816F Landfill Compactor Brake System Specifications.

Parking Brake Control Valve

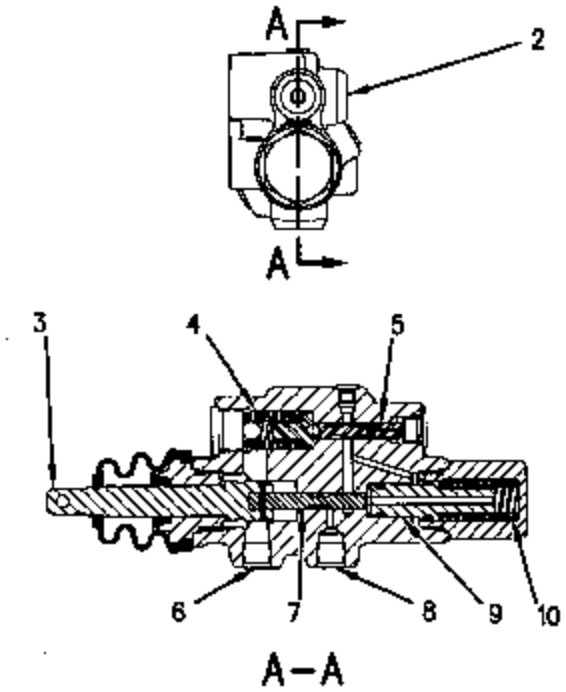


Top View
Location Of Brake Component Access Panel (Arrow)

The parking brake control valve is located in the engine end frame of the machine under the access panel to the rear of the operator's platform. It is to the right of the two accumulators. The valve controls the flow of pressure oil to and from the parking brake actuator.

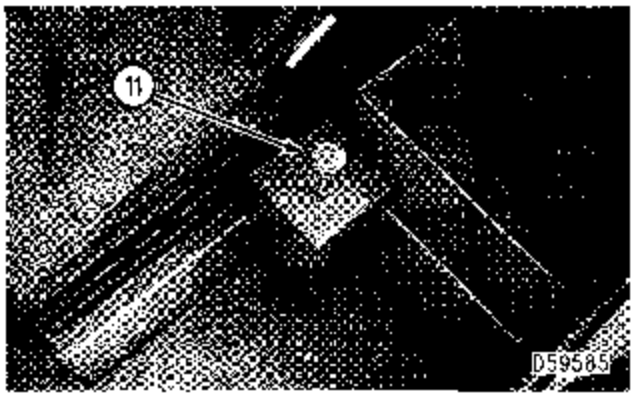


Top View
Parking Brake Control Valve Location
(1) Parking brake control valve.



Parking Brake Control Valve (Parking Brake Shown In The Engaged Position)
(2) Pressure port from brake accumulators. (3) Parking brake control knob stem. (4) Spring. (5) Spool. (6) Return to tank port. (7) Spool. (8) Parking brake actuator port. (9) Retainer. (10) Spring.

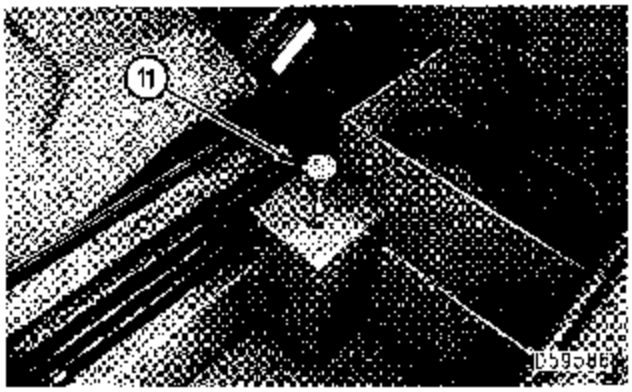
NOTE: Hydraulic tank pressure above 210 kPa (30 psi) may result in parking brake control knob stem (3) being extended to the position shown (parking brake engaged).



Parking Brake Control Knob Pushed In (Parking Brake Disengaged)
(11) Parking brake control knob.

When parking brake control knob (11) in the operator's compartment is pushed in (parking brake disengaged), spool (7) and retainer (9) move to the right to compress spring (10). This allows pressure oil to flow into the pressure port from accumulators (2), and out parking brake actuator port (8). From parking brake actuator port (8), the pressure oil flows to a cavity in the parking brake actuator assembly.

When the pressure of the oil in the brake actuator cavity is high enough to compress the spring in the actuator, the brake will disengage. This oil pressure keeps the parking brake disengaged.



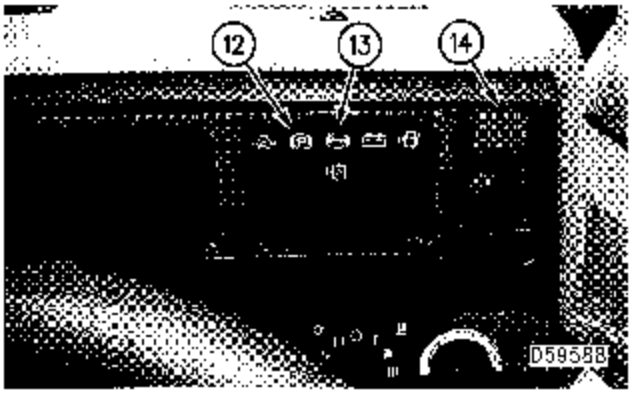
Parking Brake Knob Pulled Out (Parking Brake Engaged)
(11) Parking brake control knob.

If parking brake control knob (11) in the operator's compartment is pulled all of the way out (parking brake engaged), parking brake control knob stem (3) stops the flow of oil from the accumulator to the parking brake. Moving parking brake control knob (11) causes spool (7) to move left. This stops the supply of oil from the accumulators and dumps the actuator oil back to the tank.

With the drop in brake system oil pressure, the force of the spring in the brake actuator assembly is greater than the pressure of the oil in the cavity of the actuator assembly. This allows the spring in the actuator to engage the parking brake.

If there is an oil pressure drop in the brake system during machine operation, the parking brake control valve will automatically engage the parking brake.

With a loss of hydraulic oil pressure, the force of spring (4) will move spool (5) to the right. This blocks any flow of oil that would normally help keep spring (10) compressed. With no oil pressure compressing spring (10), the force of spring (10) moves spring retainer (9), spool (7), and parking brake control knob stem (3) out.

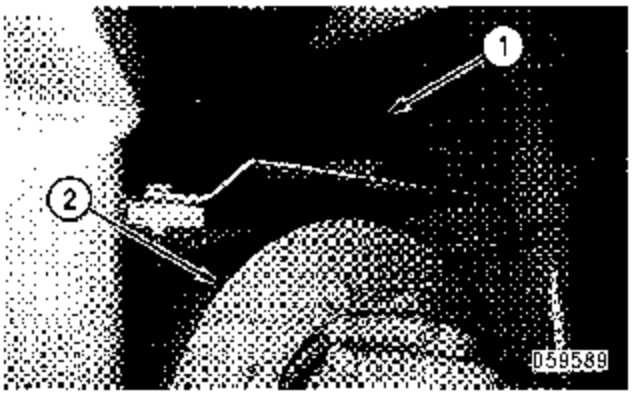


Alert Indicator And Master Action Light Locations
(12) Parking brake alert indicator. (13) Low oil pressure alert indicator. (14) Master action light.

When the hydraulic oil pressure to the parking brake actuator drops below 6890 ± 345 kPa (1000 ± 50 psi), the Caterpillar Monitoring System will indicate a Category 3 warning. The indications are: Both the parking brake alert indicator, and the master action light on the Caterpillar Monitoring System panel FLASH, and the action alarm sounds.

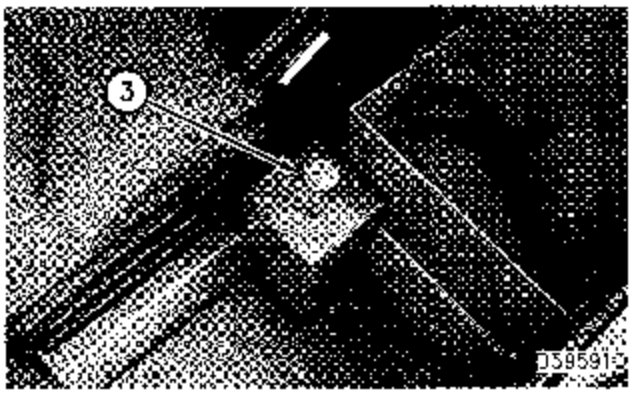
The transmission will be returned to neutral if it is in either first speed forward, or first speed reverse, when the parking brake engages.

Parking Brake

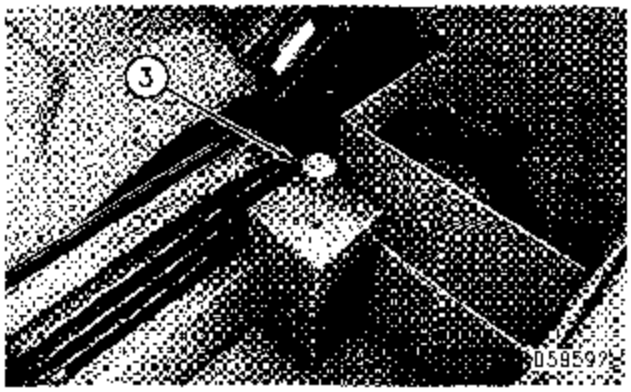


Parking Brake Location
(1) Parking brake actuator. (2) Parking brake.

The parking brake is located on the drive line on the non-engine end of the machine. The brake is engaged by pulling out on the parking brake control knob.



Parking Brake Control Knob Location (Disengaged Position)
(3) Parking brake control knob.



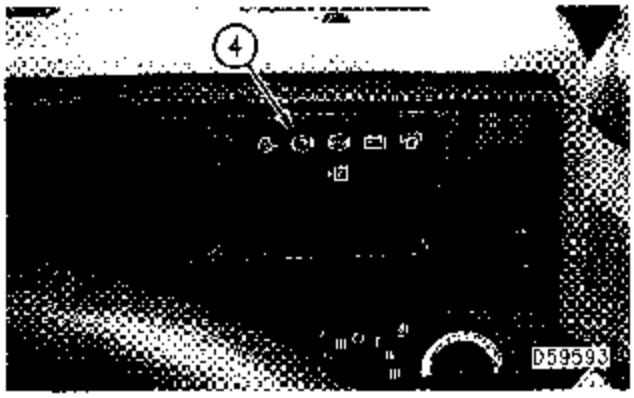
Parking Brake Control Knob Location (Engaged Position)
(3) Parking brake control knob.

The parking brake control knob is located on the left side of the operator seat on the floor.

When parking brake control knob (3) is pulled out, it moves a cable assembly which is connected to a spool in the parking brake control valve. The movement of the spool changes the flow of oil through the valve. Instead of allowing the pressure oil to flow to a cavity in the parking brake actuator assembly, the oil flows back to the hydraulic oil tank.

Without the pressure of the oil in the cavity of the actuator, the force of an internal spring in the actuator becomes stronger than the pressure of the oil. When this occurs, the force of the spring engages the parking brake mechanism.

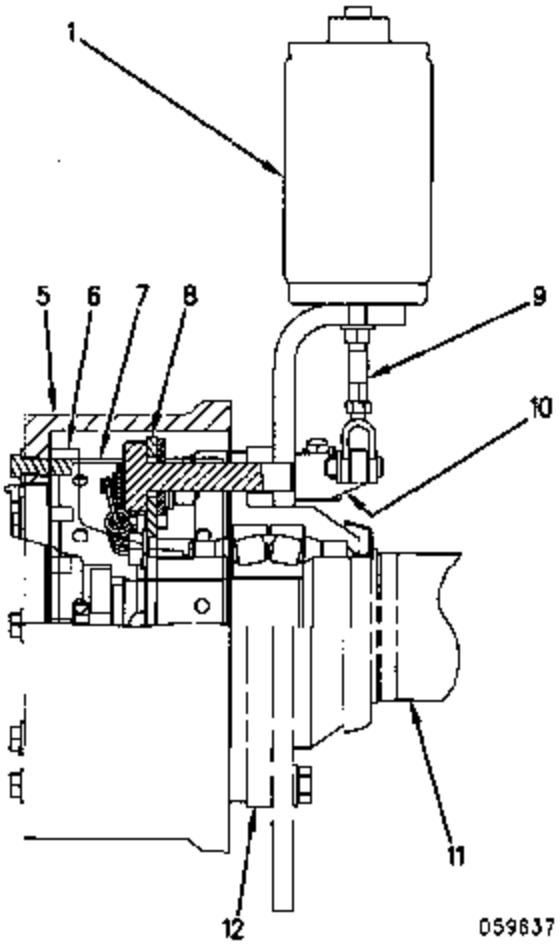
If the hydraulic oil pressure for the service brake system is inadequate, the parking brake will engage automatically. This will also cause parking brake control knob (3) to be pushed out to the engaged position.



Parking Brake Alert Indicator Location
(4) Parking brake alert indicator.

A normally closed pressure switch is located on the parking brake control valve. The switch signals both the transmission control module (TCM), and the Caterpillar Monitoring System when the parking brake has been engaged. When the parking brake is engaged, the switch activates parking brake alert indicator (4) on the dash panel.

The pressure switch also neutralizes the transmission when the parking brake is engaged, if the transmission is in either a forward or reverse speed.



Front View Of Parking Brake Control Group
(1) Actuator. (5) Drum. (6) Yoke. (7) Shoes (two). (8) Brake group. (9) Rod. (10) Lever. (11) Shaft. (12) Cage.

The parking brake is a spring engaged, oil disengaged dry drum brake system. The spring is located in actuator (1). As drive shaft (11) rotates, drum (5), and yoke (6) also rotate. Brake group (8), and lever (10) are fastened to cage (12), which remains stationary.

When the parking brake is engaged, rod (9) moves lever (10) and actuates brake group (8). Brake group (8) consists of three retraction springs and two brake shoes mounted on a plate (cam) assembly.

The brake group is configured such that when lever (10) is actuated, the plate (cam) assembly expands and presses shoes (7) against drum (5). This prevents shaft (11) and yoke (6) from turning.

Manual Release Of The Parking Brake

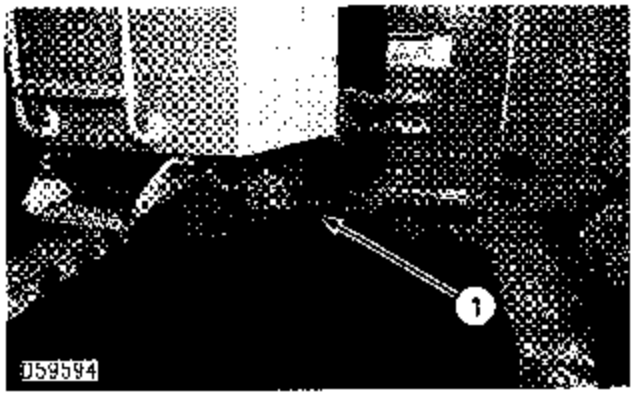
⚠ WARNING

Personal injury or death can result from a brake malfunction.

Do not operate the machine if the parking brake was engaged due to a malfunction of the oil system or the service brakes.

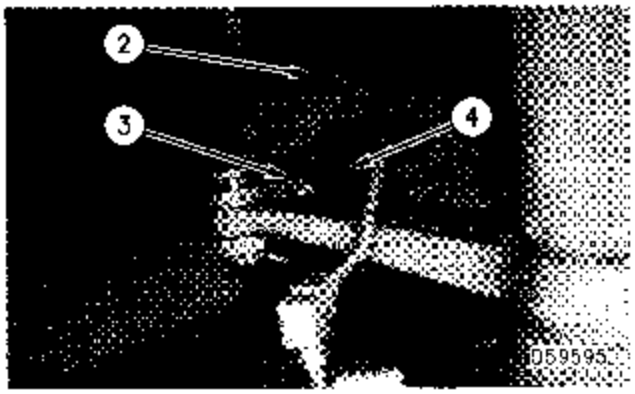
Correct any problem before attempting to operate the machine.

1. Block the wheels to keep the machine from rolling when the parking brake is disengaged.



Steering Frame Lock Link Location
(1) Steering frame lock link.

2. Connect steering frame lock link (1) to the front and rear frames.

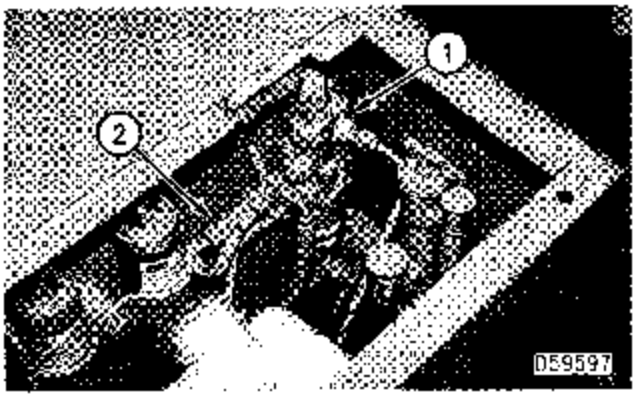


Location Of Parking Brake Actuator Assembly
(2) Parking brake actuator assembly. (3) Locknut. (4) Rod.

3. Loosen locknut (3) approximately 19.05 mm (.750 in). Rotate rod (4) until rod (4) moves out enough to totally disengage the parking brake.

NOTE: For more information on this subject or towing the machine, refer to SEBU6955, 814F Wheel Tractor, 815F Soil Compactor and 816F Landfill Compactor Operation And Maintenance Manual.

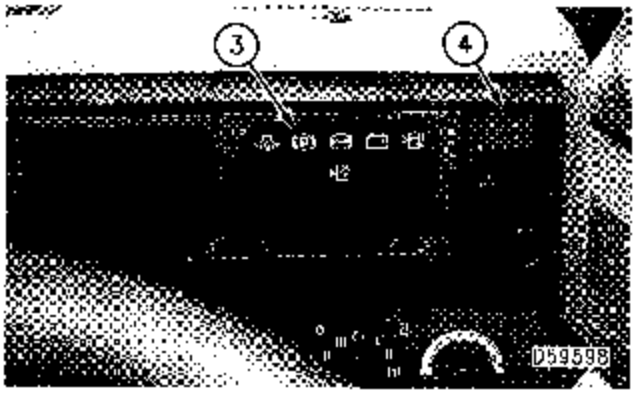
Parking Brake Pressure Switch



Parking Brake Pressure Switch Location
(1) Parking brake control valve. (2) Parking brake pressure switch.

The parking brake pressure switch is located in the engine end frame of the machine to the rear of the operator's platform. It is to the right of the two accumulators.

The purpose of this switch is to signal the transmission control module (TCM) when the parking brake is engaged. When the parking brake is engaged, the TCM shifts the transmission to neutral if either a forward or reverse speed was selected. The TCM also signals the Caterpillar Monitoring System using the CAT data link, that the parking brake is engaged.



Parking Brake Alert Indicator And Master Action Light Locations
(3) Parking brake alert indicator. (4) Master action light.

When the parking brake is engaged, the parking brake alert indicator flashes. If the operator selects a forward or reverse speed while the parking brake is engaged, the Caterpillar Monitoring System initiates a Category 3 warning. A Category 3 warning causes the master action light to flash, the parking brake alert indicator to flash, and sounds the action alarm.

Testing And Adjusting

Brake System

When making an analysis of a hydraulic system for poor performance, remember that correct oil flow and pressure are necessary for correct operation. Oil flow is a function of the output of the pump. The output of the pump is a function of engine speed. Restriction to the flow of oil causes oil pressure.

⚠ WARNING

Sudden movement of the machine or release of oil under pressure can cause injury to persons on or near the machine.

To prevent possible injury, perform the procedure that follows before testing and adjusting the brake system.

1. Move the machine to a smooth horizontal location. Move away from working machines and personnel. Stop the engine.
2. Permit only one operator on the machine. Keep all other personnel either away from the machine or in view of the operator.
3. Engage the parking brake. Lower the bucket to the ground. Put blocks in front of and behind the wheels.
4. Push on the brake pedal many times until there is no more brake oil pressure.
5. Make sure all oil pressure is released before any fitting, hose or component is loosened, tightened, removed or adjusted.

Visual Checks

⚠ WARNING

Personal injury or death can result from improperly checking for a leak.

Always use a board or cardboard when checking for a leak. Escaping air or fluid under pressure, even a pin-hole size leak, can penetrate body tissue, causing serious injury, and possible death. If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.

Tools Needed: Magnet.

1. Check the oil level in the hydraulic oil supply tank. Slowly loosen the tank fill cap. Permit the pressure in the tank to be removed before the cap is removed.
2. Inspect all oil lines, connections and outer valves for leaks or damage.
3. Inspect the brake control linkages for any damage. Check the adjustments.
4. Remove the filter elements and check for foreign material. Use a magnet to make a separation of material with iron (ferrous) from all other material. If any ferrous material is found, the component with damage must be found and a repair must be made. The hydraulic system must then be flushed.
5. Check the tightening torque of all bolts.

Instrument Checks

Tools Needed: 5P-8687 Tool Group.

8T-5320 Hydraulic Testing Group.

⚠ WARNING

Make reference to the WARNINGS on the first page of the Brake System Testing And Adjusting section.

Pump Efficiency Check

For any pump test at a given rpm, the pump flow at 690 kPa (100 psi) will be larger than the pump flow at 6900 kPa (1000 psi). The difference between the pump flow of the two operating pressures is the flow loss.

Formula I*

Method of finding flow loss:

Pump flow at 690 kPa (100 psi)	217.6 L/min (57.5 gpm)
Pump flow at 6900 kPa (1000 psi)	−196.8 L/min (52.0 gpm)
Flow loss.....	20.8 L/min (5.5 gpm)

Flow loss when expressed as a percent of pump flow is used as a measure of pump performance.

Example of finding percent of flow loss:

$$\frac{\text{L/min (gpm) flow loss}}{\text{Pump flow @ 690 kPa (100 psi)}} \times 100 = \text{Percent of flow loss}$$

$$\text{or} \quad \frac{20.8^{*}\ \text{L/min}\ (5.5^{*}\ \text{gpm})}{217.6^{*}\ (57.5^{*})} \times 100 = 9.6\%$$

If the percent of flow loss is more than 10%, pump performance is not good enough.

*Numbers in examples are for illustration and are not values for any specific pump or pump condition. See Specifications for pump flow of a new pump at 690 kPa (100 psi) and 6900 kPa (1000 psi).

Machine Test

Install a Flow Meter. For Formula I, measure pump flow at 690 kPa (100 psi) and at 6900 kPa (1000 psi) with the engine at high idle rpm.

Formula I:

$$\frac{\text{L/min @ 690 kPa} - \text{L/min @ 6900 kPa}}{\text{L/min @ 690 kPa}} \times 100 = \text{Percent of flow loss}$$

$$\frac{\text{gpm @ 100 psi} - \text{gpm @ 1000 psi}}{\text{gpm @ 100 psi}} \times 100 = \text{Percent of flow loss}$$

Bench Test

If the test bench can be run at 6900 kPa (1000 psi) and at full pump rpm, find the percent of flow loss using Formula I.

If the test bench cannot be run at 6900 kPa (1000 psi) and at full pump rpm, run the pump shaft at 1000 rpm. Measure the pump flow at 690 kPa (100 psi) and at 6900 kPa (1000 psi). Use these values in the top part of Formula II. For the bottom part of the formula, run the pump shaft at 2000 rpm. Measure the pump flow at 690 kPa (100 psi).

Formula II

Formula I:

$$\frac{\text{L/min @ 690 kPa} - \text{L/min @ 6900 kPa}}{\text{L/min @ 690 kPa @ 2000 rpm}} \times 100 = \text{Percent of flow loss}$$

$$\frac{\text{gpm @ 100 psi} - \text{gpm @ 1000 psi}}{\text{gpm @ 100 psi @ 2000 rpm}} \times 100 = \text{Percent of flow loss}$$

Accumulator Charging Valve

Tools Needed: 0 to 20 700 kPa (0 to 3000 psi) pressure gauge.

⚠ WARNING

Personal injury or death can result if two persons are not used in the following procedures.

Make reference to the WARNINGS on the first page of the Testing And Adjusting section.

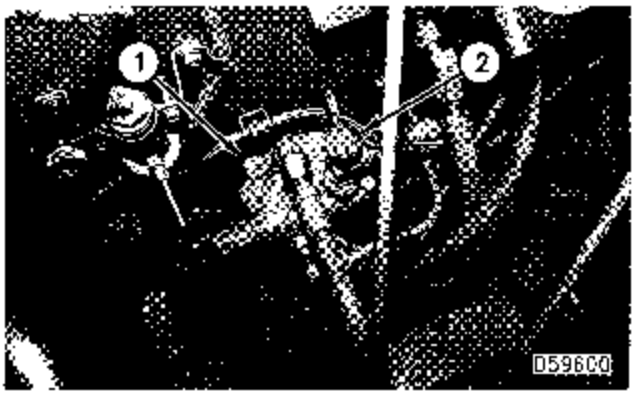
NOTE: There are two separate procedures that may be used to check the operation of the accumulator charging valve and several associated components.

Procedure 1 is a quick method to check for correct cutout pressure, and indicate whether or not the low brake oil pressure switch and alert indicator are working correctly. It will also provide an estimate of the accumulator pre-charge level, and indicate approximately how many brake applications an operator may have before the low brake oil pressure alert indicator turns on (providing the service brake system is operating correctly).

Procedure 2 determines if the cut-in and cutout pressures for the accumulator charging valve are correct. It also provides the steps required to adjust the accumulator charging valve.

Procedure 1

1. Stop the engine and completely remove all oil pressure from the brake circuit by this method: Engage the parking brake. Repeatedly push on the brake pedal until there is no brake pressure.



Accumulator Charging Valve Pressure Port Location
(1) Accumulator charging valve. (2) Test port.

2. Install a 0 to 20 700 kPa (0 to 3000 psi) pressure gauge to test port (2) on the accumulator charging valve

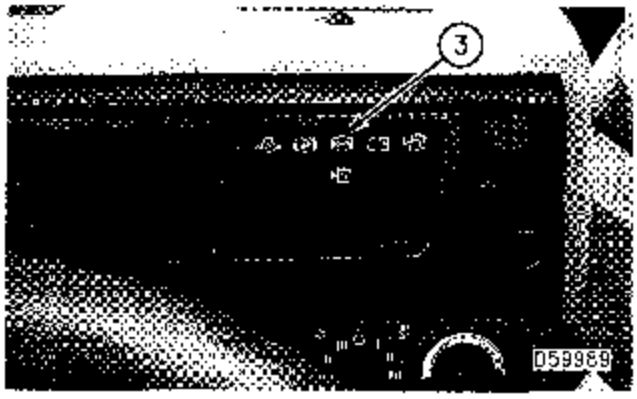
3. Look at the pressure gauge. Before the engine is started, the oil pressure must be 0 kPa (0 psi).

4. Start the engine. Allow the oil pressure to increase to the cutout pressure. The correct cutout pressure should equal 14 485 ± 345 kPa (2100 ± 50 psi).

5. After the service brake accumulators have been completely charged and the correct cutout pressure has been obtained, stop the engine.

6. Turn the engine start switch key back to the run position without starting the engine.

7. Apply the service brakes, pausing for a second or two between each brake application. Also, count the number of brake applications while watching the pressure gauge.



Low Brake Pressure Alert Indicator Location
(3) Low brake pressure alert indicator.

8. When the pressure on the gauge decreases to 8960 ± 345 kPa (1300 ± 50 psi), low brake pressure alert indicator (3) on the dash should turn on. This will indicate the operational status of the low brake pressure switch and the alert indicator.

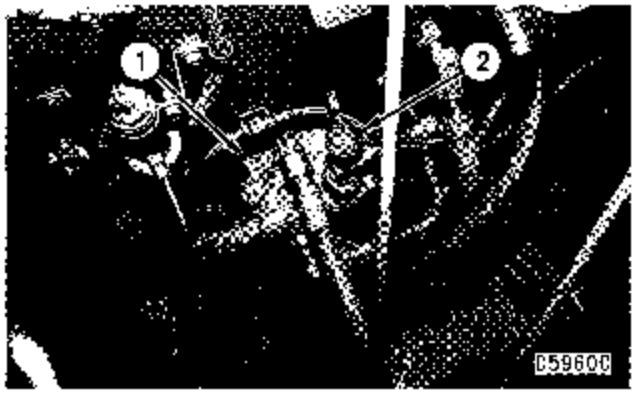
9. Continue applying the service brakes and pausing for a second or two between each brake application. Also continue counting the number of applications and observing the pressure gauge. There will be a point where the pressure drops rapidly. The point where the pressure drops off rapidly is the approximate accumulator pre-charge pressure.

10. Determine the number of brake applications that were required before the pressure dropped off rapidly in Step 9. The number of service brake applications should be approximately four to six times.

11. If the accumulator charging valve cutout pressure is not within specification, complete Steps 7 through 12 in Procedure 2. If the pre-charge pressure is not within specification, see the section Test And Charge The Accumulator.

Procedure 2

1. Stop the engine and completely remove all oil pressure from the brake circuit by this method: Engage the parking brake. Repeatedly push on the brake pedal until there is no brake pressure.



Accumulator Charging Valve Pressure Port Location
(1) Accumulator charging valve. (2) Test port.

2. Install a 0 to 20 700 kPa (0 to 3000 psi) pressure gauge to test port (2) on accumulator charging valve (1).

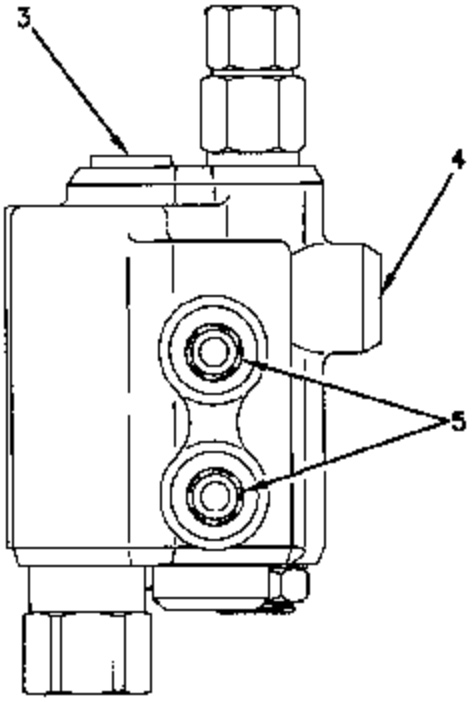
3. Look at the pressure gauge. Before the engine is started, the oil pressure must be 0 kPa (0 psi).

4. Start the engine. Look for a stop (pause) in the increase of oil pressure. Make a record of the oil pressure at this point. This is the approximate nitrogen charge (pre-charge) pressure in the accumulator. If the pre-charge pressure is not within specification, see the section Test And Charge The Accumulator.

5. The oil pressure must increase to a maximum. Make a record of this pressure also. This is the cutout pressure of the accumulator charging valve. The correct cutout pressure equals 14 485 ± 345 kPa (2100 ± 50 psi).

6. Apply the service brakes several times while the engine is running. Confirm that pressure drops consistently, and at the point of specified cut-in, the pressure begins to increase quickly.

7. If the cut-in and cutout pressures are not within specification, stop the engine and completely remove all oil pressure from the brake circuit by pushing on the brake pedal many times until there is no brake pressure. Be sure there is no residual pressure in the hydraulic oil tank by loosening the hydraulic oil tank filler cap.



Accumulator Charging Valve
(3) Adjustment cover. (4) Pressure port. (5) Accumulator ports.

8. Remove adjustment cover (3).

NOTE: The charge limits will move together. The range between the cut-in and cutout pressures is not adjustable.

9. Turn the hex plug that is located under cover (3), one quarter of a turn. Turning the hex plug clockwise will increase the cut-in and cutout pressure. Turning the hex plug counterclockwise will decrease the cut-in and cutout pressure

10. Install adjustment cover (3) on the accumulator charging valve, and tighten the hydraulic tank filler cap that was loosened in Step 7.

11. Start the machine and verify that the cut-in and cutout pressures are within specification. If they are not, repeat Steps 7 through 11.

12. If the cut-in and/or cutout pressures are not within specification, replace the accumulator charging valve assembly with a new one.

Test And Charge The Accumulator

Tools Needed: 7S-5437 Nitrogen Charging Group

⚠ WARNING

Dry nitrogen is the only gas approved for use in the accumulators. The charging of oxygen gas in the accumulator will cause an explosion. An explosion can be eliminated by using nitrogen cylinders with standard CGA (Compressed Gas Association, Inc.) No. 580 Connections. When nitrogen gas is ordered, make sure to order the cylinders with CGA No. 580 Connections.

Do not use color codes or other methods of identification to tell the difference between nitrogen and oxygen cylinders. In any application, never use an adapter to connect your nitrogen charging group to a valve outlet used on both nitrogen, oxygen, or other gas cylinders. BE SURE YOU USE DRY NITROGEN (99.8% purity).

⚠ WARNING

Make reference to the WARNINGS on the first page of the Brake System Testing And Adjusting section.

Stop the engine. Push on the brake pedal many times until there is no brake pressure. The piston in each brake accumulator must be on the bottom of the cylinder to be sure that the pressure of the nitrogen charge is correct.

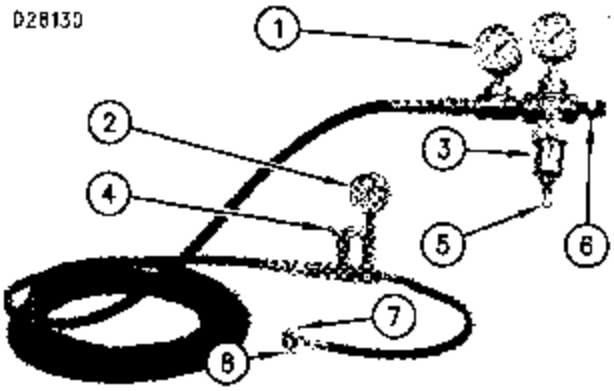
NOTE: To ensure that the nitrogen gas charge for an accumulator is correct, the accumulator piston must be at the bottom of the cylinder. Nitrogen gas pressure is variable with temperature. To obtain the most accurate nitrogen gas charge before checking or pressurizing an accumulator, the temperature of each accumulator should be the same as the air around it.

However, in some cases, the temperature of the accumulator could be higher than the temperature of the surrounding air. If this is the case, the temperature of the accumulator should be used instead of the temperature of the surrounding air.

NOTE: The pressures in the following chart are for 21°C (70°F) ambient air temperature. Adjust the pressure as required for other ambient conditions.

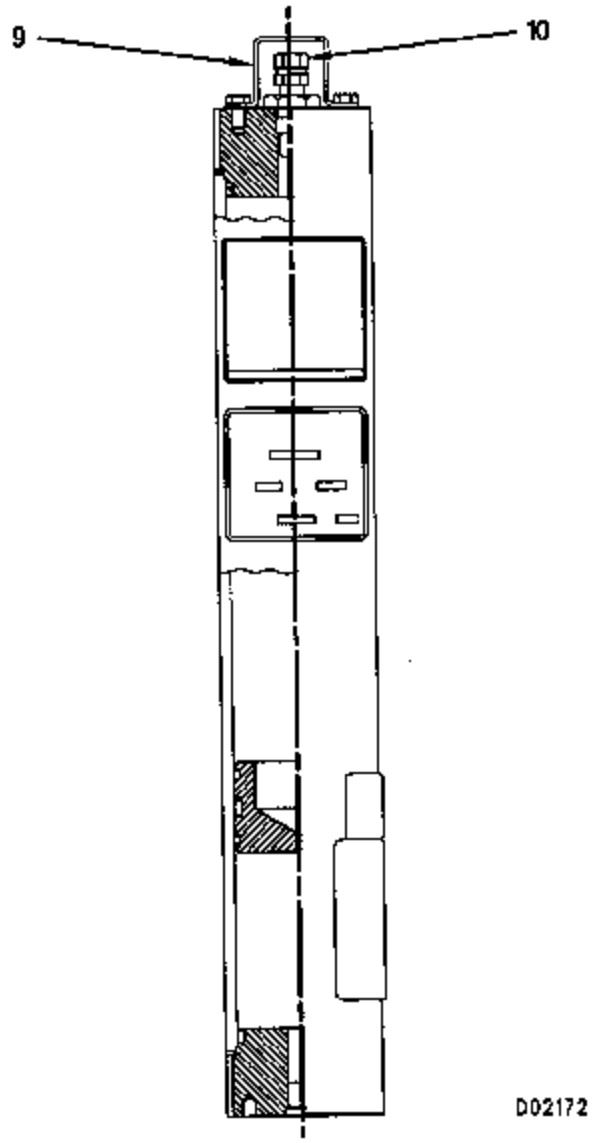
CHARGING PRESSURE AND TEMPERATURE RELATIONSHIP FOR A TYPICAL 6900 kPa (1000 psi) ACCUMULATOR	
Temperature °C (°F)	**Pressure kPa (psi)[1]**
−7 (20)	6250 (907)
−1 (30)	6380 (926)
4 (40)	6510 (945)
10 (50)	6640 (964)
16 (60)	6770 (983)
21 (70)	6900 (1000)
27 (80)	7030 (1020)
32 (90)	7160 (1039)
38 (100)	7290 (1058)
43 (110)	7420 (1077)
49 (120)	7550 (1096)

[1] Nominal allowable pressure tolerance equals ± 70 kPa (10 psi).



Nitrogen Charging Group
(1) Pressure gauge. (2) Pressure gauge. (3) Regulator assembly. (4) Valve. (5) Pressure regulating screw. (6) Connection to nitrogen cylinder valve. (7) Valve handle. (8) Chuck.

Check for Nitrogen Charge in the Accumulator



(9) Cover. (10) Cap.

NOTE: The accumulators are located behind the operator compartment under the access cover. Facing the rear of the machine, the left accumulator is for the front service brakes and the right accumulator is for the rear service brakes and the parking brake.

1. Remove cover (9) from the accumulator assembly. Remove cap (10) from the valve assembly on the accumulator.
2. Use a 0 to 13 800 kPa (0 to 2000 psi) gauge (2) to check the nitrogen charge in the accumulator.
3. Install chuck (8) on the valve of the accumulator.
4. Turn valve (7) on chuck (8) completely in (clockwise). Check the temperature of the air around the accumulator. The pressure on the gauge must be within the tolerances shown in the chart.
5. If the pressure on the gauge is too high, slowly open valve (4) to lower the pressure.
6. If the pressure on the gauge is too low, charge the accumulator as follows:

Accumulator Charge Procedure

7. Connect the hose from the nitrogen cylinder to valve (4).
8. Close valve (4) and open the valve on the nitrogen cylinder. Make an adjustment to screw (6) on the regulator assembly until gauge (1) is at the pressure needed to correctly put a charge into the accumulator. Use the chart as a reference for the correct charging pressure.
9. Open valve (4) and put a charge into the accumulator. Turn valve (4) off. If the pressure on gauge (2) is the same as gauge (1) and does not change, the accumulator has the correct charge.

If there is a decrease in pressure on gauge (2), open valve (4) and allow more nitrogen to go to the accumulator.

Perform this procedure as many times as necessary until the pressure on gauge (2) is the same as gauge (1) and does not change when valve (4) is turned off.

10. Turn off valve (4). Turn the valve on the nitrogen cylinder off.
11. Turn valve (7) on chuck (8) completely out (counterclockwise).
12. Remove the test equipment.
13. Complete this procedure for the other accumulator.

Rebuilt Accumulator Charge Procedure

It is necessary to remove all air from the nitrogen end of the accumulator. When the accumulator is rebuilt, put approximately 1.9 liters (2 quarts) of SAE 10W hydraulic oil in the nitrogen end of the accumulator. This oil will be used to help remove the air out of the nitrogen end of the accumulator and also to put a lubricant at the top seal of the accumulator piston. After the accumulator is installed on the machine, charge it as follows:

NOTICE

Low nitrogen charge can cause early pump failure because of short cycle times between the cut-in and cutout operations of the accumulator charging valve.

1. Use the same equipment as used to check the nitrogen charge in the accumulator.
2. Valve (7) on chuck (8) must be turned in completely (clockwise). Open valve (4).
3. Start the engine and allow it to run until it is warm. As oil flows into the bottom of the accumulator, the air, and then the oil, will be pushed out of the top through the test equipment. When the oil flow stops, the top of the accumulator will be free of air.
4. Close valve (4) completely.
5. Stop the engine and push the brake pedal several times. This will permit the oil pressure in the brake system to be removed. The piston in the accumulator will be at the top of the accumulator.
6. Put a charge of nitrogen in the accumulator. Follow the procedure in Steps 7 through 13 in the Accumulator Charge Procedure. The charging cycle will take longer because the piston will have to be moved to the bottom and the oil will have to be moved out of the accumulator.

Service Brake Control Valve Assembly

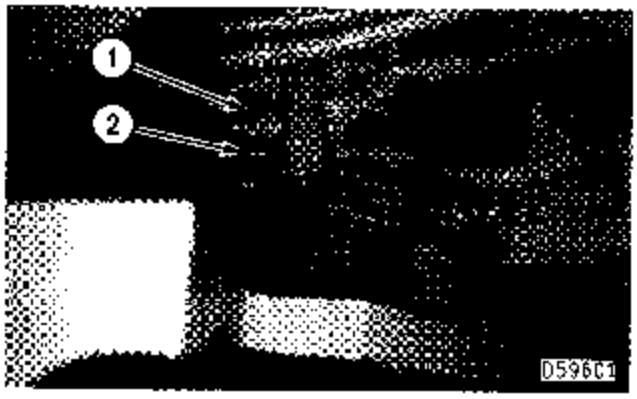
Tools Needed: 0 to 20 700 kPa (0 to 3000 psi) pressure gauge.

⚠ WARNING

Personal injury or death can result if two persons are not used in the following procedure.

Make reference to the WARNINGS on the first page of the Testing And Adjusting section.

1. Stop the engine, move the transmission control switch to neutral, and engage the parking brake.
2. Completely remove all oil pressure from the brake circuit by pushing on the brake pedal many times.



Typical View Of Service Brake Control Valve
(1) Brake test port for rear service brakes. (2) Brake test port for front service brakes.

3. Remove the protective cap from test port (2) on the brake control valve to check the brake pressure for the front service brakes. Install a 0 to 20 700 kPa (0 to 3000 psi) pressure gauge.
4. Look at the pressure gauge. Before the engine is started, the oil pressure must be 0 kPa (0 psi).
5. Start the engine and allow the hydraulic oil to reach normal operating pressure and temperature.
6. Depress and hold down either brake pedal assembly and look at the gauge. The correct brake pressure is 6900 ± 350 kPa (1000 ± 50 psi).
7. If the brake pressure is not in this range, but the accumulator charging valve tested correctly, replace the brake control valve assembly with a new one.

8. Repeat this procedure for testing the pressure at test port (1) for the rear service brakes on the 814F Wheel Tractor.

NOTE: Pressure from the upper brake port should be approximately 350 kPa (50 psi) higher than the pressure from the lower brake port.

Service Brake Test Procedure

⚠ WARNING

Personal injury can result if the machine moves while testing.

If the machine begins to move during a test, reduce the engine speed immediately and engage the parking brake.

Make reference to the WARNING on the first page of the Brake System Testing And Adjusting section.

NOTE: Be sure to use the correct oil viscosity in the hydraulic system according to ambient temperature and operating conditions. To determine the correct oil viscosity, see "Lubricant Viscosities And Refill Capacities" in the Lubrication Specification section in SEBU6955, 814F Wheel Tractor, 815F Soil Compactor and 816F Landfill Compactor Operation And Maintenance Manual.

Be sure the area around the machine is clear of personnel and obstructions.

Be sure the steering frame lock link is in the stored position.

Test the service brakes on a dry, level surface.

Fasten the seat belt before testing the brakes.

1. Start the engine, and raise the dozer blade slightly.
2. Place the transmission neutralizer switch in the OFF position.
3. Apply the service brake and release the parking brake.
4. Move the transmission to second speed forward.
5. Gradually increase the engine speed to high idle. The machine should not move.
6. Reduce the engine speed to low idle, move the transmission control lever to NEUTRAL. Engage the parking brake, lower the dozer blade to the ground and stop the engine.

NOTICE

If the machine moved while testing the service brakes, inspect and repair the service brake components as required before returning the machine to service.

Service Brake Disc Thickness And Groove Depth Check

It is recommended that grooves on both sides of each disc in both the front and rear brakes be checked. This is necessary because wear may vary from one end of the machine to the other, and from one side of the machine to the other. The chart shows the estimated wear remaining for a given groove depth.

Also, it is very important to change the friction discs as soon as possible once the groove depth has reached the maximum wear limit. As the depth of the grooves is reduced, the flow of the cooling oil is reduced. This causes heat to build up and cause the disc material to wear much more rapidly. Eventually, the friction material will wear off the disc and cause metal to metal contact (spalling) between the disc and reaction plates.

The combination of the friction material debris in the oil and the spalling, will ruin the very smooth surface finish of the plate. This will make replacement of these brake components necessary.

If the failure has progressed to metal to metal contact, the complete axle must be thoroughly cleaned. If the cleaning process is not done correctly, the debris will continue to contaminate the oil and cause the brake material to wear more quickly. This will cause premature failure of the brakes.

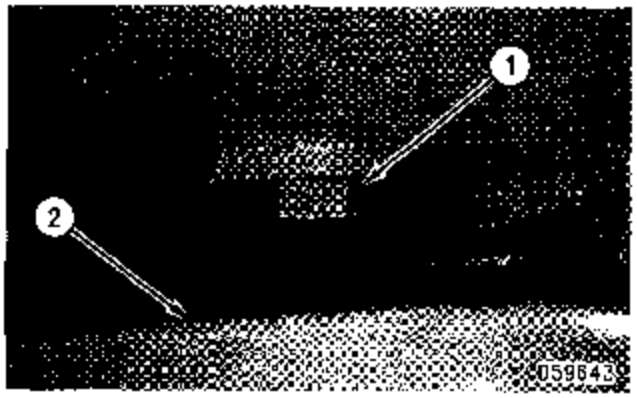
Brake service life expectancy can vary greatly because of the extremes in applications. If brake system service life is less than expected, there are several things that could be at fault. The first is water and debris. Water and debris can enter the axle through the lip seal at the drive yoke. If this occurs, the water and debris can mix with the oil that cools and lubricates the brakes and damage the seals in the axle.

Another possibility is a plugged breather. The breather should be checked for mud packing, damage, or any other condition that could keep it from venting correctly.

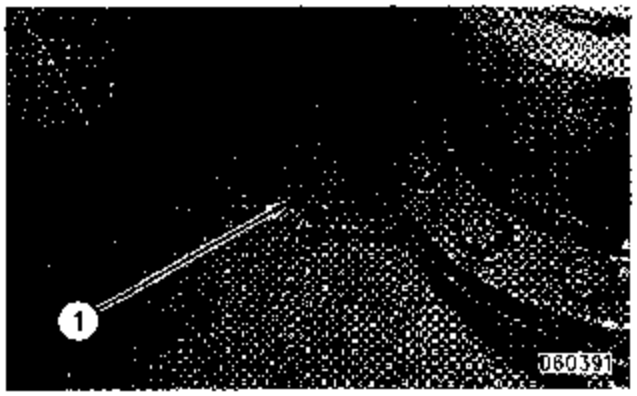
Check for oil leaks at the yoke and drive axle areas. A leak can also allow contamination from water and debris to occur.

Excessive heat is another problem, and can be generated if the brakes are used as a retarder or a torque stalling device, to maintain a slower than normal ground speed. This type of operation should be avoided by using a lower transmission gear range.

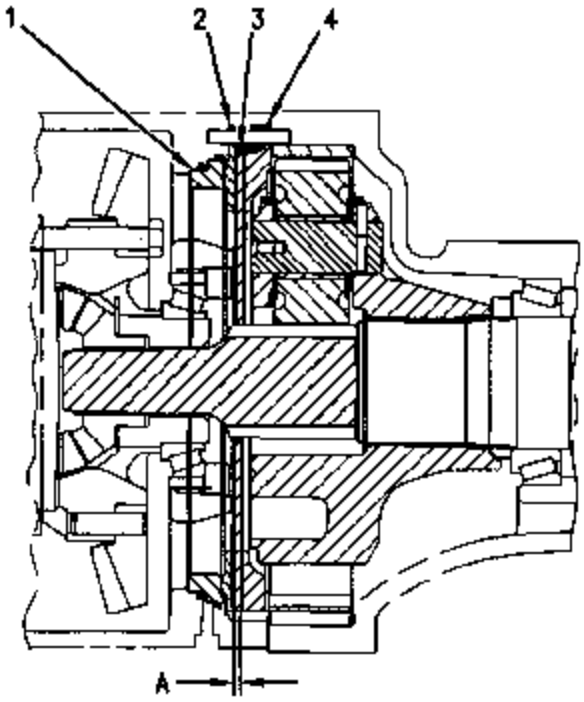
If excessive or premature wear is suspected, it could be beneficial to get an S•O•S report prior to machine tear down. This will help to establish a possible cause or remedy to the problem.



Service Brake Disc Left Inspection Port (Front Axle)
Viewed from beneath machine looking up.
(1) Inspection port. (2) Guard.

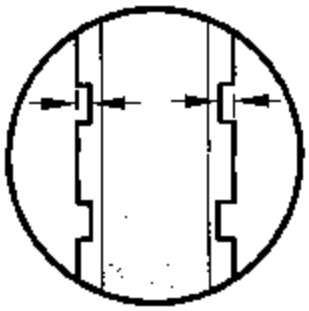


Service Brake Disc Left Inspection Port (Front Axle)
Viewed from beneath machine looking up, guard removed.
(1) Inspection port.



Service Brake Disc
(A) Thickness of a disc. (1) Piston. (2) Plate. (3) Disc. (4) Plate.

1. The minimum thickness (A), of disc (3) worn, equals 7.65 mm (.301 in). The thickness (A) of disc (3) new, equals 9.10 ± 0.13 mm (.358 ± .005 in). Service the brake before the thickness (A) of disc (3) is less than 7.65 mm (.301 in).



Measuring Depth Of Brake Disc Oil Grooves

NOTE: Groove depth is the most critical dimension. If the depth of the grooves on the brake discs are too shallow or nonexistent, oil flow will be inadequate and cause excessive wear and abrasion. See the chart.

2. Using a wire gauge, measure the depth of the oil grooves on BOTH sides of each service brake disc in each service brake axle housing.

3. The depth of the oil grooves must be greater than 0.32 mm (.013 in).

Disc Thickness Wear Chart		
Estimated Percent Of Disc Life Remaining	Disc Thickness mm (in)	Disc Groove Depth[1] mm (in)
100	9.10 (.358)	1.05 (.041)
80	8.81 (.347)	0.90 (.036)
60	8.52 (.335)	0.76 (.030)
40	8.23 (.324)	0.61 (.024)
20	7.94 (.313)	0.47 (.018)
0	7.65 (.301)	0.32 (.013)

[1] Groove depth is the most critical measurement.

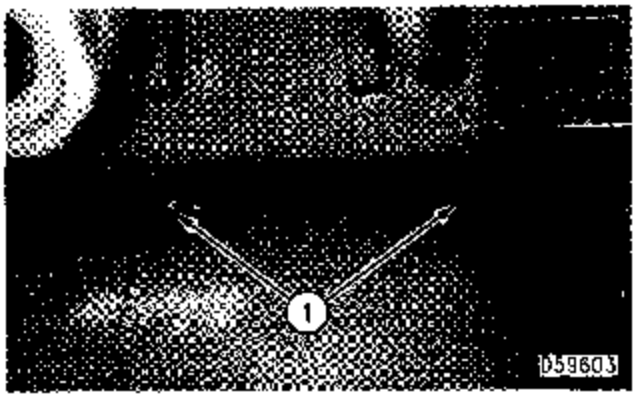
Remove Air From Brake System (Bleed The Brakes)

⚠ WARNING

Personal injury or death can result if two persons are not used in the following procedure.

Make reference to the WARNINGS on the first page of the Testing And Adjusting section.

The four bleeder screws for the service brakes are located on the top of the corresponding differential housing.



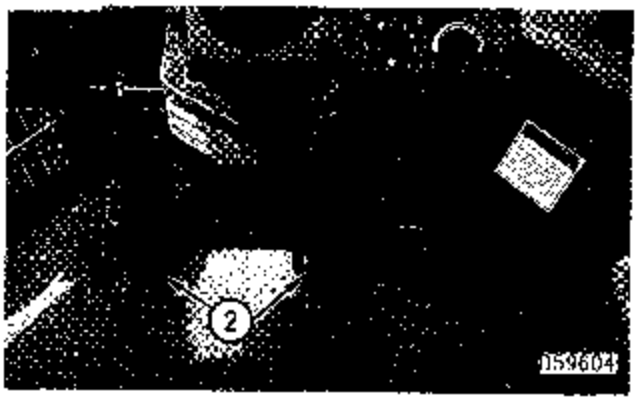
Typical Location Of The Bleeder Screws For Front Service Brakes.
(1) Bleeder screw.
The location of the bleeder screws for the rear service brakes is similar.

Perform the following procedure for each service brake.

1. Check the hydraulic tank oil level. Keep the tank full all through the air removal procedure.

2. Start the engine and allow the oil pressure to increase to the cutout pressure. Stop the engine.

3. Fasten one end of a 6.4 mm (.25 in) diameter clear (transparent) hose to bleeder screw (1) for one of the service brakes. Put the other end of the hose in a container to collect the oil. Loosen bleeder screw (1).



Service Brake Pedal Locations
(2) Service brake pedals.

4. Instruct the operator to slowly push and hold a brake pedal down until brake oil flows out of the bleeder screw.

5. The hydraulic oil in the brake system will flow out of the bleeder screw, through the tube, and into the container. Look for air bubbles in the oil. Continue to allow the oil to flow into the container until no air is visible in the oil from bleeder screw (1).

6. When there are no air bubbles visible in the oil flowing through the tube and into the container, tighten bleeder screw (1).

7. Complete this procedure for each service brake, but bleed only one service brake at a time. Be sure to tighten bleeder screw (1) when finished with Step 6.

8. Fill the hydraulic tank if required.

NOTE: If the service brakes feel soft (spongy) during application in the first few hours of operation, perform the air removal procedure again.

Parking Brake Test Procedure

⚠ WARNING

Personal injury can result if the machine moves while testing.

If the machine begins to move during the test, reduce the engine speed immediately and engage the service brakes.

Make reference to the WARNING on the first page of the Brake System Testing And Adjusting section.

Be sure the area around the machine is clear of personnel and obstructions.

Be sure the steering frame lock link is in the stored position.

Test the brakes on a dry, level surface.

Fasten the seat belt before performing the following brake test.

1. Start the engine, and raise the dozer blade slightly.

NOTE: The following step will produce a Category 3 warning. The parking brake indicator light will come on, the action lamp will flash, and the action alarm will sound.

2. With the parking brake engaged, move the transmission to third speed forward.

3. Gradually increase the engine speed to high idle. The machine should not move.

4. Reduce the engine speed, move the transmission to NEUTRAL. Lower the dozer blade to the ground, and stop the engine.

NOTICE

If the machine moved while testing the parking brake, inspect and repair the parking brake components as required before returning the machine to service.

Troubleshooting

This section provides probable causes to a known problem. Since there may be several probable causes, specific inspections or instrument tests may be recommended. These inspections and tests will help identify which of the causes is most probable.

NOTE: Be sure to use the correct oil viscosity in the hydraulic system according to ambient temperature and operating conditions. To determine the correct oil viscosity, see "Lubricant Viscosities And Refill Capacities" in the Lubrication Specification section in SEBU6955, 814F Wheel Tractor, 815F Soil Compactor and 816F Landfill Compactor Operation And Maintenance Manual.

Problem List

Service Brake Problem List

1. Front service brakes do not operate.
2. Rear service brakes do not operate.
3. Service brakes slip.
4. Service brake application is not smooth.
5. Too much force needed to push brake pedals.

Parking Brake Problem List

Parking brake does not hold.

Service Brake Problems

Problem 1: Front service brakes do not operate.

Probable Cause:

1. Accumulator (left accumulator) damaged or faulty.
2. Damaged or worn seal in internal brake line or brake group.
3. Damaged or failed accumulator charging valve assembly.
4. Damaged or failed brake pump.
5. Damage to the brake group within the carrier.

Problem 2: Rear service brakes do not operate.

Probable Cause:

1. Accumulator (right accumulator) damaged or faulty.
2. Damaged or worn seal in internal brake line or brake group.
3. Damaged or failed accumulator charging valve assembly.
4. Damaged or failed brake pump.
5. Damage to the brake group within the carrier.

Problem 3: Service Brakes Slip.

Probable Cause:

1. Damaged or worn seal in internal brake line or brake group.
2. Worn brake disc in the carrier.

Problem 4: Service brake application is not smooth.

Probable Cause:

1. Air in the hydraulic fluid to the brake group within the carrier.
2. Excessive wear on a brake disc and associated components in the carrier.
3. Sticking or damaged brake valve assembly caused by contaminated oil.

Problem 5: Too much force needed to push brake pedals.

Probable Cause:

1. Damage to the brake pedals and pedal linkages.
2. Hydraulic pump output too low or with no pressure.
3. Sticking or damaged brake valve assembly caused by contaminated oil.

Parking Brake Problems

Problem: Parking brake does not hold.

Probable Cause:

1. Parking brake needs adjustment.
2. Too much wear on the brake linings.
3. Grease or oil on brake drum and lining.

CATERPILLAR®

SENR1315
February 1996

Specifications

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Hydraulic System

814F	815F	816F
9DM1-UP	1GN1-UP	5FN1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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Introduction

When the words "use again" are in the description, the specification given can be used to determine if a part can be used again. If the part is equal to or within the specification given, use the part again.

When the word "permissible" is in the description, the specification given is the "maximum or minimum" tolerance permitted before adjustment, repair and/or new parts are needed.

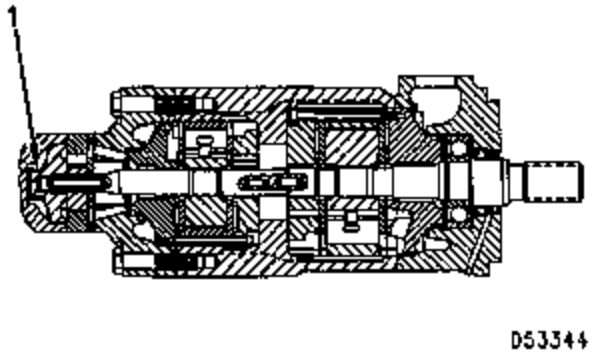
A comparison can be made between the measurements of a worn part and the specifications of a new part to find the amount of wear. A part that is worn can be used if an estimate of the remainder of its service life is good. If a short service life is expected, replace the part.

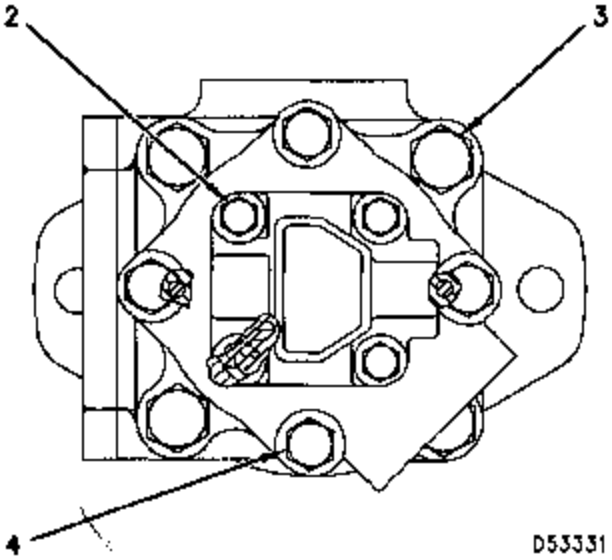
REFERENCE: For Systems Operation and Testing and Adjusting make reference to SENR1316, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Hydraulic System, Testing & Adjusting.

Specifications

814F & 816F Implement, Steering And Pilot Systems Hydraulic Pump

121-3409





Rotation is counterclockwise when seen from drive end.

Type of pump: Vane

For test, use SAE 10W oil at 65°C (150°F).

(1) 1U-2816 Spring:
- Length under test force ..... 14.7 mm (.579 in)
- Test force ..... 192 ± 14 N (43.1 ± 3.1 lb)
- Free length after test ..... 29.7 mm (1.170 in)
- Outside diameter ..... 29.65 ± 0.52 mm (1.167 ± .020 in)

(2) Torque for four bolts ..... 55 ± 7 N•m (40 ± 5 lb ft)

(3) Torque for four bolts ..... 203 ± 14 N•m (150 ± 10 lb ft)

(4) Torque for four bolts ..... 95 + 7 N•m (70 ± 5 lb ft)

Drive End Section (Steering)

Test at Full Speed:

Output ..... 144 liter/min (38 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Output ..... 130 liter/min (34 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 72 liter/min (19 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Output ..... 65 liter/min (17 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Center Section (Implement)

Test at Full Speed:

Output ..... 112 liter/min (29 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Output ..... 101 liter/min (26 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 2000 rpm
- With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 56 liter/min (15 U.S. gpm)
- At a pressure of ..... 690 kPa (100 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Output ..... 50 liter/min (13 U.S. gpm)
- At a pressure of ..... 6900 kPa (1000 psi)
- With pump at ..... 1000 rpm
- With engine at ..... 1100 rpm

Cover End Section (Pilot)

Test at Full Speed:

Output ..... 24 liter/min (6.5 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 21 liter/min (5.5 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

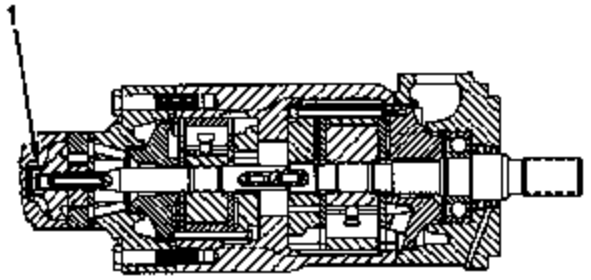
Output ..... 12 liter/min (3 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

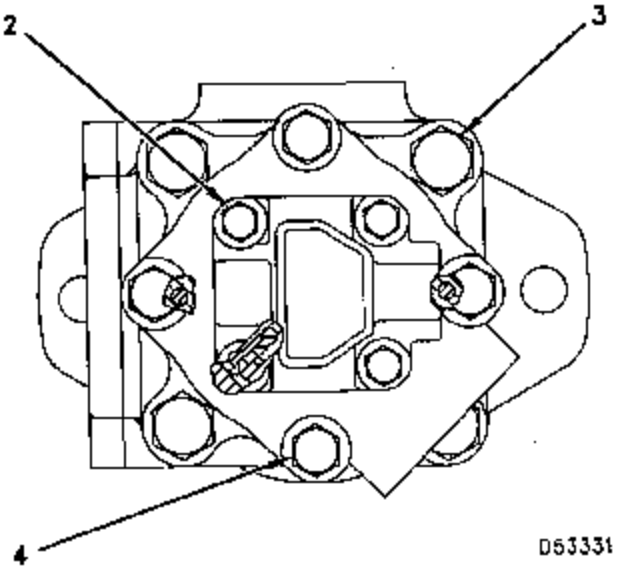
Output ..... 10 liter/min (2.6 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

NOTE: Discharge and drain flows must be teed together to measure flow correctly.

815F Implement, Steering And Pilot Systems Hydraulic Pump

123-6785





Rotation is counterclockwise when seen from drive end.

Type of pump: Vane

For test, use SAE 10W oil at 65°C (150°F).

(1) 1U-2816 Spring:
Length under test force ..... 14.7 mm (.579 in)
Test force ..... 192 ± 14 N (43.1 ± 3.1 lb)
Free length after test ..... 29.7 mm (1.170 in)
Outside diameter ..... 29.65 ± 0.52 mm (1.167 ± .020 in)

(2) Torque for four bolts ..... 55 ± 7 N•m (40 ± 5 lb ft)

(3) Torque for four bolts ..... 203 ± 14 N•m (150 ± 10 lb ft)

(4) Torque for four bolts ..... 95 ± 7 N•m (70 ± 5 lb ft)

Drive End Section (Steering)

Test at Full Speed:

Output ..... 144 liter/min (38 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 130 liter/min (34 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 72 liter/min (19 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 65 liter/min (17 U.S. gpm)

At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Center Section (Implement)

Test at Full Speed:

Output ..... 76 liter/min (20 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 68 liter/min (18 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

Output ..... 38 liter/min (10 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 34 liter/min (9 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Cover End Section (Pilot)

Test at Full Speed:

Output ..... 24 liter/min (6.5 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Output ..... 21 liter/min (5.5 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 2000 rpm
With engine at ..... 2200 rpm

Test at Half Speed:

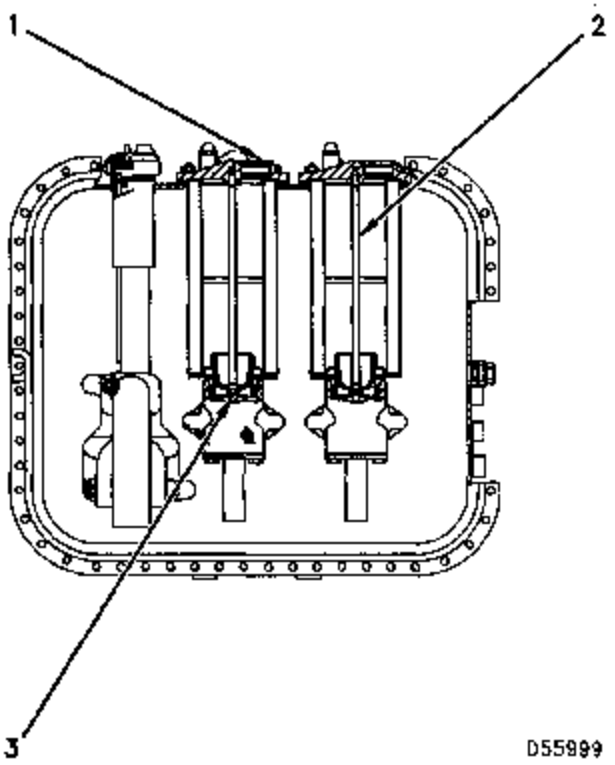
Output ..... 12 liter/min (3 U.S. gpm)
At a pressure of ..... 690 kPa (100 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

Output ..... 10 liter/min (2.6 U.S. gpm)
At a pressure of ..... 6900 kPa (1000 psi)
With pump at ..... 1000 rpm
With engine at ..... 1100 rpm

NOTE: Discharge and drain flows must be tied together to measure flow correctly.

Filter And Tank Group

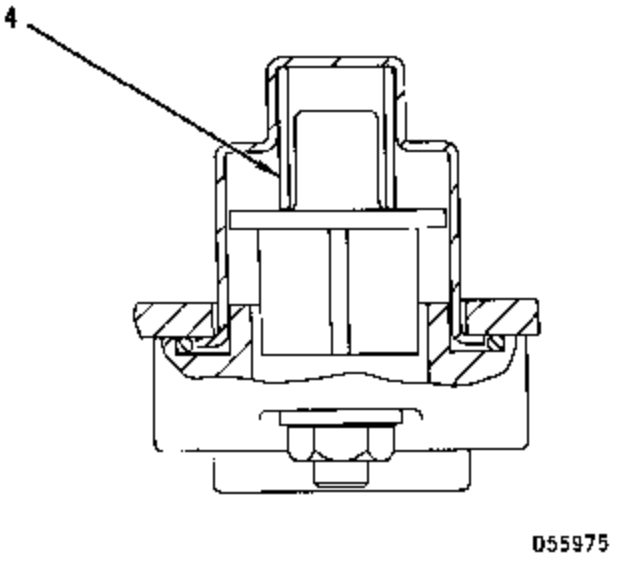
9T-8409



(1) Torque for two plugs ..... 45 ± 7 N•m (33 ± 5 lb ft)

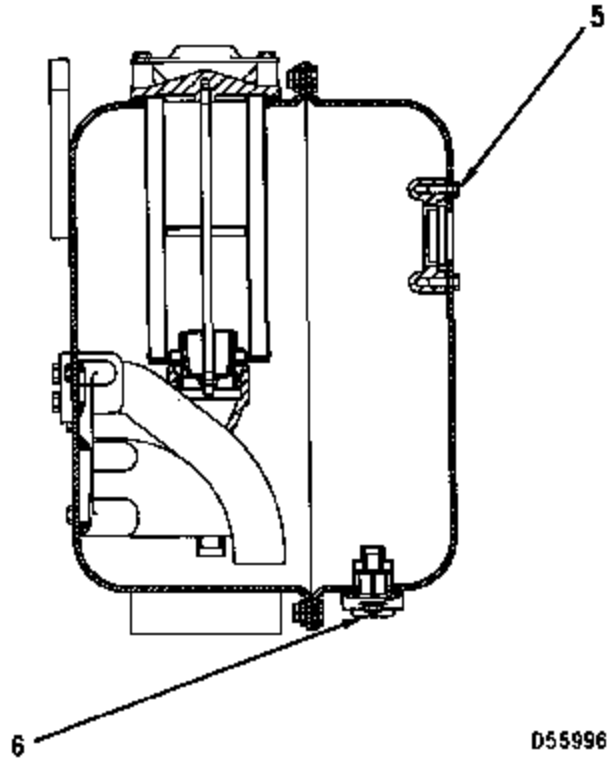
(2) Torque for two studs ..... 35 ± 5 N•m (25 ± 4 lb ft)

(3) Torque for two locknuts ..... 10 ± 1.5 N•m (7 ± 1 lb ft)



(4) 7B-3039 Spring for drain valve.

Length under test force	26.2 mm (1.03 in)
Test force	14.3 to 16.8 N (3.22 to 3.78 lb)
Free length after test	36.6 mm (1.44 in)
Outside diameter	19.8 mm (.781 in)



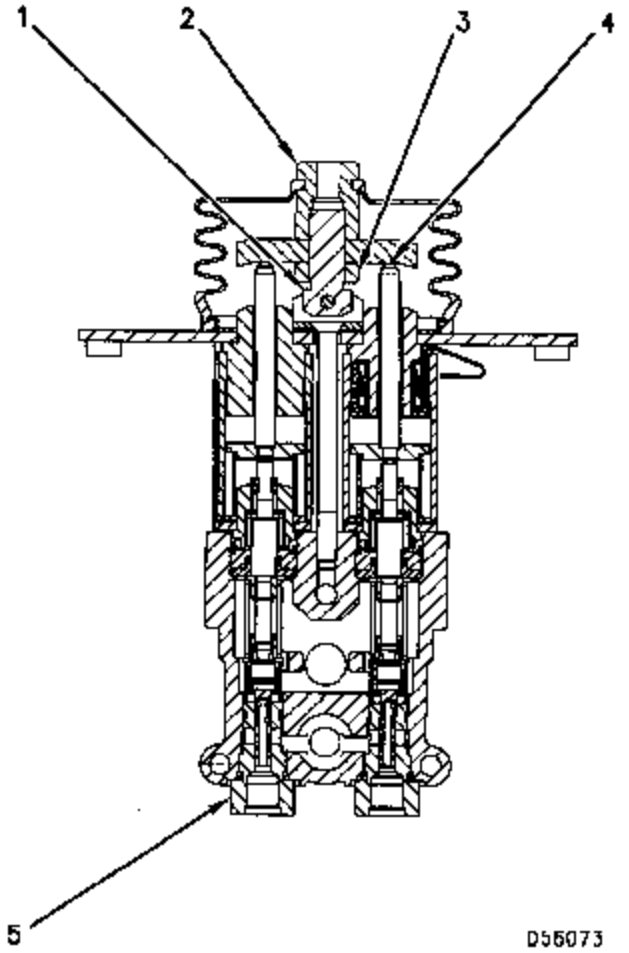
(5) Torque for sight glass screws ..... 30 ± 7 N•m (22 ± 5 lb ft)

(6) Torque for drain plug ..... 68 ± 7 N•m (50 ± 5 lb ft)

Pilot Control Valves

Lift Pilot Control Valve

815F & 816F – 122-1748



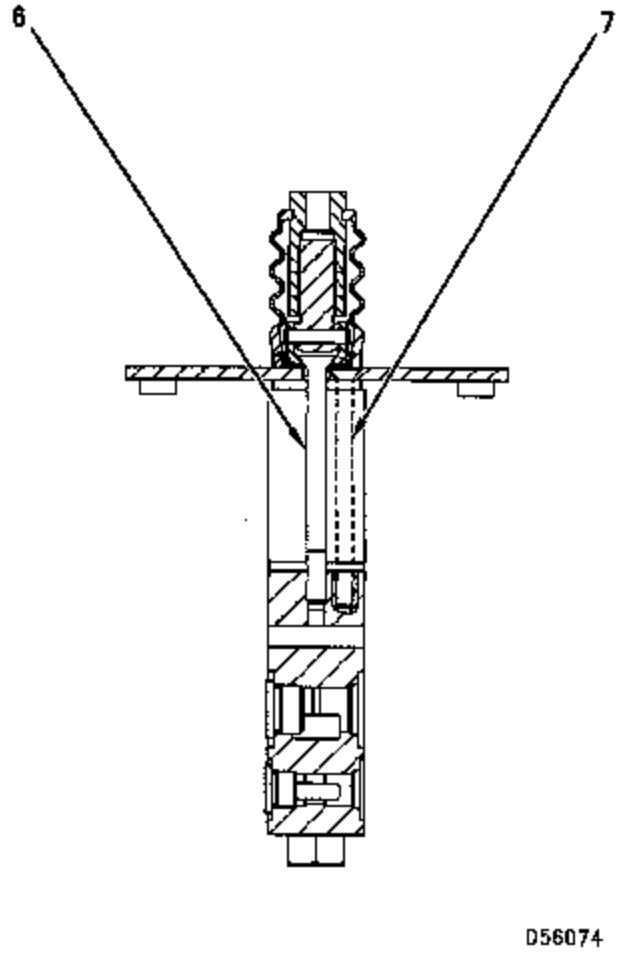
(1) Apply 9S-3263 sealant to top three threads.

(2) Torque for control lever nut ..... 100 ± 20 N•m (75 ± 15 lb ft)

(3) Torque for pivot plate (jam nut) ..... 160 ± 30 N•m (120 ± 20 lb ft)

(4) Lubricate pin joint and plunger contact area with 5P-0960 grease.

(5) Torque for two valve groups (metering capsule assembly) ..... 45 ± 9 N•m (35 ± 7 lb ft)



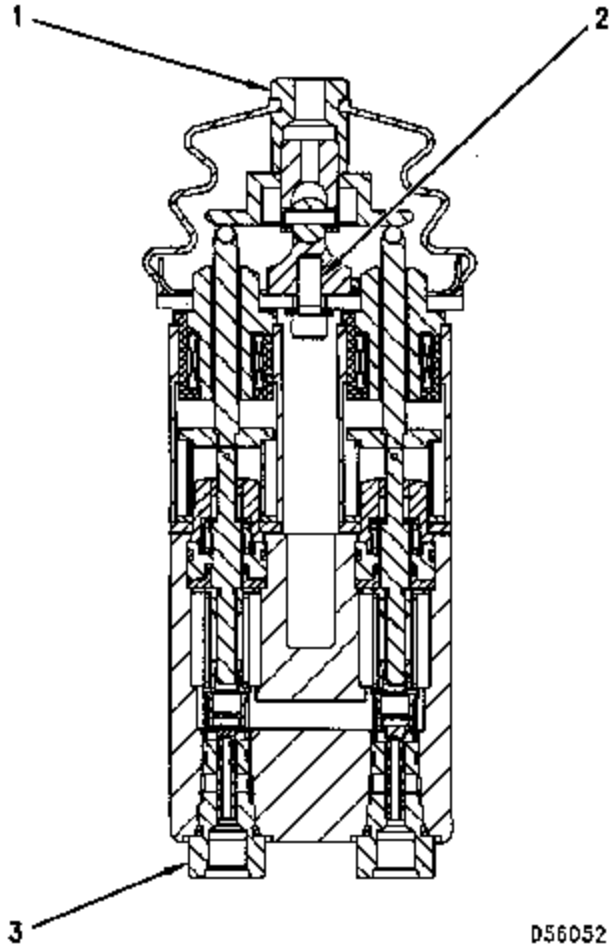
(6) Apply 7M-7260 sealant to screw threads and torque to ..... 15 ± 3 N•m (9.5 ± 2.5 lb ft)

(7) Torque for screw ..... 5.5 ± 1.5 N•m (6 ± 1.5 lb ft)

Lift & Tilt Pilot Control Valve

814F – 107-9597

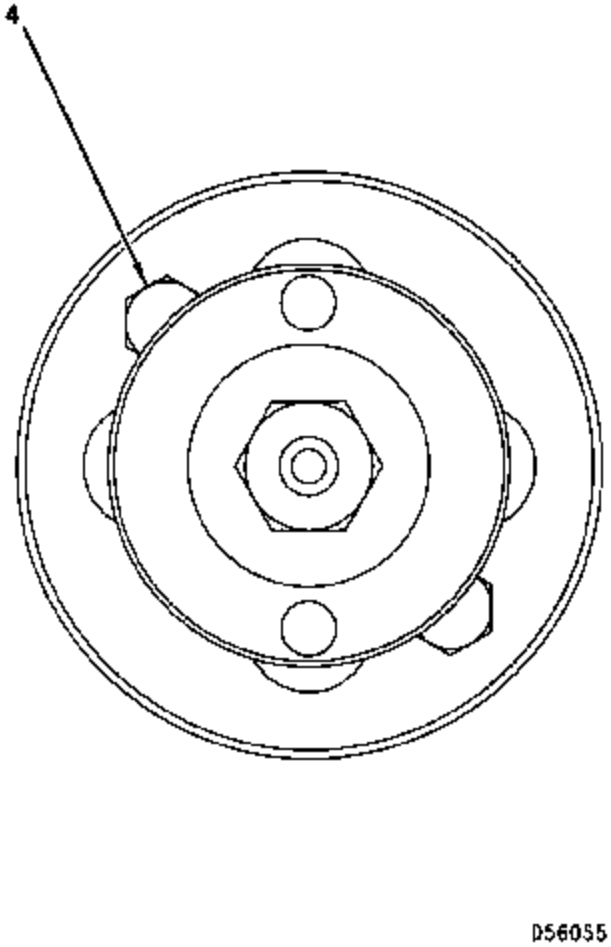
815F – 6E-2094



(1) Torque for control lever nut ..... 65 ± 12 N•m (45 ± 9 lb ft)

(2) Apply 7M-7260 sealant to threads and torque bolt to ..... 10 ± 2 N•m (9.5 ± 2.5 lb ft)

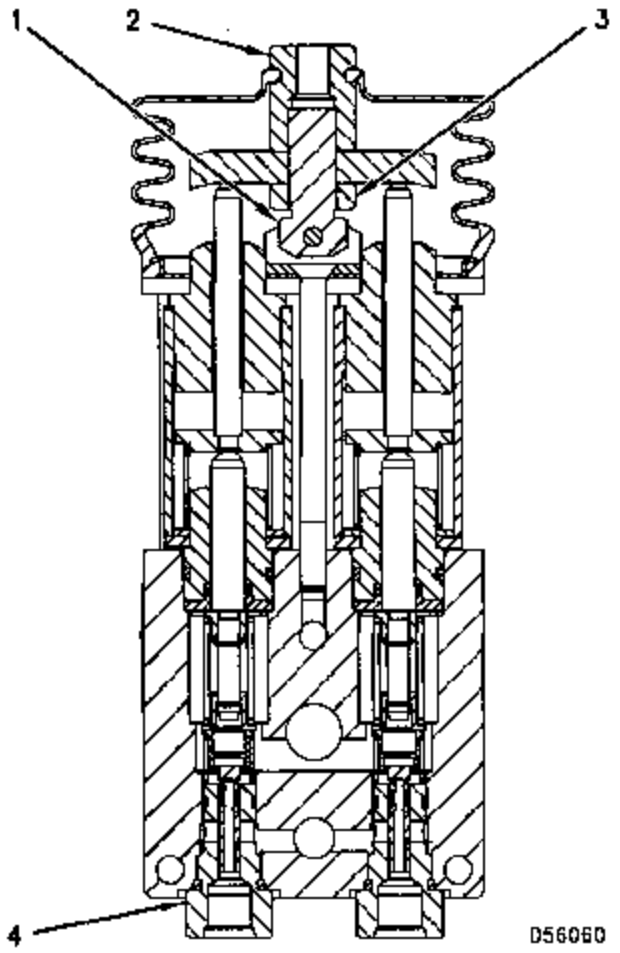
(3) Torque for two valve groups (metering capsule assembly) ..... 45 ± 9 N•m (35 ± 7 lb ft)



(4) Torque for two bolts ..... 20 ± 5 N•m (15 ± 3.5 lb ft)

Tip Pilot Control Valve

814F – 108-3927

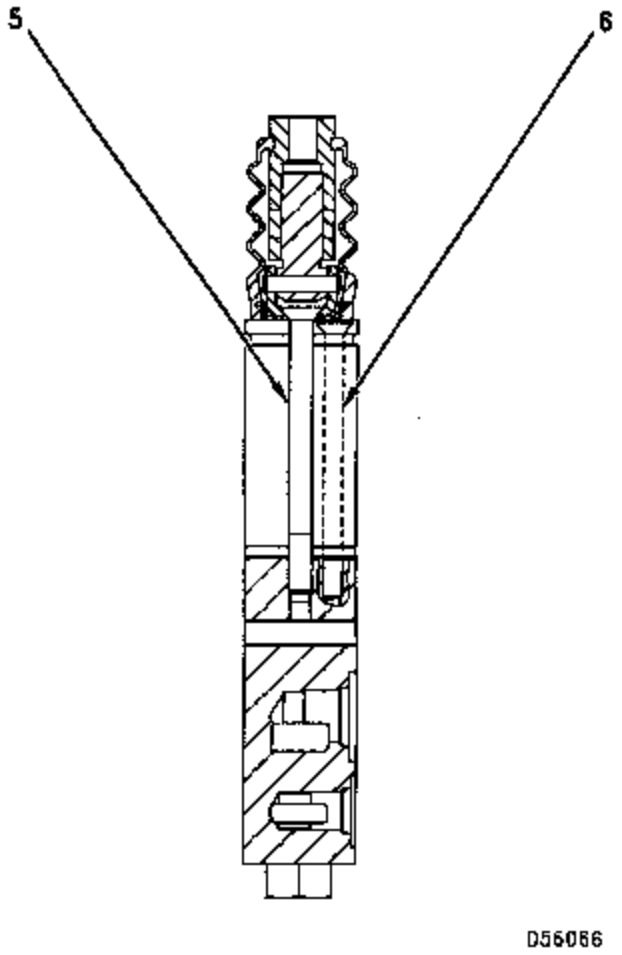


(1) Apply 9S-3260 sealant to top three threads.

(2) Torque for control lever nut .... 100 N•m ± 20 (75 ± 15 lb ft)

(3) Torque for pivot plate (jam nut) ..... 160 ± 30 N•m (120 ± 20 lb ft)

(4) Torque for two valve groups (metering capsule assembly) .... 45 ± 9 N•m (35 ± 7 lb ft)



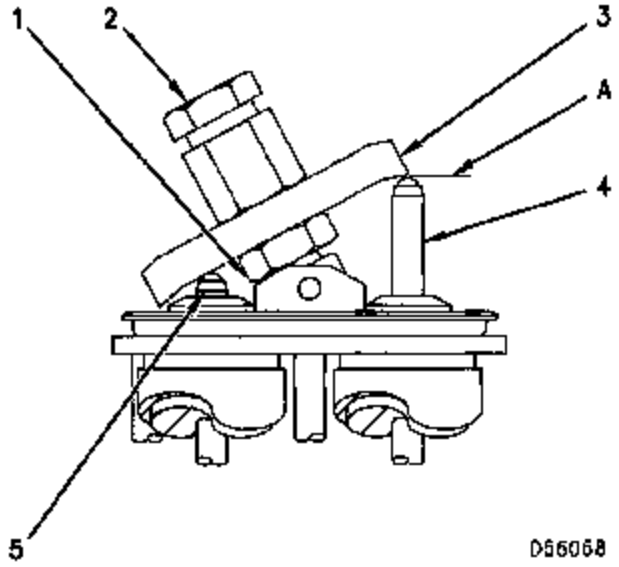
(5) Apply 7M-7260 sealant to screw threads and torque to ..... 15 ± 3 N•m (9.5 ± 2.5 lb ft)

(6) Torque for screw ..... 5.5 ± 1.5 N•m (6 ± 1.5 lb ft)

Pivot Plate Adjustment

814F – 108-3927

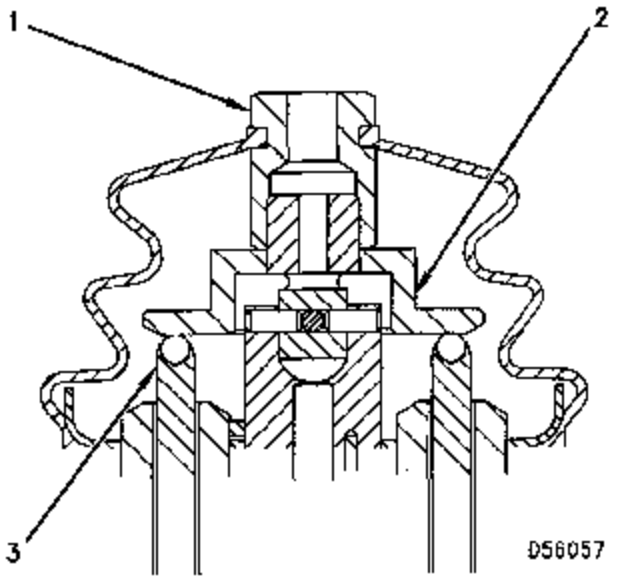
815F & 816F – 122-1748



1. Move pilot control lever to fully stroke the pilot valve.
2. Adjust jam nut (1) and lever nut (2) to obtain dimension A between pivot plate (3) and plunger (4).
   Dimension A ..... 0.13 to 0.75 mm (.005 to .030 in)
3. Move pilot control lever to fully stroke the pilot valve in opposite direction.
4. Check dimension A between pivot plate (3) and plunger (5). If necessary, Adjust nuts (1) and (2) to maintain dimension A on both sides of the pilot valve.

814F – 107-9597

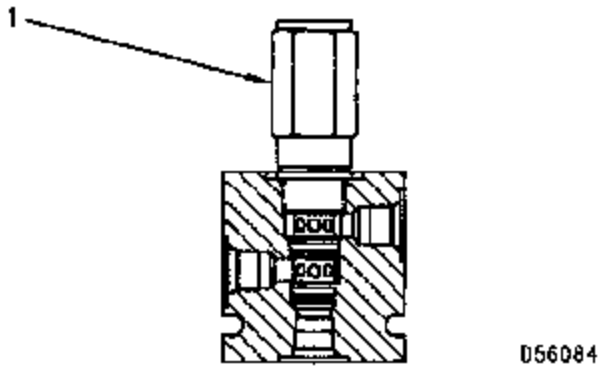
815F – 6E-2094



1. Loosen control lever nut (1).
2. Advance pivot plate (2) to contact all plungers (3).
3. Back off pivot plate one-eighth of a turn and tighten control lever nut (1).

Pilot Oil Pressure Reducing Valve

9U-3346

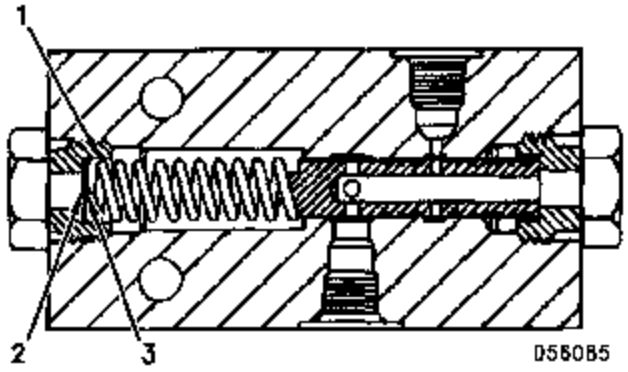


(1) Torque for valve to body ..... 50 ± 3 N•m (37 ± 2 lb ft)

Output ..... 11.4 liter/min (3 U.S. gpm)
At a reduced pressure of ..... 2410 ± 140 kPa (350 ± 20 psi)

Pressure Control And Selector Valve

1U-2226



(1) 7S-8553 Spring:
Color code ..... blue stripe
Length under test force ..... 44.07 mm (1.735 in)
Test force ..... 267 ± 21 N (60.0 ± 4.8 lb)
Free length after test ..... 50.55 mm (1.990 in)
Outside diameter ..... 14.27 mm (.562 in)

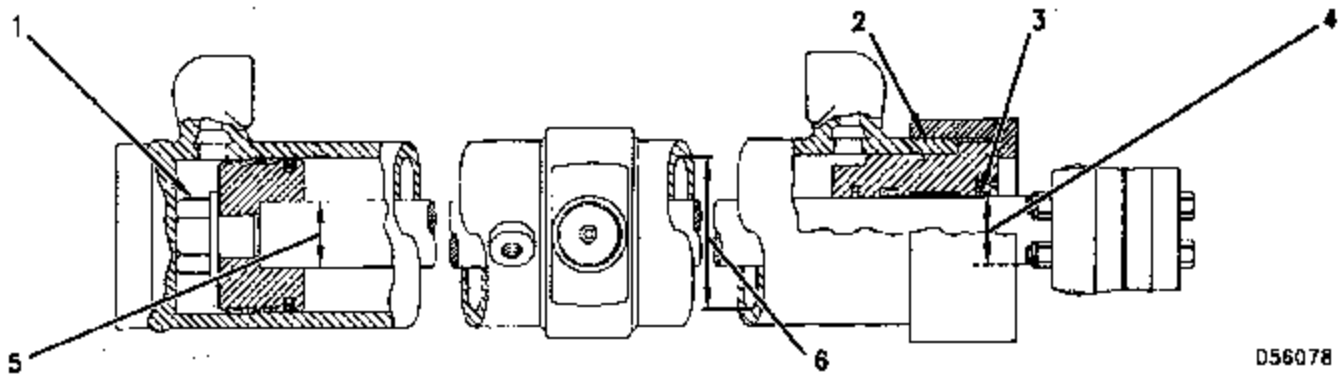
(2) 5S-7001 Spacer:
Thickness ..... 0.9 mm (.035 in)

(3) 5S-7018 Spacer:
Thickness ..... 0.25 mm (.010 in)

Use spacers (2) to obtain an assembled load of ... 200 ± 10 N (45 ± 2 lb)

Lift Cylinders

814F & 816F – 1U-2068



(1) Lubricate threads and torque bolt to .... 3600 ± 360 N•m (2650 ± 265 lb ft)

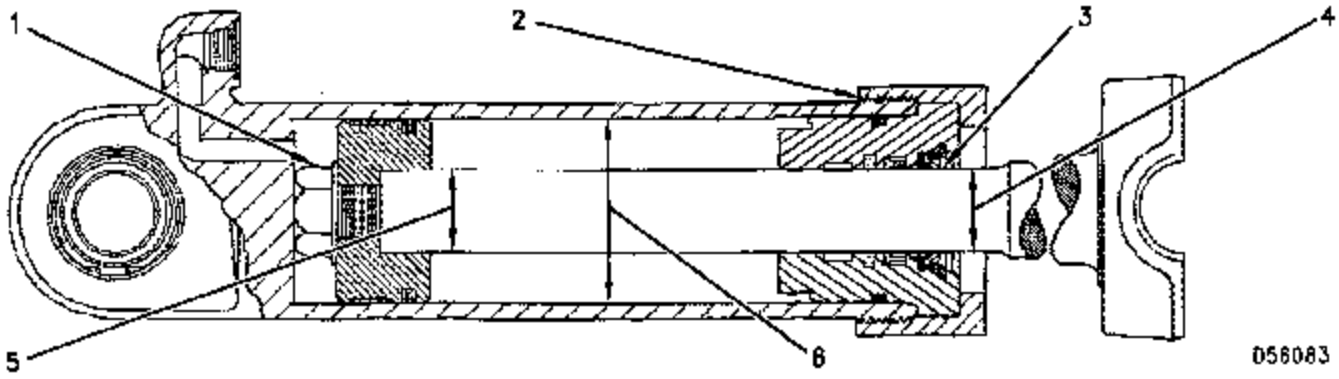
(2) Put lubricant on head and crown. Tighten to ..... 475 + 270 - 0 N•m (350 + 200 - 0 lb ft)

(3) Lubricate sealing lips with a small amount of oil being sealed.

(4) Bore of head (new) .... 63.78 ± 0.03 mm (2.511 ± .001 in)

(5) Diameter of rod (new) ..... 63.450 ± 0.038 mm (2.498 ± .001)

(6) Bore of cylinder (new) .... 120.65 + 0.13 - 0.05 mm (4.750 + .005 - .002 in)



(1) Lubricate threads and torque bolt to .... 1100 ± 110 N•m (800 ± 80 lb ft)

(2) Put lubricant on head and crown. Tighten to ..... 475 + 270 - 0 N•m (350 + 200 - 0 lb ft)

(3) Lubricate sealing lips with a small amount of oil being sealed.

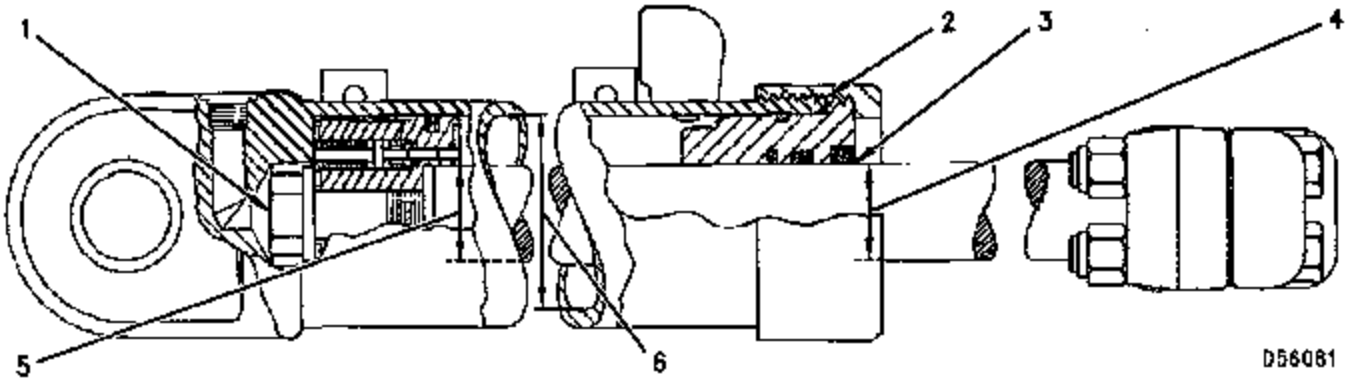
(4) Bore of head (new) .... 51.08 ± 0.03 mm (2.011 ± .001 in)

(5) Diameter of rod (new) .... 50.750 ± 0.038 mm (1.998 ± .001)

(6) Bore of cylinder (new) ..... 101.60 + 0.13 - 0.05 mm (4.000 + .005 - .002 in)

Tilt Cylinders

814F – 1U-2137



(1) Lubricate threads and torque bolt to ... 1080 ± 108 N•m (790 ± 80 lb ft)

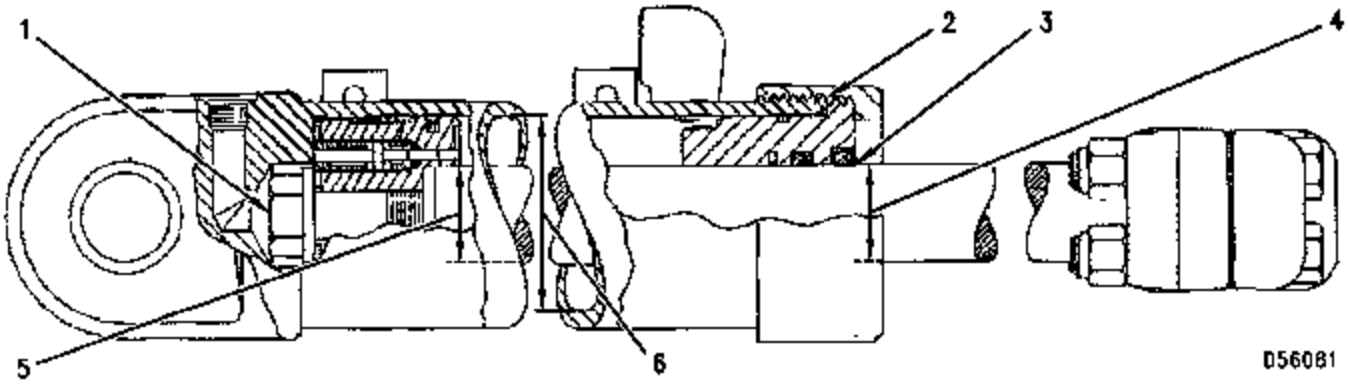
(2) Put lubricant on head and crown. Tighten to ..... 475 + 270 - 0 N•m (350 + 200 - 0 lb ft)

(3) Lubricate sealing lip with a small amount of oil being sealed.

(4) Bore of head (new) ... 50.88 ± 0.02 mm (2.003 ± .001 in)

(5) Diameter of rod (new) ..... 50.750 ± 0.038 mm (1.998 ± .001)

(6) Bore of cylinder (new) ..... 114.3 + 0.13 - 0.05 mm (4.500 + .005 - .002 in)



(1) Lubricate threads and torque bolt to .... 1080 ± 108 N•m (790 ± 80 lb ft)

(2) Put lubricant on head and crown. Tighten to .... 475 + 270 - 0 N•m (350 + 200 - 0 lb ft)

(3) Lubricate sealing lip with a small amount of oil being sealed.

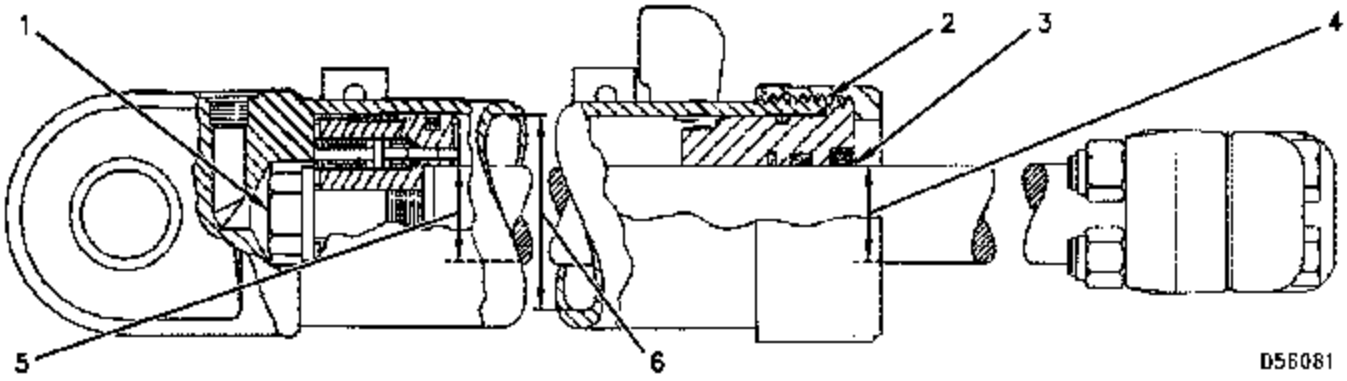
(4) Bore of head (new) .... 51.06 ± 0.03 mm (2.011 ± .001 in)

(5) Diameter of rod (new) .... 50.750 ± 0.038 mm (1.998 ± .001)

(6) Bore of cylinder (new) ..... . 101.6 + 0.13 - 0.05 mm (4.000 + .005 - .002 in)

Tip Cylinder

814F – 1U-4744



(1) Lubricate threads and torque bolt to .... 1080 ± 108 N•m (800 ± 80 lb ft)

(2) Put lubricant on head and crown. Tighten to ..... 475 + 270 - 0 N•m (350 + 200 - 0 lb ft)

(3) Lubricate sealing lips with a small amount of oil being sealed.

(4) Bore of head (new) .... 51.08 ± 0.03 mm (2.011 ± .001 in)

(5) Diameter of rod (new) ..... 50.750 ± 0.038 mm (1.998 ± .001)

(6) Bore of cylinder (new) ..... 101.60 + 0.13 - 0.05 mm (4.000 + .005 - .002 in)

Bit & Cutting Edge Groups

Torque for 22.225 mm (0.875 in) bolts and nuts on cutting edge and bits .... 765 ± 115 N•m (560 ± 85 lb ft)

Torque for 19.05 mm (0.750 in) bolts and nuts on cutting edge and bits ..... 475 ± 70 N•m (350 ± 50 lb ft)

CATERPILLAR®

SENR1316
March 1996

Systems Operation Testing & Adjusting

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Hydraulic System

814F	815F	816F
9DM1-UP	1GN1-UP	5FN1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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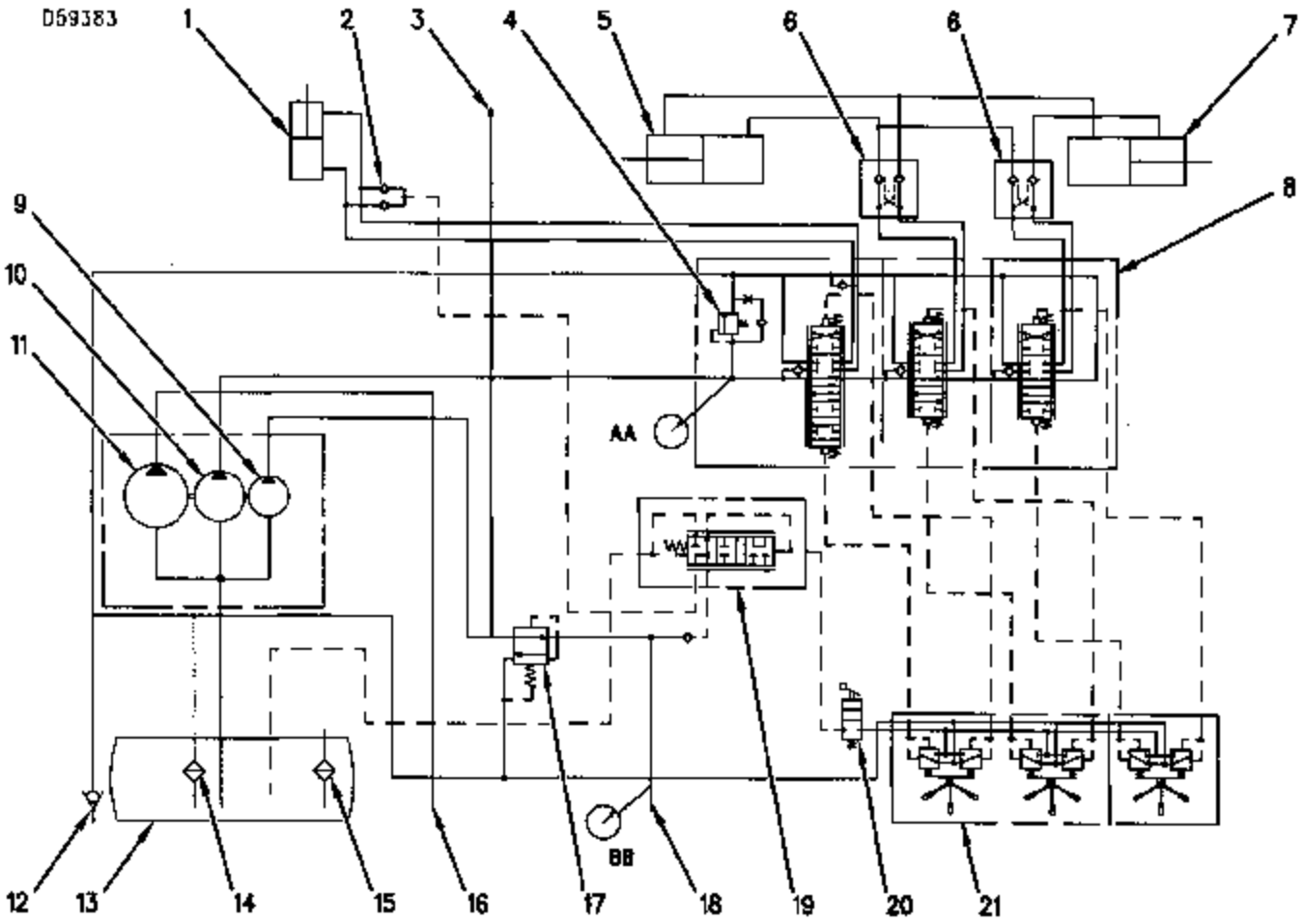
REFERENCE: For Specifications with illustrations, make reference to SENR1315, 814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Hydraulic Systems Specifications. If the Specifications in SENR1315 are not the same as in the Systems Operation and the Testing and Adjusting, look at the printing date on the cover of each book. Use the Specification in the book with the latest date.

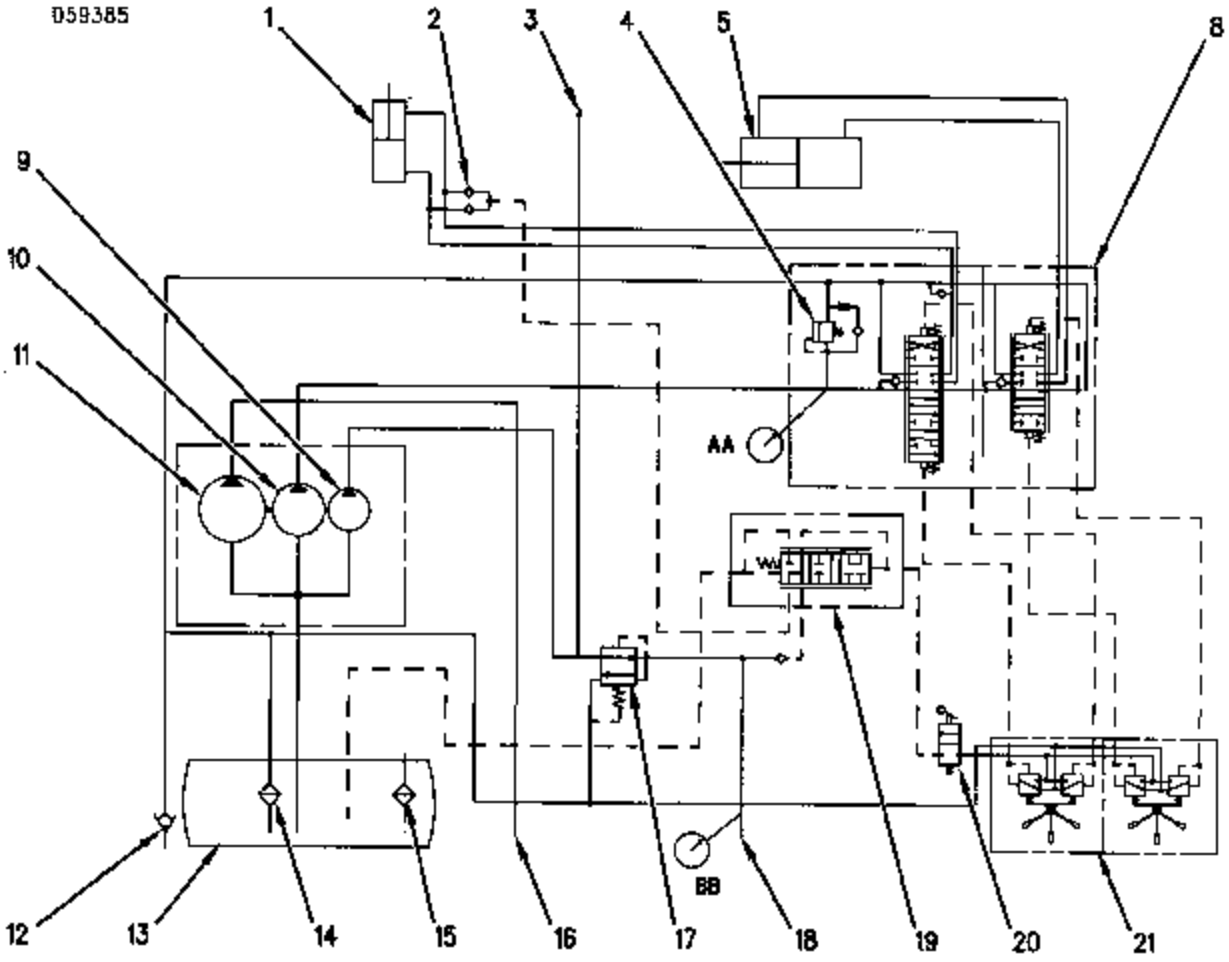
Systems Operation

Hydraulic Schematics



814F Hydraulic Schematic

(1) Lift cylinder.
(2) Check valve.
(3) Line to hydraulic brake system.
(4) Main relief valve.
(5) Tilt cylinder.
(6) Pilot operated check valve group.
(7) Tip cylinder.
(8) Implement control valve.
(9) Pilot/brake pump.
(10) Implement pump.
(11) Steering pump.
(12) Implement system oil sample valve.
(13) Hydraulic oil tank.
(14) Implement system oil filter elements.
(15) Steering system oil filter elements.
(16) Steering pump pressure oil line to steering system.
(17) Pressure reducing valve.
(18) Steering pilot line.
(19) Pressure control and selector valve.
(20) Hydraulic lockout valve.
(21) Implement pilot valve.
(AA) Implement relief.
(BB) Pilot pressure.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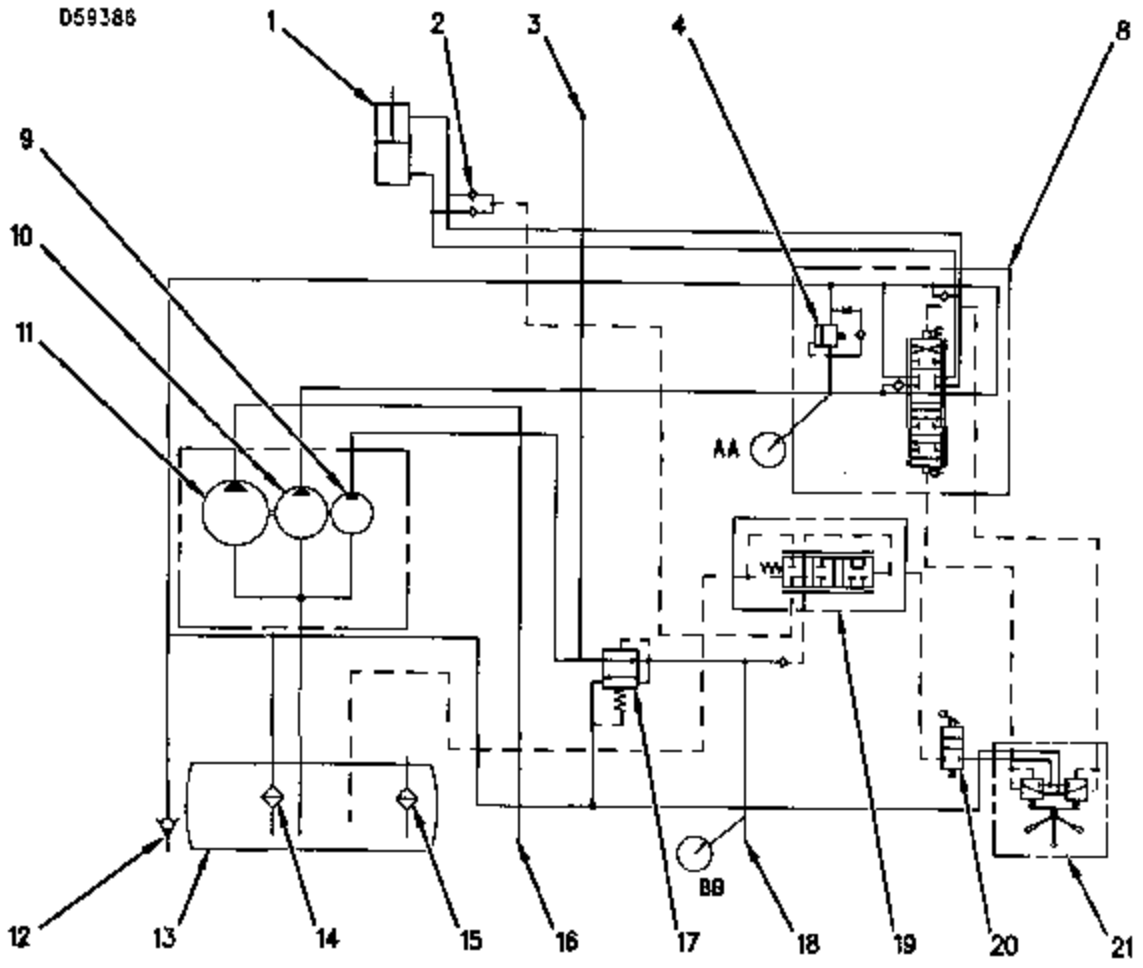
815F Hydraulic Schematic

(1) Lift cylinder.
(2) Check valve.
(3) Line to hydraulic brake system.
(4) Main relief valve.
(5) Tilt cylinder.
(8) Implement control valve.
(9) Pilot/brake pump.
(10) Implement pump.
(11) Steering pump.
(12) Implement system oil sample valve.
(13) Hydraulic oil tank.
(14) Implement system oil filter elements.
(15) Steering system oil filter elements.
(16) Steering pump pressure oil line to steering system.
(17) Pressure reducing valve.
(18) Steering pilot line.
(19) Pressure control and selector valve.
(20) Hydraulic lockout valve.
(21) Implement pilot valve.
(AA) Implement relief.
(BB) Pilot pressure.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816F Hydraulic Schematic

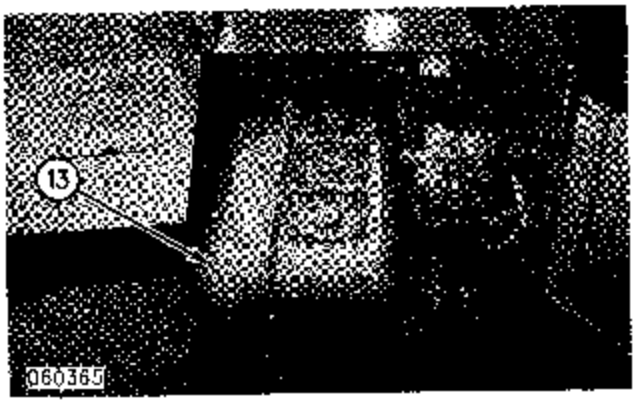
(1) Lift cylinder.
(2) Check valve.
(3) Line to hydraulic brake system.
(4) Main relief valve.
(8) Implement control valve.
(9) Pilot/brake pump.
(10) Implement pump.
(11) Steering pump.
(12) Implement system oil sample valve.
(13) Hydraulic oil tank.
(14) Implement system oil filter elements.
(15) Steering system oil filter elements.
(16) Steering pump pressure oil line to steering system.
(17) Pressure reducing valve.
(18) Steering pilot line.
(19) Pressure control and selector valve.
(20) Hydraulic lockout valve.
(21) Implement pilot valve.
(AA) Implement relief.
(BB) Pilot pressure.

Introduction

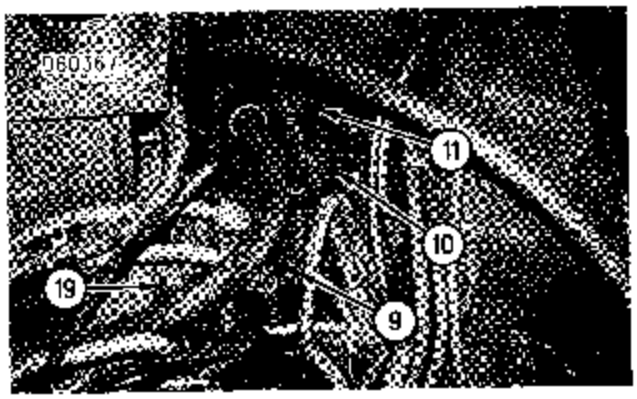
The implement hydraulic system is made up of two basic circuits: The high pressure circuit and the pilot circuit.

The main components of the high pressure circuit are: Hydraulic oil tank (13), implement pump (10), main relief valve (4), implement control valve (8), check valves (2), pilot operated check valve groups (6), lift cylinder (1), and, tilt cylinder (5), and tip cylinder (7) if equipped.

The main components of the pilot circuit are: Hydraulic oil tank (13), pilot/brake pump (9), pressure reducing valve (17), pressure control and selector valve (19), hydraulic lockout valve (20), and implement pilot valve (21).

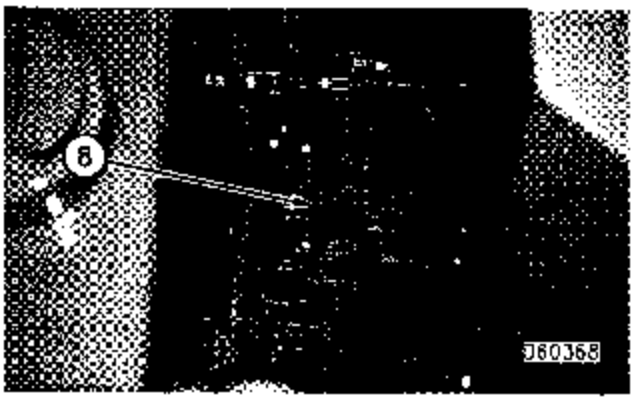


Hydraulic Oil Tank Location
(13) Hydraulic oil tank.

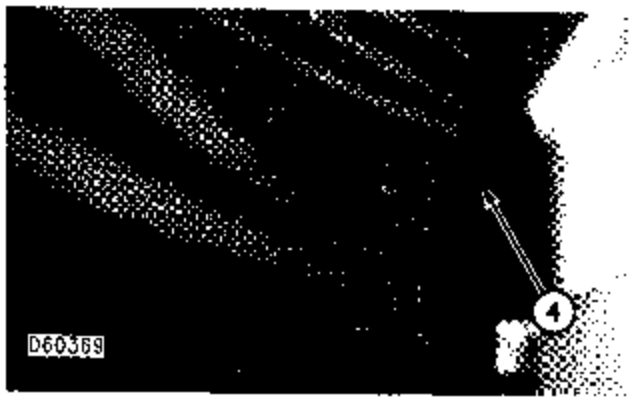


Hydraulic Pump Location
(9) Pilot/brake pump. (10) Implement pump. (11) Steering pump. (19) Pressure control and selector valve.

Implement pump (10) is a vane pump which is attached to the torque converter housing, and draws oil from hydraulic oil tank (13). The function of implement pump (10) is to provide high pressure oil flow for hydraulic actuated lift cylinder (1), and, tilt cylinder (5), and tip cylinder (7) if equipped.



Implement Control Valve Location
(8) Implement control valve.

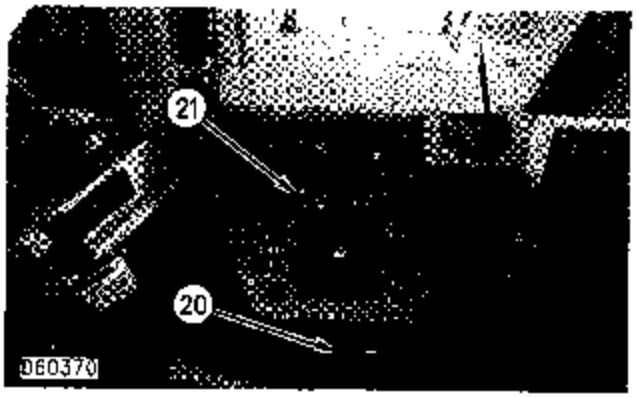


Implement Relief Valve Location
(4) Implement relief valve.

Pressure oil from implement pump (10) flows to implement control valve (8). Implement relief valve (4) limits the amount of oil pressure flowing to implement control valve (8), to 15 500 ± 350 kPa (2250 ± 50 psi).

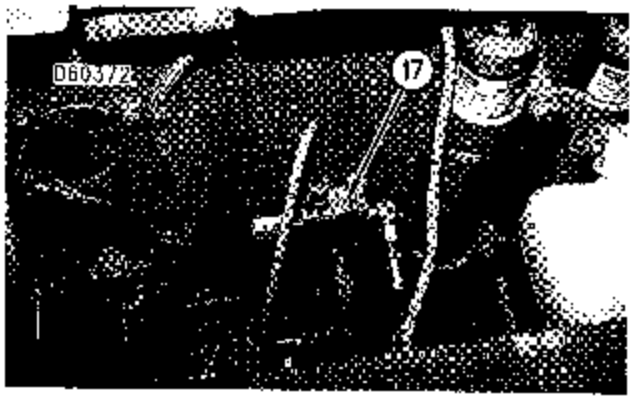
Implement control valve (8) routes the pressure oil from implement pump (10), to operate lift cylinder (1), and, tilt cylinder (5), and tip cylinder (7) if equipped.

Steering pump (11) is also a vane pump which provides oil flow to the steering system. Pilot/brake pump (9) is mounted on the end of implement pump (10) and the transmission pump. Pilot/brake pump (9) is a vane pump which provides oil flow for the implement pilot circuit, the steering pilot circuit, and the hydraulic brake system.



Implement Pilot Valve Location
(20) Hydraulic lockout valve. (21) Implement pilot valve.

The oil flow from pilot/brake pump (9) controls implement pilot valve (21). Implement pilot valve (21) determines if and when, and which implement cylinders to actuate.



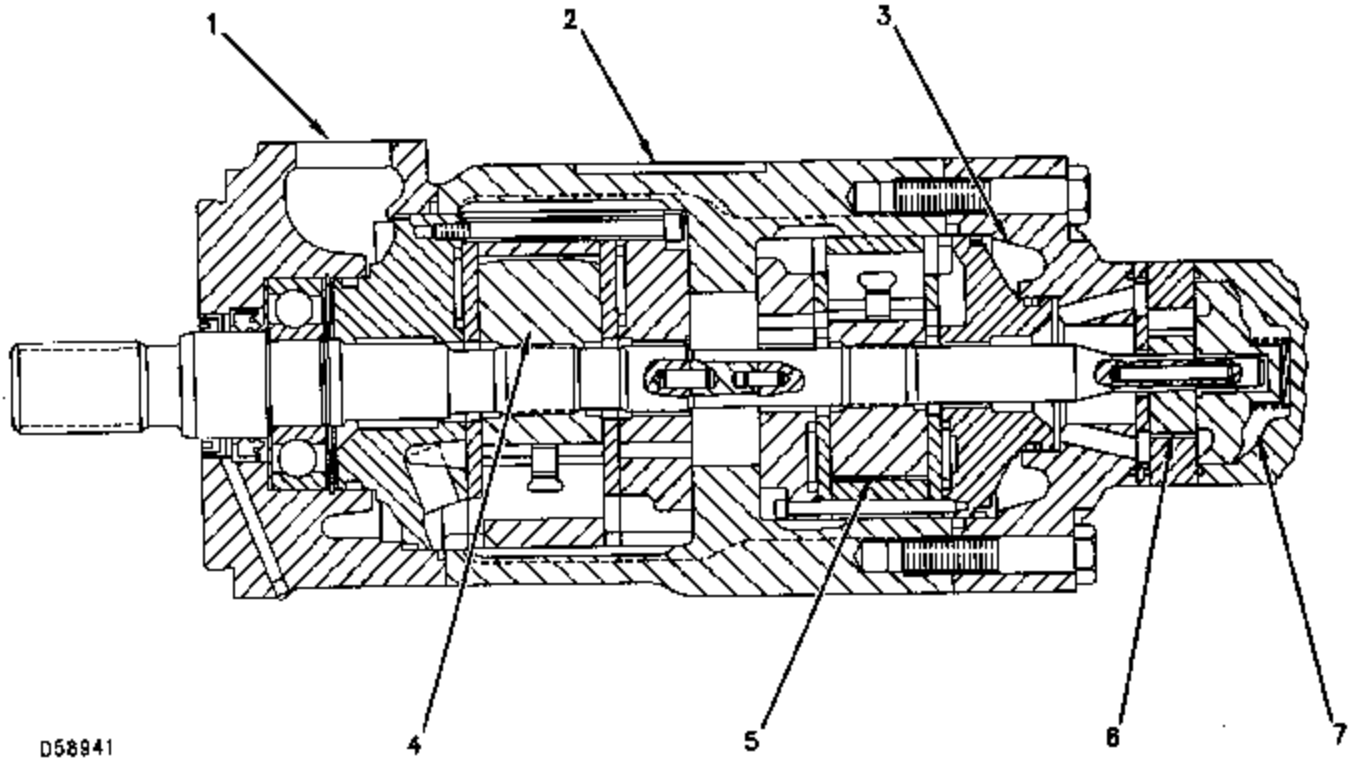
Pressure Reducing Valve Location
(17) Pressure reducing valve.

Pressure reducing valve (17) reduces pilot pump and brake oil pressure to 2410 ± 140 kPa (350 ± 20 psi) for use in the implement and steering pilot oil systems.

Pressure control and selector valve (19) routes pilot oil to pilot control valves (21). The pressure control and selector valve also provides pressure oil from the lift cylinder to pilot valve (21) to lower the blade or machine with the engine stopped.

Hydraulic lockout valve (20) is a ball valve that controls the flow of pilot oil to pilot control valve (21).

Hydraulic Pump Group



Hydraulic Pump Group Cross Section
(1) Steering pressure outlet. (2) Inlet from tank. (3) Implement pressure outlet. (4) Steering section. (5) Implement section. (6) Pilot section. (7) Pilot pressure outlet.

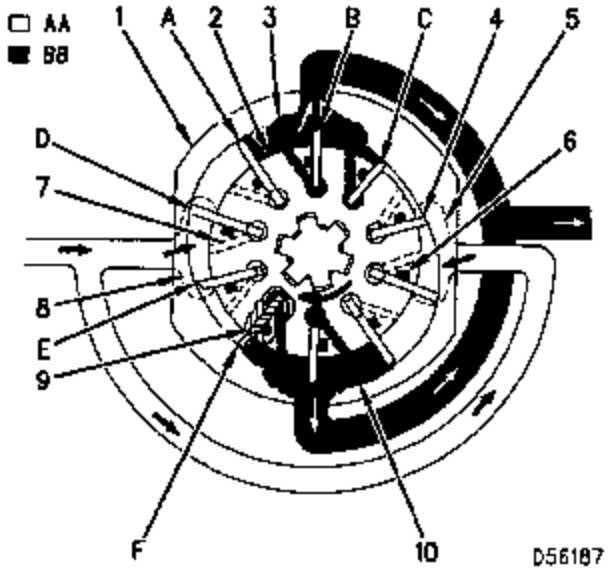
The hydraulic pump group is a three section vane pump. Pilot section (6) is a vane pump. The pilot section provides the oil needed to operate the pilot control valves of the implement hydraulic system. It also provides the oil needed to operate the metering pump (steering) in the steering system and provides oil for the brake system.

Implement section (5) is a vane pump. The implement section provides the oil needed to operate the blade and any attachments in the implement hydraulic system.

Steering section (4) is also a vane pump. The steering section provides the oil needed to operate the steering cylinders.

All three pump sections rotate on a common shaft. All three sections draw oil from the hydraulic tank through inlet (3). Each section has its own outlet.

Operation Of The Steering And Implement Pump Sections



Schematic Of Steering And Implement Sections
(1) Cam ring. (2) Rotor. (3) Outlet. (4) Vane. (5) Inlet. (6) Slot. (7) Passage. (8) Inlet. (9) Insert. (10) Outlet. A, B, C, D, E and F. Positions of vanes. (AA) Inlet oil. (BB) Pressure oil.

The components of both the implement and steering vane cartridges are similar: inlet and outlet support plates, seal packs, flex plates, cam ring (1), rotor (2), vanes (4) and inserts (9).

NOTE: For additional information on vane-type pumps refer to SMHS7047, Special Instruction.

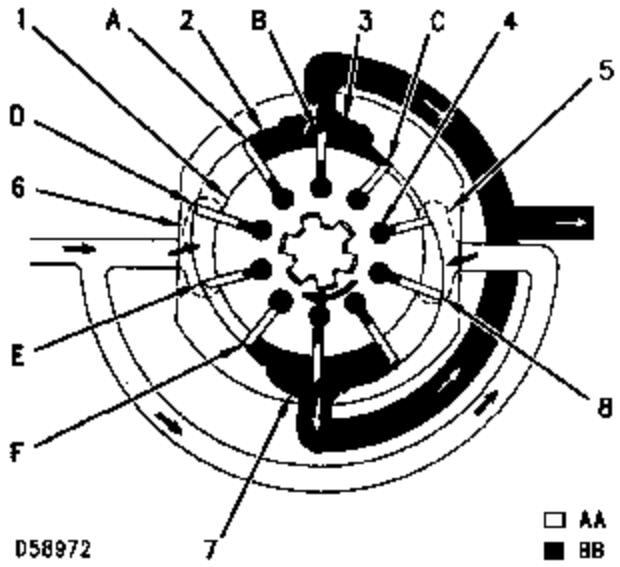
Since the implement and steering pump sections are similar, only one cartridge description is given. Grooves in the flex plates send pressure oil to slots (6) in rotor (2). Oil from these slots flows into the area between inserts (9) and vanes (4). This pushes the vanes out against cam ring (1).

As rotor (2) turns, the vanes in positions (E) and (F) move out and follow the shape of the cam ring. As the chamber area between the vanes increases it causes a low pressure or vacuum in the chamber. This pressure difference causes oil to flow from the hydraulic tank through inlet (8). The oil fills the space between vanes at positions (E) and (D) and continues to fill the space through positions (D) and (A).

Oil between the vanes at positions (D) and (A) will be trapped when the vane at position (D) passes the end of inlet (8). As rotor (2) continues to turn, the vanes are pushed in by the contour of cam ring (1). The chamber area between the vanes now decreases. Oil between the vanes at positions (A) and (B) is pushed into outlet (3). The oil continues to be pushed out through positions (B) and (C). When the vane at position (B) passes the end of outlet (3), the cycle is completed.

Both ends of the vanes are connected by passages (7) in the rotor. The oil found in these passages keeps the pressure even on both ends of the vanes and permits the oil behind the vanes to escape as the vanes are pushed back in.

Operation Of The Pilot Pump Section



Schematic Of Pilot Pump Section
(1) Rotor. (2) Cam ring. (3) Outlet. (4) Passage. (5) Inlet. (6) Inlet. (7) Outlet. (8) Vane. A, B, C, D, E, and F. Positions of vanes. (AA) Inlet oil. (BB) Pressure oil.

The components of the pilot section are a plate, adapter, seal packs, cam ring (2), rotor (1) and vanes (8). The operation of the pilot section is similar to the other two sections, except that the pilot section does not have inserts inside the vanes.

At first, vanes (8) are pushed out against cam ring (2) by centrifugal force. Pressure oil in passages (4) of rotor (1) keeps the vanes pushed out against the cam ring. Both ends of the vanes are connected by these passages. This oil keeps the pressure even on both ends of the vanes and permits the oil behind the vanes to escape as the vanes are pushed back in.

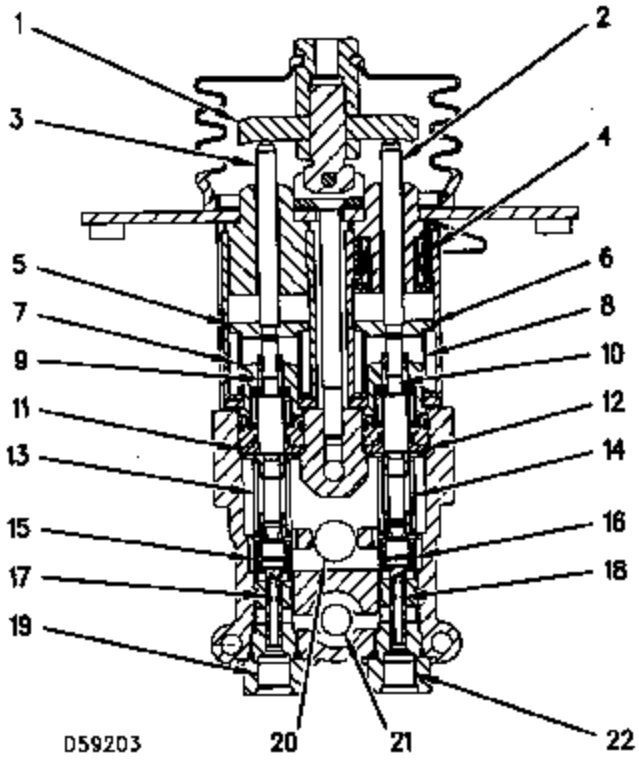
As rotor (1) turns, the vanes in positions (E) and (F) move out and follow the shape of the cam ring. As the chamber area between the vanes increases, it causes a low pressure or vacuum in the chamber. This pressure difference causes oil to flow from the hydraulic tank through inlet (6). The oil fills the space between vanes at positions (E) and (D).

Oil between the vanes at positions (D) and (A) will be trapped when the vane at position (D) passes the end of inlet (6). As rotor (1) continues to turn, the vanes are pushed in by the contour of cam ring (2). The chamber area between the vanes now decreases. Oil between the vanes at positions (A) and (B) is pushed into outlet (3). The oil continues to be pushed out through positions (B) and (C). When the vane at position (C) passes the end of outlet (3), the cycle is completed.

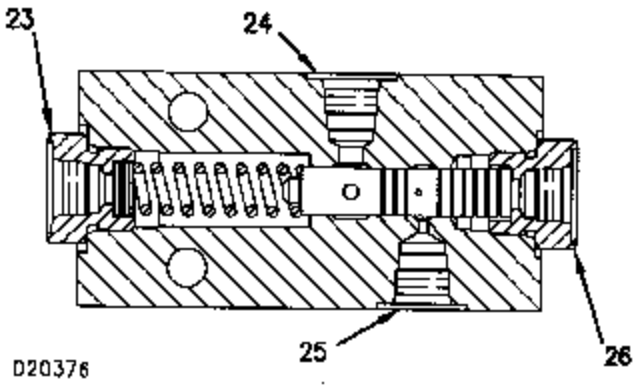
Valves

Pilot Circuits

Lift Pilot Control Valve



Lift Pilot Control Valve
(1) Pivot plate. (2) Lift upper plunger. (3) Lower upper plunger. (4) Float coil assembly. (5) Retainer. (6) Retainer. (7) Centering spring. (8) Centering spring. (9) Lower plunger. (10) Lower plunger. (11) Retainer. (12) Retainer. (13) Centering spring. (14) Centering spring. (15) Metering spring. (16) Metering spring. (17) Metering stem. (18) Metering stem. (19) Port to main control valve. (20) Port to hydraulic tank. (21) Port from pilot pump. (22) Port to main control valve.



Pressure Control And Reducing Valve
(23) Port to hydraulic tank. (24) Pump supply port. (25) Port to lift cylinder. (26) Port to pilot lockout valve.

With the engine running, oil flows from the pilot pump, through the pressure reducing valve to port (24) of the pressure control and selector valve. The oil flows through the valve to port (26) and then flows to the pilot lockout valve.

When the hydraulic lockout lever is in the up position, the oil is blocked at the lockout valve. When the lever is in the down position, the oil flows through the lockout valve and on to the pilot control valves.

When the valve is in the HOLD position, centering springs (7), (8), (13) and (14) keep pivot plate (1) in its centered position, as shown. Pump oil flows from the hydraulic lockout valve through port (21) to metering stems (17) and (18). In this position the metering stems block the flow of oil to the main control valve and causes the oil to flow through port (20). The oil flows from port (20) back to the hydraulic tank.

When the control lever is moved to the RAISE position, pivot plate (1) causes upper plunger (2) to move down. As plunger (2) moves down, the force on retainer (6) overcomes spring (8) allowing plunger (2) to contact plunger (10).

Plunger (2) causes plunger (10) to also move down. As plunger (10) moves down, it forces retainer (12) to overcome spring (14). As plunger (10) moves down it causes metering spring (16) and metering stem (18) to move down.

When the metering stem moves down, slots in the metering stem allow pilot oil to flow from port (21) out port (22) to the main control valve.

Centering springs (7) and (13) and metering spring (15) force metering stem (17), lower plunger (9) and upper plunger (2) to move up.

When the control lever is moved to the LOWER position, pivot plate (1) causes upper plunger (3) to move down. As plunger (3) moves down the force on retainer (5) overcomes spring (7) allowing plunger (3) to contact plunger (9).

Plunger (3) causes plunger (9) to also move down. As plunger (9) moves down, it forces retainer (11) to overcome spring (13). As plunger (9) moves down, it causes metering spring (15) and metering stem (17) to move down.

When the metering stem moves down, slots in the metering stem allow pilot oil to flow from port (21) out port (19) to the main control valve.

Centering springs (8) and (14) and metering spring (16) force metering stem (18), lower plunger (10) and upper plunger (2) to move up.

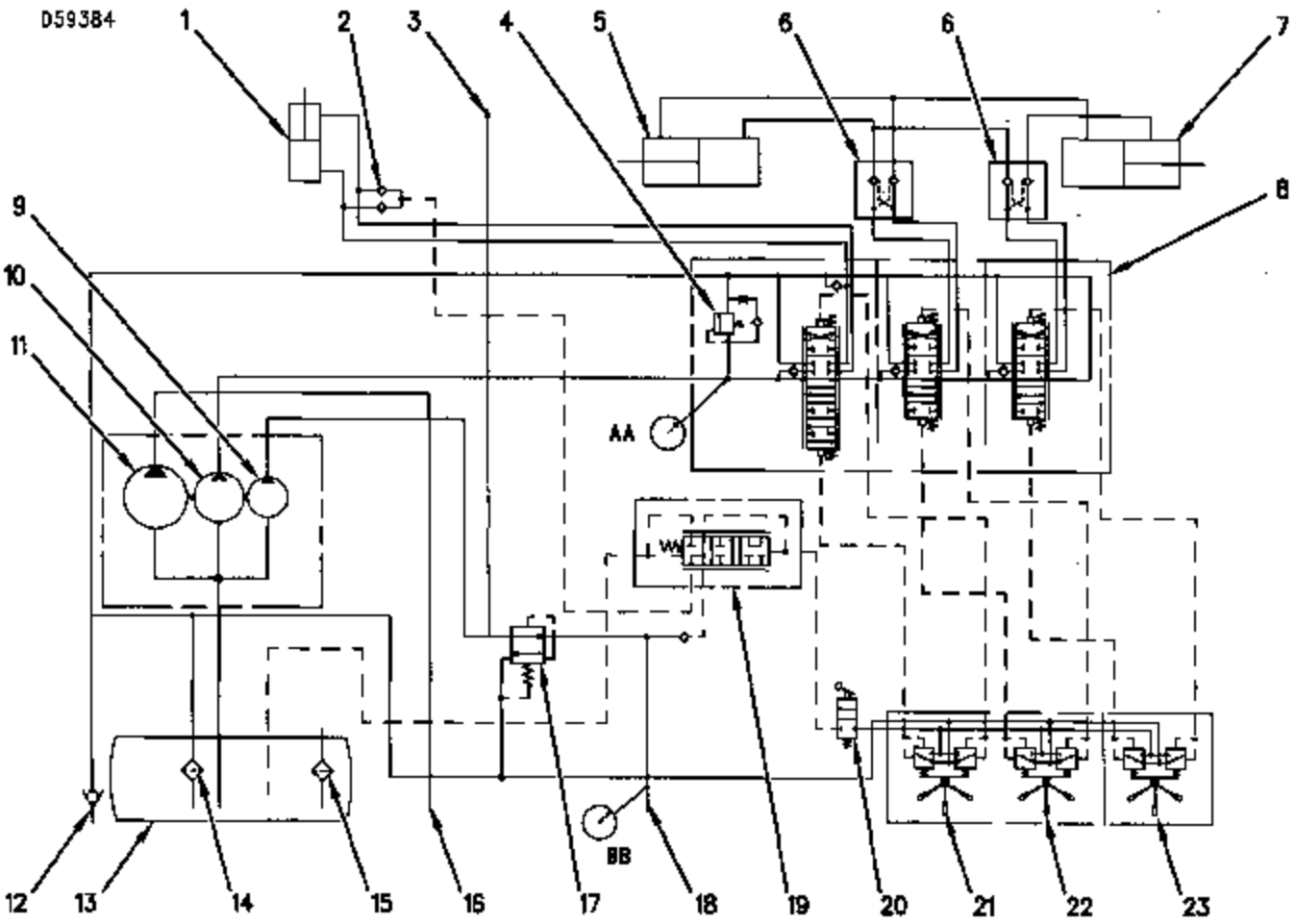
When the control lever is moved past the LOWER position to the FLOAT position, pivot plate (1) moves to the last position. Coil (4) is energized and holds retainer (4) and plunger (2) in place. The maximum pilot pressure is now sent to the main lift control valve. The main lift control valve spool is moved to the FLOAT position. The blade can now move up and down with the ground contour.

The lift circuit will remain in FLOAT position until the operator moves the lift control lever to another position.

If the engine is stopped with the blade in the raised position or with the machine raised with the blade, the pressure control and selector valve provides pilot oil to the implement system to enable the blade/machine to be lowered. Because of the weight of the load, oil from the lift cylinders to the lift control valve is under pressure. This oil also flows into port (25). Then the oil pressure is reduced and flows out port (26) to the pilot control valves.

NOTE: The pilot control valves for the tilt and tip are all similar and operate in the same manner as the lift pilot control valve. The tilt and tip pilot control valves do not have an electrical coil installed.

Lift Pilot Control Circuit



814F Hydraulic Schematic Shown

(1) Lift cylinder.
(2) Check valve.
(3) Line to hydraulic brake system.
(4) Main relief valve.
(5) Tilt cylinder.
(6) Pilot operated check valve group.
(7) Tip cylinder.
(8) Implement control valve.
(9) Pilot/brake pump.
(10) Implement pump.
(11) Steering pump.
(12) Implement system oil sample valve.
(13) Hydraulic oil tank.
(14) Implement system oil filter elements.
(15) Steering system oil filter elements.
(16) Steering pump pressure oil line to steering system.
(17) Pressure reducing valve.
(18) Steering pilot line.
(19) Pressure control and selector valve.
(20) Hydraulic lockout valve.
(21) Lift pilot control valve.
(22) Tilt pilot control valve.
(23) Tip pilot control valve.
(AA) Implement relief.
(BB) Pilot pressure.

The pilot system uses low pressure oil to operate the main control valves. The main components of the pilot system are pilot pump (9), pressure control and selector valve (19), lockout valve (20) and pilot valves (21), (22) and (23).

With the engine running, oil flows from pilot pump (9), through pressure reducing valve (19) to pilot lockout valve (20).

From the hydraulic lockout valve the oil flows into the pilot control valves. Lift control pilot valve (21) is a closed center valve that has three positions, RAISE, LOWER, and, FLOAT. The oil can not flow through the valve when it is in the HOLD position because it is a closed center valve.

Oil lines connect the output of the tilt control pilot valve to the pilot inlets on the lift main control valve.

When the control lever on the lift control pilot valve is moved to the RAISE position, oil flows from the pilot control valve, through oil lines to the pilot oil inlets of the lift main control valve. This causes the main control valve spool to move. Movement of the spool opens passages for implement pressure oil to flow to the rod end of lift cylinder (1).

Main control valve spool movement also opens a passage for return oil from the head end of the lift cylinder to flow back to hydraulic tank (13). Implement pressure oil acts on the rod end of the lift cylinder and, because the head end of the lift cylinder is now vented to tank, the blade will raise.

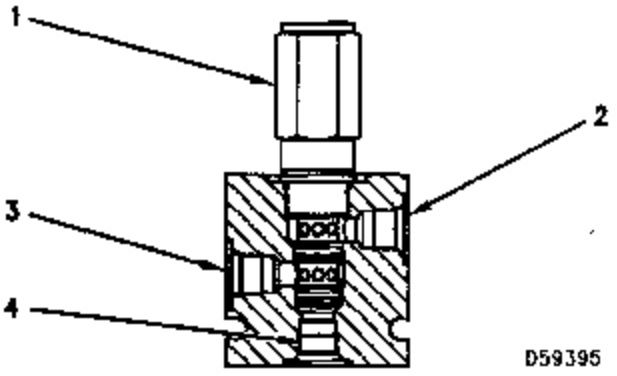
When the control lever on the lift control pilot valve is moved to the LOWER position, oil flows from the pilot control valve, through oil lines to the pilot oil inlets of the lift main control valve. This causes the main control valve spool to move in the opposite direction.

When the main control valve spool is in this position, a passage opens for pressure oil to flow to the head end of the lift cylinder. The main control valve spool movement also opens a passage for return oil from the rod end of the lift cylinder to flow back to the hydraulic tank. Implement pressure oil acts on the head end of the lift cylinder and because the rod end of the cylinder is now vented to tank, the blade will lower.

When the control lever on the lift control pilot valve is moved to the FLOAT position, oil flows from the pilot control valve, through oil lines to the pilot oil inlets of the lift main control valve. This causes the main control valve spool to move all the way down to the float position.

When the main control valve spool is in the float position, a passage opens that connects both ends of the lift cylinder to the hydraulic tank. The weight of the blade will cause the blade to lower to the ground. The blade can now move up and down with the ground contour.

Pressure Reducing Valve



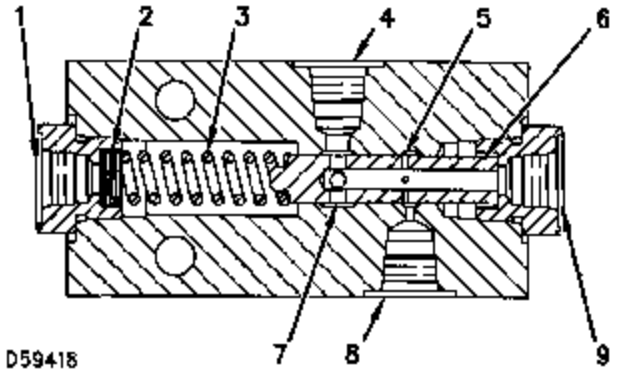
Pilot System Pressure Reducing Valve
(1) Valve. (2) Drain outlet. (3) Inlet. (4) Reduced pressure outlet.

Oil from the pilot pump flows to the brake system and to remainder of the oil flows to pressure reducing valve (1).

Oil flows through inlet (3) into valve (1). Reducing valve (1) is a cartridge type valve that maintains pilot pressure to the pilot and steering circuits at 2410 ± 140 kPa (350 ± 20 psi).

Reduced pressure oil flows to the pilot circuits through outlet (4). Excess oil returns to the hydraulic tank through outlet (2).

Pressure Control And Selector Valve



Pressure Control And Selector Valve
(1) Drain passage. (2) Spacers. (3) Spring. (4) Inlet passage from pilot pump section. (5) Holes (two). (6) Valve spool. (7) Holes (four). (8) Inlet passage from head end of lift cylinder. (9) Outlet passage to pilot valves.

The pressure control and selector valve is part of the pilot oil system. The pressure control and selector valve is between the pressure reducing valve and the pilot valves. The selector and pressure control valve provides pressure oil to the pilot valves when the engine is stopped.

During normal operation, pressure oil from the pilot pump flows through inlet passage (4). The pressure of this oil is controlled by the pressure reducing valve. The oil flows through holes (7) in valve spool (6), through the center of the valve spool and outlet passage (9) to the pilot valves.

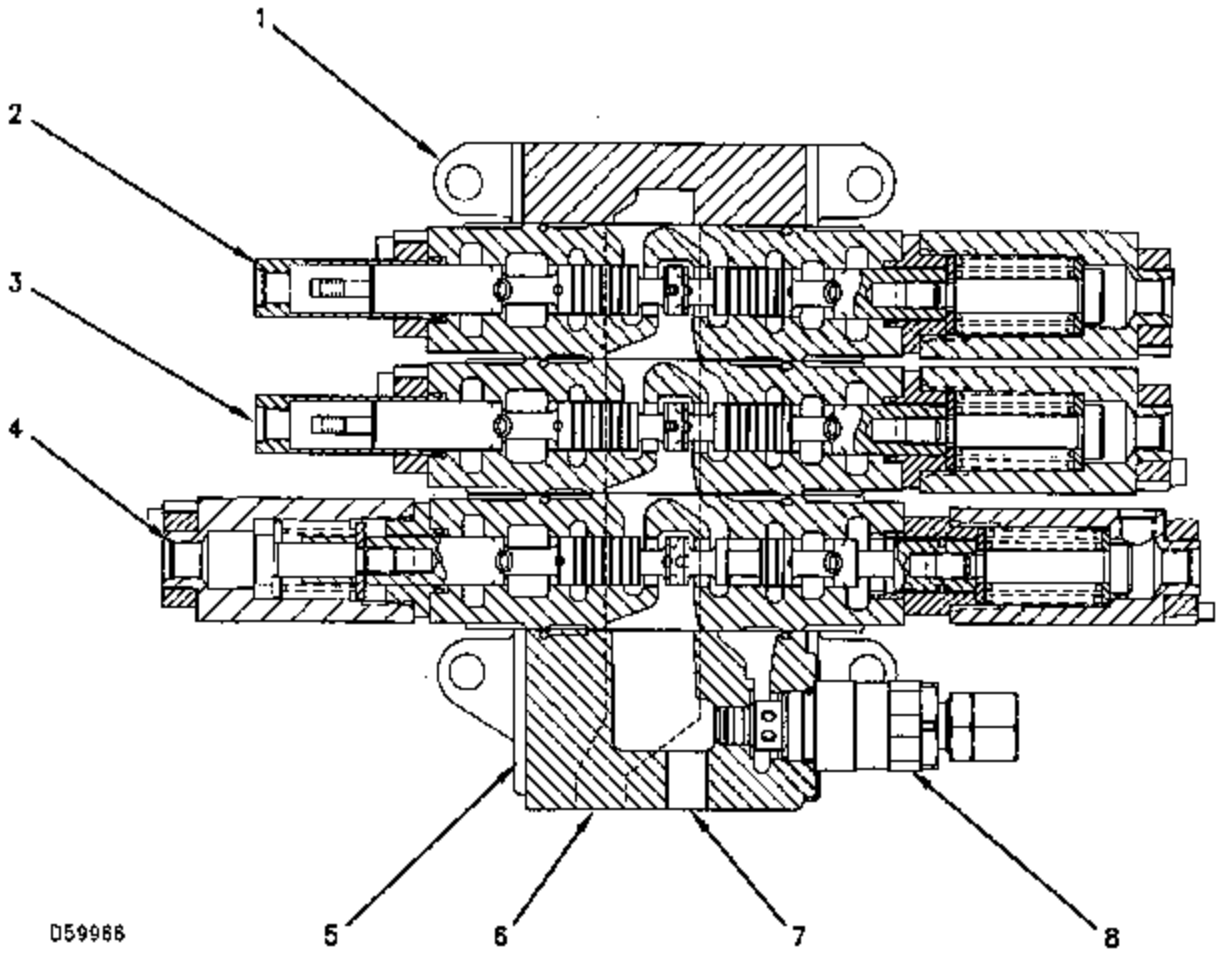
A check valve is in the line from each end of the lift cylinder to passage (8) to stop the flow of oil to the ends of the lift cylinder. Oil from the pilot pump can not go through holes (5) and inlet passage (8) because of the lift cylinder check valves.

When the engine is stopped, there is no pressure oil at inlet passage (4). When the engine is stopped and the blade is raised, the weight of the blade provides oil pressure from the rod end of the lift cylinder in inlet passage (8). When the engine is stopped and the machine is raised by the blade, the weight of the machine provides oil pressure from the head end of the lift cylinder in inlet passage (8). This oil is stopped in the lines as long as the lift stems in the pilot valves are in the HOLD position.

If the blade is raised, when the pilot valve lift stem is moved to the LOWER position, the pressure oil from the rod end of the lift cylinder can now flow through holes (5) in valve spool (6). The oil then flows through outlet passage (9), the pilot valve, and on to the lift valve spool in the main control valve. The control valve allows oil to flow from the lift cylinder and the blade will lower. A check valve in the line from inlet passage (4) prevents oil from going to the pilot pump section.

If the machine is raised by the blade, when the pilot valve lift stem is moved to the RAISED position, the pressure oil from the head end of the lift cylinder can now flow through holes (5) in valve spool (6). The oil then flows through outlet passage (9), the pilot valve, and on to the lift valve spool in the main control valve. The control valve allows oil to flow from the lift cylinder and the machine will lower. A check valve in the line from inlet passage (4) prevents oil from going to the pilot pump section.

When the engine is stopped, and the blade or machine is raised, valve spool (6) also reduces the oil pressure at inlet passage (8) to approximately 2400 kPa (350 psi). When the pressure through outlet passage (9) rises too high, the pressure will cause valve spool (6) to move left against the force of spring (3). This decreases the flow of oil through holes (5) in the valve spool and decreases the pressure in outlet passage (9).



Implement Control Valve Group (814F Shown)
(1) Housing. (2) Tip control valve. (3) Tilt control valve. (4) Lift control valve. (5) Housing. (6) Outlet to tank. (7) Inlet from pump. (8) Implement relief valve.

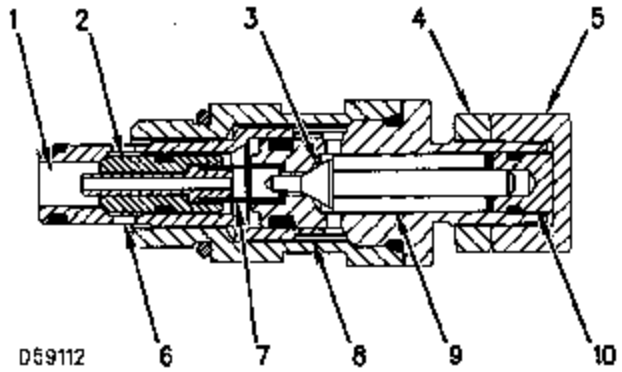
The implement control valve can have from one to three valves depending on the machine and the attachments installed. The valves are installed between two housings. Lift control valve (4) is installed on all machines and is always installed next to bottom housing (5). Tilt control valve (3) is installed next. The tilt control valve is installed on all 814F Wheel Tractors and is an attachment on 815F Soil Compactors. Tip control valve (2) is the last valve and is only installed on the 814F Wheel Tractors.

The top housing contains a passage that connects the pump oil passage from the last valve to the tank return oil passage in the last valve. The tank return oil passage in the last valve connects to the tank return oil passages of any other valves that are installed and then connects to the tank return oil passage in the bottom housing.

The bottom housing contains pump oil inlet passage (7), tank return oil passage (6), and implement relief valve (8). Implement relief valve (8) is the only relief valve in the implement hydraulic system.

The implement control valves are open centered, pilot operated valves. Lift control valve (4) is installed on the bottom housing and has priority over any other valves that are installed. If the lift control valve spool is moved to send oil to the lift cylinder, a reduced amount of oil is available to any other valves installed.

Implement Relief Valve



Implement Relief Valve
(1) Oil inlet opening. (2) Valve. (3) Pilot valve. (4) Locknut. (5) Cap. (6) Oil outlet opening. (7) Spring. (8) Passage. (9) Spring. (10) Plunger.

The implement relief valve is ahead of all other valves in the implement hydraulic system. It is a pilot-operated, cartridge valve. The pressure setting of the implement relief valve is approximately 15 500 kPa (2250 psi).

Implement system oil flows into inlet opening (1), through the orifice in center of valve (2) and into the chamber for spring (7). The oil in the spring chamber contacts pilot valve (3). When the pressure of the oil in the circuit is less than the setting of the relief valve, the force of the pilot valve spring keeps it closed.

If the pressure of the oil through inlet opening (1) and in the chamber for spring (7) gets as high as the setting of the relief valve, the oil overcomes spring (9) tension and moves pilot valve (3) to the right. When the pilot valve opens, the oil in the spring chamber flows past the open pilot valve and through passage (8) to the tank.

With only the pilot valve open, the force of spring (7) is acting on valve (2). The pressure of the oil in inlet opening (1) moves valve (2) far enough to the right to allow implement oil flow through the inlet opening and through outlet openings (6) back to the hydraulic tank. The pressure of the oil can not increase to a pressure higher than the setting of the relief valve.

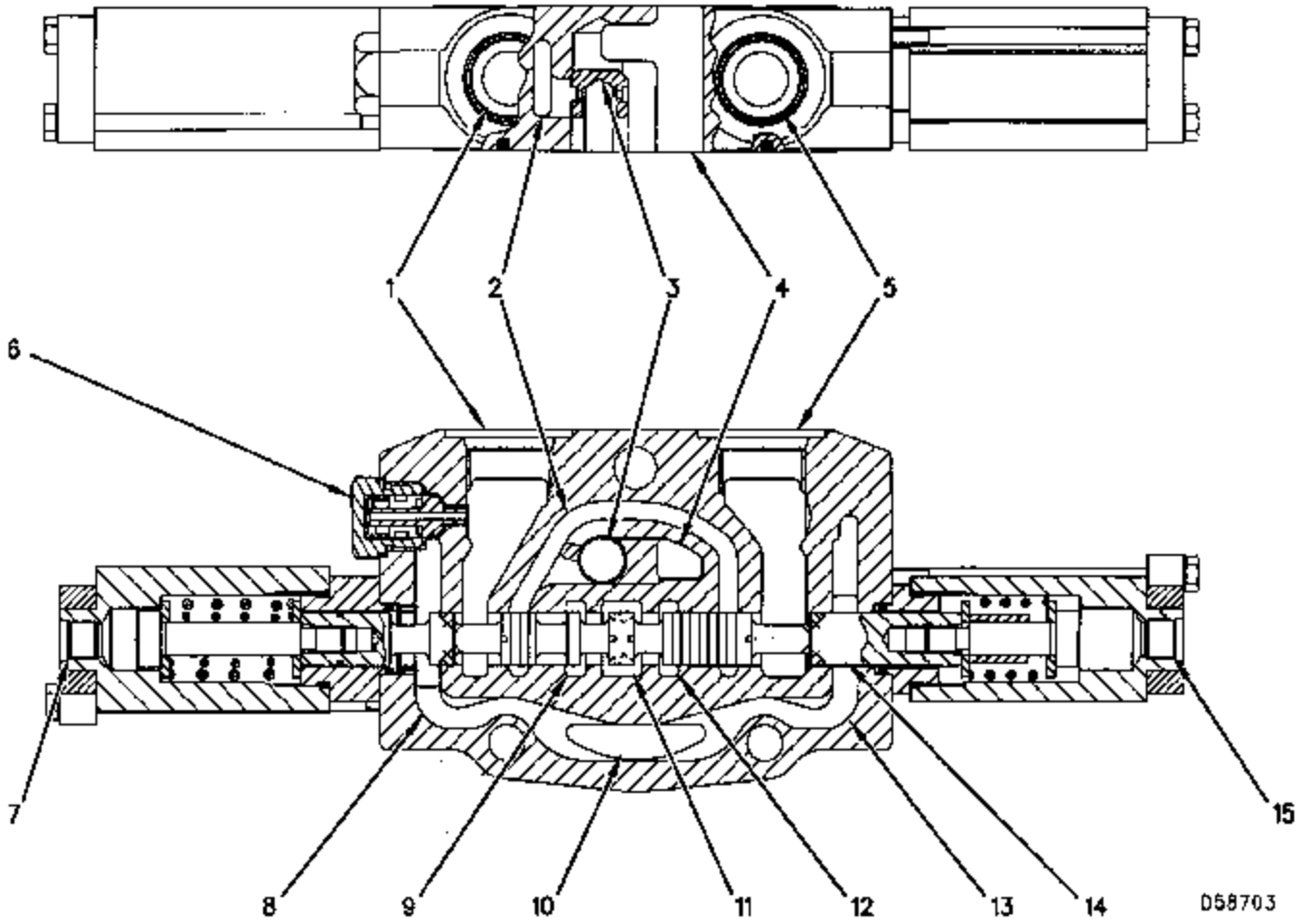
The pressure setting of the relief valve can be adjusted by changing the force of spring (9) that keeps pilot valve (3) closed. Loosen locknut (4) and turn cap (5) clockwise to increase or counterclockwise to decrease the pressure setting of the relief valve. Moving cap (5) allows plunger (10) to move and change the spring pressure on pilot valve (3).

Lift Control Valve

Oil flow from the pump enters the lift control valve first. Then the oil flows to the tilt valve and finally the tip valve. From the tip valve it flows through the tank return oil passage and back to tank.

This arrangement gives a priority series connection for the flow of implement pressure oil. This means that when the lift control valve is activated there is reduced flow of oil to the tilt or tip valves. Also when the tilt valve is activated there is reduced flow of oil to the tip valve.

Hold Position



Lift Control Valve (Hold position)
(1) Port to head end of lift cylinder. (2) Passage. (3) Load check valve. (4) Pump oil passage. (5) Port to rod end of lift cylinder. (6) Make-up valve. (7) Pilot oil port. (8) Passage to tank. (9) Pump oil passage to next valve or housing. (10) Passage to tank. (11) Pump oil passage from previous valve or housing. (12) Pump oil passage to next valve or housing. (13) Passage to tank. (14) Valve spool. (15) Pilot oil port.

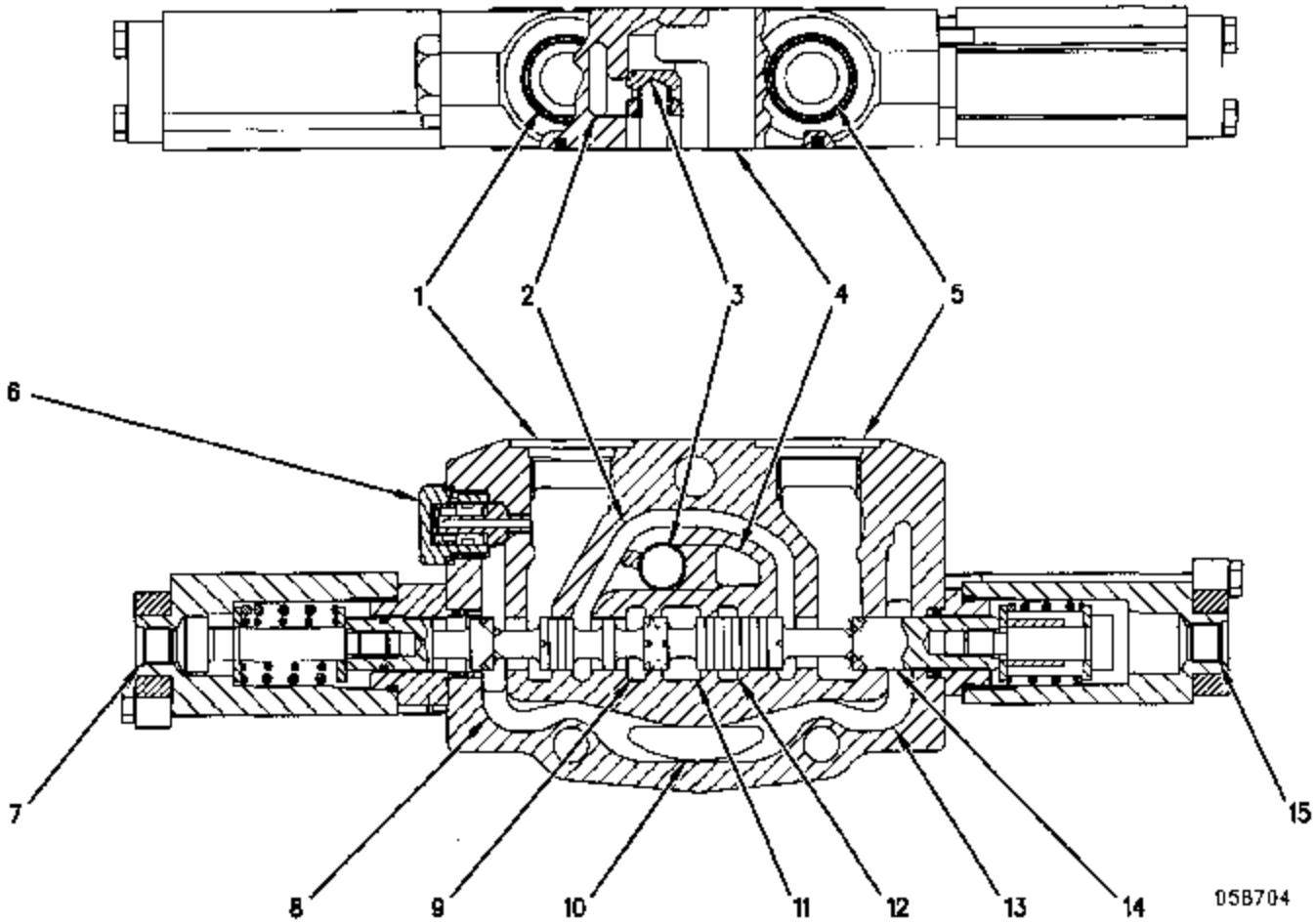
With the engine running, oil flows from the pump and enters the bottom housing. Then the oil flows into passage (11). When the lift control valve is in the HOLD position, the oil flows around valve spool (14), into passages (9) and (12).

The oil flows through passages (6) and (8) and to the tilt valve. If the tilt and tip valves are also in the HOLD positions the oil flows through the tilt valve into the tip valve. Then the oil flows through the tip valve and returns to the hydraulic tank.

In the HOLD position valve spool (14) blocks the flow of oil in ports (1) and (5). With the oil in the lines to the lift cylinder blocked, the cylinder can not move until the control lever and valve spool (14) are moved to either the RAISE, LOWER, or FLOAT position.

Springs on both ends of valve spool (14) keep the spool in the centered position when no pilot oil is routed to the spool.

Raise Position



Lift Control Valve (Raise position)
(1) Port to head end of lift cylinder. (2) Passage. (3) Load check valve. (4) Pump oil passage. (5) Port to rod end of lift cylinder. (6) Make-up valve. (7) Pilot oil port. (8) Passage to tank. (9) Pump oil passage to next valve or housing. (10) Passage to tank. (11) Pump oil passage from previous valve or housing. (12) Pump oil passage to next valve or housing. (13) Passage to tank. (14) Valve spool. (15) Pilot oil port.

When the control lever is moved to the RAISE position, pilot oil flows from the pilot control valve and enters port (15). Pilot oil combines with the force of the springs on the right side of valve spool (14) and overcomes the force of the springs on the left side of the spool. This causes the spool to move to the left.

When valve spool (14) moves to the left into the RAISE position, pump oil flow from passage (11) into passages (9) and (12) is blocked. The increase in oil pressure in passages (11) and (4) opens check valve (3). When the check valve opens, the pump oil in passages (11) and (4) flow through the open check valve into passage (2) and out port (5). Then the oil flows to the rod end of the lift cylinders.

The pump oil going into the rod end of the lift cylinder retracts the rod inward causing the blade to raise. Return oil from the head end of the cylinder flows through port (1) and then through passages (8) and (10) to the tank.

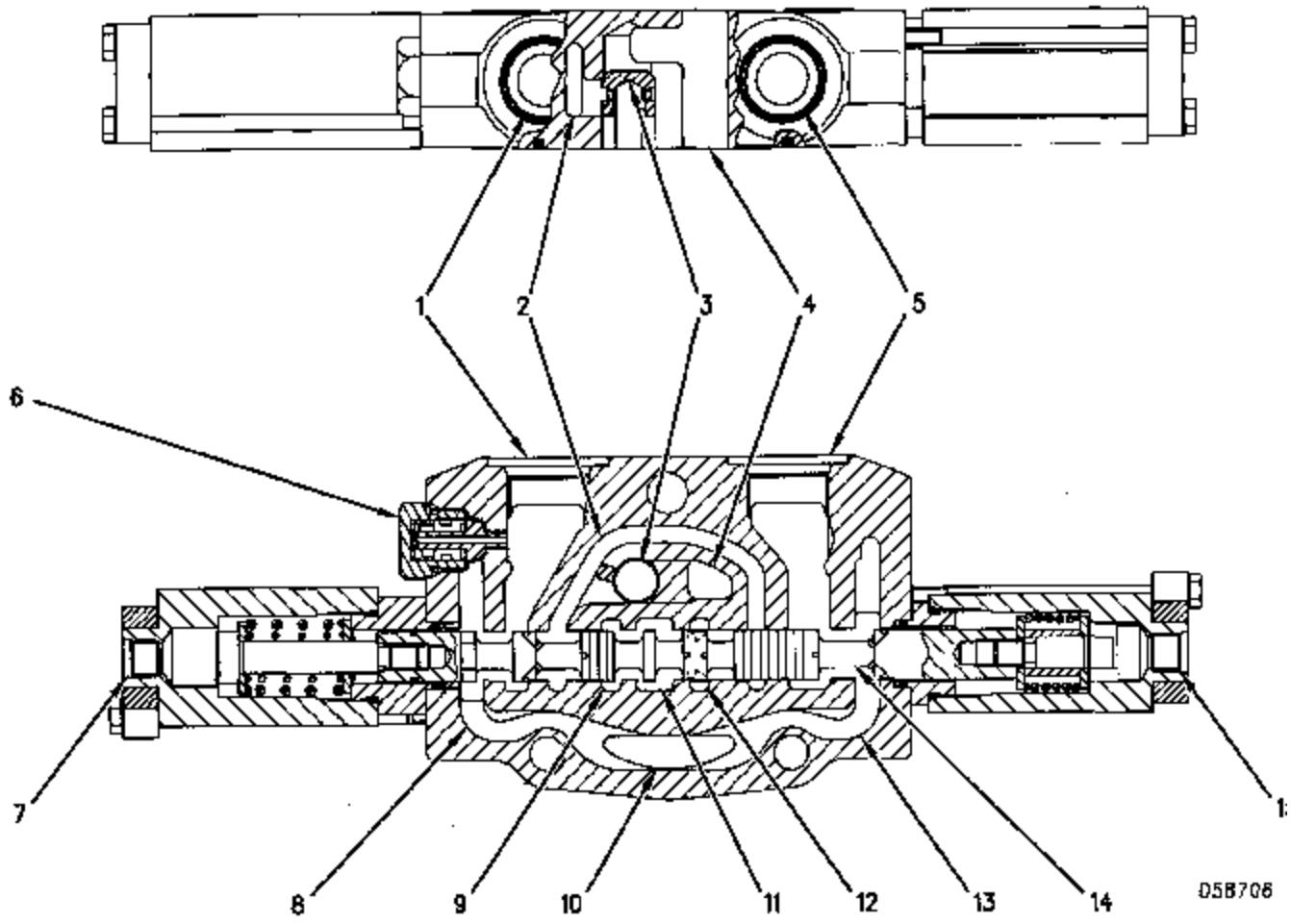
Lift Control Valve LOWER Position

When the control lever is moved to the LOWER position, pilot oil flows from the pilot control valve and enters port (7). Pilot oil combines with the force of the springs on the left side of valve spool (14) and overcomes the force of the springs on the right side of the spool. This causes the spool to move to the right.

When valve spool (14) moves to the right into the LOWER position, pump oil flow from passage (11) into passages (9) and (12) is blocked. The increase in oil pressure in passage (11) and (4) opens check valve (3). When the check valve opens, the pump oil in passage (11) flows through passage (4) and the open check valve into passage (2) and port (1). From port (1) the oil flows to the head end of the lift cylinder.

The pump oil flowing into the head end of the lift cylinder forces the rod outward. The rods extend, causing the blade to lower. Return oil from the rod end of the cylinder flows through port (5) and then through passages (13) and (10) to the tank.

Float Position



Lift Control Valve (Float position)
(1) Port to head end of lift cylinder. (2) Passage. (3) Load check valve. (4) Pump oil passage. (5) Port to rod end of lift cylinder. (6) Make-up valve. (7) Pilot oil port. (8) Passage to tank. (9) Pump oil passage to next valve or housing. (10) Passage to tank. (11) Pump oil passage from previous valve or housing. (12) Pump oil passage to next valve or housing. (13) Passage to tank. (14) Valve spool. (15) Pilot oil port.

When the control lever is moved to the FLOAT position, pilot oil flows from the pilot control valve and enters port (7). Pilot oil combines with the force of the springs on the left of valve spool (14) and overcomes the force of the springs on the right side of the spool. This causes the spool to move to the right.

When valve spool (14) moves to the right into the FLOAT position, pump oil flow from passage (11) into passage (12) is blocked. The oil from passage (11) now flows into passage (9) and back to tank. The position of the blade is not controlled by pump oil.

The position of spool (14) allows head end oil to flow through port (1) into passage (8). Rod end oil in port (5) is open to passage (13). Passages (8) and (13) are connected to each other and to passage to tank (10). With the oil in both ends of the lift cylinder at equal pressure, the weight of the push arms and blade cause the blade to lower to the ground.

As long as the control lever and valve spool are in the FLOAT position the blade will follow the contour of the ground as the machine moves.

An electromagnet detent assembly in the pilot control valve will hold the control lever in the FLOAT position until the pilot control valve lever is moved from that position.

Makeup Valve

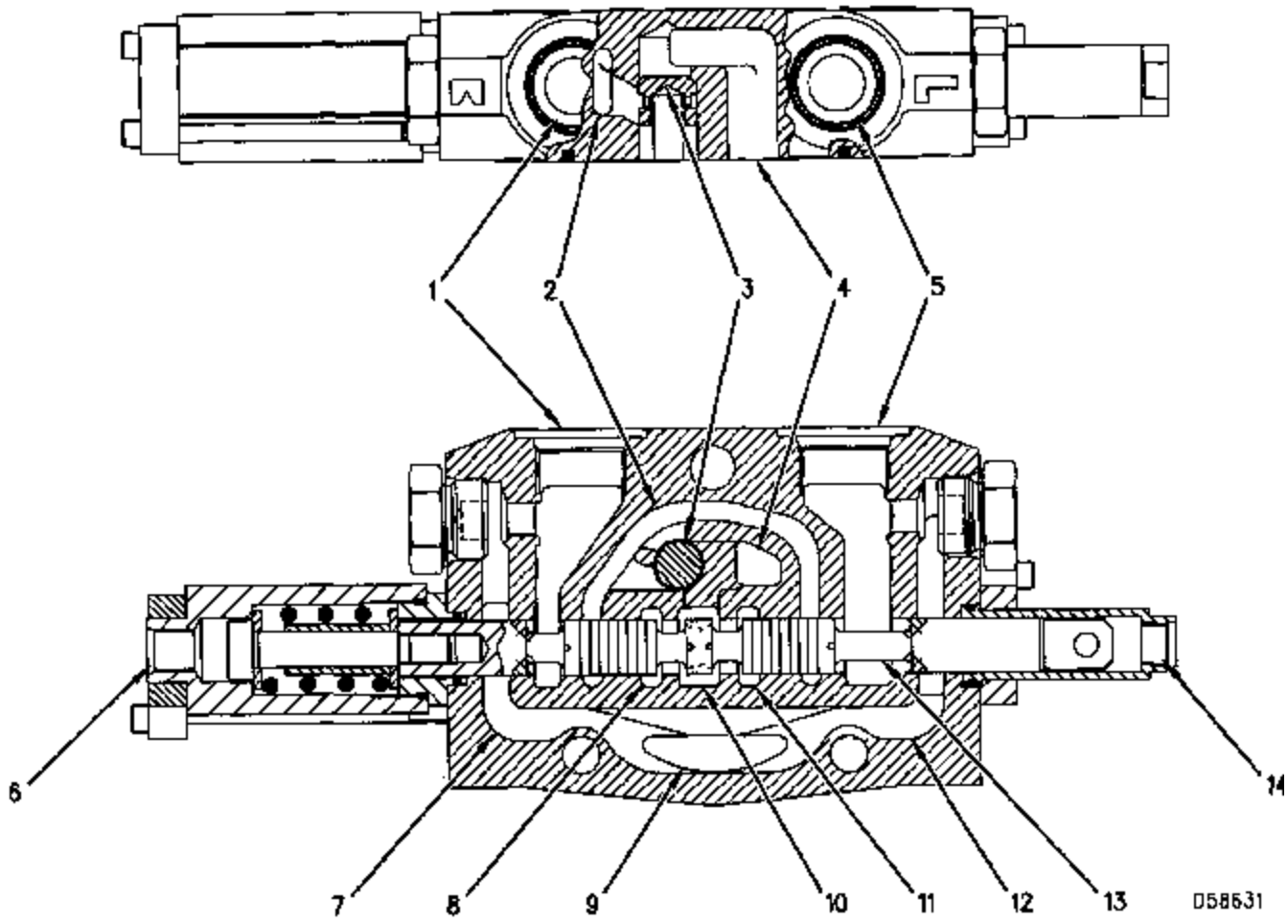
A makeup valve is located in passage (1) to the head end of the lift cylinders. The makeup valve functions when the control valve spool is in either the FLOAT or LOWER position.

A spring combines with oil pressure in the spring chamber to hold makeup valve (6) closed. The makeup valve opens only when the head end of the lift cylinder require more pump oil flow than the pump can supply oil to the cylinder. This prevents cavitation in the lift cylinder.

When the flow of oil to the head end of the cylinder is not enough, the pressure of the oil in passage (1) is low. The higher return oil pressure in the passage to the tank opens the valve and allows more oil to flow to the head end of the cylinder.

Tilt Control Valve

Tilt Hold Position



Tilt Control Valve (Hold position)
(1) Port to rod end of tilt cylinder. (2) Passage. (3) Load check valve. (4) Pump oil passage. (5) Port to head end of tilt cylinder. (6) Pilot oil port. (7) Passage to tank. (8) Pump oil passage to next valve or housing. (9) Passage to tank. (10) Pump oil passage from previous valve or housing. (11) Pump oil passage to next valve or housing. (12) Passage to tank. (13) Valve spool. (14) Pilot oil port.

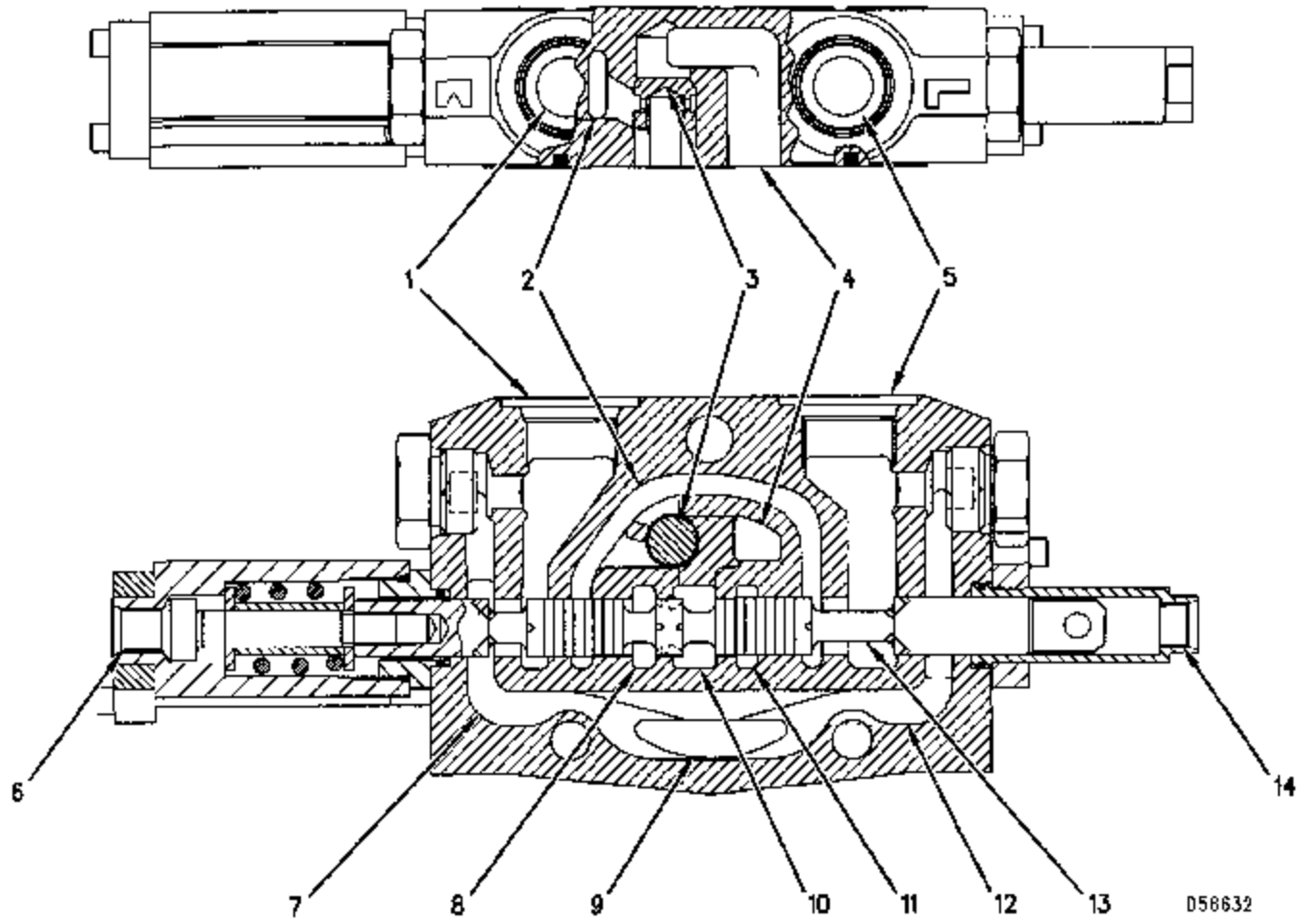
The tilt control valve is the next control valve in the valve group series. With the engine running, oil flows from the pump and enters the bottom housing. Then the oil flows through the lift control valve into passage (10).

If the tilt control valve is in the HOLD position the oil flows around valve spool (13), into passages (8) and (11) and on to the tip valve. If the tip valve is also in the HOLD position the oil flows through the tip valve and returns to the hydraulic tank.

In the HOLD position tilt valve spool (13) blocks the flow of oil in ports (1) and (5). With the oil in the lines to the tilt cylinder stopped, the cylinder can not move until the control lever and valve spool (13) are moved to either the TILT LEFT or TILT RIGHT position.

The springs on the left end of valve spool (13) and the springs on the right side of the spool keep the spool in the centered position when no pilot oil is routed to the spool.

Tilt Right Position



Tilt Control Valve (Tilt Right position)
(1) Port to rod end of tilt cylinder. (2) Passage. (3) Load check valve. (4) Pump oil passage. (5) Port to head end of tilt cylinder. (6) Pilot oil port. (7) Passage to tank. (8) Pump oil passage to next valve or housing. (9) Passage to tank. (10) Pump oil passage from previous valve or housing. (11) Pump oil passage to next valve or housing. (12) Passage to tank. (13) Valve spool. (14) Pilot oil port.

When the control lever is moved to the TILT RIGHT position, pilot oil flows from the pilot control valve and enters port (14). Pilot oil combines with the force of the springs on the right side of valve spool (13) and overcomes the force of the springs on the left side of the spool. This causes the spool to move to the left.

When valve spool (13) moves to the left into the TILT RIGHT position, pump oil flow from passage (10) into passages (8) and (11) is blocked. The increase in oil pressure in passage (10) and (4) opens check valve (3). When the check valve opens, the pump oil in passage (10) flows through passage (4) and the open check valve into passage (2) and port (5). From port (5) the oil flows to the head end of the tilt cylinder.

The pump oil flowing into the head end of the tilt cylinder pushes the rod out. The rod extends, causing the right side of the blade to tilt down. Return oil from the rod end of the cylinder flows through port (1) and then through passages (7) and (9) to the tank.

Tilt Left

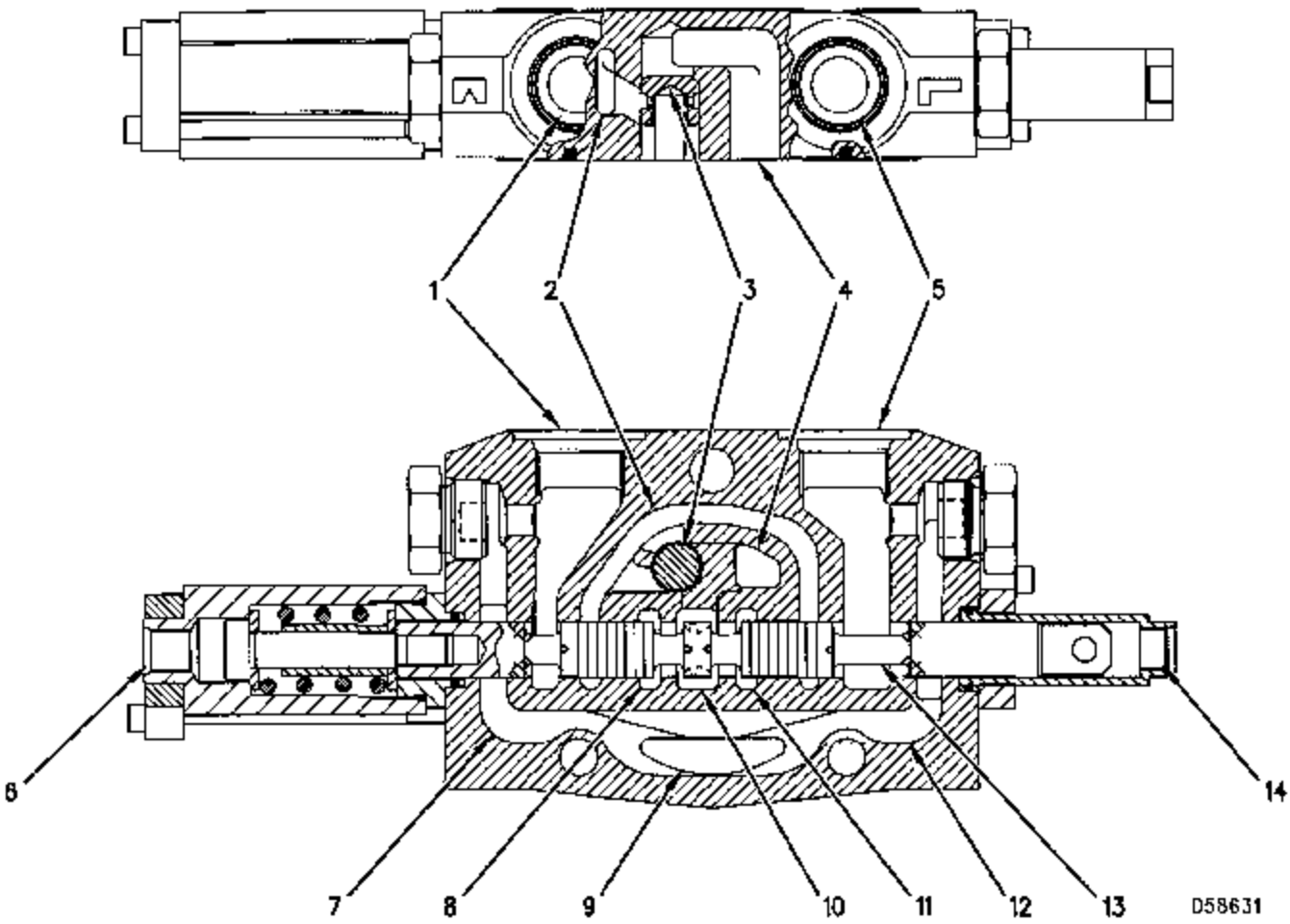
When the control lever is moved to the TILT LEFT position, pilot oil flows from the pilot control valve and enters port (6). Pilot oil combines with the force of the springs on the left side of valve spool (13) and overcomes the force of the springs on the right side of the spool. This causes the spool to move to the right.

When valve spool (13) moves to the right to the TILT LEFT position, pump oil flow from passage (10) into passages (8) and (11) is blocked. The increase in oil pressure in passages (10) and (4) opens check valve (3). When the check valve opens, the pump oil in passages (10) and (4) flows through the open check valve into passage (2) and out port (1). Then the oil flows to the rod end of the tilt cylinder.

The pump oil going into the rod end of the tilt cylinder pulls the rod in. The rod retracts, causing the left side of the blade to tilt down. Return oil from the head end of the cylinder flows through port (5) and then through passage (12) to the tank.

Tip Control Valve

Hold Position



Tip Control Valve (Hold position)
(1) Port to rod end of tip cylinder. (2) Passage. (3) Load check valve. (4) Pump oil passage. (5) Port to head end of tilt cylinder. (6) Pilot oil port. (7) Passage to tank. (8) Pump oil passage to next valve or housing. (9) Passage to tank. (10) Pump oil passage from previous valve or housing. (11) Pump oil passage to next valve or housing. (12) Passage to tank. (13) Valve spool. (14) Pilot oil port.

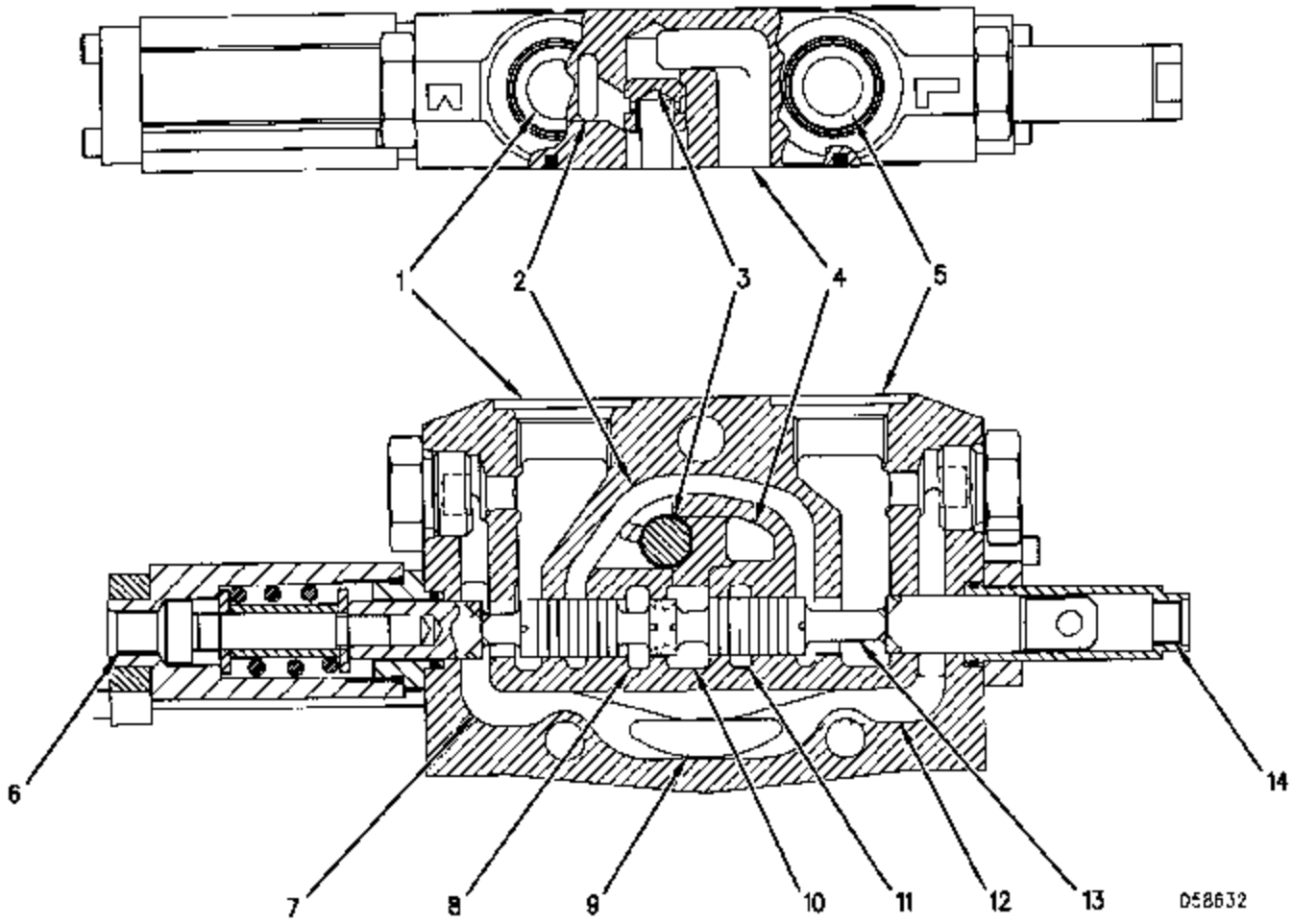
The tip control valve is the last control valve in the valve group series. With the engine running, oil flows from the pump and enters the bottom housing. Then the oil flows through the tilt control valve into passage (10).

If the tilt control valve is in the HOLD position the oil flows around valve spool (13) into passages (8) and (11) and on to the top housing. From the top housing the oil flows back to the hydraulic tank.

In the HOLD position tilt valve spool (13) blocks the flow of oil in ports (1) and (5). With the oil in the lines to the tip cylinder stopped, the cylinder can not move until the control lever and valve spool (13) are moved to either the TIP FORWARD or TIP BACKWARD position.

The springs on the left end of valve spool (13) and the springs on the right side of the spool keep the spool in the centered position when no pilot oil is routed to the spool.

Tip Forward Position



Tip Control Valve (Tip Forward position)
(1) Port to rod end of tip cylinder. (2) Passage. (3) Load check valve. (4) Pump oil passage. (5) Port to head end of tilt cylinder. (6) Pilot oil port. (7) Passage to tank. (8) Pump oil passage to next valve or housing. (9) Passage to tank. (10) Pump oil passage from previous valve or housing. (11) Pump oil passage to next valve or housing. (12) Passage to tank. (13) Valve spool. (14) Pilot oil port.

When the control lever is moved to the TIP FORWARD position, pilot oil flows from the pilot control valve and enters port (14). Pilot oil combines with the force of the springs on the right side of valve spool (13) and overcomes the force of the springs on the left side of the spool. This causes the spool to move to the left.

When valve spool (13) moves to the left into the TIP FORWARD position, pump oil flow from passage (10) into passages (8) and (11) is blocked. The increase in oil pressure in passage (10) and (4) opens check valve (3). When the check valve opens, the pump oil in passage (10) flows through passage (4) and the open check valve into passage (2) and port (5).

From port (5) the oil flows to the head end of the TILT cylinder. The oil flows to the TILT cylinder because of the check valve groups installed in the lines to the tilt and tip cylinders. For operation of the check valve groups refer to the topic 814F Pilot Operated Check Valve Group (Tilt And Tip)

The pump oil flowing into the head end of the tilt cylinder pushes the rod out. The rod extends, and pushes oil from the rod end of the tilt cylinder. The line from the rod end of the tilt cylinder is connected to the head end of the tip cylinder. The tip cylinder rod is also pushed out. When the rods of the cylinders extend, the top of the blade moves forward.

Return oil from the rod end of the tip cylinder flows through the check valve group to port (1) and then through passages (7) and (9) to the tank.

Tilt Backward

When the control lever is moved to the TIP BACKWARD position, pilot oil flows from the pilot control valve and enters port (6). Pilot oil combines with the force of the springs on the left side of valve spool (13) and overcomes the force of the springs on the right side of the spool. This causes the spool to move to the right.

When valve spool (13) moves to the left into the TIP BACKWARD position, pump oil flow from passage (10) into passages (8) and (11) is blocked. The increase in oil pressure in passage (10) and (4) opens check valve (3). When the check valve opens, the pump oil in passage (10) flows through passage (4) and the open check valve into passage (2) and port (1). From port (1) the oil flows to the rod end of the tip cylinder.

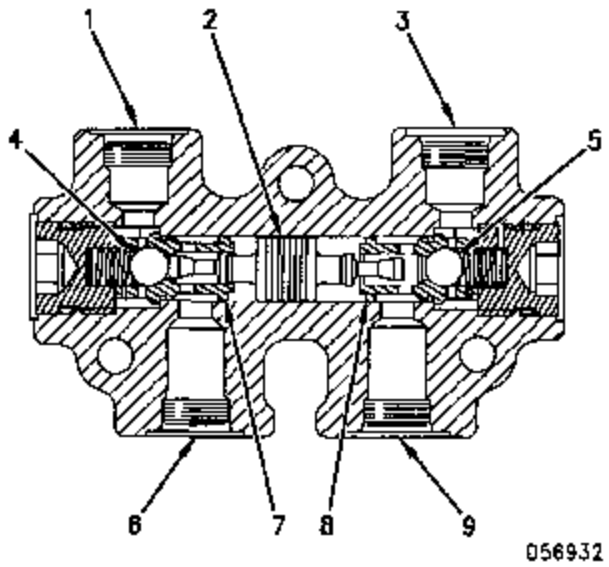
The pump oil flowing into the rod end of the tip cylinder pulls the rod in. The rod retracts, and pushes oil from the head end of the tip cylinder. The line from the head end of the tip cylinder is connected to the rod end of the tilt cylinder. The tilt cylinder rod is also pulled in. When the rods of the cylinders retract, the top of the blade moves backward.

The oil flows to the rod end of the TILT cylinder because of the check valve groups installed in the lines to the tilt and tip cylinders. For operation of the check valve groups refer to the topic 814F Pilot Operated Check Valve Group (Tilt And Tip)

Return oil from the head end of the tilt cylinder flows through the check valve group to port (5) and then through passages (12) and (9) to the tank.

814F Pilot Operated Check Valve Group (Tilt And Tip)

This check valve is in both the tilt and tip circuits. The check valve is located between the implement valves and the hydraulic cylinders. The operation of each check valve is the same.



814F Pilot Operated Check Valve Group (Tilt And Tip)
(1) Cylinder port. (2) Piston. (3) Cylinder port. (4) Ball. (5) Ball. (6) Implement valve port. (7) Seat. (8) Seat. (9) Implement valve port.

With the implement valve in the HOLD position, oil at ports (1) and (3) is blocked. The rod in the cylinder can not move in or out. Spring force on balls (4) and (5), plus the trapped oil at ports (1) and (3) keeps the balls against seats (7) and (8). The oil at ports (6) and (9) is at tank pressure.

Moving the position of the control lever allows pressure oil to flow from the implement valve through passage (6). Pressure oil to the right of seat (7) moves piston (2) left against ball (4). This allows balls (4) and (5) to move off of seats (7) and (8).

Pressure oil now has a path through the check valve. Oil flows through passage (1) into the cylinder. Oil pressure in the cylinder moves the rod, pushing oil out the opposite end of the cylinder. Return oil flows through passage (3), past ball (5), through passage (9) to the implement valve, and back to the hydraulic oil tank.

Testing And Adjusting

Hydraulic System

⚠ WARNING

Personal injury or death can result from improperly checking for a leak.

Always use a board or cardboard when checking for a leak. Escaping air or fluid under pressure, even a pin-hole size leak, can penetrate body tissue, causing serious injury, and possible death. If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.

⚠ WARNING

Sudden movement of the machine or release of oil under pressure can cause injury to persons on or near the machine.

To prevent possible injury, perform the procedure that follows before testing and adjusting the hydraulic system.

1. Move the machine to a smooth, hard, and dry horizontal surface. Move away from working machines and personnel. Lower the blade or implement to the ground. Stop the engine.
2. Permit only one operator on the machine. Keep all other personnel either away from the machine or in view of the operator.
3. Engage the parking brake. Put blocks in front of and behind the wheels.
4. Push on the brake pedal many times until there is no more brake oil pressure.
5. When the blade or an implement is raised for tests or adjustments, make sure that the blade or implement has correct support. The lift circuit has high oil pressure when the lift arms raise the front of the machine. Do not stop the engine with the front of the machine off the ground, unless a system test requires it. Lower the machine to the ground and stop the engine.
6. Install the steering frame lock link so the machine can not turn.
7. Move the hydraulic control levers to all positions to release the pressure in the hydraulic system. Place the tilt control lever in the HOLD position. Place the lift control lever in the FLOAT position.
8. Carefully loosen the fill cap on the hydraulic tank to release the pressure in the tank.
9. Make sure all hydraulic pressure is released before any fitting, hose, or component is loosened, tightened, removed, or adjusted.
10. Tighten the fill cap on the hydraulic tank.

During a diagnosis of the hydraulic system, remember that correct oil flow and pressure are necessary for correct operation. The output of the pump increases with an increase in engine speed, and decreases when engine speed is decreased. Oil pressure is caused by resistance to the flow of oil.

Visual Checks

The 8T-5320 Hydraulic Test Group, 4C-4890 Fittings Group, and 1U-5481 Pressure Gauge Group, are used to make the pressure tests for the hydraulic system. Before any tests are made, visually inspect the complete hydraulic system for leakage of oil and for parts that have damage. For some of the tests a magnet and a measuring rule (either for inches or millimeters), are usable tools.

Visual checks and measurements are the first step when troubleshooting a possible problem. Then perform the Operation Checks, and then the Instrument Tests.

1. Lower the blade or implement to the ground and stop the engine.
2. Slowly turn the hydraulic tank fill cap until it is loose. If oil starts to seep out, allow the tank pressure to decrease before the fill cap is completely removed. Check the hydraulic tank oil level.
3. Look for air bubbles in the hydraulic oil. Perform this step immediately after the machine is stopped. Use a clear bottle or container to collect a sample of the oil. Look for air bubbles in the oil that is in the bottle.
4. Remove the hydraulic oil filter elements, and look for particles removed from the oil by the filter element. A magnet will separate ferrous particles from nonferrous particles (piston rings, O-ring seals, etc.). If any ferrous material is found, the component with damage must be found, and a repair must be made. The hydraulic system must then be flushed.
5. Check the tightening torque of all bolts.
6. Check all oil lines and connections for damage or leaks.
7. Inspect control linkages for bent, broken, or damaged components.

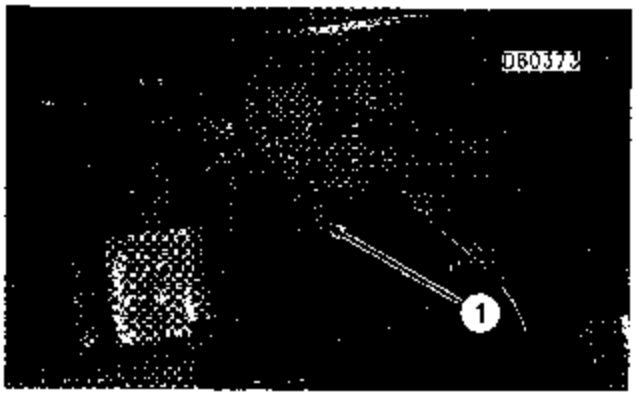
Hydraulic Oil Contamination Test

⚠ WARNING

Make reference to the WARNINGS on the first page of the Hydraulic System Testing And Adjusting section.

The hydraulic oil in this system is SAE 10W. If the oil becomes contaminated, premature component failure could result. Contaminated oil can also contribute to overheating. Use the following steps to sample the oil in the hydraulic system.

1. Start the engine and run it at high engine rpm.
2. Actuate all cylinders through at least ten full strokes.
3. Lower all attachments to the ground.



Implement Oil Sample Valve Location
(1) Implement oil sample valve.

4. Draw a 50 ml oil sample through the implement system oil sample valve. The contaminant level must be equal to, or less than the values shown in the following chart.

Hydraulic Oil Contamination Values	
Particle Size (Microns)	**Maximum Number Of Particles**
10 to 20	48 000
21 to 50	2580
51 to 100	150
100–Up	20

Performance Tests

1. The lift, tilt, and tip circuits are connected in a series arrangement. The hydraulic pump and relief valve for implement pressure is common to the lift, tilt, and tip circuits.
2. Relief valve pressures that are too low will cause a decrease in the lift and dig characteristics of the machine. Pressures that are too high will cause a decrease in the life of hoses, seals, and related components.
3. Drift rates in the lift and tilt circuits: Cylinder drift is caused by oil leakage past the cylinder pistons, O-ring seals in the control valves, check valves, or makeup valves that do not seat correctly, or poor adjustment or fit in the control valves.
4. Cycle times in either the lift or the tilt circuits: Cycle times that are longer than those shown are the result of leakage, pump wear, and/or pump speed (rpm).

If the basic tests give an indication of circuit leakage, install a flow meter and perform a system test. This will help locate the source of the leakage.

Pump Efficiency Check

For any pump test at a given rpm, the pump flow at 690 kPa (100 psi) will be larger than the pump flow at 6900 kPa (1000 psi). The difference between the pump flow of the two operating pressures is the flow loss.

Formula I*

Method of finding flow loss:

Pump flow at 690 kPa (100 psi)	217.6 L/min (57.5 gpm)
Pump flow at 6900 kPa (1000 psi)	−196.8 L/min (52.0 gpm)
Flow loss.....	20.8 L/min (5.5 gpm)

Flow loss when expressed as a percent of pump flow is used as a measure of pump performance.

Example of finding percent of flow loss:

$$\frac{\text{L/min (gpm) flow loss}}{\text{Pump flow @ 690 kPa (100 psi)}} \times 100 = \text{Percent of flow loss}$$

$$\text{or} \quad \frac{20.8^{*}\ \text{L/min}\ (5.5^{*}\ \text{gpm})}{217.6^{*}\ (57.5^{*})} \times 100 = 9.6\%$$

If the percent of flow loss is more than 10%, pump performance is not good enough.

*Numbers in examples are for illustration and are not values for any specific pump or pump condition. See Specifications for pump flow of a new pump at 690 kPa (100 psi) and 6900 kPa (1000 psi).

Machine Test

Install a Flow Meter. For Formula I, measure pump flow at 690 kPa (100 psi) and at 6900 kPa (1000 psi) with the engine at high idle rpm.

Formula I:

$$\frac{\text{L/min @ 690 kPa} - \text{L/min @ 6900 kPa}}{\text{L/min @ 690 kPa}} \times 100 = \text{Percent of flow loss}$$

$$\frac{\text{gpm @ 100 psi} - \text{gpm @ 1000 psi}}{\text{gpm @ 100 psi}} \times 100 = \text{Percent of flow loss}$$

Bench Test

If the test bench can be run at 6900 kPa (1000 psi) and at full pump rpm, find the percent of flow loss using Formula I.

If the test bench can not be run at 6900 kPa (1000 psi) and at full pump rpm, run the pump shaft at 1000 rpm. Measure the pump flow at 690 kPa (100 psi) and at 6900 kPa (1000 psi). Use these values in the top part of Formula II. For the bottom part of the formula, run the pump shaft at 2000 rpm. Measure the pump flow at 690 kPa (100 psi).

Formula II

Formula II:

$$\frac{\text{L/min @ 690 kPa} - \text{L/min @ 6900 kPa}}{\text{L/min @ 690 kPa @ 2000 rpm}} \times 100 = \text{Percent of flow loss}$$

$$\frac{\text{gpm @ 100 psi} - \text{gpm @ 1000 psi}}{\text{gpm @ 100 psi @ 2000 rpm}} \times 100 = \text{Percent of flow loss}$$

Operation Checks

⚠ WARNING

Make reference to the WARNINGS on the first page of the Hydraulic System Testing And Adjusting section.

The operation checks can be used to find leakage in the system. They can also be used to find a worn valve or pump. The speed of rod movement when the cylinders move can be used to check the condition of the cylinders and the pump.

Lift, lower, and tilt the blade or implement several times.

1. Watch the cylinders as they extend and retract. Movement must be smooth and regular.
2. Listen for noise from the pump.
3. Listen for the sound of the relief valve. It must not open except when the cylinders are fully extended or retracted.

The lift control lever has a detent in the FLOAT position.

Lift Cylinder Travel Time

Use a stop watch or timer to measure the time for the blade to lift from the ground to the top of its travel.

Run the engine at high idle rpm when the measure of time for the blade lift is made.

The time for the blade to lift is 1.4 to 2.0 seconds to the top of its travel.

If the travel time is not correct

1. Check pump efficiency.
2. Check the setting of the relief valve.
3. Check the lift cylinder for leakage.
4. The makeup valve in the lift circuit (in the lift valve section) could have leaks.
5. The valve spools in the lift valve section could be worn.

Hydraulic Cylinder Drift

If the hydraulic cylinder drift (rod moves either in or out of the cylinder when the control lever is in the HOLD position) is enough to affect the performance of the machine during normal operations, there is either a damaged component, or a component that must be disassembled and cleaned.

Causes of cylinder drift:

1. Damaged cylinder surface.
2. Seal on piston has damage.
3. Scratch or groove in cylinder.
4. Scratch or groove on cylinder rod.
5. Damage on seal in cylinder head.
6. Dirt or damage in check valve.
7. Loose fittings or hydraulic lines with damage that have oil leaks.

Lift Cylinder Rod Drift

The drift rates will change with different conditions of the hydraulic components, as well as with the operation, and hydraulic oil temperature. Before measuring drift on the lift cylinder, the cylinder must be extended at least five times. Measure rod drift using the following procedure:

1. Check the temperature of the hydraulic oil.
2. Lift the blade until the cutting edge is approximately 254 mm (10 in.) off the ground. With the lift control lever in the HOLD position, stop the engine.
3. Measure the length of the lift cylinder rod (from the lift cylinder), and record this measurement.
4. Measure the distance and check the time that the cylinder extends. Compare the results to the information in the following chart.

NOTE: The drift distances in the charts are for new machines.

Lift Cylinder Drift			
Oil Temperature	**49°C (100 - 120°F)**	**49 - 66°C (120 - 150°F)**	**Over 66°C (Over 150°F)**
Maximum Permissible Drift	13.0 mm (.50 in)	13.0 mm (.50 in)	13.0 mm (.50 in)
Time Interval in Minutes	5	2.7	1.7

Too much cylinder rod drift is caused by:

1. Loose oil line connections and condition of the hoses between the control valve and the rod end of the lift cylinder.
2. Leakage around the piston seal in the lift cylinder.
3. Leakage in the control valve (worn valve section and spool valve and/or the makeup valve is not on its seat).

When there is to much drift with the hydraulic oil temperature below 54°C (130°F), and there is no leak in the lines to the lift cylinder, make another test.

1. Start the engine. Move the lift control lever to the LOWER position. When the rod from the lift cylinder is extended, and the front of the machine is off the ground, stop the engine.

2. Carefully disconnect the oil line from the rod end of the lift cylinder.

3. When only a very small amount of oil comes from the open oil line connection on the lift cylinder, the seals on the piston are not the cause of too much cylinder rod drift.

NOTE: When the piston seals in the lift cylinder are not the cause of too much drift, the control valve is the cause (the check valve is not on its seat and/or a worn valve spool and valve section).

Tip And Tilt Cylinder Rod Drift

Measure the tip and tilt cylinder rod drift using the following procedure:

1. Check the temperature of the hydraulic oil.

2. Lift the blade until the cutting edge is 25 mm (1 in) off of the ground.

3. Position the tip cylinder at one half the total rod extension, and position the tilt cylinder so the right corner of blade raises the front wheel off of the ground.

4. Measure the distance and check the time that the tip and tilt cylinders extend. Compare the results with the information in the following chart.

NOTE: The drift distances in the chart are for new machines.

Tip And Tilt Cylinder Drift			
Oil Temperature	38 – 49°C (100 – 120°F)	49 – 66°C (120 – 150°F)	Over 66°C (Over 150°F)
Maximum Permissible Drift	19.0 mm (.75 in)	19.0 mm (.75 in)	19.0 mm (.75 in)
Time Interval In Minutes	5	2.7	1.7

Too much tip or tilt cylinder drift is caused by:

1. Loose oil line connections and the condition of the hoses between the control valve and the rod end of the tip and tilt cylinders.

2. Leakage around the piston seals in the tip and tilt cylinders.

3. Leakage in the control valve (worn valve section and spool valve).

Hydraulic Oil Temperature Too High

When the temperature of the hydraulic oil rises above 100°C (210°F), polyurethane seals in the system may begin to fail. High oil temperature causes seal failure to become more rapid. There are many reasons why the temperature of the oil may get this hot.

1. Hydraulic pump is badly worn.

2. Heavy hydraulic loads that cause the relief valve to open.

3. The setting on the relief valve is too low.

4. Too many restrictions in the system.

5. Low oil level.

6. High pressure oil leak in one or more circuits.

7. Contaminated oil.

8. Air flow through the oil cooler core is too low.

9. Oil flow through the oil cooler is too low.

10. Air in the hydraulic oil.

NOTE: If the problem is because of air in the oil, it must be corrected before the system will operate at normal temperatures. There are two things that cause air in the oil (aeration).

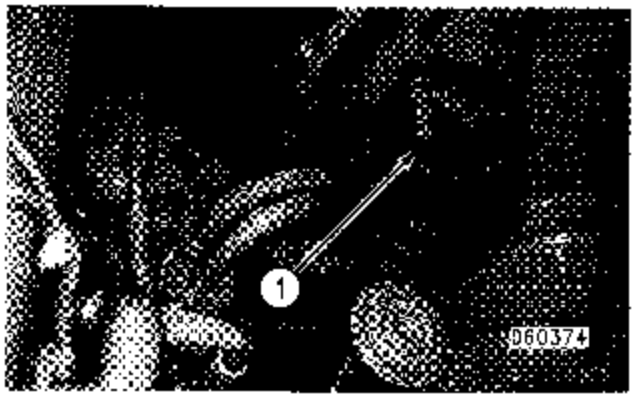
a. Return oil to the tank rises above the level of the oil in the tank.
b. Air leaks in the oil suction line between the pump and the tank.

Pilot System Pressure Test

⚠ WARNING

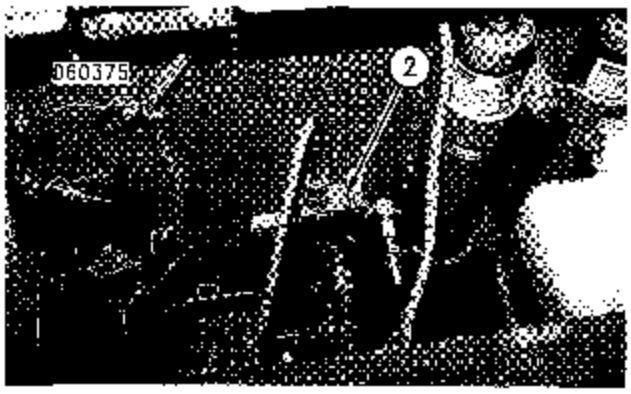
Make reference to WARNING on first page of Hydraulic System Testing And Adjusting section.

TOOLS NEEDED		
Part No.	Description	Quan.
8T-5320	Hydraulic Test Group	1
1U-5481	Pressure Gauge Group	1

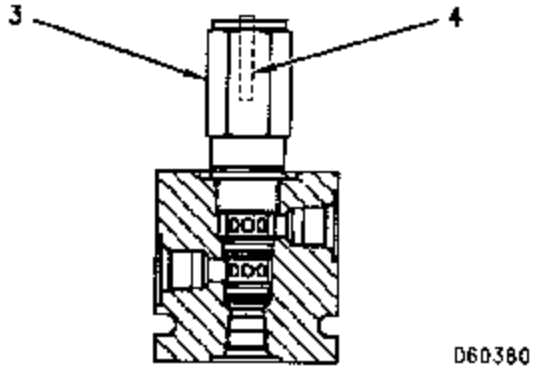


Pilot System Pressure Tap
(1) Pilot system pressure tap.

1. Attach the correct hose and pressure gauge to pressure tap (1).
2. Start and run the engine at high idle rpm. The pressure reading, with the oil at normal temperature, should be 2410 ± 140 kPa (350 ± 20 psi).
3. If the pressure reading is not correct, stop the engine.
4. Move the brake pedal to release any pilot pressure in the brake accumulators.
5. Move the control valves to all positions to release any pressure in the implement pilot circuits.
6. Carefully loosen the hydraulic tank fill cap to release any pressure in the tank. Tighten the cap.



Pressure Reducing Valve Location
(2) Pressure reducing valve.



Pressure Reducing Valve
(3) Pressure reducing valve. (4) Adjusting screw (Internal).

7. Using 8 mm (.32 in) Allen wrench, turn adjusting screw (4) inside valve (3) clockwise to increase pressure and counterclockwise to decrease pressure.
8. Repeat step 2.
9. If pressure reading is correct, stop the engine. Remove the test equipment from pressure tap (1).
10. If pressure reading is not correct stop the engine, repeat steps 4 through 8

Pressure Control And Selector Valve

⚠ WARNING

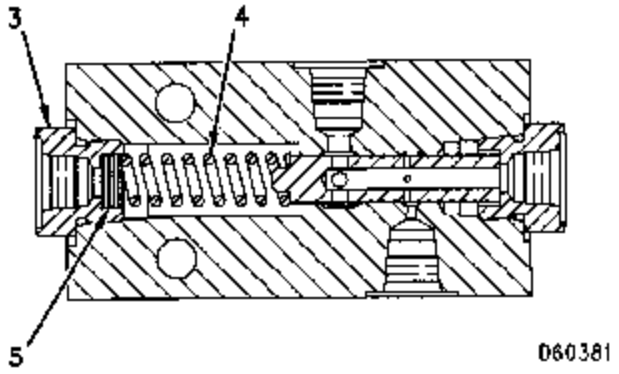
Make reference to WARNING on first page of Hydraulic System Testing And Adjusting section.

TOOLS NEEDED		
Part No.	**Description**	**Quan.**
8T-5320	Hydraulic Test Group	1
1U-5481	Pressure Gauge Group	1
6V-3965	Nipple	1
8T-8902	Swivel Tee	1

Right Side Of Cab
(1) Pilot hose to hydraulic lockout valve.

Pressure Control And Selector Valve Location
(2) Pressure control and selector valve.

1. Release the pressure in the pilot oil system. Move the control valves to all positions to release any pressure in the implement pilot circuits.
2. Carefully loosen the hydraulic tank fill cap to release any pressure in the tank. Tighten the cap.
3. Disconnect hose (1) from the valve.
4. Install a 8T-8932 Swivel Tee between the hose and valve. Install a 6V-3965 Nipple in the tee.
5. Attach the correct hose and pressure gauge to pressure tap (1).
6. Start and run the engine at high idle rpm. Raise the temperature of the hydraulic oil to the normal operating temperature.
7. Raise the blade to the maximum height.
8. Stop the engine.
9. The pressure reading must be 2400 ± 350 kPa (350 ± 50 psi).



Cross Section Of Pressure Control And Selector Valve
(3) Plug. (4) Spring. (5) Spacers.

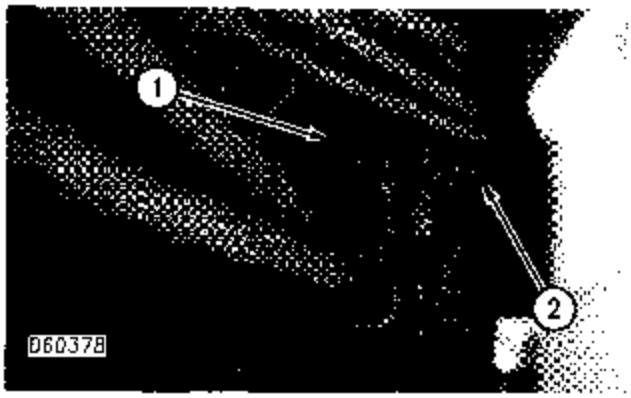
10. If the pressure reading is not correct, move the control valves to all positions to release any pressure in the implement pilot circuits.
11. Carefully loosen the hydraulic tank fill cap to release any pressure in the tank. Tighten the cap.
12. Remove plug (3) from the valve. Add spacers (5), located between the plug and spring (4), to increase pressure reading. Remove spacers to decrease the pressure reading.
13. Install plug (3). Repeat step 2.
14. If the pressure reading is correct, move the control valves to all positions to release any pressure in the implement pilot circuits.
15. Carefully loosen the hydraulic tank fill cap to release any pressure in the tank. Tighten the cap.
16. Remove the test equipment.

Implement System Pressure Relief Valve

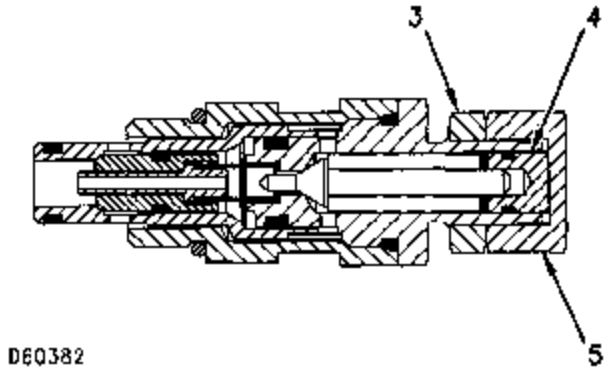
⚠ WARNING

Make reference to WARNING on first page of Hydraulic System Testing And Adjusting section.

TOOLS NEEDED		
Part No.	Description	Quan.
9T-5320	Hydraulic Test Group	1



Implement Control Valve
(1) Pressure tap. (2) Implement relief valve.



Implement Relief Valve
(3) Locknut. (4) Adjusting plunger. (5) Cap.

1. Attach the correct hose and pressure gauge to pressure tap (1).
2. Start the engine and raise the blade to the top of the blade's travel.
3. Increase the engine speed to high idle rpm. Move the control lever to the RAISE position and look at the test gauge.
4. The pressure setting of implement relief valve (2) should be 15 500 ± 350 kPa (2250 ± 50 psi).

NOTE: Do not keep the control lever in the RAISE position, at the relief valve setting, more than 5 seconds.

5. If the opening pressure of the relief valve is not to specification it will be necessary to adjust the valve.
6. Lower the bucket to the ground and stop the engine.
7. Loosen locknut (3) on implement relief valve (2). Turn cap (5) clockwise for an increase or counterclockwise for a decrease in the pressure setting of the implement relief valve. Turning cap (5) moves plunger (4) to change the pressure setting.
8. Tighten locknut (3) to 61 ± 6 N•m (45 ± 5 lb ft). Repeat steps 2 and 3.
9. When the pressure setting of implement relief valve (2) is correct, lower the blade to the ground.
10. Stop the engine.
11. Remove the test equipment from pressure tap (1).

Troubleshooting

When making an analysis of a hydraulic system for poor performance, remember that correct oil flow and pressure are necessary for correct operation. Oil flow is a function of the output of the pump. The output of the pump is a function of engine speed. Restriction to the flow of oil causes oil pressure.

Problem 1: Pump makes noise, the cylinder rods do not move smoothly, and there are air bubbles in the oil.

Probable Cause:

1. The viscosity of the oil is incorrect.
2. The relief valve opens at low oil pressure.
3. Loose connection of the oil line on the inlet side of the pump.
4. The pump has too much wear.

Problem 2: The temperature of the oil is too hot.

Probable Cause:

1. The viscosity of the hydraulic oil is incorrect.
2. The relief valve opens at low oil pressure.
3. The pump has too much wear.
4. There is a restriction in an oil passage.
5. The load of the system is too high.

6. Low oil level.

7. Air in the hydraulic oil.

NOTE: If the problem is because of air in the oil, it must be corrected before the system will operate at normal temperatures. There are two things that cause air in the oil (aeration).

a. Return oil to the hydraulic oil tank flows in above the level of the oil in the tank.
b. Air leaks in the oil suction line between the pump and the tank.

Problem 3: The output of the pump is low.

Probable Cause:

1. Low oil level.
2. The viscosity of the hydraulic oil is incorrect.
3. The pump has too much wear.

Problem 4: The pressure of the oil is low.

Probable Cause:

1. The relief valve opens at low oil pressure.
2. The pump has too much wear.
3. The failure of an O-ring seal in the system.
4. The control valve and valve spool have a large amount of wear.

Problem 5: Attachment moves with the control lever in the HOLD position.

Probable Cause:

1. The control valve and valve spool have a large amount of wear.
2. A piston seal in a cylinder has a large amount of wear.
3. A leak in a connection between the control valve and the cylinder.
4. A leak from a check valve not closing because of dirt or a worn seat.
5. Control lever not centering correctly.

Problem 6: Attachment droops when the control lever is moved from the HOLD position, to the LIFT position.

Probable Cause:

The load check valve is not closing.

a. Weak or broken spring.
b. Dirt or debris in valve.

Problem 7: A large amount of air is in the oil.

Probable Cause:

1. A leak in the oil line between the hydraulic oil tank and the pump.
2. Failure to correctly bleed the hydraulic system after assembly, inspection, or testing.
3. Relief valve constantly opens and closes.
4. Leakage in and around cylinder seals.

Problem 8: No pump pressure.

Probable Cause:

1. The hydraulic system is low on oil.
2. The pump or pump drive has failed.

TM 5-3805-380-2

CATERPILLAR®

SENR1317
March 1996

Schematic

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Hydraulic System

814F	815F	816F
9DM1-UP	1GN1-UP	5FN1-UP

815F SOIL COMPACTOR
HYDRAULIC SYSTEM

Index

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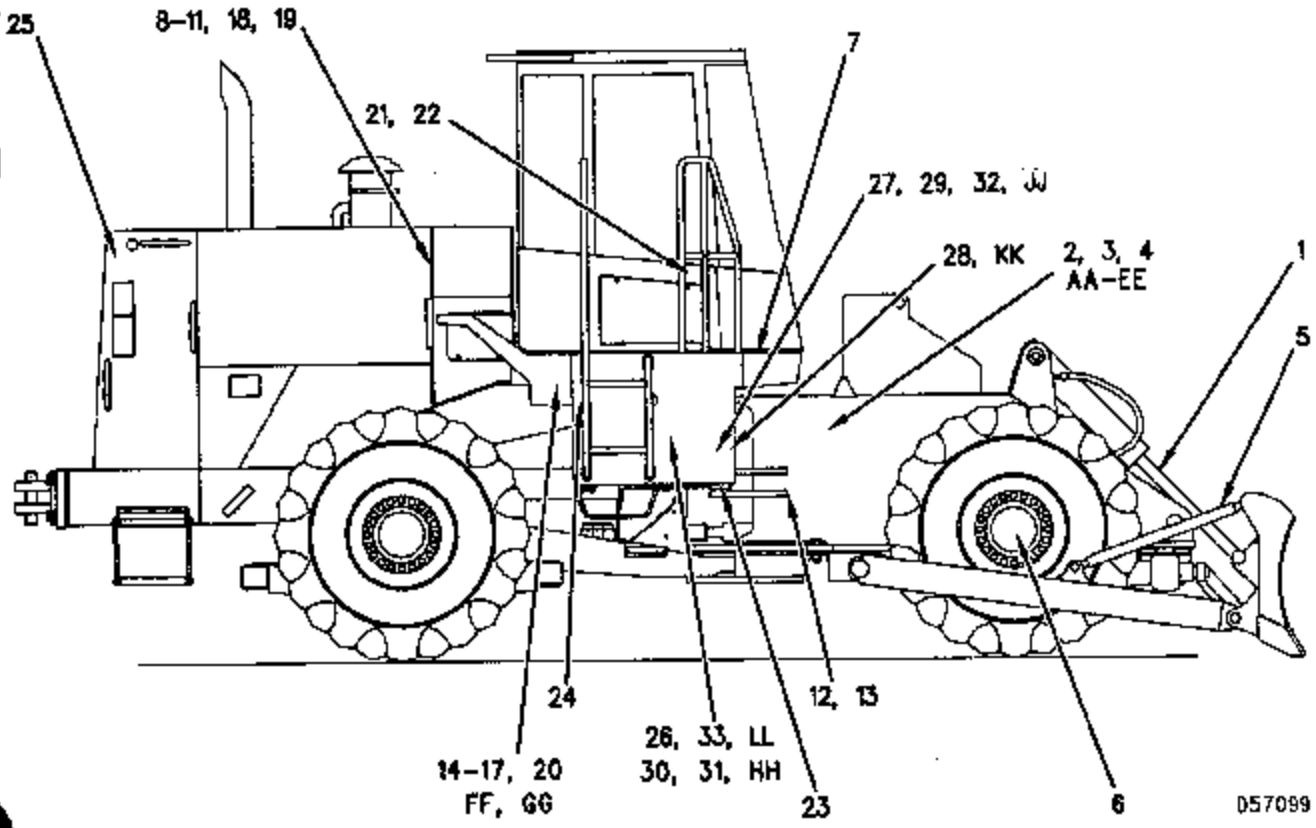
Components Location (side view and top view)	3
Component Location Chart	4
Hydraulic Schematic (Fold-out) (A, B, C, D, E, F)	5

815F SOIL COMPACTOR & 816F LANDFILL COMPACTOR



815F SOIL COMPACTOR & 816F LANDFILL COMPACTOR

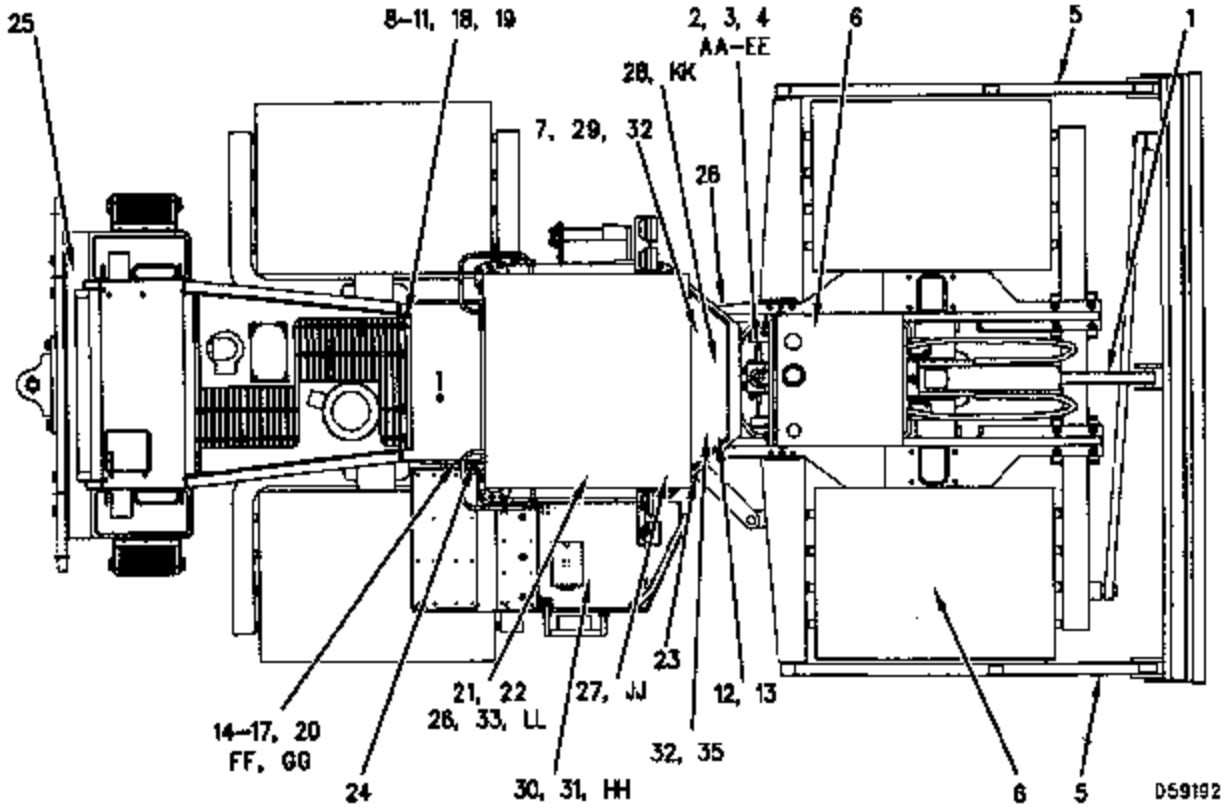


Chart C 815F Soil Compactor & 816F Landfill Compactor Hydraulic Component Locations		
Item	Description	Schematic Locations
1	Lift Cylinder	1A
2	Check Valve Group	1A
3	Main Relief Valve[1]	2A
4	Implement Valve Group[2]	2A
5	Tilt Cylinder[3]	3A
6	Front Service Brakes	5A
7	Service Brake Control Valve	6A
8	Accumulator Charging Valve	
9	Front Service Brake Accumulator	
10	Parking Brake Accumulator	6A
11	Service Brake Low Oil Pressure Switch	7A
12	Parking Brake	7A
13	Parking Brake Oil Pressure Switch	7B
14	Selector & Pressure Control Valve Group	3B
15	Steering Pump	1B
16	Implement Pump	1B
17	Pilot/Brake Pump	2B
18	Parking Brake Valve Group	7B
19	Pressure Reducing Valve	3C
20	Check Valve Group	3C
21	Ball Valve Group	3C
22	Pilot Valve Group[2]	5C
23	Steering Cylinders	6C
24	Sampling Valve	1C
25	Cooler Core Assembly	2C
26	Steering Valve Group	6C
27	Manifold	2C
28	Metering Pump (Steering)	3C
29	Neutralizer Valve Group	4C
30	Hydraulic Oil Tank Group	1D
31	Filter Elements	2D
32	Front Frame Mounted Stops	5D
33	Flow Control Valve	6D

[1] 118-4706 Relief Valve is standard on the 815F Soil Compactor & 816F Landfill Compactor. 134-6264 is an attachment on the 815F Soil Compactor only.
[2] The two section hydraulic control valve and the pilot control valve are attachments on the 815F Soil Compactor only.
[3] 10-1988 Tilt Cylinder Group is an attachment on the 815F Soil Compactor only.

Chart D 815F Soil Compactor & 816F Landfill Compactor Pressure Tap Locations		
Pressure Tap	Description	Schematic Location
AA	Lift Head End	3A
BB	Lift Rod End	4A
CC	Tilt Head End	
DD	Tilt Rod End	
EE	Implement Relief	3B
FF	Pilot/Brake Pump Pressure	2B
GG	Implement Pilot Pressure	4B
HH	Hydraulic Oil Tank Return Pressure	1C
JJ	Steering Return Pressure	3C
KK	Steering Pilot Pressure	3D
LL	Steering Relief Pressure	6D

CATERPILLAR®

GOV #3
September 1996

Disassembly & Assembly

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Machine Systems

814F:	815F:	816F:
9DM1-UP	1GN1-UP	5FN1-UP

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operation that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warning in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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⚠ WARNING

Disconnect batteries before performance of any Service work.

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are containe during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartments or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tool and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to loca regulations and mandates.

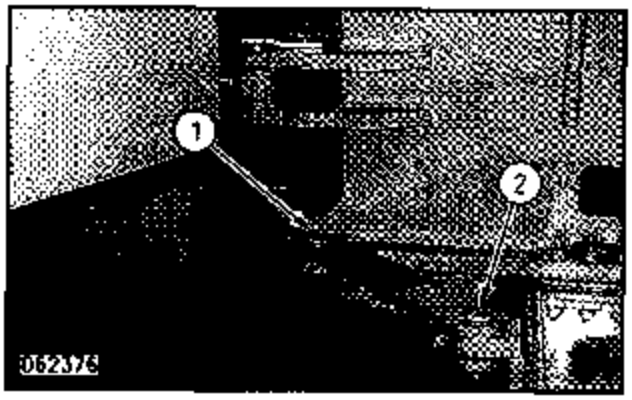
Disassembly & Assembly

Steering Frame Lock Link

Separate & Connect Steering Frame Lock Link 7506-029

⚠ WARNING

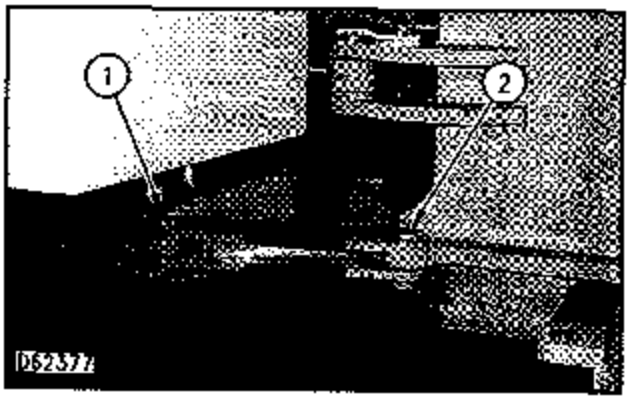
There is no clearance for a person in the area between the front and rear frames of the machine when turning the vehicle. When a machine is to be lifted, transported on another vehicle or service work is being performed near the center of the machine, connect the steering frame lock link between the front and rear frames to keep the machine in a straight ahead position. Before operation and when operating, be sure the steering frame lock link, located near the center of the machine, is disconnected and pinned to the retaining plates.



Steering Frame Lock Link In The Stored Position

1. To connect the steering frame lock link, first put the machine in a straight ahead position.

2. Remove the cotter pins from pins (1) and (2). Remove pins (1) and (2) from the steering frame lock link.



Steering Frame Lock Link In The Locked Position

3. Slide the steering frame lock link into the front frame. Be sure the bores in the lock link are in alignment with the bores in the front and rear loader frames. Reinstall pins (1) and (2) and the cotter pins that hold them.

NOTE: the following step is for the separation of the steering frame lock link.

4. Remove the cotter pins from (1) and (2). Slide the steering frame lock link into the storage position in the rear loader frame. Reinstall pins (1) and (2) to hold the steering frame lock link in the stored position. Install the cotter pins to hold pins (1) and (2) in place.

Implement, Steering & Pilot Systems Oil Pump

Remove & Install Implement, Steering & Pilot Systems Oil Pump 5055-010

Start By:

a. remove cab

Fluid Spillage Containment

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "Tools And Shop Products Guide", NENG2500 for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

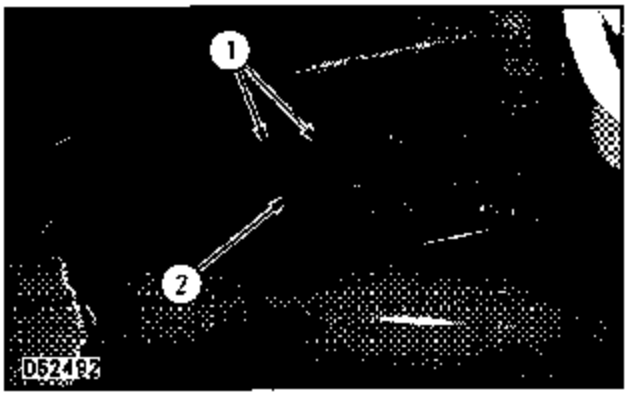
1. Activate the parking brake.

2. Connect the steering frame lock link

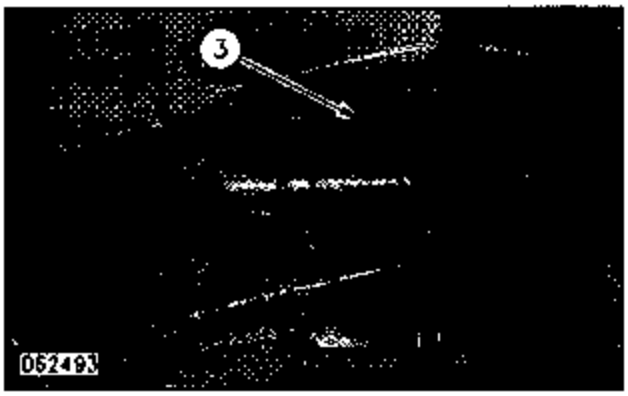
⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all the hydraulic pressure is released before any fittings, hoses or components are loosened, tightened, removed or adjusted.

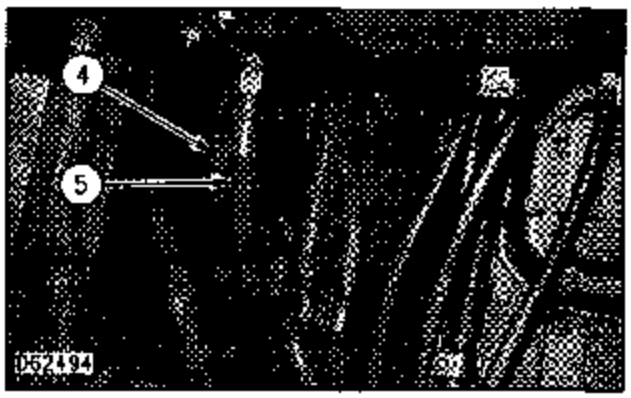
3. Drain the oil from the hydraulic tank into a suitable container for storage or disposal. The capacity of the hydraulic oil tank is **87 Liters (22.6 U.S. gal)**.



4. Remove four bolts and washers (1) to disconnect hydraulic oil inlet line (2) from the pump group. This is located between the right frame rail and the right steering cylinder.



5. Disconnect hose assembly (3) from pilot pump.

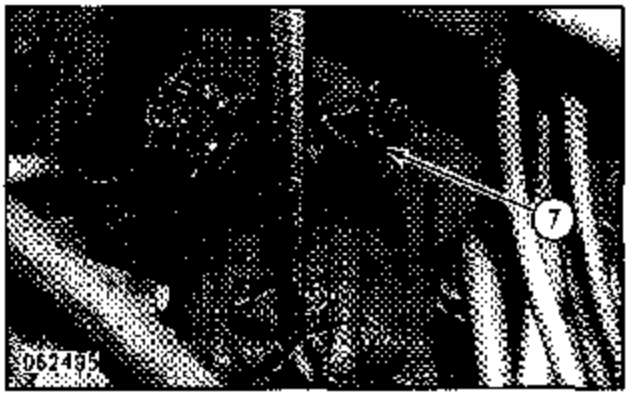


6. Disconnect hose assembly (4) from the steering pump

7. Disconnect hose assembly (5) from the firewall group and place to the side to allow clearance for pump group removal.

8. Disconnect hydraulic line assembly from the implement pump. Loosen opposite end of line (6) and place it to the side.

NOTE: Plug and cap all hydraulic connections to prevent contamination.



9. Fasten a suitable hoist and two lifting straps to the implement steering and pilot systems oil pump as shown. Remove two bolts and washers (7) and remove the pump group from the machine. The weight of the pump group is **36 kg (80 lb)**.

10. Remove the O-ring seal from the implement, steering and pilot systems oil pump.

NOTE: The following steps are for the installation of the implement steering and pilot systems oil pump.

11. Check the condition of all O-ring seals. Replace with new parts if damaged.

12. Install the implement, steering and pilot systems oil pump in the reverse order of removal.

13. Fill the hydraulic oil tank to the correct level. See the Operation and Maintenance Manual for the correct filling procedure.

14. Separate the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this manual.

End By:

a. install cab

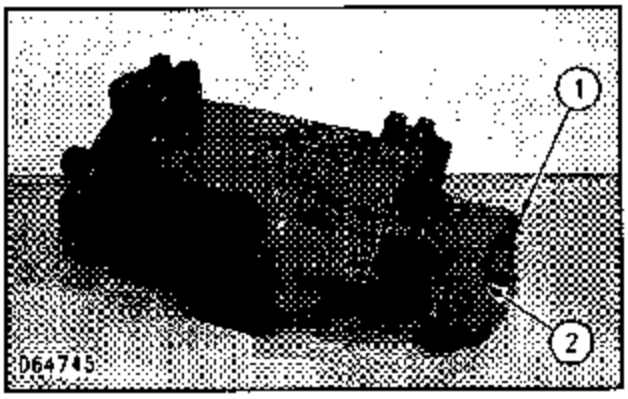
Disassemble Implement, Steering & Pilot Systems Oil Pump 5055-015

Start By:

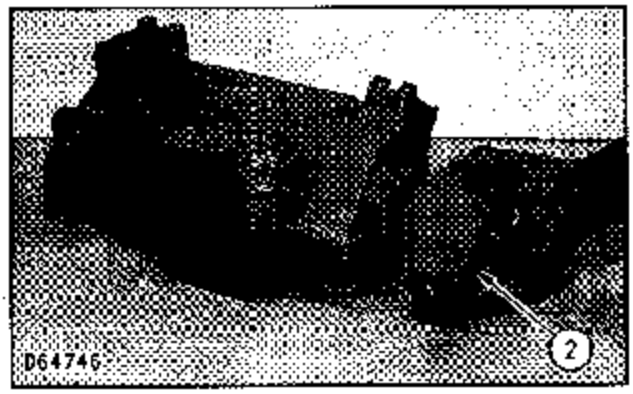
a. remove implement, steering and pilot systems oil pump

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

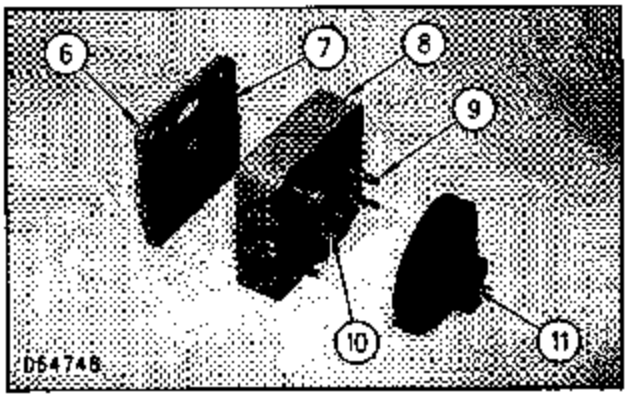


1. Remove four bolts (1) that secures pilot oil pump (2) to the hydraulic pump.



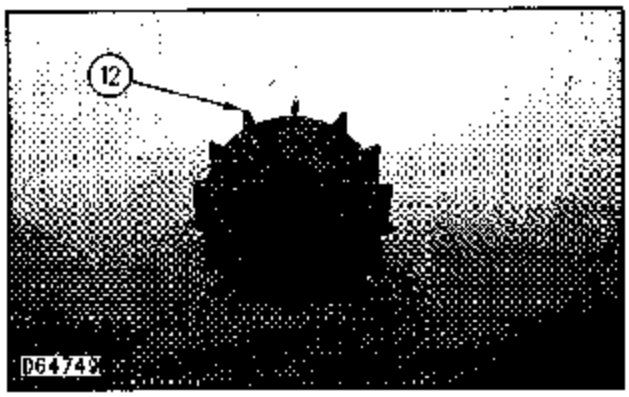
2. Remove pilot oil pump (2) from the hydraulic pump.

3. Remove rear cover (5), spring (4) and O-ring seal (3) from the pilot oil pump.

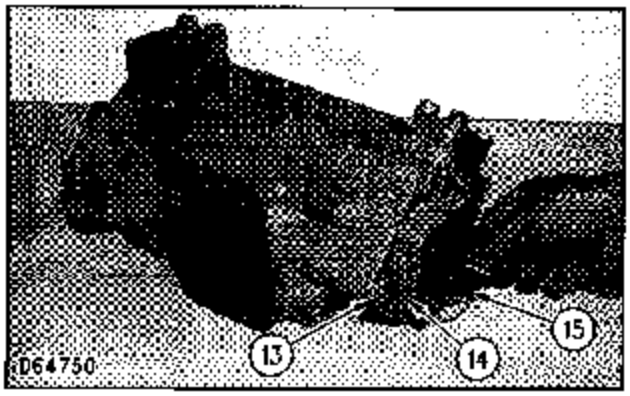


4. Remove plate (11), rotor assembly (10) and two dowel pins (9) from ring (8).

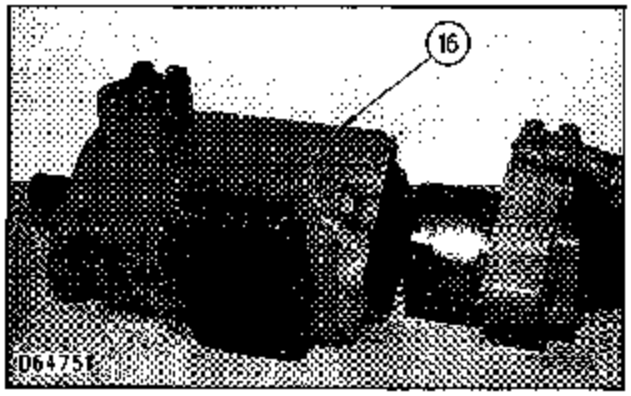
5. Remove adapter (6) and O-ring (7) from ring (8).



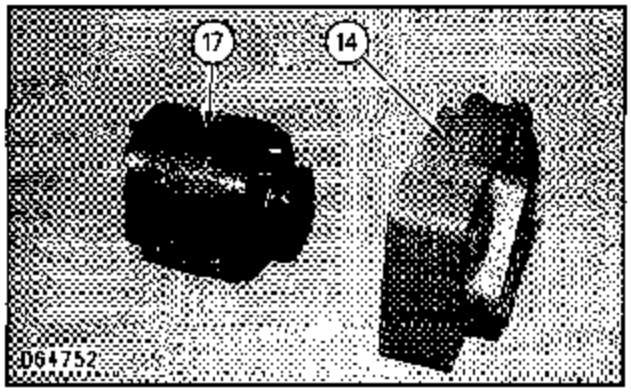
6. Remove twelve vanes (12) from the rotor.



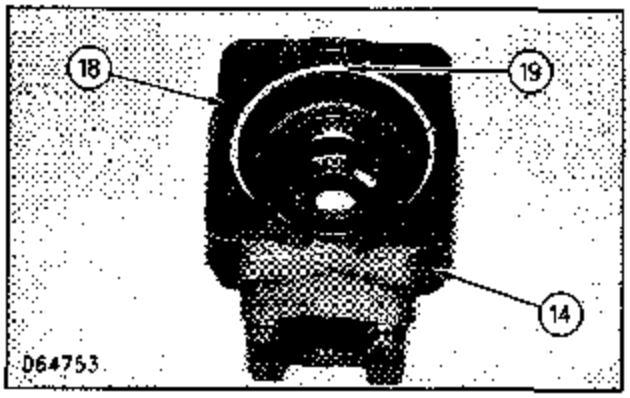
7. Remove O-ring (15) from cover (14) as shown. Place alignment marks across the pump covers for assembly purposes. Remove four bolts (13).



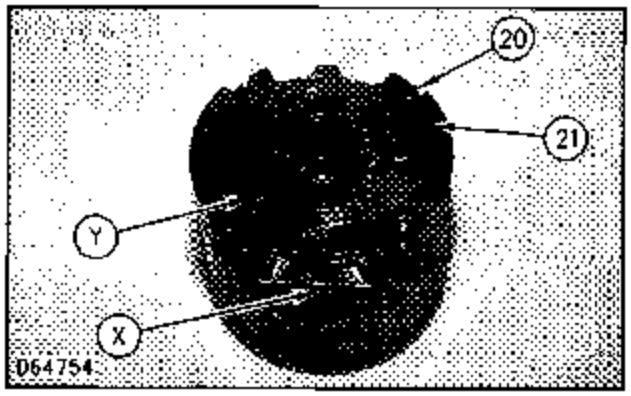
8. Separate cover and cartridge assembly from cover (16) as shown.



9. Separate cartridge assembly (17) from cover (14).

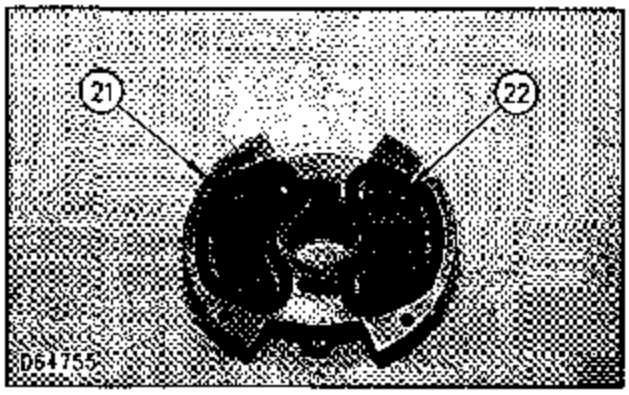


10. Remove O-ring (18) and quad ring (19) from cover (14).

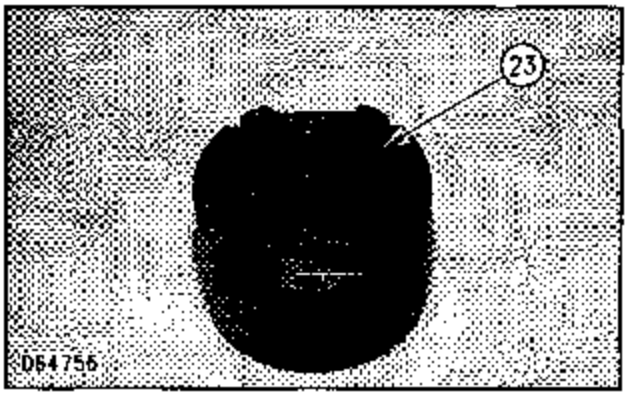


11. Remove two cap screws (20) and inlet plate (21).

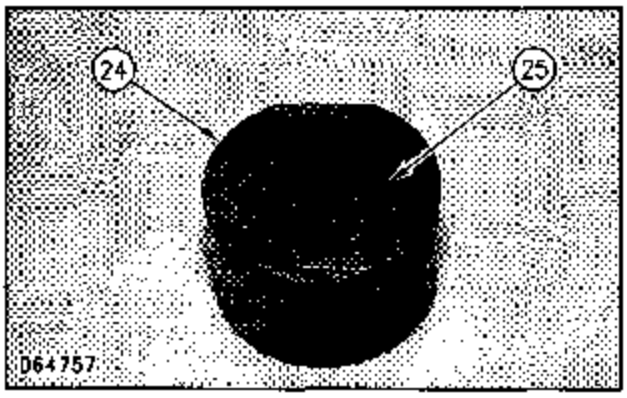
NOTE: Pay careful attention to the direction of the arrows at location (X) and (Y) and the location of screws (20) for assembly purposes. Place identification and alignment marks on the parts of the cartridge to assist in assembly.



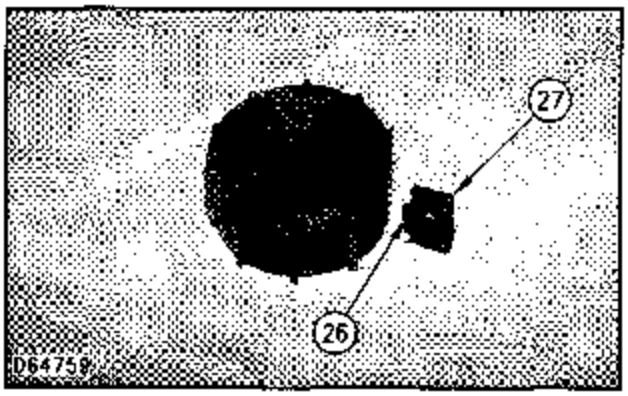
12. Remove two seals and retainers (22) from inlet plate (21).



13. Remove flexplate (23).

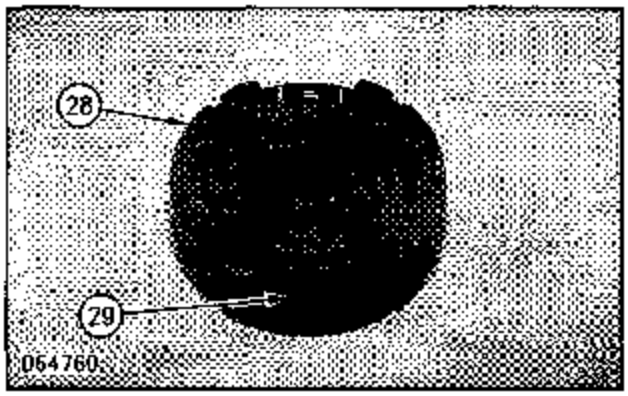


14. Remove ring (24) and rotor assembly (25).



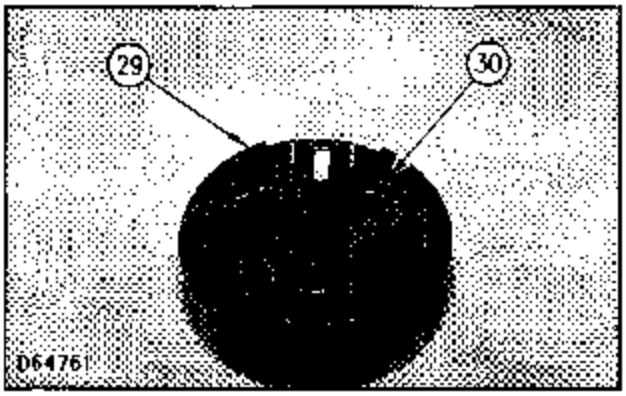
15. Remove ten vanes (27) from the rotor.

16. Remove inserts (26) from the vanes.

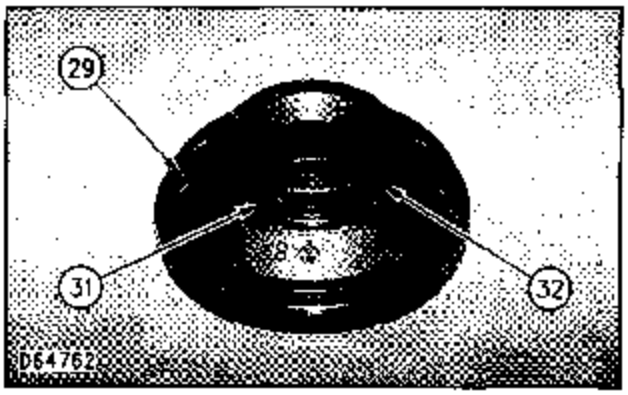


17. Remove flexplate (28) from outlet plate (29).

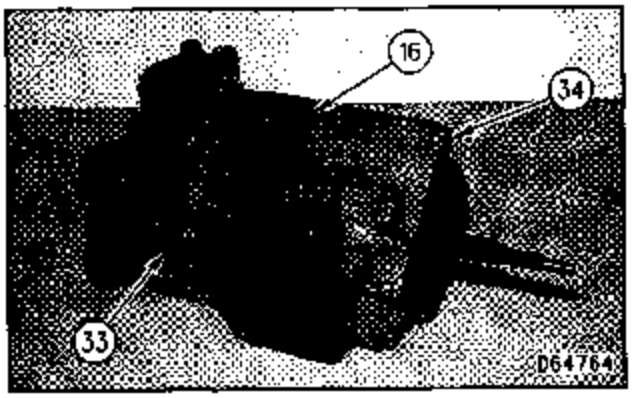
NOTE: Pay careful attention to the location of plate (28) and the arrows on it.



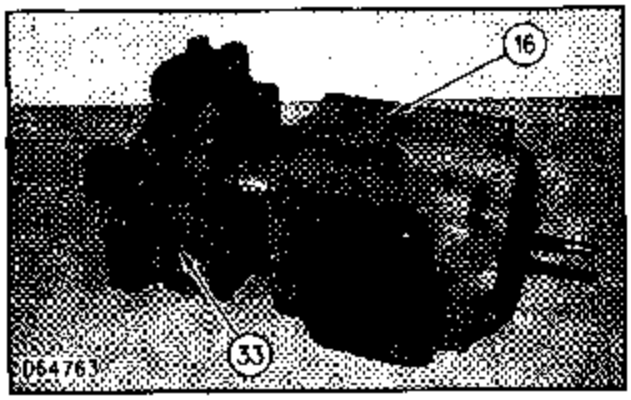
18. Remove two seals and retainers (30) from outlet plate (29).



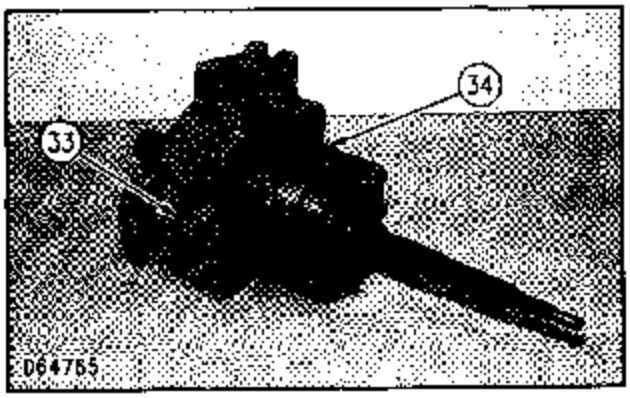
19. Remove O-ring seal (31) and ring (32) from outlet plate (29).



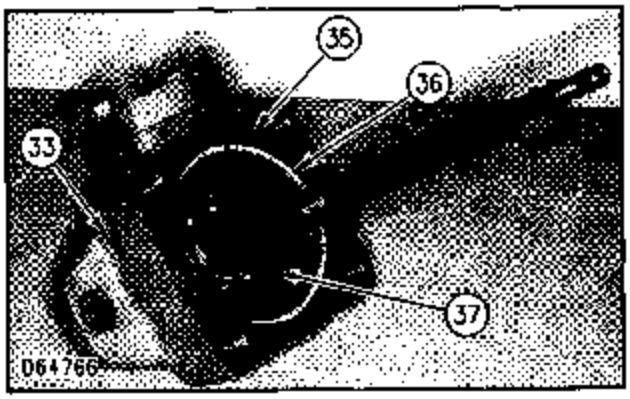
20. Remove four bolts (34) that secure cover (16) to body (33).



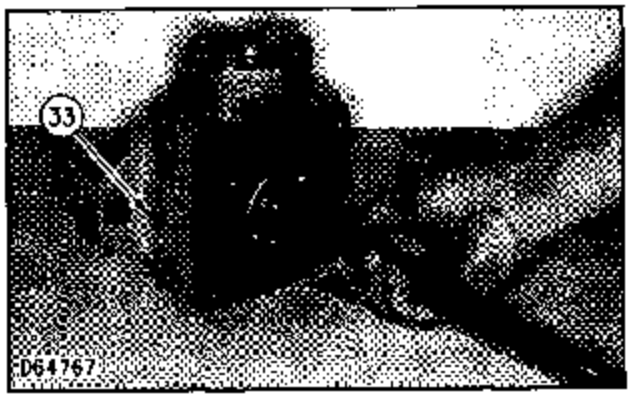
21. Remove cover (16) from body (33).



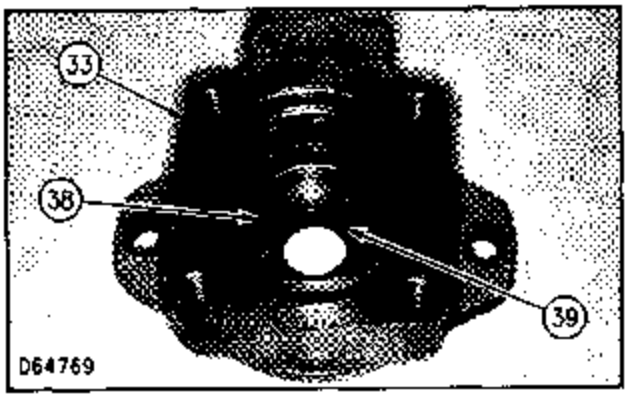
22. Remove cartridge assembly (34) from body (33).



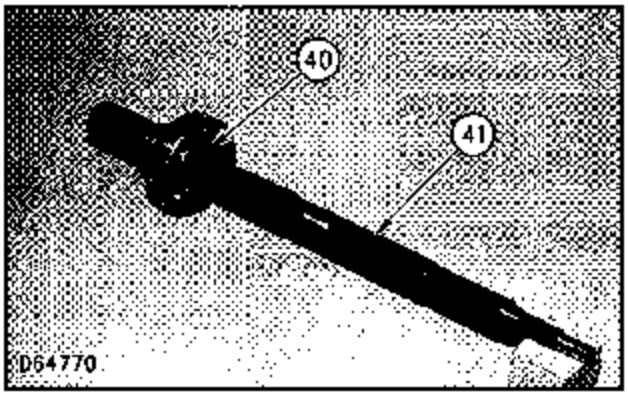
23. Remove O-ring (35), quad ring (36), and bearing retaining ring (37) from body (33).



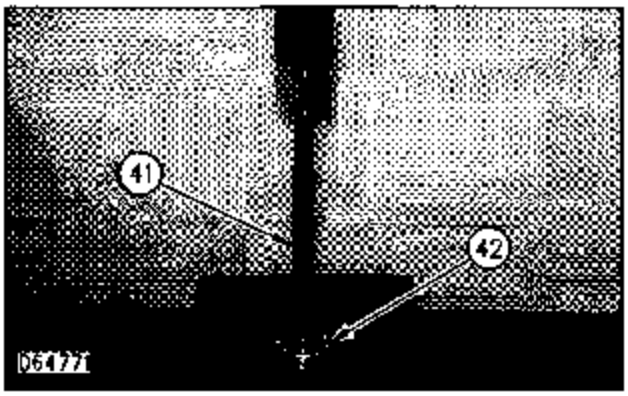
24. Remove shaft and bearing assembly from body (33) as shown.



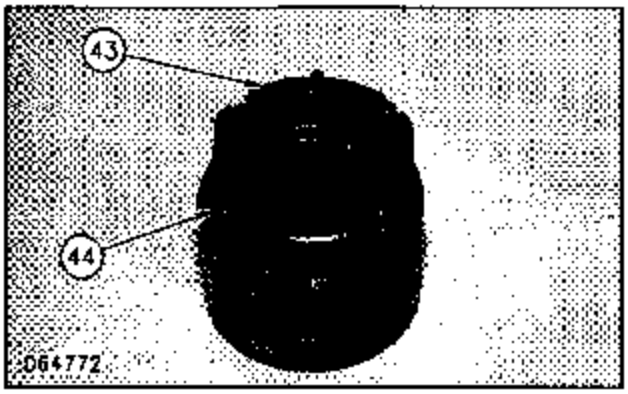
25. Remove washer (38) and two lip seals (39) from body (33).



26. Remove snap ring (40) from shaft (41).

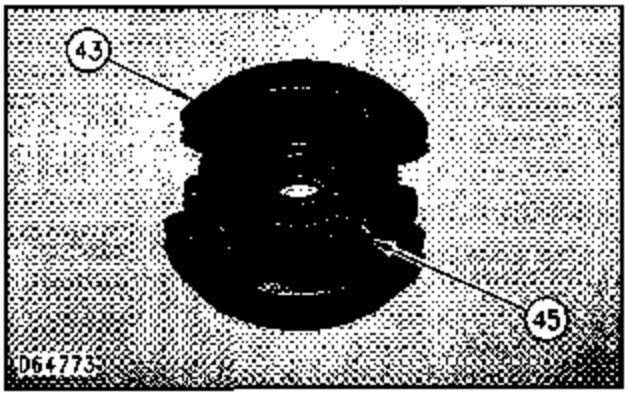


27. Remove bearing (42) from shaft (41) using suitable press as shown.

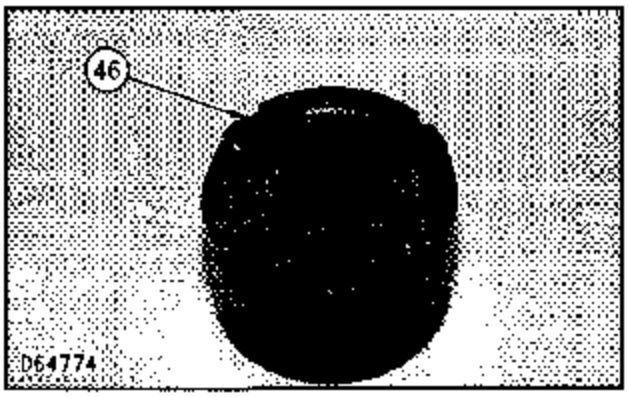


NOTE: The direction of the arrows that are nearest to bolts (44) and the direction of the arrow on the ring for assembly purposes. Mark the direction of travel.

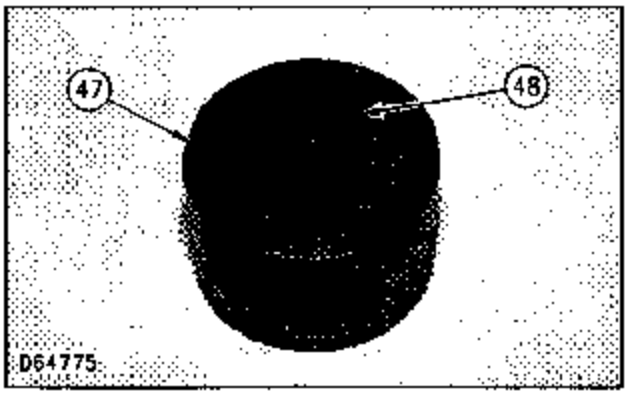
28. Remove bolts (44) and inlet plate (43).



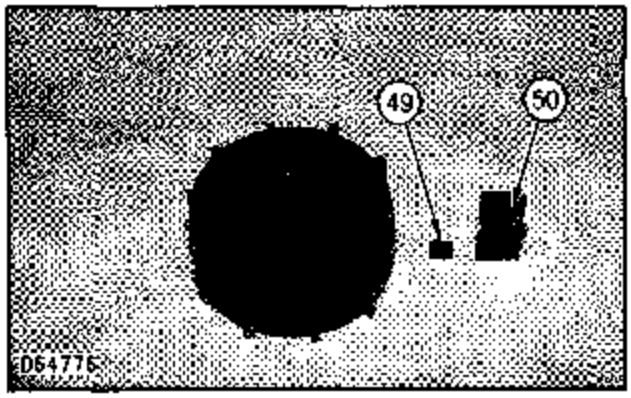
29. Remove seal retainers (45) and the O-ring seals from inlet plate (43).



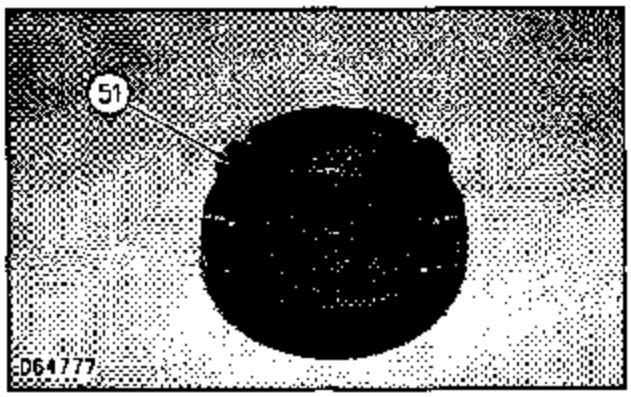
30. Remove flexolate (46).



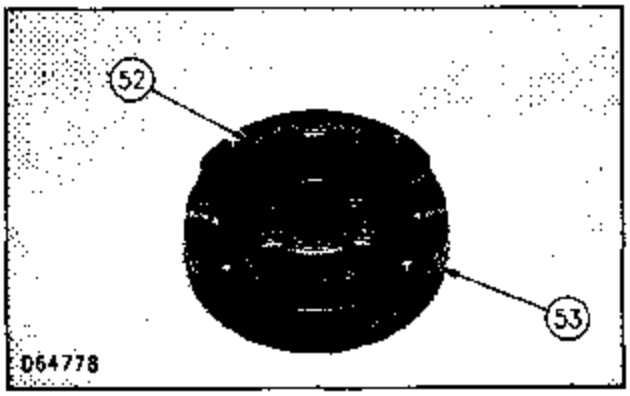
31. Remove O-ring (47) and rotor assembly (48).



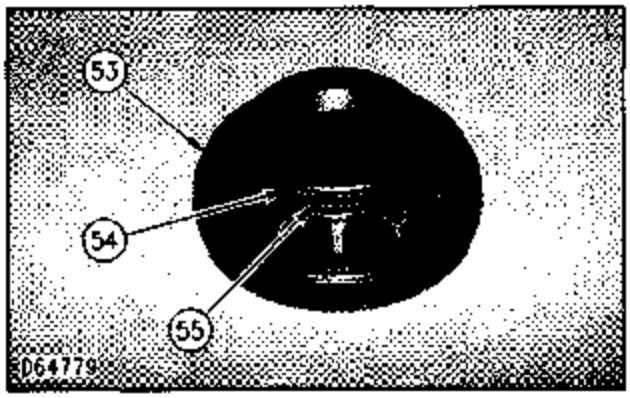
32. Remove ten vanes (50) and ten inserts (49) from the rotor.



33. Remove flexplate (51).



34. Remove and seal retainers (52) and the O-ring seals from outlet plate (53).



35. Remove O-ring (55) and backup ring (54) from outlet plate (53).

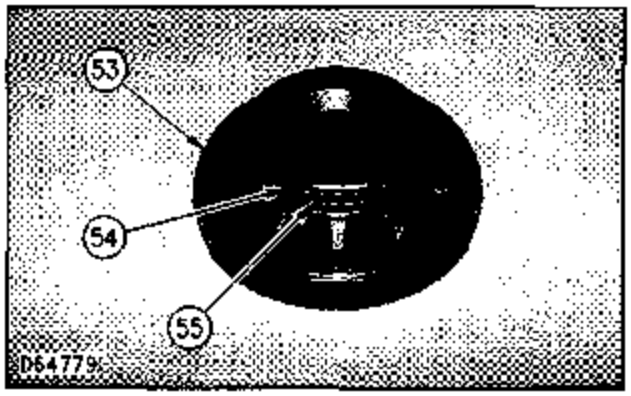
Assemble Implement, Steering & Pilot Systems Oil Pump 5055-015

Tools Needed	A
1P-0510 Driver Group	1

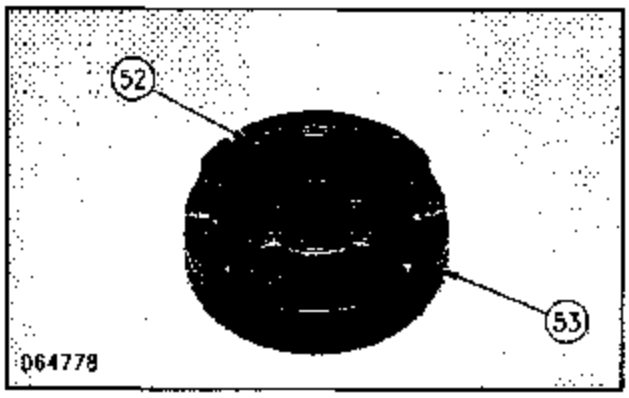
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

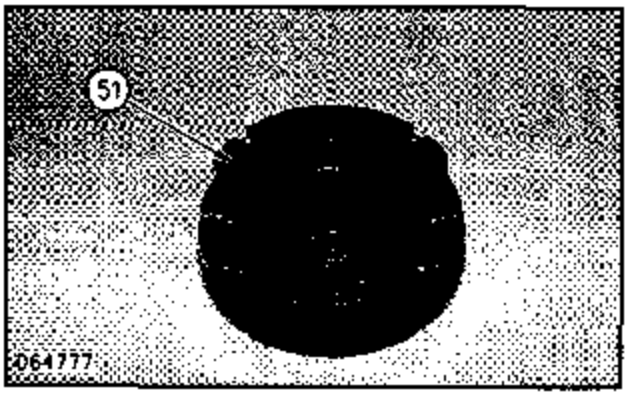
NOTE: Check the condition of all parts in the implement steering and pilot systems oil pump. If worn or damaged, replace with new parts. Lubricate parts at assembly with hydraulic oil.



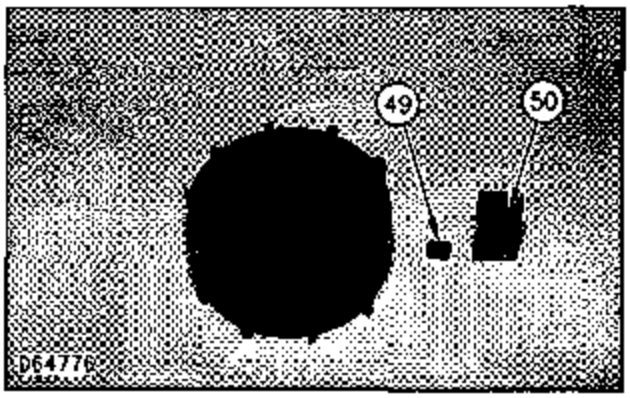
1. Install O-ring (55) and backup ring (54) in outlet plate (53).



2. Install the O-ring seals and seal retainers (52) in the opposite side of the outlet plate (53).

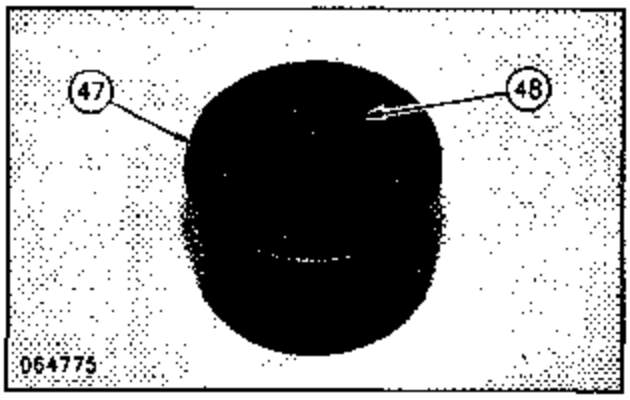


3. Install flexplate (51) with the brass face toward the rotor (brass face away from seals).



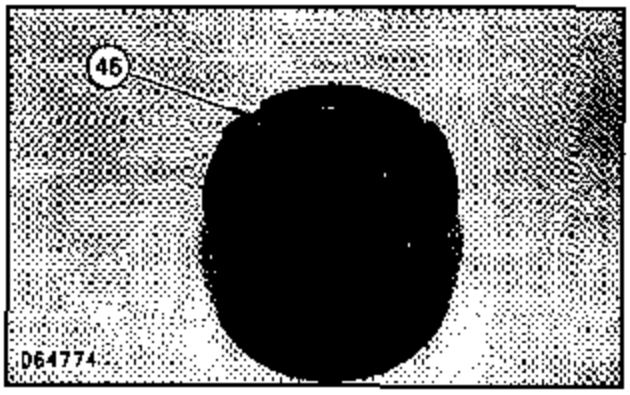
NOTE: Vanes (50) must be installed correctly for proper operation of the pump.

4. Install inserts (49) and vanes (50) in rotor (48). Install the vanes with the leading edge (sharp edge) at the outside diameter and toward the direction of rotation.

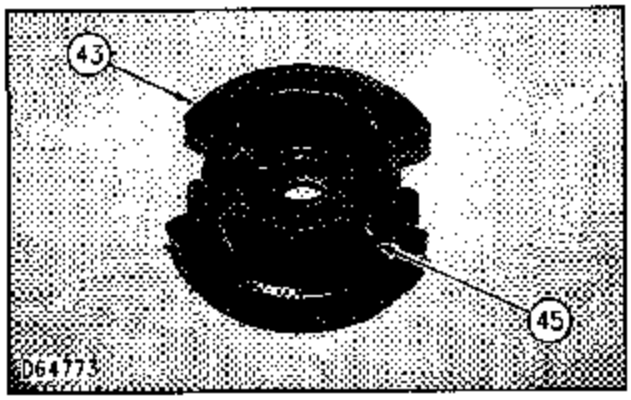


5. Install ring (47) and rotor assembly (48) as shown.

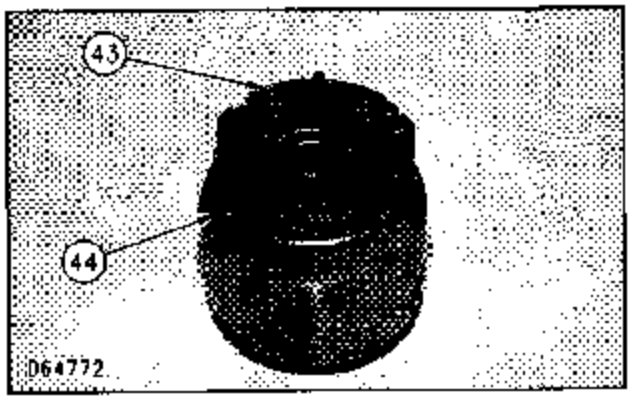
NOTE: The arrow on the ring must be facing the same direction as the rotation of the rotor.



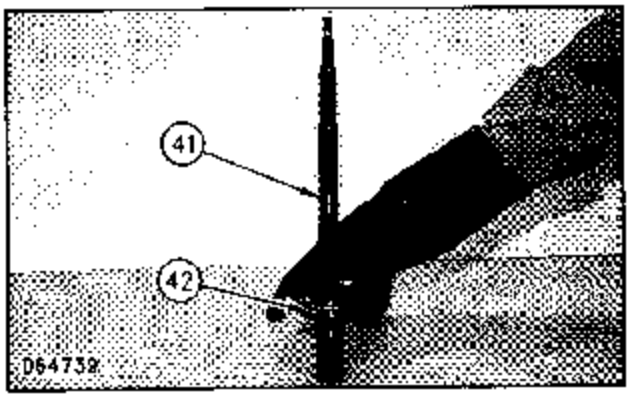
6. Install flexplate (46) with the brass side toward the rotor.



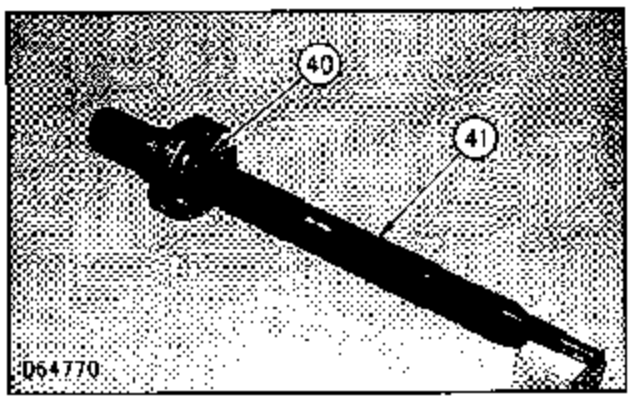
7. Install the O ring seals and seal retainers (45) on the inlet plate (43).



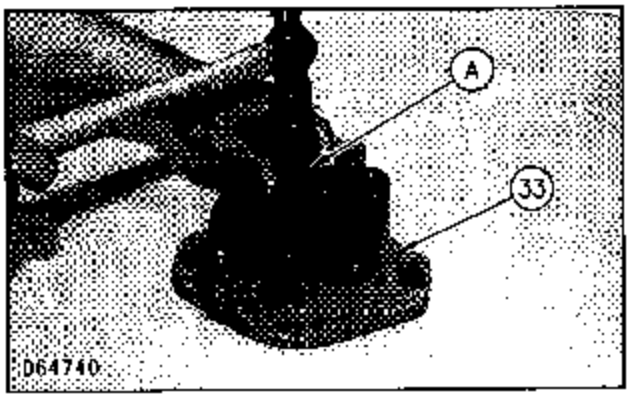
8. Install inlet plate (43) as shown. Install two screws (44) in the holes nearest the arrows indicating direction of travel of the pump. Tighten two screws to a torque of **11 ± 1 N•m (8 ± 1 lb ft)**.



9. Heat bearing (42) to a temperature of **275° F** and install on shaft (41) as shown.

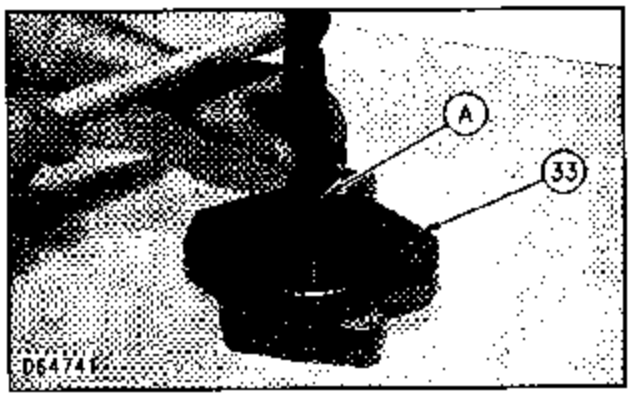


10. Install snap ring (40) on shaft (41) as shown.



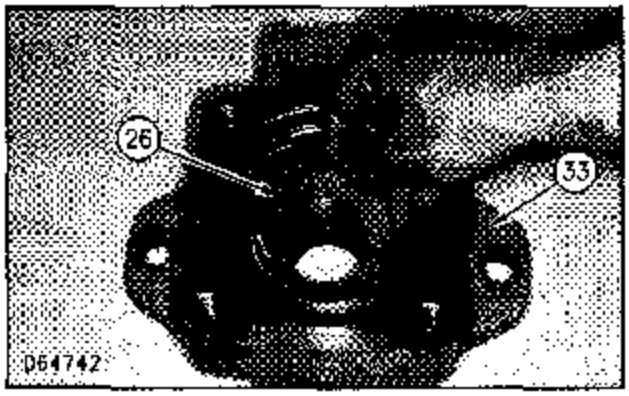
11. Using tooling (A), install the inner lip seal in body (33).

NOTE: Install the seal with the sealing lip facing toward the inside of the pump.

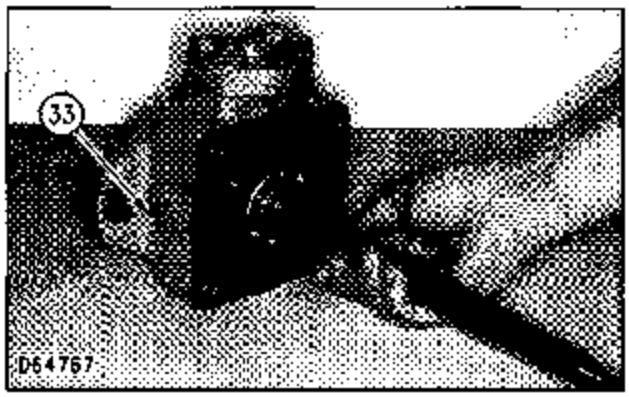


12. Using tooling (A), install the outer lip seal in body (33).

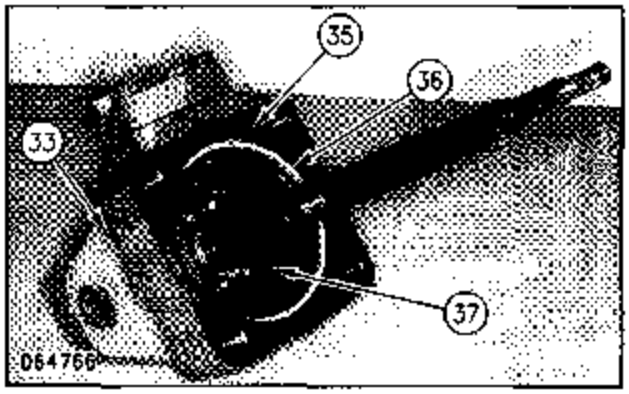
NOTE: Install the seal with the sealing lip facing toward the outside of the pump.



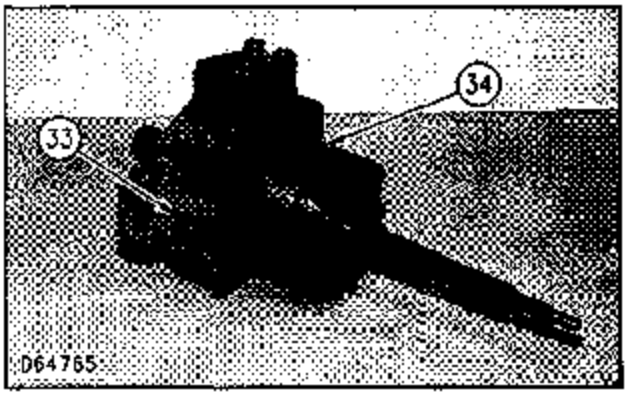
13. Install washer (26) in body (33) as shown.



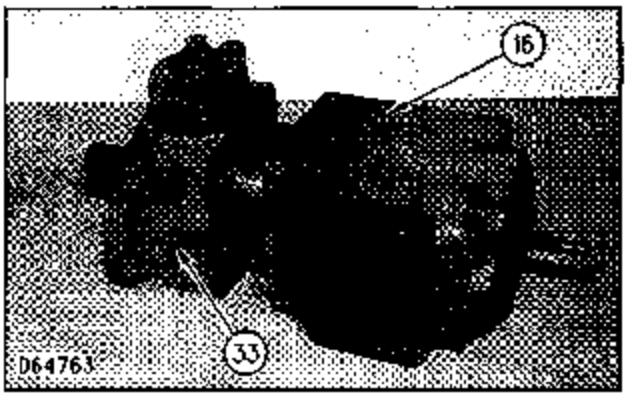
14. Install shaft and bearing assembly into body (33) as shown.

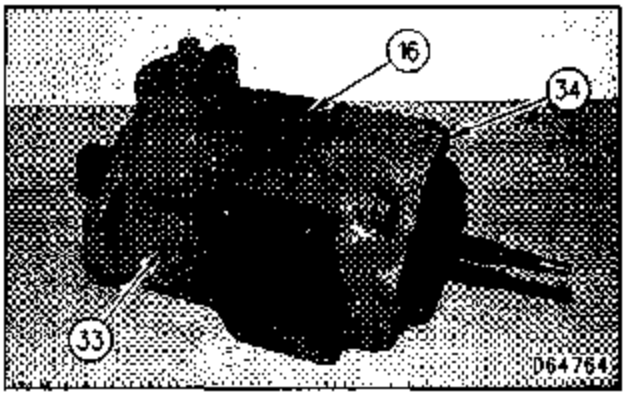


15. Install bearing retaining ring (37), quad ring (36), and O-ring (35) in body (33).

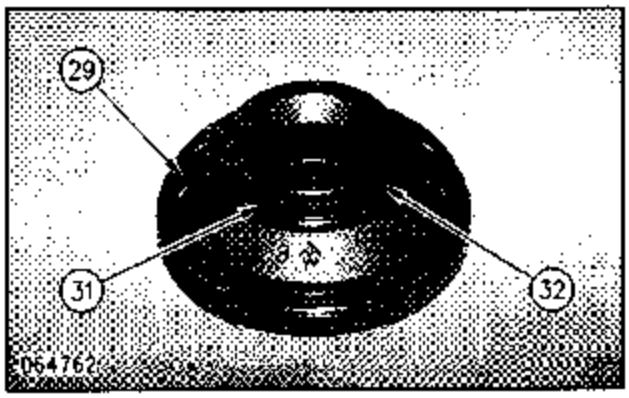


16. Install cartridge assembly (34) in body (33).

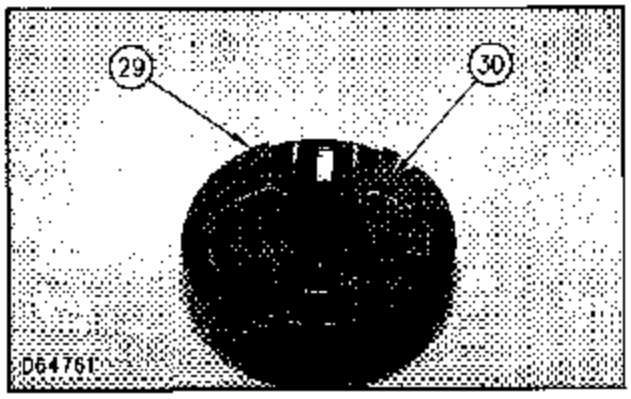




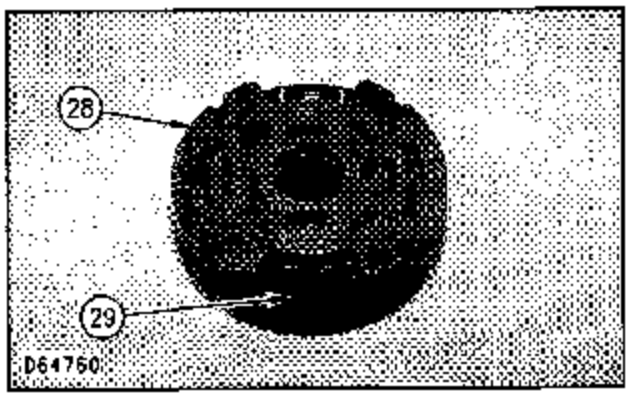
17. Install cover (16) and fasten to body (33) with four bolts (34). Tighten bolts. Tighten to a torque of **203 ± 14N•m (150 ± 10 lb ft)**.



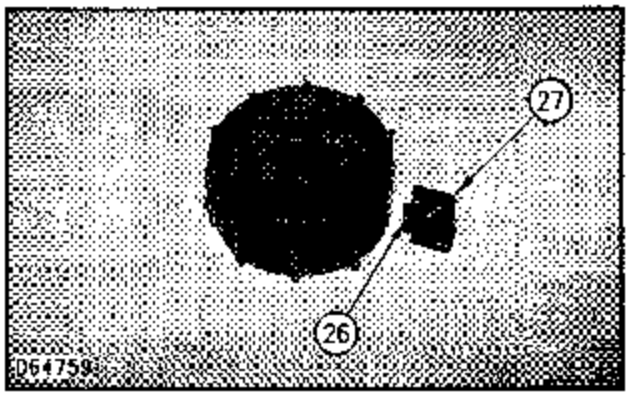
18. Install O-ring seal (31) and backup ring (32) on outlet plate (29) as shown.



19. Install the O-ring seals and seal retainers (30) on the opposite side of the outlet plate (29) as shown.

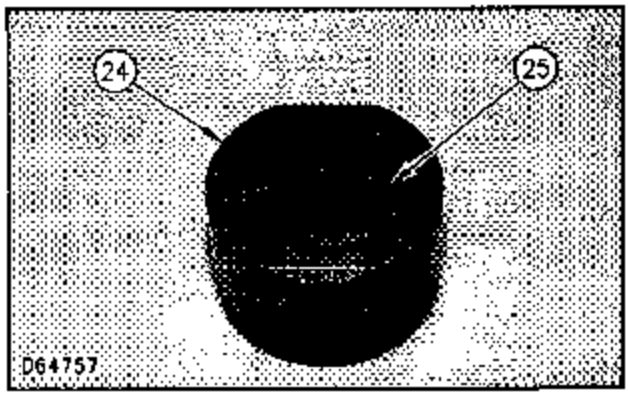


20. Install flexplate (28) on outlet plate (29) with brass side facing toward the rotor.



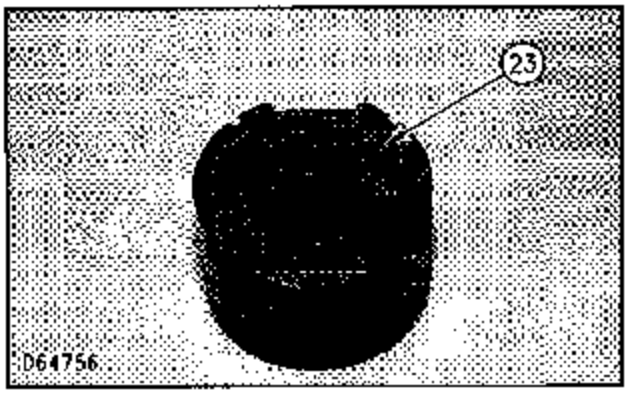
21. Install inserts (26) and vanes (27) into the rotor. Install the vanes with the leading edge (sharp edge) at the outside diameter and toward the direction of rotation.

NOTE: Vanes (27) and ring (24) must be install correctly for proper pump operation.

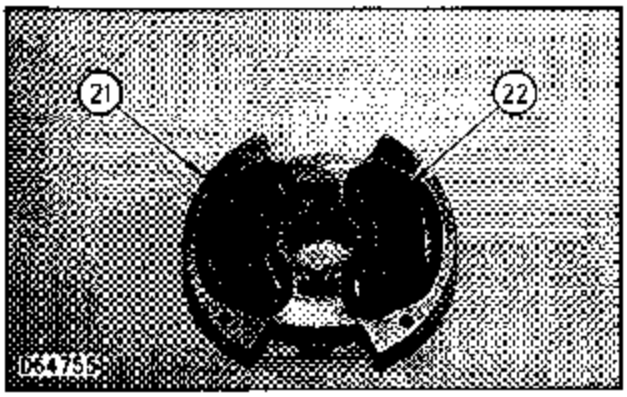


22. Install ring (24) and rotor assembly (25) as shown.

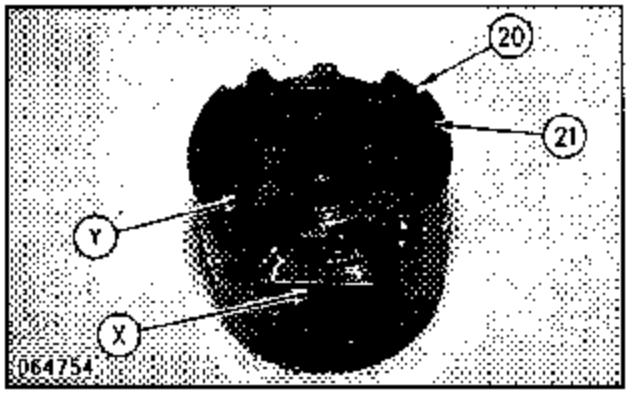
NOTE: The arrow on the ring must be facing the same direction as the rotation of the rotor.



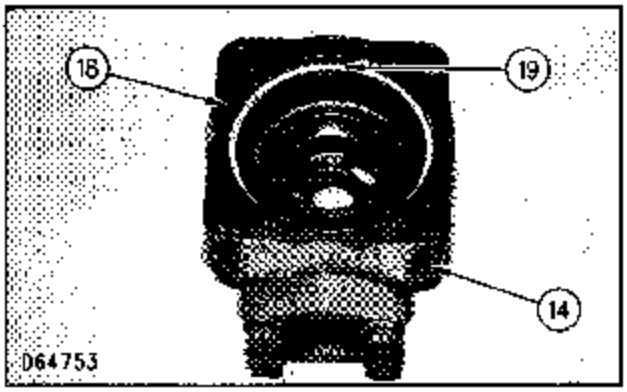
23. Install flexplate (23) with the brass face toward the rotor.



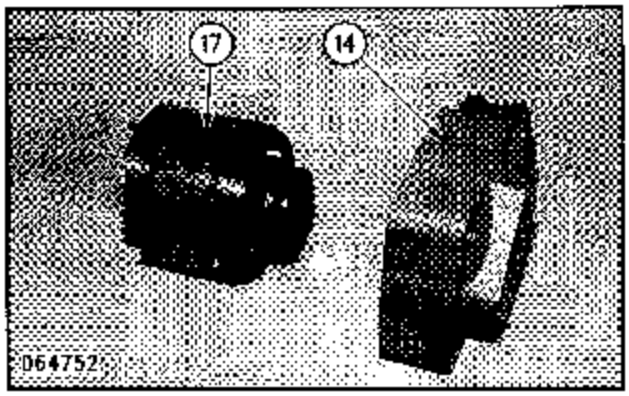
24. Install O-ring seals and seal retainers (22) on inlet plate (21) as shown.



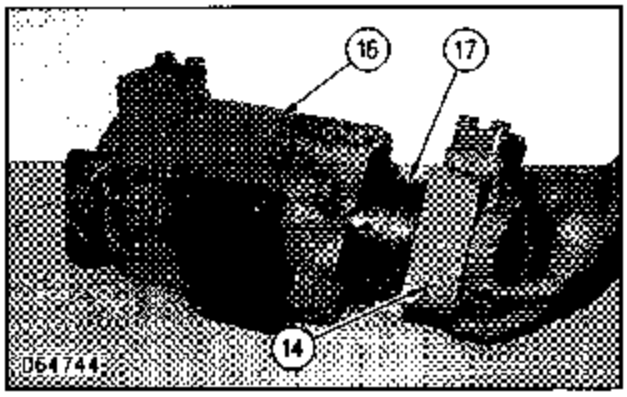
25. Install inlet plate (21). Install screws (20) nearest the arrows indicating the proper direction of rotation of the pump. The arrows at location (X) and (Y) must point toward the direction of rotation for proper pump operation. Tighten screws to a torque of **6.5 ± 1 N•m (4 ± 1 lb ft)**.



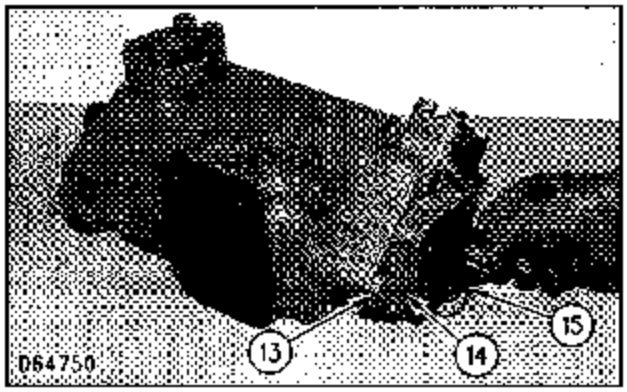
26. Install O-ring seal (18) and quad ring seal (19) in cover (14).



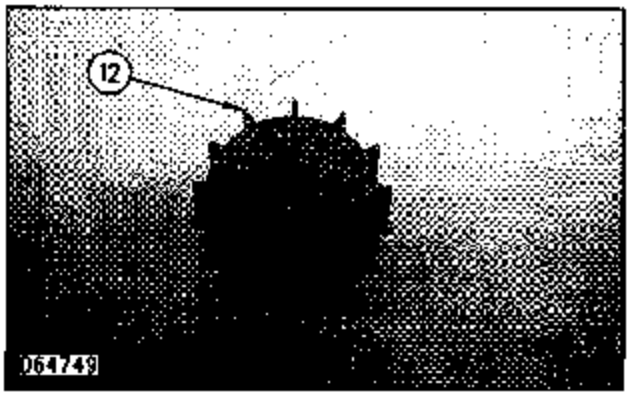
27. Install cartridge assembly (17) in cover (14).



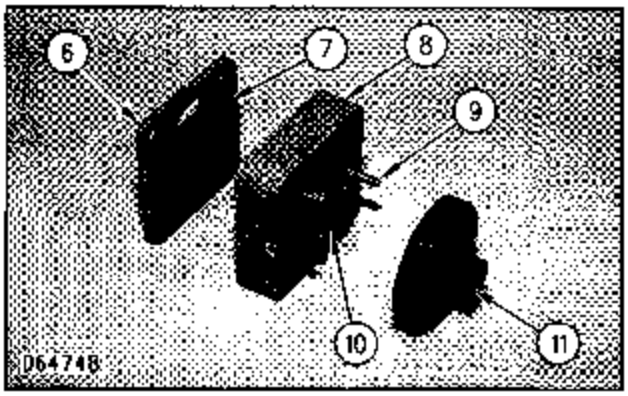
28. Install cover (14) and cartridge assembly (17) in cover (16) as shown.



29. Install four bolts (13) and tighten to a torque of **95 ± 7 N•m (70 ± 5 lb ft)**. Install O-ring seal (15) in cover (14) as shown.

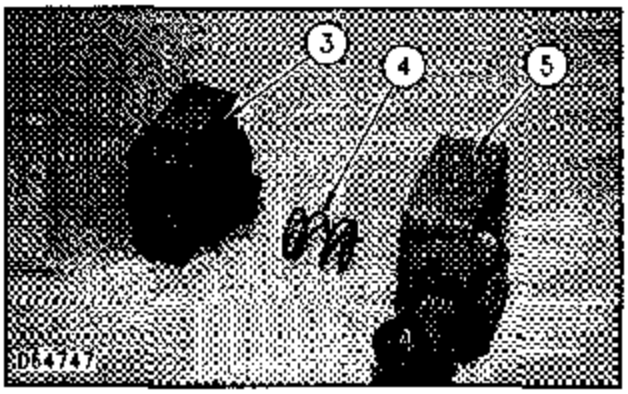


30. Install twelve vanes (12) in rotor as shown.

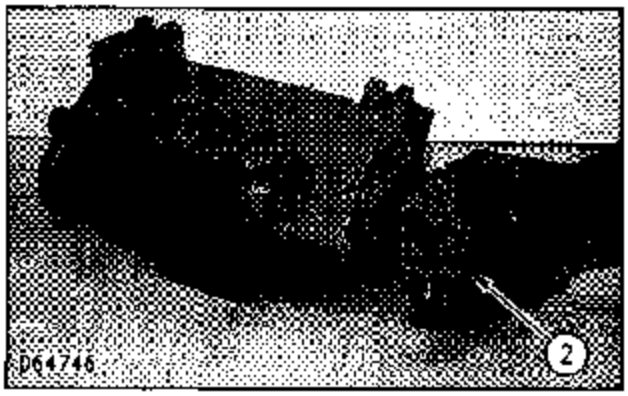


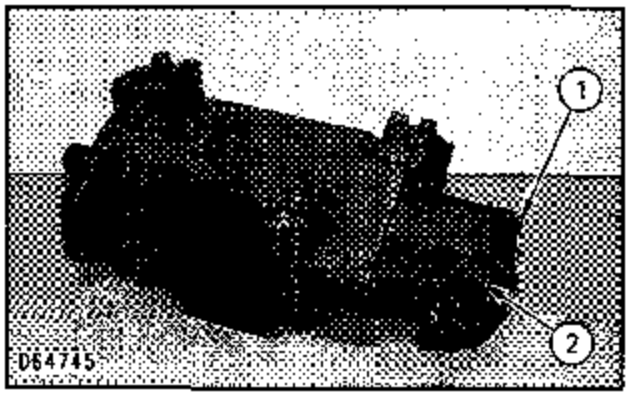
31. Install rotor assembly (10), two dowel pins (9) and plate (11) in ring (8) as shown.

32. Install O-ring (7) in adapter (6). Install the adapter and O-ring assembly on the opposite sideof ring (8) as shown.



33. Install O-ring (3), spring (4) and rear cover (5) as shown.





34. Install pilot oil pump assembly (2) as shown Install four bolts (1) torque to **55 ± 7 N•m (41 ± 3 lb ft)**.

End By:

a. install implement,steering and pilot system oil pump

Steering Control Valve

Remove & Install steering Control Valve 4307-010

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

1. Activate the parking brake.

2. Connect the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this module.

3. Release the pressure in the hydraulic system as follows:

   a. Move the lift control lever to the "Float" position.

   b. Shut off the engine.

   c. Move the lift control lever to the "Hold" position.

⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all the hydraulic pressure is released before any fittings, hoses or components are loosened, tightened, removed or adjusted.

   d. Carefully loosen the filler cap on the hydraulic oil tank to release the pressure.

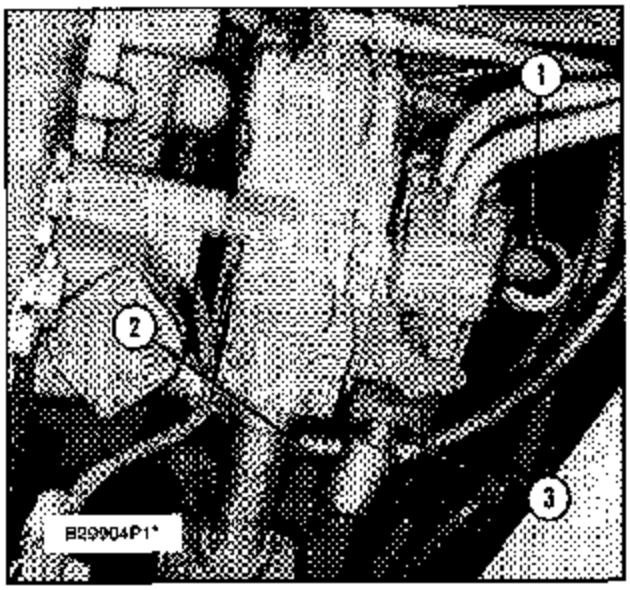
   e. Carefully loosen the plugs at the rear of the tilt cylinder. When the oil from the loosened plugs stops draining, tighten the two plugs.

NOTE: To release the pressure in the attachment cylinders, carefully loosen the two large plugs near the plugs at the top of the loader frame. When the oil from the loosened plugs stops draining, tighten the two large plugs.

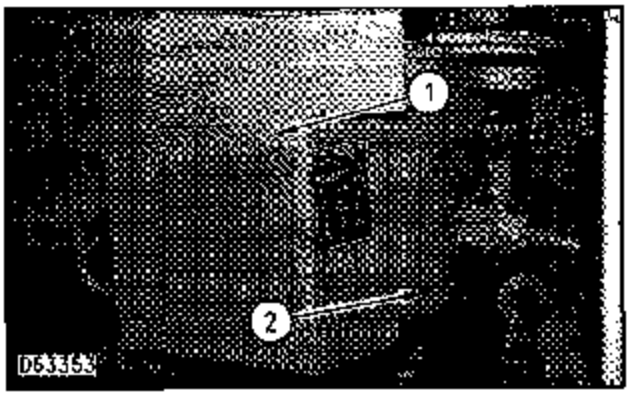
   f. Tighten the filler cap on the hydraulic oil tank.

   g. The pressure in the hydraulic system has now been released.

4. Drain the oil from the hydraulic oil tank into a suitable container for storage or disposal. The capacity of the hydraulic oil tank is **87 liters (22.6 U.S. gal).**

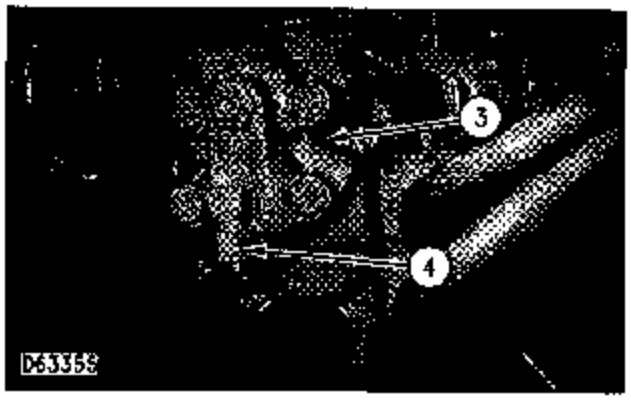


NOTE: Cap and plug all lines and fittings as they are removed to prevent excess fluid loss and contamination.

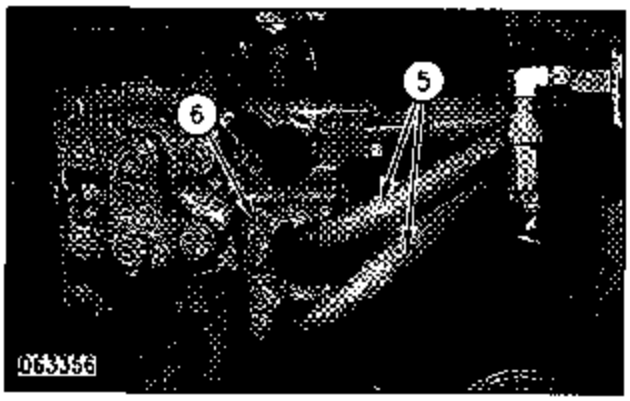


5. Remove two bolts and washers (2) and swing operators platform away from machine.

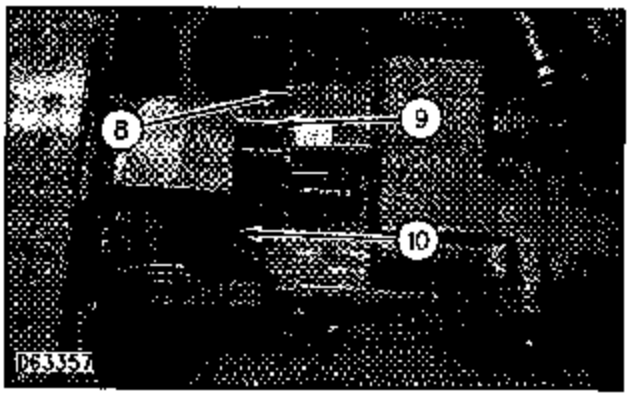
NOTE: Cap and plug all lines and fittings to prevent excess fluid loss.



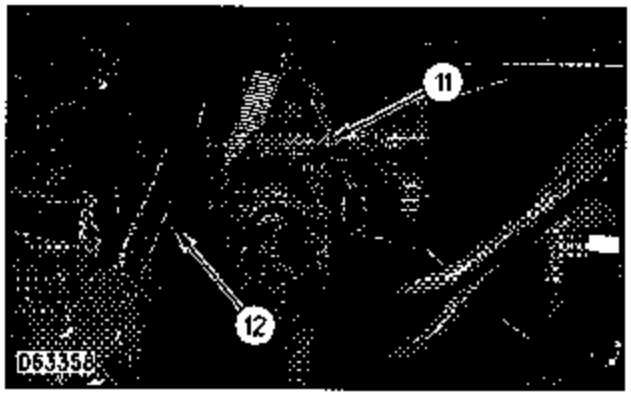
6. Disconnect hose (4) from steering control valve.



7. Remove eight bolts and washers (6) that hold two metal lines (5) to front of steering control valve. Remove four bolts and washers (7) that connect manifold block to bottom of steering control valve.



8. Remove eight bolts and washers (8) and two steel lines from the back of the steering control valve. Disconnect hose (10) from steering control valve.



9. Attach strap and hoist to the steering control valve and remove three bolts and washers (11) that hold it to bracket on hydraulic oil tank (12).

NOTE: Install the steering control valve in reverse order from removal.

10. Fill the hydraulic oil tank with oil to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

11. Separate the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this module.

12. Start the machine, and check the operation of the steering.

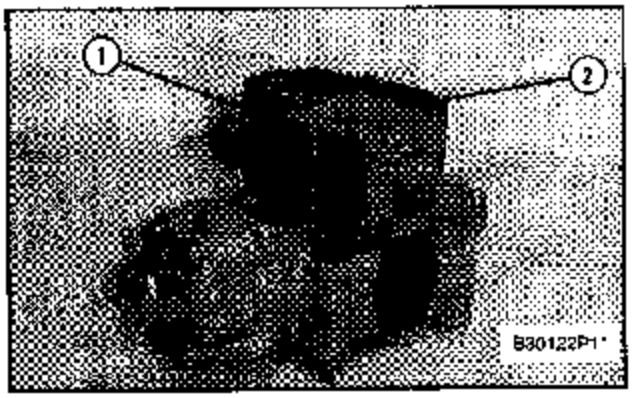
Disassemble Steering Control Valve 4307-015

Start By:

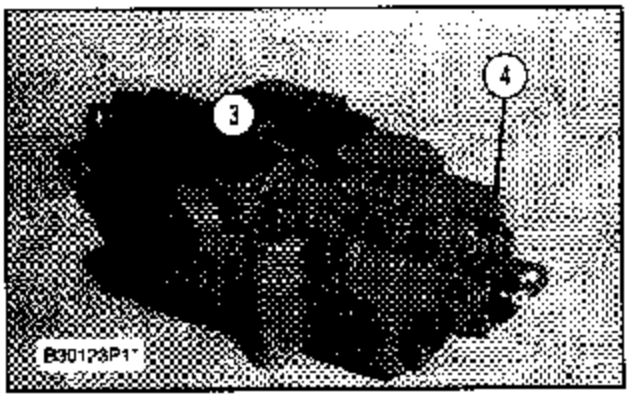
a. remove steering control valve

FLUID SPILLAGE CONTAINMENT

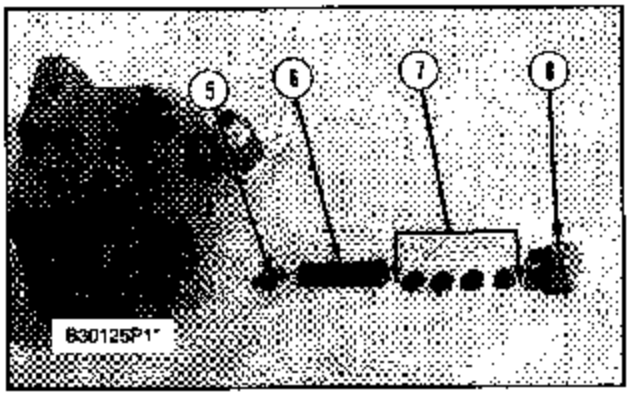
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



1. Remove bolts (2) and manifold (1) from the steering control valve.

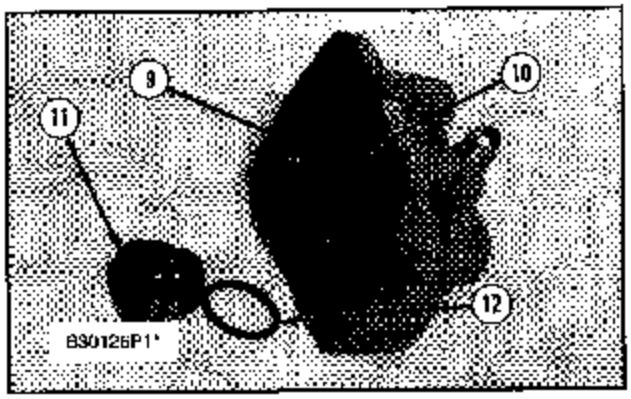


2. Remove bolts (4) and cover (3).



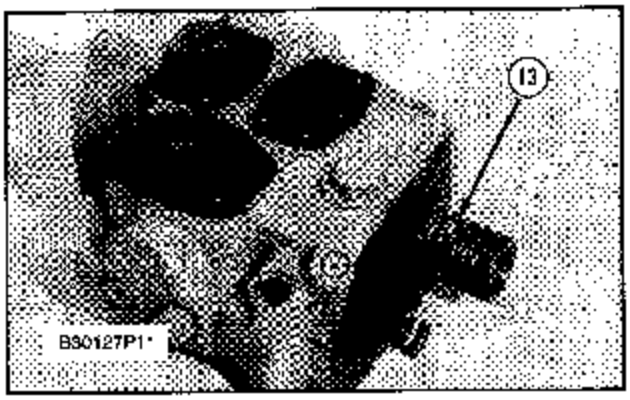
3. Remove plug (8), shims (7), spring (6) and valve (5) from the cover.

4. Remove the O-ring seal from the plug.

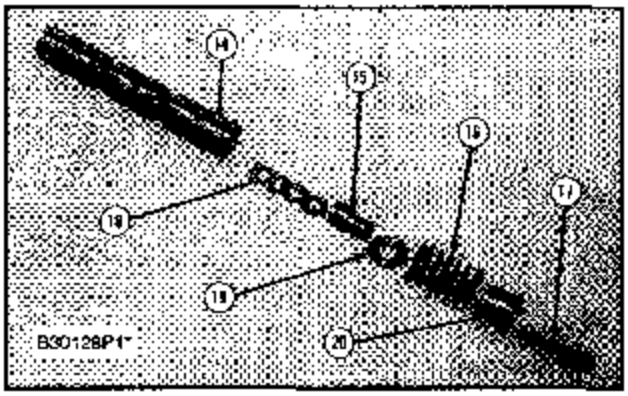


5. Remove seat (11) and O-ring seals (9) and (10) from the cover.

6. Remove O-ring seal (12) from the seat.



7. Remove directional valve spool assembly (13) from the valve body.

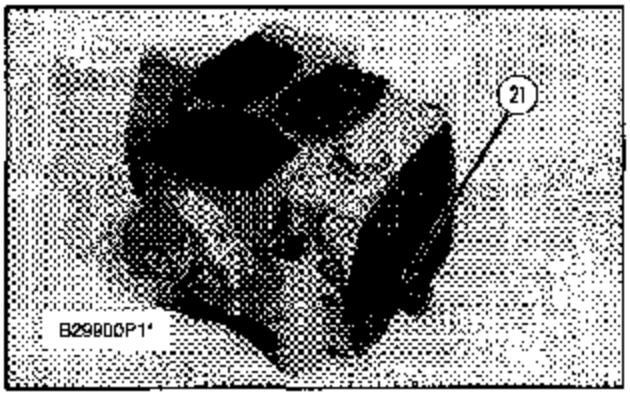


⚠ WARNING

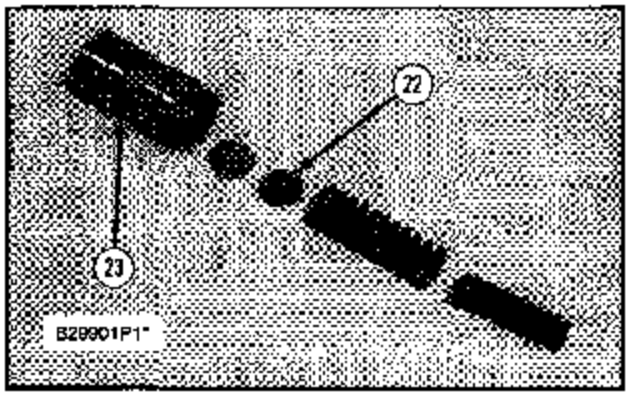
Bolt (17) holds spring (16) under compression.

6. Disassemble directional valve spool assembly (13) as follows:

   a. Remove bolt (17) and the washer, retainer (20), spring (16), spacer (19), retainer (15) and shims (18) from valve spool (14).

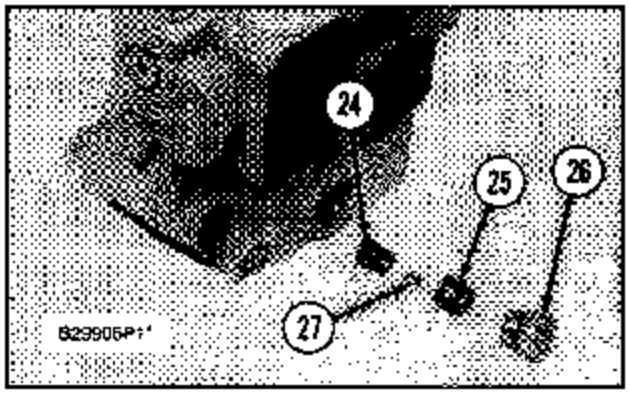


9. Remove springs (21) from the valve body.

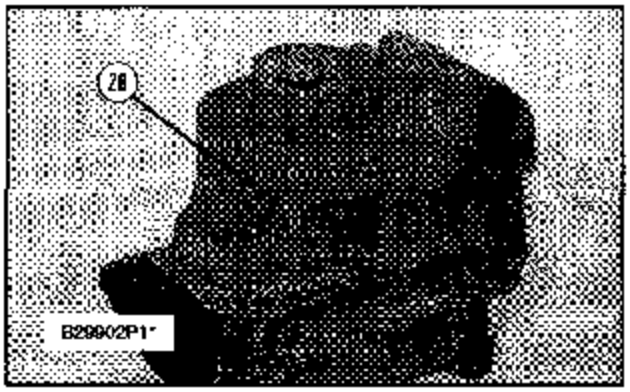


10. Remove valve spool (23) from the body.

11. Remove shims (22) from the spool.



12. Remove plug (26), seat (25), ball (27) and seat (24). Remove the O-ring seals from the seats and plug.



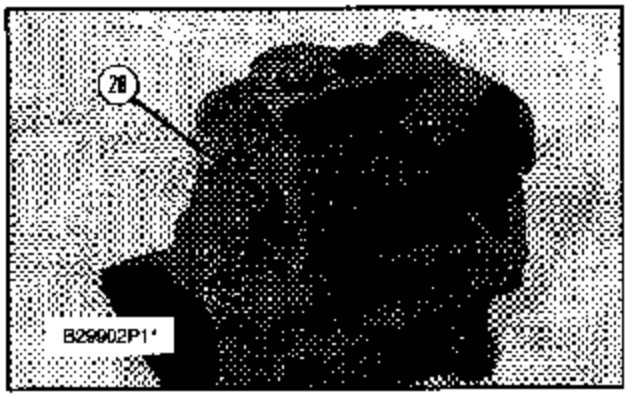
13. Remove stop assembly (28) from the body. Remove the O-ring seal from the stop assembly.

Assemble Steering Control Valve 4102-016

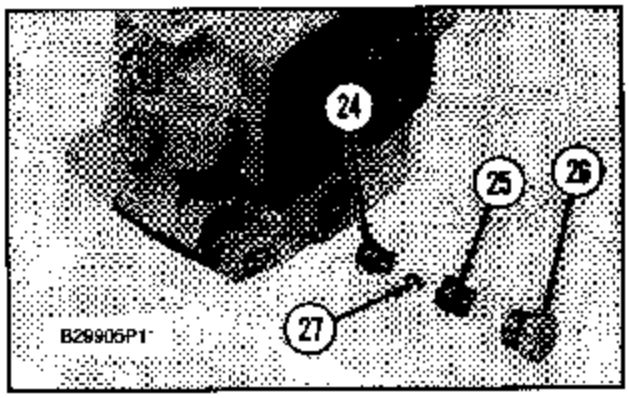
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

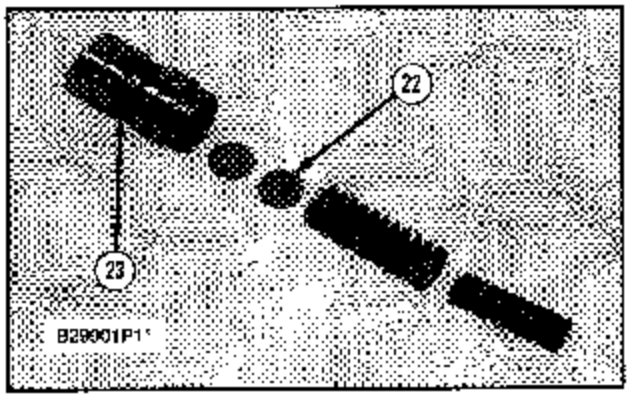
1. Be sure all parts of the steering control valve are thoroughly clean and free of dirt and debris prior to assembly. Check the condition of all O-ring seals used in the steering control valve. If the seals are worn or damaged, use new parts for replacement. Put clean hydraulic oil on the internal parts of the valve.



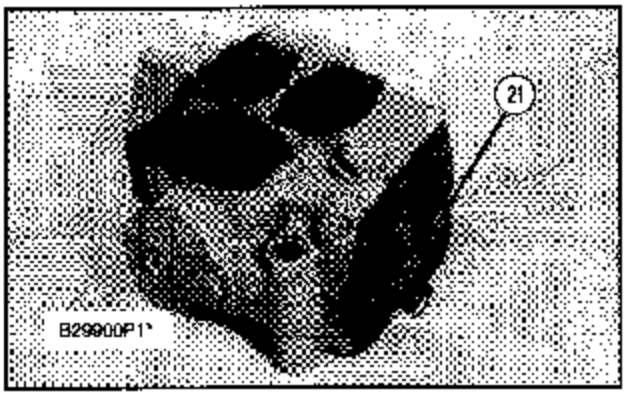
2. Put the O-ring seal on the stop assembly. Install stop assembly (28) in the valve body.



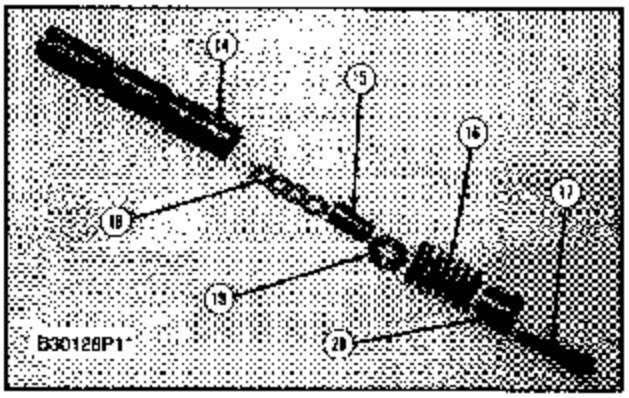
3. Put the O-ring seals on the seats and the plug.
4. Install seat (24), ball (27), seat (25) and plug (26) in the valve body.



5. Put shims (22) and the springs in position on valve spool (23).

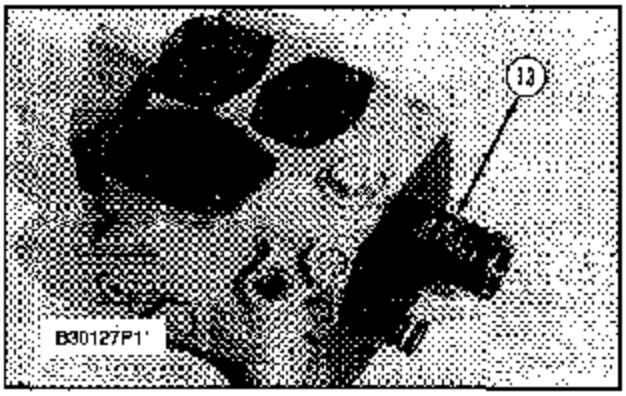


6. Install valve spool assembly (21) in the valve body.

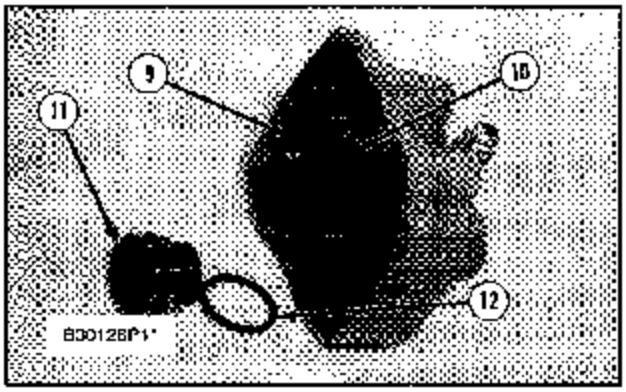


7. Assemble directional valve spool assembly (13) as follows:

   a. Install shims (18), retainer (15), spacer (19), spring (16), retainer (20), bolt (17) and the washer on valve spool (14) as shown.

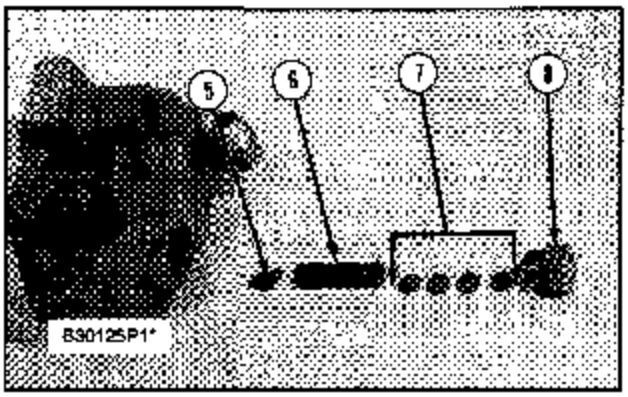


8. Install directional valve spool assembly (13) in the valve body.



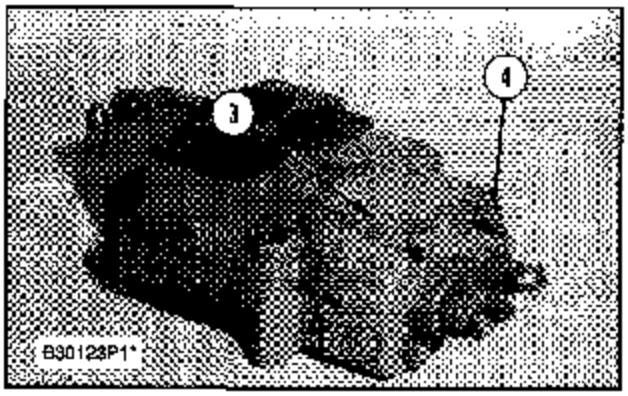
9. Put O-ring seal (12) on seat (11). Put a small amount of clean oil on the O-ring seal.

10. Install seat (11) in the body.

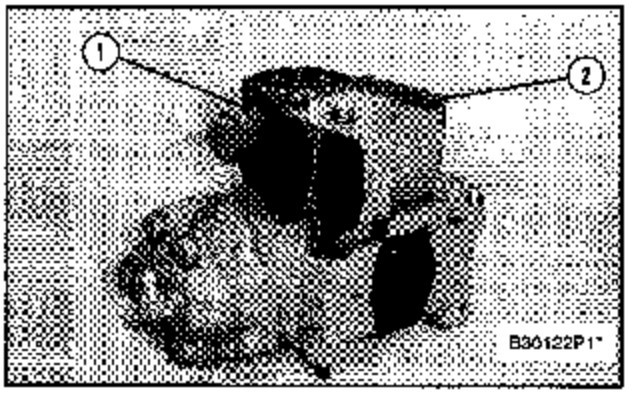


11. Install valve (5) and spring (6) in the cover.

12. Put the O-ring seal on plug (8). Install plug (8) in the cover.



13. Put the O-ring seals in position on cover (3). Install cover (3) on the valve body with bolts (4).



14. Put manifold (1) in position on the valve body. Install bolts (2) that hold it.

End By:

a. install steering control valve

Steering Cylinders

Remove & Install Steering Cylinders 4303-010

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

NOTE: The removal and installation procedure for the left hand and right hand steering cylinders is the same.

1. Activate the parking brake. With the engine running, put the bucket flat on the ground.

2. Connect the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this module.

3. Release the pressure in the hydraulic system as follows:

   a. Move the lift control lever to the "Float" position.

   b. Shut off the engine.

   c. Move the lift control lever to the "Hold" position.

⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all the hydraulic pressure is released before any fittings, hoses or components are loosened, tightened, removed or adjusted.

   d. Carefully loosen the filler cap on the hydraulic oil tank to release the pressure.

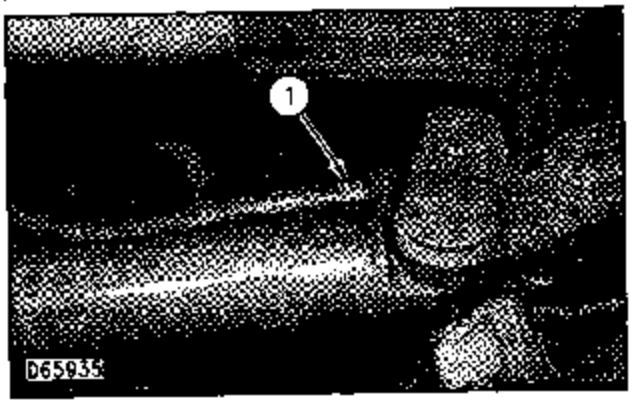
   e. Carefully loosen the plugs at the rear of the tilt cylinder. When the oil from the loosened plugs stops draining, tighten the two plugs.

NOTE: To release the pressure in the attachment cylinders, carefully loosen the two large plugs near the plugs at the top of the loader frame. When the oil from the loosened plugs stops draining, tighten the two large plugs.

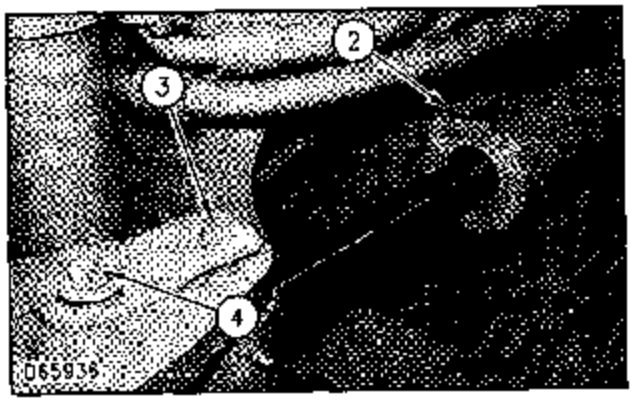
   f. Tighten the filler cap on the hydraulic oil tank.

   g. The pressure in the hydraulic system has now been released.

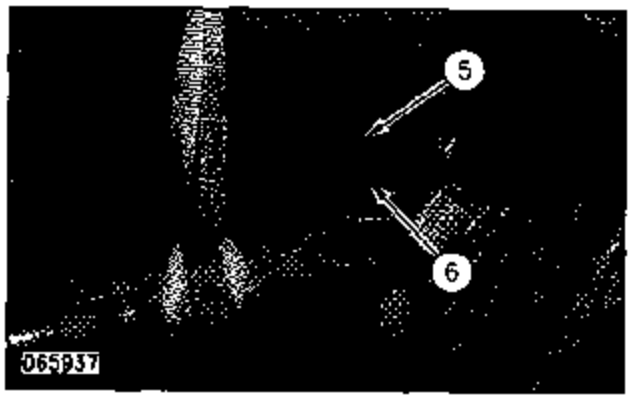
4. Drain the oil from the hydraulic oil tank into a suitable container for storage or disposal. The capacity of the hydraulic oil tank is **87 liters (22.6 U.S. gal).**



5. Disconnect hose assembly (1) at the head end of the steering cylinder.



6. Disconnect hose assembly (2) at the rod end of the steering cylinder. Remove bolt (4) and the washer that holds pin assembly (3) in position.



7. Fasten a lifting strap and a hoist to the steering cylinder as shown.

8. Remove pin assembly (3).

9. Remove bolt (5) and the washer from pin assembly (6). Remove the pin assembly.

10. Use the hoist to remove the steering cylinder from the machine. The weight of the steering cylinder is **61 kg (135 lb).**

11. Remove the other steering cylinder as in Steps 5 through 10.

NOTE: The following steps are for installation of the steering cylinder.

12. Check the condition of the O-ring seals used in the ends of the hose assemblies that connect to the steering cylinder. If any of the seals are worn or damaged, use new parts for replacement.

13. Put **5P0960 Multipurpose Grease** in the pin bores of the steering cylinder and in the pin bores in the front and rear main frames.

14. Fasten a lifting strap and a hoist to the steering cylinder, and put it in position in the machine.

15. Reinstall pin assembly (6) at the head end of the steering cylinder. Install bolt (5) and the washer that hold the pin assembly in position.

16. Reinstall pin assembly (3) at the rod end of the steering cylinder. Install bolt (4) and the washer that hold the pin assembly in position.

17. Connect hose assembly (2) at the rod end of the steering cylinder.

18. Connect hose assembly (1) at the head end of the steering cylinder.

19. Install the other steering cylinder as in Steps 13 through 18.

20. Fill the hydraulic oil tank with oil to the correct level. Lubricate the steering cylinder mounting pins. See the Operation & Maintenance Manual for the correct procedures.

21. Separate the steering frame lock link. See "Separate & Connect Steering Frame Lock Link" in this module.

22. Start the machine, and check the operation of the steering cylinders.

Disassemble Steering Cylinders 4303-015

Tools Needed		A	B
3S6224	Electric Hydraulic Pump	1	
*	Hydraulic Cylinder Repair Stand	1	
8F2243	Wrench		1

* For more information, contact Caterpillar Service Technology Group.

Start By:

a. remove steering cylinder

FLUID SPILLAGE CONTAINMENT

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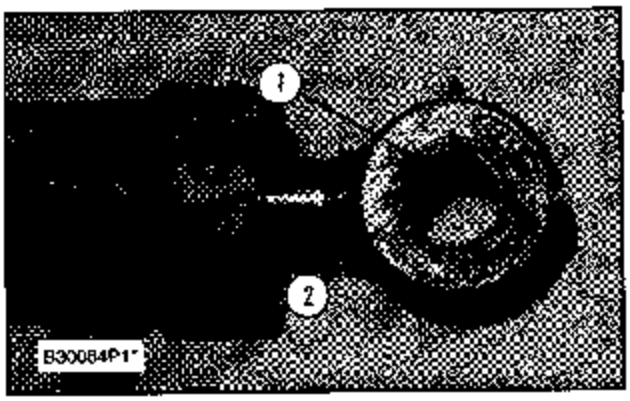
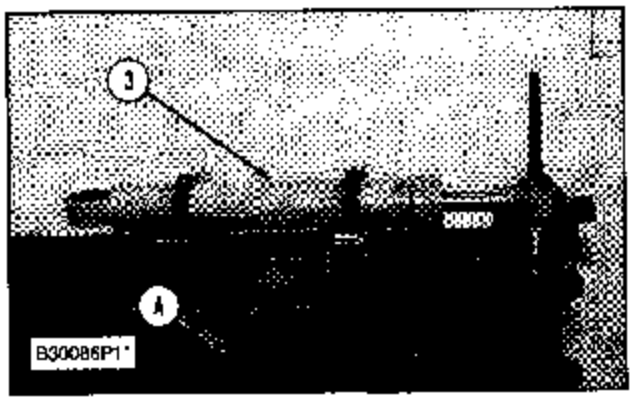
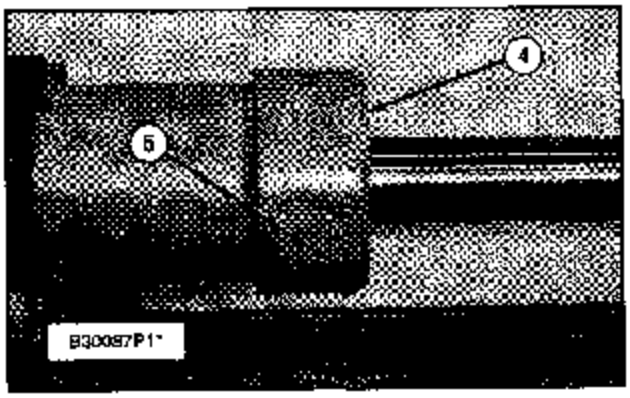


1. Remove seals (1) from each end of the steering cylinder.

2. Remove bearings (2).

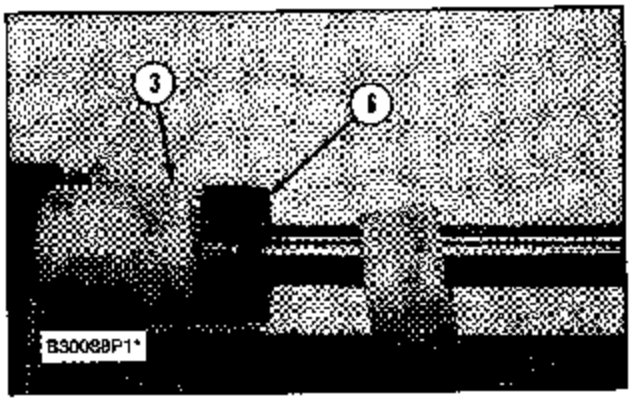


3. Put cylinder (3) in position on Cylinder Repair Stand (A).

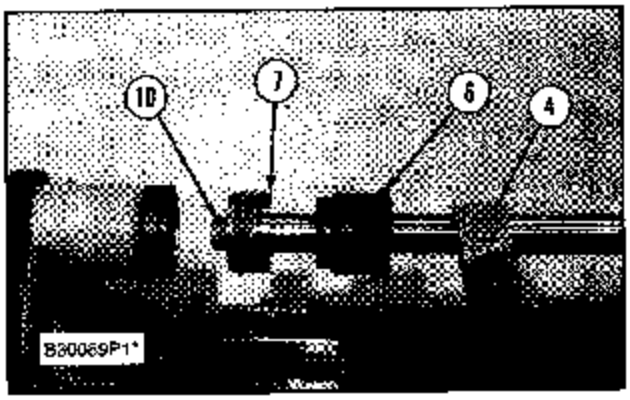


4. Loosen setscrew (5) and use Wrench (B) to remove crown (4) from the cylinder

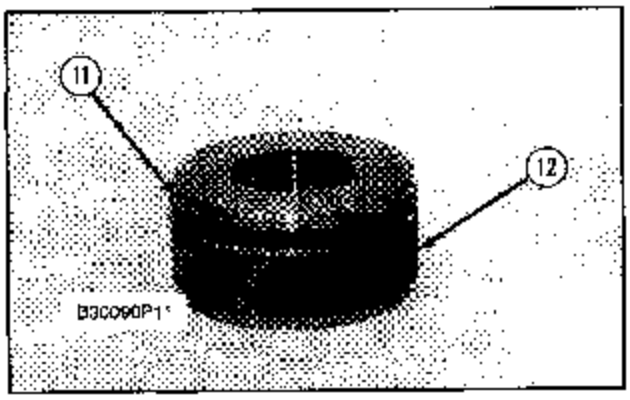
NOTE: On some models crown (4) is threaded inside cylinder (3). Even though the crown may be different all internal parts and procedures are identical.



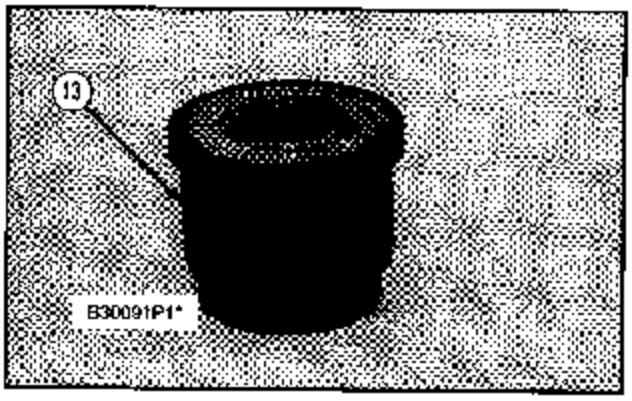
5. Use tooling (A) to pull cylinder (3) from head (6) and the rod.



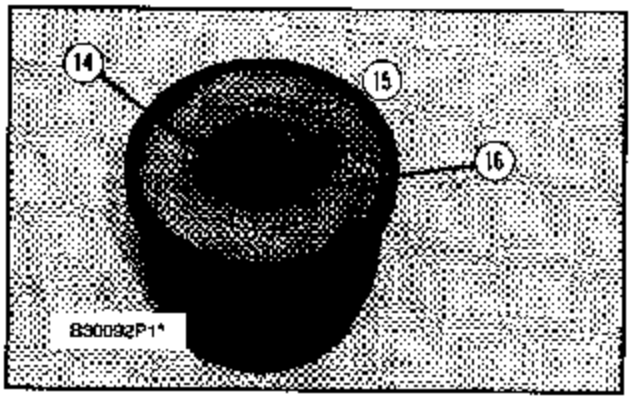
6. Remove bolt (10), piston (7), head (6) and crown (4).



7. Remove seal assembly (11) and wear ring (12) from the piston.



8. Remove seals (13) from the head.



9. Remove lip type seals (14) and (15) from the head.

10. Remove seal ring (16) from the head.

Assemble Steering Cylinders 4303-016

	Tools Needed	A	B	C	D	E	F	G
1P0510	Driver Group		1					
4S9181	Seal Expander			1				
*	Cylinder Repair Stand				1			
3S6224	Electric Hydraulic Pump				1			
1P0850	Torque Multiplier					1		
1P0851	Spline Adapter					1		
1P0852	Male Adapter					1		
1P1833	Bearing Puller						1	
9S5559	Stud, 1"						1	
7F9540	Hydraulic Puller						1	
1P0543	Nut						1	
8F2243	Wrench							1

*For further information, contact Caterpillar Service Technology Group.

FLUID SPILLAGE CONTAINMENT

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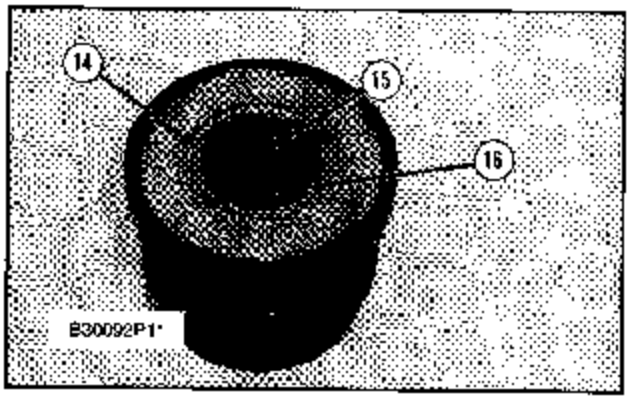
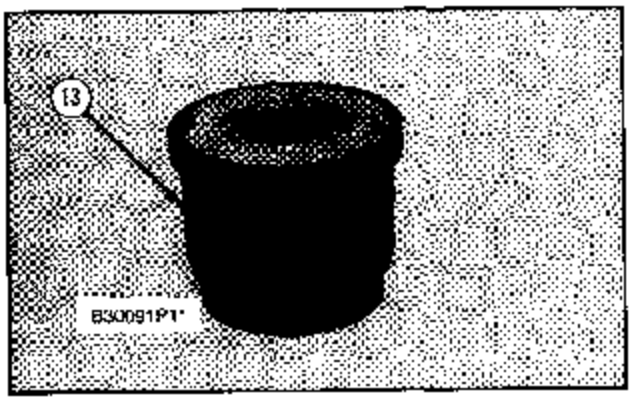
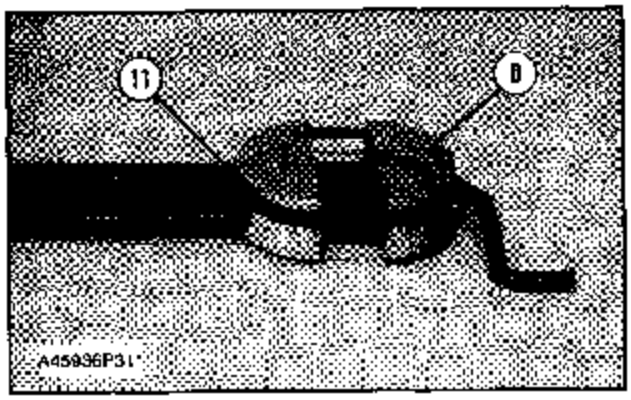


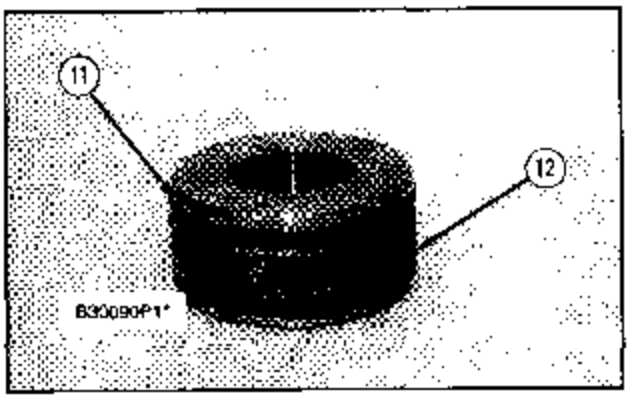
1. Install seal (16). Install seal (15) with the lip pointing in. Install seal (14) with the lip pointing out.



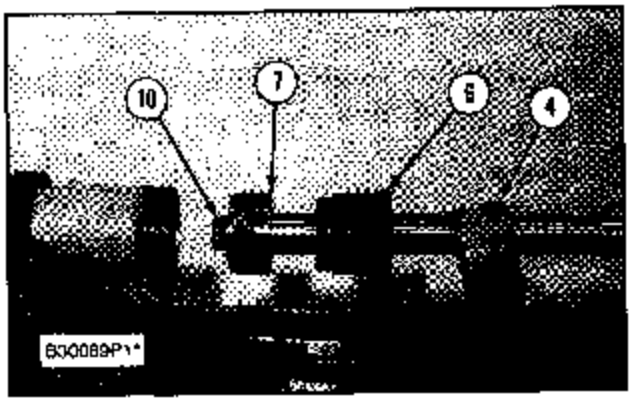
2. Install O-ring seal (13).



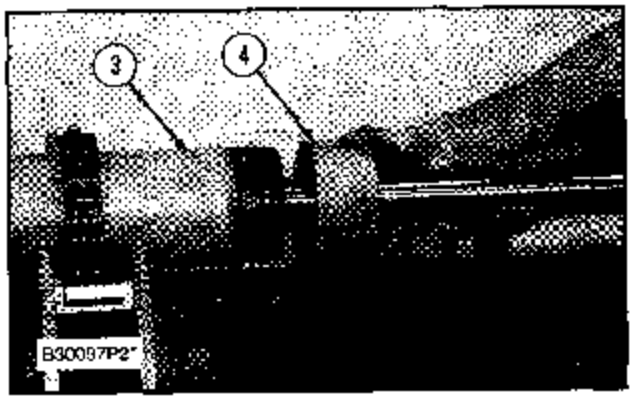
3. Use Seal Expander (D) to install the seal on the piston.



4. Install wear ring (12) and seal assembly (11).



5. Put crown (4), head (6) and piston (7) on the rod. Put clean oil on the threads of bolt (10). Tighten bolt (10), with Torque Multiplier (D) to a torque of **1085 ± 108 N•m (800 ± 80 lb ft).**

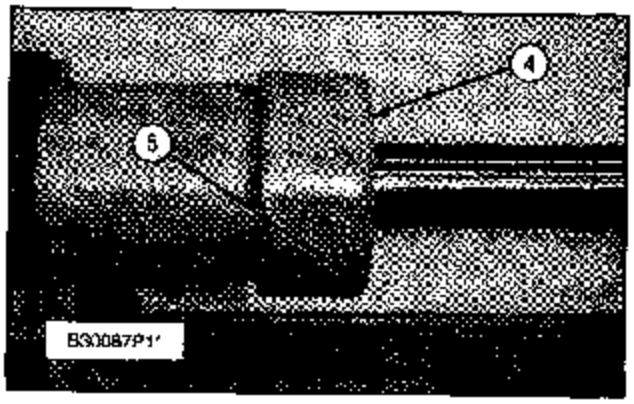


6. Apply **5P960 Multipurpose Grease** to the threads of cylinder (3) and crown (4).

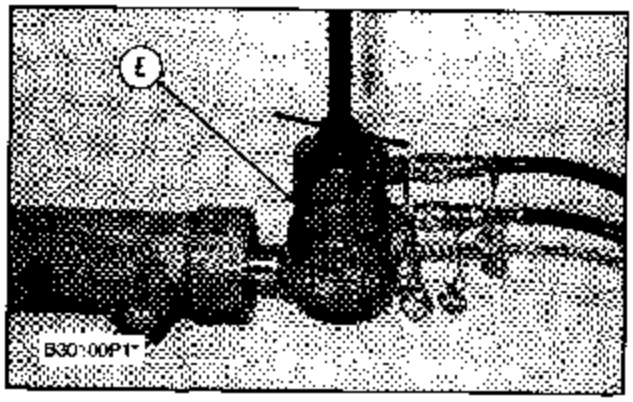
NOTE: On some models crown (4) is threaded inside cylinder (3). Even though the crown may be different all internal parts and procedures are identical.

NOTE: The rod must be fully extended when the crown is tightened.

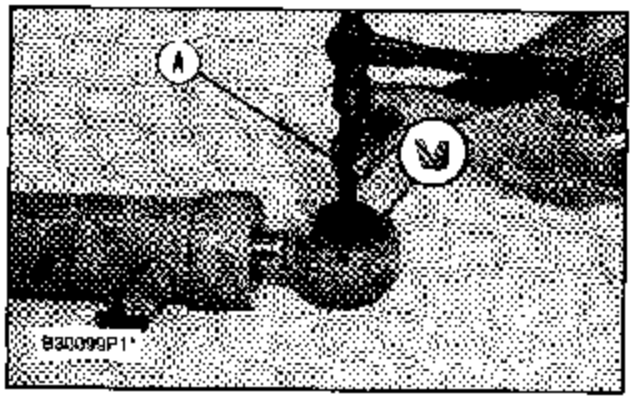
7. Install the crown on the cylinder. Use Wrench (F) to tighten the crown to a torque of **610 ± 135 N•m (450 ± 100 lb ft).**



8. Tighten setscrew (5) to a torque of **34 ± 4 N•m (25 ± 3 lb ft)** on crown (4).



9. Lower the temperature of the bearings and install them in the center of the bores with tooling (E).



10. Use Driver Group (A) to install the lip type seals. The lip of the seal must be toward the outside.

End By:

a. install steering cylinder

Steering Neutralizer Valves

Remove & Install Steering Neutralizer Valves 4330-010

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

NOTE: The steering neutralizer valves are mounted to the rear loader frame next to the upper hitch pin. The removal and installation procedure for both steering neutralizer valves is the same.

1. Activate the parking brake.

2. Connect the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this module.

3. Release the pressure in the hydraulic system as follows:

   a. Move the lift control lever to the "Float" position.

   b. Shut off the engine.

   c. Move the lift control lever to the "Hold" position.

⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all the hydraulic pressure is released before any fittings, hoses or components are loosened, tightened, removed or adjusted.

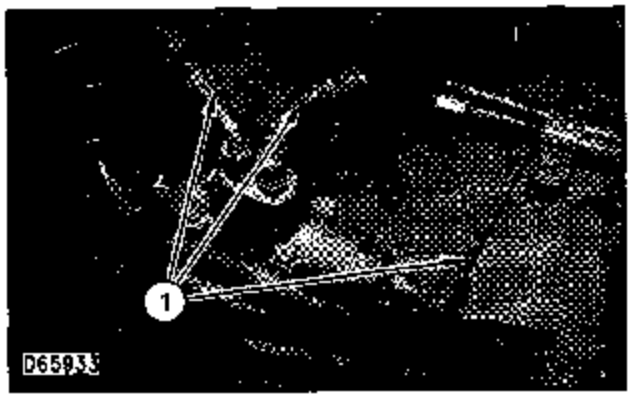
   d. Carefully loosen the filler cap on the hydraulic oil tank to release the pressure.

   e. Carefully loosen the plugs at the rear of the tilt cylinder. When the oil from the loosened plugs stops draining, tighten the two plugs.

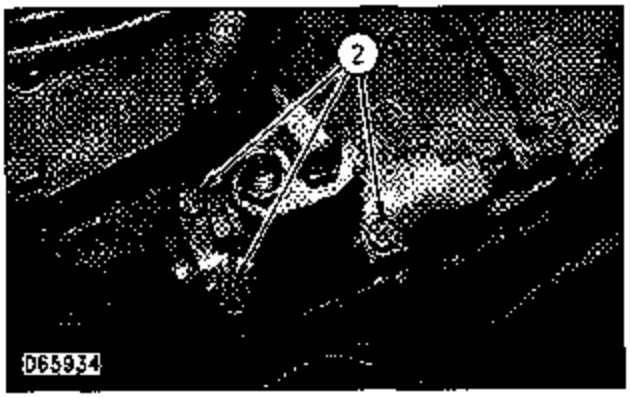
NOTE: To release the pressure in the attachment cylinders, carefully loosen the two large plugs near the plugs at the top of the loader frame. When the oil from the loosened plugs stops draining, tighten the two large plugs.

f. Tighten the filler cap on the hydraulic oil tank.

g. The pressure in the hydraulic system has now been released.



4. Disconnect three hose assemblies (1) from the steering neutralizer valve.



5. Remove the bolts that hold the steering neutralizer valve to the frame of the machine. Remove steering neutralizer valve (2).

6. Remove the other steering neutralizer valve as in Steps 4 and 5.

NOTE: Install the steering neutralizer valves in the reverse order of removal.

7. Fill the hydraulic oil tank with oil to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

8. Check the adjustment of the strikers on the steering neutralizer valves. See the topic "Neutralizer Valve" in Systems Operation Testing & Adjusting, 815F Wheel Tractor Steering System.

9. Separate the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this module.

10. Start the machine, and check the operation of the steering.

Disassemble & Assemble Steering Neutralizer Valves 4330-017

Tools Needed	A
1P0510 Driver Group	1

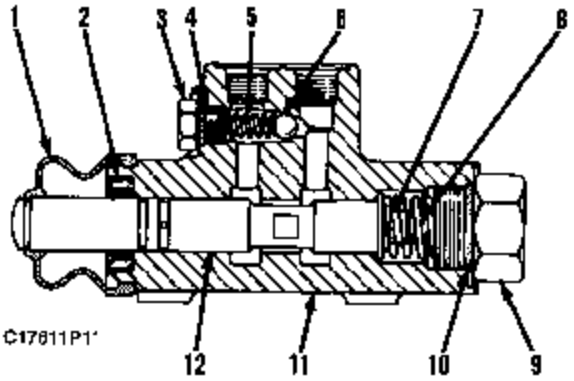
Start By:

a. remove steering neutralizer valves

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

NOTE: Be sure the steering neutralizer valve is thoroughly clean prior to disassembly.



1. Remove boot (1) from valve body (11).

2. Remove plug (9) from the valve body. Remove O-ring seal (10) from the plug. Remove spring (8) and spool (12) from valve body (11).

3. Remove the bolt, lockwasher, and washer (7) from spool (12).

4. Remove plug (3) from the valve body. Remove O-ring seal (4) from the plug. Remove spring (5) and ball (6) from valve body (11).

5. Remove lip-type seal (2) from the valve body.

NOTE: The following steps are for the assembly of the steering neutralizer valve.

6. Be sure all internal parts of the steering neutralizer valve are clean and free of dirt and debris prior to assembly. Put clean hydraulic oil on the internal components.

7. Check the condition of all O-ring seals used in the steering neutralizer valve. If the seals are worn or damaged, use new parts for replacement.

8. Install lip-type seal (2) in valve body (11) with tooling (A). Install the seal with the lip facing in toward the valve body as shown in Illustration.

9. Install ball (6) and spring (5) in valve body (11). Install O-ring seal (4) on plug (3). Install plug (3) in the valve body.

10. Install the washer, lockwasher and bolt (7) on spool (12). Install spool (12) and spring (8) in valve body (11). Install O-ring seal (10) on plug (9). Install plug (9) in the valve body.

11. Install boot (1) on the valve body.

End By:

a. install steering neutralizer valve

Hydraulic Oil Filters

Remove Hydraulic Oil Filters 5068-011

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

1. Activate the parking brake.

2. Connect the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this module.

3. Release the pressure in the hydraulic system as follows:

   a. Move the lift control lever to the "Float" position.

   b. Shut off the engine.

   c. Move the lift control lever to the "Hold" position.

⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all the hydraulic pressure is released before any fittings, hoses or components are loosened, tightened, removed or adjusted.

   d. Carefully loosen the filler cap on the hydraulic oil tank to release the pressure.

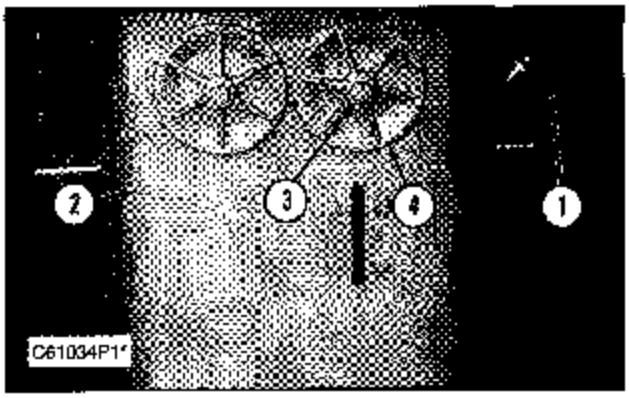
   e. Carefully loosen the plugs at the rear of the tilt cylinder. When the oil from the loosened plugs stops draining, tighten the two plugs.

NOTE: To release the pressure in the attachment cylinders, carefully loosen the two large plugs near the plugs at the top of the loader frame. When the oil from the loosened plugs stops draining, tighten the two large plugs.

f. Tighten the filler cap on the hydraulic oil tank.

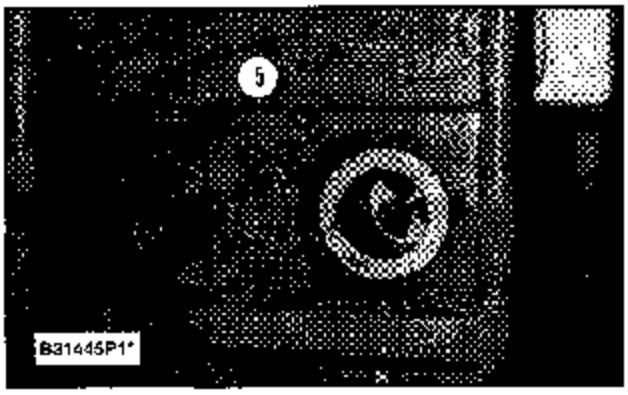
g. The pressure in the hydraulic system has now been released.

4. Drain the oil from the hydraulic tank into a suitable container for storage or disposal. The capacity of the hydraulic oil tank is **870 liters (22.6 U.S. gal).**



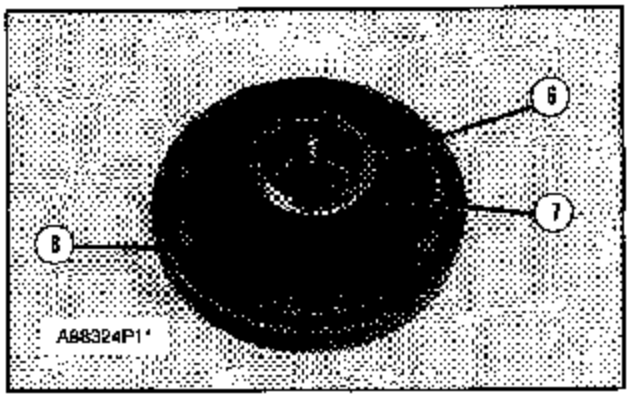
5. Remove hydraulic tank filler cap (1) slowly to be sure the pressure in hydraulic oil tank (2) has been released.

6. Loosen bolt (3), and remove cap (4).

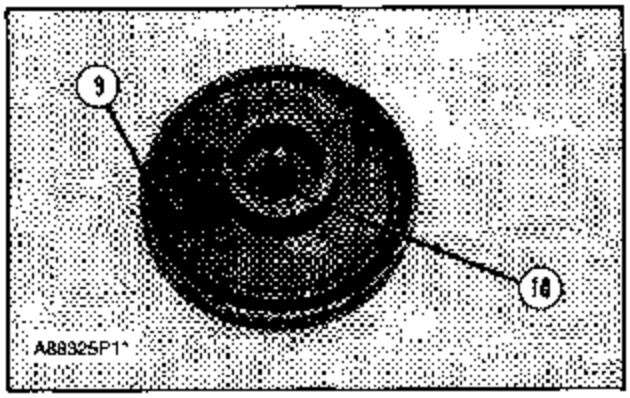


Typical Example

7. Remove element (5).



8. Remove spiral lock ring (6). Remove spacer (7) and six springs (8) from the cover.



9. Remove spiral lock ring (10). Remove bolt (3) from the cover. Remove the O-ring seal from the bolt.

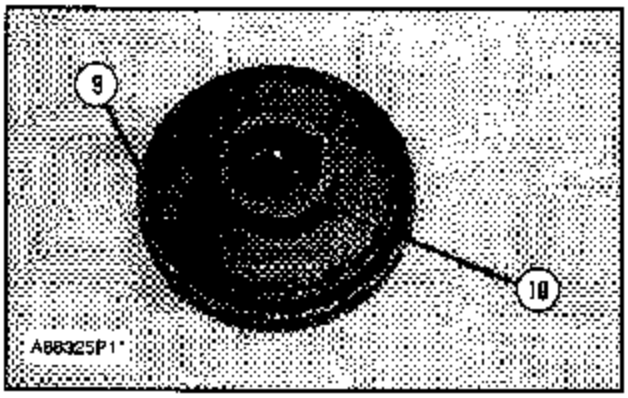
10. Remove O-ring seal (9).

11. Repeat Steps 6 through 10 for the other hydraulic oil filter.

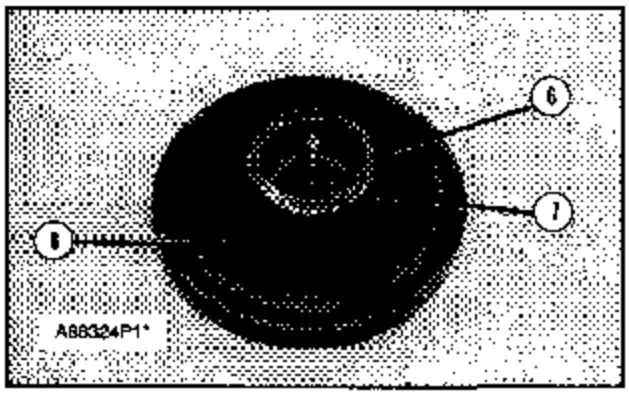
Install Hydraulic Oil Filters 5068-012

FLUID SPILLAGE CONTAINMENT

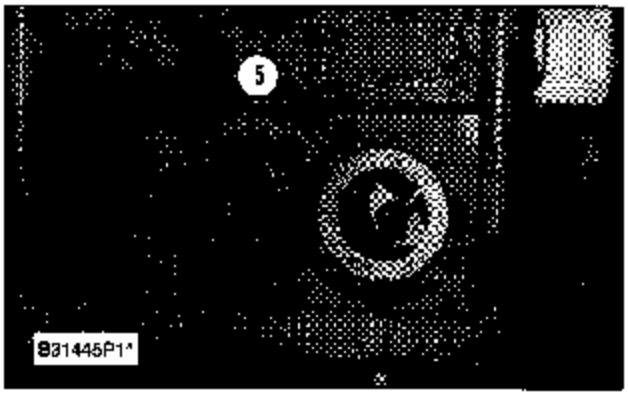
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



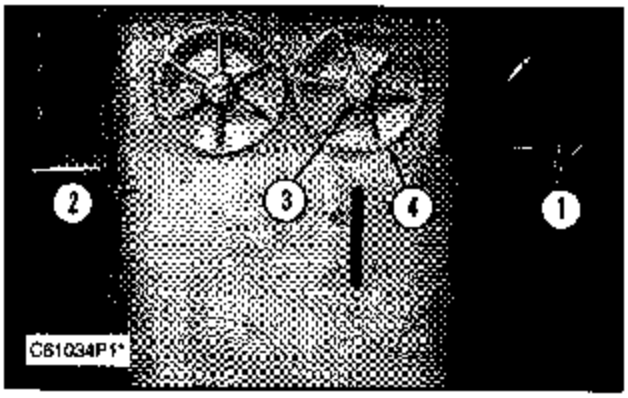
1. Install the O-ring seal on the bolt and install the bolt in the cover. Install spiral lock ring (10) and O-ring seal (9).



2. Install six springs (8), spacer (7) and spiral lock ring (6).



3. Install element (5).



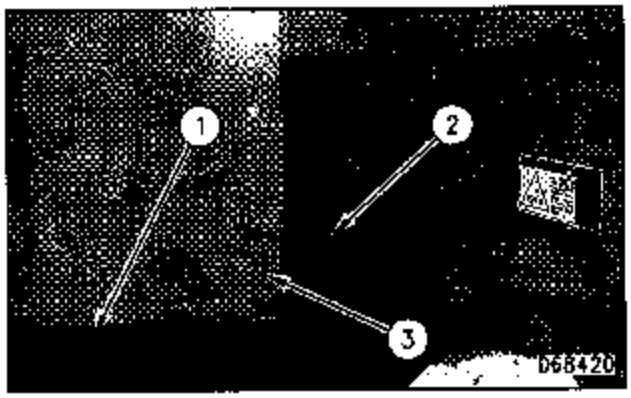
4. Put cover (4) in position and tighten bolt (3).
5. Repeat Steps 1 through 4 for the other hydraulic oil filter.
6. Fill the hydraulic oil tank with oil to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.
7. Separate the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this module.
8. Start the machine, and check for leaks.

Hydraulic Tank

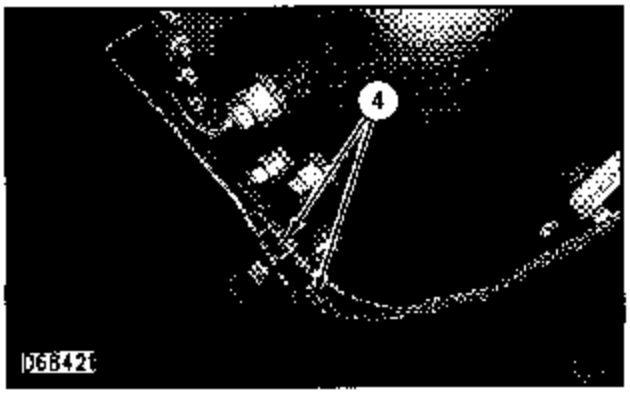
Remove Hydraulic Tank 5056-011

FLUID SPILLAGE CONTAINMENT

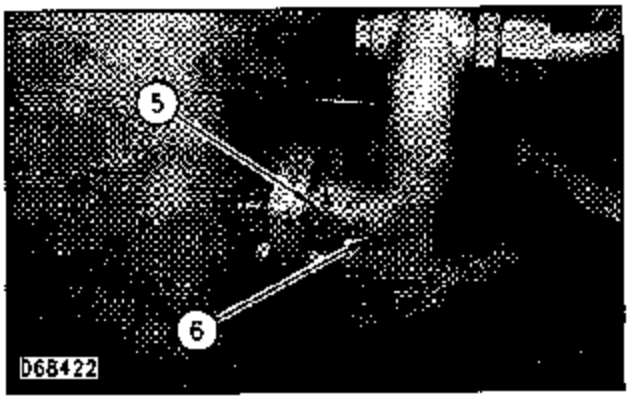
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



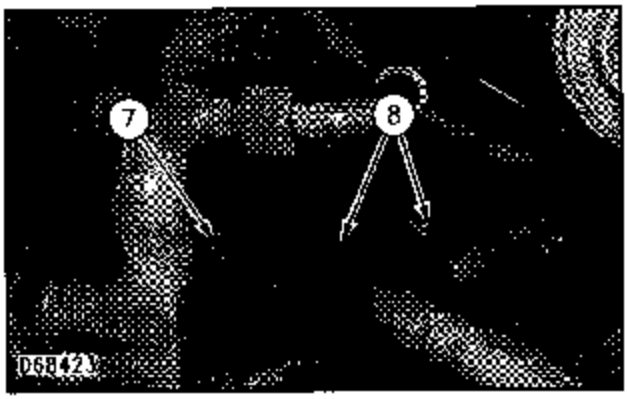
1. Remove bolts (1) and (2). Open the right side platform assembly (3).
2. Loosen the filler cap on the hydraulic tank and slowly release the pressure.
3. Drain the hydraulic tank.



4. Disconnect wires (4) from the side of the hydraulic tank.

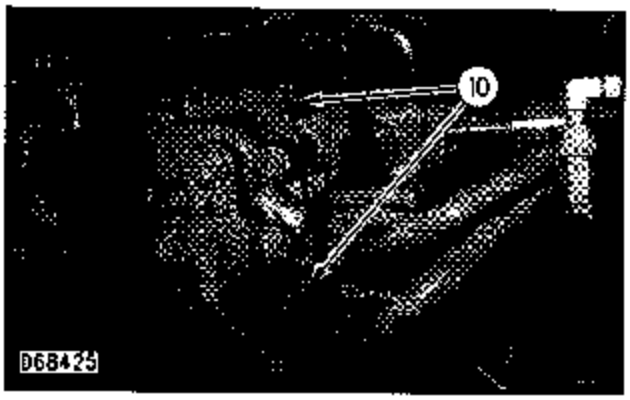


5. Remove bolts (5). Disconnect oil lines (6) from the hydraulic tank.

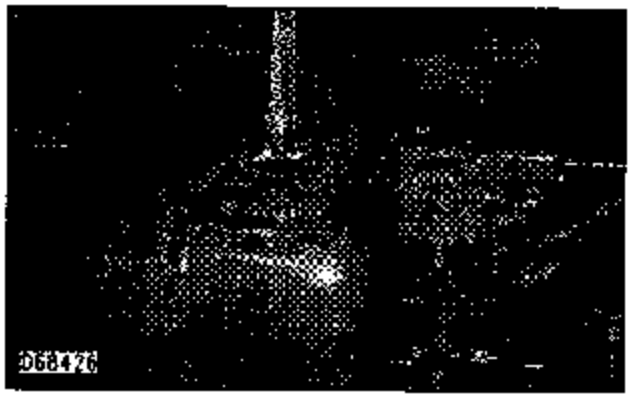


6. Remove bolts (7). Disconnect suction line (8) from the hydraulic tank.

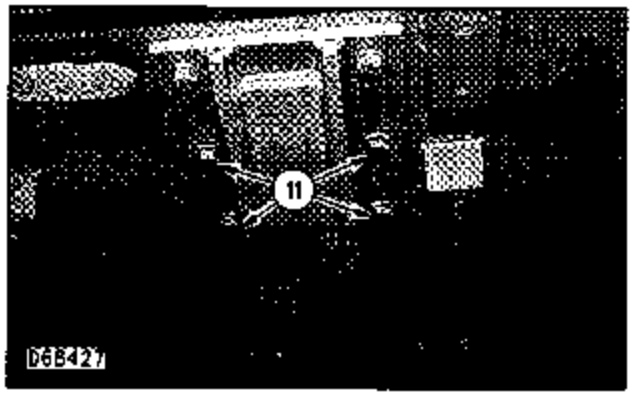
7. Remove bolts (9) from the bracket that hold the hydraulic tank.



8. Remove three bolts (10) that connect the steering control valve to the hydraulic tank.



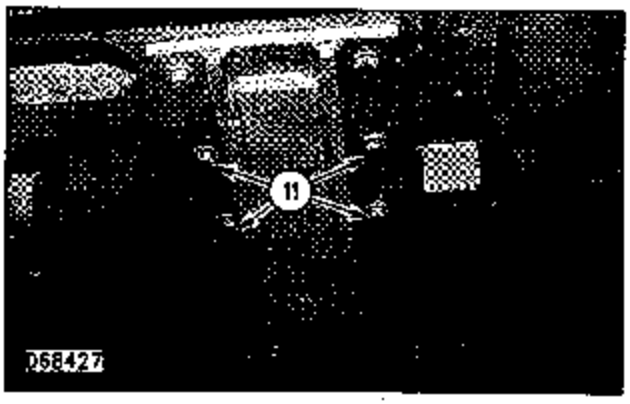
9. Install straps and a hoist to the hydraulic tank.



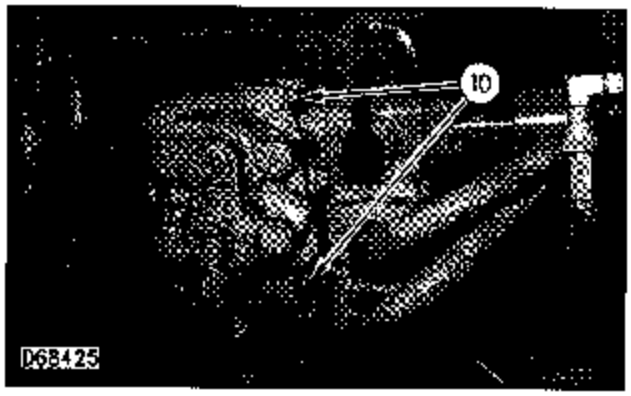
10. Remove bolts (11) that hold the hydraulic tank to the platform assembly. Remove the hydraulic tank. The weight of the tank is **97 kg (215 lb.).**

Install Hydraulic Tank 5056-012

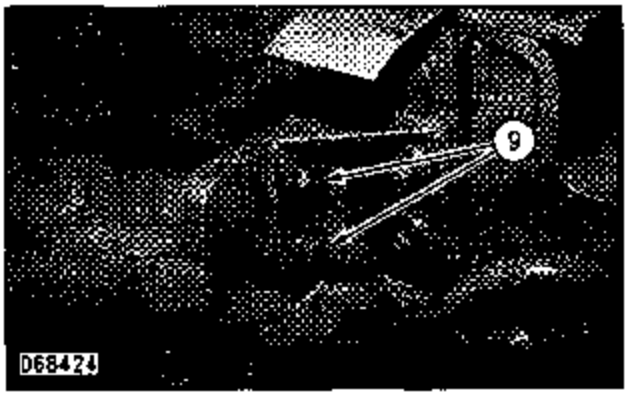
1. Fasten straps and a hoist to the hydraulic tank. Install the hydraulic tank.



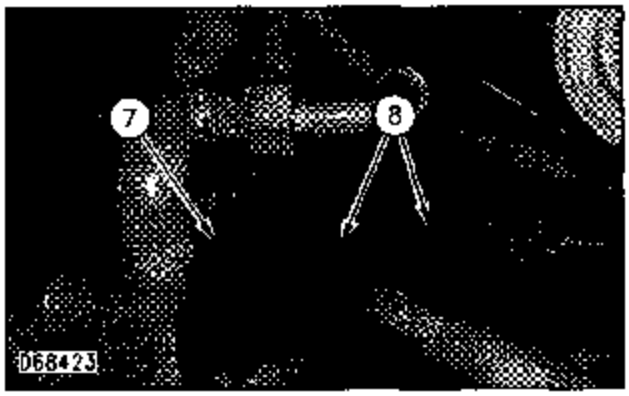
2. Install bolts (11) that hold the hydraulic tank to the platform assembly.



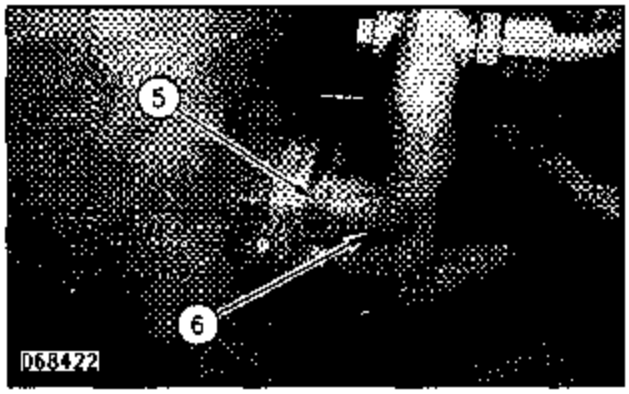
3. Install two bolts (10) that connect the steering control valve to the hydraulic tank.



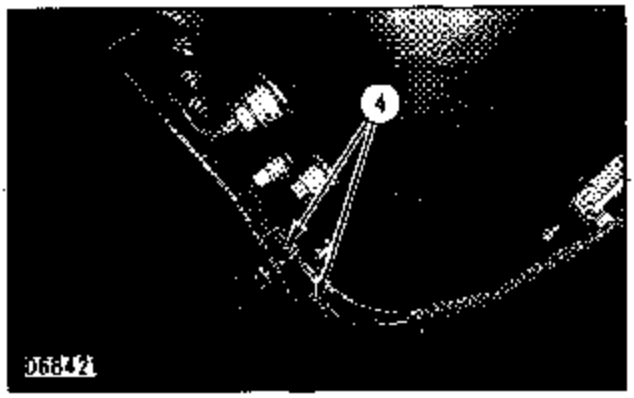
4. Install bolts (9) that hold the hydraulic tank to the bracket.



5. Install bolts (7) that connect suction line (8) to the hydraulic tank.

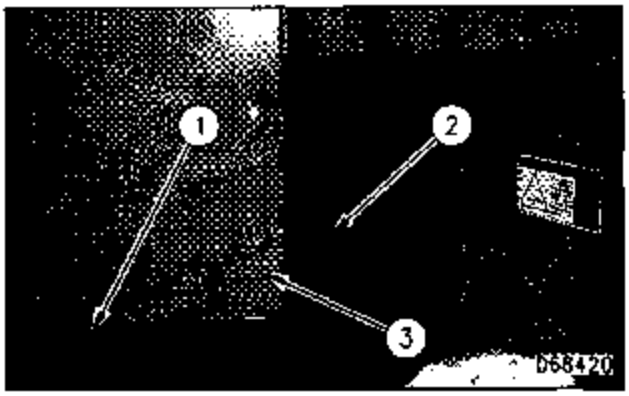


6. Install bolts (5) that connect oil lines (6) to the hydraulic tank.



7. Connect wires (4) to the side of the hydraulic tank.

8. Fill the hydraulic tank.



9. Push platform assembly (1) closed and install the bolts.

Disassemble Hydraulic Tank 5056-015

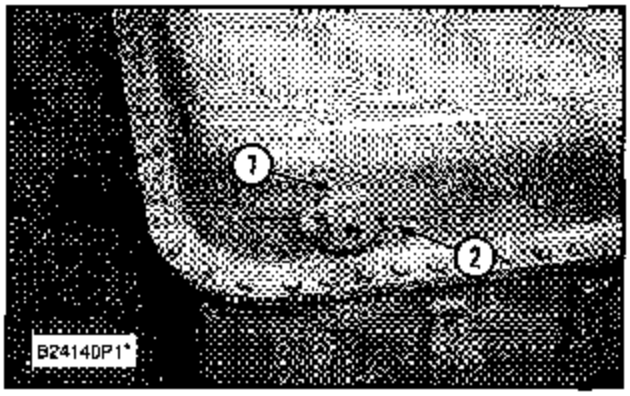
Start by:

a. remove hydraulic tank oil filters

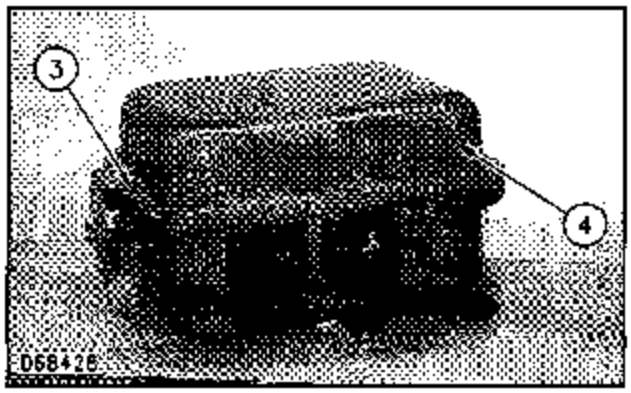
b. remove hydraulic tank

FLUID SPILLAGE CONTAINMENT

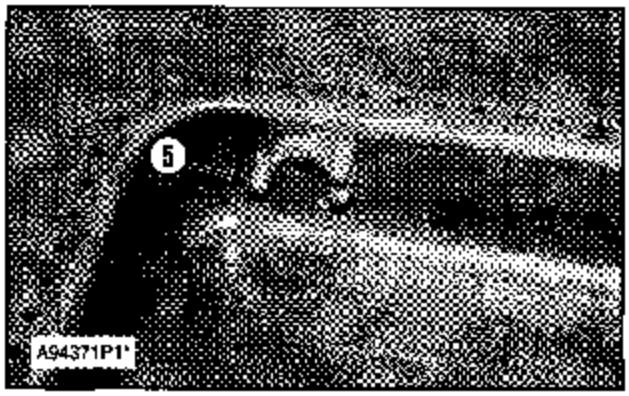
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



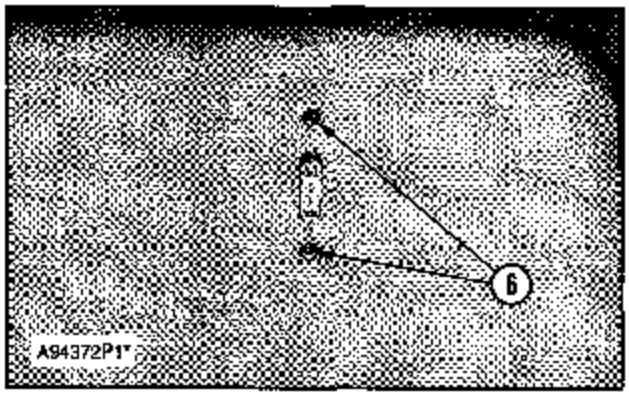
1. Remove bolts (2), body (1), guide, spring, valve and seal from the hydraulic tank.



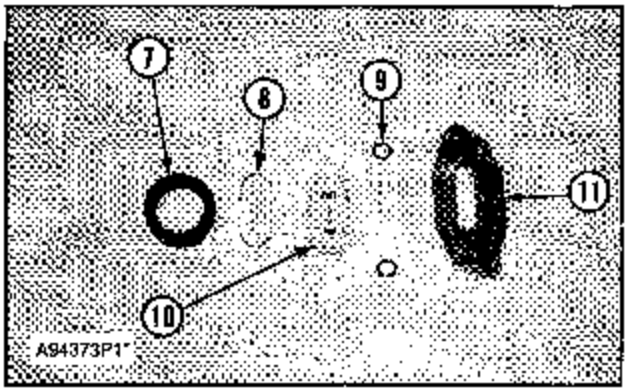
2. Remove bolts (3) that hold cover (4). Remove cover (4). Use two persons to remove the cover. Weight of the cover is approximately 31 kg (68 lb.).



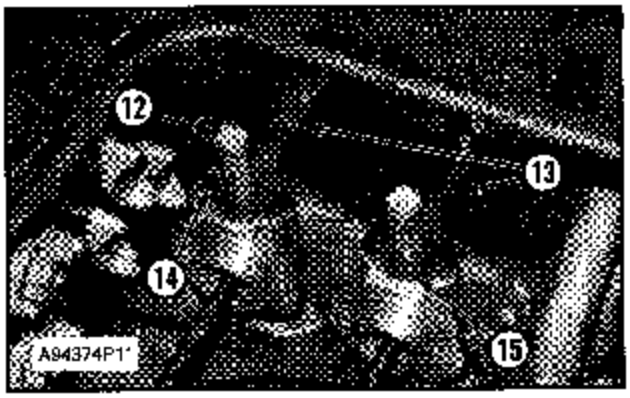
3. Remove bolt, then remove retainer (5) from cover.



4. Remove bolts (6). Remove gauge group from the hydraulic tank cover.

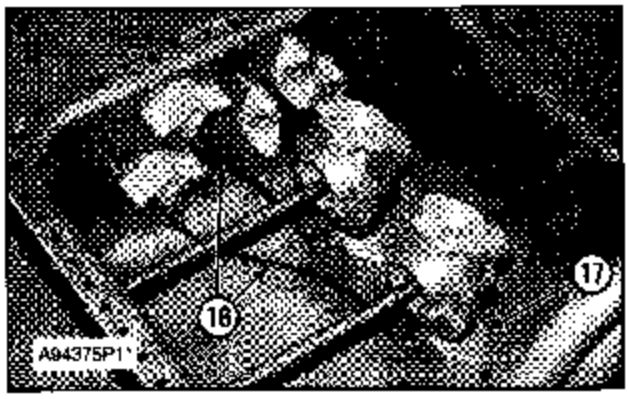


5. Remove two seals (9), plate (10), glass (8) and grommet (7) from retainer (11).

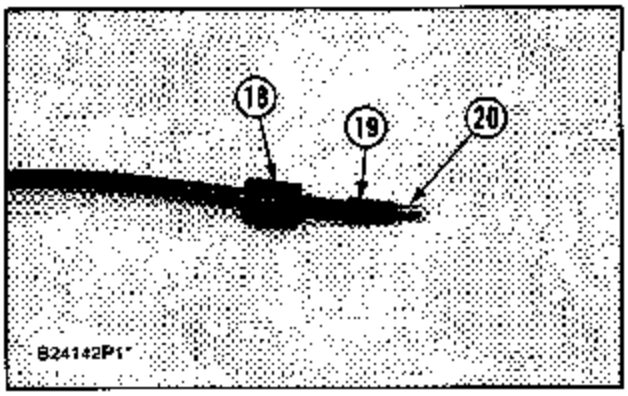


6. Remove bolts (14). Loosen the bolts slowly and evenly to release the spring tension.

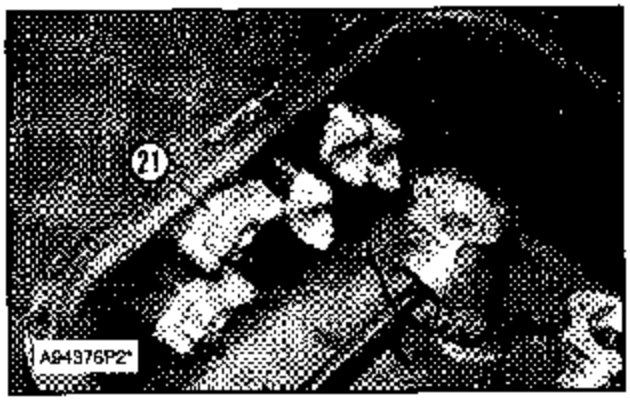
7. Remove plates (13), tubes (12), valves and flanges (15). Remove one spring from each tube.



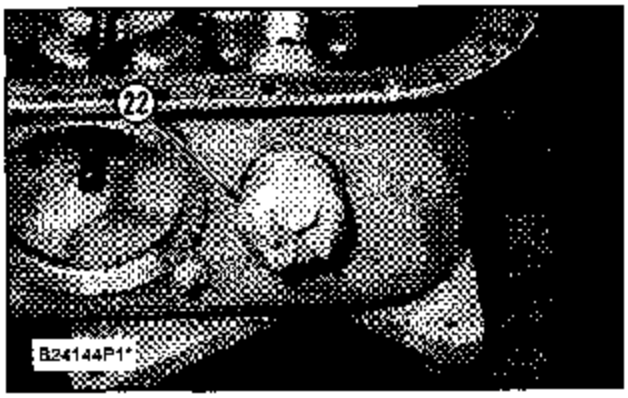
8. Remove tube assemblies (16) from bases (17).



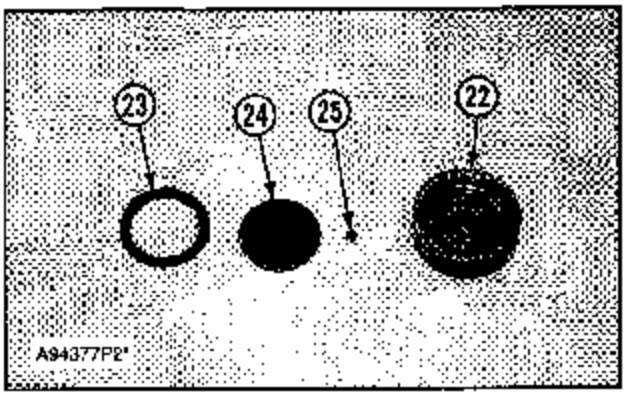
9. Remove insert (20), sleeve (19) and nut (18) from the tube assembly.



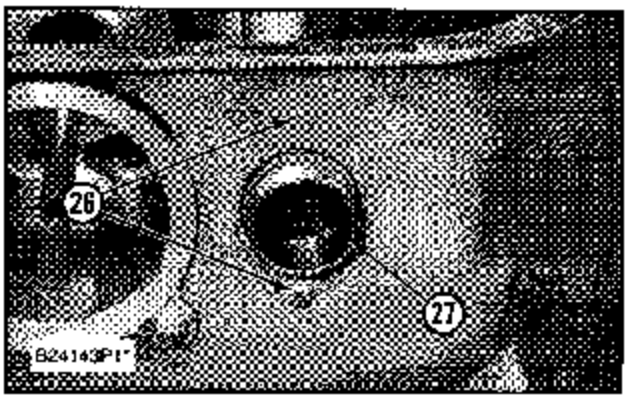
10. Remove block assemblies (21) from the tank cover.



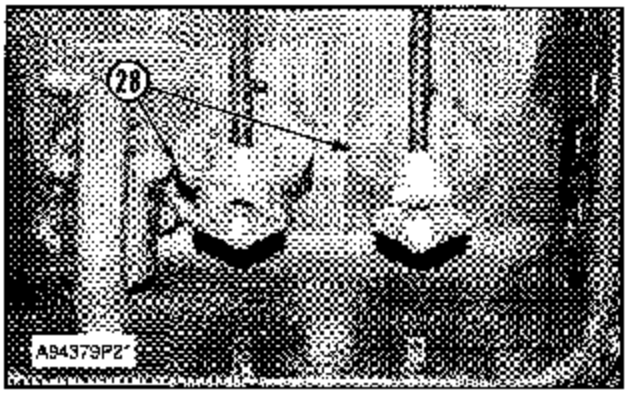
11. Remove cap (22) and the strainer from the filler.



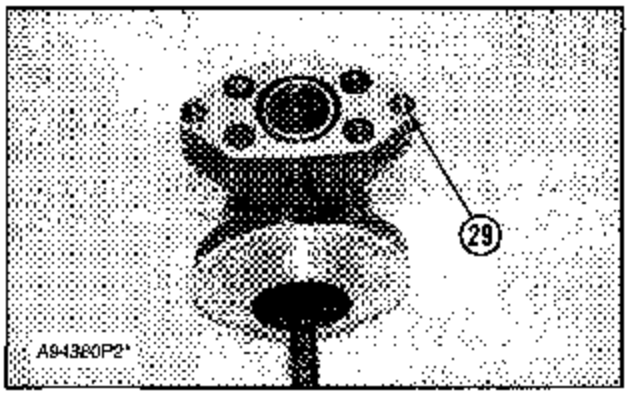
12. Remove gasket (23), plate (24) and ball (25) from cap (22).



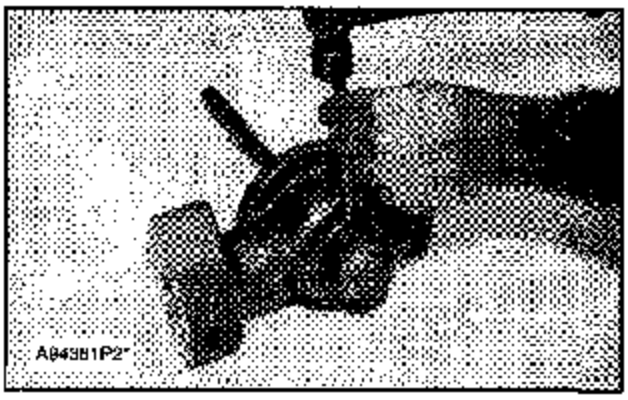
13. Remove bolts (26). Remove filler (27) from the hydraulic tank.



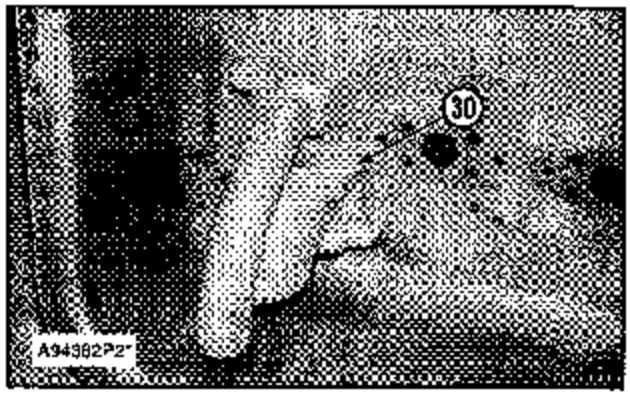
14. Remove the bolts (on backside of hydraulic tank cover). Remove bases (28) from the cover.



15. Remove O-rings seals (29) from the two bases.



16. Remove pin and rod from bases with a hammer and punch as shown.



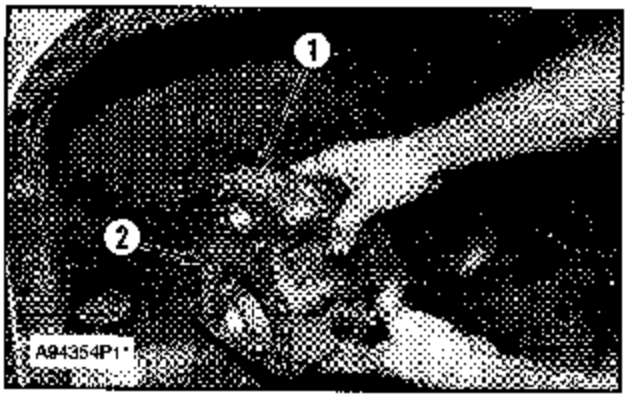
17. Remove the bolts from the back side of the tank cover. Remove manifold (30) from the tank cover. Remove the O-ring seals from the manifold.

Assemble Hydraulic Tank 5056-016

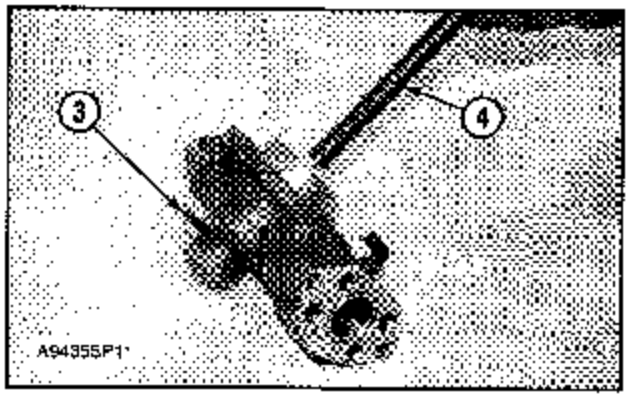
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to 'TOOLS AND SHOP PRODUCT GUIDE, NENG2500', for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

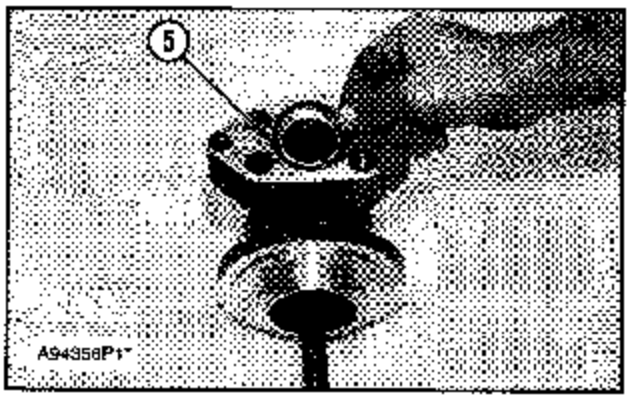
1. Clean and inspect all parts. Make a replacement of all parts that are worn or damaged.



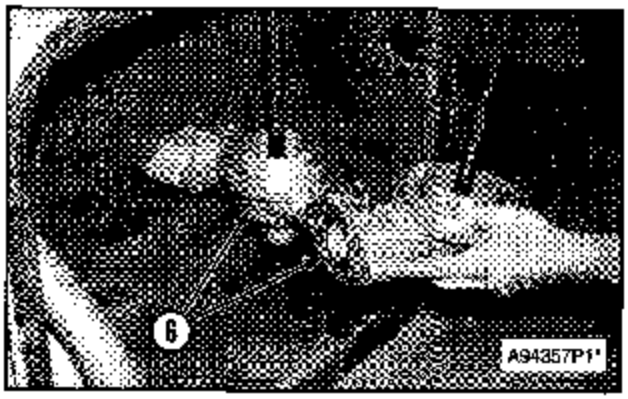
2. Install O-ring seals (2) on manifold (1). Install the manifold on the tank cover.



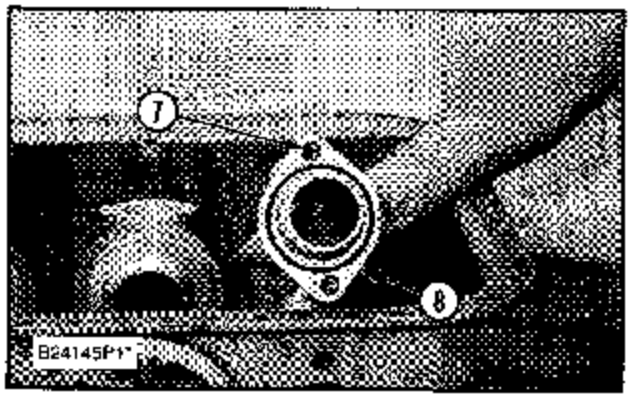
3. Install rods (4) and pins (3) in the bases.



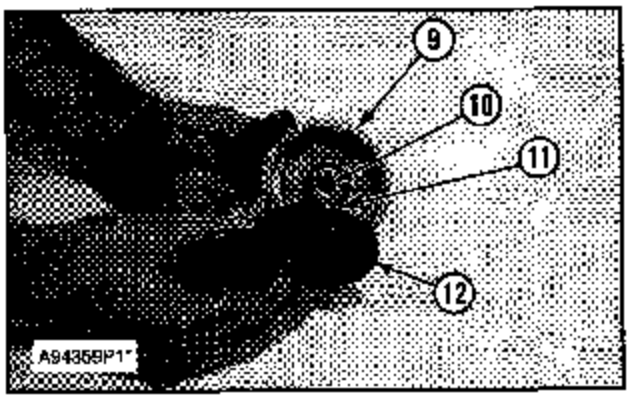
4. Install O-ring seals (5) on the bases.



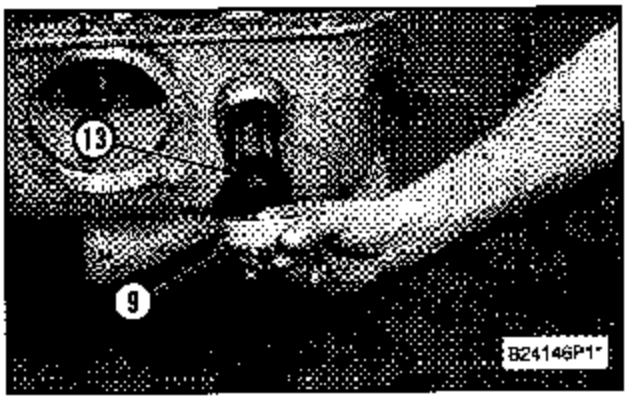
5. Install bases (6) on the tank cover.



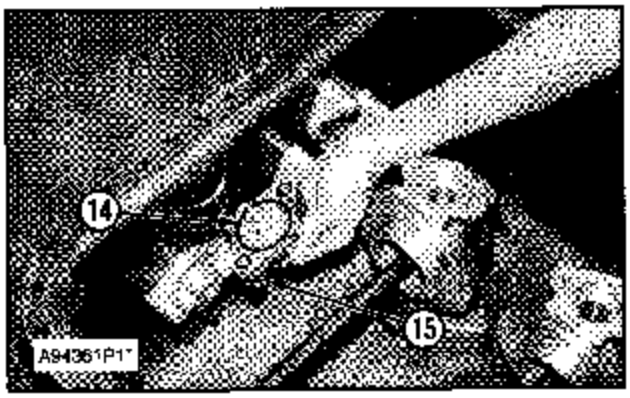
6. Install O-ring seals (7) on filler (8). Install the filler on the hydraulic tank.



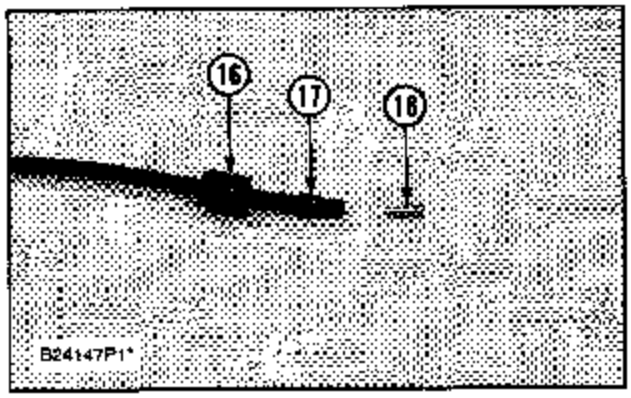
7. Install ball (10), plate (11) and gasket (12) in cap (9)



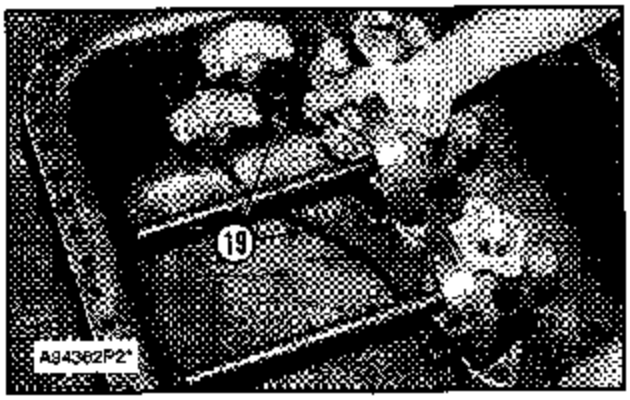
8. Install strainer (13) and cap (9) on the filler.



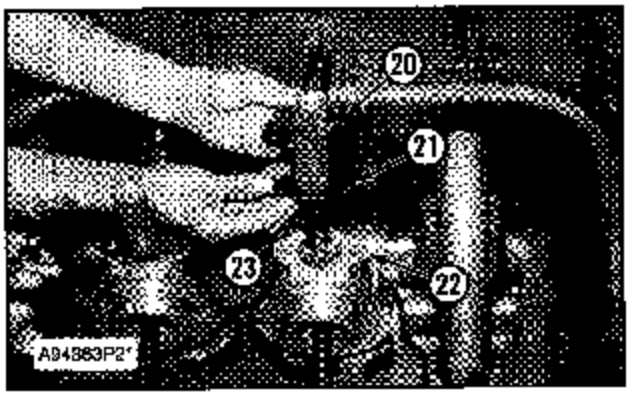
9. Install O ring seals (14) on blocks (15). Install the blocks on the tank cover.



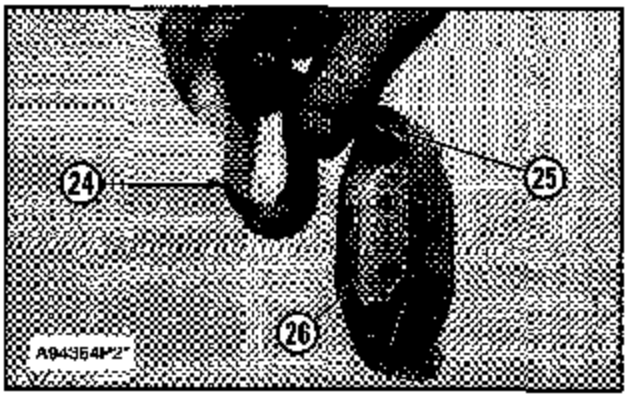
10. Install nut (16), sleeve (17) and insert (18) in the tube assemblies.



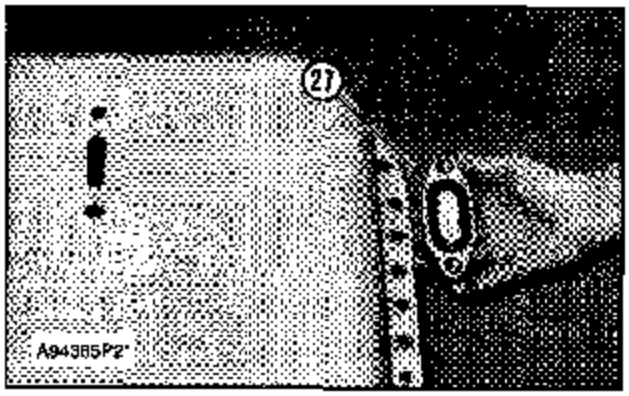
11. Install tube assemblies (19) on the blocks and the bases.



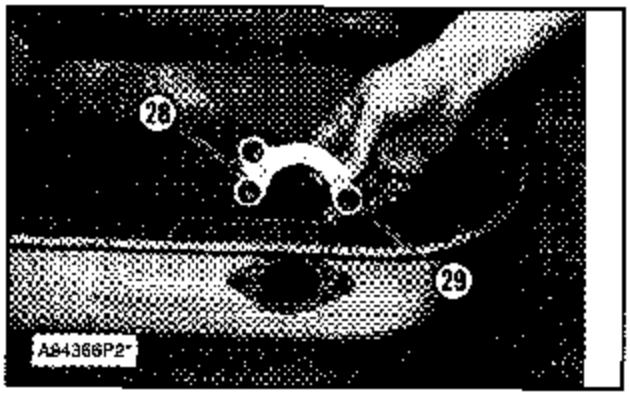
12. Install valves (22), springs (23), tube assemblies and flanges (21) in the bases. Install plates (20).



13. Install O-ring seals (25) on the retainer. Install plate (26) in retainer. Install glass on grommet (24). Install glass in the retainer.



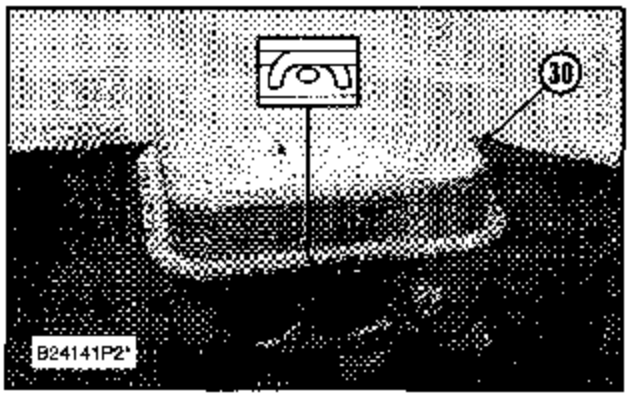
14. Install level indicator (27) in the tank cover.



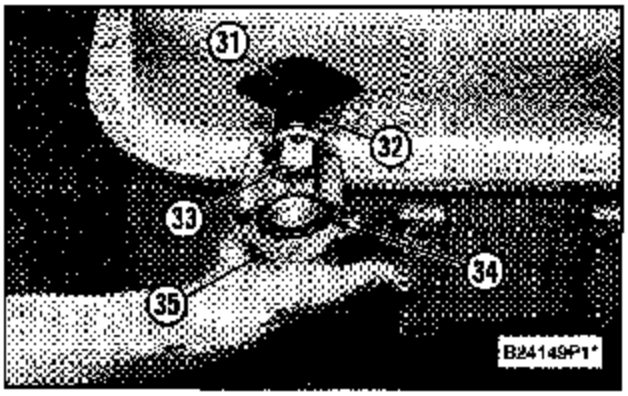
15. Install O-ring seals (29). Install retainer (28) on the tank cover.

16. Install the teflon sealant on the edge of the lower tank assembly to the inside of the bolt holes. Make sure one end of the sealant is over the other end and both ends must be around a bolt hole as shown.

NOTE: Sealant ends must cross at the top of the tank.



17. Install cover (30) and the bolts.



18. Install guide (31), spring (32) and valve (33). Install O-ring (34) on body (35). Install assembly in the tank.

End By:

a. install hydraulic tank

b. install hydraulic tank oil filters

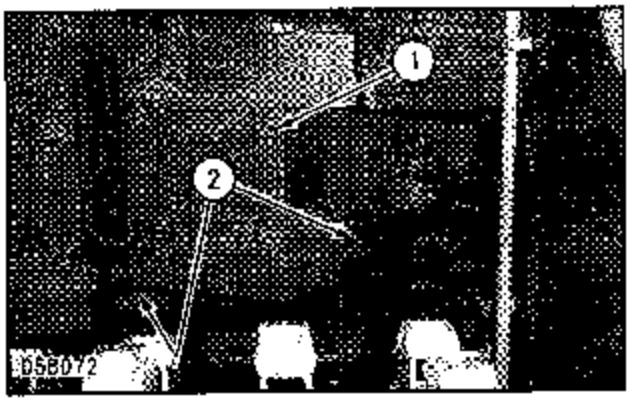
Cab

Remove & Install Cab 7301-010

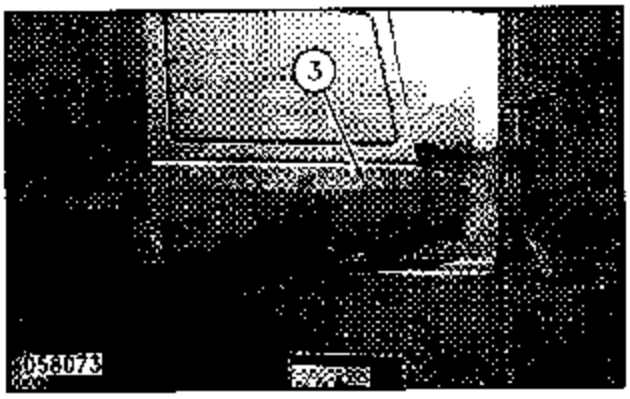
Tools Needed	A
6V-2156 Link Bracket	4

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

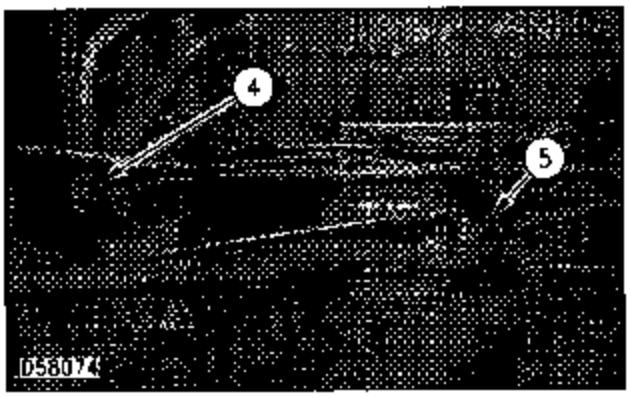


1. Remove two bolts and washers (2) and open platform assembly (1).

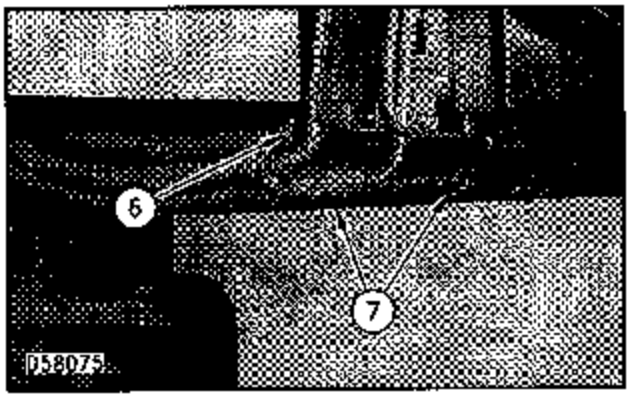


2. Remove eleven bolts and washers from front shroud (3) and remove front shroud (3).

NOTE: Two bolts on the left side are under the shroud.



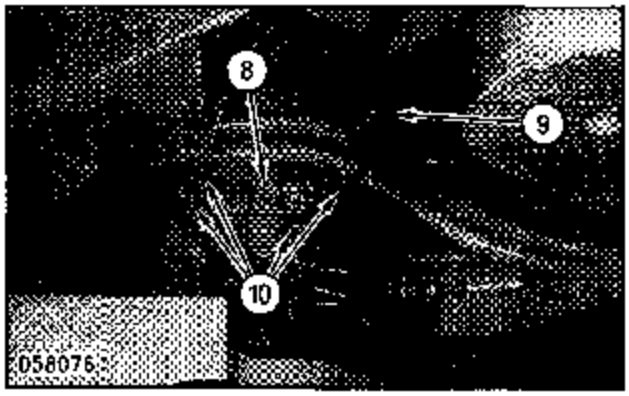
3. Turn heater hose valves (4) and (5) to the **OFF** position.



4. Disconnect two heater hoses (6).

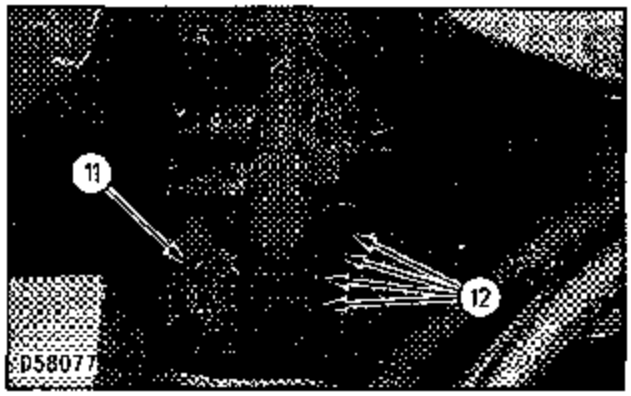
⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure. Steam can cause personal injury. Check the coolant level only after the engine has been stopped and the fill cap is cool enough to touch with your bare hand. Remove the fill cap slowly to relieve pressure. Cooling system conditioner contains alkali. Avoid contact with skin and eyes to prevent personal injury.

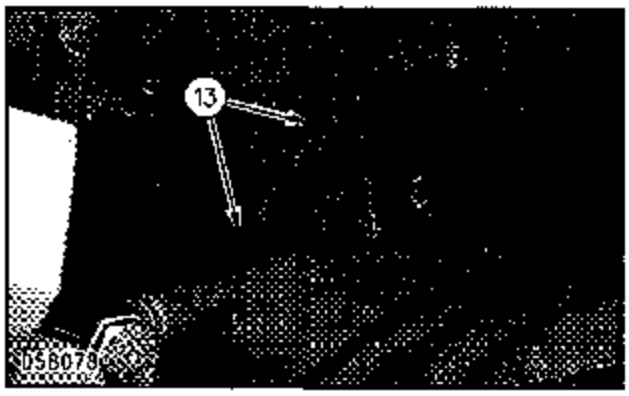


5. Identify and disconnect four hydraulic hoses (10) from brake valve (8). Disconnect electrical connection (9).

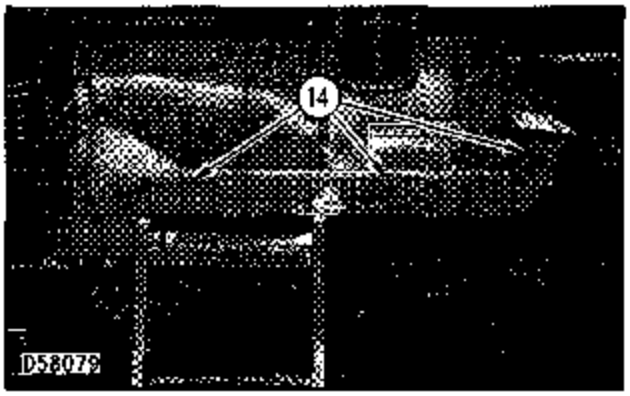
NOTE: Cap and plug all lines and fittings as they are removed to prevent excess fluid loss and to prevent dirt or debris from entering the system.



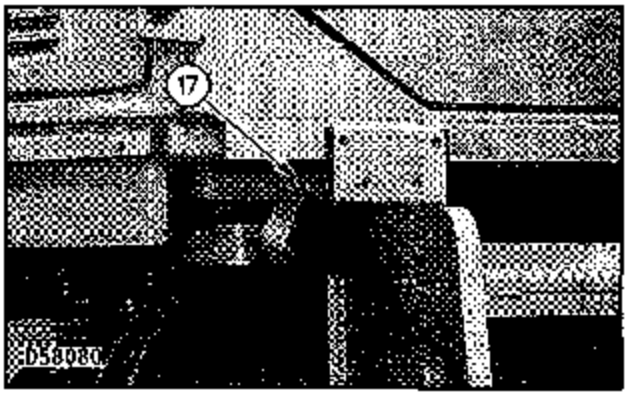
6. Identify and disconnect four hydraulic hoses (12) from steering valve (11).



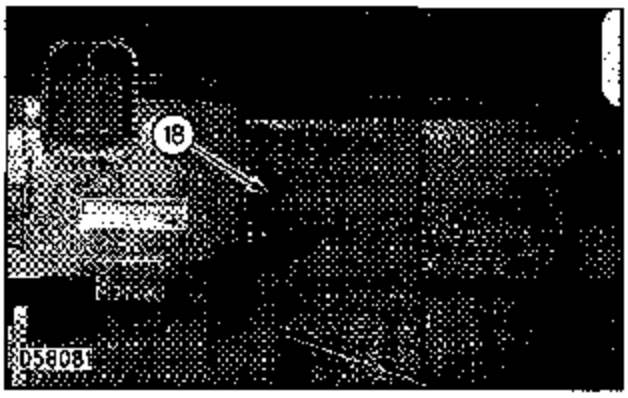
7. Cut plastic tie wraps (13) securing wiring harness to bottom of the cab.



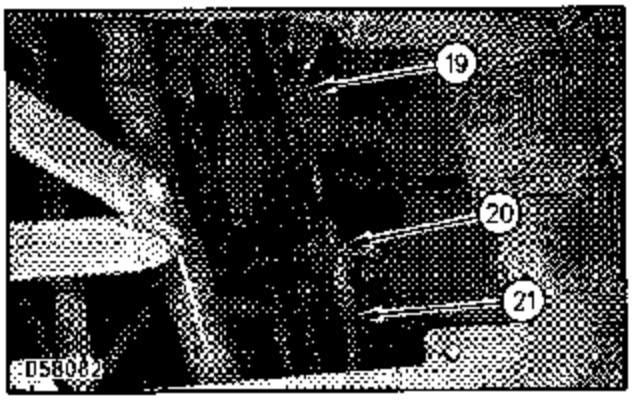
8. Remove guards (15) and (16) by removing ten bolts and washers (14).Disconnect electrical wires to horn which is mounted on the back of guard (15).



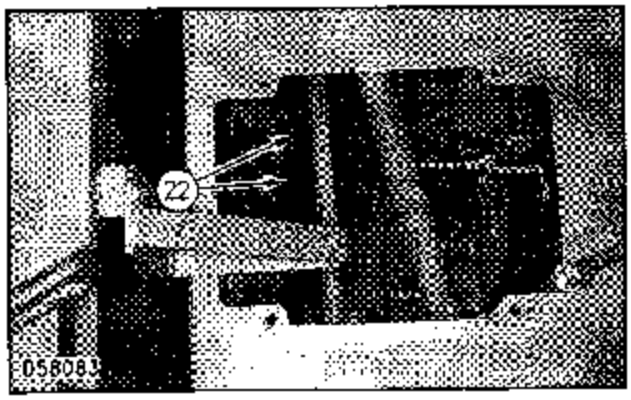
9. Disconnect ground strap (17).



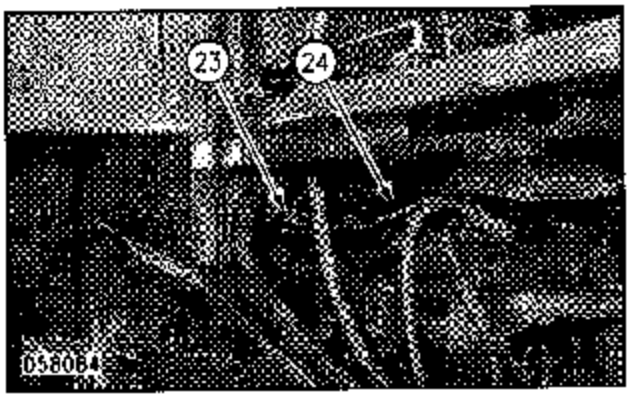
10. Remove cover (18) by removing four bolts and washers.



11. Disconnect parking brake cable (21) by removing pin and cotter pin (19), loosen cam nut (20) and remove from retaining bracket.

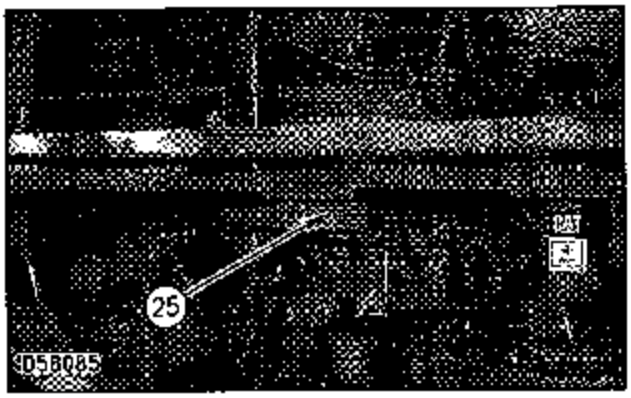


12. Disconnect two windshield washer hoses (22).

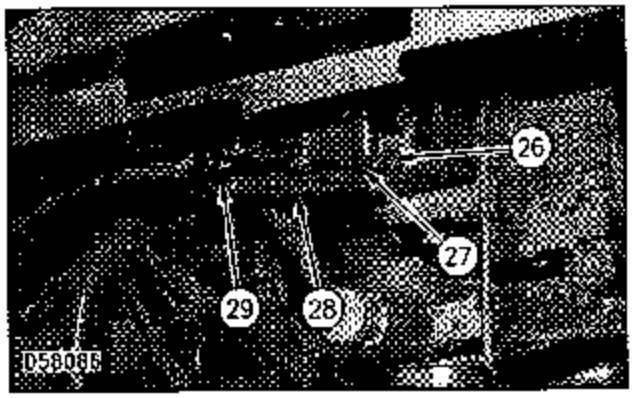


13. Disconnect two clips (23) which secures accelerator cable (24) to frame.

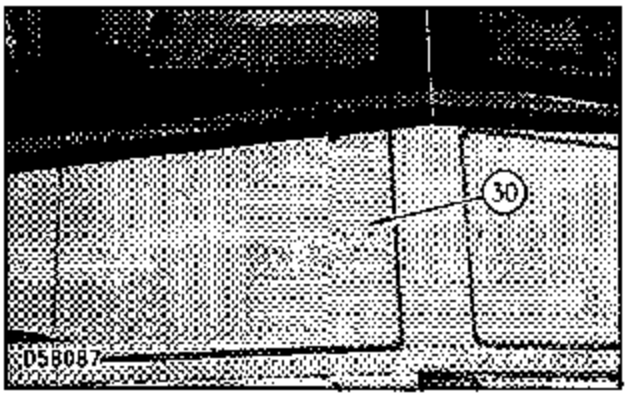
NOTE: There is a second clip located under cab directly under rear of door.

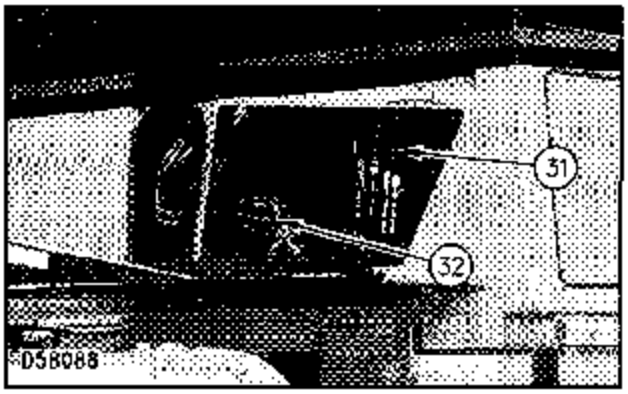


14. Remove six screws and cover (25) from fuel injection pump.

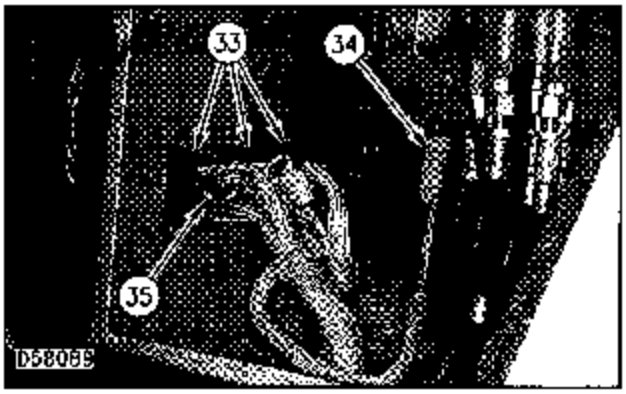


15. Remove bolt (26) and remove rod end (27) from accelerator cable (24). Remove nut and washer (29) and remove accelerator cable (24) from housing (28).

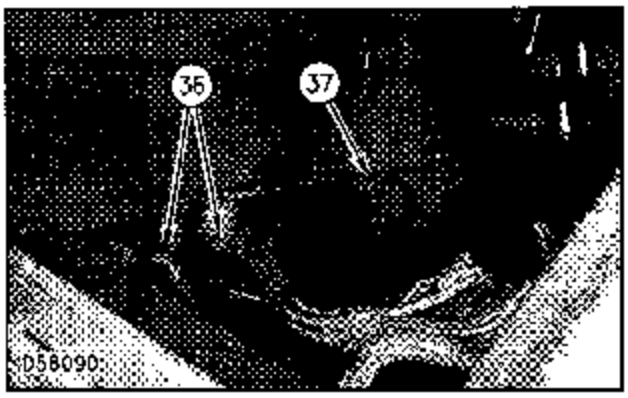




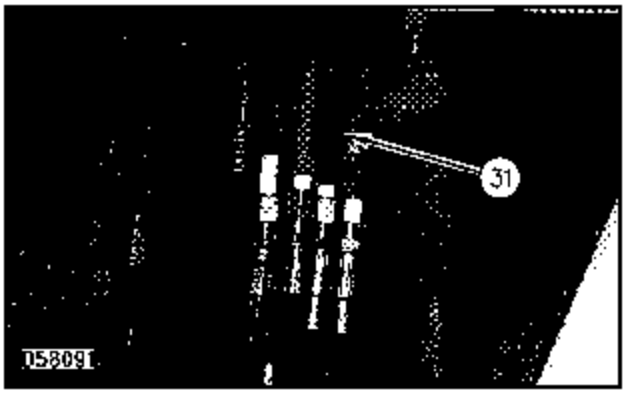
16. Open panel door (30) on the right side of the cab to access wiring harness (32) and dozer control valve (31).



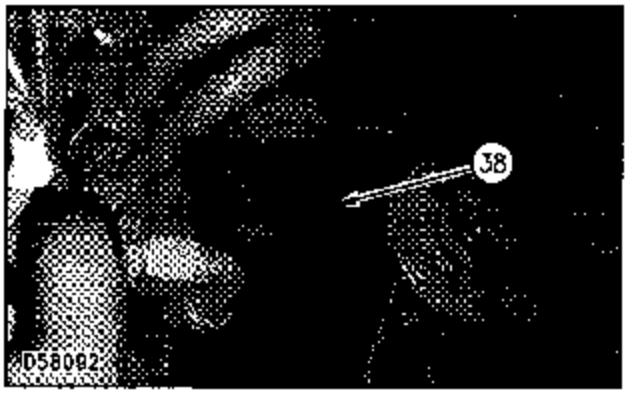
17. Disconnect three plug assemblies (33) by loosening screws (35). Disconnect electrical clip (34).



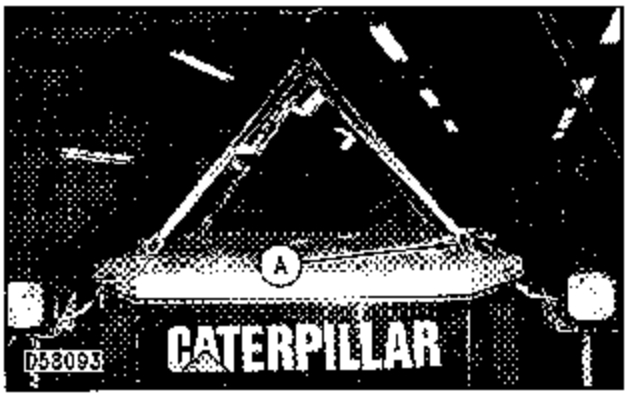
18. Disconnect three harness clips (36). (One clip is not shown. It is located under the cab.) Disconnect electrical connection (37).



19. Identify and disconnect six hydraulic hoses to dozer control valve (31).

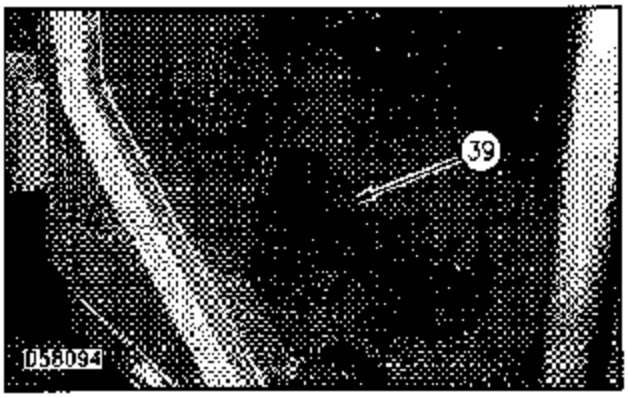


20. Disconnect electrical connection (38) located behind hydraulic tank (not shown).

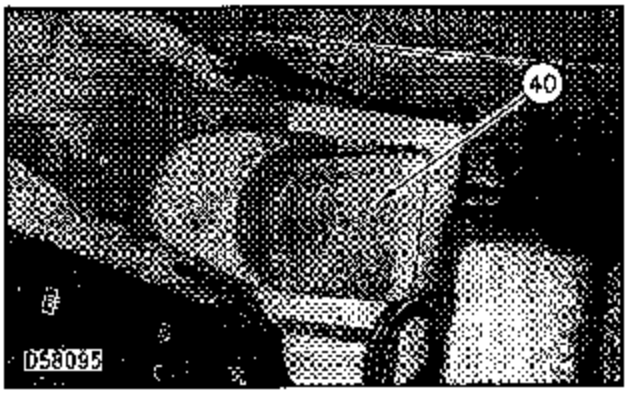


21. Install a hoist and tooling (A) to the cab.

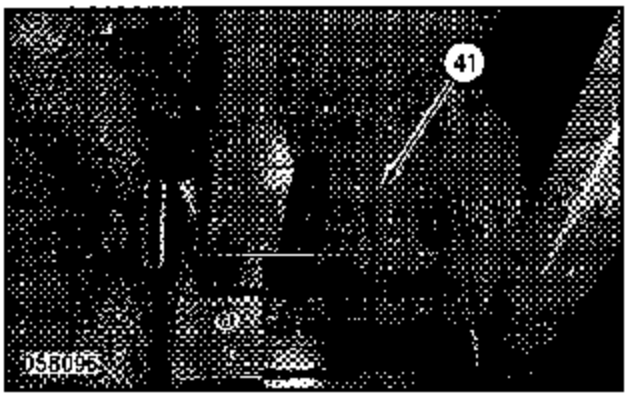
22. Remove the floor mats from the inside of the cab.



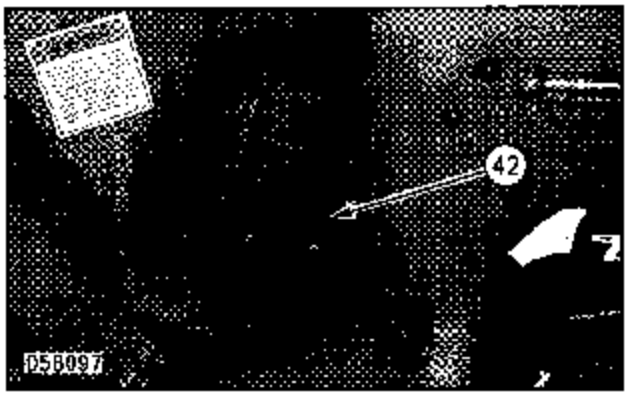
23. Remove two covers (39) from both sides of the front of the cab.



24. Remove cover (40) at right rear of seat.

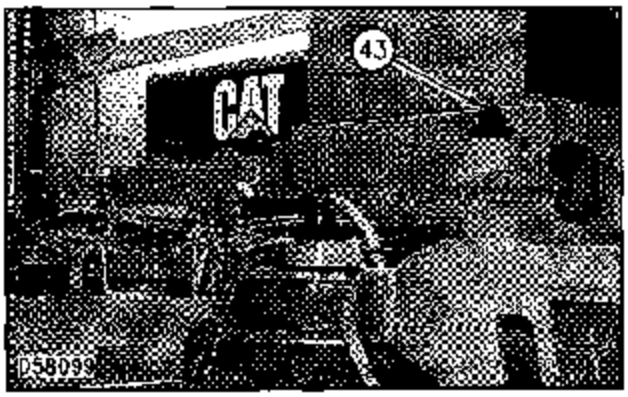


25. Remove compartment (41) by removing four screws to access cab bolt.



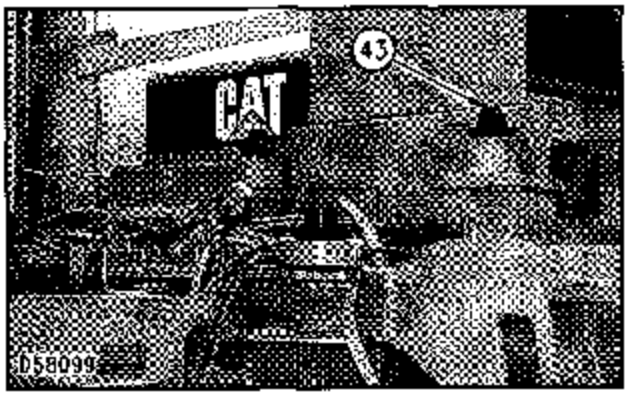
26. Remove bolt and two washers (42) from four corners of cab.

27. Using a hoist and tooling (A) remove cab from the frame. Weight of the cab is **1045 kg (2300 lb)**

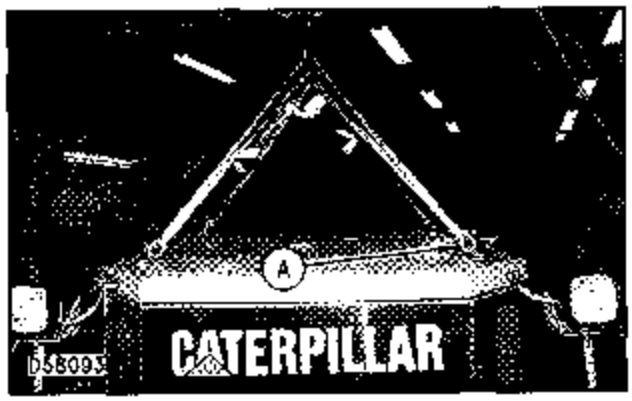


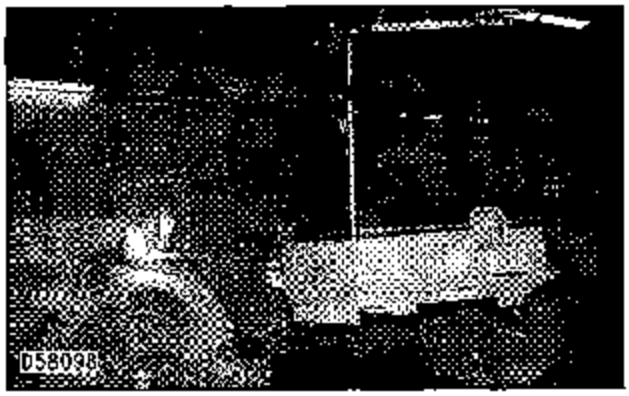
28. Remove four mount assemblies (43) from frame.

NOTE: Install the cab in the following order.

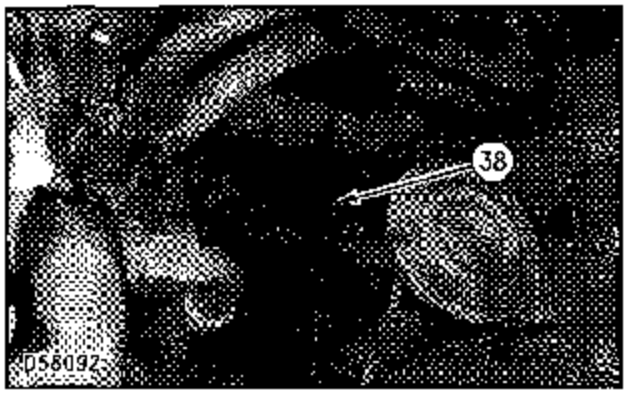


29. Install four mounting assemblies (43) onto the frame.

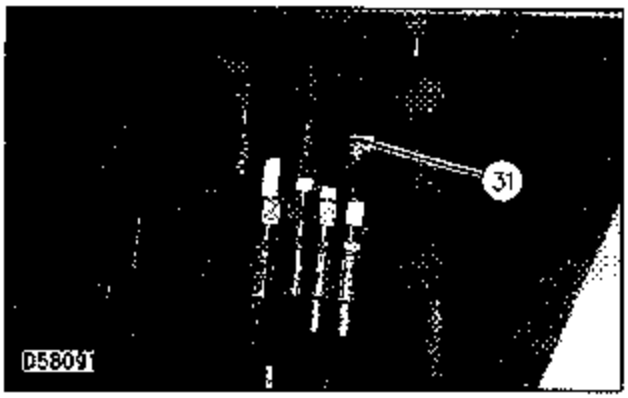




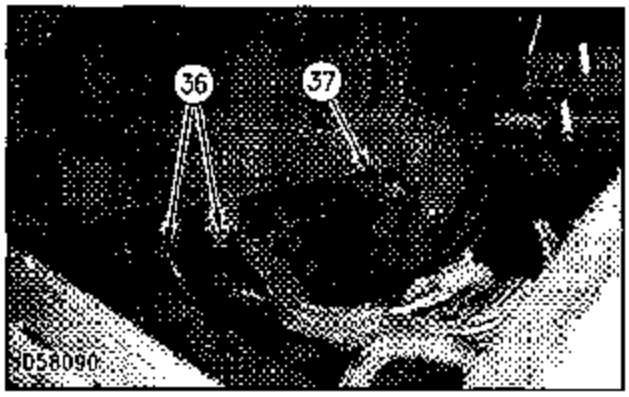
30. Using a hoist and tooling (A) install the cab in position above the mounting assemblies, but do not lower it onto the mounting assemblies at this time. Leave the cab suspended approximately six to eight inches above the mounting to allow easier connection of the electrical and hydraulic connections. Weight of the cab is **1045 kg (2300 lb)**.



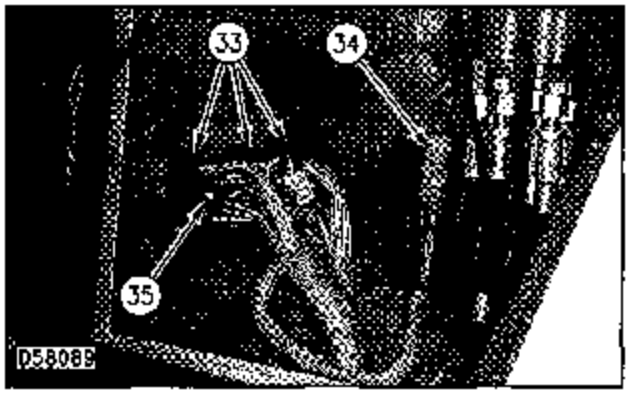
31. Connect electrical connection (38) located behind hydraulic tank (not shown).



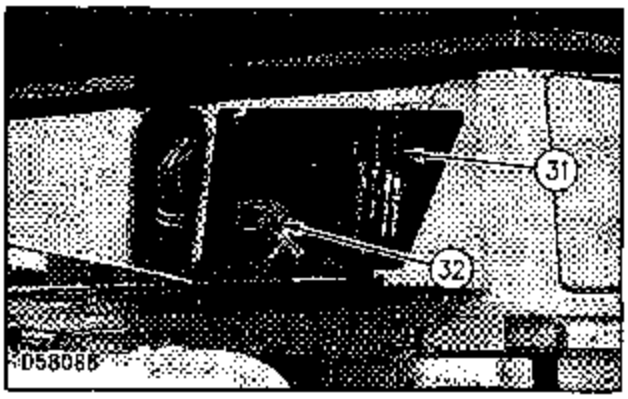
32. Connect six hydraulic hoses to dozer control valve (31). Note the identification marks placed on each of the connections during disassembly. Insure that each of the hydraulic lines is properly connected.

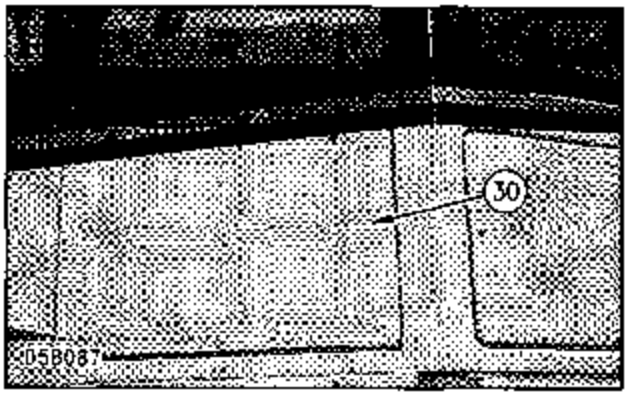


33. Connect electrical connection (37). Connect three harness clips (36). (One clip is not shown. It is located under the cab.

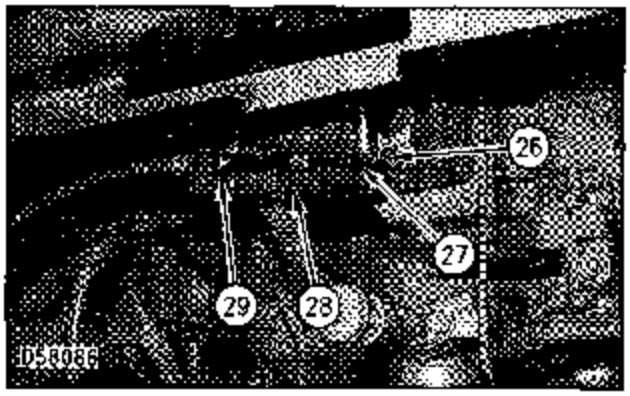


34. Connect three plug assemblies (33) and tighten screws (35). Connect electrical clip (34).

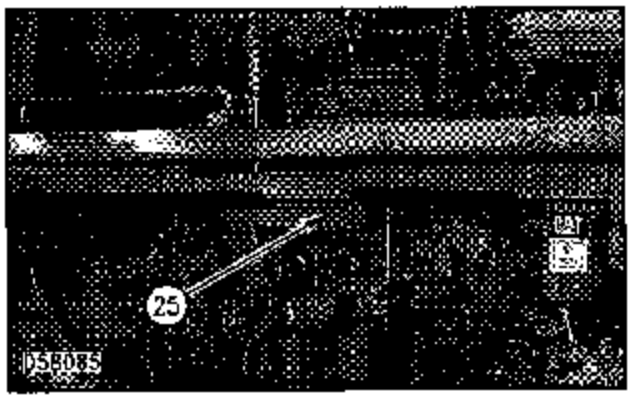




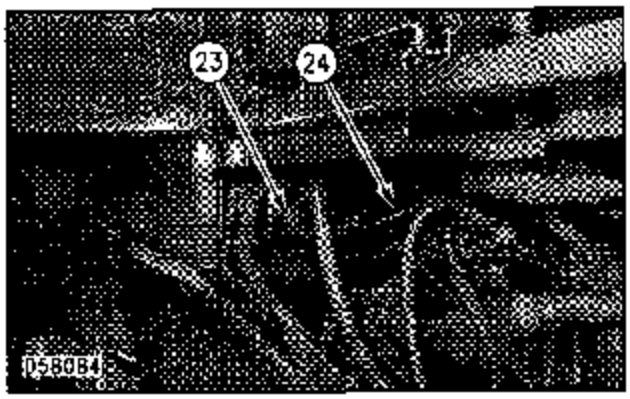
35. Connect wiring harness (32) and connect dozer control valve (31). Both of these can be accessed behind door panel (3) on the right side of the cab. Install door panel (30).



36. Install accelerator cable (24) into housing (28) using nut and washer (29). Install rod end of accelerator cable (27) and install bolt (26).

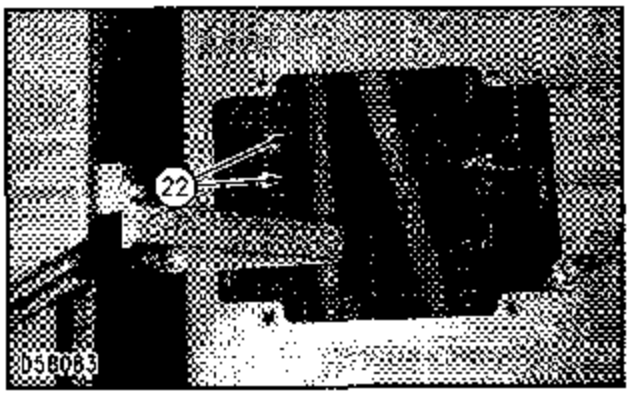


37. Install six screws and cover (25) onto the fuel injection pump.

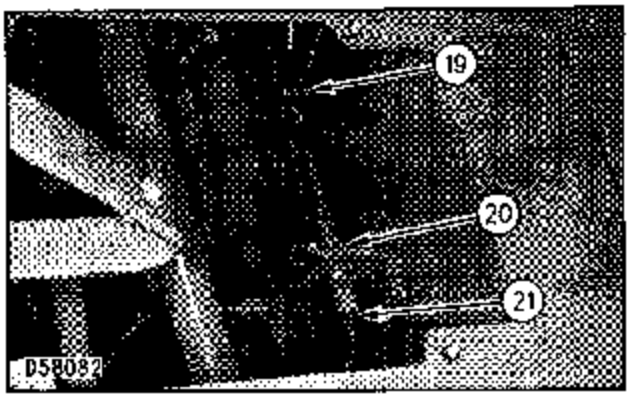


38. Connect two clips (23) which secure accelerator cable (24) to the frame.

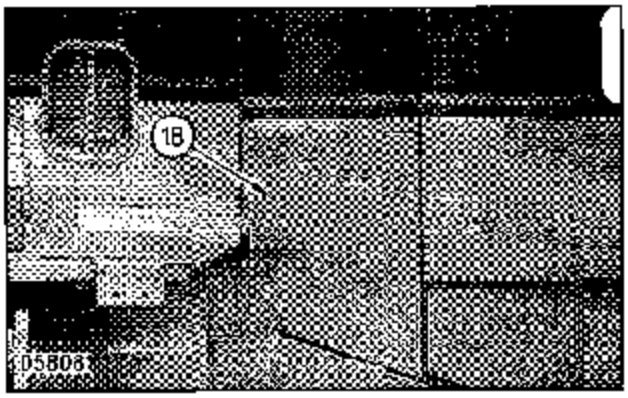
NOTE: The second clip is located under the cab directly under rear portion of the door.



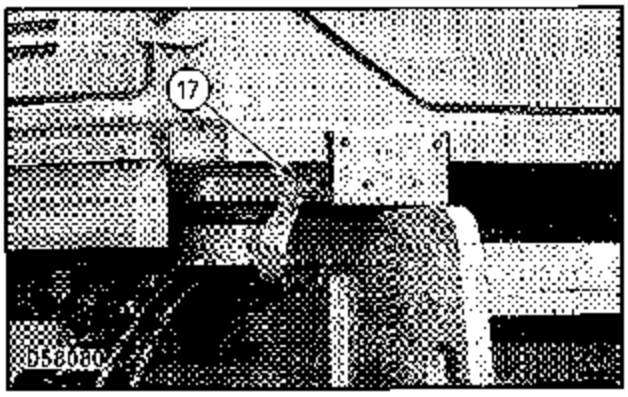
39. Connect two windshield washer hoses (22).



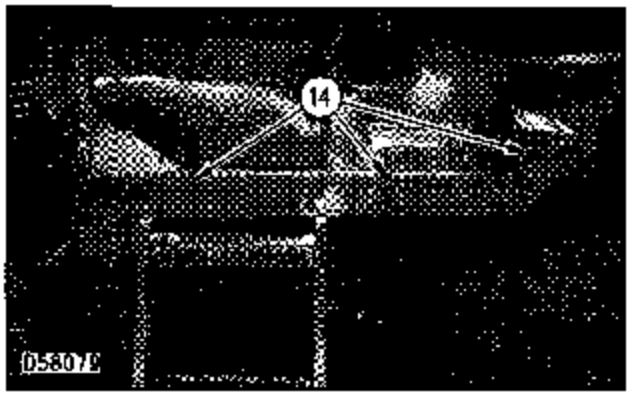
40. Install the parking by cable (21), by installing the cable through the bracket, installing cam nut (20 and installing nut and cotter pin (19).



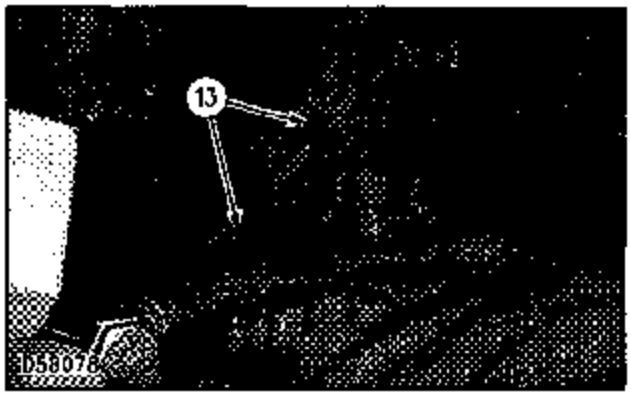
41. Install cover (18) and secure with bolts and washers.



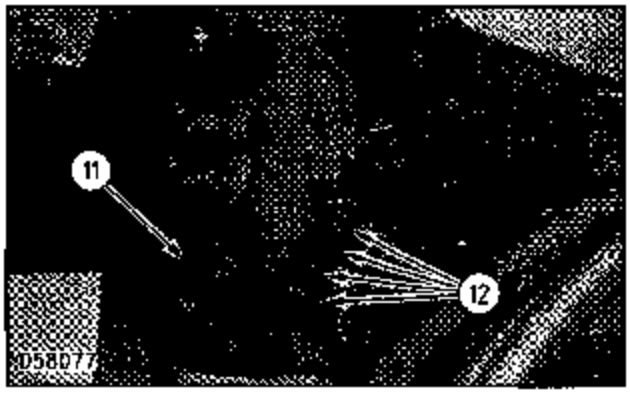
42. Install ground strap (17).



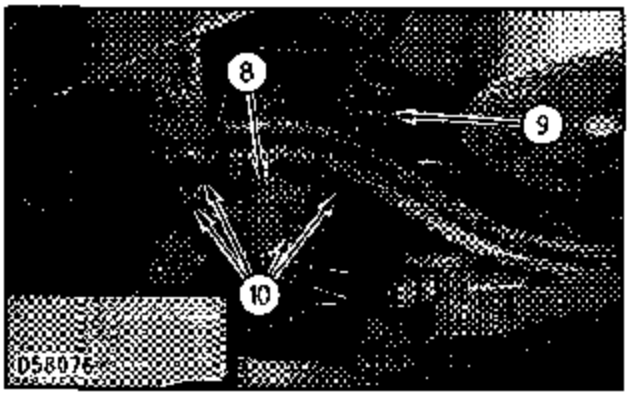
43. Install electrical wires to the horn, which is located on the back of guard (15). Install guards (15) and (16) using bolts and washers (14).



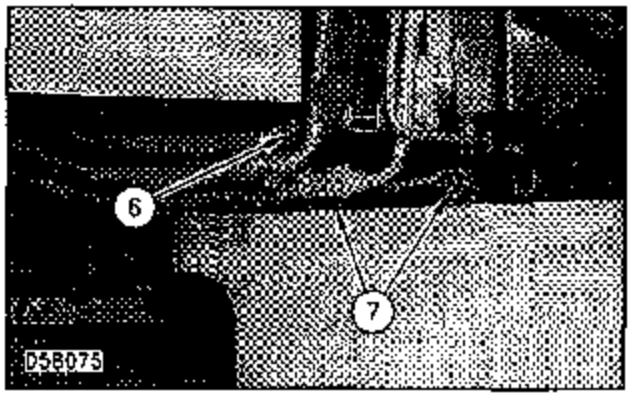
44. Secure wiring harness to the bottom of the cab using plastic plastic tie wraps (13).



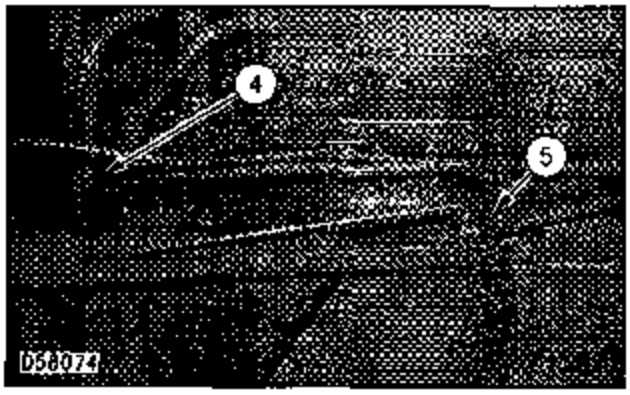
45. Connect four hydraulic hoses (12) from steering control valve (11) Note the identification marks placed on each of the connections during disassembly. Insure that each of the hydraulic lines is properly connected.



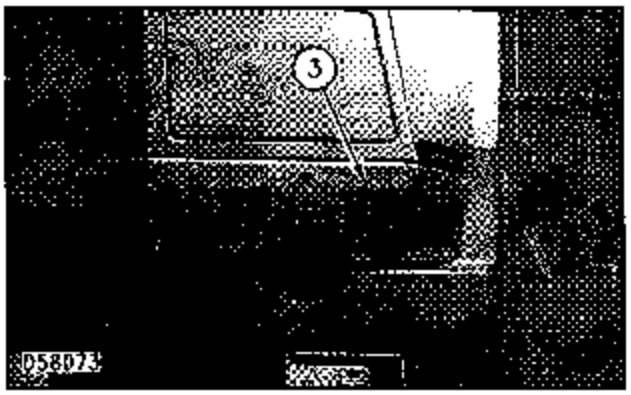
46. Connect electrical connection (9). Connect four hydraulic hoses (10) to brake valve. Note the identification marks placed on each of the connections during disassembly. Insure that each of the hydraulic lines is properly connected.



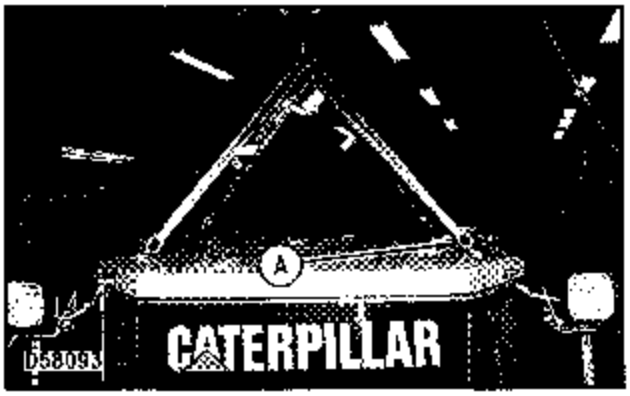
47. Connect two heater hoses (6).



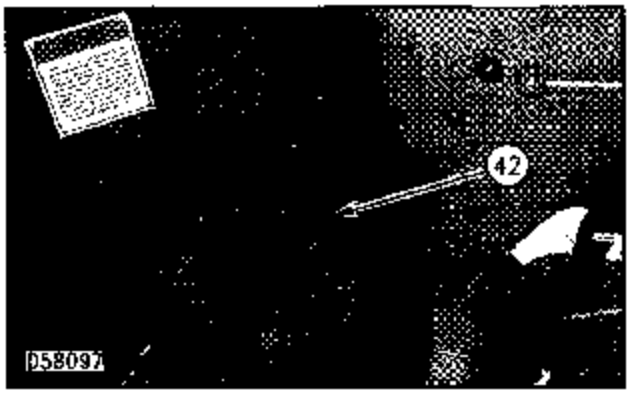
48. Turn heater hose valves (4) and (5) to the **ON** position.



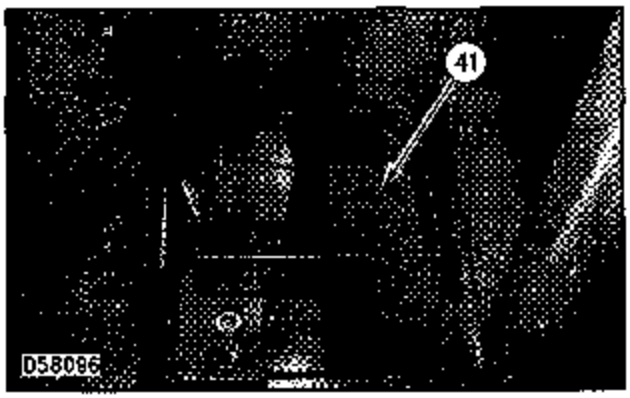
49. Install front shroud (3) and install eleven bolts that hold the front shroud.



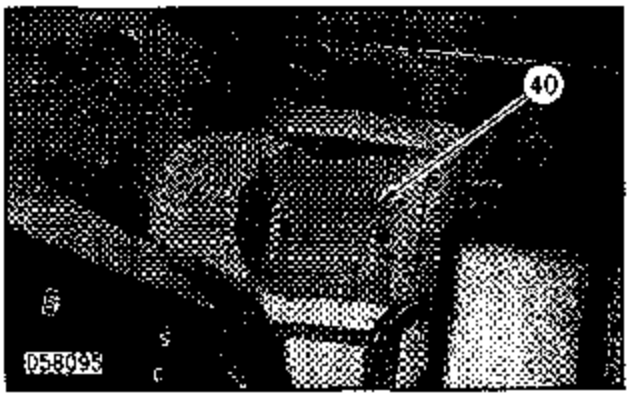
50. Slowly lower the cab assembly down using tooling (A) onto the assembly bushings.



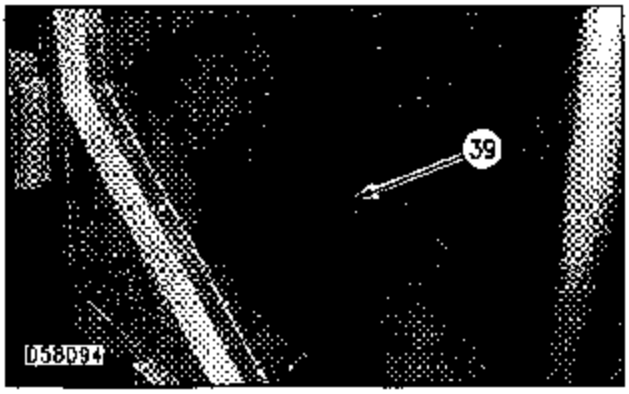
51. Install four bolts (42) securing the cab to the frame. Tighten cab bolts to a torque of **850 ± 100 N•m (626 ± 74 lb ft)**.



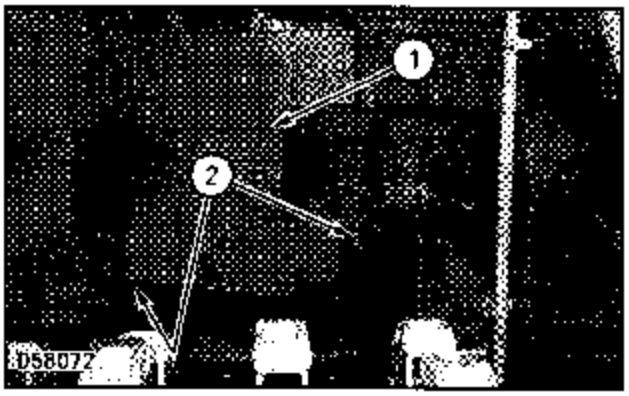
52. Install compartment (41) and secure by installing four bolts.



53. Install cover (40) at right rear of seat and secure with one bolt.



54. Install two covers (39) on both sides of the front of the cab. Secure with one bolt in each cover.



55. Install platform assembly (1) and secure using two bolts (2).

56. Check all hoses and electrical connections prior to starting the engine. Check both the cooling system and the hydraulic system for proper fluid level. Replace any fluid lost during cab removal. Consult the Operation And Maintenance Manual for proper type and quantity of fluids.

57. Start engine and check all electrical connections and all hydraulic connections for leaks.

Radiator & Hydraulic Oil Cooler

Remove & Install Radiator & Hydraulic Oil Cooler 1353 & 1374-010

Tools Needed		A
6V2156	Link Bracket	2

Start By:

a. remove hood

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

⚠ WARNING

At operating temperature, the engine coolant is hot and under pressure. Steam can cause personal injury. Check the coolant level only after the engine has been stopped and the fill cap is cool enough to touch with your bare hand. Remove the fill cap slowly to relieve pressure. Cooling system conditioner contains alkali. Avoid contact with skin and eyes to prevent personal injury.

1. Release the pressure in the cooling system by slowly loosening the filler cap on the radiator. Drain the coolant from the radiator into a suitable container for storage or disposal. The capacity of the cooling system is **43 liters (11.2 U.S. gal).**

⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all hydraulic pressure is released before any fitting, hose or component loosened, tightened, removed or adjusted.

2. Release the pressure in the hydraulic system as follows:

   a. Install the steering frame lock link.

   b. Move the lift control lever to the "Float" position.

   c. Shut off the engine.

   d. Move the lift control lever to the "Hold" position.

   e. Carefully loosen the filler cap on the hydraulic oil tank to release the pressure in the system.

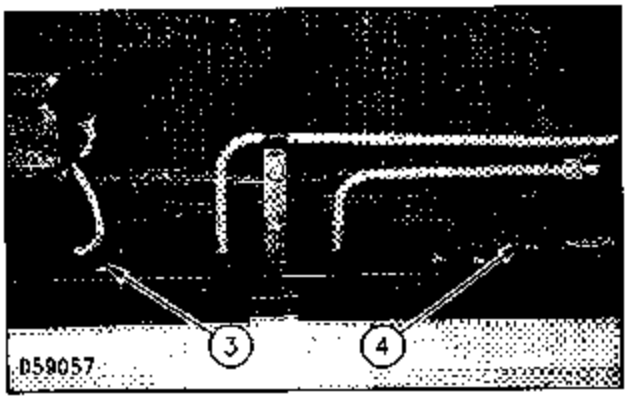
   f. With the blade on the ground, place a suitable container in under the cylinder to contain the hydraulic oil. Carefully loosen the lines on the lift cylinder. When the oil from the loosened lines stops running, tighten the lines.

   g. Tighten the filler cap on the hydraulic oil tank. The system pressure has now been released.

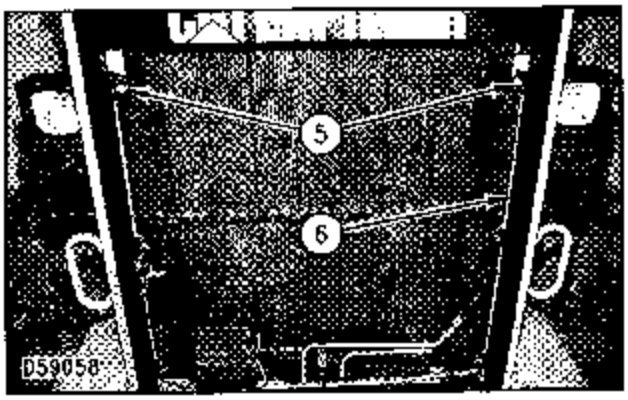
3. Drain the oil from the hydraulic system into a suitable container for storage or disposal. The capacity of the hydraulic system is **87 liters (22.6 U.S. gal).**

4. Fasten a lifting strap and a hoist to grill (2) as shown.

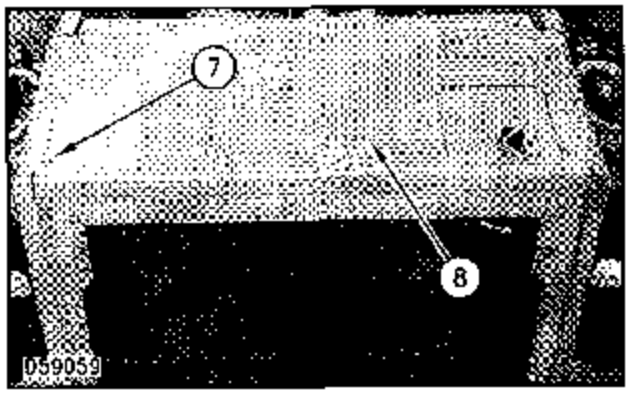
5. Remove bolt (1) and the washer. Open the grill. **Do not** remove the hoist from the grill at this time.



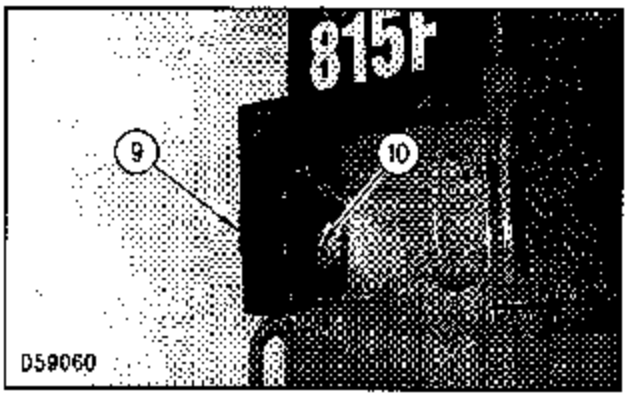
6. Disengage rod assembly (4) through hole (3) in the lower channel for the radiator guard. Remove the grill (2) from the machine. The weight of the grill is **34 kg (75 lb).**



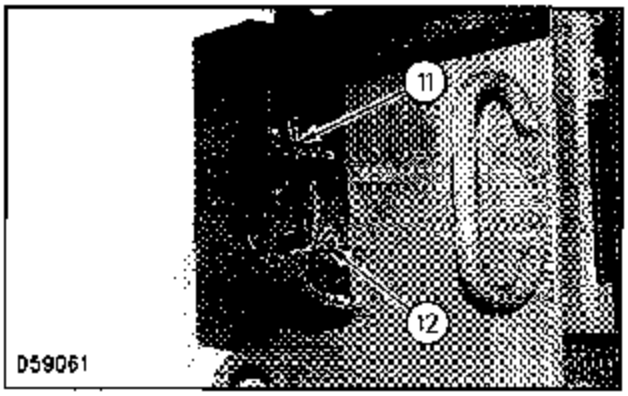
7. Remove six bolts (5) and the washers that hold frame (6) in position. Remove the frame.



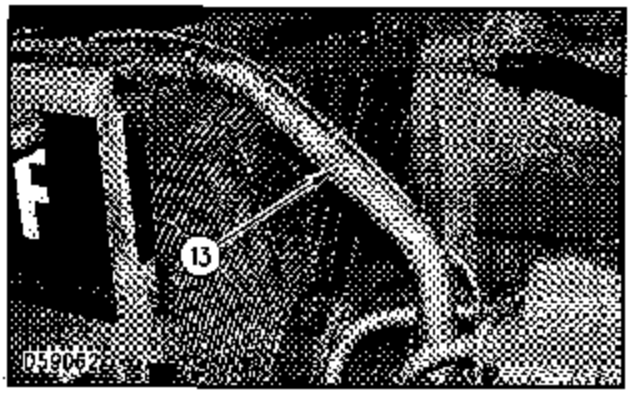
8. Remove eight bolts (7) and the washers that hold cover assembly (8) in position. Using two persons, remove the cover assembly. The weight of the cover assembly is **23 kg (50 lb).**



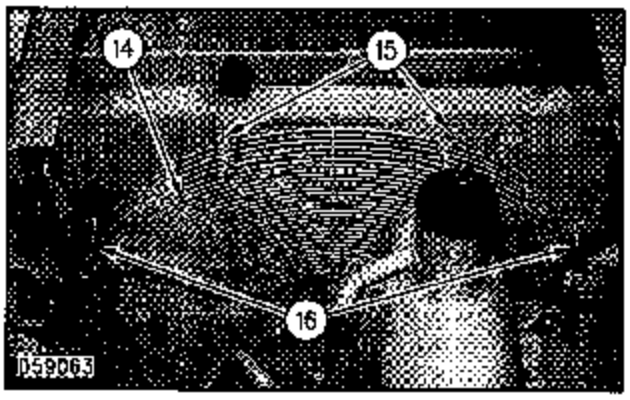
9. Remove cover (10) from each tail light (9).



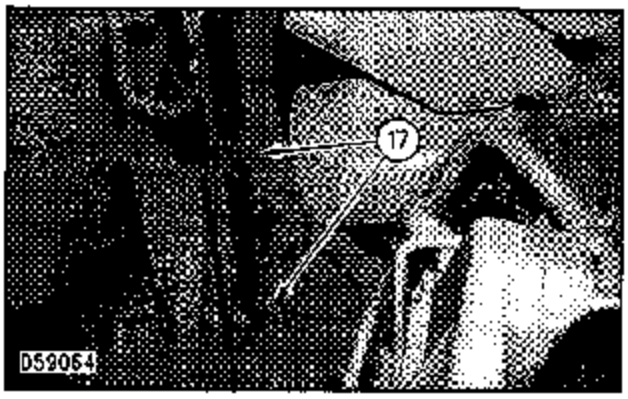
10. Disconnect wires (11) and wiring harness (12) from each tail light.



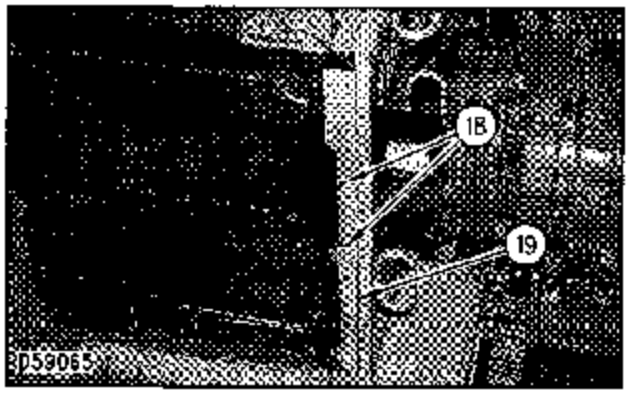
11. Loosen the clamps, and remove tube assembly (13) from the radiator top tank assembly.



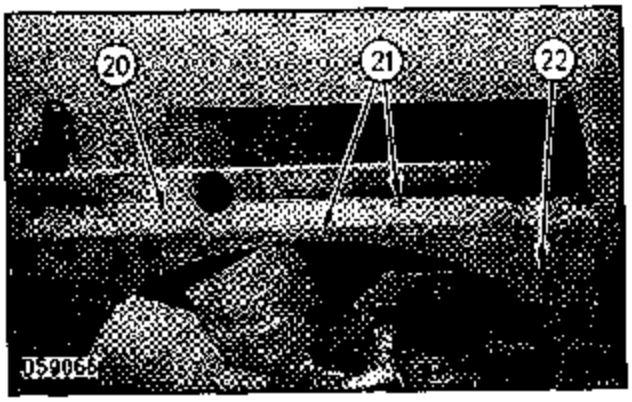
12. Remove bolts (15) and the washers that hold upper and lower fan guards (14) in position. Remove the fan guards.



13. Remove four bolts (17) and the washers (two on each side of the radiator guard) that hold the right and left panel assemblies of the radiator guard to the fan shroud.

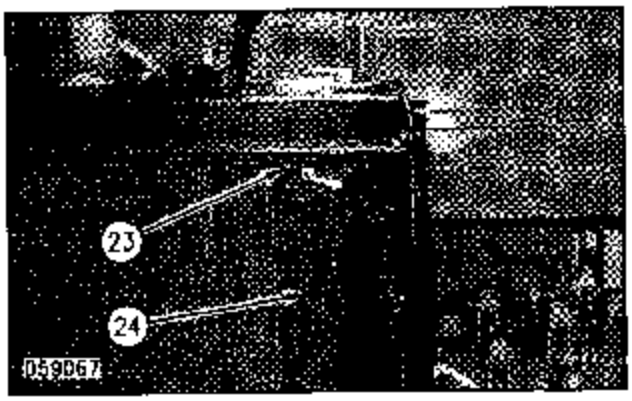


14. Fasten a hoist to right hand panel assembly (19). Remove eight bolts (18) that hold the panel assembly in position. Remove the right hand panel assembly. Remove the left hand panel assembly the same way. The weight of each panel assembly is **50 kg (110 lb).**

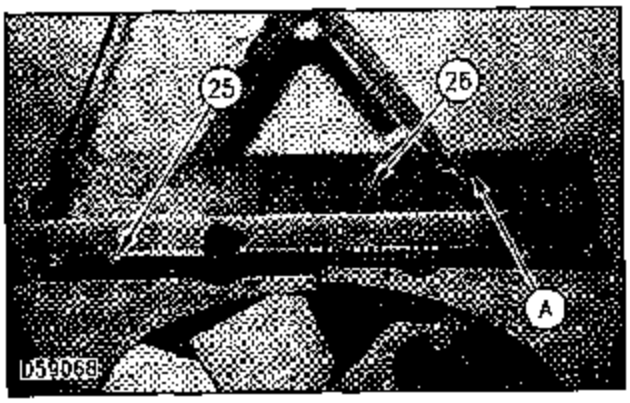


15. Remove twelve bolts (21) and the washers from fan shroud (22) and plate (20). Remove plate (20).

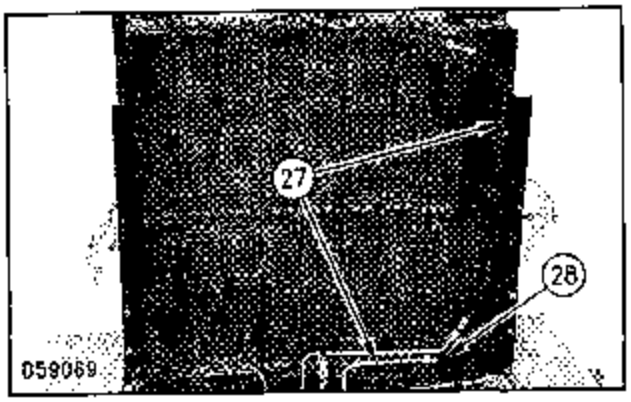
NOTE: One bolt (21) has to be removed from the bottom side of plate (20) behind the fan assembly.



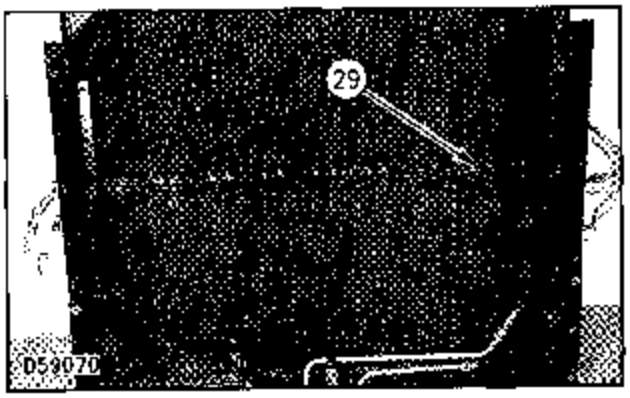
16. Remove four bolts (23) and the washers that hold the hydraulic oil cooler core (24) to the radiator top tank assembly. Two of the bolts are on the back side of the radiator top tank assembly.



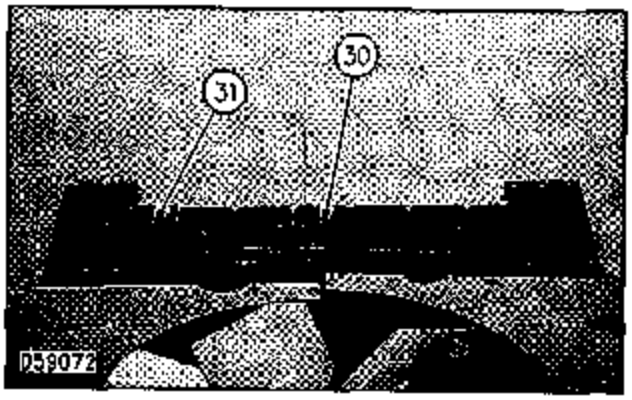
17. Remove ten bolts (25) and the washers that hold the radiator top tank assembly in place. Attach tooling (A), and a suitable lifting device to the radiator top tank assembly (26). Remove top tank assembly (26). Weight of the radiator top tank assembly is **32 kg (70 lb)**.



18. If the hydraulic oil coolers core is to be removed, remove two lines (27). Remove four bolts (28) and the washers that hold the cooler cores to the lower radiator tank assembly. Two of the bolts are located on the back side of the lower radiator tank assembly.

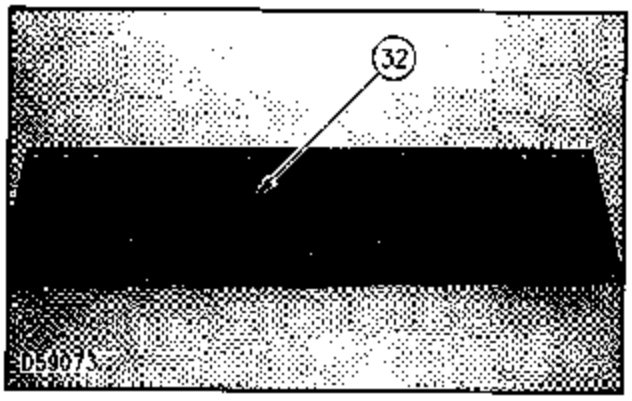


19. Remove appropriate bolts (29), the washers and nuts that hold the core together in the center.



20. Remove radiator cores (30) or hydraulic oil cooler cores (31) from the lower radiator tank assembly. The weight of a radiator core is **13 kg (29 lb).** The weight of a hydraulic oil cooler core is **21 kg (46 lb).**

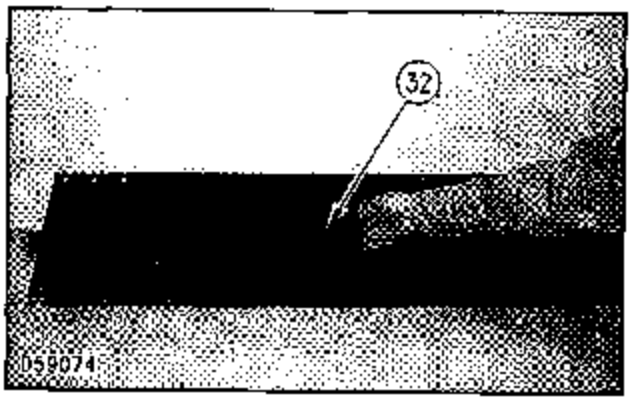
21. Remove the twelve bolts and washers that hold the lower radiator tank assembly to the frame of the machine. Fasten a hoist to the lower radiator tank assembly, and remove it from the machine. The weight of the lower radiator tank assembly is **24 kg (53 lb).**



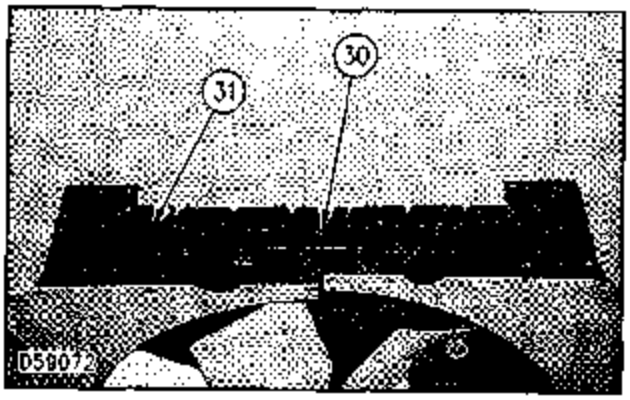
22. Remove end seals (32) from the radiator top tank assembly and the lower radiator tank assembly.

NOTE: The following steps are for the installation of the radiator and hydraulic oil cooler.

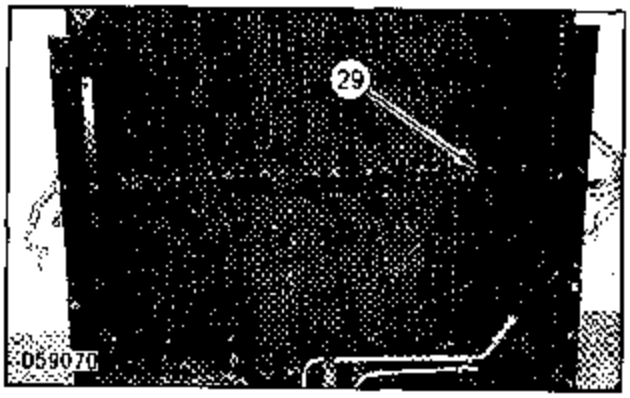
23. Fasten a hoist to the lower radiator tank assembly, and put it in its original position on the frame of the machine. Install the twelve bolts and washers that hold it.



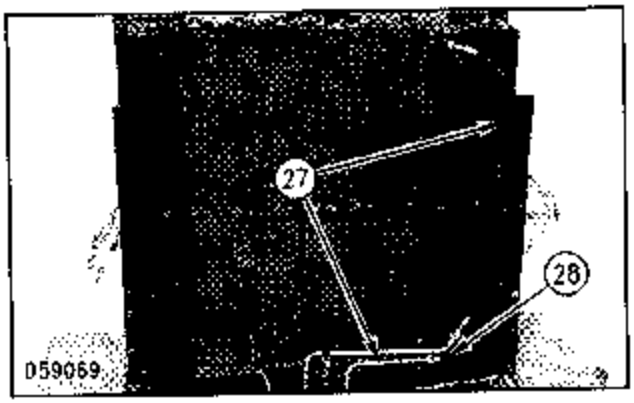
24. Check the condition of end seals (32) which are used in the radiator top tank assembly and the lower radiator tank assembly. If the seals are worn or damaged, use new parts for replacement. Install end seals (32) in the radiator top tank assembly and the lower radiator tank assembly as shown.



25. Put a coat of **5P3975 Rubber Lubricant** on the center mounting tube of radiator cores (30) or hydraulic oil cooler cores (31). Install the cores in the lower radiator tank assembly.

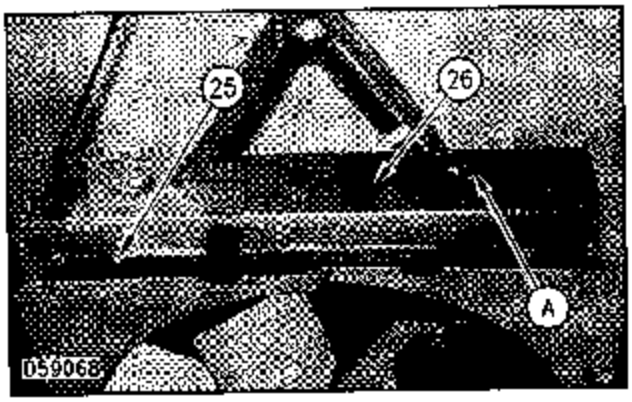


26. Install bolts (29) and the washers that hold the cores together in the center as shown.



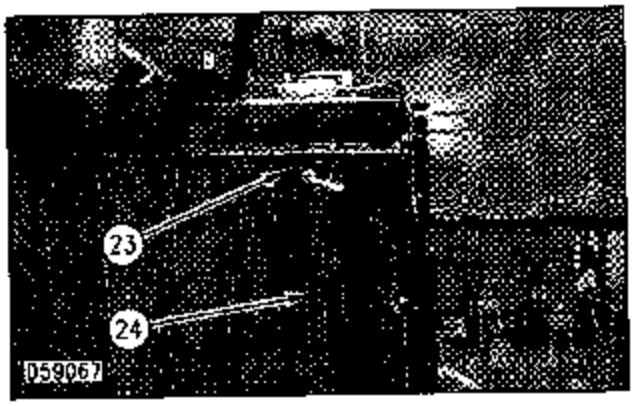
27. If the hydraulic oil cooler was removed, reinstall four bolts (28) and the washers that hold the cores to the lower radiator tank assembly.

28. Install two lines (27) to the hydraulic oil cooler.



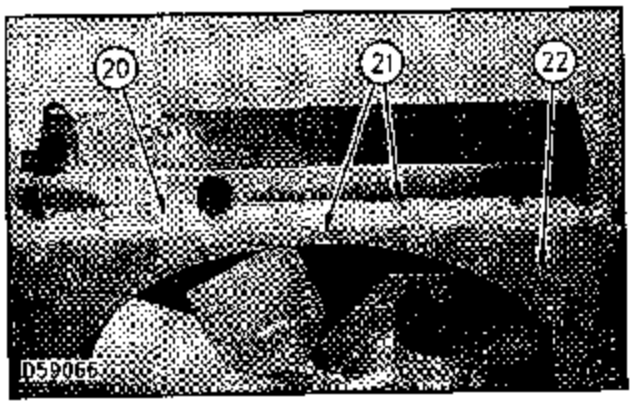
29. Fasten tool (A) and a hoist to radiator top tank assembly (26). Put a coat of **5P3975 Rubber Lubricant** in the center mounting tube of each core. Put the radiator top tank assembly in position on the radiator cores and the hydraulic oil cooler cores.

30. Reinstall ten bolts (25) and the washers that hold the radiator top tank assembly in place.

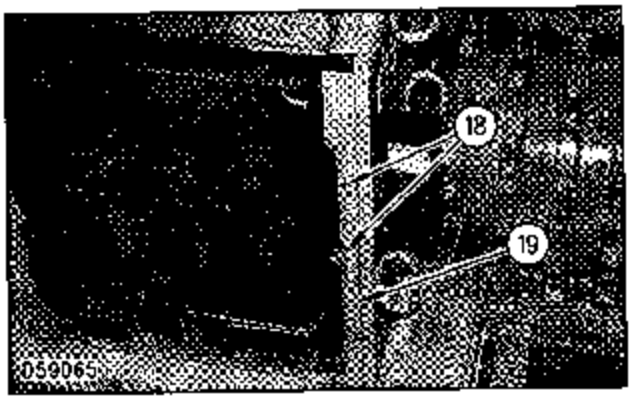


31. Install four bolts (23) and the washers that hold the hydraulic oil cooler core (24) to the radiator top tank assembly.

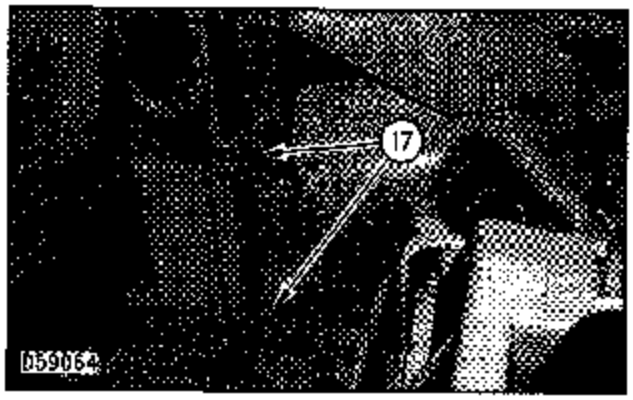
32. Install two hoses (24) and the clamps which hold them.



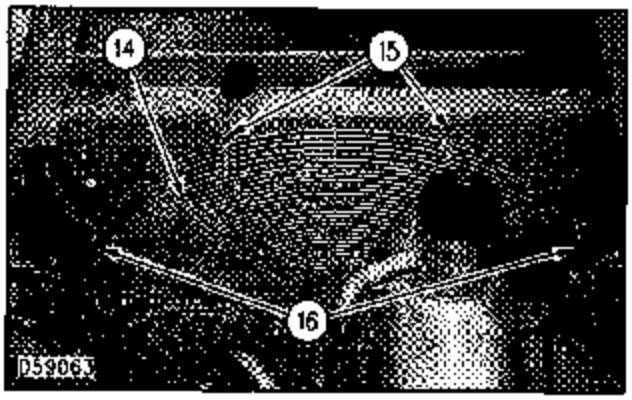
33. Install twelve bolts (21) that hold the fan shroud (22) and plate (20) in position at the top.



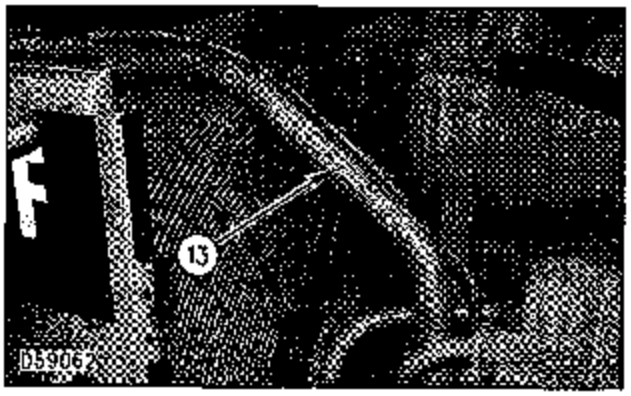
34. Fasten a hoist to left hand panel assembly (19). Put the panel assembly in place, and install eight bolts (18) which hold it. Install the left hand panel assembly the same way.



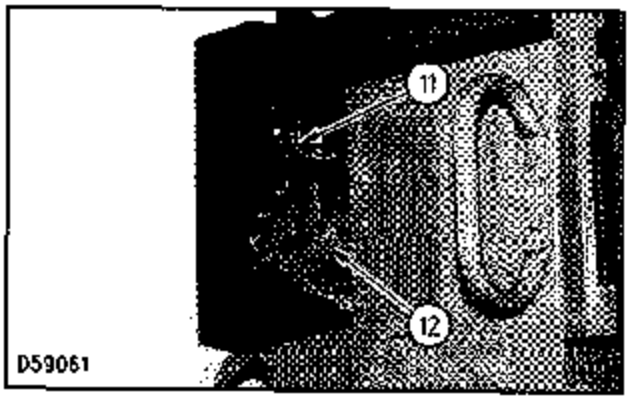
35. Install four bolts (17) and the washers (two on each side of the radiator guard) that hold the right and left hand panel assemblies of the radiator guard to the fan shroud.

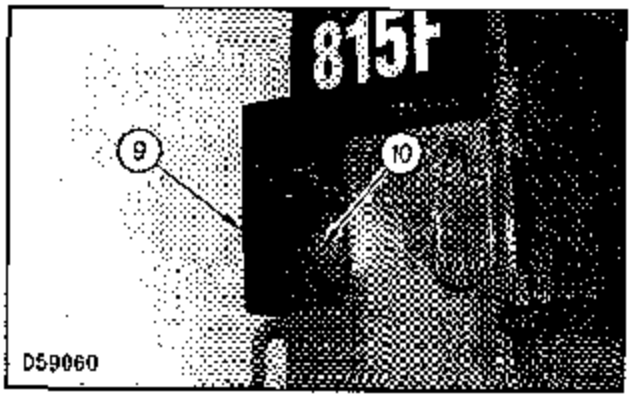


36. Install upper and lower fan guards (14) and twelve bolts (15) and washers that hold them in place.

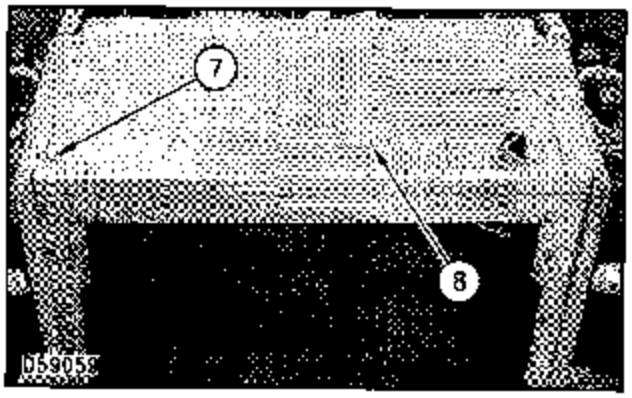


37. Connect tube assembly (13) to the radiator top tank assembly and tighten the clamps that hold it in place.

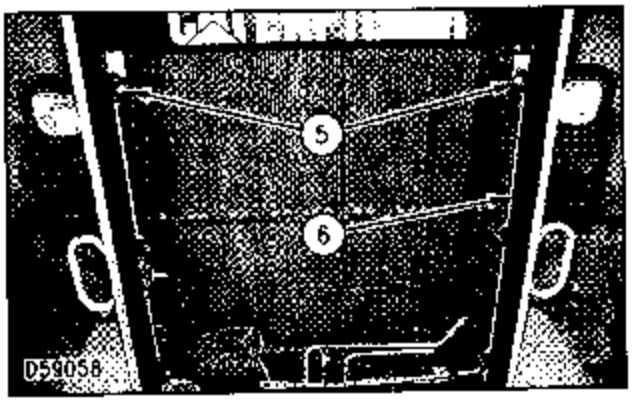




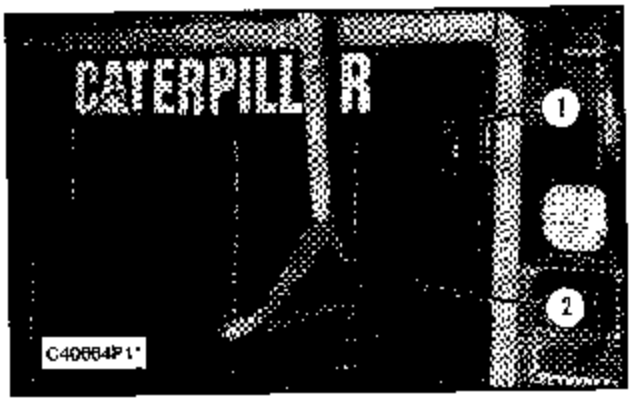
38. Connect wiring harness (12) and install wires (11) in each light assembly. Reinstall cover (10) on each tall light.

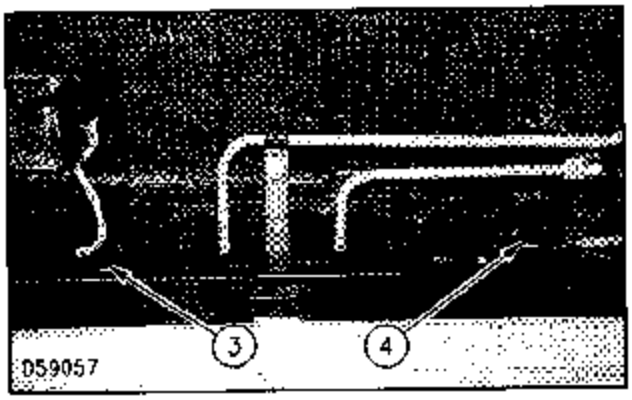


39. Using two persons, reinstall cover assembly (8) on the radiator guard. Install eight bolts (7) and the washers which hold it.



40. Reinstall frame (6) and six bolts (5) and the washers which hold it.





41. Fasten a hoist to grill (2), and put it on the radiator guard. Install rod assembly (4) in hole (3) located in the lower channel of the radiator guard. Install the bolts and washers that hold the grill in place.

42. Fill the cooling system with coolant and the hydraulic system with oil to the correct levels. See the Operation & Maintenance Manual for the correct filling procedures.

43. Start the machine, and check for leaks.

End By:

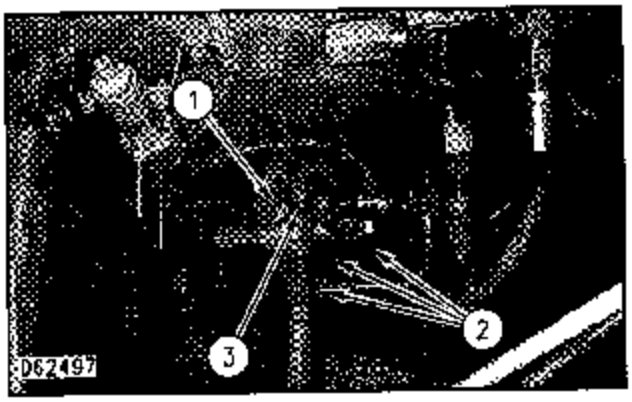
a. install hood

Accumulator Charge Valve

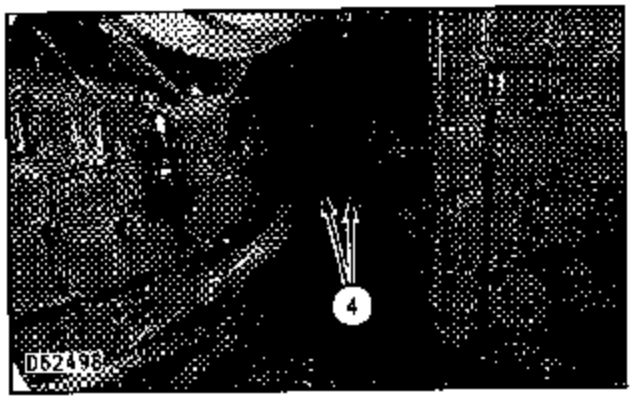
Remove & Install Accumulator Charge valve 4264-010

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



1. Disconnect five lines (2) and one hose (3) from the accumulator charge valve.



2. Remove two bolts and washers (4) that hold accumulator charge valve to firewall. Remove accumulator charge valve.

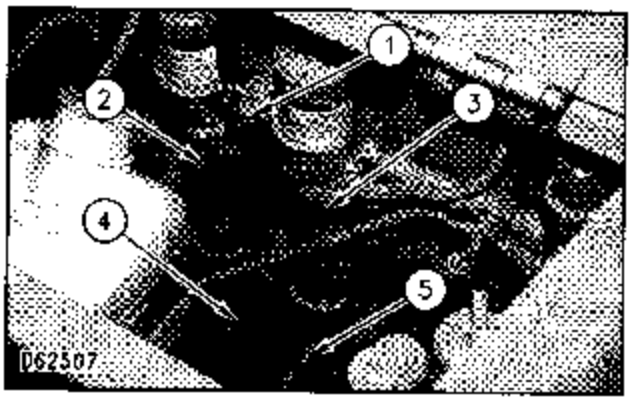
NOTE: Install the accumulator charge valve in the exact reverse order from removal.

Brake Accumulators

Remove & Install Brake Accumulators 4263-010

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



⚠ WARNING

Be sure the engine has been shutoff for a minimum of five minutes to be sure that the accumulator oil pressure is zero. The accumulator is filled with dry nitrogen. Do not loosen or remove the valve or cap from the top of the accumulator. Loosen the hard metal line at the bottom of the accumulator to release any pressure that is left in the system. Failure to follow the procedures can result in personal injury.

1. Disconnect line (4) from the bottom of accumulator (2). Disconnect two lines (5) from the bottom of accumulator (3). Remove two bolts and washers (1) and two brackets that hold accumulator to the firewall.

3. Remove brake accumulators.

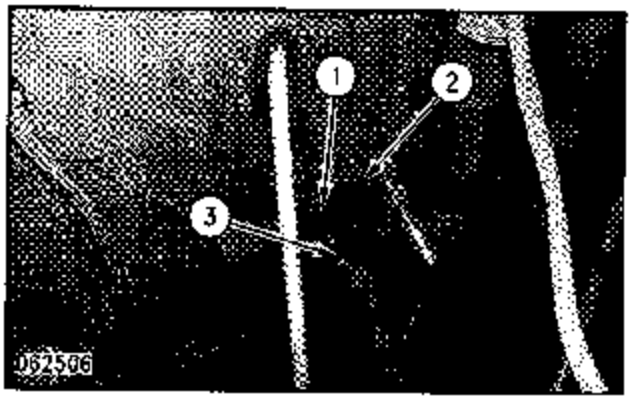
NOTE: Install accumulators in the exact reverse order from removal.

Pressure Reducing Valve

Remove & Install Pressure Reducing Valve 5467-010

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



Disconnect four oil lines and hoses (3) from pressure reducing valve (1). Remove two bolts (2) and washer that hold pressure reducing valve (1) to the firewall. Remove pressure reducing valve (1).

NOTE: Install pressure reducing valve in reverse order from removal.

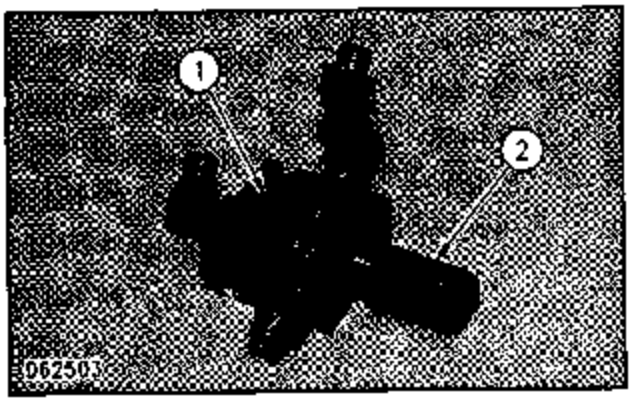
Disassemble & Assemble Pressure Reducing valve 4263-017

Start By:

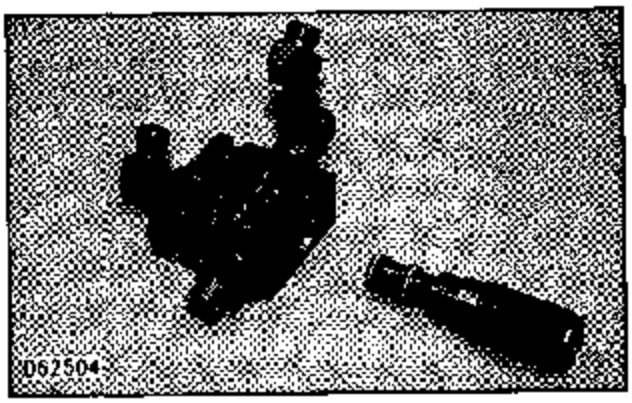
a. remove pressure reducing valve

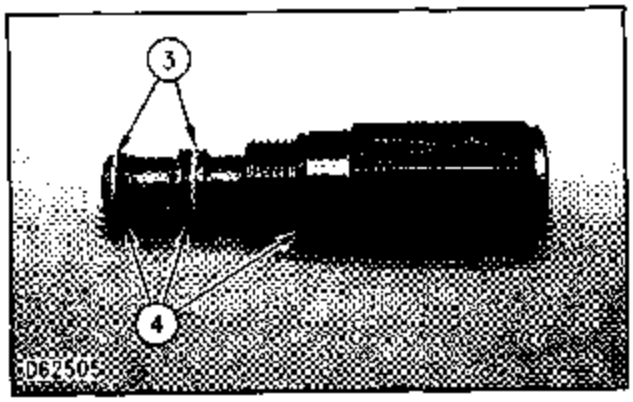
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



1. Remove reducing valve (2) from valve housing





2. Remove two backing rings (3) (white) and three O-rings (4) (brown). Replace any damaged backing rings or O-rings.

NOTE: Assemble the pressure reducing valve in the reverse order.

End By:

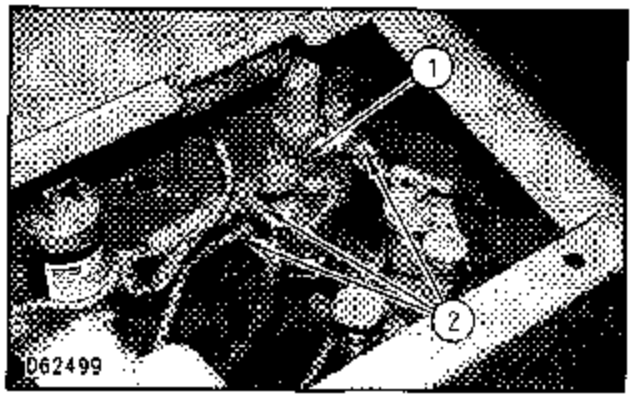
1. install pressure reducing va ve

Parking Brake Valve

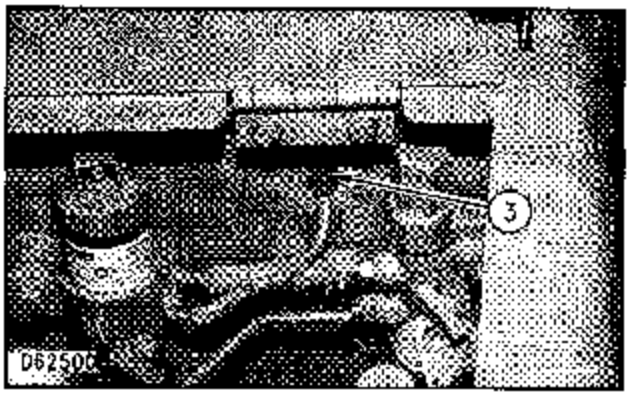
Remove & Install Parking Brake Valve 4282-010

FLUID SPILLAGE CONTAINMENT

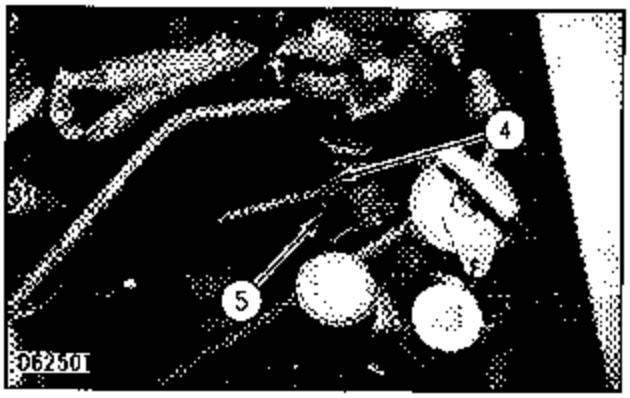
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.



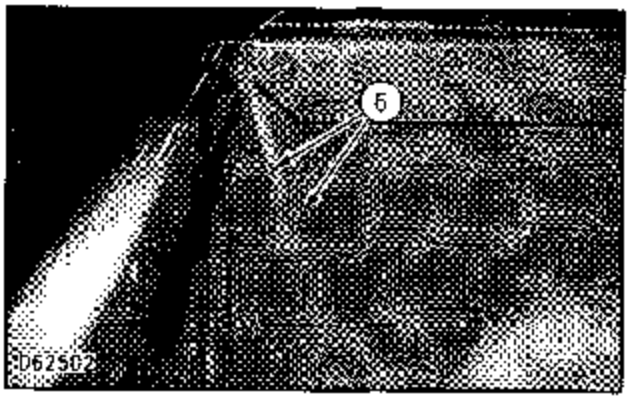
1. Disconnect hard metal lines and one hos (2) from parking brake valve (1).



2. Disconnect electrical connector (3).



3. Remove cotter pin and pin (5). Disconnect linkage (4).



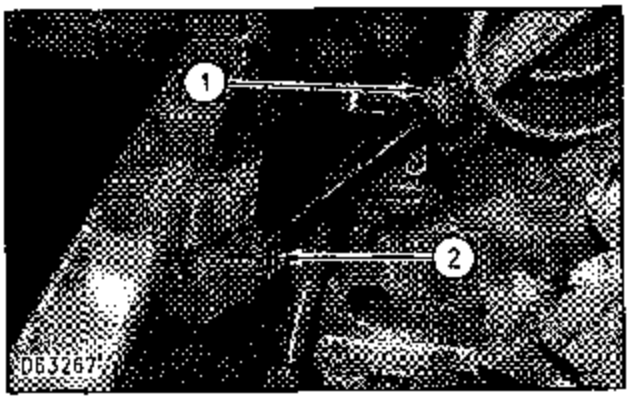
4. Remove two bolts (6) and washers on the reverse side of the firewall that hold the parking brake valve to the firewall.

NOTE: Install the parking brake valve in the reverse order of removal.

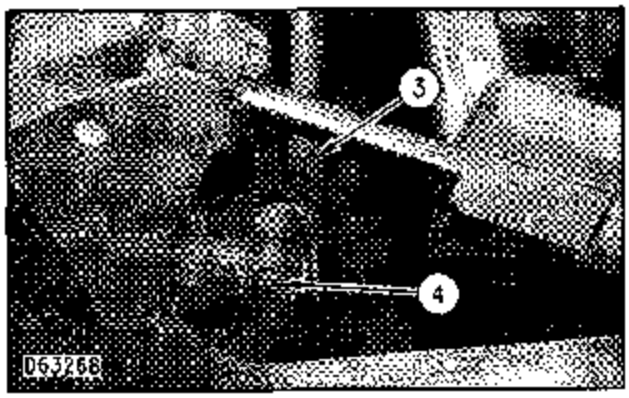
Blade

Remove & Install Blade 6060-010

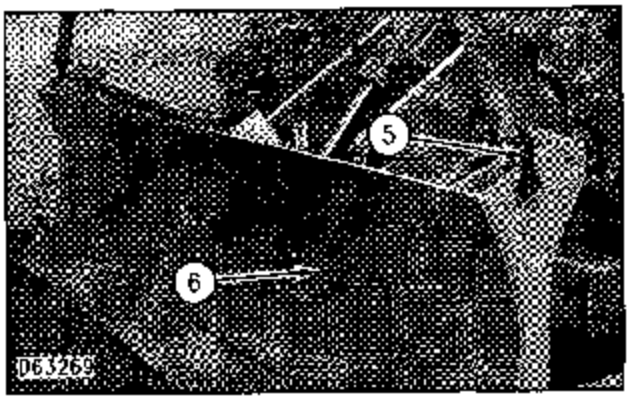
1. lower the blade to the ground so that it is level and then shut off the machine.



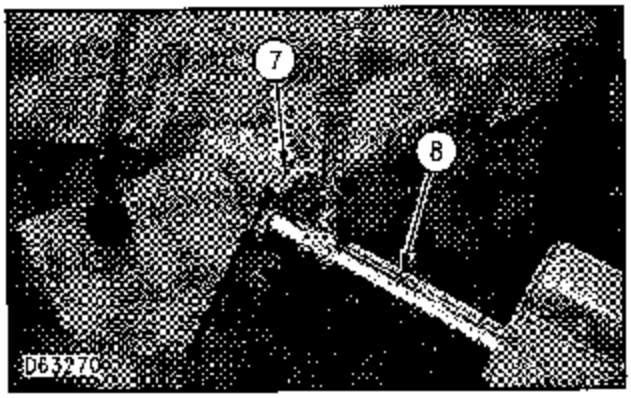
2. Support lift cylinder (1) as shown. Remove four bolts (2) cap and shims that connect lift cylinder (1) to the blade. Start the machine and retract the lift cylinder away from the blade.



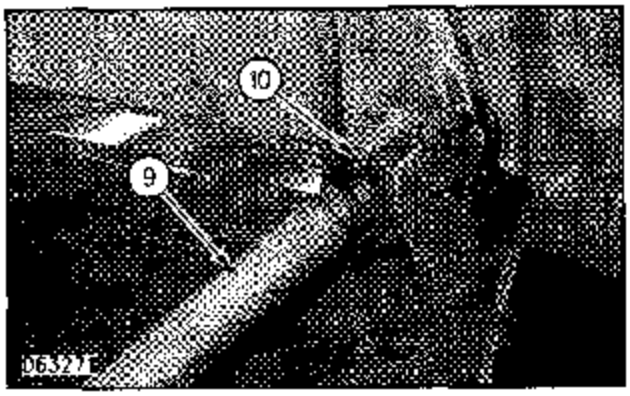
3. Support tag link (3) with strap and hoist. Remove two bolts (4), shims and cap that connect tag link to blade. Start machine and articulate to move tag link away from joint.



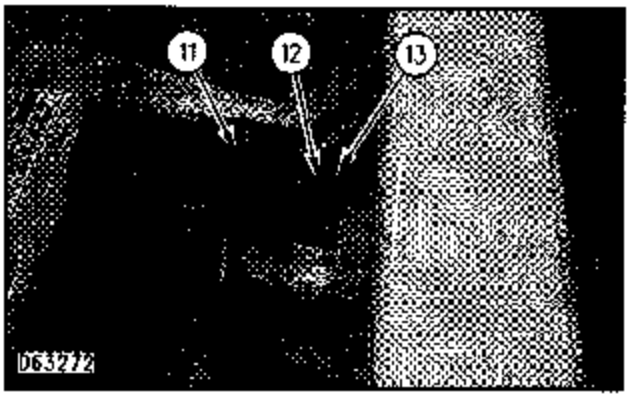
4. Fasten hoist, strap and clevis (5) to support blade (6) as shown.



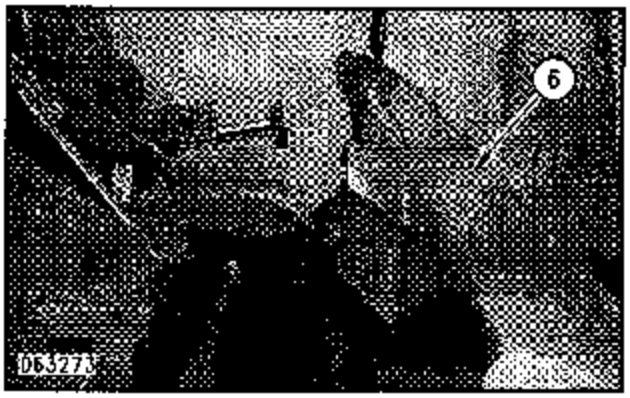
5. Support tilt cylinder (8) with strap and hoist. Remove four bolts (7), nuts and shims that connect tilt cylinder (8) to blade. Start the machine and retract the tilt cylinder from blade.



6. Support brace assembly (9) with strap and hoist. Remove four bolts (10), nuts and shims that connect brace assembly (9) to blade.



7. Place blocks under each push arm (11). Remove two cotter pins and two small pins from each large pin (12). Remove two large pins that connect push arms (11) to the blade.



8. Use a hoist to remove blade (6) from the machine. Weight of the blade is **773 kg (1700 lb)**

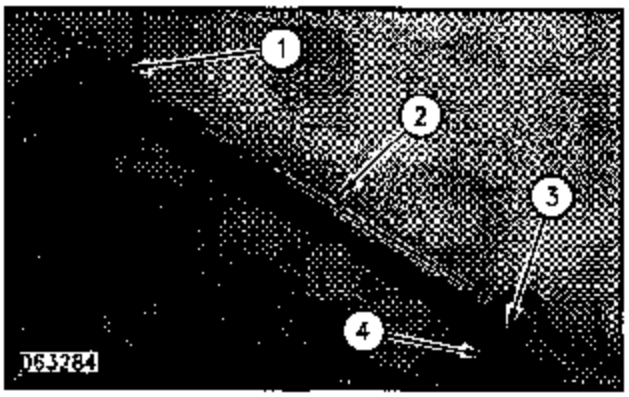
NOTE: The following steps are necessary for installation of the blade.

9. Coat all bores and pivot points with anti seize.

10. Install blade on machine in reverse order.

Push Arm Stabilizer

Remove & Install Push Arm Stabilizer 6072-010



1. Attach a strap and hoist to push arm stabilizer assembly. Remove four bolts, nuts, shims and cap (1) that connect stabilizer to the blade. Remove two bolts, washers and retaining plate (4) and pin (3) that connect push arm to stabilizer.

NOTE: Install in reverse order.

2. Coat all bolts nuts and pins with anti-seize prior to assembly.

Lift Arms & Blade Assembly

Remove & Install Lift Arms & Blade Assembly 5219 & 6060-010

Tools Needed	A
1U-9758 Stands (2 Ton Capacity)	2

FLUID SPILLAGE CONTAINMENT

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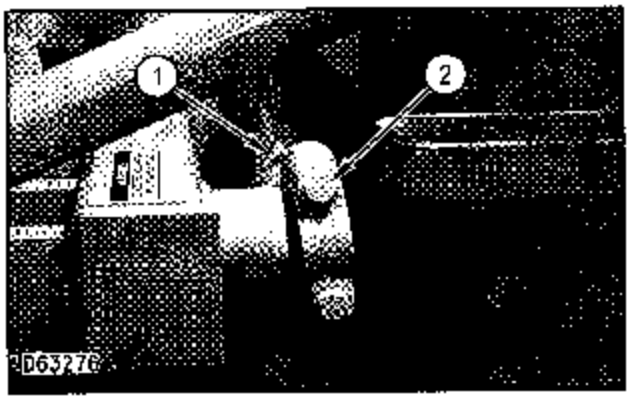
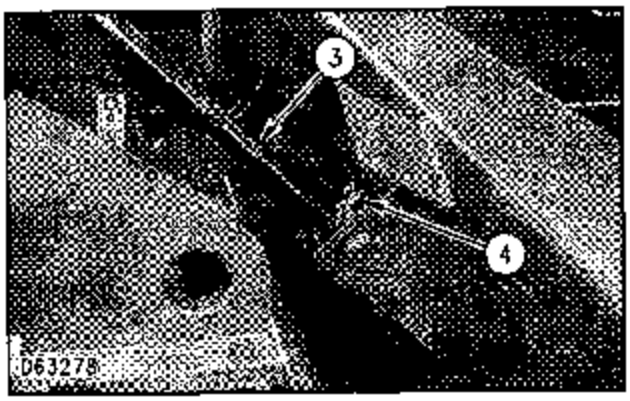
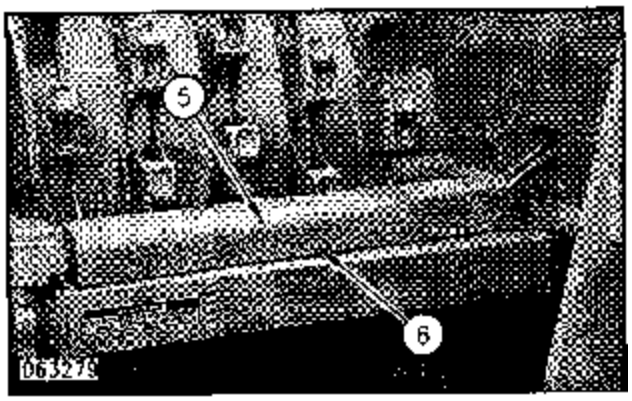


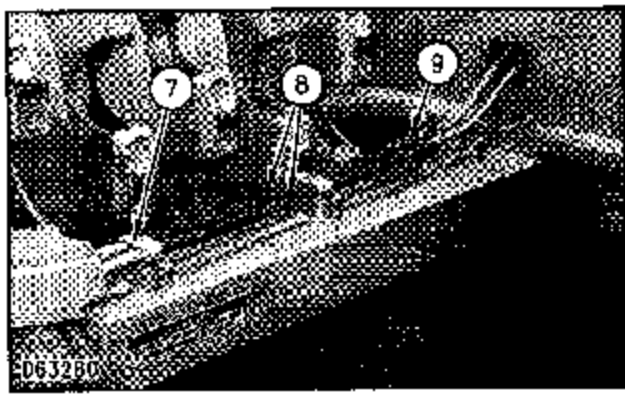
1. Fasten strap and hoist to tag link (1) and remove two bolts, shims and cap (2) that connect it to cleaner bar.



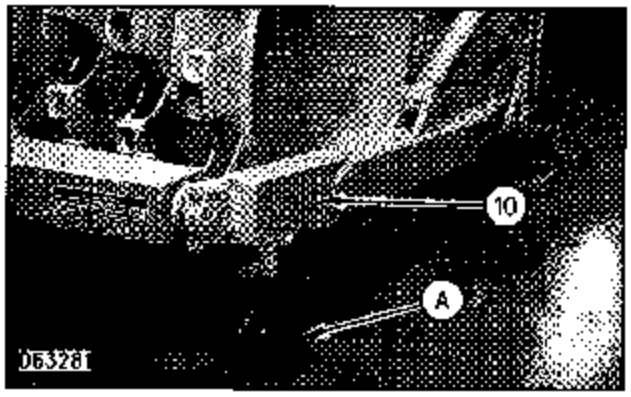
2. Fasten strap and hoist to lift cylinder (3) as shown. Remove four bolts, nuts and shims (4) that connect lift cylinder (3) to blade. Start machine and retract lift cylinder (3) away from blade.



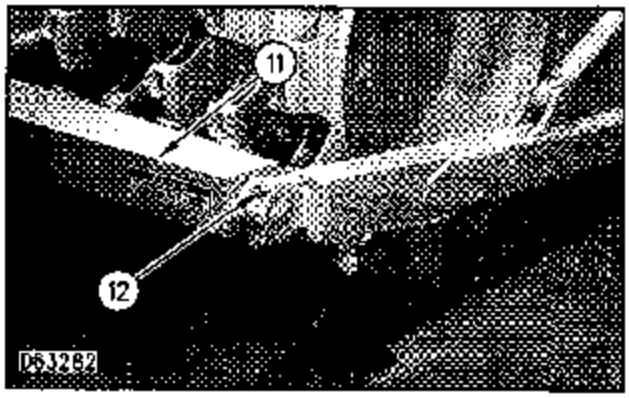
3. Remove six bolts and washers (6) from guard (5) on cleaner bar.



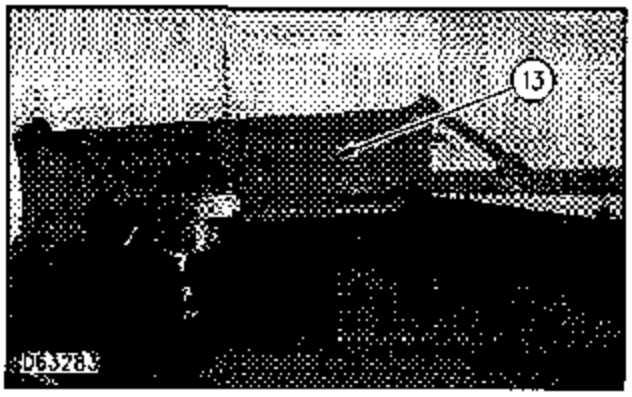
4. Disconnect, cap and plug two hydraulic oil line fittings (9) on the end of lines (8). This will prevent debris from entering the system. Remove two bolts, washers and clamps (7) that hold line (8) to cleaner bar.



5. Place tooling (A) under each lift arms (10) as shown.



6. Remove four bolts (12) (two on each side) that connect lift arm to cleaner bar (11).



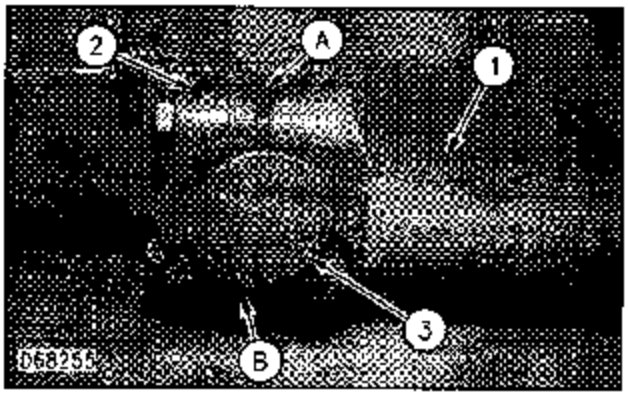
7. Start machine and carefully back away from lift arm and blade assembly (13).

NOTE: Install in reverse order from removal.

8. Coat all bores, pivots and ball joints on both the cleaner bar and the lift arm and blade assembly with lubricant prior to assembly.

Shimming Procedure (Typical)

Remove & Install Shims



Typical Example

1. Remove all shims from assembly (1)
2. Install assembly (1) and cap (2) on trunnion (3) without the shims. Tighten the bolts, maintaining equal distance on both sides of the cap.
3. Insert as many shims as possible into spaces (A) and (B) between the cap and the assembly.
4. Add two additional shims to the total shims used.
5. Install half the shims at (A) and the other half at (B). Tighten the bolts to the proper torque.
6. This allows the assembly to move on the trunnion freely and within the specified tolerance.

Blade Lift Cylinder

Remove & Install Blade Lift Cylinder 5102-010

FLUID SPILLAGE CONTAINMENT

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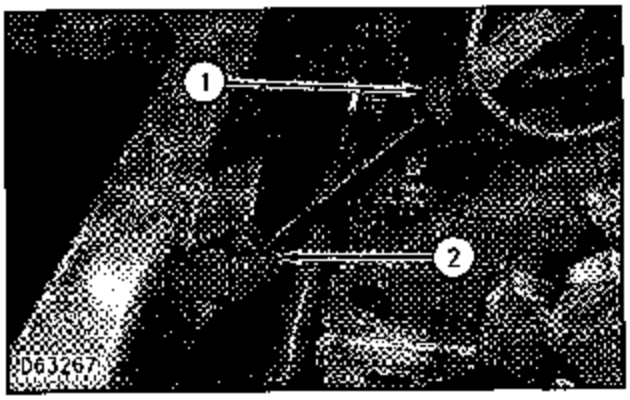
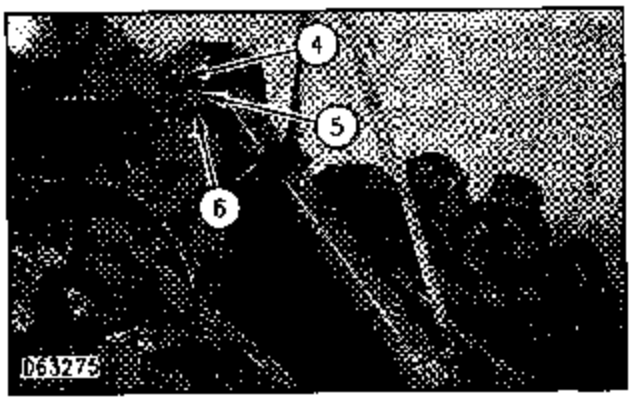


1. Attach a strap and hoist to lift cylinder (1). Remove four bolts (2) also cap and shims that connect lift cylinder (1) to blade. Start machine and retract lift cylinder away from blade.

2. disconnect two hydraulic lines (3) from lift cylinder (1). Cap and plug all lines to prevent debris from entering the the system and fluid loss.



3. Fasten second strap and hoist to lift cylinder as shown. Remove two bolts (6), retaining plate (5) and pin (4). Remove lift cylinder (1).

NOTE: Install in reverse order.

4. Coat pin (4) and bolts (6) with anti seze prior to installation.

5. See "Shimming" procedure in this publication for proper shimming.

Disassemble Lift Cylinder (814F & 816F) 5102-015

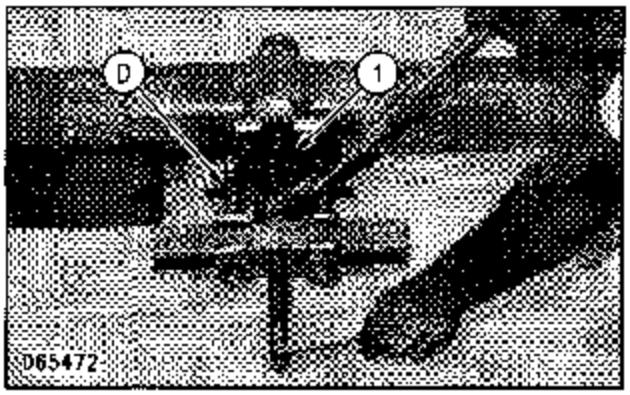
Tools Needed		A	B	C	D	E
6V-4946	Hydraulic Cylinder Repair Stand	1				
1P-0850	Torque Multiplier		1			
5P-1748	Socket		1			
3P-1534	Chain Wrench			1		
1P-0851	Spline Adapter		1			
1P-0852	Male Adapter		1			
8B-7548	Puller Assembly				1	
8B-7550	Leg				2	
8H-0684	Ratchet Box Wrench				1	
8H-0663	Bearing Puller Attachment				1	
0T-0774	Spacer				1	
5F-7353	Washer				1	
1P-1837	Adapter					1

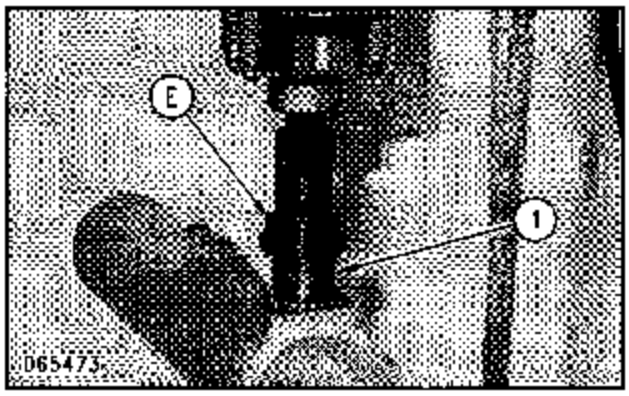
Start By:

a. remove lift cylinders

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

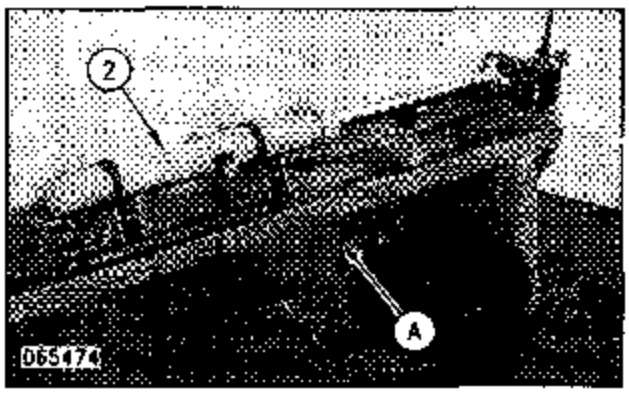




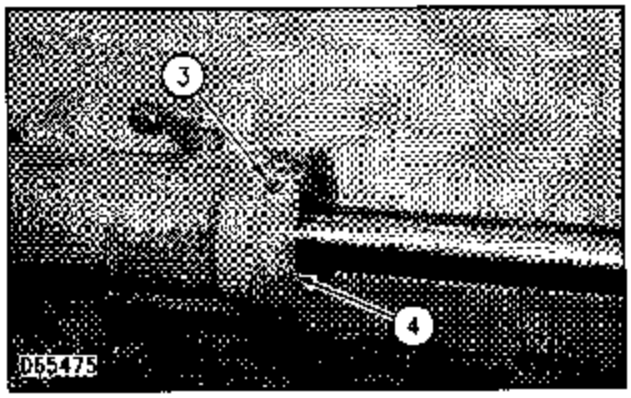
1. Remove and install the bearings on the lift cylinder as follows:

   a. Install tooling (D) and remove bearings (1) from both sides of the cylinder.

   b. Use Tool (E) and a press to install bearings (1) on both sides of the cylinder.



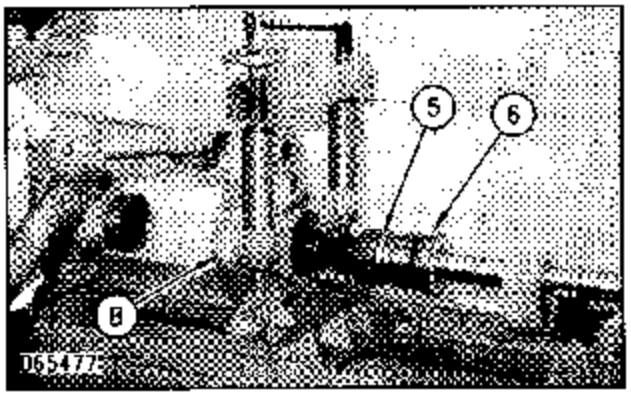
2. Put lift cylinder (2) in position on Tooling (A).



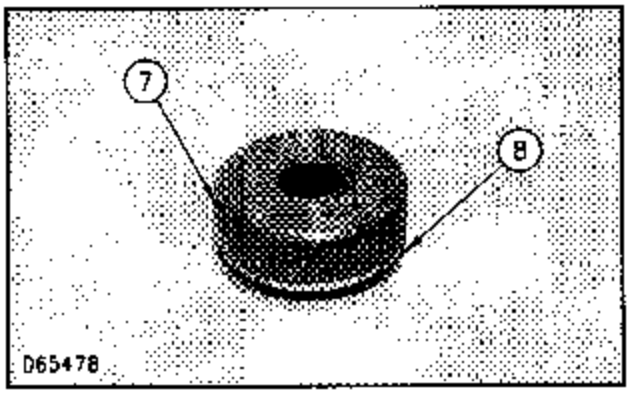
3. Remove setscrew (3) and remove crown (4) from the cylinder with Tool (C).

4. Use Tooling (A) to pull the cylinder away from the head and the rod.

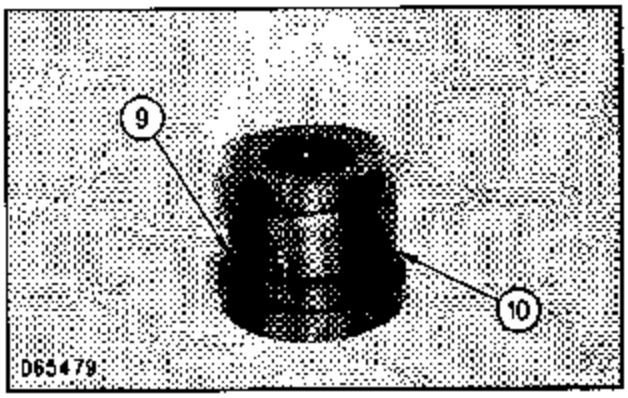
5. Use Tooling (B) to remove the bolt on the cylinder rod.



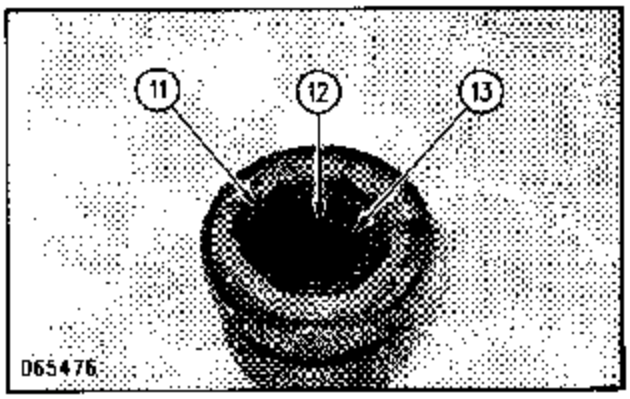
6. Remove piston (5) and head (6) from the cylinder rod.



7. Remove wear ring (7) and seal assembly (8) from the piston.



8. Remove seal (9) and ring (10) from the head.



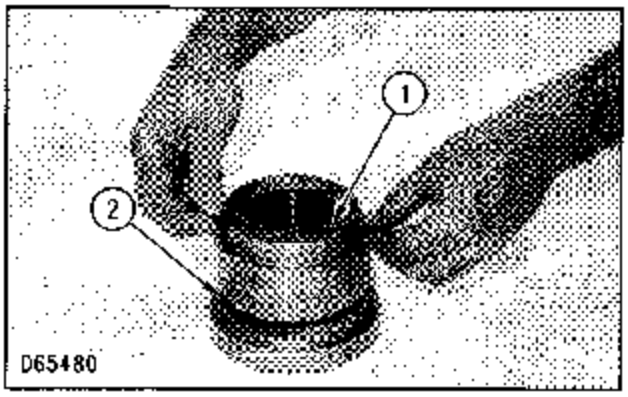
9. Remove lip type seals (11) and (13) and seal ring (12) from the head.

Assemble Lift Cylinder (814F, 816F) 5102-016

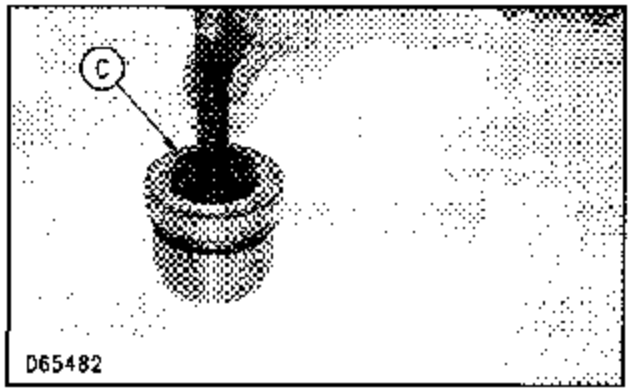
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

1. Clean and inspect all parts. Make a replacement of all parts that are worn or damaged.

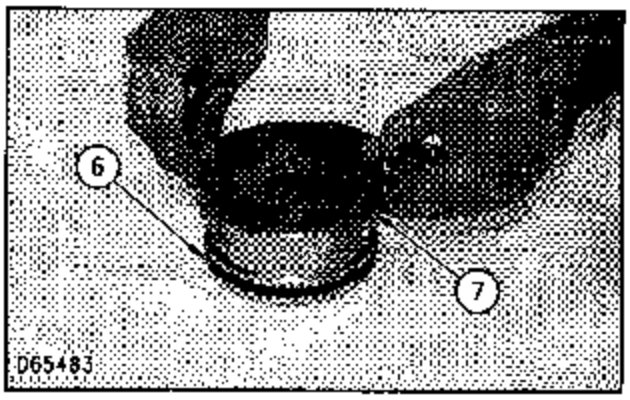


2. Install ring (2) and seal (1) on the head.

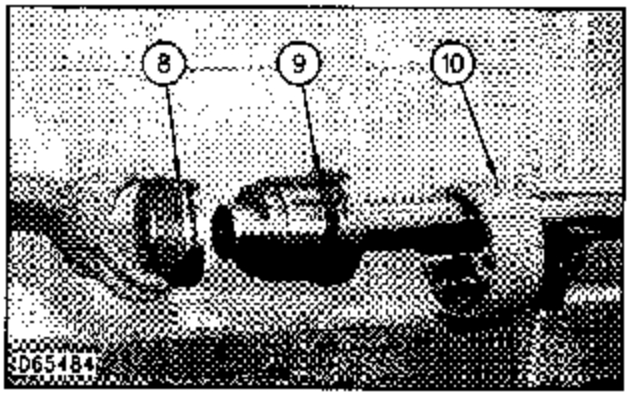


3. Install inner seal (5) in the head. The inner seal does not have a lip and can be installed either way. Install middle seal (4) with the lip in. Use tool (C) as shown and install outer seal (3) with the lip out. Put clean oil on the seals.

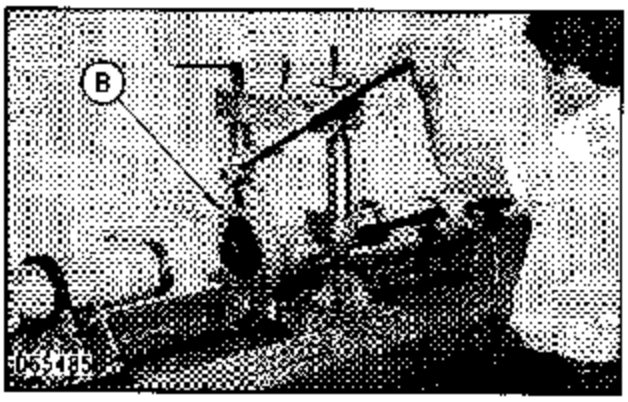
4. Use Tool (D) to cause expansion of the seal that is part of the seal assembly.



5. Install seal assembly (6) and wear ring (7) on the piston.



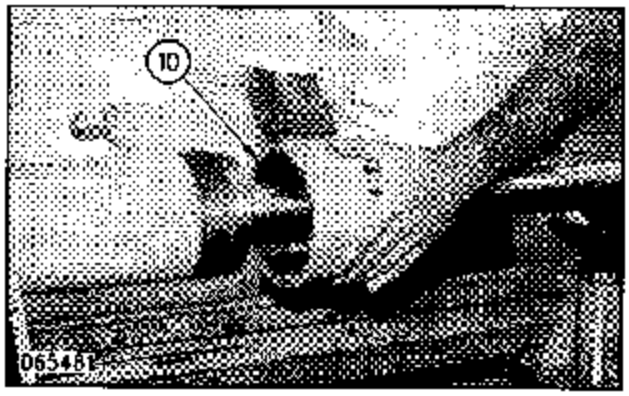
6. Install crown (10), head (9) and piston (8) on the cylinder rod.



7. Put clean oil on the threads of the bolt. Install the washer and bolt in the end of the cylinder rod. Use Tool (B) and tighten the bolt to a torque of **2580 ± 258 N•m (1900 ± 190 lb.ft.).**

8. Put **5P-0960 Multipurpose Type Grease** on the outside diameter of the head and inside diameter of the crown.

NOTE: The rod must be fully extended when the crown is tightened.



9. Install crown (10) on the cylinder and tighten the crown to a torque of **475 + 270 - 000 N•m (350 + 200 - 000 lb.ft.).**

10. Put **9S-3263 Thread Lock** on the threads of the setscrew. Install the setscrew in the crown. Tightening of the setscrew more than finger tight can put a side load on the crown and head and cause damage to the cylinder rod.

End By:

a. install lift cylinder

Disassemble Lift Cylinder (815F) 5102-015

Tools Needed		A	B	C
6V-4948	Hydraulic Cylinder Repair Stand	1		
3S-6224	Hydraulic Pump Group	1		
2P-2271	Adapter	1		
3P-1534	Chain Wrench		1	
1P-0510	Driver Group			1
5H-1273	Sleeve			1

Start By:

a. remove lift cylinders

FLUID SPILLAGE CONTAINMENT

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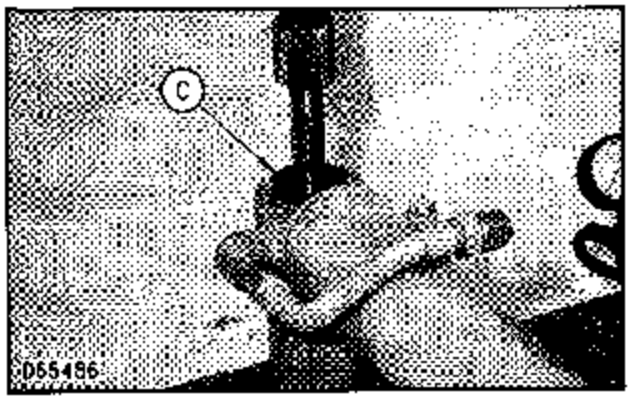
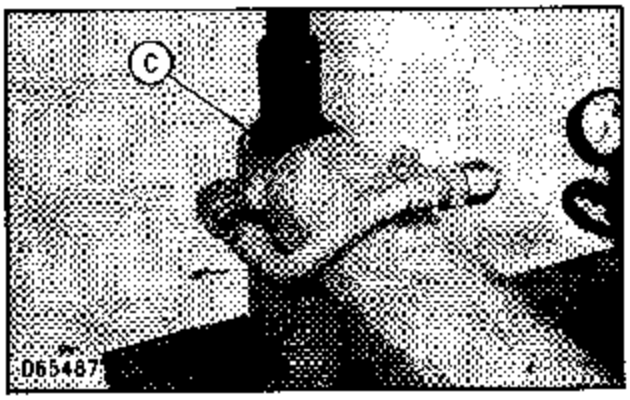
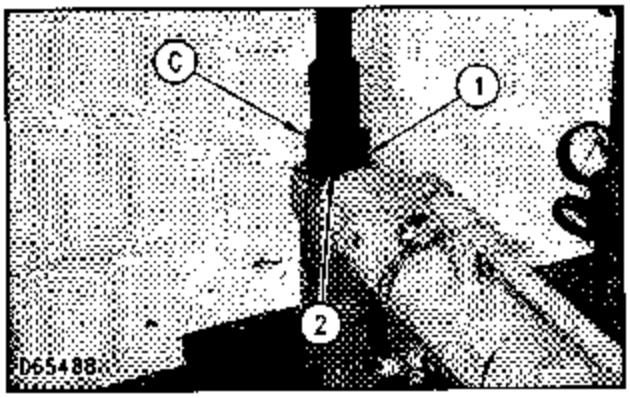




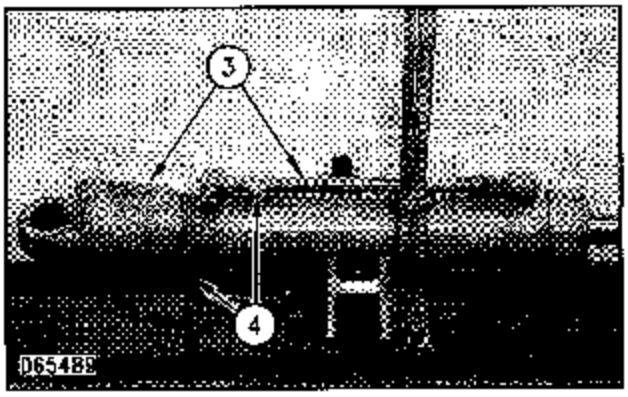


1. Remove and install the ring and the bearing in the cylinder as follows:

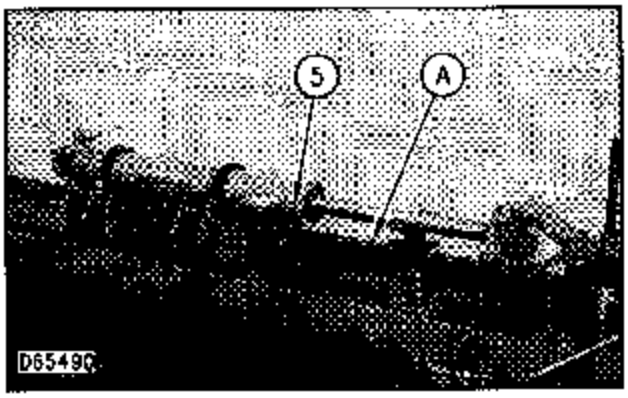
   a. Use Tooling (C) and a press to remove a ring, a bearing and a ring from the cylinder.

   b. Use Tooling (C) and a press. Install the ring with the edge of the bevel down. Install the ring until it is even with the outside surface.

   c. Turn the cylinder over. Use Tooling (C) and a press to install bearing (2) and ring (1). The ring must be installed with the edge of the bevel down even with the outside surface.

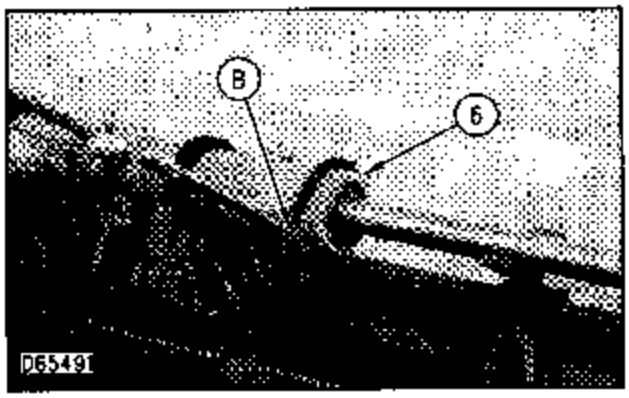


2. Remove the bolts and disconnect clips (4). Remove oil lines (3).



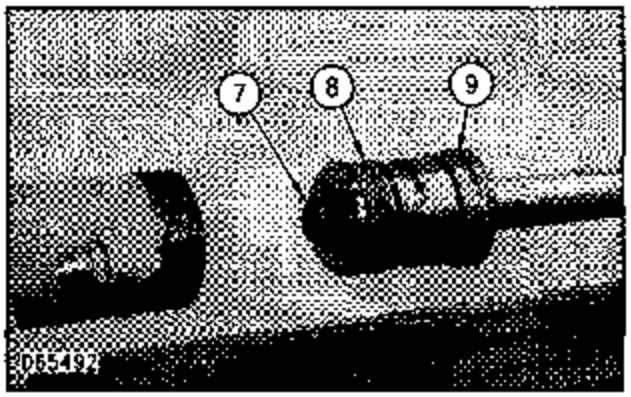
3. Install the cylinder on Tooling (A) as shown. Slowly extend and retract the cylinder rod to push the oil out of the cylinder.

4. Remove setscrew (5) from the crown.

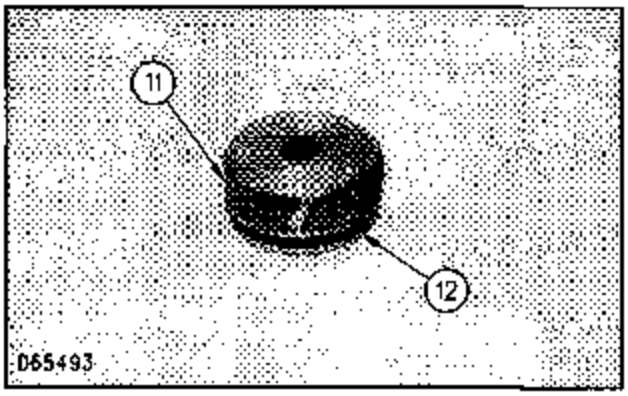


5. Use Tooling (B) to remove crown (6) from the cylinder.

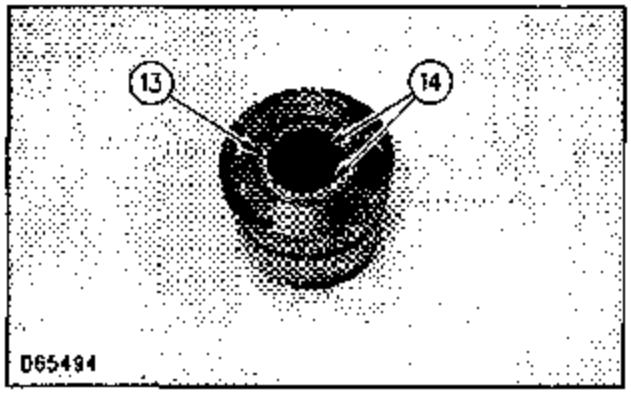
6. Make a separation of the rod assembly from the cylinder assembly.



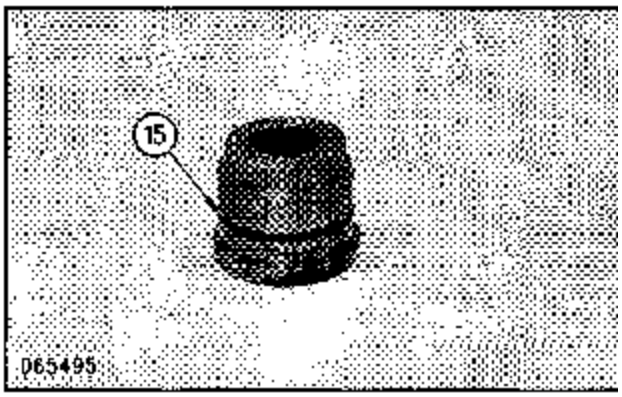
7. Remove bolt (7) and washer (10). Remove piston (8) and head (9) from the rod assembly.



8. Remove wear ring(11) and seal assembly (12) from the piston.



9. Remove seal (13) and seals (14) from the inside diameter of the head.



10. Remove O-ring seal and backup ring (15) from the outside diameter of the head.

Assemble Lift Cylinder (815F) 5102-016

Tools Needed		A	B	C	D
6V-4948	Hydraulic Cylinder Repair Stand*	1			
3S-6224	Hydraulic Pump Group	1			
2P-2271	Adapter	1			
3P-1534	Chain Wrench		1		
1P-0510	Driver Group			1	
4S-9181	Expander Assembly				1

FLUID SPILLAGE CONTAINMENT

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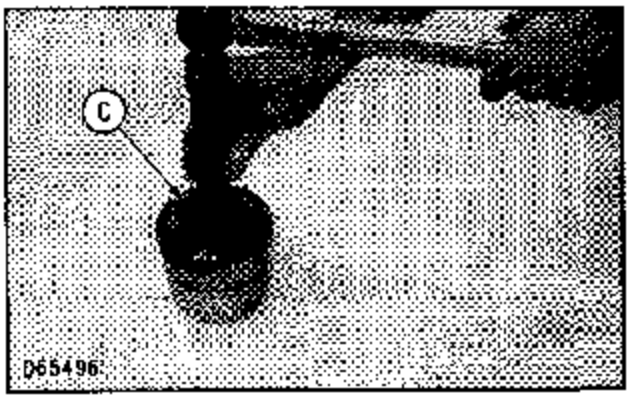
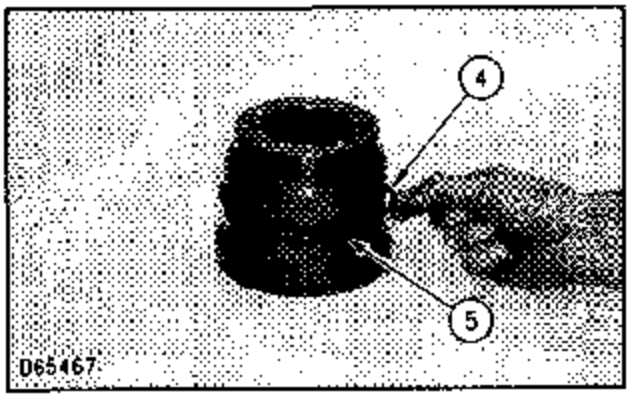
NOTE: Put clean oil on all parts during assembly.

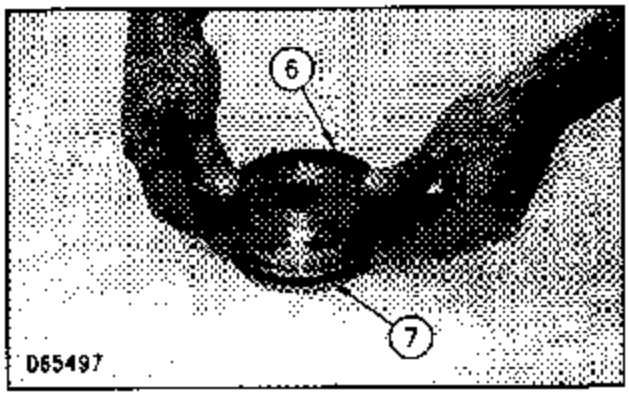
1. Clean and inspect all parts. Make a replacement of all parts that are worn or damaged.



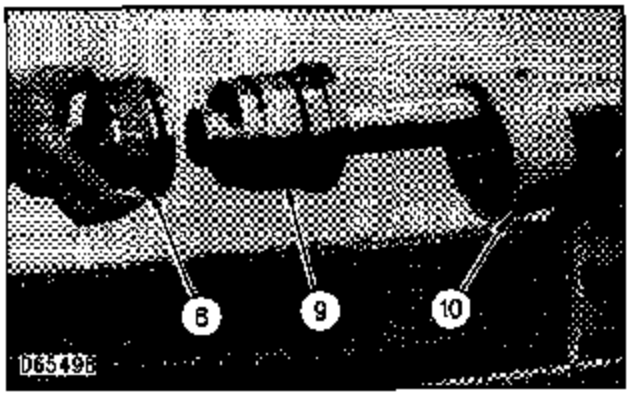
2. Install seals (1), (2) and (3) in the head. Seal (3) can be installed either way. Install seal (2) with the lip toward the inside of the cylinder when installed. Use Tooling (C) to install seal (1) with the lip toward the outside of the cylinder when installed.



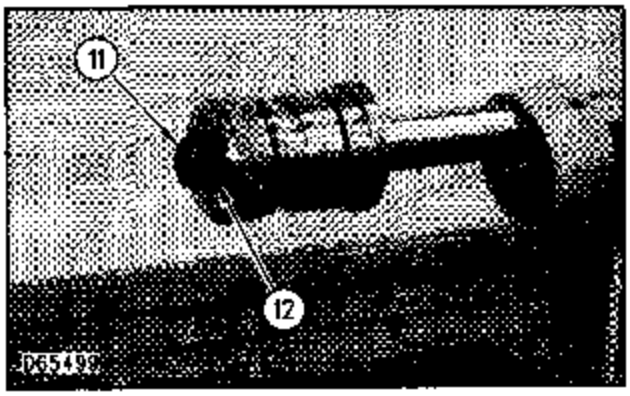
3. Install backup ring (5) and O-ring seal (4) on the head. The backup ring must be installed away from the oil in the cylinder.



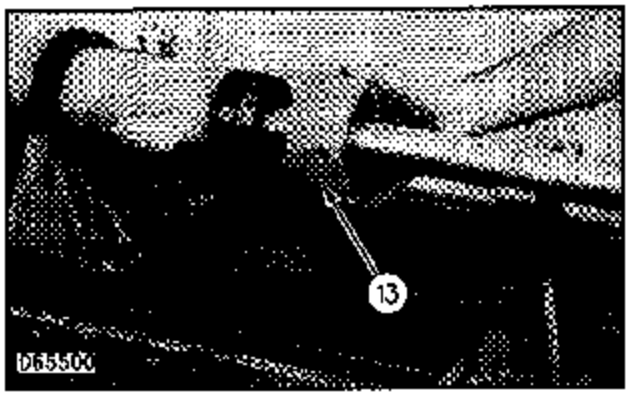
4. Install the inner part of seal assembly (7) on the piston. Use Tool(D) to make the outer part of seal assembly (7) larger (stretch) and install it on the piston. Install wear ring (6) on the piston.



5. Install crown (10), head (9), and piston (8) on the rod assembly.

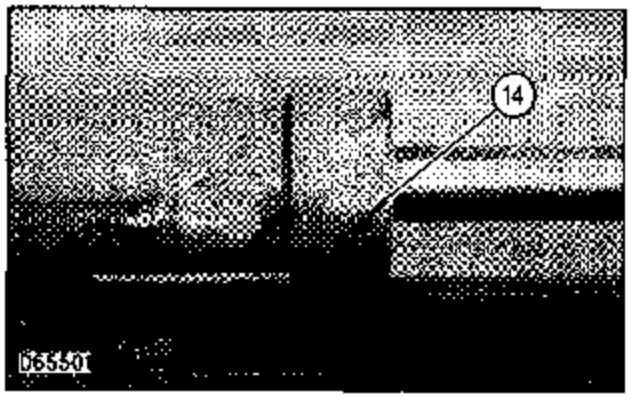


6. Put clean oil on the threads of bolt (11). Install washer (12) and bolt (11). Tighten the bolt to the torque of **1100 ± 110 N•m (820 ± 80 lb. ft.).**

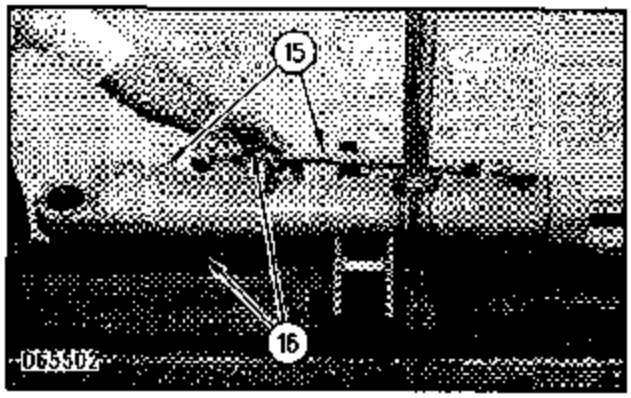


7. Put clean grease on the outside diameter of the head and inside diameter of crown (9). Install the crown and tighten to the torque of **475 + 270 - 000 N•m (350 + 200 - 000 lb.ft.).**

NOTE: The rod must be fully extended when the crown is tightened.



8. Put **9S-3263 Thread Lock** on the threads of setscrew (10). Install setscrew (10) in the crown. Tightening of the setscrew can put a side load on the crown and head and damage the cylinder rod.



9. Install oil lines (15). Connect clamps (16) that hold the lines to the cylinder.

End By:

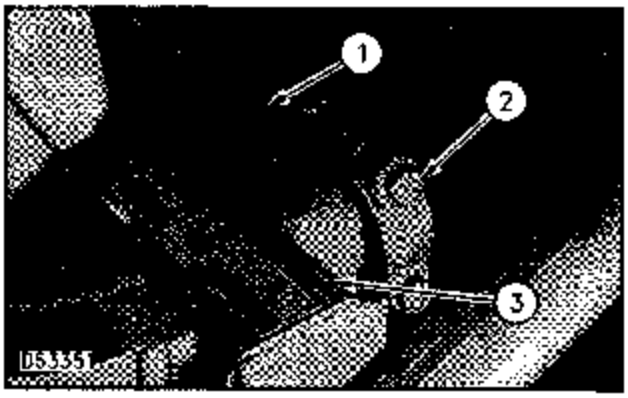
a. Install lift cylinders

Tag Link

Remove & Install Tag Link 6072-010

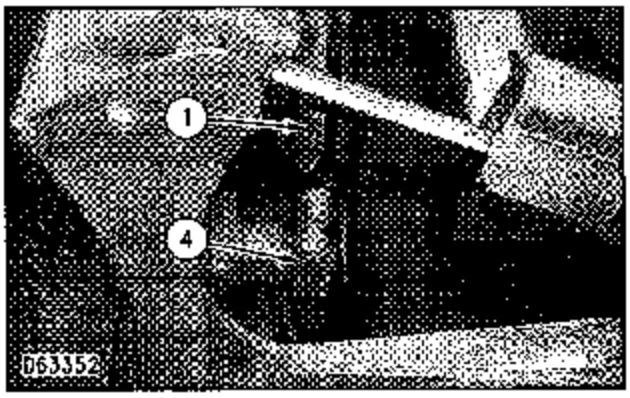
⚠ WARNING

Tag link must be installed correctly to prevent damage to the lift cylinder when blade is lifted. Make a mark on the link for correct assembly.



1. Fasten straps and a hoist to each end of tag link (1). Remove two bolts (2) cap and shims that connect tag link (1) to pivot point on front cleaner bar assembly (3).

2. Start machine and articulate just far enough to move free end of tag link away from cleaner bar (3).



3. Remove two bolts (4), shims and cap that connect tag link (1) to blade.

4. Use hoist to remove tag link (1).

NOTE: Install in reverse order.

5. Lubricate all pins and caps with anti-seize prior to installation.

6. Move the blade slightly to the right and make an alignment of tag link (1) to the ball. Install shims, cap and bolts.

NOTE: See shimming procedure in this publication for correct shims.

Main Frames

Separate Main Frames 7051-076

Tools Needed		A	B	C	D	E	F	G
9U-7536	Lift Stand (55 Ton)	2						
4C-5809	Electric Pump Group	1						
6V-6146	Load Leveler		1					
1U-8231	Lifting Strap		2					
1U-5230	Manual Pump Group			1				
8S-7620	Base Assembly				1			
8S-7650	Cylinder				1	1		
8S-7615	Pin				1	1		
3S-6224	Elec. Hydraulic Pump				1	1		1
8S-7610	Base Assembly					1		
5P-6215	Stand						2	
1M-6756	Sleeve							1
7F-5283	Head							1
4C-9634	Puller-Stud							1
5P-2998	Hydraulic Puller							1
7H-7539	Nut							1

Tools Needed		H	J	K
3S-6224	Electric Hydraulic Pump	1	1	1
1M-6756	Sleeve	1	1	
7F-5283	Head	1	1	
4C-9634	Puller-Stud	1	1	1
5P-2998	Hydraulic Puller	1	1	1
7H-7539	Nut	1	1	1
1P-1840	Puller Adapter			1
5P-7399	Puller Adapter		1	
8M-4858	Adapter		1	
6V-4011	Sleeve			1
6V-4035	Receiving Sleeve			1

Start By:

a. remove bulldozer blade group

b. connect steering frame lock link

c. remove center drive shaft

d. remove cab

FLUID SPILLAGE CONTAINMENT

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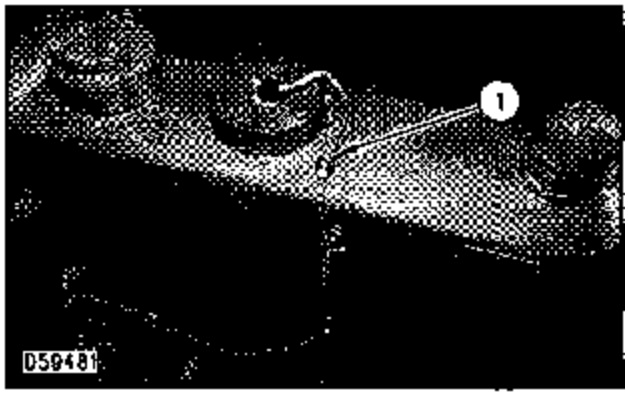
⚠ WARNING

There is no clearance for a person in the area between the front and rear frames of the machine when turning the vehicle. When a machine is to be lifted, transported on another vehicle or service work is being performed near the center of the machine, connect the steering frame lock link between the front and rear frames to keep the machine in a straight ahead position. Before operation and when operating, be sure the steering frame lock link, located near the center of the machine, is disconnected and pinned to the retaining plates.

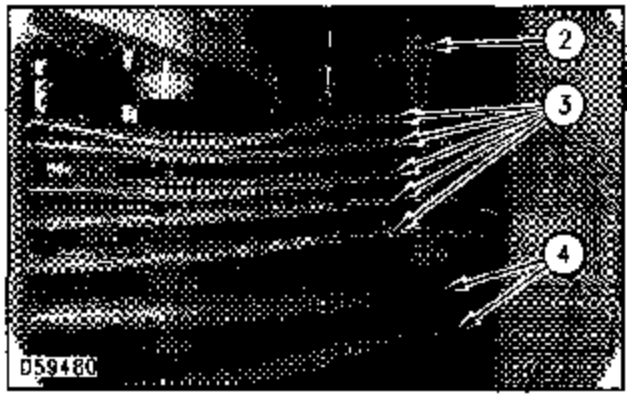
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

1. Drain the hydraulic tank into a suitable container for proper disposal or reuse. Capacity of the hydraulic tank is **67 Liters (U.S. Gal.).**



2. Disconnect electrical connection (1) for the fuel level sender assembly.

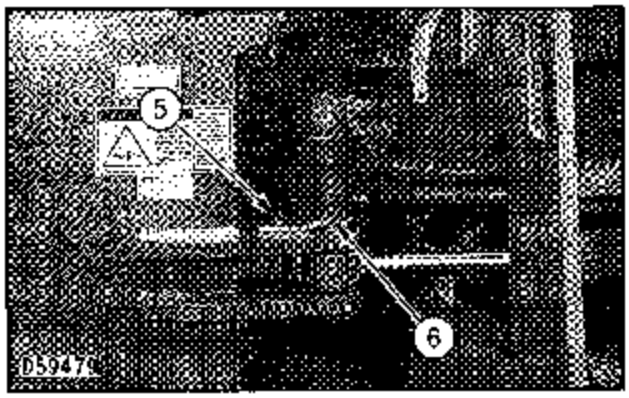


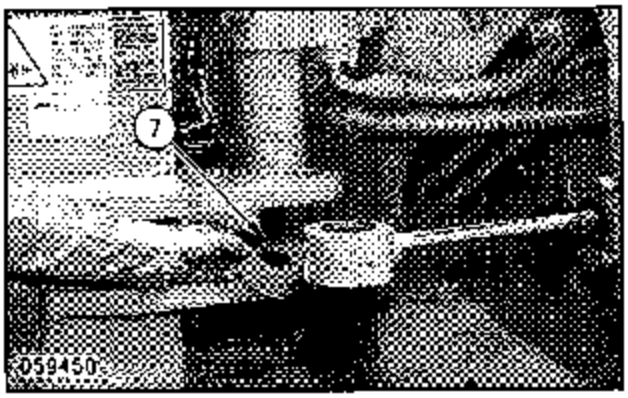
3. Place identification marks on ten hose assemblies (3). Disconnect the ten hose assemblies from the front half of the machine. Cap and plug all open connections to prevent contamination.

NOTE: The locations of the hose connections are: two connections at the fuel tank, one connection at the parking brake actuator, one connection at the front axle housing, and the remaining connections are at the dozer control valve.

4. Remove bracket (2) from the front frame.

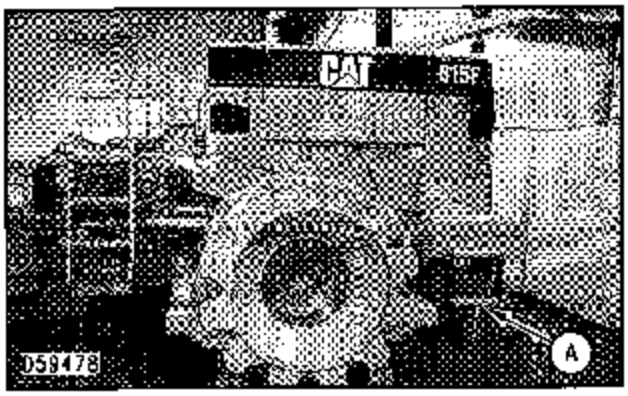
5. Place identification marks on two hose assemblies (4). Disconnect two hose assemblies from the rear half of the machine. Cap and plug open connections to prevent contamination.





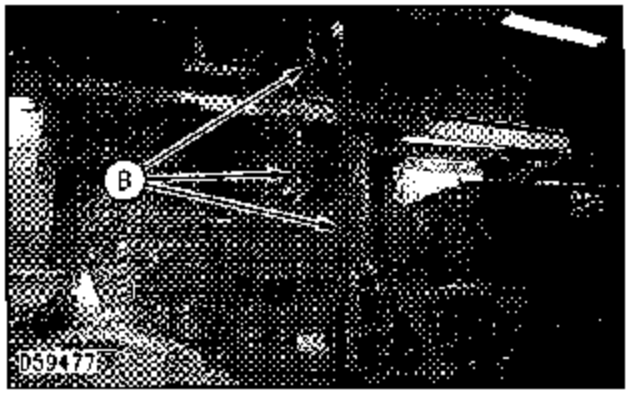
6. Remove one bolt, washer and spacer (5)Remove steering cylinder flag pin (6) and washer (7).

7. Repeat step 6 to remove the steering cylinder pin from the opposite side.



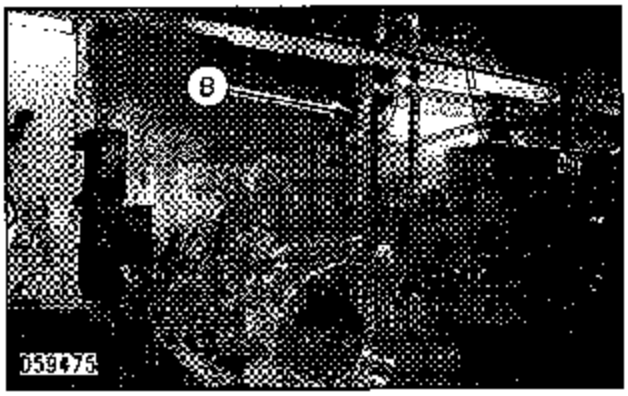
8. Place tooling (A) in position under the rear main frame of the machine as shown. Raise the rear main frame with tooling (A) high enough to place eighteen inches of cribbing under the front portion of the rear frame as shown. Lower tooling (A) until the frame is resting on cribbing.

NOTE: It is important to have weight resting on both tooling (A) and cribbing to properly stabilize the rear half of the machine.



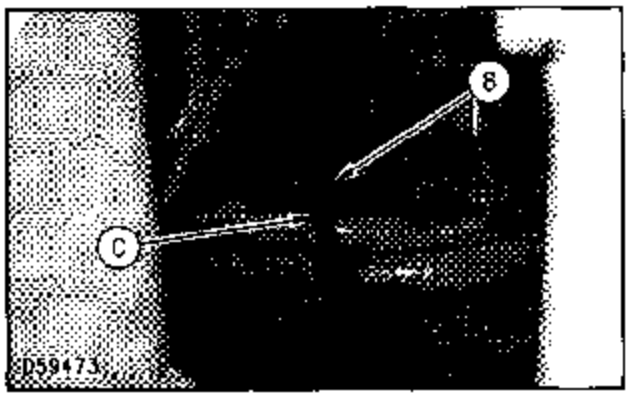
9. Attach tooling (B) and a suitable lifting device to the front main frame as shown. Weight of the front frame at the hitch is **1271 kg (2800 lb)**.

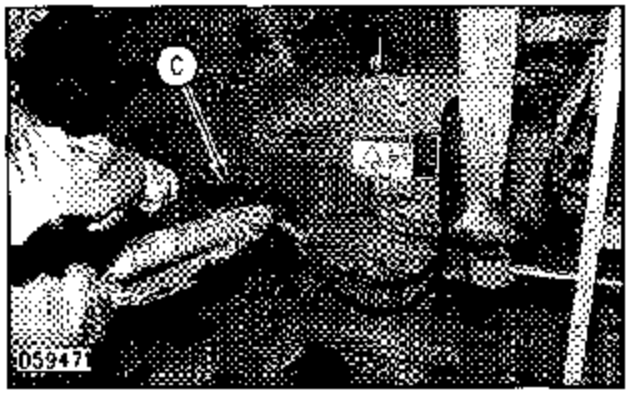
NOTE: The steering cylinder pins (6) are installed in the front main frame to keep the lifting straps in position.



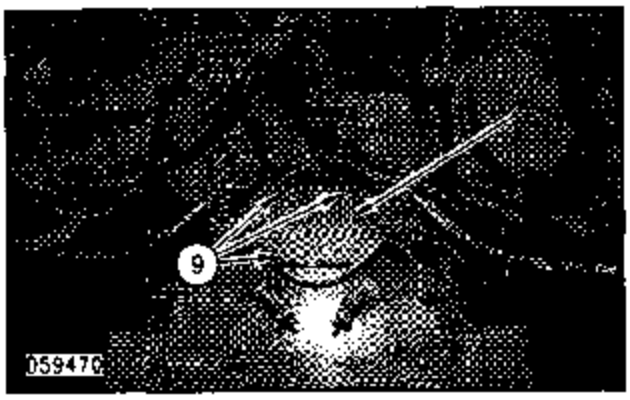
10. Attach the front main frame to the mast of a suitable power truck as shown.

NOTE: The power truck will have very little weight on the forks and will be used only to pull the front main frame away from the rear main frame.

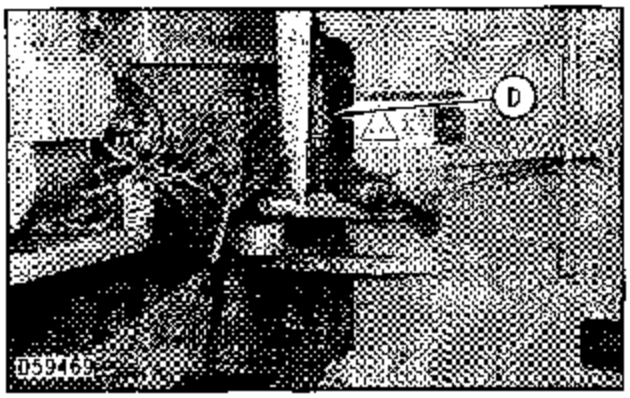




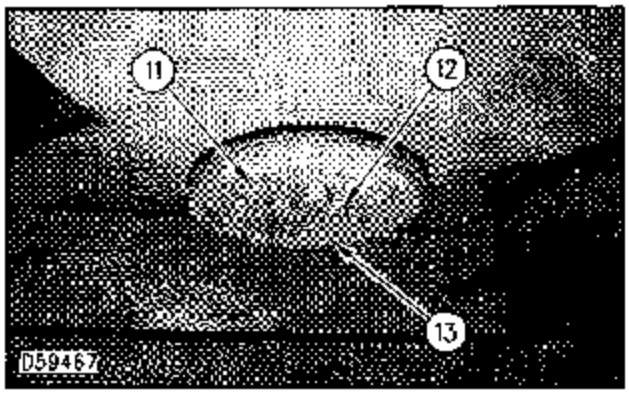
11. Connect tooling (C) to the parking brake actuator (8). Apply pressure to parking brake actuator with tooling (C) until parking brake is released. This will allow the front frame when separating the two frames at the hitch.



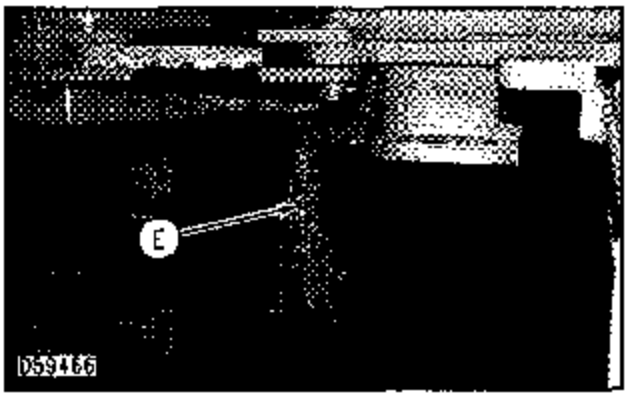
12. Remove four bolts and washers (9) that fastens upper hitch pin (10) to rear main frame.



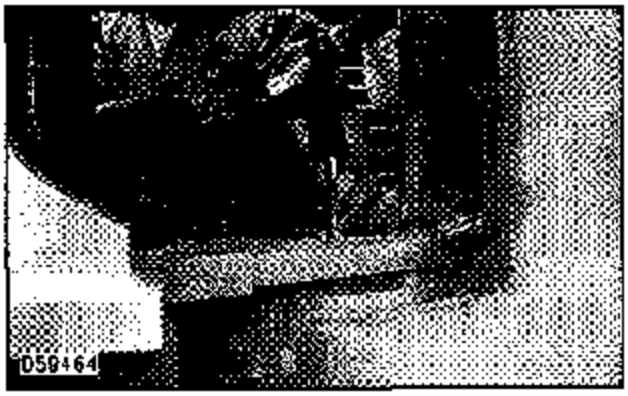
13. Place tooling (D) under top hitch pin as shown. Push top hitch pin out using tooling (D)

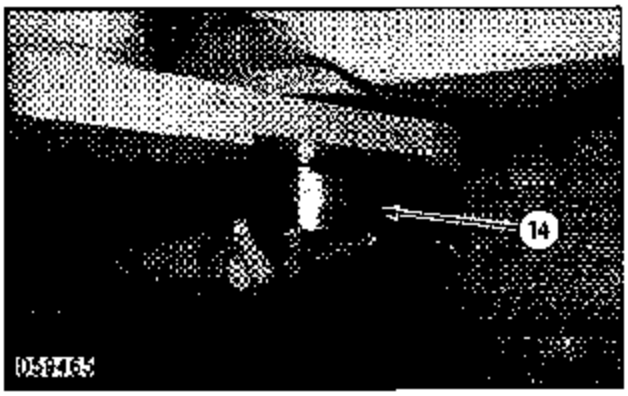


14. Remove six bolts (11), four bolts (12), plate and shims (13) from the front main frame hitch.



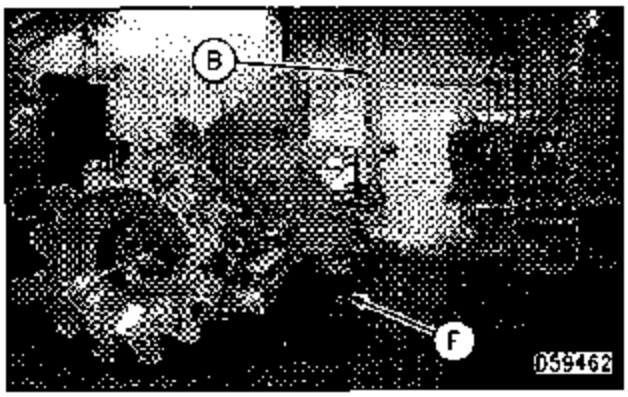
15. Place tooling (E) in position under lower pin as shown. Remove lower pin using tooling (E).





16. Use a hammer and punch to remove spacer (14) from the lower frame hitch as shown.

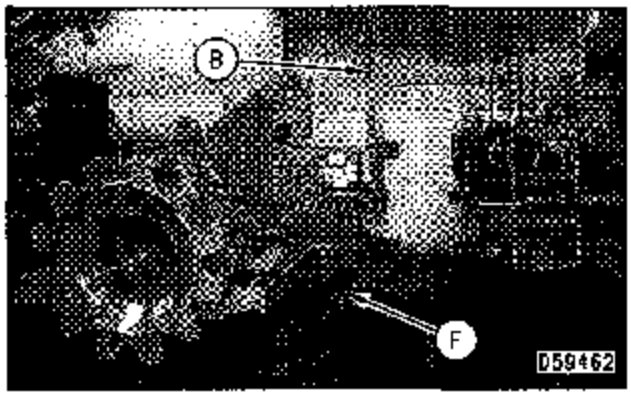
17. Disconnect steering frame link lock (15). See topic "Remove And Install Steering Frame Link Lock" in 815F Machine Systems SENR1318. Weight of the front frame **1271 kg (2800 lb)** at the hitch.



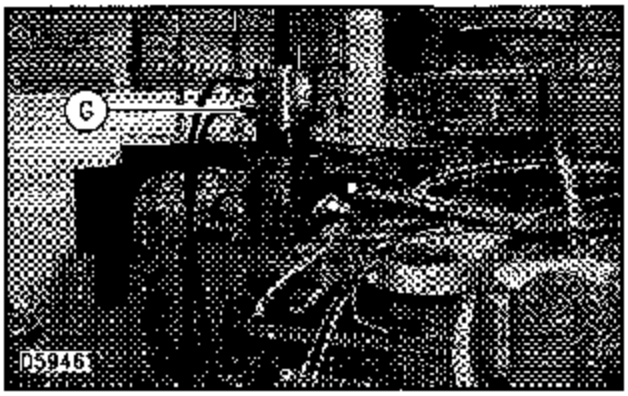
18. Carefully pull the front main frame from the rear main frame using the lift truck, suitable hoist and tooling (B).

NOTICE

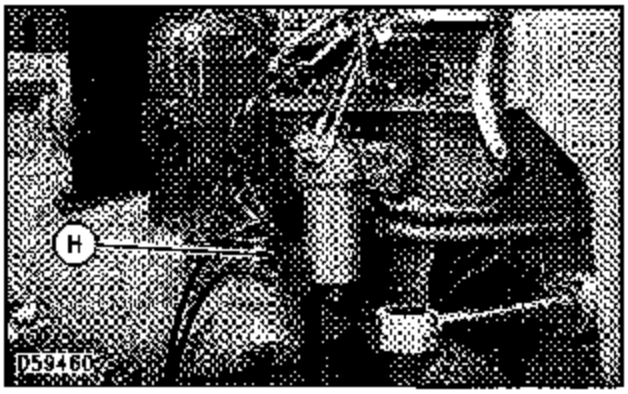
During separation of the front main frame from the rear main frame, be sure the hoist and tooling (B) are moved with the front main frame.



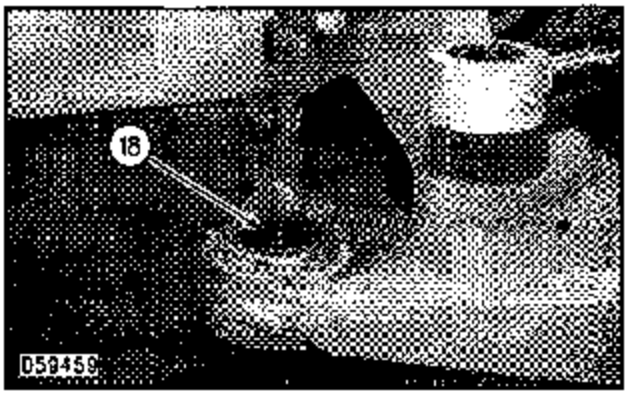
19. After separation is completed, stabilize the front main frame by placing tooling (F) under the front main frame near the hitch as shown.



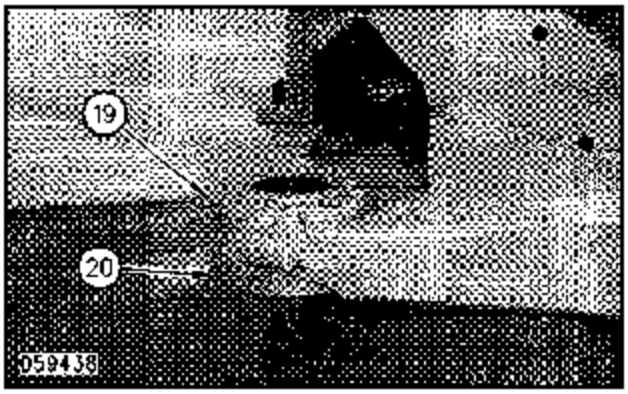
20. Use tooling (G) to remove upper bearing collar (16) (not shown) from upper portion of rear hitch.



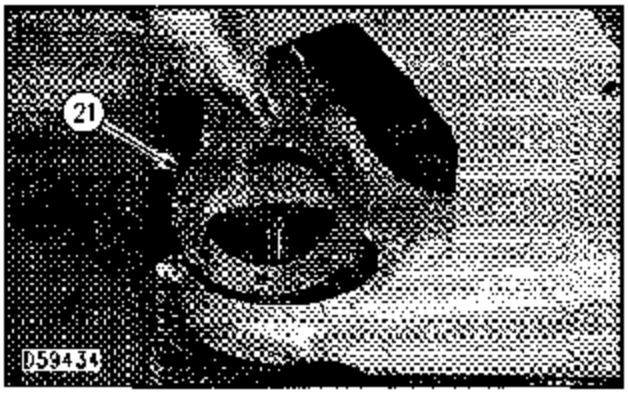
21. Support tooling (H) with a strap and hoist. Use tooling (H) to remove bearing (17) (not shown) from the upper rear hitch.



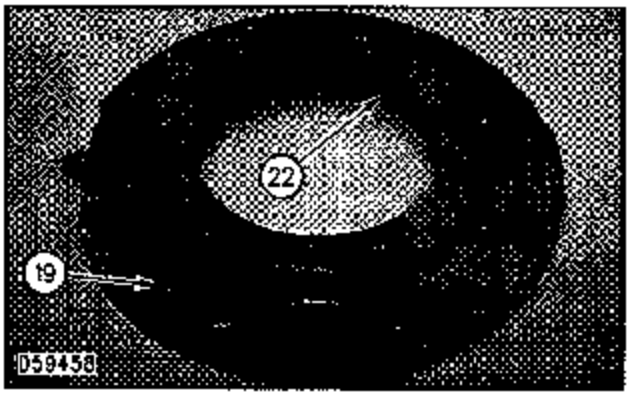
22. Remove spacer (18) from lower hitch.



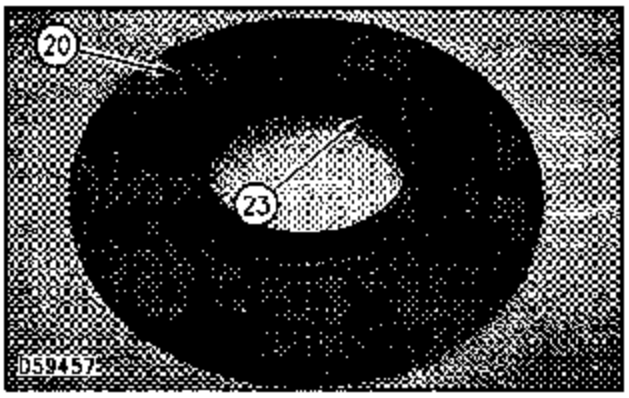
23. Mark the radial position of the upper and the lower caps. Remove eight bolts and washers and upper cap (19) and lower cap (20) from the lower hitch assembly.



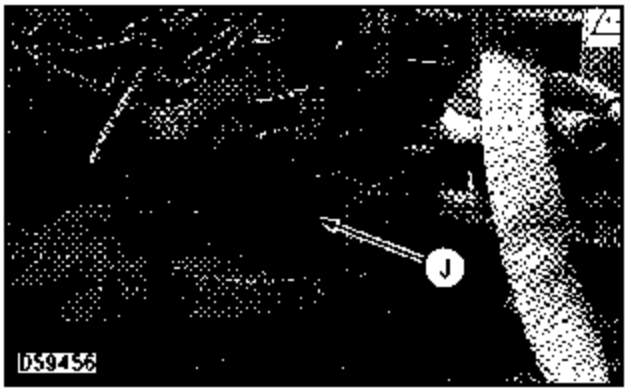
24. Remove shim pack (21) from the top side of the lower hitch.



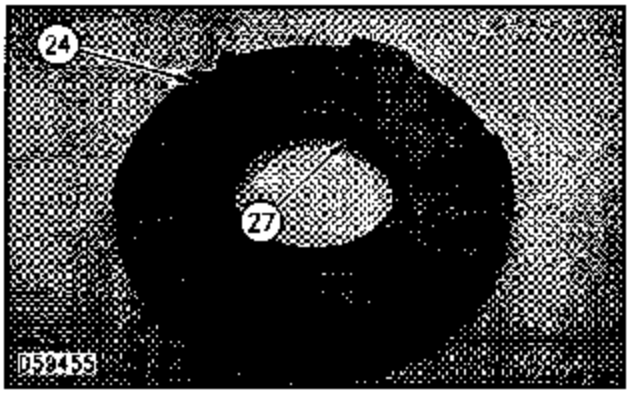
25. Remove lip seal (22) from upper cap (19).



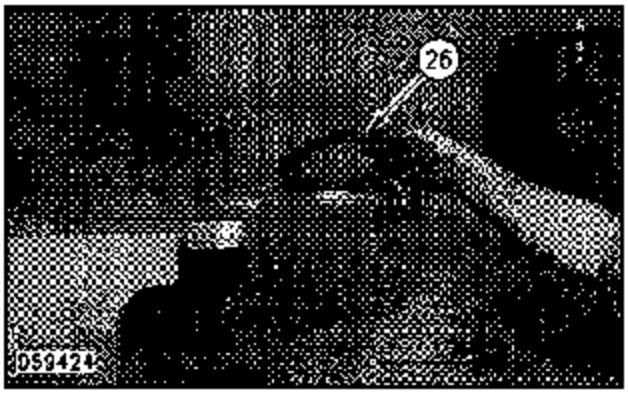
26. Remove lip seal (23) from lower cap (20).



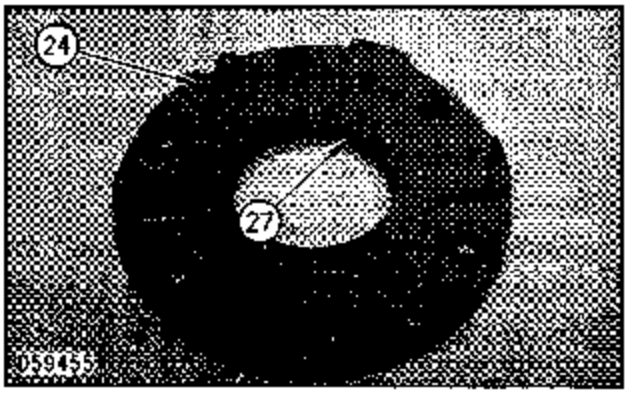
27. Use tooling (J) to remove the bearing cups and cones from the lower hitch.



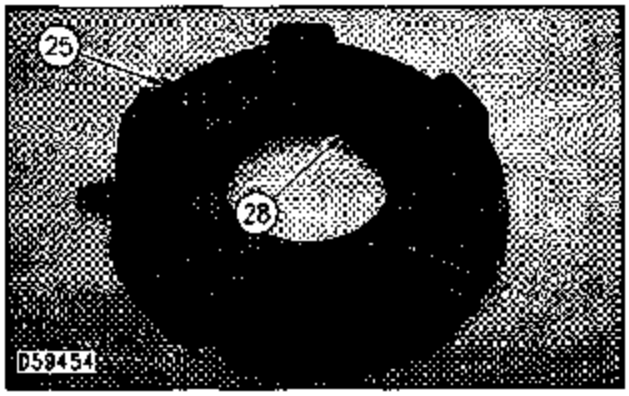
28. Mark the radial position of the upper and lower caps. Remove six bolts and washers and upper cap (24). Remove lower cap (25) from the upper portion of the front hitch.



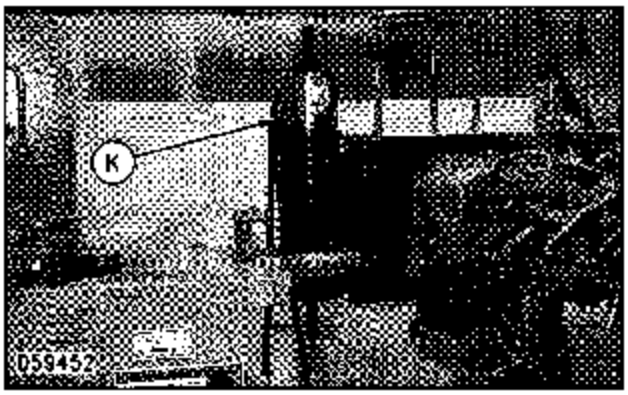
29. Remove shim pack (26) from the top side of the upper hitch.



30. Remove lip seal (27) from upper cap (24).



31. Remove lip seal (28) from lower cap (25).



32. Use tooling (K) to remove the bearing cups and cones from the upper hitch.

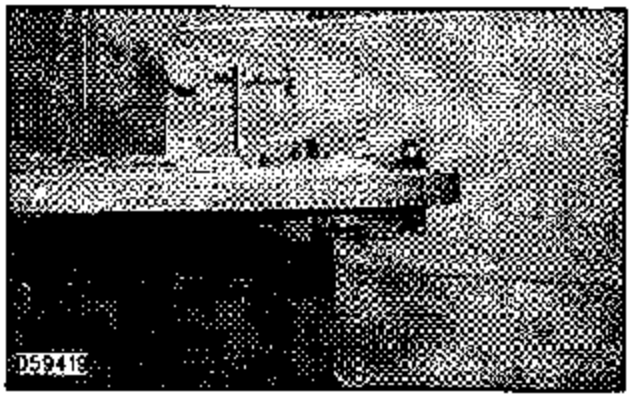
Connect Main Frames 7051-077

	Tools Needed	A	B	C	D	E	F	G
9U-7536	Lift Stand (55 Ton)	2						
4C-5809	Electric Pump Group	1						
6V-6146	Load Leveler		1					
1U-8231	Lifting Strap		2					
1U-5230	Manual Pump Group			1				
1D-5976	Bolt 7/8" - 9NC 7" Long				1			
1B-4332	Nut 7/8' - 9NC				2			
1P-1837	Bearing Pulling Adapter				2			
8F-6302	Bolt 1/4" - 20 NC X 3.75" long					1		
1B-4330	Nut 1/4" - 20NC					2		
1P-0502	Drive Plate					2		
5P-6215	Stand						2	
1P-0520	Driver Group							1

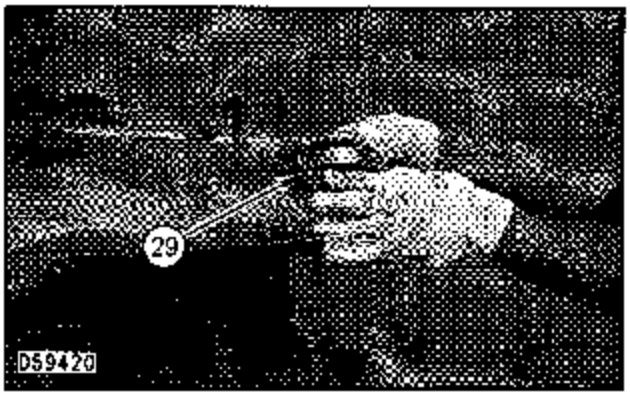
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

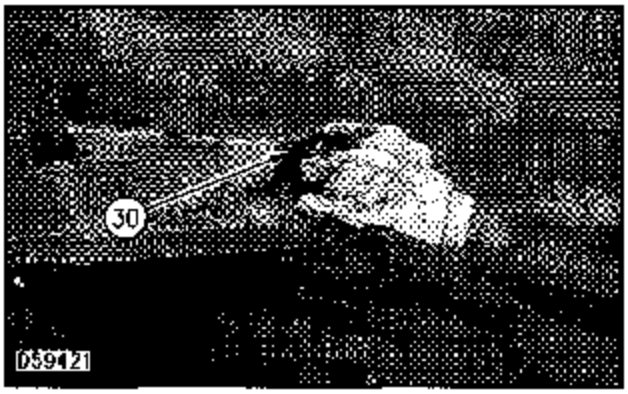
1. Insure that the bores in both the upper and lower hitch areas are completely clean and free of any dirt or debris prior to the installation of new parts. Any dirt or debris in the hitch area will cause incorrect measurements for the shimming process.



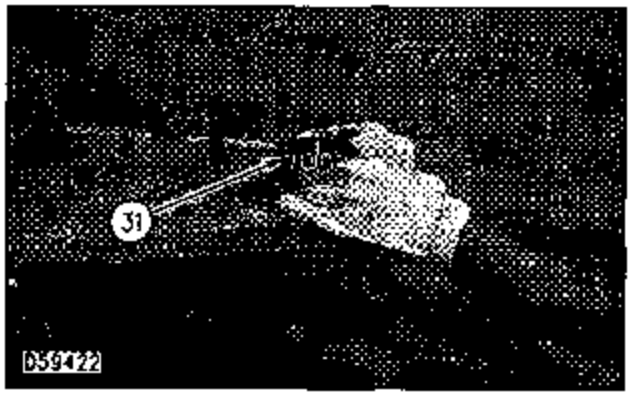
2. Install lower cap (25) on the upper front hitch using three equally spaced bolts as shown.



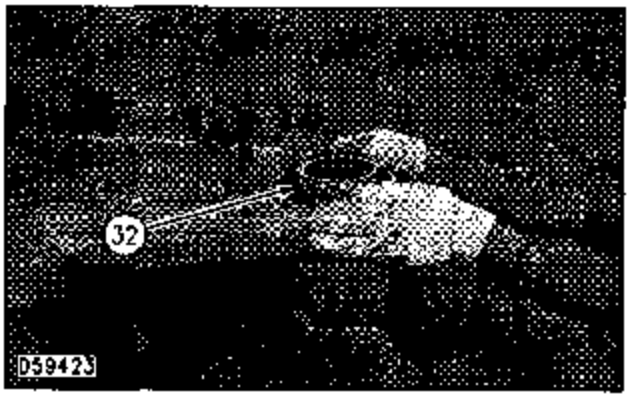
3. Coat the bore of the upper front hitch with **5P0960 Multipurpose Grease** . Lower the temperature of bearing cup (29) as shown. The large opening of the cup should be facing upward. Drive the cup downward until contact is made with the lower cap.



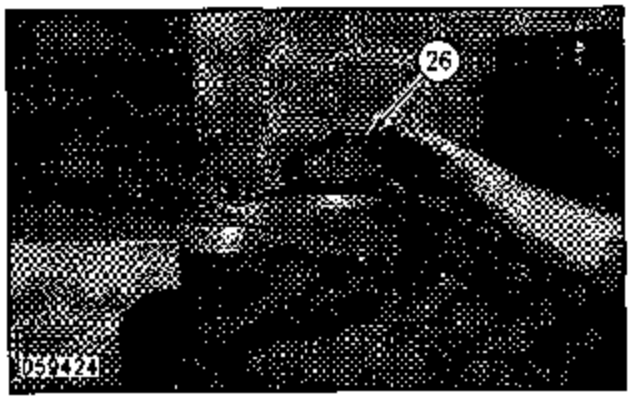
4. Lubricate bearing cone (30) with **5P0960 Multipurpose Grease** and install in the upper hitch bore facing downward as shown.

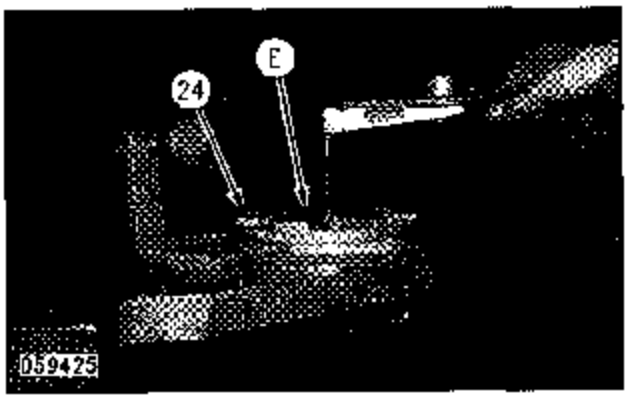


5. Lubricate bearing cone (31) and install in the upper hitch bore facing opposite bearing cone (30).



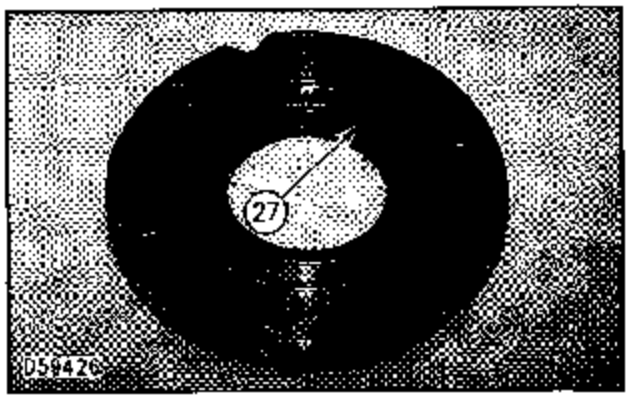
6. Lower the temperature of upper bearing cup (32) to **-75° C ± 5° C (-43°F ± 5° F)** and install in the upper hitch as shown. Drive bearing cup (32) down to insure light contact pressure on cones.



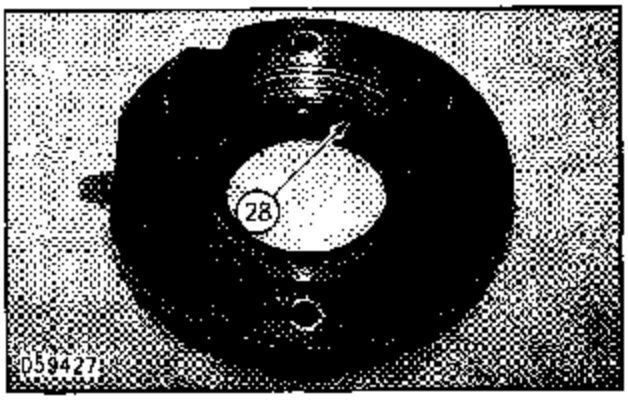


7. Instal original shim pack (26) under top cap (24). Fasten the assembly together with three equally spaced bolts and washers. Tighten the bolts to a torque of **70 ± 15 N•m (52 ± 11 lb ft)**. Install tooling (E). Using tooling (E) and a torque wrench, slowly turn the bearing cones to check the amount of rolling torque. The correct rolling torque is **2.3 to 13.6 N•m (1.7 to 10 lb ft)**. Adding shims will decrease the rolling torque. Removing shims will increase the rolling torque.

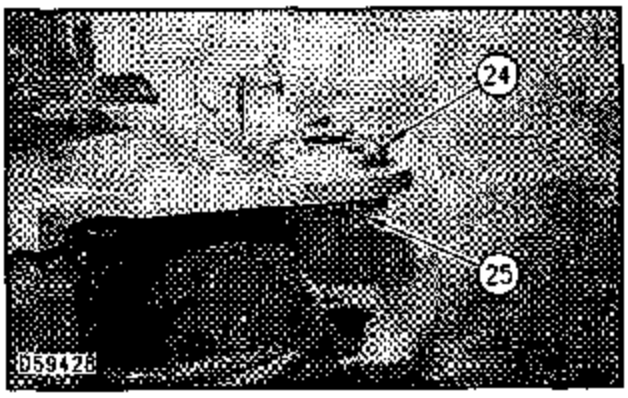
8. When the correct amount of rolling torque is obtained, remove the upper and lower caps and tooling (E).



9. Install lip seal (27) in the upper cap using tooling (G). The proper installation of the seal is with the sealing lip facing toward the outside of the cap.

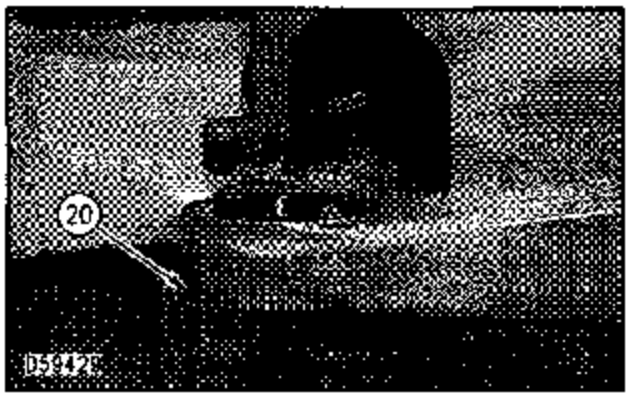


10. Install lip seal (28) in the lower cap using tooling (G). The proper installation is with the sealing lip facing toward the inside of the cap.

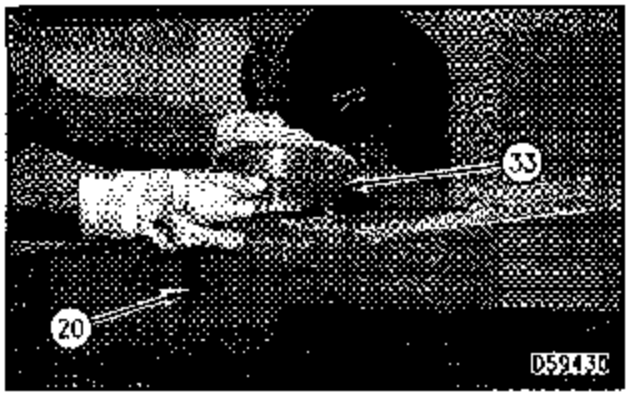


11. Lubricate the lip seals with **5P0960 Multipurpose Grease.** Align the marks on upper cap (24) and lower cap (25) with marks on the lower hitch frame and reinstal with the proper amount of shims. Tighten the six bolts to a torque of **70 ± 15 N•m (52 ± 11 lb ft)**. This completes the assembly of the upper front hitch bearings.

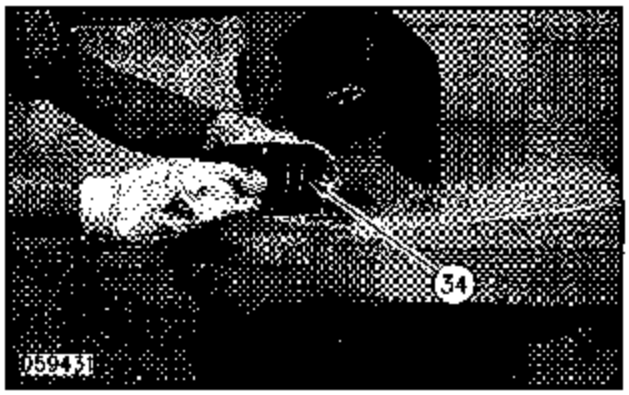
NOTE: The following steps are for assembly of the lower hitch bearings.



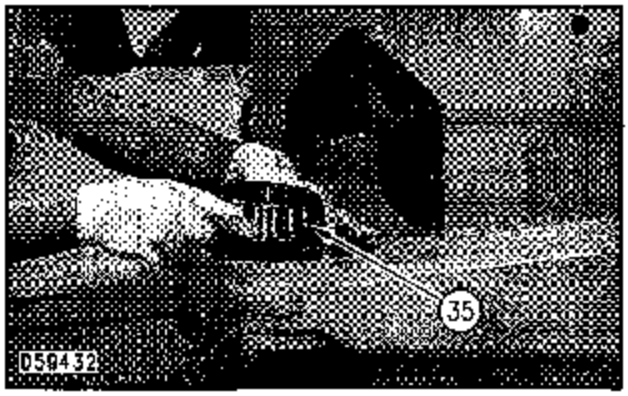
12. Fasten lower cap (20) to the lower rear hitch with four equaly spaced bolts as shown.



13. Coat the bore of the lower rear hitch with **5P0960 Multipurpose Grease. Lower the temperature of bearing cup (33) to -75° C ± 5° C (-43°F ± 5° F)** and install in the lower hitch facing upward as shown. Drive cup (33) down to insure contact with lower cap (20).

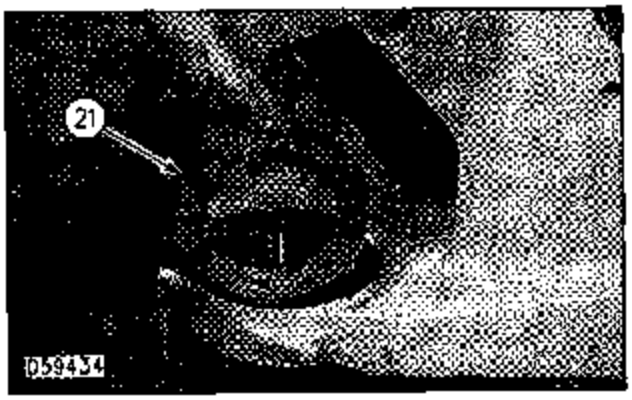


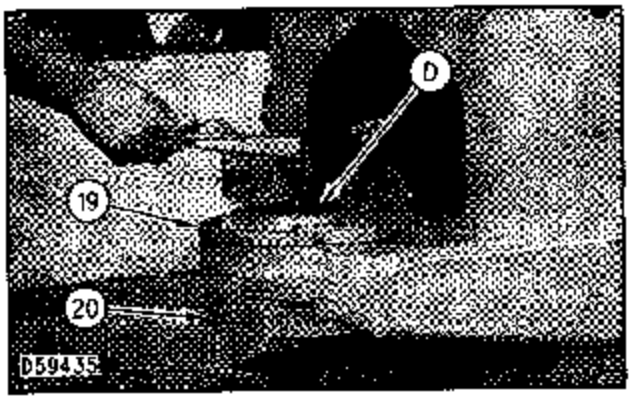
14. Lubricate bearing cone (34) and install in the lower hitch bore facing downward as shown.



15. Lubricate bearing cone (35) and install in the lower hitch bore facing opposite bearing cone (34).

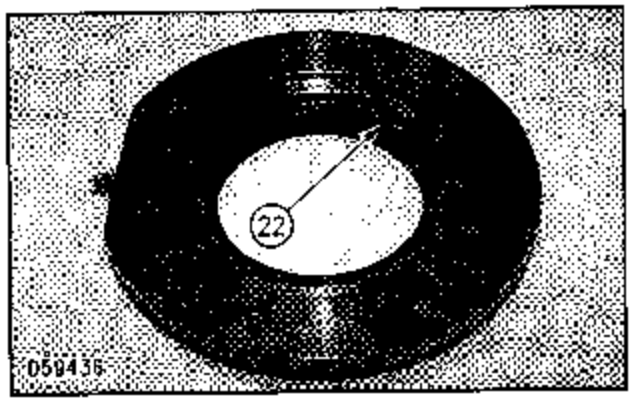
16. Lower the temperature of upper bearing cup (36) to **-75° C ± 5° C (-43°F ± 5° F)** and install in the lower hitch bore as shown. Drive bearing cup (36) down to insure light contact pressure on bearing cones.



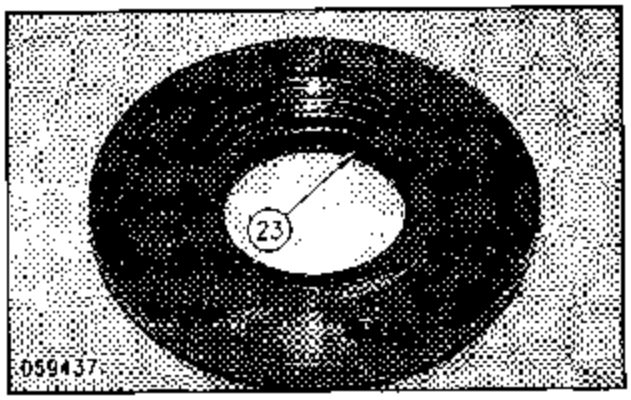


17. Install the original shim pack (21) under the upper cap (19). Fasten upper cap, shim pack and lower cap to lower hitch with four equally spaced bolts and washers. Tighten the bolts to **105 ± 20 N•m (78 ± 15 lb ft)**. Install tooling (D) on the bearing cones. Using tooling (D) and a torque wrench, slowly turn the bearing cones to check the amount of rolling torque is **7.9 to 22.6 N•m (5.8 to 16.7 lb ft)**. Adding shims will decrease the rolling torque. Removing shims will increase the rolling torque.

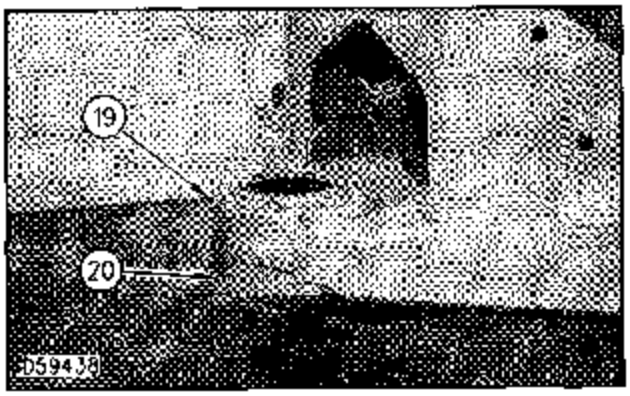
18. When the correct amount of rolling torque is obtained, remove the upper and lower caps and tooling (D).



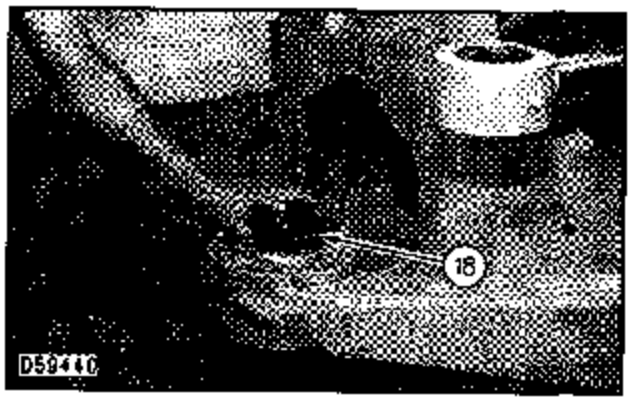
19. Install lip seal (22) in the upper cap using tooling (G). The proper installation is with the sealing lip facing toward the inside of the cap.



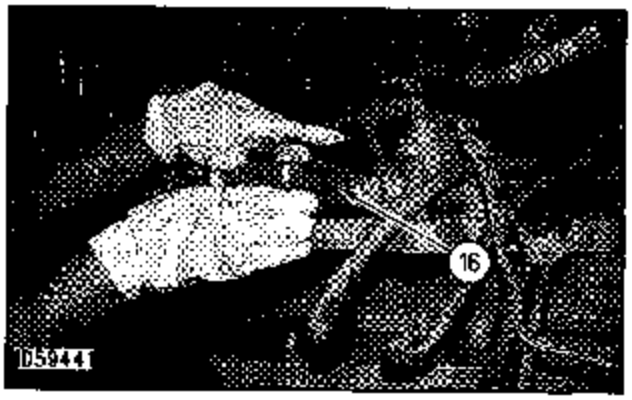
20. Install lip seal (23) in the lower cap using tooling (G). The proper installation is with the sealing lip facing toward the inside of the cap.



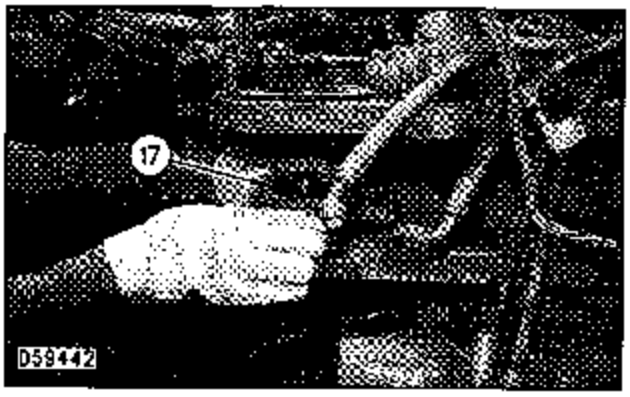
21. Lubricate the lip seals in the upper and lower caps with **5P0960 Multipurpose Grease**. Align the marks on upper cap (19) and lower cap (20) with the marks on the lower hitch frame and reinstall with the proper amount of shims. Tighten eight bolts to a torque of **105 ± 20 N•m (78 ± 15 lb ft)**.



22. Install spacer (18) in lower hitch. This completes the assembly of the lower hitch bearings.

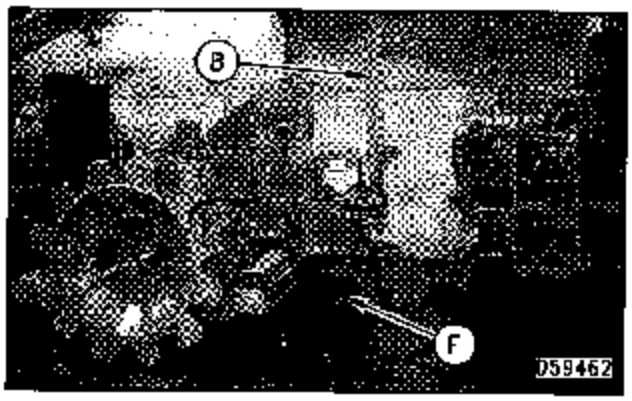


23. Coat the upper rear hitch bores with **5P3931 Anti-seize Compound** Lower the temperature of bearing collar (16) to **-75° C ± 5° C (-43°F ± 5° F)** and install into the upper bore of the upper portion of the rear hitch as shown.

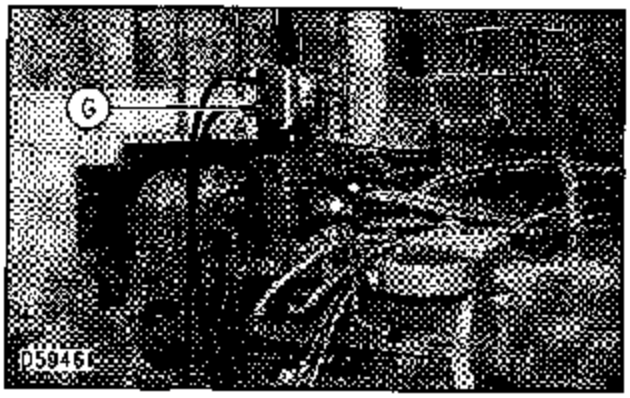


24. Lower the temperature of sleeve bearing (17) to **-75° C ± 5° C (-43°F ± 5° F)** and install into the lower bore of the upper rear hitch.

NOTE: The following steps are necessary for the connection of the front and rear main frames.

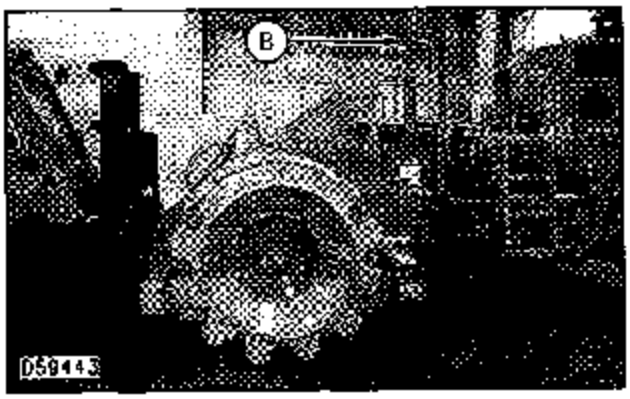


25. Raise the front main frame at the hitch with tooling (B) high enough to remove tooling (F). Remove tooling (F).



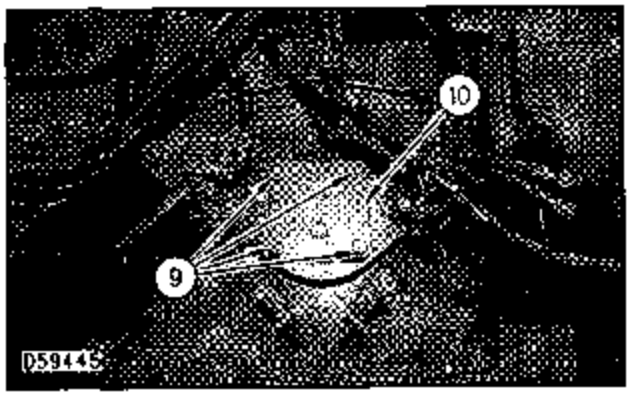
26. Using a lift truck and tooling (B), carefully push the the front main frame toward the rear main frame. Be sure to move hoist and tooling (B) with the front main frame until the front and rear hitches are in alignment.

NOTE: Use a chain or other suitable device to secure the front main frame to the mast of the lift truck.

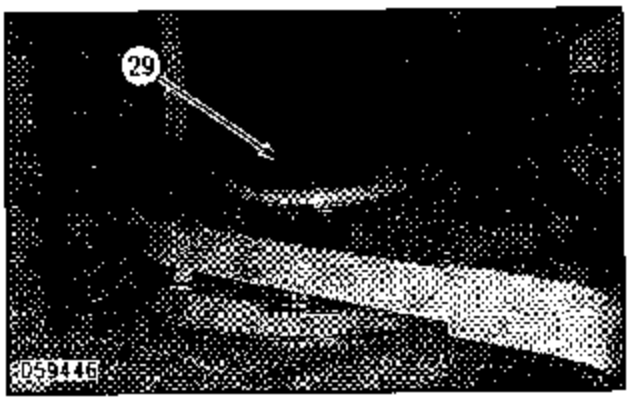


27. Use tooling (B) and a hoist to raise or lower the front main frame at the hitch. Use tooling (A) to raise or lower the rear main frame at the hitch.

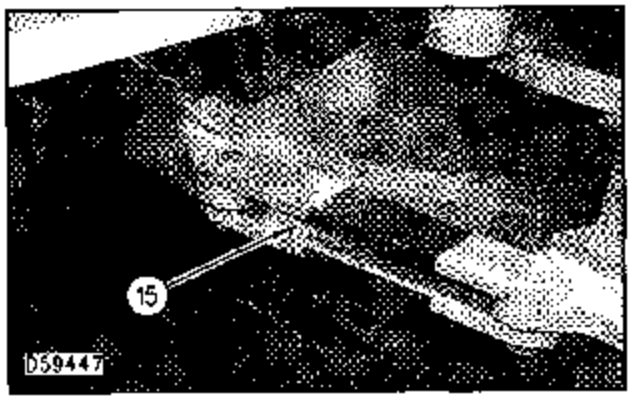
NOTE: Tooling (A) (hydraulic lift stands) can be operated independently to help align the upper and lower pin bores from from side to side as well as front to rear.



28. Coat upper pin bore with **5P3931 Anti-seize Compound.** Install upper hitch pin (10). Fasten pin in place with four bolts and washers (9). Do not tightenbolts (9) at this time.

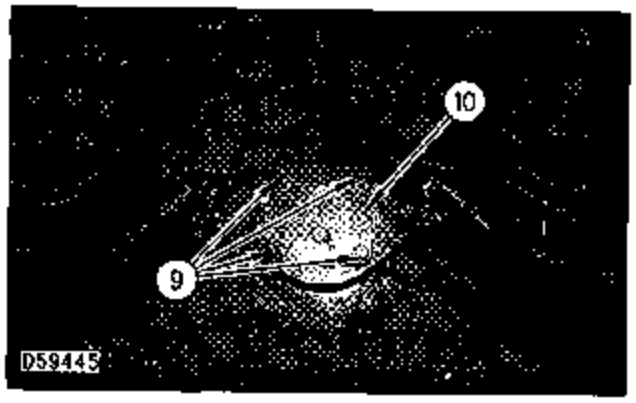


29. Coat lower hitch pin bore with **5P3931 Anti-seize Compound.** Install lower hitch pin (29) as shown.



30. Connect the steering frame lock link (15). See topic "Remove And Install Steering Frame Link Lock" in this module.

31. Install spacer (14) in the lower front hitch frame from the bottom as shown. Spacer (14 is a slip fit in the lower hitch bores if the two main frame bores are properly aligned.

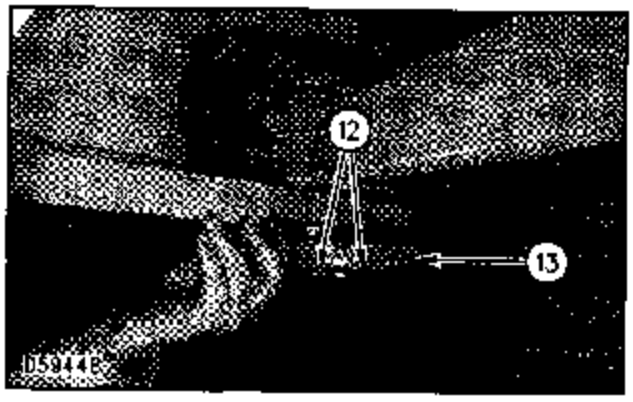


32. With the lower hitch pin and spacer installed, tighten the upper hitch pin bolts (9) as follows:

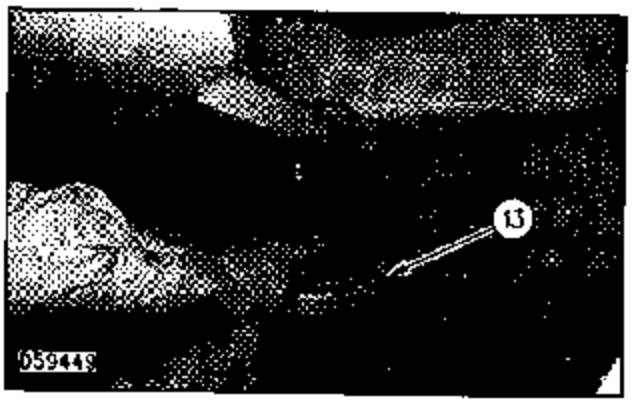
a. Tighten two diagonally opposite bolts an equal amount.

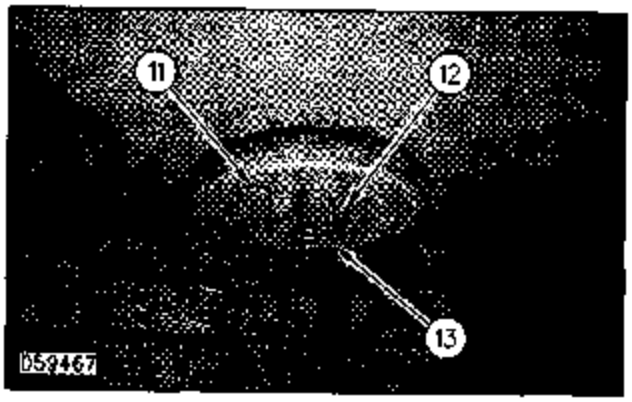
b. Tighten the two remaining bolts an equal amount.

c. Repeat this procedure until all bolts are tighten to a torque of **105 ± 20 N•m (78 ± 15 lb ft)**.

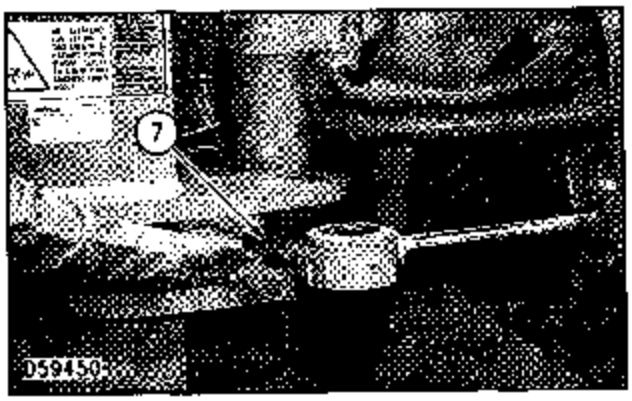


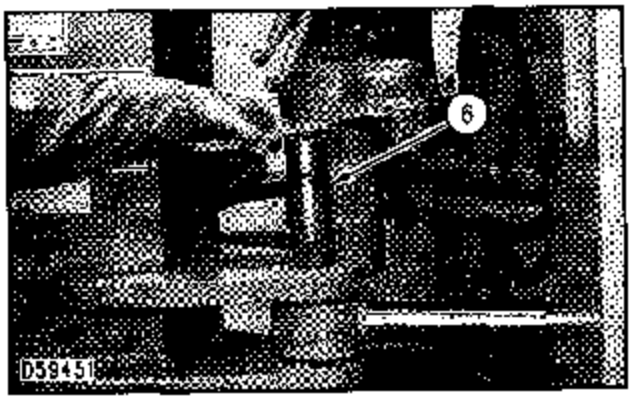
33. Install lower plate (13) with two bolts and washers (12) **180 degrees apart**. Tighten the bolts to a torque of **68 ± 14 N•m (50 ± 10 lb ft)**. Measure the gap 360 degrees around with a feeler gauge, between the front main frame and plate (13).



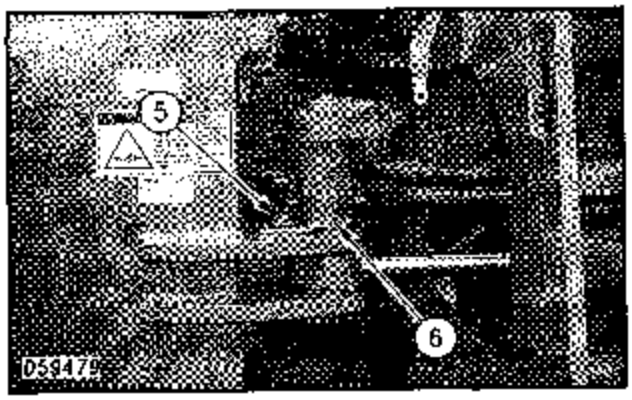


34. Remove plate (13). Install shim under plate (13) equal to the minimum measurement found in step 32 **minus 0.25 mm (.010 in)**. Fasten plate (13) to lower hitch pin with four bolts and washers (12). Fasten plate (13) to the frame with six bolts and washers (11). It may be necessary to rotate the plate and the lower pin slightly to align the holes for bolts (11). Tighten bolts (12) to a torque of **215 ± 4 N•m (159 ± 30 lb**. Tighten bolts (11) to a torque of **105 ± 20 N•m (78 ± 15 lb ft)**.



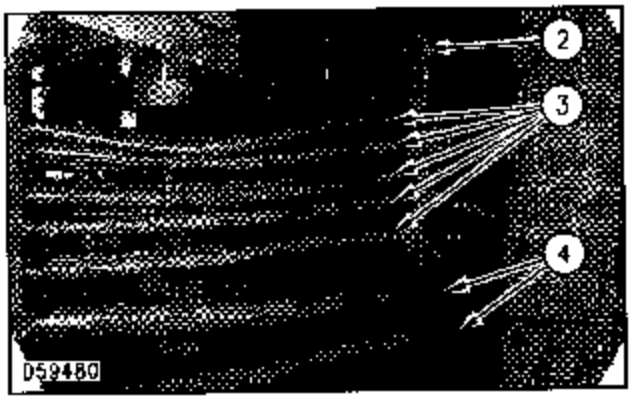


35. Install washers (7) on the lower side of steering cylinder rod as shown. Install steering cylinder flag pin (6).



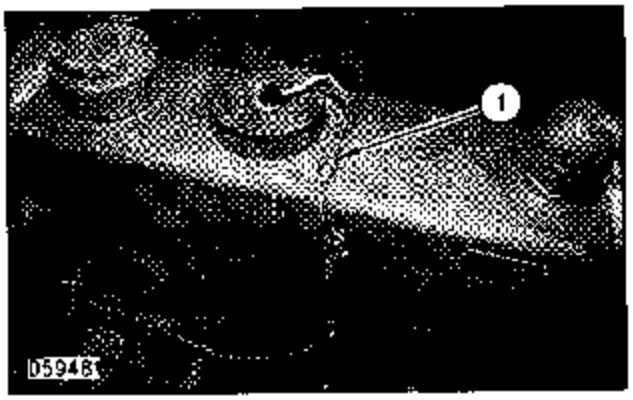
36. Fasten steering cylinder flag pin (6) to the front main frame with one bolt, washer and spacer (5). Tighten the bolt to a torque of **370 ± 50 N•m (274 ± 37 lb ft)**.

37. Repeat steps 35 and 36 for the opposite side of the machine.



38. Connect hose assemblies (4) to their original locations.

39. Install bracket (2) and connect ten hose assemblies (3) to their original locations.



40. Connect fuel sender assembly at electrical connection (1).

41. Fill the hydraulic tank with clean or new hydraulic oil.

End By:

a. install cab

b. install center drive shaft

c. install steering frame lock link

d. install bulldozer blade group

Hydraulic Control Valve

Remove & Install Hydraulic Control Valve 5051-010

Start By:

a. remove cab

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

1. Release pressure in the hydraulic system as follows:

   a. Move the lift control to the "float Position".

   b. Shut off the engine.

   c. Move the lift control lever to the "Hold Position".

   d. Carefully loosen the filler cap on the hydraulic oil tank to release pressure.

   e. Carefully loosen the fittings on the blade lift cylinder, but do not remove. Place a container under the fittings to prevent oil spillage to the ground. When the oil from the loosened fittings stops running, tighten the fittings.

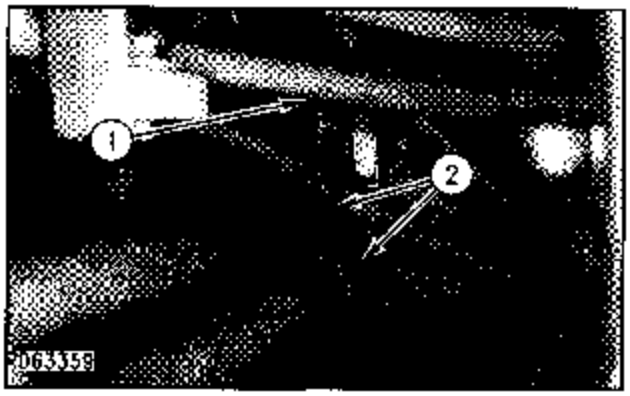
   f. Tighten the filler cap on the hydraulic oil tank.

   h. The pressure in the hydraulic system has now been released.

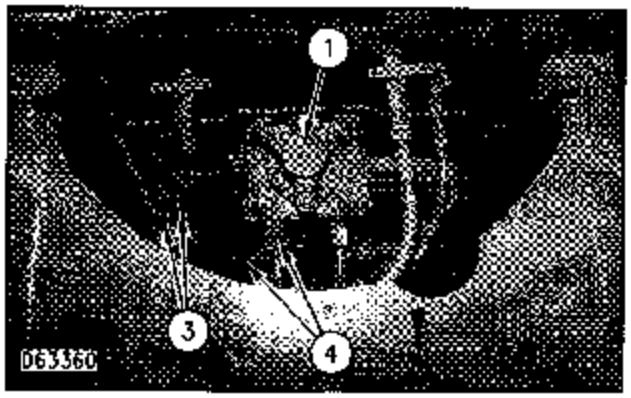
⚠ WARNING

At operating temperature, the hydraulic oil, the hydraulic oil tank, hoses and fittings are hot and under pressure. Hot oil can cause burns. Remove the fill plug only when the engine is stopped and the fill plug is cool enough to touch with your bare hand.

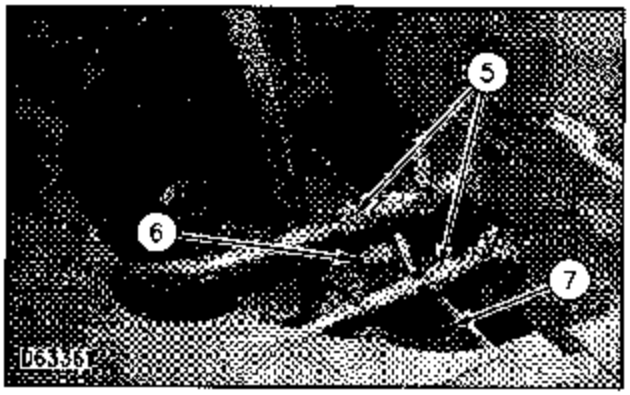
NOTE: Place identification marks, caps and plugs on all tube and hose assemblies to assist in installation and and prevent fluid loss.



2. Disconnect two lines (2) from bottom of hydraulic control valve (1).



3. Disconnect four hydraulic hoses (3) (two on each side) from the sides of the hydraulic control valve (1). Disconnect four steel lines (4) from the back of the hydraulic control valve.



4. Fasten straps and hoist to hydraulic control valve as shown.

5. Disconnect two fuel lines (5) from back of fuel tank.

6. Remove three bolts, washers and nuts that connect hydraulic control valve (1) to plate (7).

7. Remove hydraulic control valve (1). Weightof the control valve is 55 lbs.

NOTE: Install the hydraulic control valve in the reverse order from removal.

8. After installation, check and refill the hydraulic system of any fluid loss. Start the engine and check for any leakage.
9. Operate the controls in several directions to insure that all air is purged from the system.

10. Recheck the hydraulic fluid level and add if necessary.

End By:

a. Install cab

Disassemble & Assemble Hydraulic Control Valve 5051-010

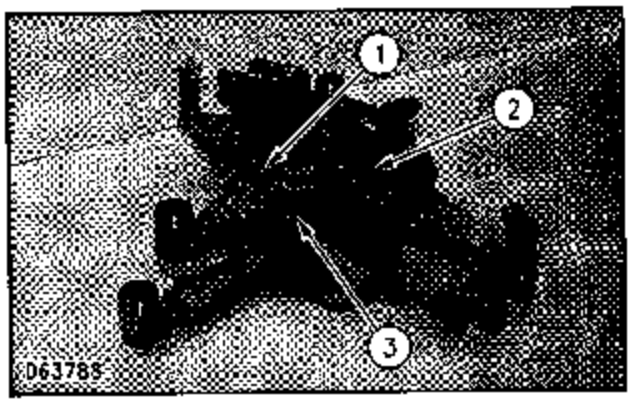
Start By:

a. remove hydraulic control valve

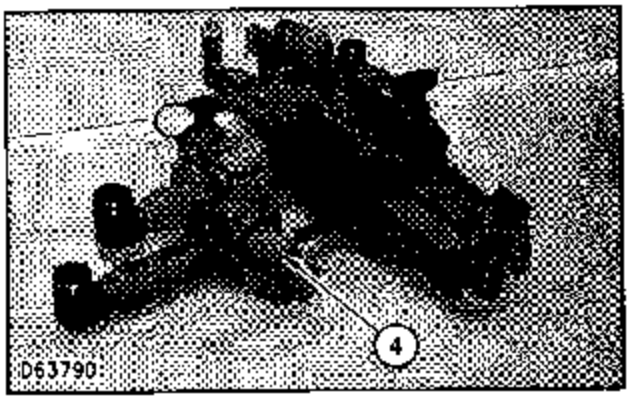
FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE, NENG2500", for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

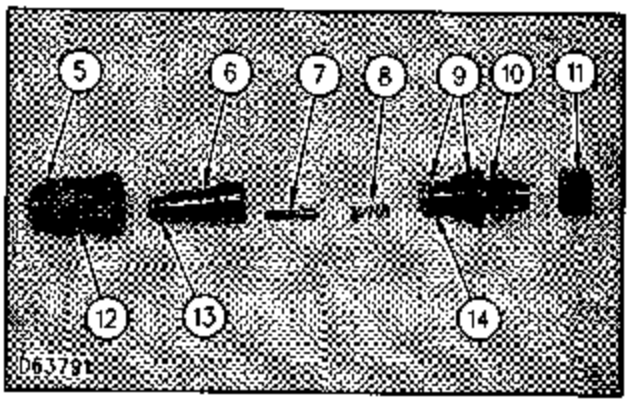
NOTE: Place identification marks on all valves and all components prior to disassembly. Do not mix parts from one valve to another. Even though some parts may fit the valve will not operate properly unless the exact parts are replaced into the proper valve.



1. Remove three nuts (1) from valve group (2). Remove valve assembly (3) from valve group (2).



2. Remove pilot relief valve (4) from valve assembly (3).



3. Disassemble pilot relief valve (4) as follows:

   a. Remove cap (11) from valve body (10).

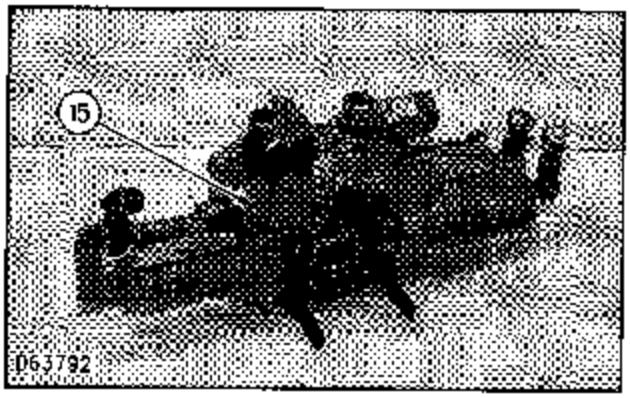
   b. Remove valve body cap (12) from valve body (10).

   c. Remove O ring (5) from valve body cap (12).

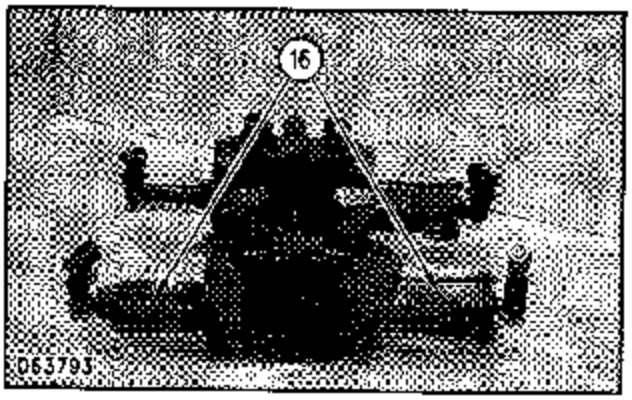
   d. Remove O-rings (9) and backup rings (14) (white) from valve body (10).

   e. Remove valve (6), poppet (7) and spring (8) from valve body cap (12).

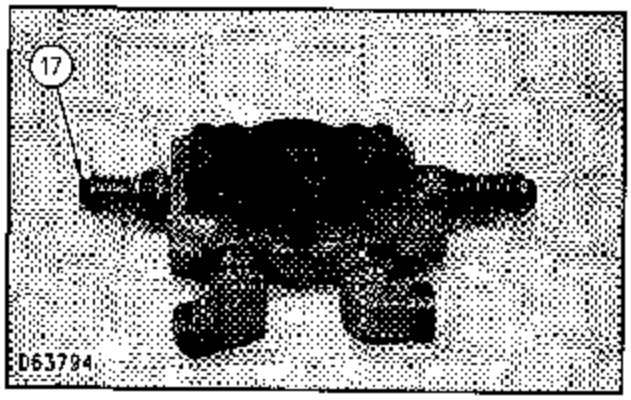
   f. Remove O-ring (13) and seal ring from valve (6).



4. Remove lift cylinder valve assembly (15) from valve group.



5. Remove four bolts and caps (16) from lift cylinder valve assembly.



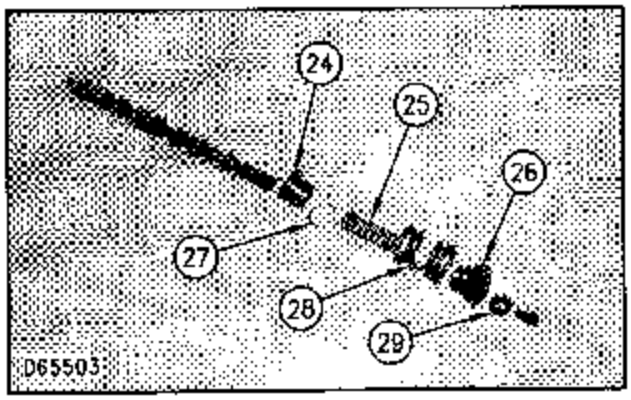
6. Disassemble valve spool (17) as follows:

   a. Remove bolt (23) and washer (22).

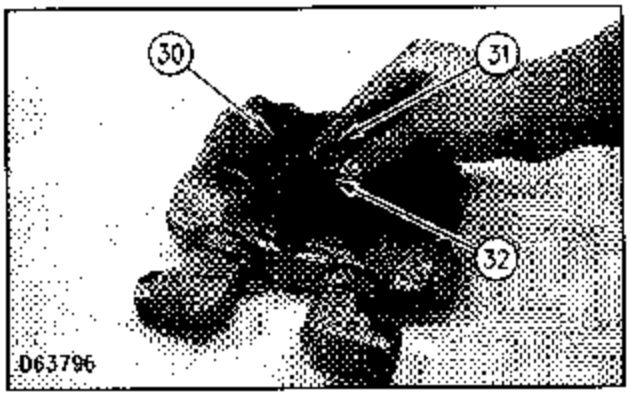
   b. Remove spacer (21) and spring (20).

   c. Remove washer (19) and adapter (18).

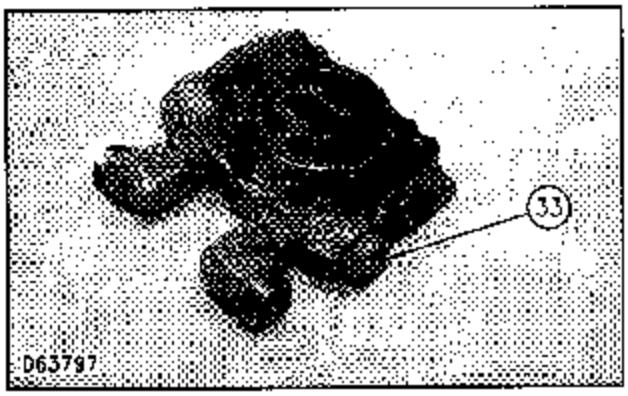
   d. Remove valve spool from valve assembly (17).



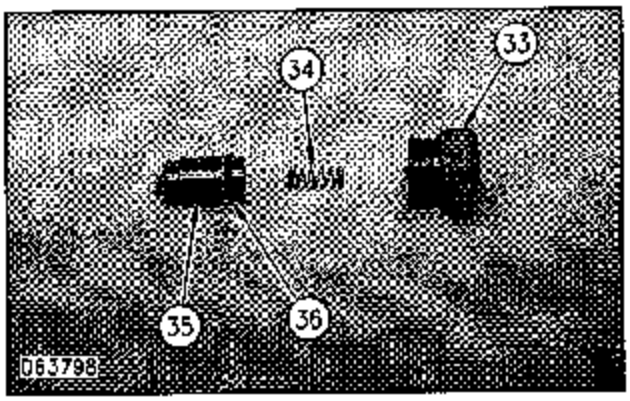
7. Remove bolt and washers (29), outside retainer (28), spring (25) and inside retainer (24) from spool. Remove shim (27) from inside retainer.



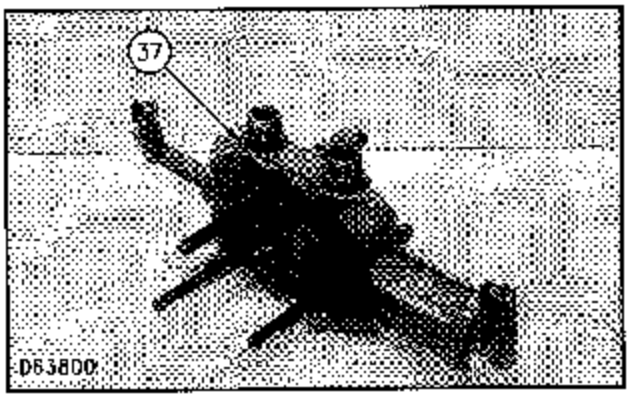
8. Remove O-ring (30), spring (31) and poppet (32) from lift cylinder valve assembly.



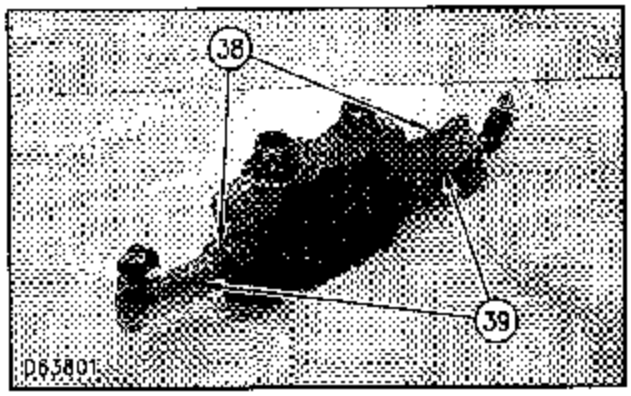
9. Remove plug (33) from lift control valve assembly. Remove O-ring from plug (33).



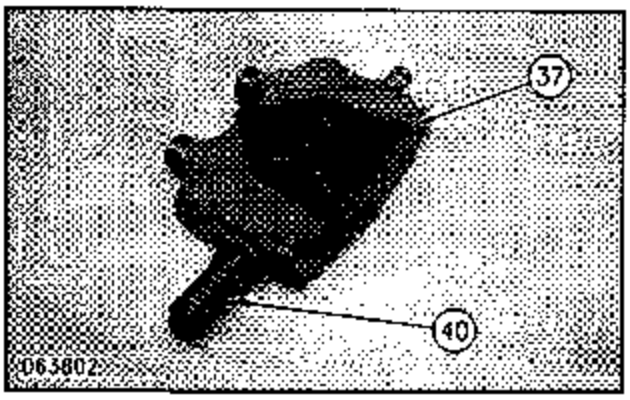
10. Remove spring (34) and check valve (35) from plug (33). Remove O-ring (36) from check valve (35).



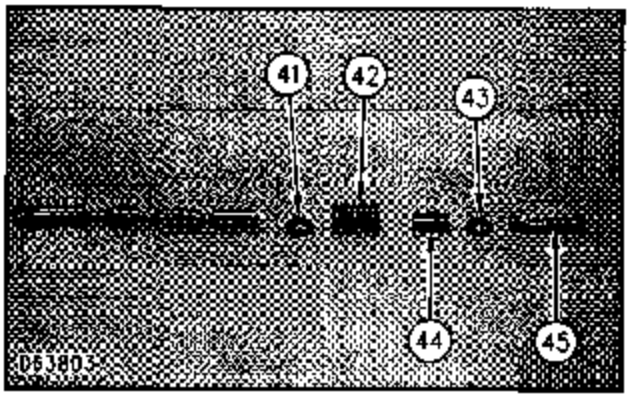
11. Remove tilt control valve assembly (37) from valve group (2).



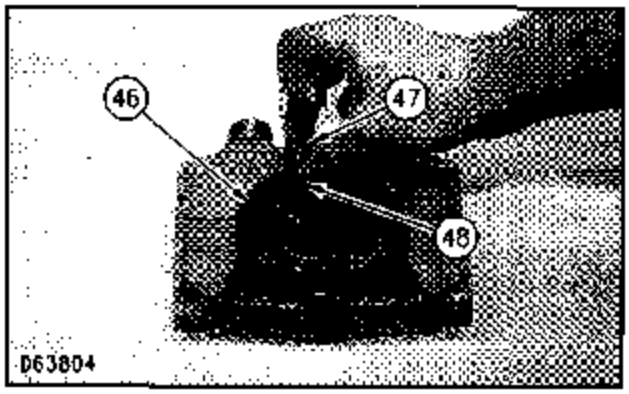
12. Remove four bolts (38) and caps (39) from tilt control valve assembly (37).



13. Remove valve spool (40) from tilt control valve assembly (37).

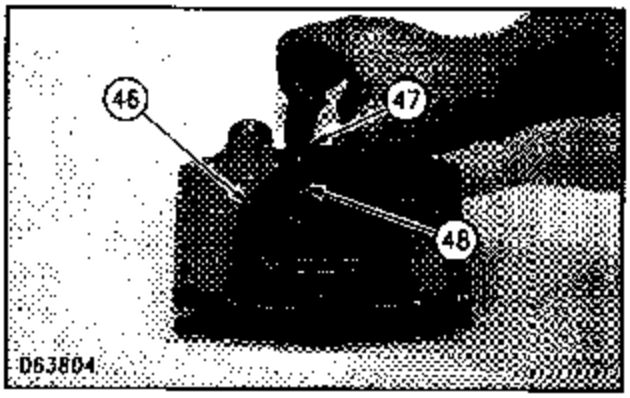


14. Disassemble spool assembly (40). Remove bolt (45), washer (43), spacer (44), spring (42) and washer (41) from the spool.

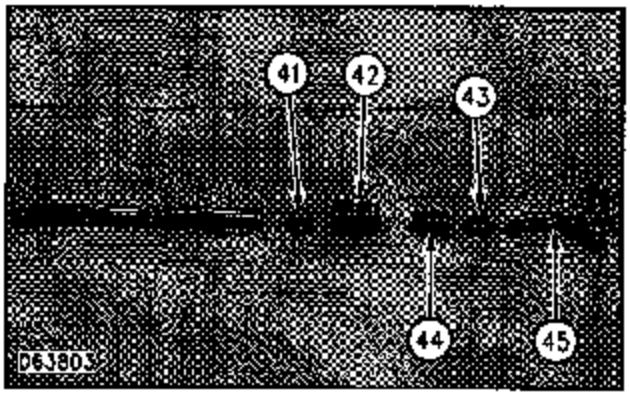


15. Remove O-ring (46), spring (47) and poppet (48) from tilt control valve assembly.

NOTE: The following steps are necessary for the assembly of the hydraulic control valve.



16. Install O-ring (46), spring (47) and poppet (48) in the tilt control valve assembly.



17. Assemble spool assembly (40) as follows:

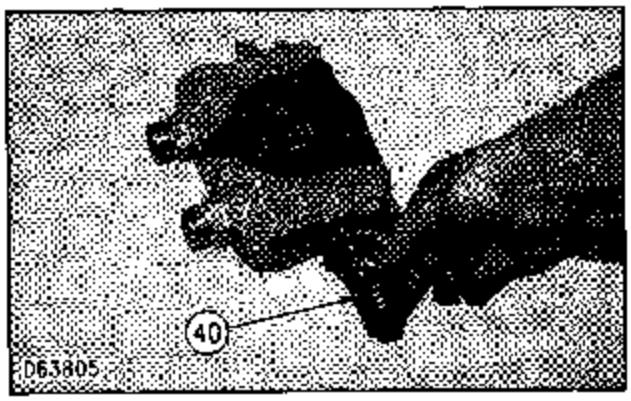
a. Install washer (43) onto bolt (45).

b. Install spacer (44) onto bolt (45).

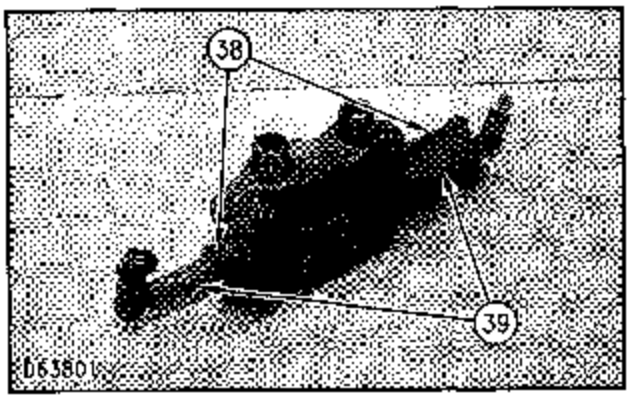
c. Install spring (42) over spacer (44) and onto bolt (45).

d. Install washer (41) onto bolt (45).

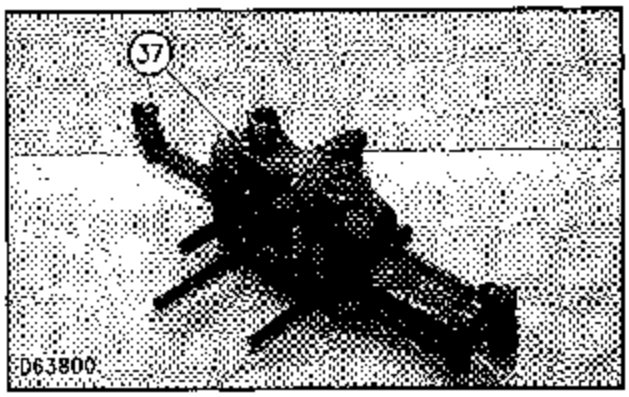
e. Thread bolt (45) into the end of spool and tighten to a torque of **7 ± 1 N•m (5 ± 1 lb ft).**



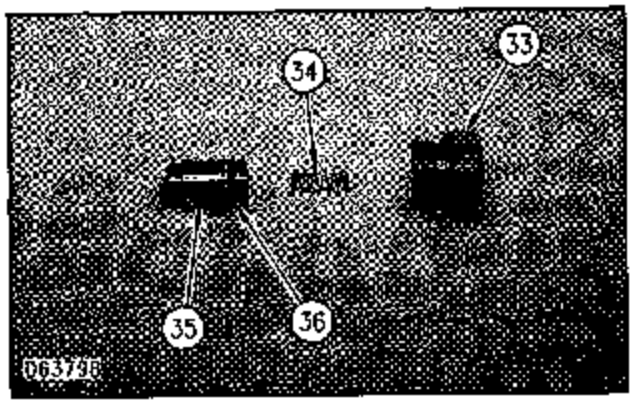
18. Install spool assembly (40) into valve assembly (37).



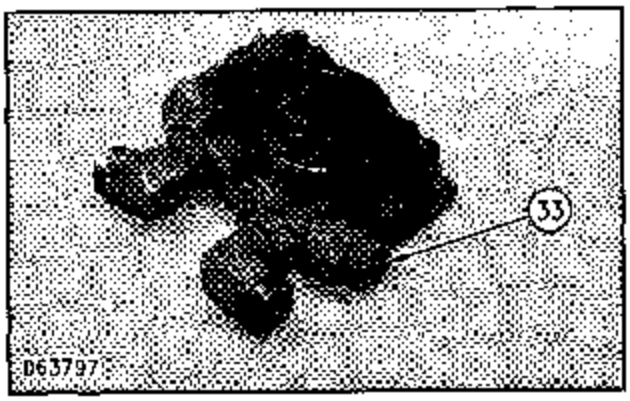
19. Install two valve spool caps (39) and four bolts that hold them to tilt control valve assembly (37). Tighten bolts to a torque of **7 ± 1 N•m (5 ± 1 lb ft)**.



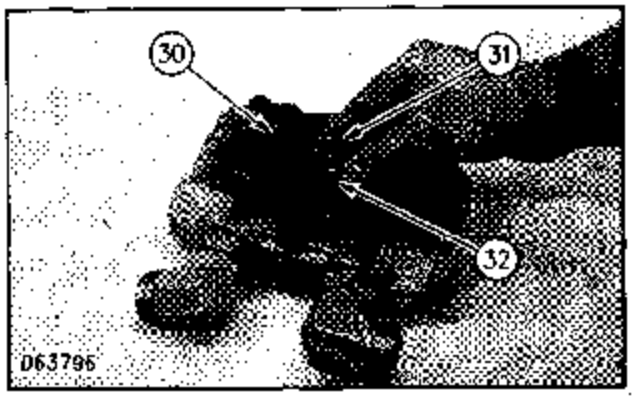
20. Install tilt valve assembly (37) to valve group (2).



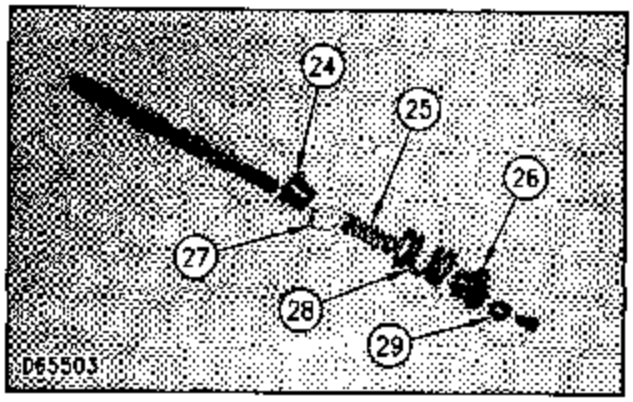
21. Install O-ring (36) on check valve (35). Install spring (34) and check valve in plug.



22. Install O-ring on plug (33). Install plug (33) into lift control valve assembly (15).



23. Install O-ring (30), spring (31) and poppet (32) in lift control valve assembly.



24. Assemble the spool assembly as follows:

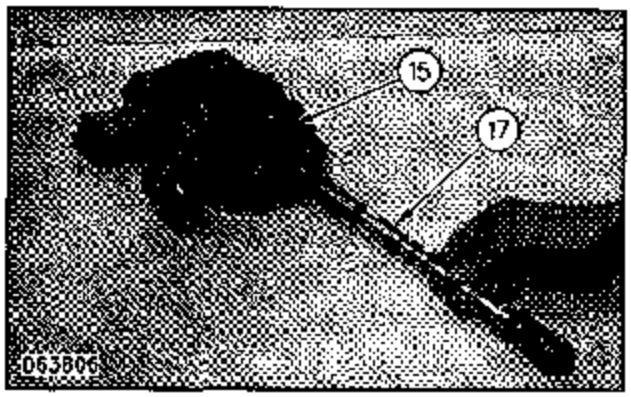
a. Install shim (27) into inside retainer (24).

b. Install inside retainer (24), and spring (25) onto the spool.

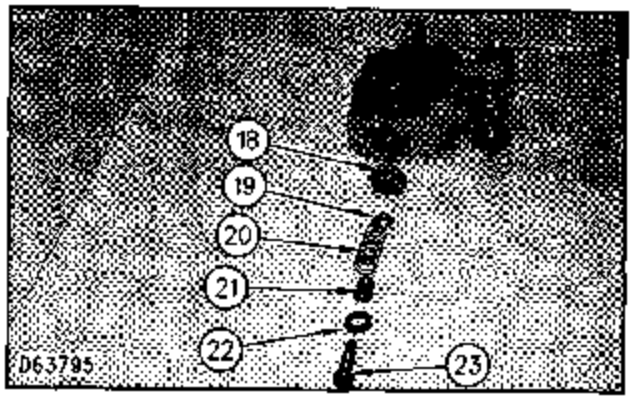
c. Install spring (28) and outside retainer (26) onto spool.

d. Install washer (29) and thread bolt onto the end of the spool.

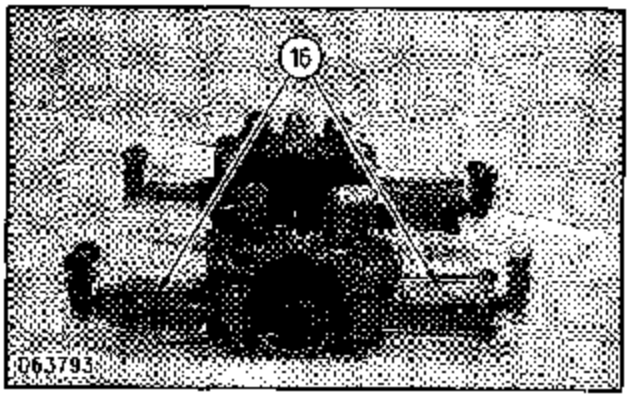
e. Tighten bolt to a torque of **10 ± 1 N•m (7 ± 1 lb ft)**.



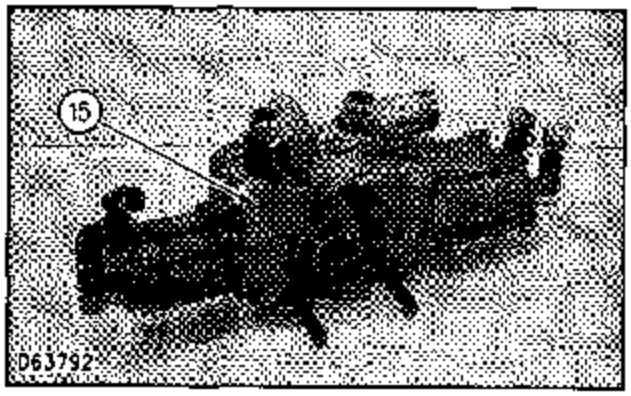
25. Install spool assembly (17) into lift control valve assembly (15) as shown.



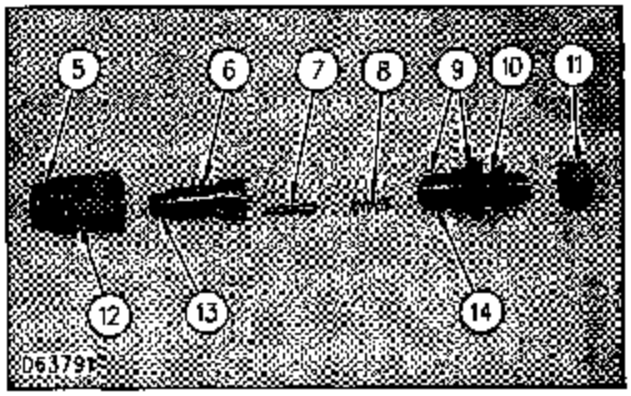
26. Install fitting (18), washer (19), spring (20), spacer (21), washer (22) and bolt (23) to end of valve spool. Tighten bolt to a torque of **10 ± 1 N•m (7 ± 1 lb ft)**.



27. Install two caps (16) that cover the ends of the valve spool and the four bolts that hold them in place.



28. Install lift control valve assembly (15) to valve group (2).



29. Assemble the pilot relief valve (4) as follows:

a. Install O-ring (13) and seal ring on valve (6).

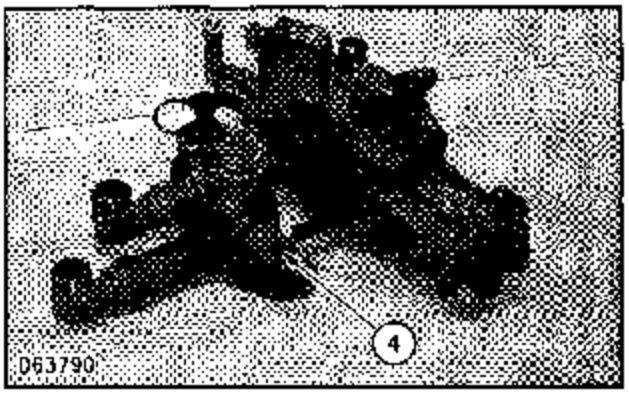
b. Install valve (6), poppet (7) and spring (8) into valve body cap (12).

c. Install O-rings (9) and back-up rings (14) (white) on valve body (10).

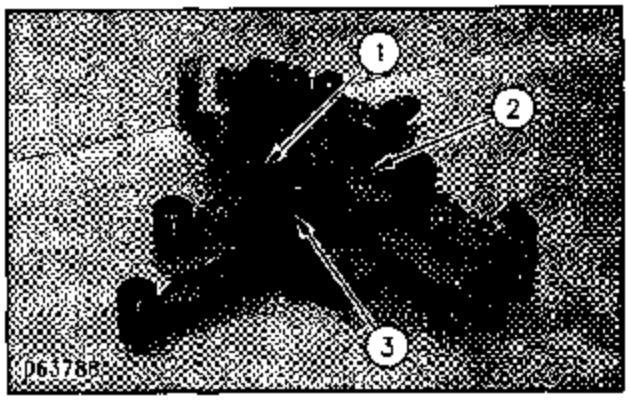
d. Install O-ring (5) on valve body cap.

e. Install valve body cap (12) on valve body (10).

f. Install cap (11) on valve body (10).



30. Install pilot relief valve (4) to valve assembly (3).



31. Install valve assembly (3) to valve group (2) and three nuts (1) that hold valve group together.

End By:

a. Install hydraulic control valve.

Parking Brake Group

Remove & Install Parking Brake Group 4267-010

Start By:

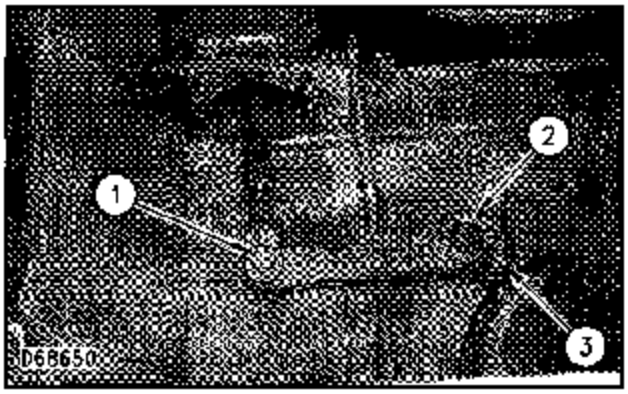
a. remove center drive shaft

1. Move machine to a level smooth location. Move machine away from other working machines and personal. Install blocks on all four steel wheels to prevent any possibility of machine movement.

2. Lower the blade to the ground.

3. Relieve all hydraulic pressure from the system prior to any work on the parking brake.

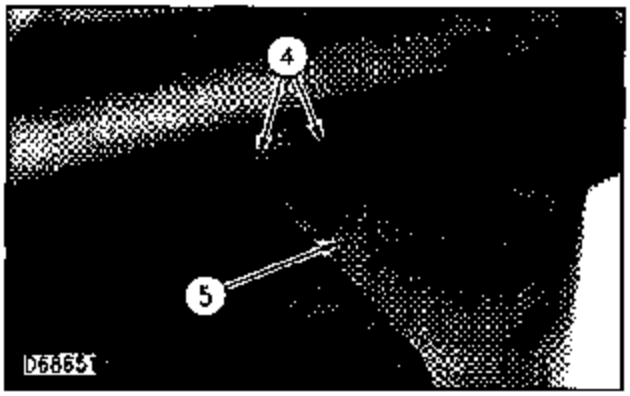
4. Install the steering frame lock link. See topic "Separate & Connect Steering Frame Lock Link" in this publication.



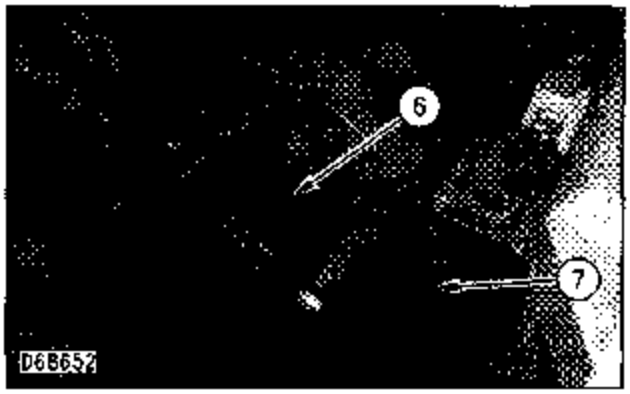
5. Remove cotter pin and pin and pin (1) from lever (2).

6. Place an alignment mark on lever (2) and the shaft for installation purposes.

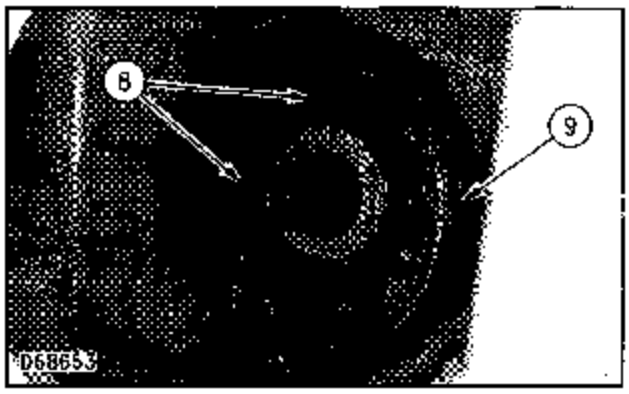
7. Loosen bolt (3) that secures lever (2) in position.



8. Remove four bolts (4) and plate (5).

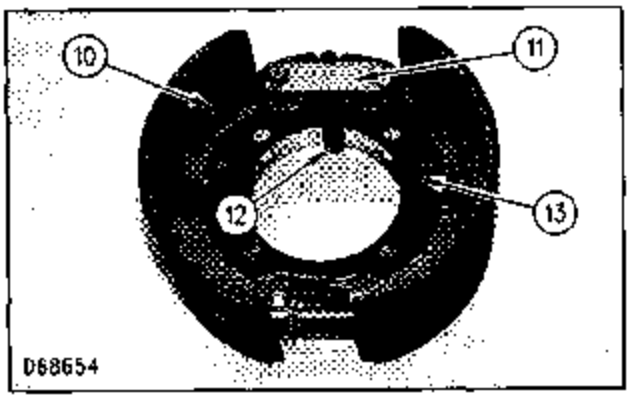


9. Remove bolt, plate and O-ring (6). Remove yoke and drum (7) as a unit. Place a mark on the splined end of the drive shaft for installation purposes.

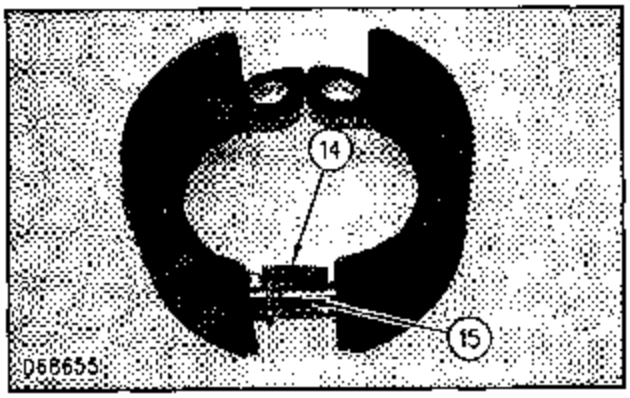


10. Remove four bolts and washers (8) and parking brake group (9).

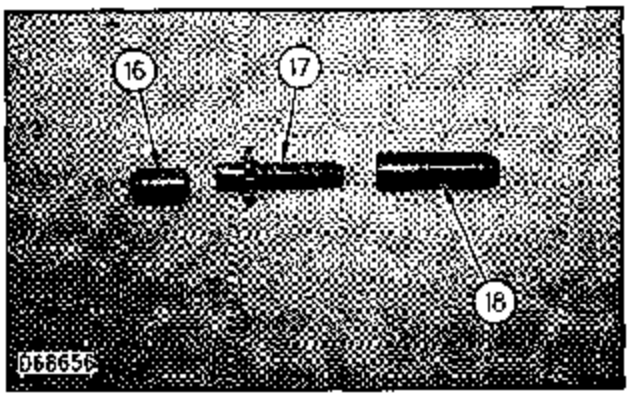
NOTE: Lever (2) and spring washer are free to fall when the brake shoe assembly is removed.



11. Remove two springs (10), anchor pin brace (11), cam (12) and plate assembly (13).

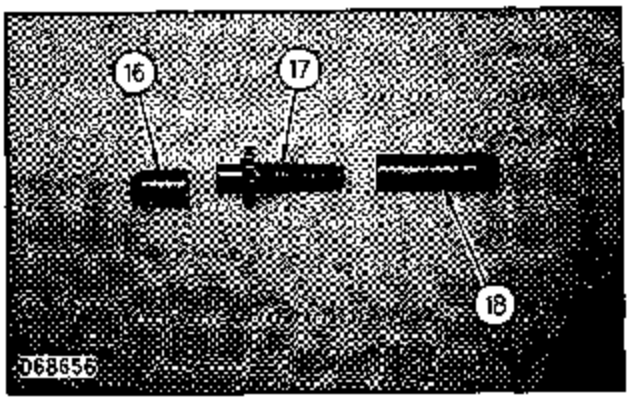


12. Remove spring (14) and adjuster assembly (15).

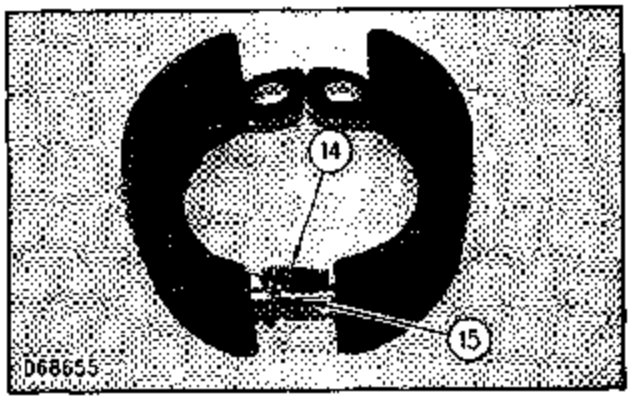


13. Remove sprocket (16), screw (17) from nut (18).

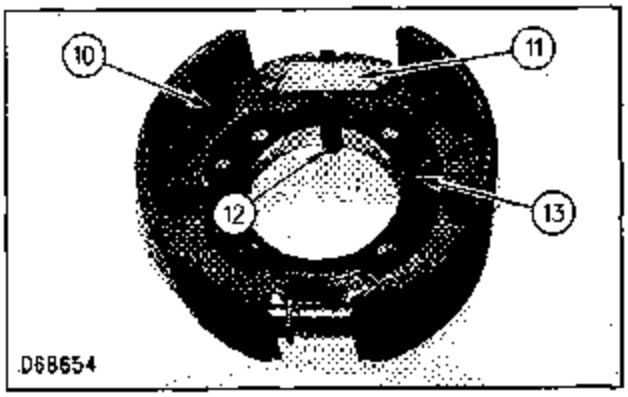
NOTE: The following steps are for the installation of the parking brake.



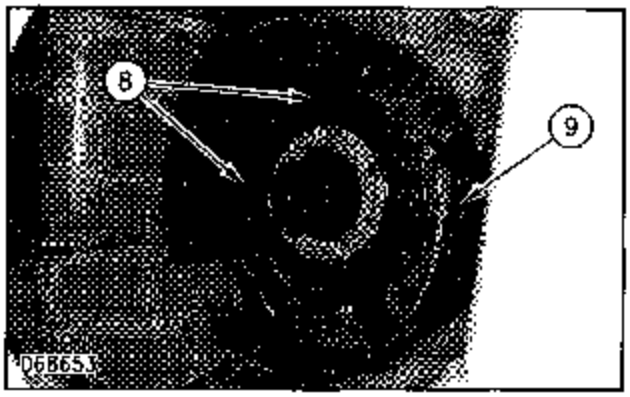
14. Install screw (17) in nut (18). Put socket (16) in position on the screw.



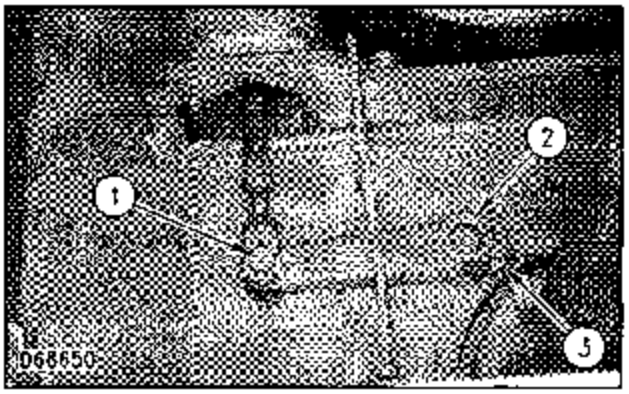
15. Install spring (14) and put the adjuster assembly (15) in position between the shoes.



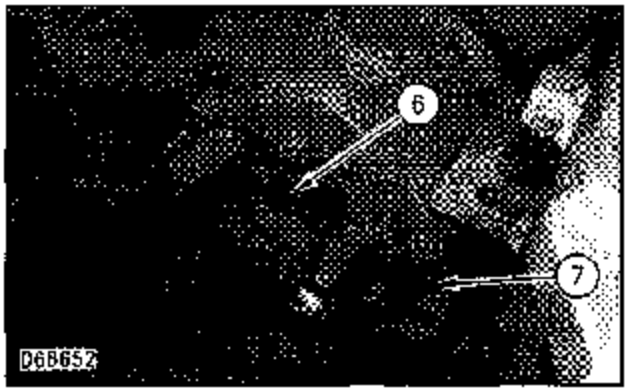
16. Put plate assembly (13) in position. Install cam (12), anchor pin brace (11) and springs (10) in position.



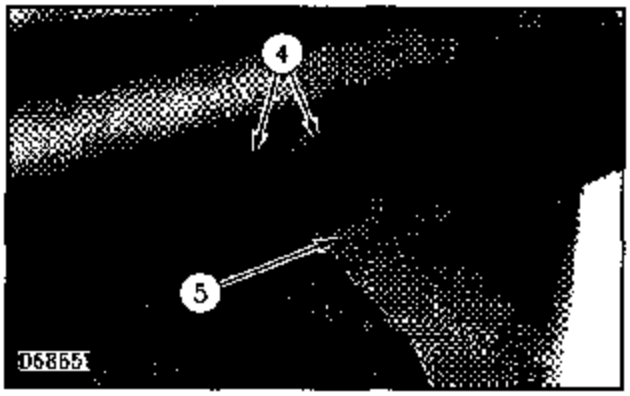
17. Put parking brake assembly (9) in place and install four bolts, and washers (8).



18. Install spring washer and lever (2) in its original position. Install bolt (3) that holds lever in position. Install Pin (1) and cotter pin.



19. Place drum and yoke unit (7) in position. Install bolt, retainer and O-ring (6). Tighten bolt (6) to a torque of **135 ± 15N•m (100 ± 11 lb ft)**.



20. Install plate (5) and bolts and washers (4) that secure it to the frame.

21. Adjust the parking brake. See 815F Systems Operation Test And Adjust Manual for proper parking brake adjustment.

22. Remove the Steering Frame Lock Link

23. Remove blocks from wheels.

End By:

a. install center drive shaft

Parking Brake Actuator

Remove & Install Parking Brake Actuator 5078-010

Tools Needed	A
Portable hydraulic pump	1

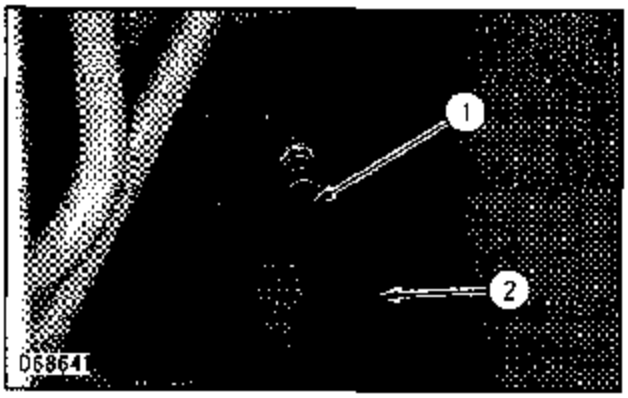
Start By:

a. install steering frame lock link

⚠ WARNING

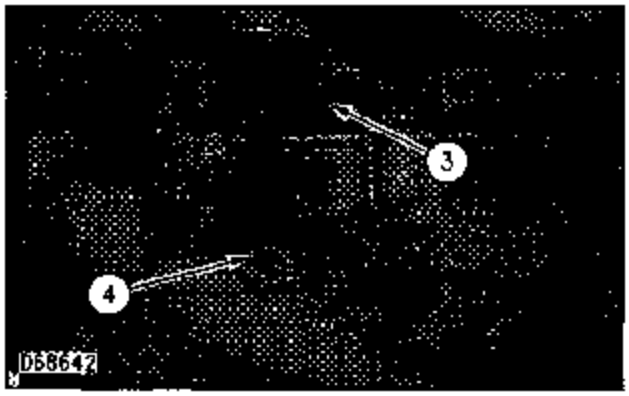
Be sure the engine has been shutoff for a minimum of five minutes and release all hydraulic pressure to be sure that the actuator oil pressure is zero. Failure to follow this procedure can result in personal injury.

1. Move machine to a level surface and lower the blade to the ground. Install blocks on all four wheels to prevent any machine movement.



2. Apply parking brake from the cab. This will release hydraulic pressure at actuator (2). Remove hose (1) and plug to prevent loss of hydraulic oil.

3. Connect tooling (A) to actuator (2). Apply enough hydraulic pressure to release the parking brake.



4. Remove cotter pin and pin (4). This will separate brake actuator yoke from parking brake lever. Remove two nuts and washers (3) securing brake actuator to machine frame. Remove parking brake actuator from the machine.

5. Disconnect tooling (A) from the brake actuator.

NOTE: Assemble parking brake in reverse order.

⚠ WARNING

Do not attempt to disassemble any portion of the parking brake actuator cylinder. It does not contain any serviceable parts and is under pressure Serious injury could result from any attempt to disassemble the parking brake actuator.

End By:

remove steering frame lock link

Brake Valve (Foot Operated)

Remove & Install Brake Valve (Foot Operated) 4269-010

Start By:

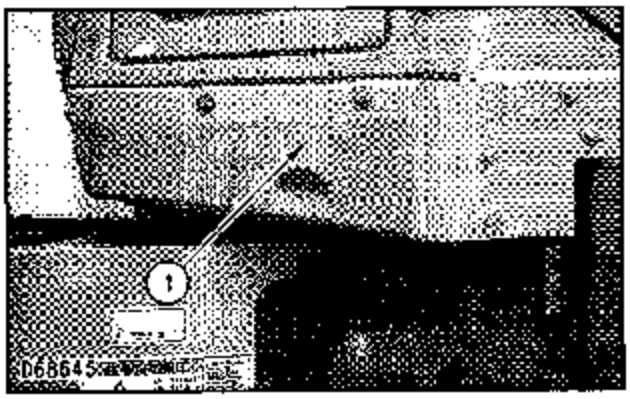
a. install steering frame lock link

b. remove brake pedal assembly

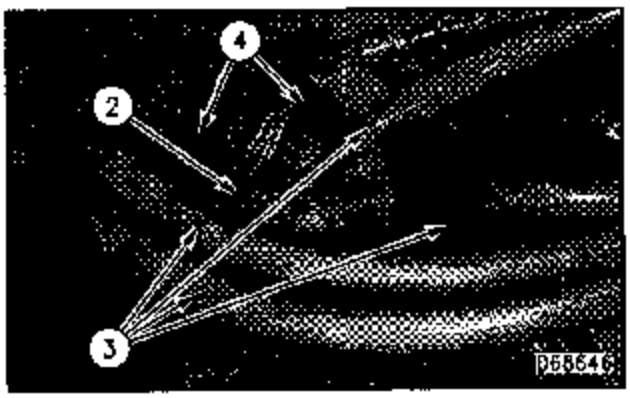
1. Move machine to a smooth flat location. Move away from working machines and personal.

2. Activate the parking brake. Lower the blade to the ground. Put wood blocks in front and behind each of the wheels.

3. Relieve all pressure from the hydraulic system.



4. Remove bolts and washers (1) that hold cab panel. Remove cab panel from the lower front of the cab.



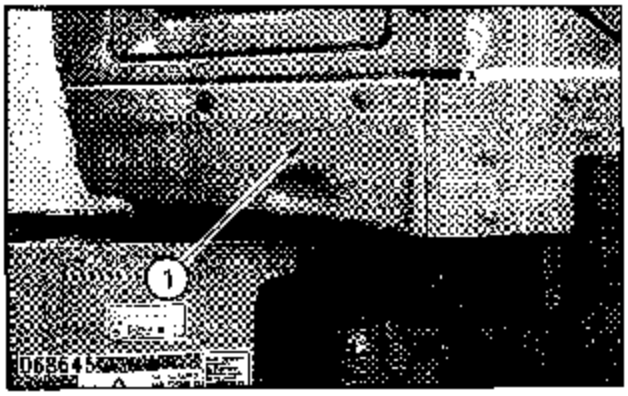
5. Identify, disconnect and cap four hoses (3) from brake valve (2).

6. Remove two bolts (4) from the cab floor and remove brake valve (2).

NOTE: The following steps are necessary for the installation of the brake valve.

7. Put brake valve (2) in position in the cab floor and secure with two bolts (4).

8. Remove plugs and connect hoses (3) to brake valve (2).



9. Install cab panel at the lower front of the cab. Install bolts and washers that hold the panel and tighten to a torque of **20 ± 5 N•m (15 ± 4 lb ft)**.

End By:

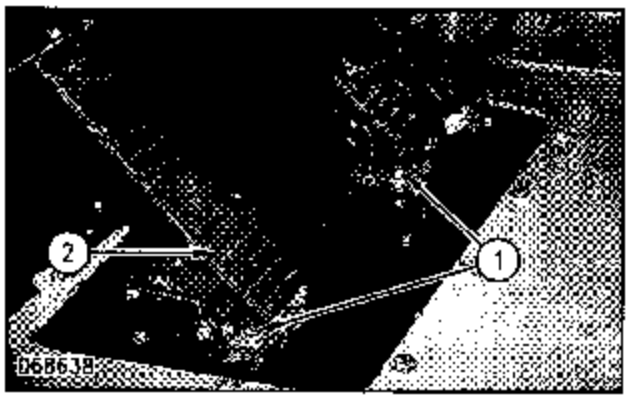
a. install brake pedal assembly

b. remove steering frame lock link

Foot Brake (Pedals)

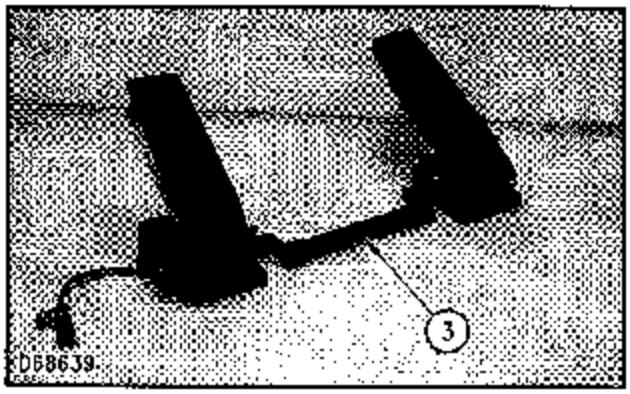
Remove & Install Foot Brake (Pedals) 4269-010

1. Remove cab mats.

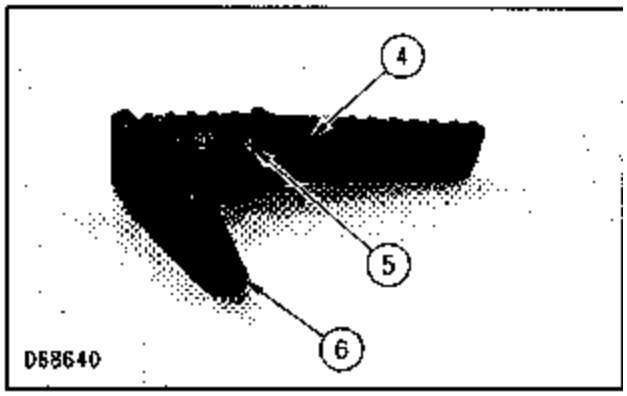


2. Remove eight bolts (1) and washers that hold pedal assembly (2) to the floor.

3. Disconnect electrical connector (not shown). Remove pedal assembly.



4. Remove bar (3) which connects the brake pedals.



5. Remove clips and two pins (5). Remove pedal (4) from base (6).

NOTE: Install in reverse order.

Hand Metering Pump

Remove & Install Hand Metering Unit 4312-010

1. Activate the parking brake.

2. Connect the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this module.

3. Release the pressure in the hydraulic system as follows:

   a. Move the lift control lever to the "Float" position.

   b. Shut off the engine.

   c. Move the lift control lever to the "Hold" position.

⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all the hydraulic pressure is released before any fittings, hoses or components are loosened, tightened, removed or adjusted.

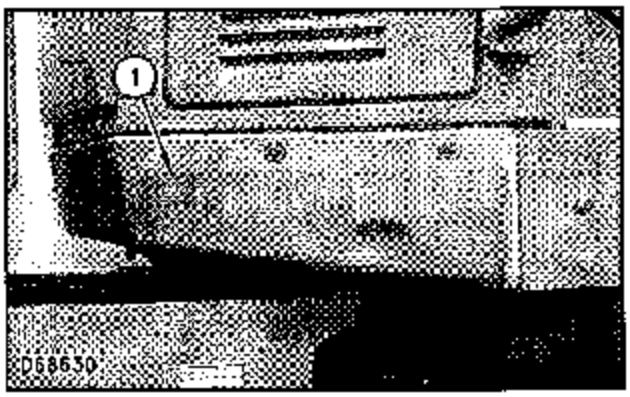
   d. Carefully loosen the filler cap on the hydraulic oil tank to release the pressure.

   e. Carefully loosen the plugs at the rear of the tilt cylinder. When the oil from the loosened plugs stops draining, tighten the two plugs.

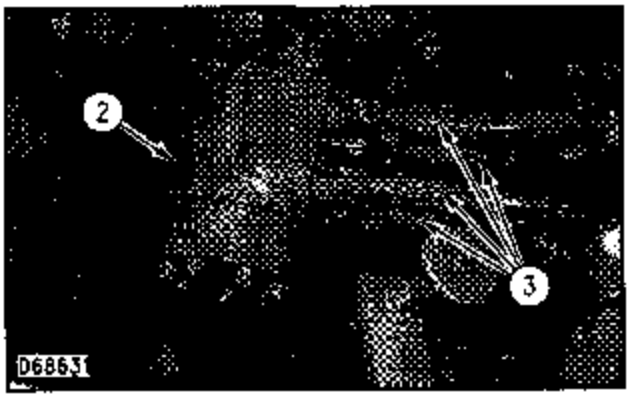
NOTE: To release the pressure in the attachment cylinders, carefully loosen the two large plugs near the plugs at the top of the loader frame. When the oil from the loosened plugs stops draining, tighten the two large plugs.

   f. Tighten the filler cap on the hydraulic oil tank.

   g. The pressure in the hydraulic system has now been released.



4. Remove the bolts and washers that hold cab panel (1) in position. Remove the cab panel from the lower front of the cab.



5. Put identification marks on all hose assemblies connected to the hand metering pump for installation purposes.

6. Disconnect all hose assemblies (3) from the hand metering unit.

7. Remove the nuts that hold the mounting brackets for the hand metering unit.

8. Loosen the four bolts that hold hand metering unit (2) to the mounting brackets. Remove the hand metering pump from the machine.

NOTE: The following steps are for the installation of the hand metering unit.

9. Put hand metering unit (2) in position under the floor of the cab. Align the splined steering shaft with the splines in the hand metering unit.

10. Install the four bolts that hold the hand metering unit to the mounting brackets.

11. Install the nuts that hold the mounting brackets for the hand metering unit to the cab floor.

12. Connect hose assemblies (3) to the hand metering unit in their original locations.

13. Install cab panel (1) at the lower front of the cab. Tighten the bolts that hold the panel to a torque of **20 ± 5 N•m (15 ± 4 lb ft).**

14. Fill the hydraulic oil tank with oil to the correct level. See the Operation & Maintenance Manual for the correct filling procedure.

15. Separate the steering frame lock link. See the topic "Separate & Connect Steering Frame Lock Link" in this module.

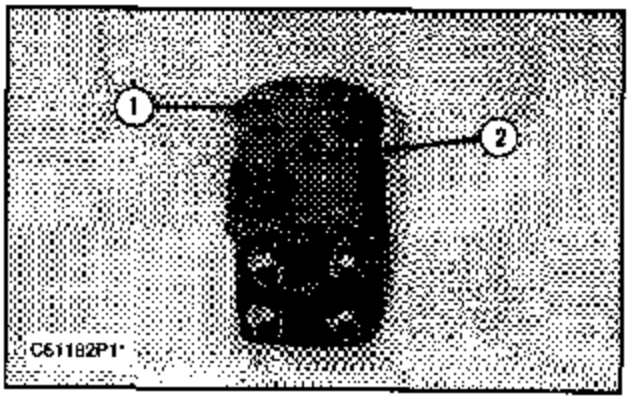
16. Start the machine, and check the operation of the steering.

Disassemble Hand Metering Unit 4312-015

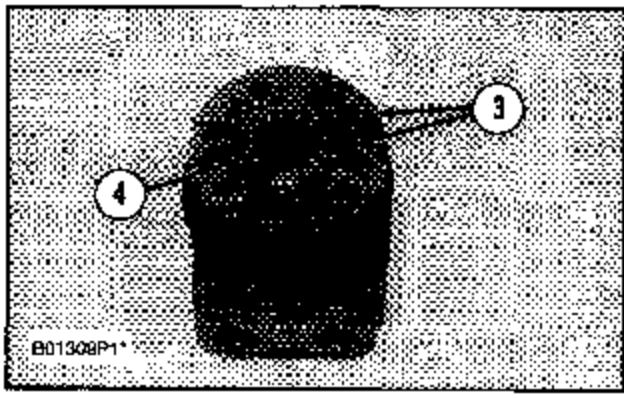
Start By:

a. remove hand metering unit

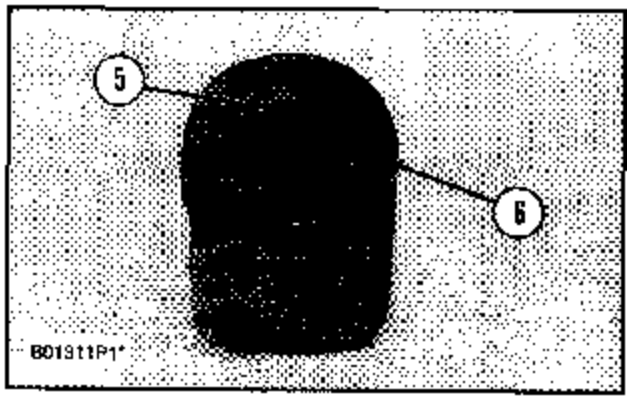
1. Be sure the hand metering unit is thoroughly clean and free of dirt and debris prior to disassembly.



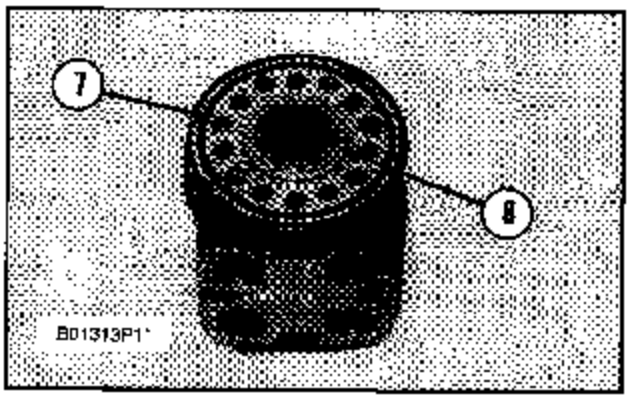
2. Remove seven bolts (1) and cap (2) from the gerotor assembly. Remove the O-ring seal from the cap.



3. Remove gerotor assembly (3) and spacer (4) from the unit body. Remove the O-ring seal from the gerotor assembly.

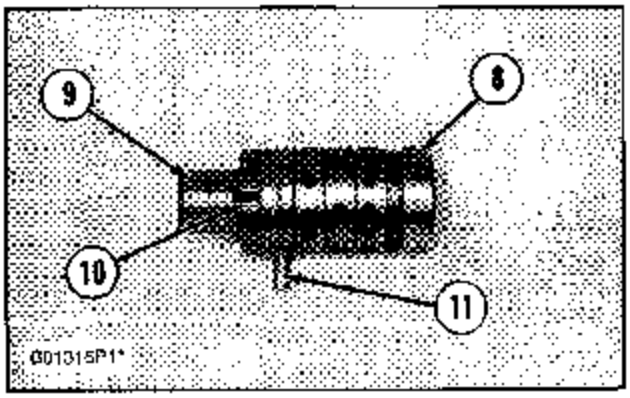


4. Remove drive (5) and spacer (6) from the unit body.

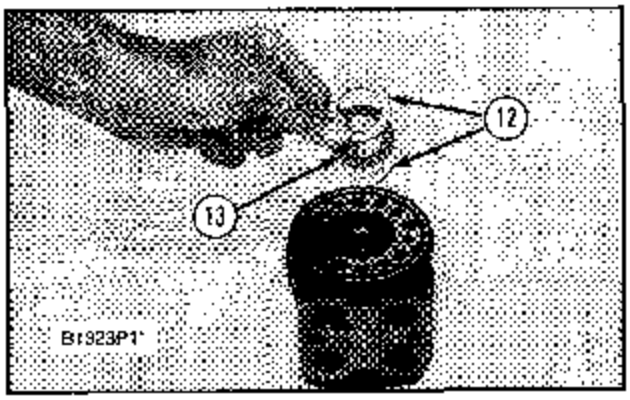


5. Remove O-ring seal (7) from the unit body.

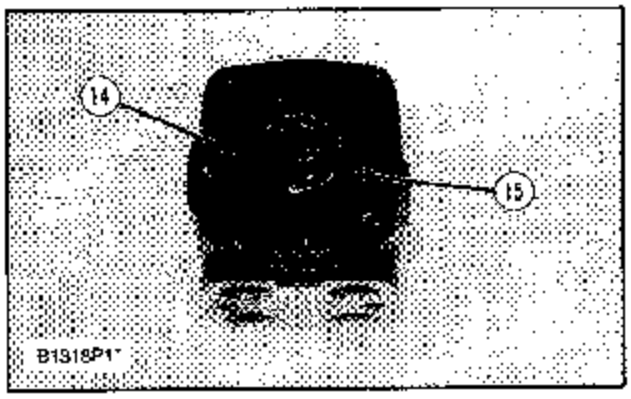
6. Remove sleeve assembly (8) from the unit body.



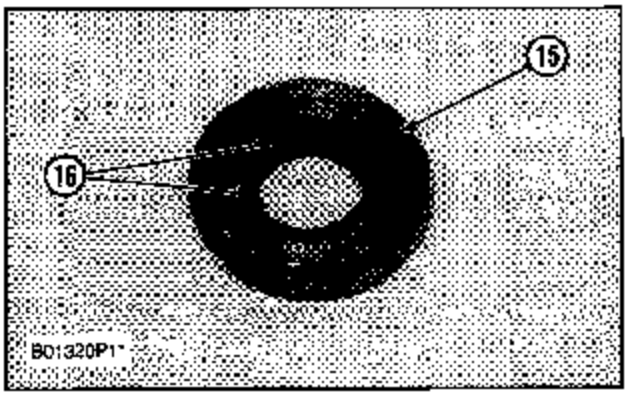
7. Disassemble the sleeve assembly. Remove pin (11). Remove spool (9) from sleeve (8). Remove six springs (10) from spool (9)



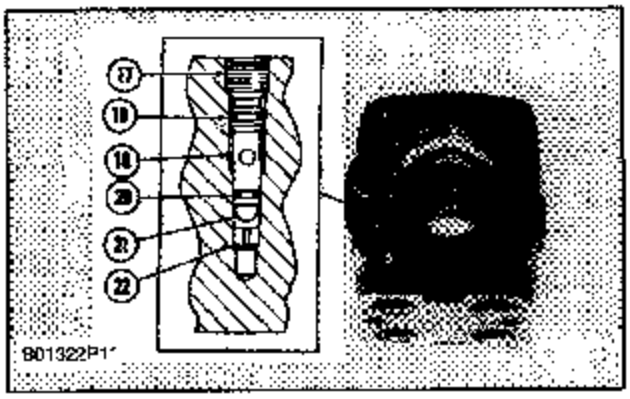
8. Remove bearing races (12) and bearing (13) from the unit body.



9. Turn the unit body over. Remove spiral lockring (14). Remove bushing (15).



10. Remove seals (16) from bushing (15).

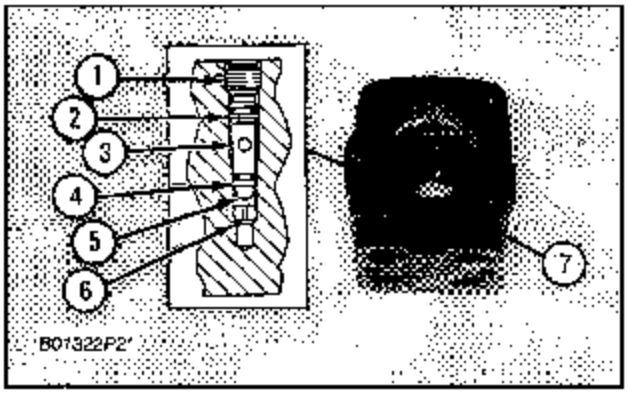


11. Remove plug (17), seat (19), ball (21) and retainers (22) from the unit body. Remove O-ring seals (18) and (20) from the seat.

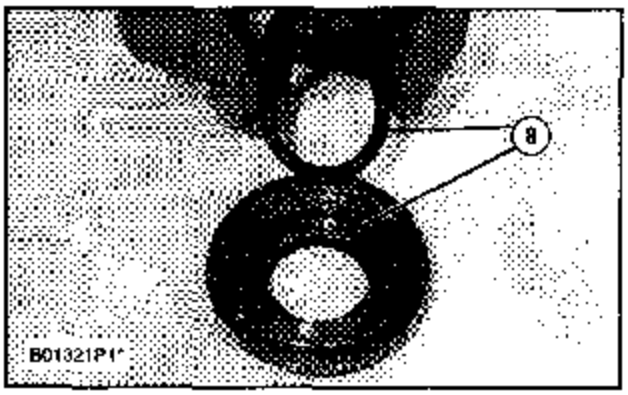
Assemble Hand Metering Unit 4312-016

1. Be sure all parts of the hand metering unit are clean and free of dirt and debris prior to assembly. Check the condition of all O-ring seals used in the hand metering unit. If the seals are worn or damaged, use new parts for replacement.

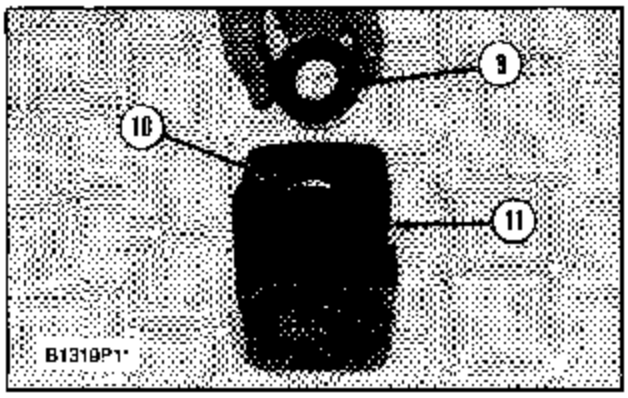
2. During reassembly, put clean SAE 10 oil on the internal parts of the hand metering unit.



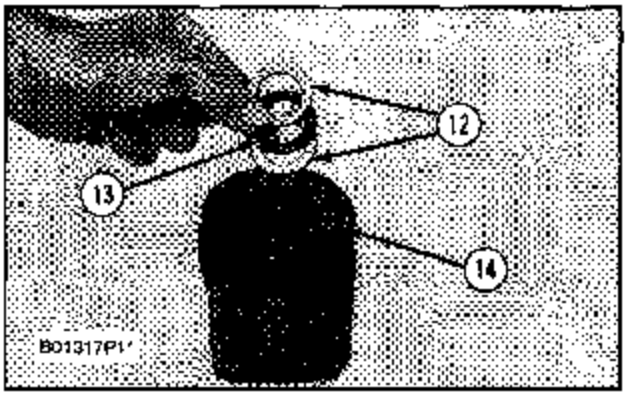
3. Install O ring seals (2) and (4) on seat (3). Install retainer (6), ball (5), seat (3) and plug (1) in unit body (7). Tighten the plug to a torque of **11.3 N•m (100 lb in).** Be sure the plug is even with or below the unit body surface after it is tightened.



4. Install seals (8) in the bushing.

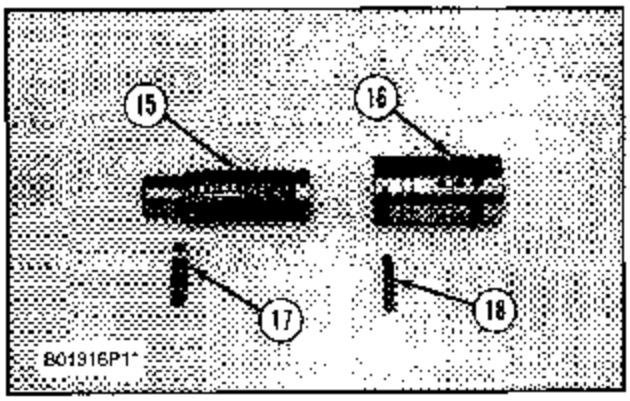


5. Install O-ring seal (10) in unit body (11). Put bushing (9) in position in unit body (11). Install the spiral lockring which holds it.



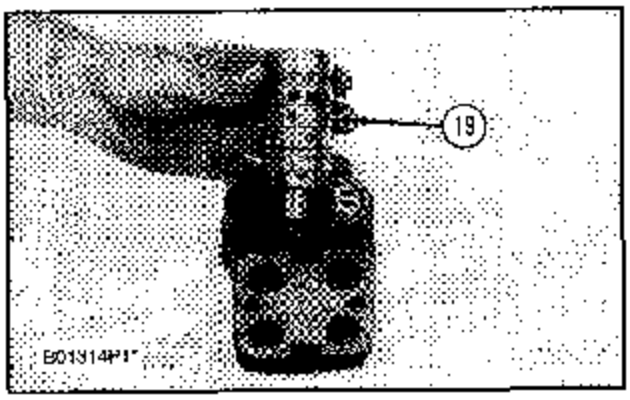
6. Turn the unit body over. Install O-ring seal (14) in the unit body.

7. Install bearing races (12) and bearing (13) in the unit body as shown.

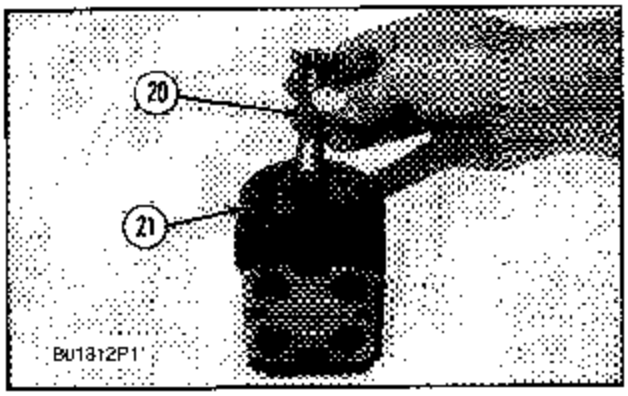


8. Assemble the sleeve assembly. Install six springs (17) in spool (15) with three springs on each side. Be sure the curves of the springs are in contact and in the center of the spool. The notched side of the spring ends must be facing toward the sleeve.

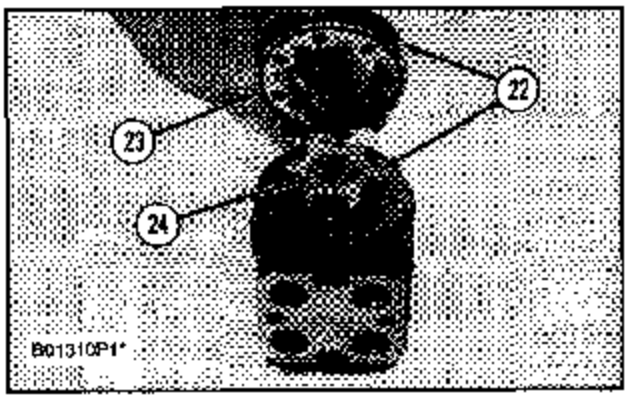
9. Install sleeve (16) over spool (15) so the notch (slot) in the sleeve engages with the ends of spring (17). Install pin (18) in the sleeve and spool.



10. Install sleeve assembly (19) in the unit body as shown.



11. Install drive (20) in the unit body as shown. Be sure the notch (slot) in the drive engages with pin (18) that holds the sleeve and spool together.

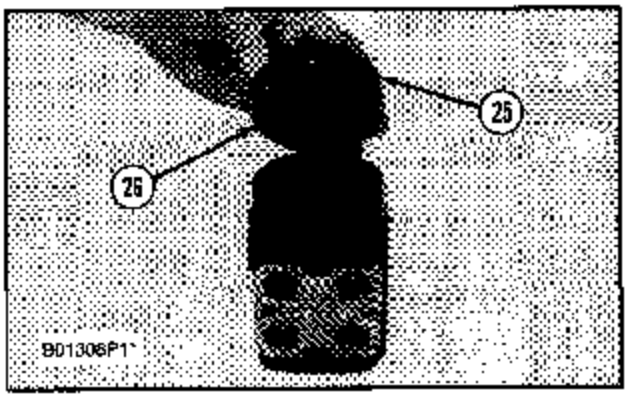


12. Install O-ring seal (23) on the gerotor assembly.

13. Install spacer (24) and gerotor assembly (22).

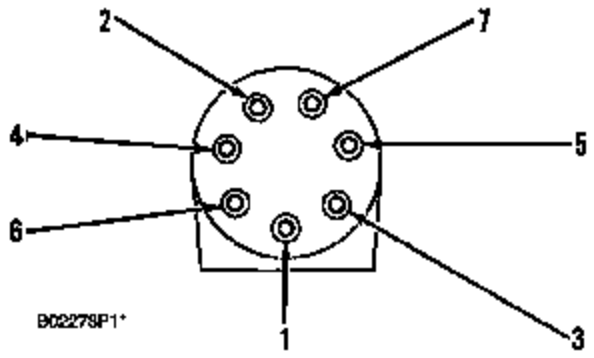
NOTICE

Be sure gerotor assembly (22) is in alignment with pin (18) as shown in the above illustration.



14. Install O-ring seal (26) in cap (25).

15. Put cap (25) in position on the gerotor assembly.



NOTICE

The bolts that hold the cap and gerotor assembly to the unit body must be clean and dry when they are installed.

16. Install the seven bolts that hold the cap and gerotor assembly to the unit body. Tighten the bolts as follows:

a. First, tighten the bolts in number sequence to a torque of **14.1 ± 2.8 N•m (125 ± 25 lb in).**

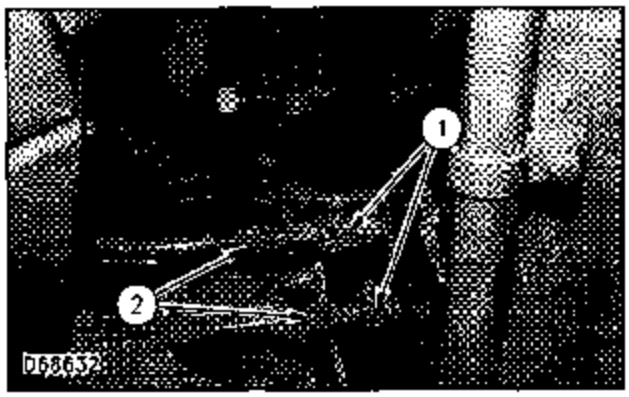
b. Tighten the bolts in number sequence to a final torque of **28.2 ± 2.8 N•m (250 ± 25 lb in).**

End By:

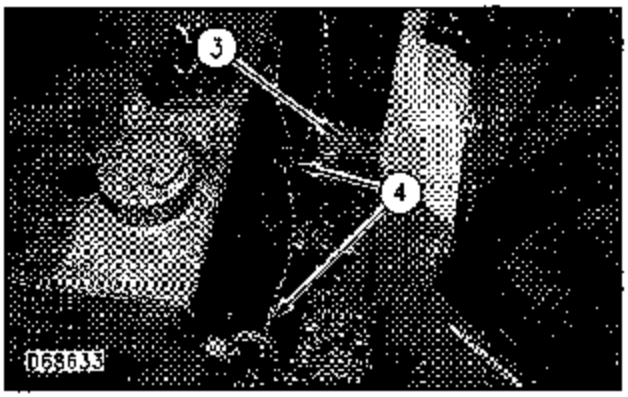
a. install hand metering unit

Fuel Tank

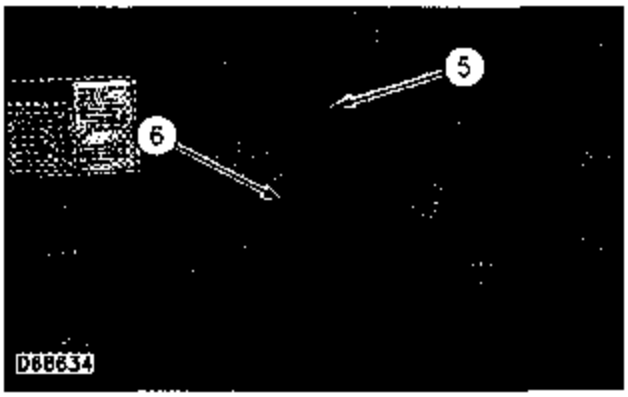
Remove & Install Fuel Tank 1273-010



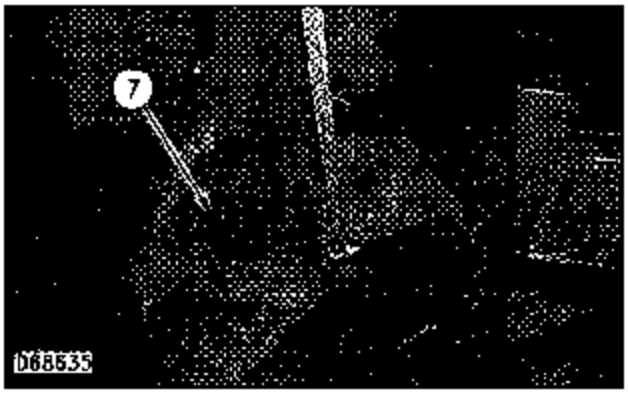
1. Turn two fuel valves (1) to the **OFF** position. Remove two lines (2) from valves (1). Cap and plug lines to prevent fuel loss.



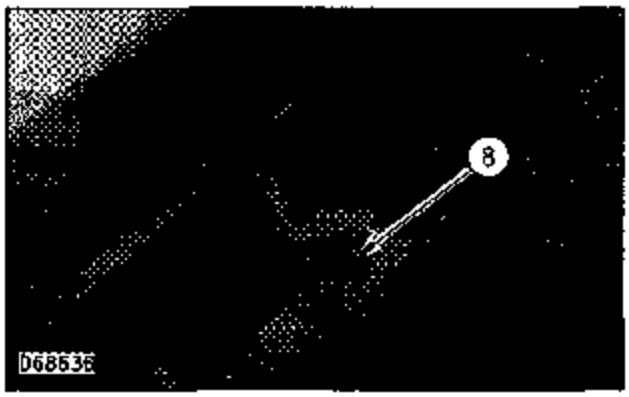
2. Disconnect electrical connectors (3) and remove ties (4) holding harness to fuel tank.



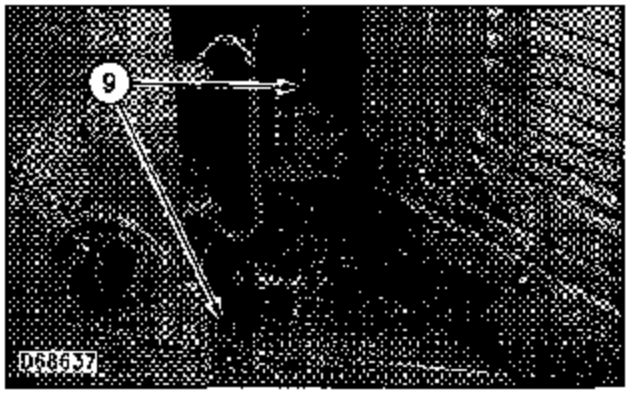
3. Remove bolt (6) and bracket holding vent tube (5) to frame.



4. Fasten straps and a hoist to fuel tank (7) as shown.



5. Remove bolt and washer (8) at front of fuel tank connecting it to the machine frame.



6. Remove two bolts and washers (9) at rear of fuel tank.

7. Remove fuel tank. The empty weight of the fuel tank is **159 kg (350 lb)**.

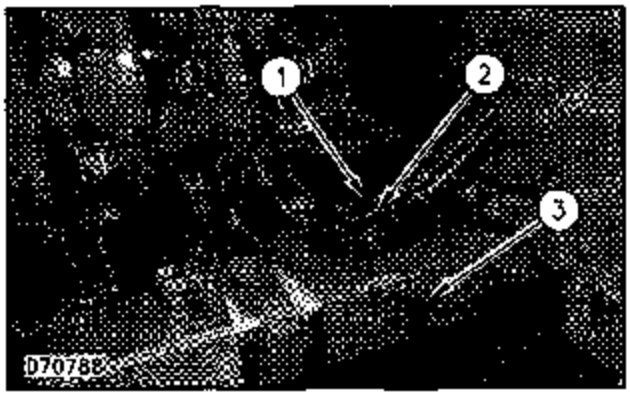
NOTE: Install the fuel tank in reverse order.

Cleaner Bar (Non Engine End-Rear) (815F)

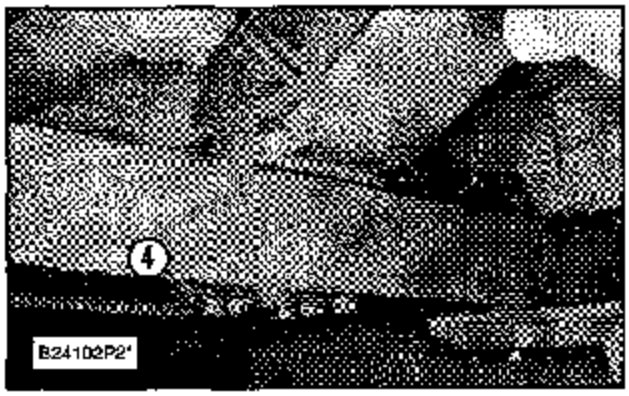
Remove & Install Cleaner Bar (Non Engine End-Rear) (815F) 7160-010

Start By:

a. remove lift arms and blade assembly

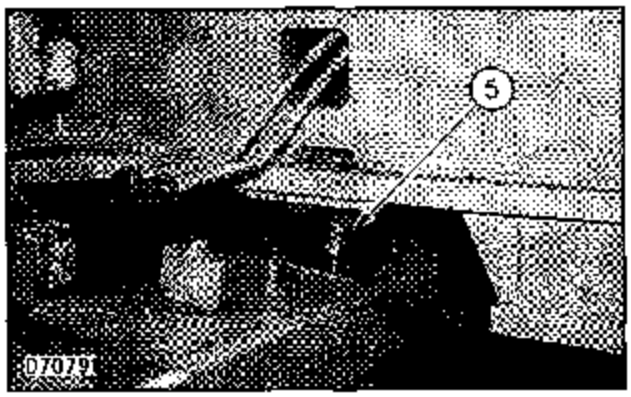


1. Fasten a strap and hoist to each side of the cleaner bar. Remove bolt (1) and clamp (2) that hold the oil lines to the cleaner bar.

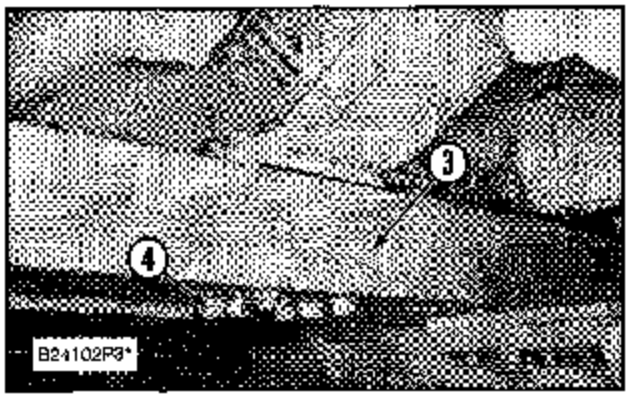


2. Remove bolts (4) from both sides of the cleaner bar. Remove the cleaner bar. The weight of the cleaner bar is approximately **531 kg (1180 lb.).**

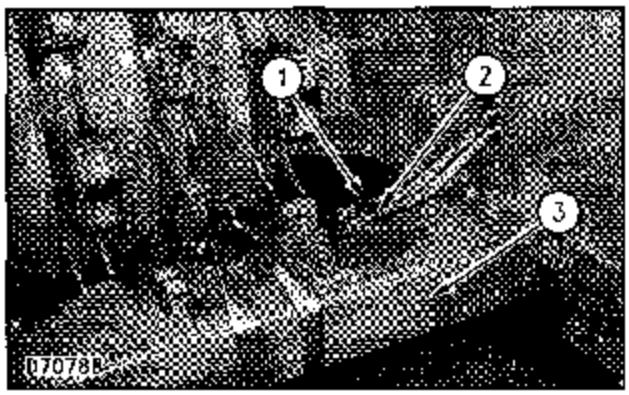
Install Cleaner Bar (Non Engine End-Rear)(Blade Removed) (815F) 6050-011



1. Make an alignment of dowels (5) and the machine. Install the cleaner bar.



2. Install bolts (4) that secure cleaner bar (3) to frame.



3. Install clamp (2) and bolt (1) that hold the hydraulic oil lines into cleaner bar (3).

End By:

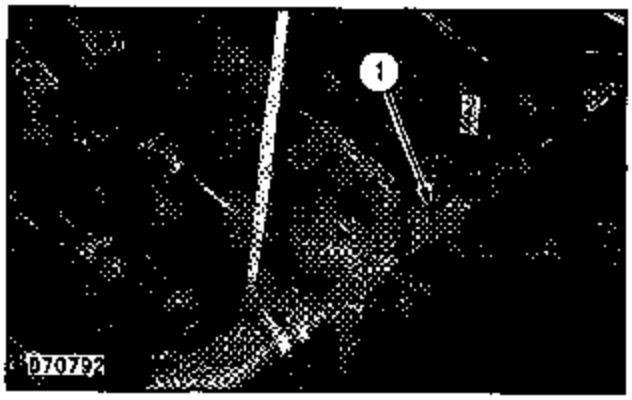
a. install lift arms and blade assembly

Cleaner Bar (Non Engine End-Front) (815F)

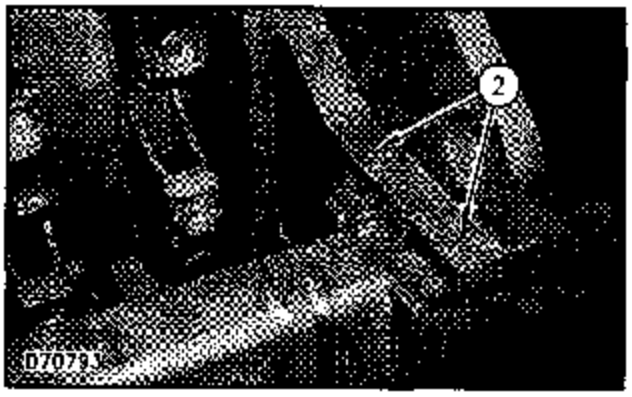
Remove Cleaner Bar (Non Engine End-Front) (815F) 7160-011

Start By:

a. remove tag link



1. Fasten straps and a hoist to cleaner bar (1) as shown.

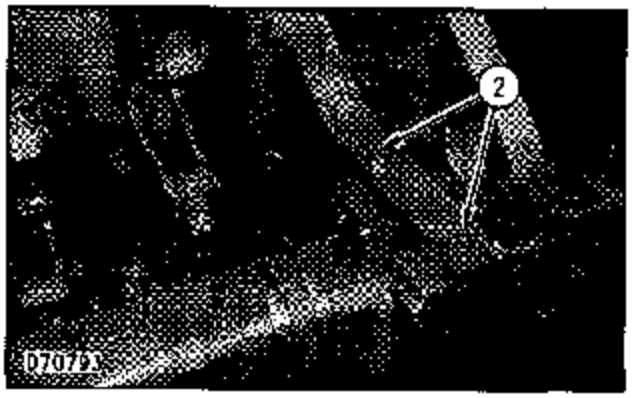


2. Remove bolts and nuts (2) from both sides of the cleaner bar. Lower the cleaner bar to the ground.

3. Lift the blade and move the machine away from the bar. The weight of cleaner bar is **320 kg (720 lb.).**

Install Cleaner Bar (Non Engine End-Front) (815F) 7160-012

1. Put the cleaner bar in position under the machine.



2. Fasten the straps and hoist to cleaner bar (1). Make an alignment of the cleaner bar to the machine.

3. Install bolts and nuts (2) to both sides of the cleaner bar.

End By:

a. install tag link

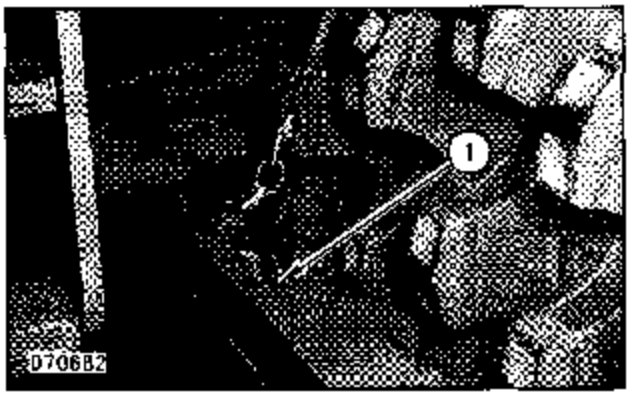
Cleaner Bar-Engine End (815F)

Remove Cleaner Bar (Engine End)(815F) 7160-011

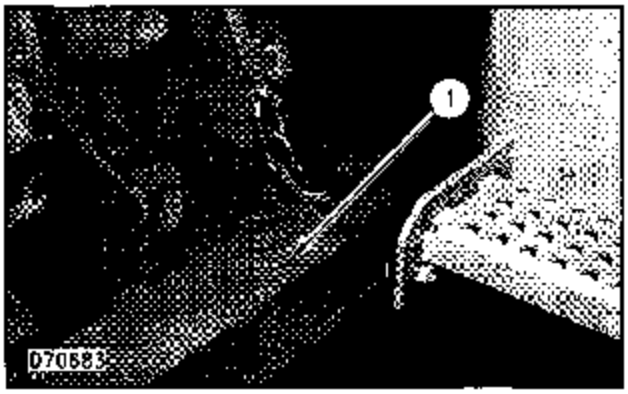
Tools Needed	A
138-7574 Link Bracket	1

Start By:

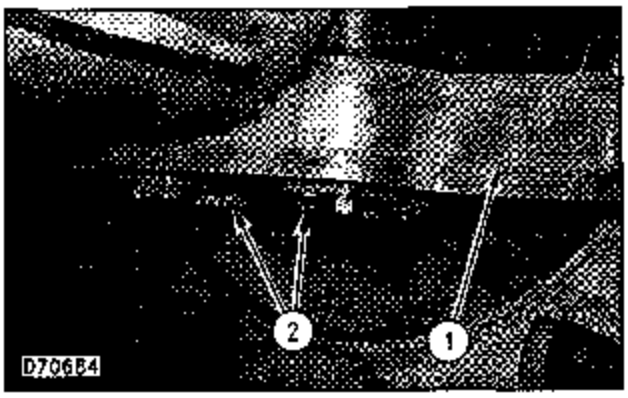
a. Remove cleaner assemblies (815F)



1. Install Tool A. Fasten a strap and hoist to the front cleaner bar (1) as shown.



2. Install Tool A. Fasten a strap and hoist to the rear cleaner bar (1) as shown.



3. Put blocks under cleaner bar (1). Remove bolts (2).

4. Remove the blocks and lower cleaner bar (1) to the ground. The approximate weight of the cleaner bar is **234 kg (520 lb.)**.

5. Drag cleaner bar (1) from underneath the machine.

Install Cleaner Bar (Engine End) (815F) 7160-012

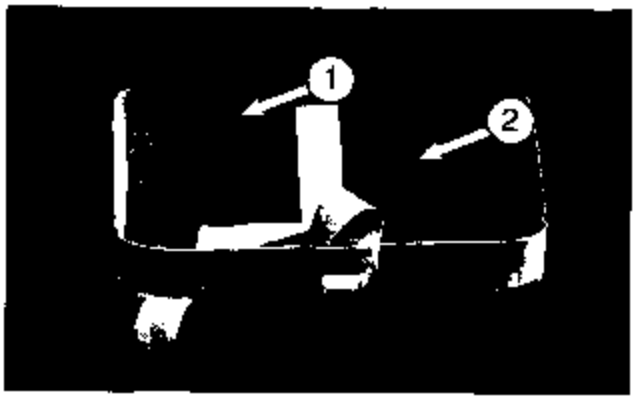
1. Fasten straps and a hoist to the cleaner bar (1). Make an alignment of dowels (2) with the holes in the differential housing. Install the cleaner bar and bolts.

End By:

a. install cleaner assemblies (815F)

Decontamination Apparatus Mounting Bracket

Remove and Install Decontamination Apparatus Mounting Bracket



1. Remove four bolts and washers (1) and remove decontamination apparatus mounting bracket (2) from frame.

NOTE: Install the decontamination apparatus mounting bracket as follows.

2. Secure decontamination apparatus mounting bracket to frame with four bolts and washers.

Hydraulic Oil Sampling Valve

Remove and Install Hydraulic Oil Sampling Valve

FLUID SPILLAGE CONTAINMENT

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the machine. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids. Refer to "TOOLS AND SHOP PRODUCT GUIDE NENG2500" for tools and supplies suitable to collect and contain fluids in Caterpillar machines. Dispose fluids according to local regulations and mandates.

⚠ WARNING

At operating temperature, the hydraulic oil tank is hot and under pressure. Hot oil can cause burns. Remove the filler cap on the hydraulic oil tank only when the engine is stopped, and the filler cap is cool enough to touch with your bare hand. Be sure all hydraulic pressure is released before any fitting, hose, or component is loosened, tightened, removed, or adjusted.

1. Release the pressure in the hydraulic system as follows.
   - a. Install the steering frame lock link.
   - b. Move the lift control lever to the "Float" position.
   - c. Shut off the engine.
   - d. Move the lift control lever to the "Hold" position.
   - e. Carefully loosen the filler cap on the hydraulic oil tank to release the pressure in the system.
   - f. Tighten the filler cap on the hydraulic oil tank. The system pressure has now been released.

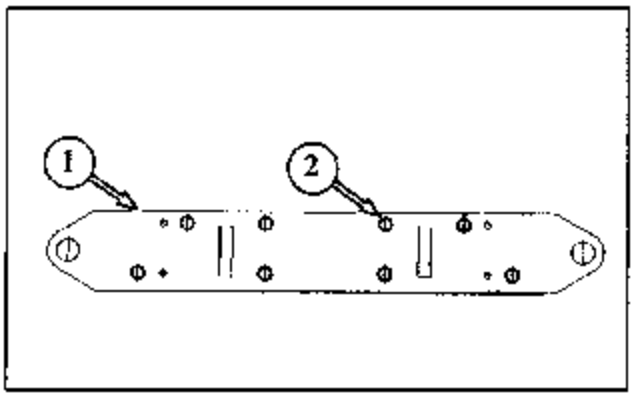
2. Disconnect hydraulic oil sampling valve (1) from hydraulic line.

NOTE: The following steps are for the installation of the hydraulic oil sampling valve.

3. Connect hydraulic oil sampling valve to hydraulic line.
4. Start the machine and check for leaks.

Lifting Plate

Remove and Install Lifting Plate



1. Install a hoist to the lifting plate (1).

2. Remove eight bolts and washers (2) securing lifting plate to bumper.

3. Using a hoist remove the lifting plate from the bumper. Weight of the lifting plate is 265 kg (584 lb).

NOTE: The following steps are for the installation of the lifting plate.

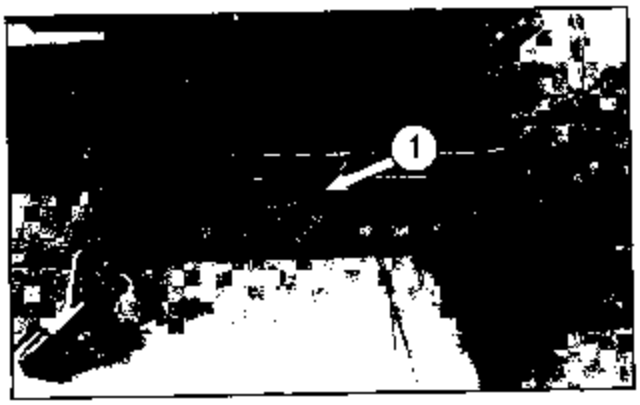
4. Using a hoist, install the lifting plate on the bumper. Weight of the lifting plate is 265 kg (584 lb).

5. Install eight bolts and washers.

6. Remove hoist.

Rifle Bracket

Remove and Install Rifle Bracket



1. Remove six bolts and washers (1) and remove rifle bracket from frame.

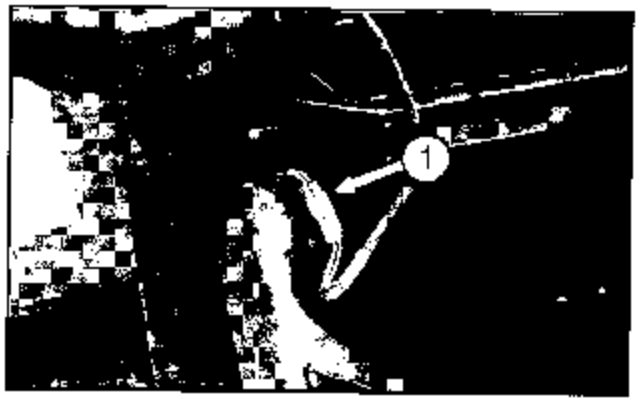
Note: Install the rifle bracket as follows.

2. Secure rifle bracket to frame with six bolts and washers.

Rollover Protective Structure (ROPS)

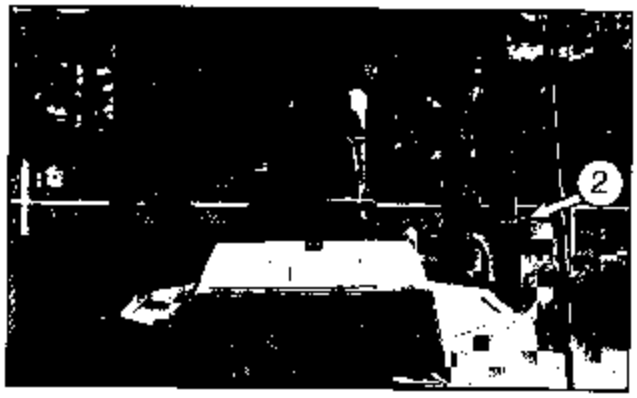
Remove and Install Rollover Protective Structure (ROPS)

Tools Needed	A
6V-2156 Link Bracket	4



1. Identify and disconnect lighting electrical connection (1).

2. Install a hoist and tooling (A) to the lifting eyes on the top of the ROPS.



3. Remove five bolts, nuts, and washers (2) from each of the four legs of the ROPS.

4. Using a hoist and tooling (A) remove ROPS from the frame. Weight of the ROPS is 263 kg (579 lb).

NOTE: The following steps are for the installation of the ROPS.

5. Using a hoist and tooling (A) install the ROPS on the frame. Weight of the ROPS is 263 kg (579 lb).

6. Install five bolts, nuts, and washers in each of the four legs of the ROPS.

7. Remove hoist.

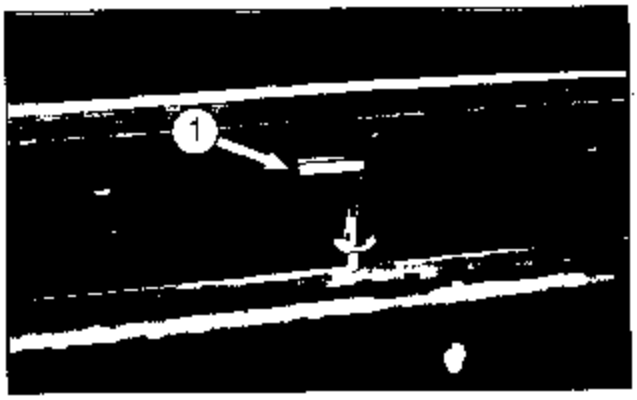
8. Connect electrical connection.

9. Check lights to ensure proper electrical connection.

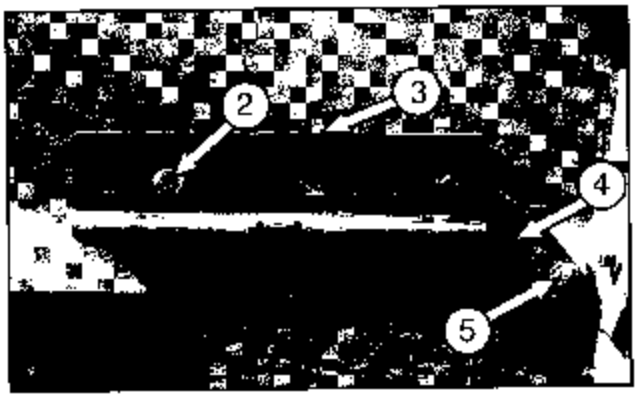
Tool Box, Tool Box Mounting Bracket, and Mounting Plate

Remove and Install Tool Box, Tool Box Mounting Bracket, and Mounting Plate

1. Open tool box and remove tray.



2. Remove tool box retaining pin (1) and lift tool box from mounting bracket.



3. Remove two bolts, four washers, and two nuts (2) and remove tool box mounting bracket (3) from mounting plate (4).

4. Remove two bolts and nuts (5) and remove mounting plate (4) from frame.

NOTE: The following steps are for the installation of the tool box, mounting bracket, and mounting plate.

5. Attach mounting plate to frame with two bolts and nuts.

6. Attach tool box mounting bracket to mounting plate with two bolts, four washers, and two nuts.

7. Install tool box on mounting bracket with mounting pin.

8. Place tool tray in tool box and close tool box.

TM 5-3805-360-44

CATERPILLAR®

SENR1319
March 1996

Schematic

814F Wheel Tractor, 815F Soil Compactor & 816F Landfill Compactor Electrical System

814F	815F	816F
9DM1-UP	1GN1-UP	3FN1-UP

815F SOIL COMPACTOR
ELECTRICAL SYSTEM

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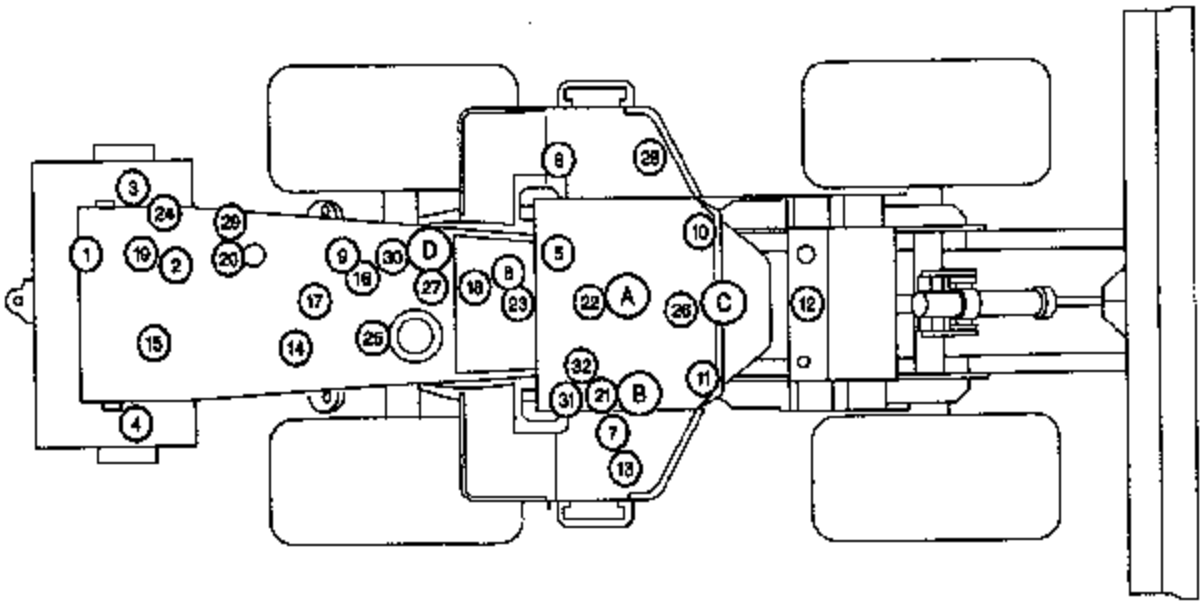
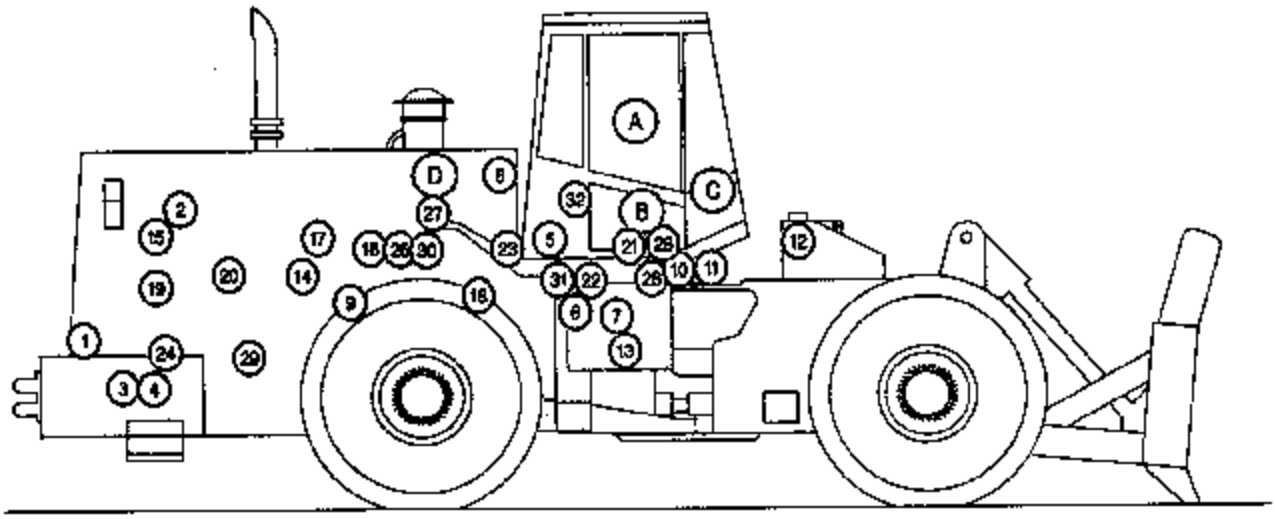




MACHINE HARNESS CONNECTOR AND COMPONENT LOCATIONS

055094

COMPONENT LOCATION CHART

Component	Schematic Location	Machine Location
Alarm - Action	E-5	C
Alarm - Backup	D-15	1
Alternator	D-13	2
Battery	F-14	3
Battery	F-14	4
Breaker - Alternator (80A)	C-15	D
Breaker - Blower Motors (15A)	C-10	B
Breaker - Engine Shutdown	C-15	D
Breaker - Main (80A)	C-15	D
Breaker - Running Lamp (15A)	C-15	D
Breaker - Seat Air Comp (15A)	C-10	B
Control - Autoshift Trans	E-12	5
Control - Dimmer	E-4	C
Control - Engine Shutdown	C-13	27
Converter - Voltage	F-7, F-8	A
Fuses (10A)	C-10	B
Fuses (10A)	C-15	D
Gauges - Quad Package	E-4	C
Gauges - Tachometer/Speedometer	E-4	C
Ground - Cab	C-5	28
Ground - Frame	D-13	29
Horn - Forward (High Tone)	D-2	6
Horn - Forward (Low Tone)	A-1	7
Lamp - Action	D-4	C
Monitor - Caterpillar Monitoring System	E-5	C
Motor - Blower	C-3	10
Motor - Blower	C-3	11
Motor - Front Washer	C-13	8
Motor - Front Wiper	B-3	C
Motor - Rear Washer	C-14	8
Motor - Rear Wiper	F-10	5
Motor - Starter	F-14	9
Relay - Main	C-15	D
Relay - Start	C-15	D
Resistor	C-14	D
Resistor - Blower Motor Speed	C-3	10

Component	Schematic Location	Machine Location
Resistor - Starter Diagnostic	F-13	9
Sender - Fuel Level	D-1	12
Sender - Hydraulic Oil Temperature	A-3	13
Sender - Trans Oil Temperature	B-14	14
Sensor - Engine Coolant Temp	B-15	15
Sensor - Engine Speed	C-12	16
Sensor - Trans Speed	C-12	18
Shifter - Transmission	E-3	A
Solenoid - A/C Clutch	F-13	19
Solenoid - Engine Shutdown	E-13	20
Solenoid - Float Detent	B-6	21
Solenoid - Raise Detent	B-6	21
Solenoid - Start Aid	A-14	23
Solenoids - Transmission Valve (6)	C-12	22
Suppressor - Arc	F-13	19
Switch - A/C Thermostat	C-3	A
Switch - Battery Disconnect	F-14	19
Switch - Beacon	D-10	B
Switch - Blower Motor	D-5	C
Switch - Brake Oil Pressure	A-13	23
Switch - Coolant (Start Aid)	A-15	15
Switch - Engine Oil Pressure	A-15	17
Switch - Flood Lamp	E-11	B
Switch - Front Intermittent Wiper	F-8	B
Switch - Horn	C-4	A
Switch - Hydraulic Oil Level	A-3	13
Switch - Key Start	E-9	B
Switch - Monitoring System Operator	E-8	B
Switch - Park Brake Pressure	A-13	8
Switch - Rear Wiper	E-8	B
Switch - Refrigerant	F-13	19
Switch - Start Aid	E-8	B
Switch - Stop Lamp	C-1	26
Switch - Trans Neutralizer	C-1	26
Switch - Trans Upshift/Downshift	B-6	B

Machine locations are repeated for components located close together.
A = Components located in operator's compartment.
B = Components located in right console.
C = Components located in dash area.
D = Components located in relay panel.

RELATED ELECTRICAL SERVICE MANUALS	
Title	Form No.
Alternator (107-7977)	SENR4757
Caterpillar Monitoring System	SENR6717
Electronic Transmission Control	SENR5922
Starting And Charging Systems	SENR2947
Starting Motor: (6V-5227)	
Consist No. 6V-5537	SENR3581
Consist No. 105-8552	SENR3636
Consist No. 6V-5538	SENR4975

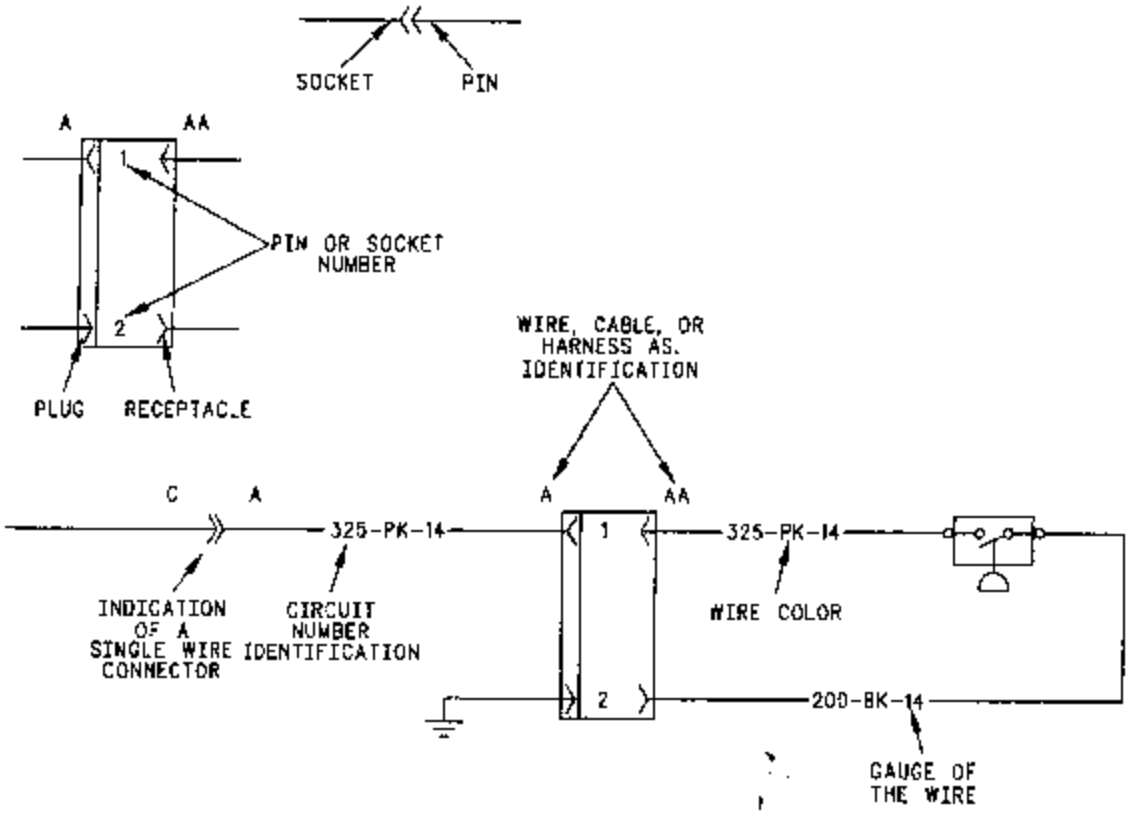
OFF MACHINE SWITCH SPECIFICATIONS				
Part No.	Function	Actuate	Deactuate	Normal Condition
8N-1693	Engine Coolant Temp (St Aid)	37.8 ± 2.8°C (100.0 ± 5.0°F)	26.7°C MIN (80.0°F MIN)	Normally Closed
9W-2653	Park Brake Pressure	8270.0 kPa MAX (1200.0 psi MAX)	6890.0 ± 345.0 kPa (1000.0 ± 50.0 psi)	Normally Closed
9X-0378	Engine Oil Pressure	62.0 kPa MAX (9.0 psi MAX)	38.0 ± 20.0 kPa (5.5 ± 3.0 psi)	Normally Open
9X-9643	Brake Oil Pressure	10700.0 kPa MAX (1552.0 psi MAX)	8960.0 ± 345.0 kPa (1300.0 ± 50.0 psi)	1-2. Normally Open 1-3 Normally Closed
114-5334	Refrigerant Pressure (A/C)	275 to 1750 kPa [1] (40 to 255 psi)	– –	Normally Open [2]

[1] A hysteresis band exists: with increasing pressure the closed condition can be maintained up to 2800 kPa (405 psi), with decreasing pressure the closed condition can be maintained down to 170 kPa (25 psi).
[2] Contact position at the contacts of the harness connector.

RESISTOR AND SOLENOID SPECIFICATIONS		
Component	Part No.	Resistance (Ohms) [1]
Resistor	6T-2217	150.0 ± 7.5
Resistor - Blower Speed	9G-1950	Overall 2.00 ± .10 Tap 1.00 ± .05
Solenoid - A/C Clutch	102-0347	14.4 ± 0.6
Solenoid - Engine Shutdown	110-6465	5.12 ± 0.26
Solenoid - Start Aid	9G-4365	6.0
Solenoids - Transmission	3E-3746	8.5

[1] At room temperature.

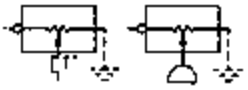
HARNESS AND WIRE ELECTRICAL SCHEMATIC SYMBOLS



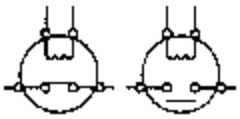
ELECTRICAL SCHEMATIC SYMBOLS AND DEFINITIONS

FUSE—A component in an electrical circuit that will open the circuit if too much current flows through it.

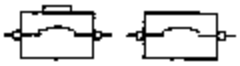
REED SWITCH—A switch whose contacts are controlled by a magnet. A magnet closes the contacts of a normally open reed switch; it opens the contacts of a normally closed reed switch.



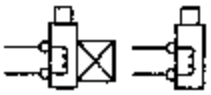
SENDER—A component that is used with a temperature or pressure gauge. The sender measures the temperature or pressure. Its resistance changes to give an indication to the gauge of the temperature or pressure.



RELAY (Magnetic Switch)—A relay is an electrical component that is activated by electricity. It has a coil that makes an electromagnet when current flows through it. The electromagnet can open or close the switch part of the relay.



CIRCUIT BREAKER (C/B)—A component in an electrical circuit that will open the circuit if too much current flows through it. This does not destroy the circuit breaker and it can be reset to become part of the circuit again.



SOLENOID—A solenoid is an electrical component that is activated by electricity. It has a coil that makes an electromagnet when current flows through it. The electromagnet can open or close a valve or move a piece of metal that can do work.

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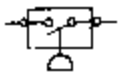
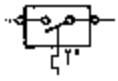
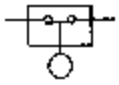
ELECTRICAL SCHEMATIC SYMBOLS AND DEFINITIONS



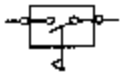
PRESSURE SYMBOL



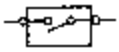
TEMPERATURE SYMBOL



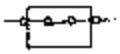
LEVEL SYMBOL



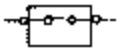
FLOW SYMBOL



Normally open switch that will close with an increase of a specific condition (temp-press-etc.).

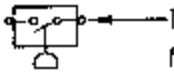


Normally open switch that is closed due to an applied condition, and will open again with a specific decrease in that condition.

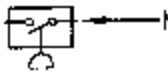


Normally closed switch that will open with an increase of a specific condition.

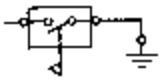
Normally closed switch that is open due to an applied condition, and will close again with a specific decrease in that condition.



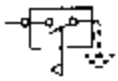
The circle indicates that the component has screw terminals and a wire can be disconnected from it.



No circle indicates that the wire cannot be disconnected from the component.



This indicates that the component has a wire connected to it that is connected to ground.



This indicates that the component does not have a wire connected to ground. It is grounded by being fastened to the machine.

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WIRE DESCRIPTION CHART

Wire Number	Wire Color	Description
		Power Distribution Circuits
101	RD	BAT (+)
102	BU	HD LMP
105	BR	KEY SW
107	WH	ENG SHUT
108	BU	AUX CKT
109	OR	ALT OUTPUT (+) TERM.
112	PU	MAIN POWER RLY OUTPUT
113	OR	OPR MON PANEL B+ SWITCHED
114	GN	WARNING HORN (FORWARD)
116	BR	AUX CKT
118	GY	AUX CKT
120	YL	AUX CKT
121	YL	BCKP ALARM TO LAMP
124	GN	A/C
126	PK	XMSN CTRL
127	OR	AUX CKT
128	PK	AUX CKT
129	BU	AUX CKT
130	GN	AUX CKT
135	BU	AUX CKT
138	GN	AUTO LUBE PUMP TO PAYLOAD MON
144	GN	AUX CKT
154	WH	HYDRO CTRL WTL POWERTRAIN CTRL
177	OR	MAIN BRKR
		Ground Circuits
200	BK	MAIN CHASSIS
201	BK	OPR MON PANEL
202	BK	XMSN CTRL
203	BK	CHASSIS DIAGNOSTIC
207	BK	STARTER DIAGNOSTIC
228	BK	FUEL LEVEL SENDER
261	BK	PAYLOAD MON - SYSTEM GND
270	BK	IDENT CODE 0
271	BK	IDENT CODE 1
272	BK	IDENT CODE 2
273	BK	IDENT CODE 3
274	BK	IDENT CODE 4
275	BK	IDENT CODE 5
290	BK	SERVICE
291	BK	CLEAR
A221	BK	XMSN CTRL OPTIONS CODE 0
A222	BK	XMSN CTRL OPTIONS CODE 1
A232	BK	XMSN CTRL OPTIONS CODE 2
		Basic Machine Circuits
301	BU	STARTER NO. 1 SOL
302	OR	STARTER NO. 1 RESISTOR TO DIAGNOSTIC
304	WH	STARTER RLY NO. 1 OUTPUT
306	GN	STARTER RLY COIL TO NEUT START SW
307	OR	KEY START SW TO NEUT START SW
308	YL	MAIN POWER RLY COIL
310	PU	START AID SW TO START AID SOL
311	WH	START AID SOL TO TEMP SW
321	BR	BCKP ALARM LAMP TRAVEL ALARM
322	GY	WARNING HORN (FORWARD)
326	PU	KEY SW "C" TERM.
327	PK	SHUTDOWN SOL
334	BU	START AID SOL #2
338	PK	FLOOD LAMP RLY COIL
373	GN	START AID SWITCH TO TIMER
		Monitoring Circuits
403	GN	ALTERNATOR (R) TERM.
405	GY	OPR MON OIL PRESS. (LO SETTING)
409	OR	OPR MON NEUT
410	WH	OPR MON FAULT ALARM
411	PK	OPR MON MASTER FAULT LAMP
416	OR	SUPPL STER SW
417	GY	PRIMARY STER SW
419	YL	OPR MON PARKING BRAKE
428	YL	OPR MON BRAKE OIL TEMP
432	PK	OPR MON BRAKE PRESS. (OIL)
439	YL	LAMP INDICATOR
441	OR	ENG COOLANT TEMP GAGE
442	GY	HYD SYSTEM TEMP GAGE
443	YL	POWER TRAIN TEMP GAGE
447	PK	FUEL LEVEL GAGE
450	YL	TACH SENDER (+)
496	WH	OPR MON PANEL HYD OIL LEVEL
A401	YL	ELECTRICAL SYSTEM NO.1 VOLTAGE
B412	YL	PMS LIFT POS SENSOR
B413	PU	PMS LIFT CYL PRESS. SENSOR
C413	YL	DISPLAY DATA
C414	BU	DISPLAY LOAD

Wire Number	Wire Color	Description
		Accessory Circuits
500	BR	WIPER - FRONT (PARK)
501	GN	WIPER - FRONT (LO)
502	OR	WIPER - FRONT (HI)
503	BR	WIPER - REAR (PARK)
504	YL	WIPER - REAR (LO)
505	BU	WIPER - REAR (HI)
506	PU	WASHER - FRONT
507	WH	WASHER - REAR
508	PU	RADIO SPEAKER - LEFT
509	WH	RADIO SPEAKER - LEFT (COMMON)
511	BR	RADIO SPEAKER - RIGHT
512	GN	RADIO SPEAKER - RIGHT (COMMON)
513	OR	A/C COMPRESSOR/REFRIGERANT PRESS. SW
515	GY	BLOWER MOTOR (HI)
516	GN	BLOWER MOTOR (MEDIUM)
517	BU	BLOWER MOTOR (LO)
521	YL	A/C SW TO REFRIGERANT SW
522	WH	A/C CLUTCH TO THERMOSTAT SW
537	GN	TURN SIGNAL SW TO FLASHER
538	BR	HAZARD INDICATOR
A513	PK	DC/DC CONVERTER MEMORY OUTPUT
A538	OR	REAR WINDOW DEFROSTER
		Lighting Circuits
603	PK	ROTARY BEACON
604	OR	STOP LAMP
605	YL	TURN LAMP - LEFT
606	GY	TURN LAMP - RIGHT
608	GN	FLOOD LAMP - REAR
610	OR	HEAD LAMP BASIC
611	PU	HEAD LAMP HI
614	PU	PARK/TAIL/DASH LAMP
615	YL	CAB FLOOD LAMP/ROPS
617	BR	TAIL/POSITION LAMP - LEFT (ROAD PKG)/WIDTH
619	GN	HEAD LAMP LO
661	GN	TACHOMETER LAMP
682	YL	SPEEDOMETER LAMP
683	GY	GAGE LAMPS
		Control Circuits
710	GN	XMSN SPEED PICKUP SIGNAL
720	PU	XMSN BRAKE SW
751	GN	XMSN SHIFT SOL NO. 1 OR 3
752	YL	XMSN SHIFT SOL NO. 2
754	BU	XMSN SHIFT SOL NO. 3 OR 1
755	OR	XMSN SHIFT SOL NO. 4 OR 5
761	GY	LIFT KICKOUT SOL SW
762	YL	BUCKET POSITIONER SOL SW
795	YL	DUAL HP SOL
D735	PK	XMSN CONT PARK BRK LEVER SW TO GND
D743	GN	RIDE CONT - WTL IMPL CONT SW TO GND N/O
D744	WH	RIDE CONT - WTL IMPL CONT SW TO GND N/C
E701	PK	AUTO RIDE CNTL SW
E702	OR	AUTO RIDE CNTL SW
E707	GN	DISPLAY +V
E708	PK	DISPLAY CLOCK
E735	PU	TACK/SERV MTR/ODOMETER SELECT
900	PU	XMSN SHIFT SOL NO. 5 OR 4
901	WH	XMSN SHIFT SOL NO. 6
910	YL	XMSN NEUTIZER OVERRIDE INDICATOR
921	WH	XMSN SOL NO 1 OR 3 RETURN
922	BR	XMSN SOL NO 2 RETURN
923	GY	XMSN SOL NO 3 OR 1 RETURN
924	GN	XMSN SOL NO 4 OR 5 RETURN
925	YL	XMSN SOL NO 5 OR 4 RETURN
926	BU	XMSN SOL NO 6 RETURN
944	OR	DATA LINK + (CAT)
945	BR	DATA LINK - (CAT)
963	GN	BUCKET/FORK POSITION DETENT COIL
964	BU	FORK POSITION SELECT
965	WH	TRANS SOL 1 SW TO GND
966	GY	TRANS SOL 3 SW TO GND
968	BR	TRANS SOL 2 SW TO GND
969	YL	TRANS SOL 3 SW TO B+
970	GN	TRANS SOL 4 SW TO GND
971	YL	TRANS SOL 5 SW TO GND
972	BU	TRANS SOL 6 SW TO GND
973	BR	CST AUTOSHIFT- AUTO/MANUAL SW 2
974	PU	CST AUTOSHIFT- SLOW MODE SW
975	WH	CST AUTOSHIFT- SOL RETURN
976	OR	RIDE CONT SOL
977	YL	CST AUTOSHIFT- AUTO/MANUAL SW 1
978	GN	CST AUTOSHIFT- SLOW MODE SW 1
987	WH	DIVERTER SOL
B989	GN	TRANS SOL 1 SW TO B+
D953	BU	SENSOR MODULE #1 +5V SUPPLY
G953	BU	IMPL PILOT VALVE
G954	GN	DUAL LOW IDLE SOL

CONNECTOR LOCATION[1]

Connector Number	Schematic Location	Machine Location
CONN 1	A-3	31
CONN 2	A-3	13
CONN 3	C-2	11
CONN 4	C-2	26
CONN 5	C-2	11
CONN 6	C-3	C
CONN 7	B-5	21
CONN 8	F-5	C
CONN 9 Service Tool Connector	F-5	C
CONN 10	E-5	C
CONN 11	B-7	21
CONN 12	D-7	B
CONN 13	D-7	B
CONN 14	D-7	B
CONN 15	E-8	B
CONN 16	F-10	32
CONN 17	E-10	B
CONN 18	D-10	B
CONN 19	C-10	B
CONN 20	B-10	31
CONN 21	B-11	21
CONN 22	C-12	22
CONN 23	A-13	21
CONN 24	B-13	23
CONN 25	E-13	30
CONN 26	D-15	24
CONN 27	E-14	24
CONN 28	A-15	25
CONN 29	B-15	14
CONN 30	B-15	D
CONN 31	D-2	26
CONN 32	D-10	B
CONN 33	B-2	31

[1] The connectors shown in this chart are for harness to harness connectors. Connectors that join a harness to a component are generally located at or near the component. See the Component Location Chart.

MODULE IDENTIFIER (MID)	
MID No.	Module
30	Caterpillar Monitoring System
81	Electronic Transmission Control

MONITORING SYSTEM MODE	
Mode Of Operation	Mode Number
Normal	0
Harness Code	1
Numeric Readout	2
Service	3
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Units (U.S./Metric)	5
Setup	6

COMPONENT IDENTIFIER (CID) LIST	
CID No.	**Component**
Caterpillar Monitoring System (Mid No. 30)	
096	Fuel Level Sensor
110	Engine Coolant Temperature Sensor
177	Torque Converter Oil Temperature Sensor
248	CAT Data Link
263	8 Volt Sensor Power Supply
271	Action Alarm
324	Action Lamp
600	Hydraulic Oil Temperature Sensor
601	Brake Air Pressure
819	Display Data Link
821	9 Volt Display Power Supply
830	Brake Oil Temperature
Electronic Transmission Control (Mid No. 81)	
168	Electrical System Voltage
190	Engine RPM Sensor
248	CAT Data Link
362	Ride Control Solenoid
368	Auto/Manual Switch
617	Air Inlet Heater Relay
621	Downshift Switch
631	Solenoid 1 (reverse)
632	Solenoid 2 (forward)
633	Solenoid 3 (speed 4)
634	Solenoid 4 (speed 3)
635	Solenoid 5 (speed 2)
636	Solenoid 6 (speed 1)
668	Shift Handle
671	Transmission Speed Sensor
680	Ride Control Switch
685	Service Identification Code
687	Options Identification Code
688	Dual Horsepower Solenoid

CID list applies to Transmission and Monitor Controls.

FAILURE MODE IDENTIFIER (FMI) LIST	
FMI No.	**Failure Description**
0	Data valid but above normal operational range.
1	Data valid but below normal operational range.
2	Data erratic, intermittent, or incorrect.
3	Voltage above normal or shorted high.
4	Voltage below normal or shorted low.
5	Current below normal or open circuit.
6	Current above normal or grounded circuit.
7	Mechanical system not responding properly.
8	Abnormal frequency, pulse width, or period.
9	Abnormal update.
10	Abnormal rate of change.
11	Failure mode not identifiable.
12	Bad device or component.
13	Out of calibration.

CATERPILLAR®

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Service Manual

Caterpillar Monitoring System

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety Is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

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NOTE: A "C" in the left margin is an indication of a change from the former issue.

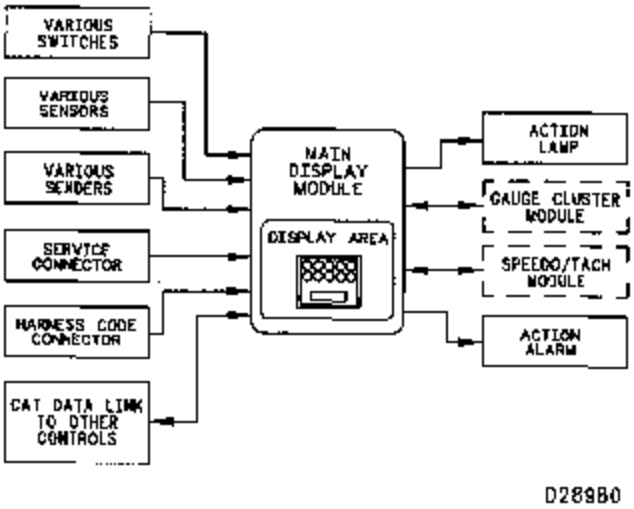
REFERENCE: For machine specific operation information, see the Operation And Maintenance Manual for the machine being serviced.

REFERENCE: For machine specific electrical circuit information, see the Electrical System Schematic module for the machine being serviced.

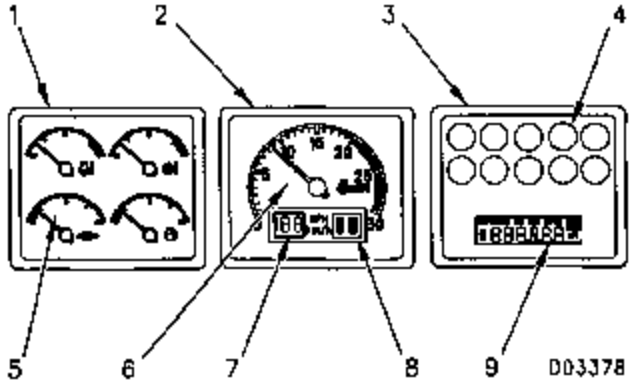
C **TERMINOLOGY:** In other publications that include D series trucks the Caterpillar Monitoring System may be referred to as the Caterpillar Electronic Monitoring System.

Systems Operation

Introduction



Caterpillar Monitoring System Block Diagram
The gauge cluster and speedo/tach modules are optional components.



Caterpillar Monitoring System Display Components
(1) Gauge cluster module. (2) Speedometer/tachometer module. (3) Main display module. (4) Alert indicators. (5) Gauges. (6) Tachometer. (7) Speed readout. (8) Gear readout. (9) Display area.

The Caterpillar Monitoring System is an electronic monitoring system that continuously watches machine systems. The system is a flexible, modular monitoring system that includes: a main display module, various switches and sensors, an action lamp and an action alarm. The system may or may not include a speedometer/tachometer module and one or more gauge modules. The main display module is the heart of the system. This module receives information from the switches, sensors and other electronic controls on the machine via the CAT® data link. The main display module processes all of this information and activates various outputs. These outputs could be in the display portion of the main display module, the gauge cluster module, the speedometer/tachometer module, the action lamp or the action alarm. The display components show the operator the condition of machine systems and system diagnostic information.

The same monitoring system operates on a variety of different machines. All the possible system functions are not performed on every machine. The main display module recognizes the machine on which it is installed and performs only the intended functions for that machine. The main display module is required for the monitoring system to operate. The gauge cluster and the speedometer/tachometer modules may not be used on some machines. The maximum number of other modules that can be used with the main display module at any one time is four; two gauge cluster modules and two speedometer/tachometer modules.

The maximum quantity and type of available indications shown on the display area of each module are:

Main Display Module

- Ten alert indicators (4) show abnormal machine conditions.
- One display area (9) provides a six digit readout that shows machine operational hours (service meter), engine speed (tachometer), machine distance (odometer) or diagnostic codes. The information for the speedometer/tachometer and any gauge of the gauge cluster can also be shown numerically on this readout. The display area also contains seven unit indicators and a service indicator. What information to show on the display area is selected by the operator.
- Seven unit indicators (part of display area), °C, kPa, MILES, KM, RPM, LITERS and HOURMETER symbol show the units of measurement for the data being shown on the six digit readout. The indicators are turned ON and OFF to correspond with the information being shown on the six digit readout.
- One service code indicator (part of display area), used in service and diagnostic scrolling mode to indicate when a fault is currently present.

Speedometer/Tachometer Module

- One tachometer gauge (6) shows engine speed (RPM) information.
- One 3 digit speed readout (7) shows ground speed information [MPH (km/h)].
- One 2 digit gear readout (8) shows transmission actual gear and direction information.

Gauge Cluster Module

- Four electronic gauges (5) show changing machine conditions. These could be oil pressure, fuel level or coolant temperature.

The type and quantity of indications used in the display areas varies according to the application. All of the indications are not used on each machine. Some machines may use up to two of the gauge cluster and speedometer/tachometer modules. In addition to the above indications, an external action lamp and action alarm function to indicate the severity (warning category) of a problem. To determine what functions are used on a particular machine, see the corresponding Operation And Maintenance manual.

Component Description

The same Caterpillar Monitoring System operates on a variety of different machines. The monitoring system is a flexible modular system that includes the main display module and optional display modules (speedometer/tachometer and gauge cluster). The main display module is used in all applications. The type and quantity of display modules used depends on the machine the monitoring system is used on. All of the following electrical components are not present on every machine. The main display module recognizes the machine on which it is installed and therefore knows which components are present. For the location of electrical components see the Electrical System Schematic in the machine service manual.

Main Display Module

CONTACT DESCRIPTION OF MAIN MODULE CONNECTOR		
No.	**Function**	**Type**
1	+ Battery	Input - Voltage (Power)
2	Ground	Ground
3	Harness Code 1	Switch Input - Programming
4	Action Alarm	Output
5	CAT Data Link +	Input/Output - Data Link
6	Harness Code 5	Switch Input - Programming
7	PWM/Switch 1	Sensor Or Switch Input - Uncommitted
8	PWM/Switch/Sender 1	Sensor, Switch Or Sender Input - Uncommitted
9	Switch/Sender 1	Switch Or Sender Input - Uncommitted
10	PWM/Switch/Sender 2	Sensor, Switch Or Sender Input - Uncommitted
11	Switch 1	Switch Input - Uncommitted
12	Harness Code 2	Switch Input - Programming
13	Action Lamp	Output
14	CAT Data Link –	Input/Output - Data Link
15	Display Module Load	Output
16	Harness Code 4	Switch Input - Programming
17	PWM/Switch 2	Sensor Or Switch Input - Uncommitted
18	Switch/Sender 2	Switch Or Sender Input - Uncommitted
19	Switch 2	Switch Input - Uncommitted
20	Switch 3	Switch Input - Uncommitted
21	Switch 4	Switch Input - Uncommitted
22	Harness Code 3	Switch Input - Programming
23	Service	Switch Input - Service
24	Sensor Power Supply	Output
25	Display Module Clock	Output
26	Frequency 1	Sensor Input - Frequency
27	PWM/Switch 3	Sensor Or Switch Input - Uncommitted
28	PWM/Switch/Sender 3	Sensor, Switch Or Sender Input - Uncommitted
29	Switch 5	Switch Input - Uncommitted
30	Alternator R terminal	Sensor Input - Frequency
31	Harness Code 0	Switch Input - Programming
32	Switch 6	Switch Input - Uncommitted
33	Clear	Switch Input - Service
34	Display Module Power Supply	Output
35	Display Module Data	Input/Output
36	Frequency 2	Sensor Input - Frequency
[illegible]	PWM/Switch 4	Sensor Or Switch Input - Uncommitted
[illegible]	[illegible]/Switch/Sender 4	Sensor, Switch Or Sender Input - Uncommitted
39	Switch 7	Switch Input - Uncommitted
40	Switch 8	Switch Input - Uncommitted

The main display module continuously monitors all machine systems. The main display module makes decisions based upon the input from the machine systems or other electronic control modules on the machine. The main display module sends information to other electronic controls on the machine. The input and output of this information takes place over the CAT data link. The main display module outputs notify the operator and the service person of the status of the machine systems. These outputs are: the gauge cluster, the speedometer/tachometer, the main display module display, the action lamp and the action alarm. A connector with 40 contacts, on the rear of the module, connects the necessary harness wiring to the inputs and outputs.

Input/Output

CAT Data Link

The CAT data link (connector contacts 5 and 14) is used to communicate with other electronic control modules on the machine. The CAT data link is bidirectional; which allows the modules to input and output information. This permits sharing of information such as engine oil pressure, harness codes and diagnostics.

Display Data Link

The display data link (connector contacts 15, 25 and 35) provides the electrical signals to operate the display modules. These display modules, in addition to the main display module, provide information about machine systems to the operator. Each module (and each display indicator in the module) is identified by a unique identifier or address. Data is continuously output from the main display module to the display module(s). The addressed module returns data to the main display module to confirm receipt of data.

Inputs

The inputs tell the main display module how to operate and the status of the machine systems. Three types of inputs exist; switch type, sensor type and sender type. Switches and harness wiring provide a ground or an open (floating) signal to the switch inputs. Sensors (frequency, PWM) provide a changing signal to the sensor inputs of the main display module. Senders provide a changing resistance to the sender inputs of the main display module.

Some inputs are multi-purpose (switch, sensor or sender input). For example: connector contacts 7, 17, 27 and 37 may be either switch inputs or PWM sensor inputs; connector contacts 9 and 18 may be either switch inputs or 0-240 ohm sender inputs; and connector contacts 8, 10, 28 and 38 may be switch inputs, PWM sensor inputs or 70-800 ohm sender inputs. These inputs are programmed at the time of installation, to define which components are to be monitored and therefore which input types (switch or sensor) are active. To determine how the main display module inputs are programmed, see the Electrical System Schematic in the service manual for the machine being serviced.

Switch Inputs – Uncommitted

The uncommitted switch inputs (connector contacts 11, 19, 21, 20, 29, 32, 39, and 40) provide the information used to operate the ten alert indicators that are part of main display module outputs. These switch inputs may be programmed at the time of installation to work independently or in combination with other switch and/or sensor inputs to operate an alarm indicator and to determine the appropriate warning category (1,2 or 3). During normal operation, these switch inputs are closed to ground. The grounded inputs tell the main display module that the system conditions are normal and no alert indicators should be ON. These inputs receive information from pressure, temperature, flow, level and mechanical switches located within the machine systems.

Other main display module inputs may be programmed at the time of installation to function as uncommitted switch inputs. For more information, see the topics Sensor Inputs – PWM, Sender Inputs – 0-240 ohm and Sender Inputs – 70-800 ohm.

Any one of the switch inputs may be programmed to operate from an operator switch that is used to operate the main display module display area. For location of this switch input see the machine wiring diagram. For information on the operation of this switch see Mode 0 of the Modes of Operation section.

C **NOTE**: The alert indicators may also be programmed to operate from sensor inputs. One of the ten alert indicators is normally dedicated to charging system , which uses the battery power input and the alternator R terminal input.

Switch Inputs – Programming

The programming switch inputs (connector pins 31, 3, 12, 22, 16 and 6) tell the main display module how to operate. The main display module operates in a manner that corresponds to the open or grounded state of the programming switch inputs. These inputs receive information from permanent connections or a harness code connector within the harness wiring. The programming switch inputs consist of harness code information.

The harness code switch inputs tell the main display module which machine model it is installed on. Model information is necessary because of the differences in machines. Engine size, idle speed, tire size and other machine information is necessary for the main display module to make decisions.

Switch Inputs – Service

The service switch inputs (connector contacts 23 and 33) control set-up, mode of operation and certain diagnostic functions. Grounding service input (connector contact 23) and clear input (connector contact 33) at the same time, initiates changing the monitoring system mode of operation. Removing ground from these two inputs locks the main display module in the selected mode. Other diagnostic functions are also performed when the service inputs are grounded and/or opened at the proper time. For more information, see the topic Modes Of Operation.

Sensor Inputs – PWM

Each PWM sensor input (connector contacts 7, 17, 27 and 37) may be programmed to operate either as a sensor input or a switch input.

When programmed to operate as a PWM sensor input, a PWM signal is present which represents the condition of a machine system. Temperature, pressure and level are examples of the conditions which are monitored. The main display module measures the duty cycle of the PWM sensor output and then sends this information to the gauge cluster to be shown on one of the gauges.

NOTE: See Switch Input – Uncommitted for input operation when programmed to operate as a switch input. Use the Electrical System Schematic of the machine being serviced to determine how these inputs are programmed.

NOTE: The PWM sensor input may be programmed to operate a gauge, an alarm indicator, or a gauge and alarm indicator.

Sensor Input – Frequency

At each frequency sensor input (connector contacts 26, 30 and 36), an AC signal is present which represents the speed of a machine system. Frequency sensors for engine speed and machine speed provide a AC signal to the main display module. The main display module measures the frequency (Hz) of the AC signals and then sends this information to the speedometer/tachometer module.

At the alternator R terminal input (connector contact 30), the R terminal of the alternator provides an AC signal to the main display module. The main display module measures the frequency (Hz) of the AC signal and determines the speed at which the alternator is rotating. The alternator R terminal helps determine the condition of the electrical charging system. Harness wiring directly connects the alternator R terminal to the alternator R sensor input. The alternator R terminal information is used with other inputs (engine oil pressure, engine speed, etc.) to determine when the engine is running.

Sender Input – 0–240 Ohm

Each 0–240 ohm sender input (connector contacts 9 and 18) may be programmed to operate either as a sender input or a switch input.

When programmed as a sender input, a resistance value is present which corresponds to a system condition. The fuel level sender (or a component with a similar output signal) provides this information. The fuel level sender output resistance corresponds to the depth of fuel within the tank. The main display module measures the resistance value and then sends this information to the gauge cluster to be shown on one of the gauges.

NOTE: See Switch Input – Uncommitted for input operation when programmed to operate as a switch input. Use the Electrical System Schematic of the machine being serviced to determine how these inputs are programmed.

NOTE: The 0–240 ohm sender input may be programmed to operate a gauge, an alarm indicator, or a gauge and alarm indicator.

Sender Input – 70–800 Ohm

Each 70–800 ohm sender input (connector contacts 8, 10, 28 and 38) may be programmed to operate as a sender input, a PWM sensor input or a switch input.

- When programmed as a 70–800 ohm sender input, a resistance value is present which corresponds to a system condition. The temperature sender (or a component with a similar output signal) provides this information. The temperature sender output resistance corresponds to the temperature of the fluid being measured. For example a 4W-9972 temperature sender is (800 Ω = 50°C, 70 Ω = 121°C). Oil, coolant and hydraulic temperature are examples of fluid temperatures measured. The main display module measures the resistance value and then sends this information to the gauge cluster to be shown on one of the gauges.

NOTE: See Switch Input – Uncommitted for input operation when programmed to operate as a switch input. Use the Electrical System Schematic of the machine being serviced to determine how these inputs are programmed.

NOTE: See Sensor Input – PWM for input operation when programmed to operate as a PWM sensor input. Use the Electrical System Schematic of the machine being serviced to determine how these inputs are programmed.

NOTE: The 70–800 ohm sender input may be programmed to operate a gauge, an alarm indicator, or a gauge and alarm indicator.

Input – Voltage

The voltage input (connector contact 1) provides the main display module with power and is used by the main display module to monitor the machine electrical system. This voltage information helps determine the condition of the electrical system.

When an alert indicator is used to indicate machine system voltage, the battery signal is combined with the R terminal signal within the main display module. When an electrical system fault occurs, there are two possible warning categories. The category is set by the type of fault.

- Category 1: R terminal frequency less than 90 Hz or system voltage greater than 29.5 volts for at least 2 seconds or system voltage less than 24.8 volts for a least 2 seconds.

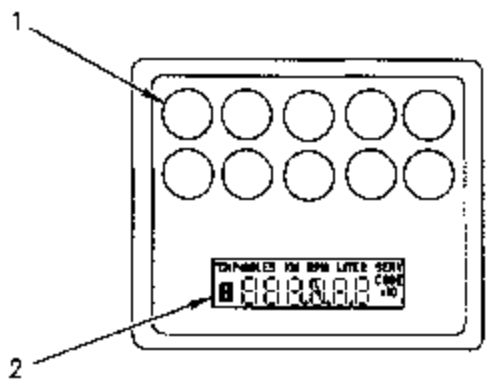
- Category 3: System voltage is less than 23.0 volts for at least 2 seconds (this is optional on some machines) or system voltage is greater than 32.0 volts for at least 2 seconds.

Outputs

The outputs of the Caterpillar Monitoring System notify the operator of the status of the machine systems. The main display module provides electrical power for the other display modules and the sensors.

The outputs are: the main display module display, the display data link, the alert indicators, the action lamp, the action alarm, the sensor power supply and the display module power supply.

Main Display Module



Main Display Module
(1) Alert indicators. (2) Display area.

The outputs in the main display module display are alert indicators (1) and display area (2).

The alert indicators notify the operator of abnormal machine conditions. The main display module uses the status of the uncommitted switch inputs, sender inputs and/or sensor inputs to determine when an abnormal condition is present. Then the main display module FLASHES the appropriate alert indicator. The pictograph symbol of the FLASHING alert indicator identifies the responsible machine system. When an alert indicator FLASHES, an abnormal condition exists. For more information, see the topic Warning Operation.

NOTE: The main display module may use inputs in combination to determine abnormal conditions. For example, engine oil pressure, engine rpm, etc. may be used to enable the machine electrical system alert indicator. Then if an abnormal condition exists on the R terminal input or +battery input, the machine electrical system alert indicator will FLASH.

The display area has a row of six digits, a decimal point between certain digits, six text (units of measure) symbols, a x10 symbol and a service meter symbol that are used to show machine system conditions and other service and setup information. The type of information shown on the display depends on the main display module operating mode. For more information about the display area see the topic Modes of Operation.

Action Lamp

When a serious abnormal condition exists (category 2 or 3), the main display module activates the action lamp output (connector contact 13) and the action lamp FLASHES. For more information, see the topic Warning Operation.

Action Alarm

When a critical abnormal condition exists (category 3), the main display module activates the action alarm output (connector contact 4) and the action alarm SOUNDS. For more information, see the topic Warning Operation.

Power Supply Output – Sensor

The sensor power supply output (connector contact 24) provides +8 DCV power for up to eight PWM sensors connected to the main display module inputs.

Power Supply Output – Display Modules

The display module power output (connector contact 34) provides +9 DCV power for up to four display modules (gauge or speedometer/tachometer). The gauge and speedometer/tachometer modules cannot function without this power output.

Display Components

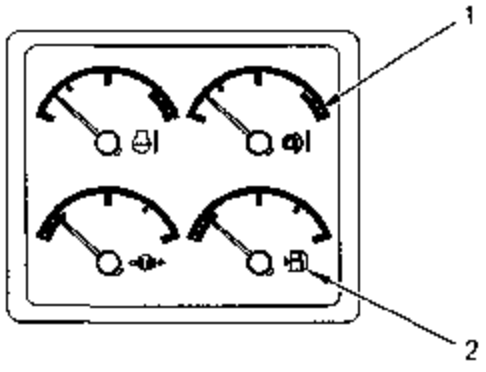
The following chart shows the contact description for all display components.

CONTACT DESCRIPTION OF DISPLAY COMPONENTS CONNECTOR		
No.	Function	Type
1	+9 DCV	Input
2	Ground	Ground
3	Display Clock	Input
4	Display Data	Input
5	Display Load	Input
6	Harness Code	Input[1]

[1] Used to give two display components of the same type a unique component number. This is needed so the main display module can send unique information to each identical component. With this input grounded the component is assigned a module number of 1, with this input open the component is assigned a module number of 2.

The display components receive information from the main display module. This information is shown by the display components to notify the operator and the service person of the status of the machine systems. The components are gauge cluster module and speedometer/tachometer module.

Gauge Cluster Module

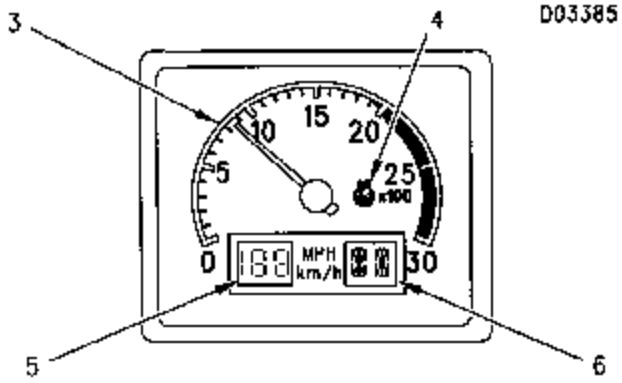


Gauge Cluster Module
(1) Gauge warning area. (2) Pictograph symbol.

Four gauges show information like: temperature, pressure and level, which is received from sensor inputs. The main display module uses the information from sensor inputs or the CAT data link to calculate the value shown on the gauges.

Each gauge is dedicated to a parameter within a machine system. Some of the possible machine systems parameters are: engine oil pressure, power train oil temperature, brake oil temperature, brake air pressure, system air pressure, hydraulic oil temperature and fuel level. Pictograph symbol (2) identifies the machine system parameter that is shown on each gauge. Abnormal range values are shown by gauge warning area (1).

Speedometer/Tachometer Module



Speedometer/Tachometer Module
(3) Tachometer. (4) Pictograph symbol. (5) Speed readout. (6) Gear readout.

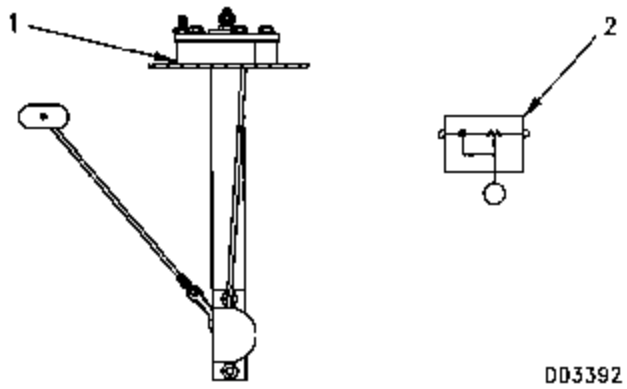
C Speed readout (5) consists of three digits and may show machine ground speed in MPH (km/h). The main display module calculates speed using the information from a frequency sensor input or the CAT data link. Illumination of the appropriate digits shows the speed.

Gear readout (6) consists of two digits that show the transmission actual gear which is engaged. The left digit shows the actual gear; such as "1", "2", "3" etc. The right digit shows the direction selected; "F", "N" or "R".

Tachometer (3) shows engine speed in RPM. The engine speed is determined using information sent to the main display module over the CAT data link or from a frequency sensor input.

Senders

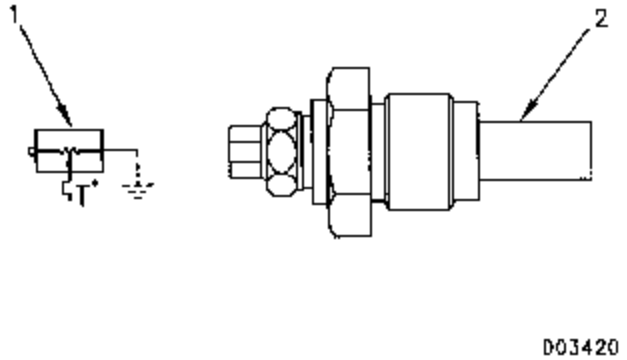
Fuel Level Sender



Fuel Level Sender
(1) Sender. (2) Schematic symbol.

Fuel level sender (1) provides fuel level sensing. A resistive signal which corresponds to the depth of fuel within the fuel tank is sent from the sender to the main display module. Typically, there are two possible sender types; 0 to 90 ohms and 33 to 240 ohms. The main display module measures the resistance value to determine the fuel remaining in the tank.

Temperature Sender



Temperature Sender
(1) Schematic symbol. (2) Sender

Temperature sender (2) provides fluid temperature sensing. A resistive signal which corresponds to the temperature of the fluid being monitored is sent from the sender to the main display module. Typically, this sender resistance range is 70 to 800 ohms. The main display module measures the resistance value to determine the fluid temperature.

Switches

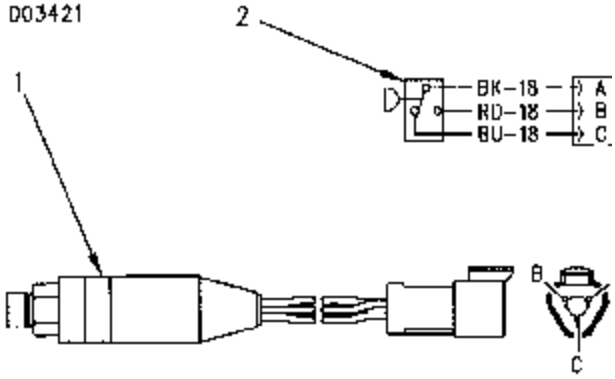
Switches provide information (input) to the main display module. Switches are two state devices. The two states are:

- Closed - the switch connects the control input to frame ground.
- Open - the switch does not connect the control input to anything (the input is floating).

During normal operation all switches are closed to ground. When a condition exceeds the trip point of the switch, the switch opens. This tells the main display module of the abnormal condition. Then the main display module goes into warning operation and notifies the operator of the abnormal condition (problem).

NOTE: For switch specifications; see the Electrical System Schematic in the machine service manual.

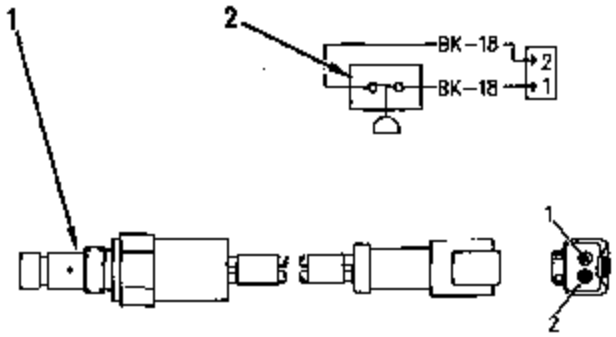
Engine Oil Pressure Switch



Engine Oil Pressure Switch
(1) Switch. (2) Schematic symbol.

During normal operation, engine oil pressure switch (1) is closed to ground. The switch opens when engine oil pressure is less than the specified value for the switch. The open switch tells the main display module to notify the operator of the insufficient engine oil pressure. Off the machine (on the bench), the switch is open (normally open).

Differential Oil Filter Pressure Switch

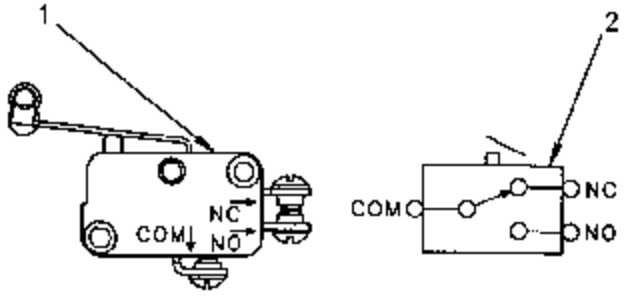


D26100

Differential Oil Filter Pressure Switch
(1) Switch. (2) Schematic symbol.

During normal operation, switch (1) is closed to ground. The switch opens when the differential oil filter is restricted (dirty) and the oil pressure is greater than the specified value for the switch. The open switch tells the main display module to notify the operator that the differential filter is restricted (dirty). Off the machine (on the bench), the switch is closed (normally closed).

Transmission Neutral Limit Switch



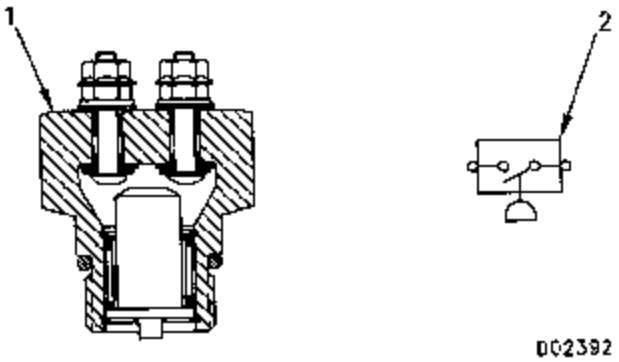
D03572

Transmission Neutral Limit Switch
(1) Switch. (2) Schematic symbol.

When in neutral, transmission neutral limit switch (1) is closed to ground. The switch opens when the shift lever is in any other position. On the machine, the normally closed (NC) and common (COM) terminals are used. The open or closed condition of limit switch (1) tells the main display module when the transmission control linkage is in the NEUTRAL position. The main display module uses this information to make decisions about related systems. Off the machine (on the bench); the NC and COM terminals are closed (normally closed), the NO and COM terminals are open (normally open).

NOTE: Instead of a transmission neutral limit switch, a switch inside of the electric shift lever may be used to determine when neutral is selected.

Filter Indicator Switches

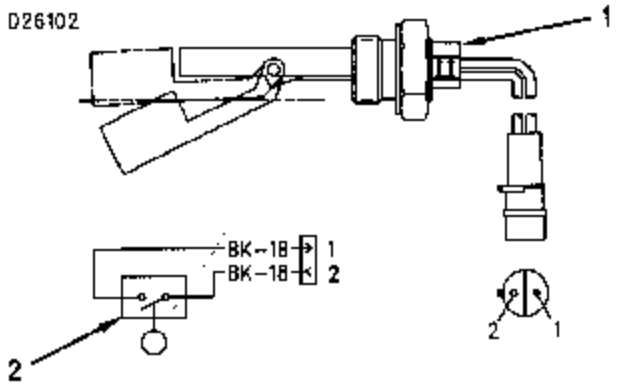


Filter Bypass Switch
(1) Switch. (2) Schematic symbol.

Filter indicator switch (1) has a plunger within the switch that closes the contacts with an acceptable pressure drop across the filter. During normal operation the switch grounds the signal circuit. When the pressure across the filter is greater than specified, the switch plunger moves and allows the switch contacts to open. The open switch tells the main display module to notify the operator that the filter is restricted (dirty). Off the machine (on the bench): the switch is open (normally open).

NOTE: The main display module also considers the fluid temperature before notifying the operator. Cold fluid has a higher viscosity which causes a higher differential pressure than fluid at normal temperature. The operator is not notified when filter bypass occurs with cold fluid. Temperature inhibit is not used with the fuel filter.

Liquid Level Switch



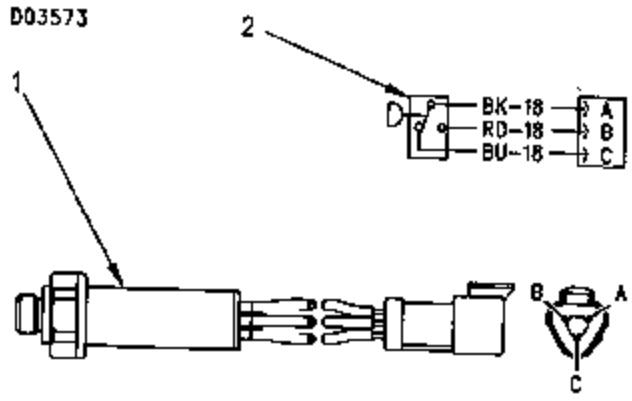
Liquid Level Switch
(1) Switch. (2) Schematic symbol.

During normal operation, level switch (1) is closed to ground. The switch opens when the liquid level is less than the minimum level. The open switch tells the main display module to notify the operator of the low level. Off the machine (on the bench), the switch is open with the float in the DOWN position.

Operator Mode Selector Switch

On some machines, an operator mode selector switch is available. The switch is used to change the operator mode on machines with operator modes. When in normal mode, the display area can be used to show various machine system conditions to the operator (Operator Modes). The operator modes available depend on the machine the monitoring system is installed on. A list of possible operator modes is shown at the beginning of the Modes of Operation section. See the Operation And Maintenance Manual to determine which Operator Modes are available for the machine being serviced.

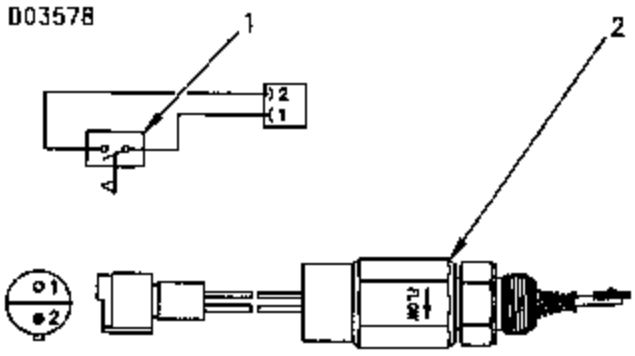
Brake Oil Pressure Switch



Brake Oil Pressure Switch
(1) Switch. (2) Schematic symbol.

During normal operation, brake oil pressure switch (1) is closed to ground. The switch opens when the oil pressure in the brake system is less than specified. The open switch tells the main display module to notify the operator that the brake oil pressure is too low. Off the machine (on the bench); connector contacts A and C are closed (normally closed), and connector contacts A and B are open (normally open).

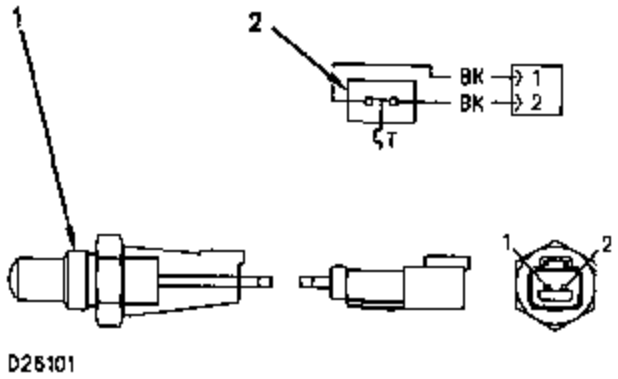
Supplemental Steering Flow Switch



Steering Flow Switches
(1) Schematic symbol. (2) Switch.

During normal operation, steering flow switch (2) is closed to ground. The switch opens when steering system oil flow is less than specified. The open switch tells the main display module to notify the operator of low oil flow in the steering system. Switch (2) is used in the primary and supplemental steering systems. Off the machine (on the bench), the switch is open (normally open).

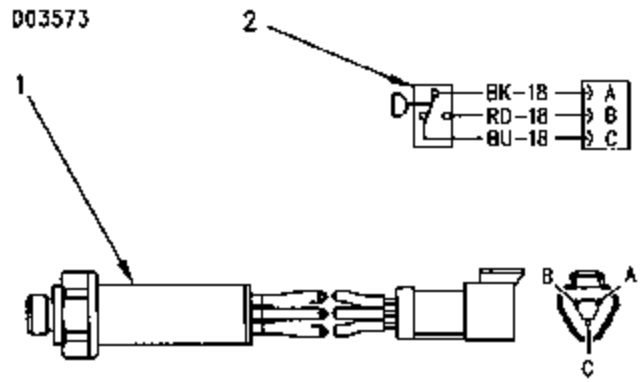
Temperature Switch



Temperature Switch
(1) Switch. (2) Schematic symbol.

A machine may have more than one temperature switch. During normal operation, temperature switch (1) is closed to ground. The switch opens when the temperature of the fluid system is greater than the specified value. The open switch tells the main display module to notify the operator of the high temperature Off the machine (on the bench), the switch is closed (normally closed).

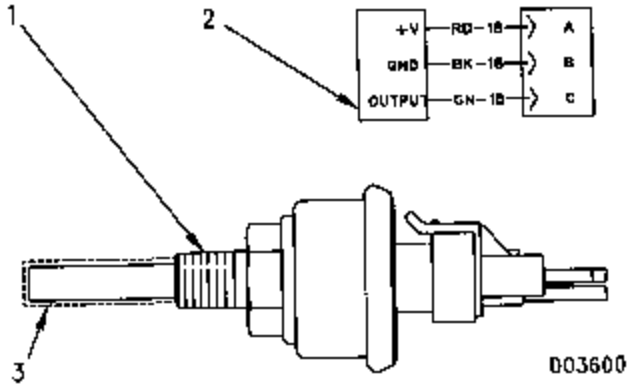
Steering Pressure Switch



Steering Pressure Switch
(1) Switch. (2) Schematic symbol.

During normal operation, steering pressure switch (1) is closed to ground. The switch opens when the pressure in the steering system is less than specified. The open switch tells the main display module to notify the operator that the steering oil pressure is too low. Off the machine (on the bench); connector contacts A and C are closed (normally closed), and connector contacts A and B are open (normally open).

Coolant Level Switch



Coolant Level Switch
(1) Switch. (2) Schematic symbol. (3) Plastic sleeve (see note).

The coolant level switch is an electronic switch that is activated by coolant. During normal operation, coolant level switch (1) is closed to ground. The switch opens when the coolant level is too low. The open switch tells the main display module to notify the operator of a low coolant condition in the cooling system. The switch has a connector with three contacts; contact A connects to +8 DCV sensor power from the main display module. contact B connects to ground and contact C (switch output) connects to the main display module input. Off the machine (on the bench); with power and ground disconnected the switch is open, but cannot be tested. See the Testing And Adjusting section for more information.

NOTE: DO NOT remove plastic sleeve (3) from the probe. This plastic sleeve is required for proper switch operation.

Sensors

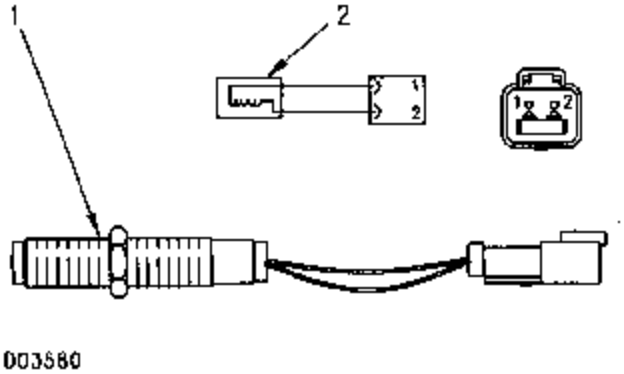
Sensors provide information (input) to the main display module about changing conditions, such as speed and temperature. The sensor signal changes in a proportional manner to reflect the changing condition. The main display module shows the sensor information on the gauges. The type of sensor signals that the main display module recognizes are:

- Frequency – The sensor produces an AC signal in which the frequency (Hz) varies as the condition changes.
- Pulse width modulated (PWM) – The sensor produces a digital signal in which the duty cycle varies as the condition changes. The frequency of this signal is constant.

Frequency Sensors

Frequency sensors produce an AC signal in which the frequency (Hz) varies as the condition changes.

Speed Sensors

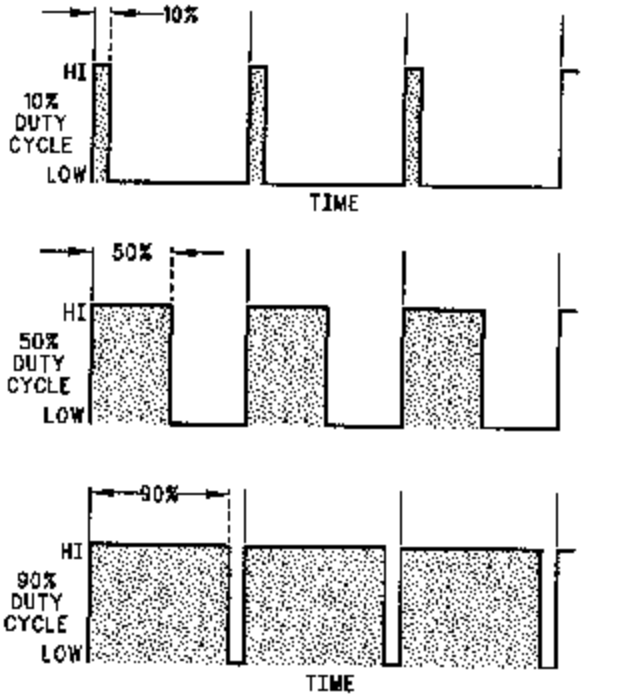


Speed Sensor
(1) Sensor. (2) Schematic symbol.

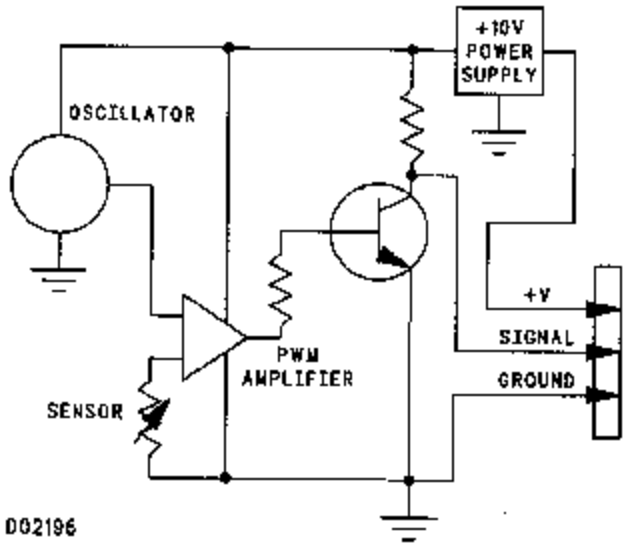
Speed sensor (1) is a frequency sensor. Speed sensors are used to measure engine RPM and machine MPH (km/h). The sensor generates an AC signal, from passing gear teeth, which is sent to the main display module. The main display module measures the sensor frequency (one pulse per gear tooth), then determines and shows the engine speed or machine speed.

The engine speed sensor is located on the flywheel housing. The machine speed sensor is located at the output end of the transmission housing.

Pulse Width Modulated (PWM) Sensors



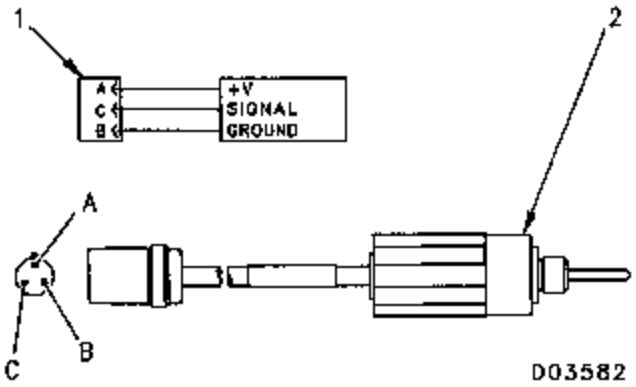
Pulse Width Modulated Signal



Typical PWM Sensor Schematic

Pulse width modulated (PWM) sensors produce a digital signal in which the duty cycle varies as the condition changes. The frequency remains constant.

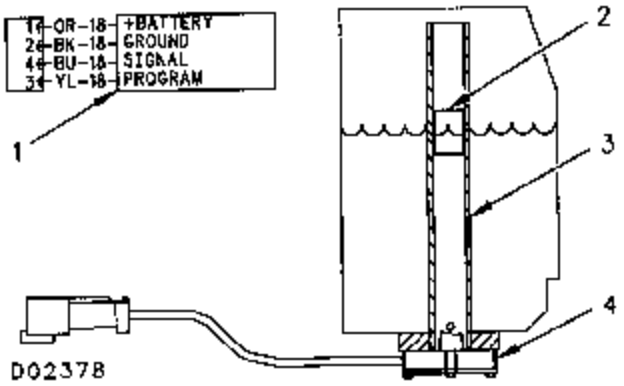
Temperature Sensor



Temperature Sensor
(1) Schematic symbol. (2) Sensor.

Temperature sensor (2) reacts to the temperature of fluids; such as hydraulic oil, power train oil, or engine coolant. The sensor receives operating power from the main display module (8 DCV) or from the battery (24 DCV). The sensor sends the main display module a PWM signal which changes as the fluid temperature changes. The main display module measures the duty cycle of the sensor signal to determine the fluid temperature.

Fuel Level Sensor – Ultrasonic Type



Fuel Level Sensor – Ultrasonic Type
(1) Schematic symbol. (2) Float. (3) Guide tube. (4) Sensor.

Fuel level sensor (4) reacts to the level of the fuel in the fuel tank. Sensor (4) emits an ultrasonic signal up guide tube (3). The ultrasonic signal is reflected off a metal disk on the bottom of float (2) and the signal returns to the sensor. The sensor measures the time it takes for the ultrasonic signal to travel from the sensor to the float and back to the sensor. The sensor also measures the temperature of the fuel and compensates accordingly. The status (open or grounded) of connector contact 3, tells the sensor whether it is installed in a deep tank or a shallow tank. Contact 3 should be open for a tank (deep) that has a maximum depth of 2300 mm (90 in). Contact 3 should be grounded for a tank (shallow) that has a maximum depth of 1150 mm (45 in). The sensor receives operating power from the machine electrical system. The sensor sends the main display module a PWM signal which changes as the fuel level changes. The main display module measures the duty cycle of the sensor signal to determine the fuel level.

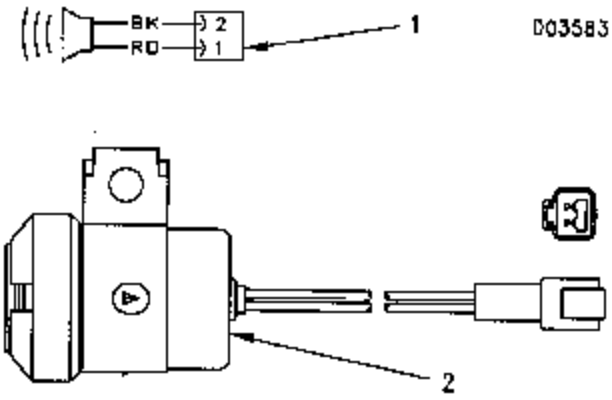
NOTE: The fuel level sensor cannot be bench tested. The sensor must have fuel in guide tube (3) in order to operate properly. The sensor can only be tested while installed on the machine. For specifications and test procedures, see the topic PWM Sensor Tests in the Testing And Adjusting section.

Action Lamp

Action Lamp Symbol

The action lamp connects to an output of the main display module. The action lamp is an incandescent lamp, located within the operator's viewing area. The FLASHING of the action lamp tells the operator that a condition exists that requires changing the operation of the machine. The main display module FLASHES the action lamp whenever a warning category 2 or 3 problem exists.

Action Alarm



Action Alarm
(1) Schematic symbol. (2) Action alarm.

The action alarm connects to an output of the main display module. The SOUNDING of the action alarm tells the operator to immediately shutdown the machine safely. The main display module SOUNDS the action alarm whenever a warning category 3 problem exists.

The action alarm does not operate when the engine is stopped. The main display module uses functions such as: engine oil pressure, alternator speed and engine speed to determine when the engine is running. When the main display module decides the engine is running, the action alarm SOUNDS when necessary.

Related Components

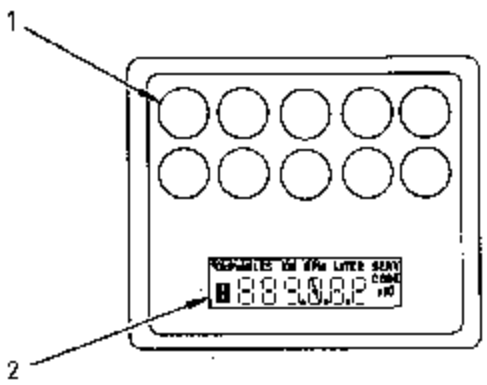
Alternator

The R terminal of the alternator is connected to an input of the main display module. The main display module monitors the frequency at the R terminal of the alternator. This tells the main display module if the alternator is rotating.

Other Electronic Controls

Some machines have electronic control modules that communicate with the main display module. The CAT data link connects these electronic controls together. This allows the sharing of information such as: engine oil pressure, harness codes and diagnostic information. For example; an electronic engine control sends engine speed information to the main display module over the CAT data link. In this situation, the engine speed sensor is not Caterpillar Monitoring System component. If there is a problem with the engine speed sensor, the electronic engine control service manual would be used to troubleshoot the speed sensor circuit.

Modes Of Operation



Main Display Module Display
(1) Alert indicators. (2) Display area.

Display Area (Mode 2), Typical Example

The Caterpillar Monitoring System has 12 different possible modes of operation. Each mode provides important information regarding the condition of the machine and setup of the monitoring system. All modes are not available on all machines. The machine that the system is installed on will determine which modes are available. In this manual all 12 modes are given names and referred to by name. On main display module display area (2) each mode is shown as a number. This number is assigned by software in the main display module. To determine what mode name that corresponds to the mode number shown on the display area, use the Monitoring System Mode chart on the Electrical System Schematic of the machine being serviced.

The mode of operation is changed using the service and clear inputs of the main display module. On some machines, certain modes are available to the operator (operator modes). The operator accesses these modes using the operator mode selector switch located in the operators compartment. The following chart shows the available modes and which modes are available as operator modes. See the Operation And Maintenance Manual of the machine being serviced for specific operator mode information.

Mode Of Operation	Mode Number	Available As Operator Mode
Normal	0	Yes
Harness Code	1	No
Service Meter	*	Yes
Odometer	*	Yes
Tachometer	*	Yes
Numeric Readout	*	Yes
Diagnostic Scrolling	*	Yes
Service	*	No
Tattletale	*	No
Units	*	No
Setup	*	No
Calibration	*	No

* See the Monitoring System Mode chart on the Electrical System Schematic of the machine being serviced, to determine the mode number.

When power is applied, the Caterpillar Monitoring System performs the Self Test and then enters Normal Mode. To enter the other modes, the service and clear inputs are grounded at the same time. This causes the mode numbers to scroll sequentially on the six digit readout of the main display module display area. When ground is removed from the service and clear inputs, the monitoring system enters the mode which corresponds to the number that is presently shown. For example; removing ground when mode number "-1-" is shown on readout, causes the monitoring system to enter harness code mode.

NOTE: Normal mode and harness code mode are always available and have the mode numbers 0 and 1, respectively. Other modes may or may not be available. Modes will always be scrolled in the order shown in the preceding chart, but the mode number may vary for modes other than normal and harness code. As the modes are scrolled, when in mode 0 the display shows the default information selected by the operator. The "-0-" is not shown on the display to indicate mode 0.

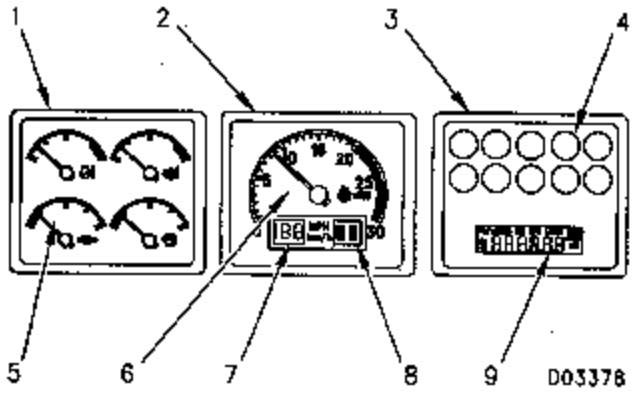
NOTE: If the service and clear inputs are grounded when power is applied, the monitoring system performs the self test and then scrolls the mode numbers.

C The service connector, or service switches located within the operator compartment, provides access to the service and clear inputs. For more information on the service connector location, see the Electrical System Schematic for the machine being serviced.

The mode of operation is changeable at any time. Grounding the service and clear inputs at the same time initiates the scrolling of the mode numbers. Removing ground causes the monitoring system to enter the operating mode which corresponds to the mode number shown. When scrolling through the modes, mode 0 (normal mode) is not shown on the

display area as a number. When mode 0 is reached, the display area begins showing the mode 0 (normal mode) information.

Normal Mode (Mode 0)



Caterpillar Monitoring System Display Components
(1) Gauge cluster module. (2) Speedometer/tachometer module. (3) Main display module. (4) Alert indicators. (5) Gauges. (6) Tachometer. (7) Ground speed readout. (8) Transmission actual gear readout. (9) Display area.

Normal mode is used during normal machine operation. When in normal mode, main display module (3), speedometer/tachometer module (2) and gauge cluster module (1) display areas show the operator:

- Whether the monitoring system is operating properly. Whenever the key switch is turned to the ON position, the outputs briefly operate. The monitoring system is performing a self test; see Self Test Operation.
- A value for system condition. The main display module continuously watches machine systems. The gauges in the gauge cluster module show a normal range value (in the central region). Ground speed readout (7) and transmission actual gear readout (8) show numeric values. The value for a condition may also be shown in the display area.
- Whether a machine system problem exists. The main display module continuously watches machine systems. When an abnormal condition (problem) exists, the corresponding alert indicator (4) FLASHES. As the severity of the problem increases, the action lamp FLASHES and the action alarm SOUNDS. See Warning Operation section.

NOTE: The main display module may notify the operator when a fault exists in other electronic systems. This is done in different ways. For example; when an engine electronic system fault is present, the main display module FLASHES the alert indicator for check engine, but the service code indicator does not show "SERV CODE". For more specific machine information, see the Operation And Maintenance Manual for the machine being serviced.

Operator Modes

In normal mode, the six digit readout of display area (9) is used to show various machine system conditions to the operator (Operator Modes). Operator modes available to the operator depend on the machine the monitoring system is installed on. A list of possible operator modes is shown at the beginning of the Modes of Operation section. See the Operation And Maintenance Manual to determine which Operator Modes are available for the machine being serviced.

When the main display module enters normal mode, the default condition is shown on the six digit readout. This condition is normally the service meter. For more information see Service Meter Mode.

An operator switch is available to the operator when operator modes are available. The operator switch connects to one of the main display module uncommitted switch inputs (operator switch input). Any one of the uncommitted switch inputs could be used to perform this function (connector contact 18 is the most common). See the Electrical System Schematic for the machine being serviced to determine the uncommitted switch input used. Grounding the operator switch input will cause the six digit readout to scroll through the available operator modes. Opening the switch input will stop the scrolling on the currently shown mode.

The order in which the functions scroll is not the same for all machines. Mode numbers are not displayed when operator modes are scrolling. The most common operator modes in the most common order that they are scrolled is as follows:

- Service Meter Mode. Value on the six digit readout and the service meter symbol ON.
- Odometer Mode. Value on the six digit readout and the MILES or KM symbol ON.
- Tachometer Mode. Value on the six digit readout and the RPM symbol ON.
- Diagnostic Scrolling Mode. Service code are scrolled on the six digit readout.

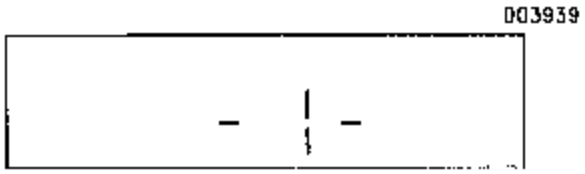
For a more detailed explanation of each mode, see the topic with the corresponding mode name on the pages that follow.

Optional Machine Conditions

The display area may be used to show other machine condition information. For example: the display area may be used as a gear readout when the speedometer/tachometer module is not used. To function as a gear readout, the six digit readout switches from the default condition (normally service meter) to gear readout when the parking brake is DISENGAGED (switch closes to ground). The service meter symbol turns OFF and the actual transmission gear information is shown on the six digit readout.

C The display area may also be used when ether is being injected with a flashing "E" or when prelubing with a flashing "P". Other parameters in separate display modes such as load count, engine oil pressure and charge pressure could be available. See the Monitoring System Mode chart on the Electrical System Schematic of the machine being serviced, to determine the mode number.

Harness Code Mode (Mode 1)



Display Area

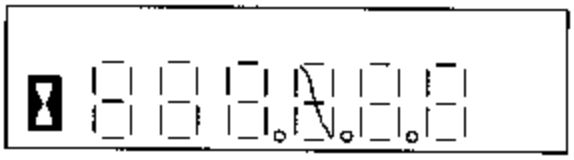
C Harness code mode is always mode 1. When in harness code mode, the machine code is shown on the six digit readout. The machine code must correspond to the machine sales model that the monitoring system is installed on, see the following Machine Code chart. The machine code is a two digit representation of the harness code. An incorrect harness code (one that does not match the machine) will result in incorrect operation of the monitoring system and could result in excessive diagnostic service codes being recorded.

MACHINE CODES	
Sales Model	**Machine Code**
938F,IT38F	03
953C	09
D10R	27
D11R	28
769D, 771D, 773D, 775D, 777D	34
5110	35
950F	39
960F	40
966F	43
970F	45
980G	46
824G	47
825G	48
826G	49
525 1DN1-374	51
24H	53
814F, 815F, 816F	58
515, 525 1DN375-UP	60

C NOTE: The preceding chart is changed from the former issue.

Service Meter Mode

D03585



Display Area

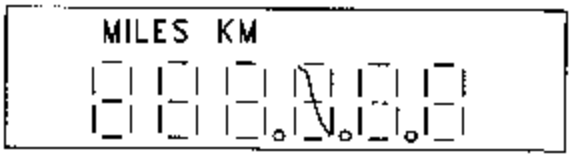
NOTE: This mode is most often used as an operator mode only. To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

The main display module keeps track of the total number of hours the engine has been operated. When in service meter mode, the total machine operating hours are shown on the six digit readout. The service meter symbol is ON to indicate the display is functioning as a service meter. The value is continuously updated as long as the machine engine is operating.

The main display module monitors the engine speed, alternator R terminal and engine oil pressure inputs to determine when the machine engine is operating. On some machines additional inputs may also be used. When any one of these inputs is in the normal range, the main display module starts the machine service meter.

Odometer Mode

D03586



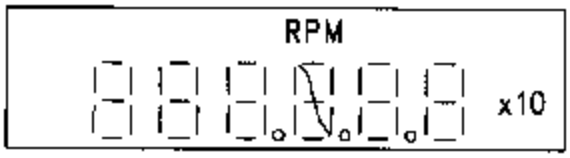
Display Area

NOTE: This mode is most often used as an operator mode only. To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

When the main display module is in odometer mode, the total distance the machine has traveled is displayed on the six digit readout. The units indicator shows "MILES" or "KM" depending on the units of measure setting of the main display module. The main display module can use various sources and methods to determine the distance traveled. The main display module may calculate the distance traveled using a frequency sensor input and software information based on the machine code. The main display module may also receive frequency sensor information from another electronic control module by way of the CAT data link. The unit of measure can be set using the units mode. For more information on the units mode, see the topic Units Mode.

Tachometer Mode

D03587



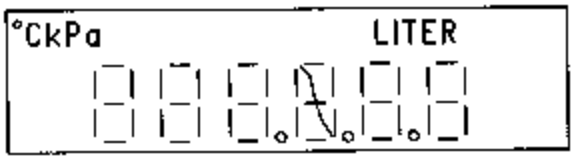
Display Area

NOTE: This mode is most often used as an operator mode only. To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

When the main display module is in tachometer mode, engine RPM is displayed on the six digit readout. The units indicator shows "RPM". The main display module may calculate engine speed using a frequency sensor or receive frequency sensor information from another electronic control module by way of the CAT data link.

Numeric Readout Mode

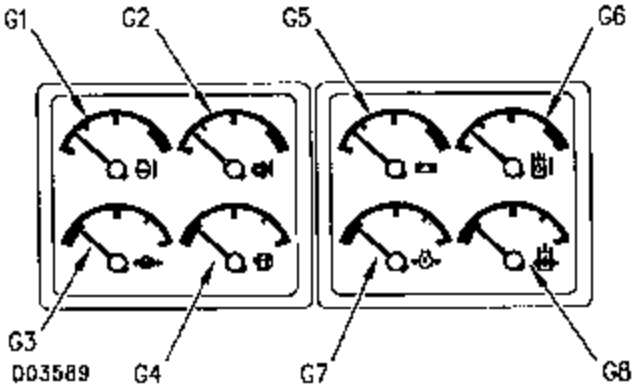
D03588



Display Area

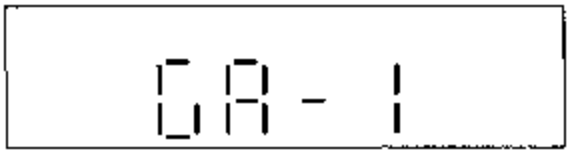
NOTE: To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

Numeric readout mode assists service personnel with troubleshooting of sensor inputs. These inputs supply information for the gauges in the gauge cluster modules. Numeric readout mode more accurately shows the same information as that shown on the gauges in normal mode. The system identifier and numeric value for the system is scrolled on the six digit readout. The system identifier identifies the system that is currently shown on the six digit readout. See the System Identification chart and the following illustration to match the system identifier to the appropriate gauge.



Gauge Cluster Modules

D03940



Display Area – Example Display

SYSTEM IDENTIFICATION		
System Identifier	Gauge Cluster Module	Gauge (System)
GA-1	1	1
GA-2	1	2
GA-3	1	3
GA-4	1	4
GA-5	2	1
GA-6	2	2
GA-7	2	3
GA-8	2	4

UNITS	
Condition	Units Of Measurement
Temperature	°C
Pressure	kPa
Voltage	0.1 volts
Level	% of full

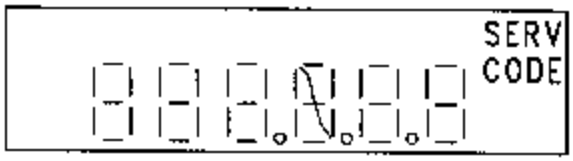
In addition to the chart and illustration, only the gauge for the system being shown on the six digit readout is operational or shows a value. All other gauges in the gauge cluster modules are shut off (gauge needles move to the far left position).

Upon entering Numeric readout mode, the six digit readout is showing information for system GA-1. The display momentarily shows first the system identifier, then the corresponding system value on the six digit readout. Grounding the service input causes all the systems to be scrolled on the display, showing the system identifiers. Ungrounding the service input, when the desired system is shown, stops the scrolling. The six digit readout continues to show the system identifier momentarily then switches to show the system value. The system is now shown on-hold. While on hold, the system numeric value is continuously updated.

C Only the system identifiers for gauge modules present are shown. For example, if one gauge module is present, system identifiers GA-1, GA-2, GA-3, and GA-4 will be shown; if an additional gauge module is present, GA-5, GA-6, GA-7, and GA-8 will be shown.

Diagnostic Scrolling Mode

003590



Display Area

NOTE: This mode is most often used as an operator mode only. To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

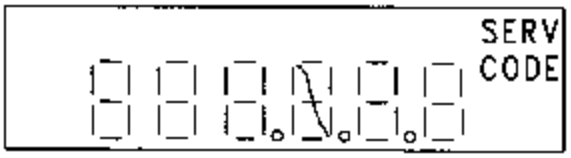
Diagnostic scrolling mode allows service personnel or an operator to see service codes that the main display module has stored. These are the same service codes that may be seen when the main display module is in the service mode. The service code can not be placed on-hold or cleared in this mode.

Upon entering the diagnostic scrolling mode, the service codes are momentarily scrolled on the display area. As each service code is shown, the MID is shown first (for about one second) then the corresponding CID and FMI is shown (for about two seconds). When the last service code has been shown, "End" is shown, then the service codes are shown again. When no faults are detected, there are no service codes to show and "– – –" is shown continuously.

The service code indicator (SERV CODE) functions as a fault present indicator in diagnostic scrolling mode. When "SERV CODE" is ON, the fault that caused the service code currently being shown is present. If "SERV CODE" is OFF, the fault is not present at this time, but has occurred previously.

Service Mode

003590



Display Area

NOTE: To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

While in normal mode, the main display module detects faults that occur with sensor/sender inputs and main display module outputs. A fault is detected when the signal (at the contact of the main display module) is outside a valid range. The main display module then records a service code for the fault. If the fault goes away (not present), the service code remains stored for future reference.

The main display module detects and diagnoses faults in the following circuits:

- Display output modules.
- Action alarm output.
- Action lamp output.
- Sensor inputs (voltage, frequency, PWM and resistive).
- Harness code (only the validity of).

NOTE: The main display module does not detect switch input faults.

Service mode allows service personnel to see and troubleshoot service codes for the faults that the main display module has detected. All detected faults are shown in the display area as a service code. Service codes can be placed on-hold and cleared while the main display module is in service mode.

The main display module enters service mode when ground is removed from the service and clear inputs while the corresponding mode number for service mode is shown on the readout. To determine the corresponding mode number, see Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced. The main display module leaves service mode when the service and clear inputs are grounded at the same time. For more information on changing Modes, see the beginning of the Modes of Operation section.

NOTE: When in Service Mode (on appropriately equipped machines), service codes from other machine systems under electronic control are shown in the main display module display area. The CAT data link allows the transfer of diagnostic information from other electronic control modules to the main display module. This diagnostic information is then shown when the main display module is in service mode. The service code for faults from other electronic control modules have a MID that is unique to that control. These service codes can be scrolled similar to a Caterpillar Monitoring System service codes. See the following description of Module Identifier (MID).

When placed in service mode, the diagnostics of the Caterpillar Monitoring System are available to assist with the troubleshooting of faults. A service code is used to specify each fault. The service code is made up of three identifiers (MID, CID and FMI). These identifiers are shown in the display area. The display area continuously switches between showing the MID (first display) and CID and FMI (second display) while a service code is on hold. The identifiers are:

- Module Identifier (MID) – The MID is a three digit code shown on the display area. MID is shown for approximately one second before the service code is shown in the same area. The MID tells which electronic control module diagnosed the fault. For example, monitoring system, transmission control, engine control, ether injection control, payload monitor, traction control, etc. Some of the MIDs are:

  Caterpillar Monitoring System 30
  Traction Control 28
  Electronic Transmission Control 81

For the most complete MID list, see Module Identifier (MID) chart on the Electrical System Schematic for the machine being serviced. To troubleshoot faults, use the service manual for the control that detected the fault.

- Component Identifier (CID) – The CID tells which component or system is faulty. For example; transmission oil temperature, speed sensor, action lamp or engine boost pressure. The CID is a three digit code shown on the six digit readout. The CID and FMI are displayed together immediately following the MID. For a list of CID codes for the main display module, see the Detected Faults chart under the topic Troubleshooting Faults With Service Codes in the Testing And Adjusting section.

- Failure Mode Identifier (FMI) – The FMI tells what type of failure has occurred. For example; voltage above normal, current below normal or abnormal frequency. The FMI is a two digit code shown on the six digit readout. The CID and FMI are displayed together immediately following the MID. The letter 'F' precedes the FMI. For a list of FMI codes for the main display module, see the Detected Faults chart under the topic Troubleshooting Faults With Service Codes in the Testing And Adjusting section.

Upon entering service mode, the MID, CID and FMI codes for the first available service code are shown. At this time, the service code shown is on-hold. When a service code is on hold, the display continuously switches between the MID and the CID and FMI. This is maintained as long as the service and clear inputs remain open. Troubleshooting is performed while the service code is on-hold.

NOTE: When there are no service codes to show, the display shows "– – –" continuously.

Scrolling the service codes, shows all service codes one at a time in the display area. Grounding the service input, while in service mode, causes the display to scroll, momentarily showing the MID then the corresponding CID and FMI. Removing ground from the service input, when the desired service code is shown, stops the scrolling. The service code shown is now on-hold.

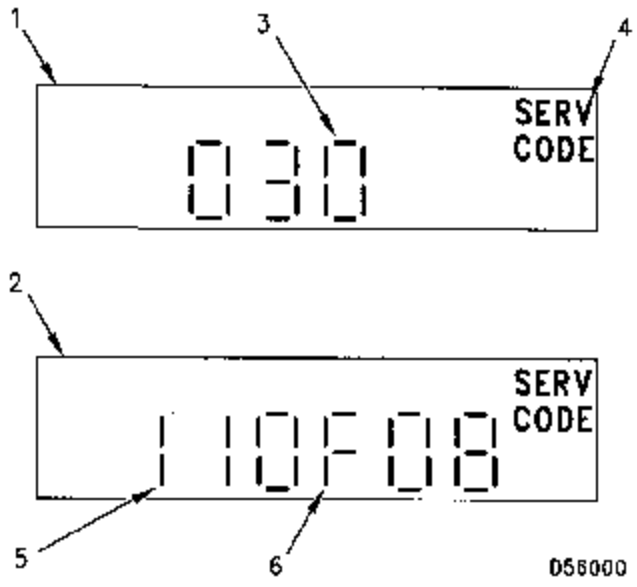
NOTE: Service codes from certain other electronic control modules (MID not 30) can be scrolled and placed on-hold using the same procedure.

Diagnostics are provided to assist service personnel during troubleshooting of intermittent faults. While in service mode, the service code indicator (SERV CODE) functions as a fault present indicator during service code scrolling. When "SERV CODE" is ON, the fault that caused the service code currently being shown is present. If "SERV CODE" is OFF, the fault is not present at this time, but has occurred previously. This can aid in troubleshooting of intermittent faults. When the fault changes status from not present to present, the fault present indicator (SERV CODE) also changes respectively from "SERV CODE" OFF to "SERV CODE" ON. When the service code for a fault is on-hold, the action alarm also SOUNDS briefly during this change of status. These diagnostics signal the service personnel while inspections are performed; thereby assisting in troubleshooting intermittent faults by one service person.

Clearing a service code removes it from the memory of the main display module. When a fault is corrected, it is necessary to remove the corresponding service code from the memory of the main display module. Placing the service code on-hold and then momentarily grounding the clear input removes the service code from memory. A service code is saved in the memory of the main display module until it is cleared. The main display module does not allow clearing of a service code that corresponds to a fault which is present.

NOTE: Service codes from certain other electronic control modules (MID not 30) should also be cleared using the main display module.

Diagnostic Example



Diagnostic Example
(1) First display. (2) Second display. (3) Module Identifier (MID). (4) Service code indicator (SERV CODE). (5) Component identifier (CID). (6) Failure mode Identifier (FMI).

The following explains the information shown in the Diagnostic Example illustration.

Brief Explanation

The Diagnostic Example illustration shows that the main display module is currently receiving an out of range signal from the transmission oil temperature sensor.

Detailed Explanation

MID (3) = "30". Module identifier code "30" means the service code concerns the Caterpillar Monitoring System and that the Caterpillar Monitoring System service manual should be used to troubleshoot the service code. If the MID shown was "81", the service code would concern the transmission control and the transmission control service manual should be used to troubleshoot the service code.

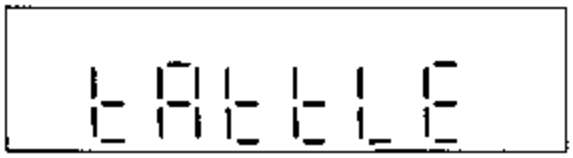
CID (5) = "110". Component identifier code "110" means that the fault is in the engine coolant temperature sensor circuit of MID "30". For a list of CID codes for the Caterpillar Monitoring System, see the Detected Faults chart under the topic Troubleshooting Faults With Service Codes in the Testing And Adjusting section.

FMI (6) = "F08". Failure mode identifier "F08" means that a signal of abnormal frequency, pulse width or period is being received concerning CID "110". For a list of FMI codes for the Caterpillar Monitoring System, see the Detected Faults chart under the topic Troubleshooting Faults With Service Codes in the Testing And Adjusting section.

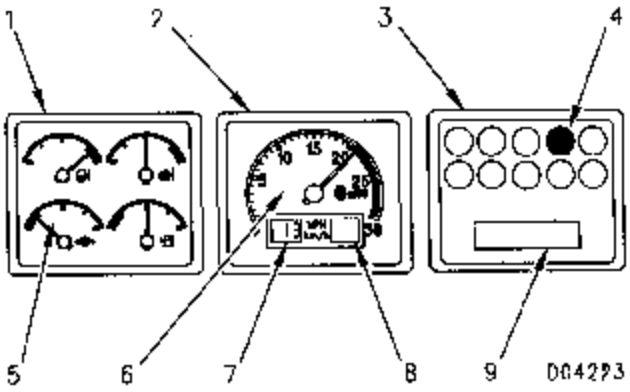
Service code indicator (4) is ON. In service mode service code indicator (4) functions as a fault present indicator. Therefore the "110" CID fault is present now. If the "110" CID fault changes status from present to not present, service code indicator also changes respectively from ON to OFF. In addition, the action alarm sounds each time the "110" changes status, while in service mode.

Tattletale Mode

D03595



Display Area



Caterpillar Monitoring System Display Components
(1) Gauge cluster module. (2) Speedometer/tachometer module. (3) Main display module. (4) Alert indicators. (5) Gauges. (6) Tachometer. (7) Speed readout. (8) Gear readout. (9) Display area.

C **NOTE:** For the D series trucks the Tattletale Mode is referred to as the Log Mode.

NOTE: To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

Tattletale Mode is a management and maintenance tool, useful for tracking machine history. The main display module records the extreme value for each machine condition monitored. The values come from sensor inputs, switch inputs and the CAT data link. Tattletale values are updated whenever a value occurs which is more extreme than the previous recorded value. These values are ignored for a short period of time after each start-up. This allows the machine systems to stabilize before the recording of information.

Gauges (5) show the highest or lowest reading that the corresponding machine system has attained. The highest reading for gauges with increasing abnormal values and the lowest reading for gauges with decreasing abnormal values. For gauges that are double ended, the gauge alternates between the highest and lowest reading.

Tachometer (6) and speed readout (7) show the highest reading obtained.

Alert indicators (4) turn on when an abnormal condition has existed.

Tattletale information is retained until the information is cleared. Grounding the clear input erases the information. After clearing, all information is reset to a nominal value and the recording of new extreme values begins.

NOTE: The date, time or duration of when the extreme value occurred is not recorded.

Example

This example explains the information shown in the Tattletale Mode illustration.

- Gauge (5) for engine coolant temperature; pointer indicates a value above the normal temperature range. Therefore, a high abnormal value has existed in this system.
- Gauge (5) for brake air pressure; pointer indicates a value below the normal pressure range. Therefore a low abnormal value has existed in this system.
- Gauges (5) for brake oil temperature; pointer indicating a value in the normal range. Therefore, no abnormal value has existed in these systems.
- Gauges (5) for fuel level; pointer indicating a level of 50%. Therefore, the highest amount of fuel that has existed is 50%.
- Tachometer (6); pointer indicates a maximum value (2100 RPM). Therefore an engine speed of at least 2100 rpm has existed.
- Speed readout (7) shows "13 MPH". Therefore 13 MPH is the highest ground speed attained.
- Alert indicator (4) is ON for engine oil pressure. Therefore an abnormal condition has existed in this system.
- Alert indicators (4) are OFF for: parking brake ON, electrical system, brake oil pressure, primary steering, supplemental steering, brake oil temperature, hydraulic oil pressure and secondary brake. Therefore, no abnormal values have existed in these systems.

NOTE: No tattletale information is stored for the highest or lowest machine gear selected.

c Digital Tattletale Mode

D55553

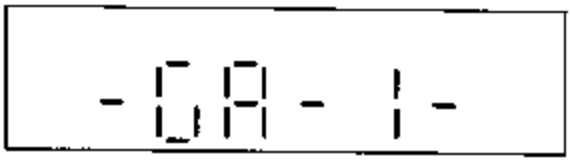
Display Area

NOTE: To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

Digital Tattletale Mode is a management and maintenance tool, useful for tracking machine history. The main display module records the extreme value for each machine condition monitored. The values come from sensor inputs, switch inputs and the CAT data link. Digital tattletale values are updated whenever a value occurs which is more extreme than the previous recorded value. These values are ignored for a short period of time after each start-up. This allows the machine systems to stabilize before the recording of information.

In this mode, the default is to display the worst case conditions that have occurred. Use the CLEAR switch to reset all of the information in this mode.

D55612



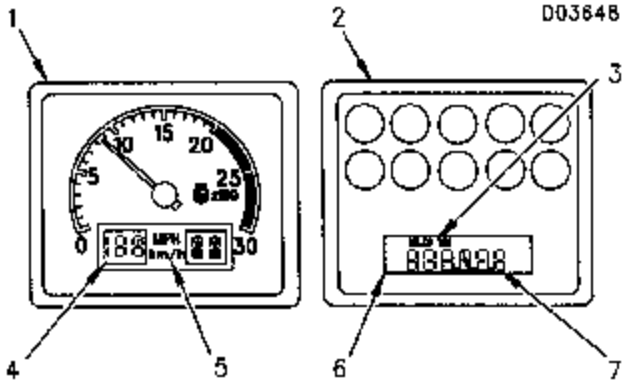
Display Area – Example Display

To look at the gage data digitally, use the SCROLL switch. The scrolling works in the same way as in the numeric readout mode except the description also has the two outside dashes.

The value displayed is the worst case reading since last cleared. When looking at a single gage, none of the indicators will be on and only that one gage will be on. The clear switch, when looking at one value, will only clear the value being viewed. When the value is cleared, it will then flash a value outside or at the end of the expected range.

NOTE: The date, time or duration of when the extreme value occurred is not recorded.

Units Mode



Caterpillar Monitoring System
(1) Speedometer/tachometer module. (2) Main display module. (3) Odometer units. (4) Speed readout. (5) Speedometer units. (6) Display area. (7) Six digit readout.

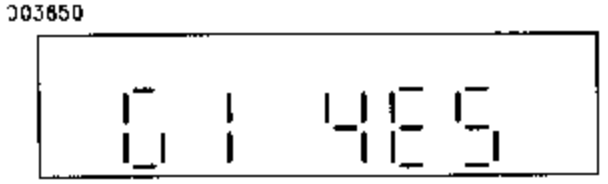
NOTE: To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

The unit modes is used to toggle the monitoring system displays between U.S. and Metric units of measure. When the main display module enters units mode, six digit readout (7) shows the current setting. "US" when set to U.S. units and "SI" when set to Metric units.

When set to U.S. units the main display module shows "MILES" on display area (6) when in odometer mode. The speedometer/tachometer display shows "MPH". When the main display module is set to Metric units display area (6) shows "KM". The speedometer/tachometer display shows " km/h ".

Grounding the clear input while the service input is open toggles the units. The units continuously toggle as long as the clear input is grounded. Opening both inputs will set the main display module to the currently displayed setting.

Setup Mode



Display Area

NOTE: To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

Setup mode is used to tell the main display module of changes in display modules connected to it. The main display module is initially setup when installed on the machine. This initial setup tells the main display module which attachment display modules to expect to be able to communicate with. A service code is logged when the main display module can't communicate with a display module. When a new attachment display module (was not part of the system before) is added to the Caterpillar Monitoring System, the main display module needs to be setup to communicate with this new module.

When the main display module enters setup mode, the six digit readout shows a module indicator (G1, G2, t1, t2, etc.) and the state of each module, either "YES" or "NO". The main display module knows which display modules are standard for the machine it is installed on and which modules can be added. Only the module indicator for the module(s) that may be added is shown. For example, if no gauge modules are standard, the first module indicator shown is "G1", if a gauge module may be added. If one gauge module is standard and another may be added, the module indicator shown is "G2". Speedometer/tachometer modules that may be added are shown in the same manner except with a "t" prefix (t1, t2, etc.).

The "G" indicates gauge module; "t" indicates speedometer/tachometer module. The "YES" indicates to the main display module that the corresponding module is connected. The "NO" indicates to the main display module that the corresponding module is not connected. Grounding the clear input causes the display to toggle between "YES" and "NO". Opening the clear input stops the display on what is currently being shown "YES" or "NO". When "YES" is selected, the main display module tries to communicate over the display data link with the display module indicated. If the display module does not respond, the main display module records a service code. If "NO" is selected, the main display module does not try to communicate with the display module.

Calibration mode

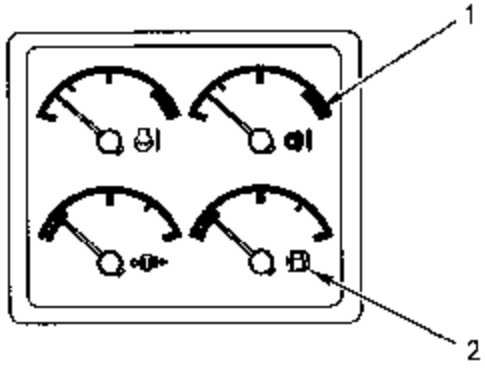
NOTE: To determine the mode number (if applicable), see the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced.

- Calibration mode is used on some machines to perform special calibration functions. The operation of calibration mode will vary depending on the machine and system being calibrated. There can be more than one calibration mode per application. The Service Manual for the controls that require calibration mode should be used to determine the operation.

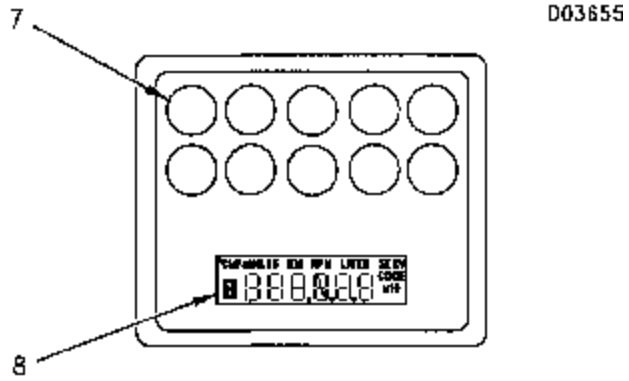
Warning Operation

WARNING OPERATION					
	Warning Indications [1]				
Warning Category	Alert Indicator Flashes [2]	Action Lamp Flashes [4]	Action Alarm Sounds [4]	Required Operator Action	Possible Result [2]
1	X			No immediate action required. The system needs attention soon.	No harmful or damaging effects.
2	X	X		Change machine operation or perform maintenance to the system.	Severe damage to components.
3	X	X	X	Immediately perform a safe engine shutdown.	Operator injury or severe damage to components.

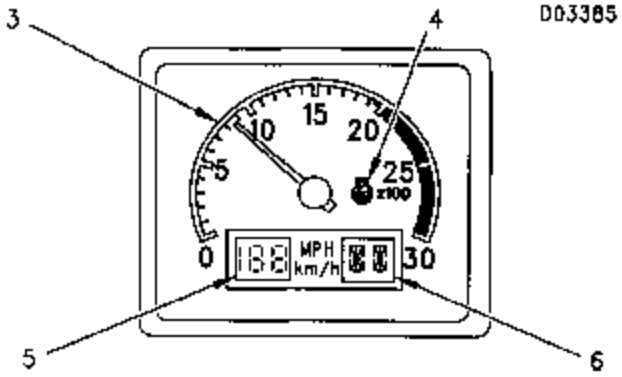
[1] The warning indications which are active, are marked with an X.
[2] Possible result if no operator action is taken
[3] At a 10 Hz rate
[4] At a 1 Hz rate.



Gauge Cluster Module
(1) Gauge warning area. (2) Pictograph symbol.



Main Display Module
(7) Alert indicator. (8) Display area.



Speedometer/Tachometer Module
(3) Tachometer. (4) Pictograph symbol. (5) Ground speed readout. (6) Transmission actual gear readout.

The Caterpillar Monitoring System notifies the operator of an immediate or impending problem with a machine system. Warning operation begins when the main display module receives a problem signal that reflects an abnormal machine condition or the main display module detects a control system problem. Switches, sensors and other electronic control modules on the machine provide signals to the main display module. The problem signals are:

- An open switch. When a condition exceeds the trip point of the switch, the switch opens.
- A sensor signal which exceeds the limits. The main display module determines the limits.
- An abnormal condition detected by another electronic control module and communicated over the CAT data link to the main display module.

The main display module analyzes the problem signals and tells the display components to activate the appropriate warning indication to notify the operator. The warning indications are:

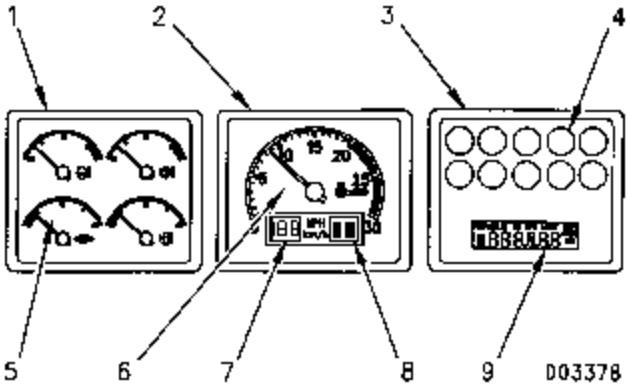
- FLASHING of the alert indicator (approximately nine times per second).
- FLASHING of the action lamp (ON one second, OFF two seconds).
- SOUNDING of the action alarm (ON one second, OFF two seconds).

NOTE: In order to activate some warning indications more than one input is required. The main display module decides when and what warning indications are activated.

Machine system problems are classified into three warning categories; 1, 2 and 3. The categories are based on how severe the problem is and dictate the required response of the operator. Warning category 1 represents the least severe problem and warning category 3 represents the most severe problem. The warning categories are identified for the operator according to the combination of warning indications that are active. See the Warning Operation chart.

NOTE: For complete warning operation information for the machine being serviced, see the Operation And Maintenance Manual.

Self Test Operation



Caterpillar Monitoring System
(1) Gauge cluster module. (2) Speedometer/tachometer module. (3) Main display module. (4) Alert indicators. (5) Gauges. (6) Tachometer gauge. (7) Speedometer readout. (8) Actual transmission gear readout. (9) Display area.

The self test verifies that the main display module and the display modules are operating properly. The main display module performs an automatic self test each time the key start switch is turned from the OFF to the ON position.

The internal circuits and the outputs (displays, action lamp and action alarm) are automatically checked. The operator must observe the outputs to determine whether or not the modules and the outputs are operating properly. The alert indicators and display area are tested for approximately one second:

- All alert indicators (4) FLASH.
- Display area (9) shows:
  All units indicators (°C, kPa, MILES, KM, RPM, LITERS).
  x10 indicator.
  Service meter symbol.
  888.8.8.8 on the six digit readout.

The display modules are tested for approximately three seconds:

- Tachometer gauge (6) and gauges (5) (on machines so equipped) jump to half scale, back to zero, then sweep to full scale. After reaching full scale the tachometer and gauges return to showing current machine values.
- Transmission actual gear readout (8) turns on every segment of the readout. It looks like a "0" with an "X" and a "+" sign laid on top of the "0". There should be two of those side by side.
- Ground speed readout (8) turns on every segment of the readout. It looks like "188". MPH and km/h are both turned ON.
- The action lamp turns ON.
- The action alarm SOUNDS once.

The main display module then goes into the normal mode of operation.

Testing And Adjusting

General Information

Troubleshooting the Caterpillar Monitoring System requires additional information from the machine Service Manual. The Electrical System Schematic, the Parts Manual and the Operation & Maintenance Manual are required support material.

As a guide, a typical system schematic is included at the end of this manual. For an accurate representation of the machine being diagnosed, see the Electrical System Schematic in the machine Service Manual.

When the troubleshooting procedure instructs to REPAIR THE HARNESS, use the Electrical System Schematic in the machine Service Manual to trace the circuit. Perform continuity checks at connectors to locate harness failures. At component connectors, always check the ground circuit. Less than five ohms of resistance is required between the connector ground contacts and frame ground. Excessive ground resistance, greater than five ohms, can cause incorrect diagnosing of problems.

During troubleshooting inspect all component and harness connections before any component is replaced. If these connections are not clean and tight they can cause electrical problems, either permanent or intermittent (come and go). Check that the wires are pushed into the connectors completely. Make sure the connections are tight before other tests are made.

Failure of an electrical component can cause, or be caused by the failure of one or more other components. Always attempt to find and correct the cause of electrical system failure before making replacement of a component.

Electrical Components And Connector Locations

The Electrical System Schematic, Parts Manual and the Operation & Maintenance Manual for the machine being serviced, should all be used to locate electrical components and connectors.

The following is a guide to reading the Harness Connector and Component Location charts, the machine profile and the area views all found on the backside of the Electrical System Schematic module.

- Component Location Chart:

  The component location chart uses white circles as location labels in the machine profile and area views. Alphabetical letters in the connector and machine location column indicate location in the area views.

- Harness Connector Location Chart:

  The harness connector location charts use black circles as location labels in the general and area views. Alphabetical letters in the connector and machine location column indicate the area views where they are located. The "*" indicates that it is connected to the component in its harness and/or components column.

c Service Tools

The following service tools should be used to make troubleshooting the electrical system easier.

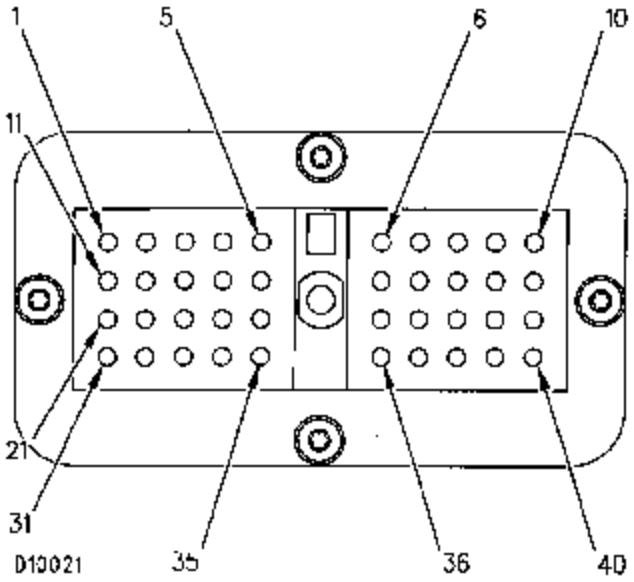
- 6V-7070 or 9U-7330 Digital Multimeter or equivalent
- 8T-3224 Needle Tip Group
- 7X-1710 Cable Probe Group
- 8T-8726 Adapter Cable
- 6V-3000 Connector Repair Kit – Sure Seal
- 9U-7246 Connector Repair Kit – Deutsch "DT" Type
- 4C-3406 Connector Repair Kit – Deutsch
- 4C-8195 Service Tool – Switch Box

For instructions on servicing Sure Seal connectors see Special Instruction SMHS7531. For instructions on servicing Deutsch "DT" Type connectors see Special Instruction SEHS9615.

Use the digital multimeter for making continuity (resistance) checks or voltage measurements. For instruction on use of the 6V-7070, see Special Instruction SEHS7734. The 7X-1710 Cable Probe Group is used to make measurements at connectors without disconnecting them. The probes are pushed in the back of the connector alongside the wire. The 8T-8726 Adapter Cable is a 3 pin breakout cable used to make measurements in sensor circuits.

NOTE: Use of continuity testers (such as 8T-0500), or voltage testers (such as 6P-7277) are not recommended for use on present-day Caterpillar electrical circuits, except for harness tests.

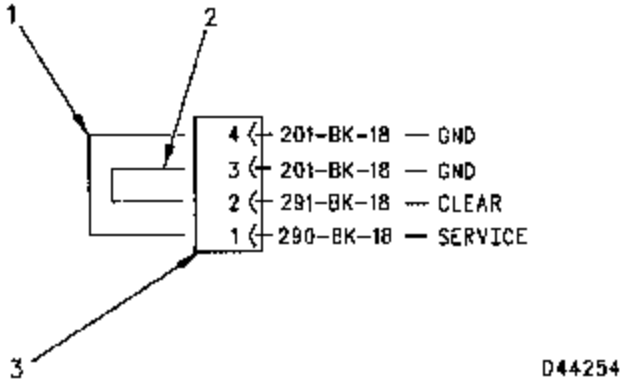
Main Display Module Connector Contact Numbers



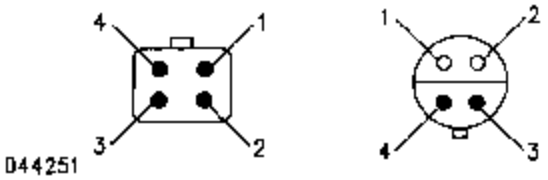
Main Display Module Connector

c Service Connector

The service connector provides access to the service and clear inputs of the main display module. Connector contact 1 is the service input and contact 2 is the clear input. Contacts 3 and 4 could be any 200 family wire. The service connector is usually located under the dash within the operator compartment. The service connector is a DT type of connector. For a more accurate service connector location and connector requirements, see the Electrical System Schematic in the Service Manual, for the machine being serviced.



Service Connector With Jumpers (Typical Example)
(1) Jumper - service contact grounded. (2) Jumper - clear contact grounded. (3) Service connector.



End View Of Service Connectors

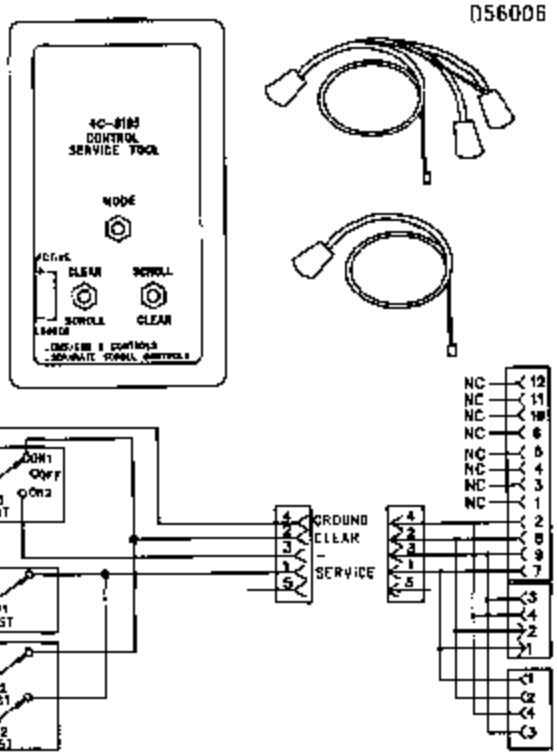
Various diagnostic functions require the grounding and/or opening of the service and clear contacts at the service connector. During troubleshooting, it is necessary for the service person to make the proper electrical connections between the contacts of the service connector. These electrical connections are made with two jumpers. Also see the topic Service Box that follows.

c Service Switches

During troubleshooting, it is necessary for the service person to use the diagnostic operations of Caterpillar Monitoring System. The service switches provide the means by which service personnel access the different display modes of diagnostic operation.

The switches are the momentary type of switch that service personnel activate by pressing and holding. Depressing the clear switch grounds clear input (contact 33) of the monitor. Depressing the set switch grounds the set input (contact 23) of the monitor. The location of the service switches will vary depending upon the machine being serviced. For a more accurate service switch location, see the Electrical System Schematic in the machine Service Manual.

C Service Box (4C-8195)



Service Box

The 4C 8195 Control Service Tool is helpful for the service person to make the proper electrical connections at the service connector during troubleshooting procedures. Three connectors are wired in parallel so that the service tool is usable on the different types of machine harnesses.

Actuating the mode switch scrolls through the display modes. Actuating the scroll switch scrolls the display with the control in the service or numeric readout mode. Actuating the clear switch when in service mode, clears the service code being continuously shown. Actuating the clear switch when in tattle tale mode, clears all extreme values.

Changing Modes

ACTIVATION OF DISPLAY OPERATIONS (Quick Reference)		
Display Operation	**Service Contact [1]**	**Clear Contact [1]**
Changing Modes:		
To Scroll	Ground	Ground
To Hold	Open	Open
Service Mode:		
To Scroll	Ground	Open
To Hold	Open [2]	Open
To Clear [3]	Open	Ground
Tattletale Mode:		
To Clear	Open	Ground
Numeric Readout Mode:		
To Scroll	Ground	Open
To Hold	Open	Open

[1] Of the service connector.
[2] Open when the desired information is shown during scrolling.
[3] A service code can be cleared only while it is on hold. The service code for a fault that is currently present can not be cleared.

See the topic Modes Of Operation in the Systems Operation section of this Service Manual for a detailed explanation of the different modes.

Troubleshooting Faults With Service Codes

CATERPILLAR MONITORING SYSTEM SERVICE CODES[1] For troubleshooting, see the procedure with the same CID And FMI No.	
CID No. / FMI No.	**Description**
CID 096 - Fuel Level Sensor:	
FMI F03	Signal voltage above normal or short to +battery.
FMI F08	Signal is abnormal.
CID 110 - Engine Coolant Temperature Sensor:	
FMI F04	Voltage below normal or short to ground.
FMI F08	Signal is abnormal.
CID 177 - Torque Converter Oil Temperature Sensor:	
FMI F04	Signal voltage below normal or short to ground.
FMI F08	Signal is abnormal.
CID 248 - Data Link:	
FMI F02	Data erratic, intermittent or incorrect.
CID 263 - 8 Volt Sensor Power Supply:	
FMI F03	Voltage above normal or short to +battery.
FMI F04	Voltage below normal or short to ground.
CID 271 - Action Alarm:	
FMI F03	Voltage above normal or short to +battery.
FMI F05	Current below normal or open circuit.
FMI F06	Current above normal or short to ground.
CID 324 - Action Lamp:	
FMI F03	Voltage above normal or short to +battery.
FMI F05	Current below normal or open circuit.
FMI F06	Current above normal or short to ground.
CID 600 - Hydraulic Oil Temperature Sensor:	
FMI F04	Signal voltage below normal or short to ground.
FMI F08	Signal is abnormal.
CID 601 - Brake Air Pressure Sensor:	
FMI F08	Signal is abnormal.
CID 819 - Display Data Link:	
FMI F02	Data erratic, intermittent or incorrect.
CID 821 - 9 Volt Display Power Supply:	
FMI F03	Voltage above normal or short to +battery.
FMI F04	Voltage below normal or short to ground.
CID 830 - Brake Oil Temperature Sensor:	
FMI F08	Signal is abnormal.

[1] For Caterpillar Monitoring System, the MID is 30. This chart pertains only to service codes for faults with MID of 30

C NOTE: The preceding chart has changed from the former issue.

NOTE: Every machine may not have all of the service codes listed in the preceding chart.

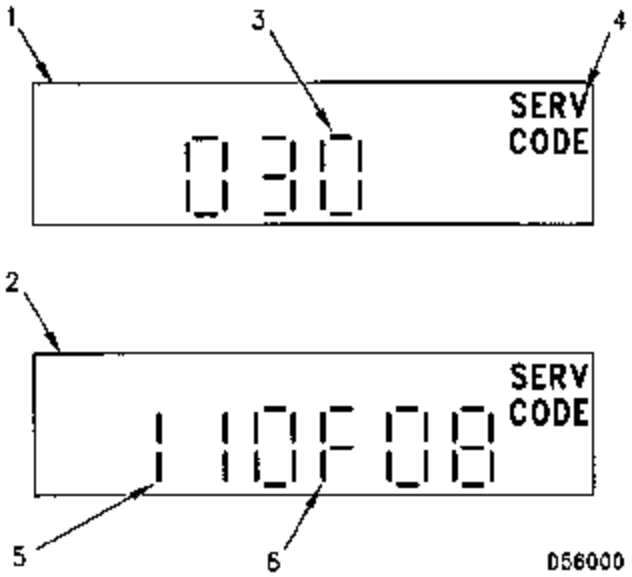
NOTE: The preceding chart of service codes and this Service Manual apply only to Caterpillar Monitoring System service codes. When in service mode (on appropriately equipped machines), service codes from other electronic control modules are shown on the Caterpillar Monitoring System display area. The service code information is transferred via the CAT data link from other electronic control modules to the main display module. This diagnostic information is shown when the main display module is in service mode. The module identifier (MID) tells which electronic control module is sending the service code. The MID code for the Caterpillar Monitoring System is "30". This Service Manual applies only to service codes with a MID of "30". The MID code of other electronic control modules on a particular machine (transmission, engine, traction, etc.) are listed on the Electrical System Schematic. Troubleshooting information for those service codes (MID is not "30"), can be found in the service manual for that system.

NOTE: When a sensor fault is present, the corresponding warning for that sensor is also activated for the operator. For example, if the signal wire for the engine coolant temperature sensor is shorted to +battery, then:

a. The corresponding service code is stored in memory.
b. The gauge for engine coolant temperature shows in the warning region.
c. The action lamp is FLASHING.

Notice that the above items b and c are the same warning indications that are activated if the engine were to actually overheat.

Initial Troubleshooting Procedure



Digital Readout Area
(1) First display. (2) Second display. (3) Module identifier (MID). (4) Service code indicator (SERV CODE). (5) Component identifier (CID). (6) Failure mode identifier (FMI).

Use the following procedure to troubleshoot the service code information.

1. Place the Caterpillar Monitoring System in Service Mode. To do so, determine the mode number for Service Mode by using the Monitoring System Mode chart on the Electrical System Schematic for the machine being serviced. Ground the service and clear contacts of the service connector. Remove ground when the mode number for Service Mode is shown on the display.

NOTE: Diagnostic Scrolling Mode may be entered to see the service codes, but the service codes can be more easily diagnosed using Service Mode. Service Mode allows service codes to be placed on-hold for further investigation and to be cleared when the problem has been fixed.

2. A service code is shown and on-hold at this time The display toggles between showing MID (3) and CID (5), FMI (6). When there are no service codes, screen (1) shows "– – –" only.

3. To see all the service codes, scroll the service codes. To do so, ground the service contact of the service connector. The display momentarily shows MID (3) then CID (5), FMI (6) for each service code. The word "End" is shown after the last service code in the list.

4. Place the desired service code on-hold (stop the scrolling). To do so, remove ground from the service contact of the service connector when the desired service code is shown.

5. Use the MID information to determine which electronic control system is generating the service code. If the MID is not "30", see Module Identifier chart on the Electrical System Schematic of the machine being serviced. Use the chart to determine what electronic control detected the fault. Then see the service manual module for that electronic control. If the MID is "30", use this Service Manual to troubleshoot the fault that generated the service code.

6. Observe service code indicator (4). In service mode the service code indicator functions as a fault present indicator.

- If fault present indicator (4) shows "SERV CODE", then the fault that caused the service code shown is currently present.
- If fault present indicator (4) is OFF, then the fault that caused the service code shown is not present at this time. The fault has occurred and then went away, sometime in the past (intermittent).

7. To troubleshoot the service code, go to the procedure with the same CID and FMI under the topic Troubleshooting Procedures. Use the service manual for the control that is generating the service code.

8. After a service code is corrected or it is no longer needed, clear the service code. To do so, momentarily ground the clear contact of the service connector while the fault is on-hold. After clearing, the display advances to the next available service code.

9. Repeat Steps 2 through 8 for the remaining service codes. Return to normal mode when finished.

Troubleshooting Procedures:

Go to the procedure which corresponds to the CID and FMI shown on the main display module.

NOTE: The following procedures may cause some new service codes to be logged by the main display module. Therefore, before performing any procedures, record all service codes to determine system problems. At the completion of each procedure clear the service codes that were caused by the test procedures.

CID 096 Procedure (Fuel Level Sender)

FMI 03

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced, find the connector contact of the main display module connector which corresponds to the current CID shown.

This fault is recorded when the main display module reads the sender signal voltage as too high. The result of this fault condition is that the corresponding gauge (fuel level) indicates an abnormally low value. The possible causes are:

- Sender is faulty.
- Sender ground circuit in the machine harness is open.
- Signal circuit in the machine harness is shorted to +battery.
- Signal circuit in the machine harness is open or sender is disconnected.
- Main display module is faulty.

STEP 1. CHECK MAIN DISPLAY MODULE AND HARNESS – Turn the disconnect and key start switch to the ON position. The fault present indicator should show "SERV CODE" for the service code CID 096/FMI 03. Disconnect the machine harness from the sender causing the fault. On the machine harness connector, connect the sender signal wire to the sender ground wire. Observe the fault present indicator.

- Fault present indicator turns OFF; sender is faulty. Replace the sender.
- Fault present indicator stays ON; harness wiring or main display module is faulty. Go to step 2.

STEP 2. CHECK FOR OPEN GROUND WIRE – Turn the disconnect and key start switch to the OFF position. Measure the resistance between frame ground and the ground wire for the sender.

- Resistance is greater than 5 Ω; harness ground wire is open. Repair or replace the ground wire for the sender.
- Resistance is 5 Ω or less; harness ground wire is correct. Go to Step 3

STEP 3. CHECK SENDER SIGNAL WIRE – Turn the disconnect and key start switch to the ON position. Measure the voltage from ground to the sender signal wire.

- Voltage is 6.0 ± 0.5 DCV; voltage is correct. Check to see if the fault is still present. If the fault is still present, repeat steps 1 through 3. If the cause of the fault is still not found replace the main display module.
- Voltage is less than 0.5 DCV; harness wiring is faulty. There is an open circuit or a short to ground in the sender signal wire or a bad connector connection. Repair or replace the harness. If the cause of the fault is still not found replace the main display module.
- Voltage is NOT 6.0 ± 0.5 but greater than 0.5 DCV; harness is shorted to a power circuit. Repair or replace the harness. If the cause of the fault is still not found replace the main display module.

C FMI 08

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced, find the connector contact of the main display module connector which corresponds to the current CID shown.

NOTE: The Sensor Voltage Test within the topic PWM Sensor Tests covers the troubleshooting of the sensor fault.

CID 110 Procedure (Engine Coolant Temperature Sensor)

C FMI 04

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced, find the connector contact of the main display module connector which corresponds to the current CID shown.

This service code is recorded when the main display module reads the sender signal as too low. The result of this fault condition is that the corresponding gauge indicates an abnormally high value. The possible causes are:

- Sender is faulty.
- Signal circuit in the machine harness is shorted to ground.
- Main display module is faulty.

NOTE: The main display module is unable to determine when a sender or sender signal harness is open (or resistance is too high). This condition is recognized as a gauge that always reads at the far left side of the scale.

STEP 1. CHECK MAIN DISPLAY MODULE AND HARNESS – Turn the disconnect and key start switch to the ON position. The fault present indicator should show "SERV CODE". Disconnect the machine harness from the sender causing the fault. Observe the fault present indicator.

- Fault present indicator turns OFF; sender is faulty. Replace the sender.
- Fault present indicator stays ON; harness wiring or main display module is faulty. Go to step 2.

STEP 2. CHECK SENDER WIRE FOR SHORT TO GROUND – Turn the disconnect and key start switch to the OFF position. Disconnect the machine harness from the sender. Turn the disconnect and key start switch to the ON position. Measure the voltage between frame ground and the sender signal wire.

- Voltage is 6.0 ± 0.5 DCV; voltage is correct. Check to see if the fault is still present. If the fault is still present, repeat steps 1 through 3. If the cause of the fault is still not found replace the main display module.
- Voltage is less than 0.5 DCV; harness wiring is faulty. There is an open circuit or a short to ground in the sender signal wire or a bad connector connection. Repair or replace the harness. If the cause of the fault is still not found replace the main display module.
- Voltage is NOT 6.0 ± 0.5 but greater than 0.5 DCV; harness is shorted to a power circuit. Repair or replace the harness. If the cause of the fault is still not found replace the main display module.

FMI 08

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced, find the connector contact of the main display module connector which corresponds to the current CID shown.

NOTE: The Sensor Voltage Test within the topic **PWM Sensor Tests** covers the troubleshooting of the sensor fault.

CID 177 Procedure (Torque Converter Temperature Sender)

FMI 04

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced, find the connector contact of the main display module connector which corresponds to the current CID shown.

This service code is recorded when the main display module reads the sender signal as too low. The result of this fault condition is that the corresponding gauge indicates an abnormally high value. The possible causes are:

- Sender is faulty.
- Signal circuit in the machine harness is shorted to ground.
- Main display module is faulty.

NOTE: The main display module is unable to determine when a sender or sender signal harness is open (or resistance is too high). This condition is recognized as a gauge that always reads at the far left side of the scale.

STEP 1. CHECK MAIN DISPLAY MODULE AND HARNESS – Turn the disconnect and key start switch to the ON position. The fault present indicator should show "SERV CODE". Disconnect the machine harness from the sender causing the fault. Observe the fault present indicator.

- Fault present indicator turns OFF; sender is faulty. Replace the sender.
- Fault present indicator stays ON; harness wiring or main display module is faulty. Go to step 2.

STEP 2. CHECK SENDER WIRE FOR SHORT TO GROUND – Turn the disconnect and key start switch to the OFF position. Disconnect the machine harness from the sender. Turn the disconnect and key start switch to the ON position. Measure the voltage between frame ground and the sender signal wire.

- Voltage is 6.0 ± 0.5 DCV; voltage is correct. Check to see if the fault is still present. If the fault is still present, repeat steps 1 through 3. If the cause of the fault is still not found replace the main display module.
- Voltage is less than 0.5 DCV; harness wiring is faulty. There is an open circuit or a short to ground in the sender signal wire or a bad connector connection. Repair or replace the harness. If the cause of the fault is still not found replace the main display module.
- Voltage is NOT 6.0 ± 0.5 but greater than 0.5 DCV; harness is shorted to a power circuit. Repair or replace the harness. If the cause of the fault is still not found replace the main display module.

FMI 08

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced, find the connector contact of the main display module connector which corresponds to the current CID shown.

NOTE: The Sensor Voltage Test within the topic PWM Sensor Tests covers the troubleshooting of the sensor fault.

CID 248 Procedure (CAT Data Link)

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE".

FMI 02

This service code is recorded when the main display module does not receive expected information. For example; engine speed or actual gear information is not received from other electronic control modules through the CAT data link. The result of this fault condition is that the readouts dependent upon the CAT data link information indicate abnormal values. The possible causes (listed in order of probability) are:

- Poor electrical connection at a machine harness connector.
- CAT data link circuit in the machine harness is shorted to ground.
- CAT data link circuit in the machine harness is shorted to +battery.
- CAT data link circuit in the machine harness is open.
- An electronic control module which uses CAT data link is faulty (main display module, engine control transmission control, etc.). If the main display module was recently replaced, see the topic Initialization.

STEP 1. Check other electronic control modules for a similar service code. If a similar service code is found, use the procedures for that electronic control module to troubleshoot the service code. Otherwise, go to Step 2.

STEP 2. INSPECT HARNESS CONNECTORS – Turn the disconnect to the OFF position. Inspect the machine harness connections related to the CAT data link. Make sure that connectors are clean and tight. If necessary, repair or replace the machine harness. Otherwise, go to Step 3

STEP 3. CHECK FOR SHORT TO GROUND – The disconnect switch remains OFF. Disconnect the machine harness from all electronic control modules that use the CAT data link. At the machine harness connector for the main display module, measure the resistance between frame ground and the CAT data link circuits (contacts 5 and 14).

- Resistance is less than 5000 Ω, the machine harness is faulty. There is a short between frame ground and the CAT data link circuit in the machine harness. Repair or replace the machine harness.
- Resistance is greater than 5000 Ω; harness circuit resistance is correct. Go to Step 4.

STEP 4. CHECK FOR SHORT TO +BATTERY – The disconnect switch remains OFF. All related control modules remain disconnected from the machine harness. At the machine harness connector for the main display module, measure the resistance between +battery (contact 1) and the CAT data link circuits (contacts 5 and 14).

- Resistance is less than 5000 Ω; the machine harness is faulty. There is a short between +battery and the CAT data link circuit in the machine harness. Repair or replace the machine harness.
- Resistance is greater than 5000 Ω; harness circuit resistance is correct. Go to Step 5.

STEP 5. CHECK FOR OPEN HARNESS – The disconnect switch remains OFF. All related control modules remain disconnected from the machine harness. Check the continuity of the CAT data link circuit in the machine harness. Measure from the main display module connector (contacts 5 and 14) to the connector for each of the related electronic control modules.

- Resistance is greater than 5 Ω; the machine harness is faulty. The CAT data link circuit is open in the machine harness. Repair or replace the machine harness.
- Resistance is less than 5 Ω; the CAT data link circuit in the machine harness is correct. The main display module is faulty. Replace the main display module; see the topic Module Replacement.

CID 253 Procedure (+8 DCV Sensor Supply)

NOTE: The procedures used to troubleshoot this service code may cause additional service codes to be logged. Find and repair the cause of this service code before troubleshooting any new service codes.

FMI 03

This service code is recorded when the control reads the voltage of the +8V sensor supply circuit as above normal or shorted to +battery.

STEP 1. CHECK VOLTAGE AT THE MAIN DISPLAY MODULE – Using the 7X-1710 Cable probes check the voltage at the main display module connector from contact 24 to 2 (ground). Do NOT disconnect the harness from the module.

- Voltage is 8.0 ± 0.5 DCV; the sensor supply voltage is correct. Check the main display module to see if the fault is still present. If the fault is still present the main display module is faulty. Replace the module; see the topic Module Replacement.
- Voltage is NOT 8.0 ± 0.5 DCV; the sensor supply voltage is NOT correct. Go to Step 2.

STEP 2. CHECK HARNESS FOR SHORT TO +BATTERY – Disconnect the machine harness from the main display module. At the machine harness connector for the main display module, measure the voltage from connector contact 24 to 2 (ground).

- Voltage is 0.0 ± 0.5 DCV; the voltage is correct. The main display module is faulty. Replace the module; see the topic Module Replacement.
- Voltage is NOT 0.0 ± 0.5 DCV; the harness or a sensor is faulty. Go to Step 3.

STEP 3. DISCONNECT SENSORS – Disconnect from the machine harness, one of the sensors that are connected to the +8 DCV sensor supply of the main display module. After disconnecting the sensor, measure the voltage from connector contact 2 (ground) to contact 24 of the machine harness connector for the main display module.

- Voltage is NOT 0.0 ± 0.5 DCV; the harness or a sensor is faulty. Repeat Step 3. If all sensors have been disconnected from the machine harness and the voltage is still NOT 0.0 ± 0.5 DCV, the machine harness is shorted to +battery. repair or replace the harness.
- Voltage is 0.0 ± 0.5 DCV; the voltage is correct. The sensor that was just disconnected is faulty. Replace the sensor.

FMI 04

This service code is recorded when the control reads the voltage of the +8V sensor supply circuit as below normal or shorted to ground.

STEP 1. CHECK VOLTAGE AT MAIN DISPLAY MODULE – Using the 7X-1710 Cable probes check the voltage at the main display module connector from contact 24 to 2 (ground). Do NOT disconnect the harness from the module.

- Voltage is 8.0 ± 0.5 DCV; the sensor supply voltage is correct. Check the main display module to see if the fault is still present. If the fault is still present the main display module is faulty. Replace the module; see the topic Module Replacement.
- Voltage is NOT 8.0 ± 0.5 DCV; the sensor supply voltage is NOT correct. Go to Step 2.

STEP 2. DISCONNECT SENSORS – Continue to monitor the sensor supply voltage as in Step 1. Disconnect from the machine harness, one of the sensors that are connected to the +8 DCV sensor supply of the main display module. After disconnecting the sensor, check the voltage reading on the multimeter.

- Voltage is 8.0 ± 0.5 DCV; the sensor supply is correct. The sensor that was just disconnected is faulty. Replace the sensor.
- Voltage is NOT 8.0 ± 0.5 DCV; repeat Step 2, removing one sensor at a time then checking the voltage. If after disconnecting all the +8 DCV sensors the voltage is still NOT correct go to Step 3.

STEP 3. CHECK FOR SHORT TO GROUND – Turn the disconnect and key start switch to OFF. The sensors remain disconnected. Disconnect the machine harness from the main display module. At the machine harness connector for the main display module, measure the resistance between frame ground and the sensor supply circuit (connector contact 24).

- Resistance is less than 5000 Ω; the machine harness is faulty. There is a short to ground in the machine harness, repair or replace the harness.
- Resistance is greater than 5000 Ω; harness circuit resistance is correct. The main display module is faulty. Replace the module; see the topic Module Replacement.

CID 271 Procedure (Action Alarm)

FMI 03

This service code is recorded when the main display module reads the voltage of the action alarm circuit (410-WH) as above normal (shorted to +battery). The result of this fault condition is that the action alarm SOUNDS CONTINUOUSLY.

CHECK ALARM CIRCUIT – Turn the disconnect switch and the key start switch to the OFF position. Disconnect the machine harness from the main display module. Turn the disconnect switch to the ON position. Listen for the SOUNDING of the action alarm. Turn the key start switch to the ON position.

- The alarm SOUNDS; harness circuit 410-WH is shorted to +battery. Repair or replace the harness.
- The alarm does NOT SOUND; the main display module is faulty. Replace the module; see the topic Module Replacement.

FMI 05

This service code is recorded when the main display module reads the current of the action alarm circuit (410 WH) as below normal (open circuit). The result of this fault condition is that the action alarm does not SOUND.

STEP 1. CHECK ALARM – Disconnect the machine harness from the alarm. At the machine harness connector for the alarm, place a jumper across the two contacts.

- Fault is NO longer present; the alarm is open. Replace the action alarm. (Note: Verify action alarm is open, the correct resistance for a good alarm is 200 ± 100 Ω.)
- Fault remains present; the action alarm is not causing the fault. Go to Step 2. (Note: Verify action alarm is correct, the correct resistance for a good alarm is 200 ± 100 Ω.)

STEP 2. CHECK HARNESS – Turn the disconnect and key start switch to the OFF position. From Step 1; remove the jumper and reconnect the alarm to the machine harness. Disconnect the machine harness from the main display module. At the machine harness connector for the module, measure the resistance between contact 4 (410-WH) and frame ground.

- Resistance is greater than 300 Ω; harness circuit is open. Go to Step 3.
- Resistance is less than 300 Ω; harness circuit resistance is correct. Go to Step 4.

STEP 3. CHECK HARNESS – Disconnect the machine harness from the alarm. Check for an open in circuit 410-WH between main display module harness connector (contact 4) and action alarm machine harness connector (contact 1). Also, check for an open in circuit 201-BK between action alarm machine harness connector (contact 2) and frame ground. Repair or replace the harness.

STEP 4. CHECK MODULE – Reconnect the machine harness connector to the main display module. Reconnect the alarm to the machine harness. Turn the disconnect and key start switch to the ON position.

- Fault remains present; the main display module is faulty. Replace the module; see the topic Module Replacement.
- Fault is NO longer present; the main display module is not causing the fault. The fault is intermittent. The probable cause is poor electrical connection at the harness connectors or a damaged harness. Check the harness for damage and clean the harness connectors as required.

FMI 06

This service code is recorded when the main display module reads the voltage of the action alarm circuit (410-WH) as below normal (shorted to ground). The result of this fault condition is that the action alarm does not SOUND.

STEP 1. CHECK ALARM – Disconnect the machine harness from the alarm.

- Fault remains present; the action alarm is not causing the fault. Go to Step 2.
- Fault is NO longer present; the alarm is faulty. Replace the action alarm. (Note: The correct resistance for a good alarm is 200 ± 100 Ω.)

STEP 2. CHECK HARNESS – Turn the disconnect switch to the OFF position. The alarm remains disconnected from the machine harness. Disconnect the machine harness from the main display module. At the machine harness connector for the main display module, measure the resistance between contact 4 (410-WH) and frame ground.

- Resistance is less than 5000 Ω; harness is faulty. Repair or replace the machine harness.
- Resistance is greater than 5000 Ω; harness resistance is correct. Go to Step 3.

STEP 3. CHECK MODULE – Using the correct service tools, remove contact 4 from the machine harness connector for the main display module. Reconnect the machine harness connector to the module. Turn the disconnect and key start switch to the ON position. Place the same service code on-hold, check the fault present indicator.

- Same fault is present; the main display module is faulty. Replace the module; see the topic Module Replacement.
- Same fault is NOT present; the main display module is not causing the fault. The fault is intermittent. The probable cause is poor electrical connection at the harness connectors or a damaged harness. Check the harness for damage and clean the harness connectors.

CID 324 Procedure (Action Lamp)

FMI 03

This service code is recorded when the main display module reads the voltage of the action lamp circuit (411-PK) as above normal (shorted to +battery). The result of this fault condition is that the action lamp is ON CONTINUOUSLY.

CHECK LAMP CIRCUIT – Turn the disconnect and key start switch to the OFF position. Disconnect the machine harness from the main display module. Turn the disconnect switch to the ON position. Observe the action lamp. Turn the key start switch to the ON position.

- The lamp is ON; harness circuit 411-PK is shorted to +battery. Repair or replace the harness.
- The lamp is OFF; the module is faulty. Replace the main display module; see the topic Module Replacement.

FMI 05

This service code is recorded when the main display module reads the current of the action lamp circuit (411-PK) as below normal (open circuit). The result of this fault condition is that the action lamp does not light.

STEP 1. CHECK LAMP – At the action lamp, use a jumper to connect wire 411-PK to frame ground.

- Fault is NO longer present; the lamp or lamp socket is open. Replace the action lamp. (Note: For the purposes of this procedure, the correct resistance for a lamp is less than 200 Ω.)
- Fault remains present; the action lamp is not causing the fault. Go to Step 2.

STEP 2. CHECK HARNESS – Turn the disconnect and key start switch to the OFF position. From Step 1; remove the jumper and make sure the action lamp is connected to the machine harness. Disconnect the machine harness from the main display module. At the machine harness connector for the main display module, measure the resistance between contact 13 (411-PK) and frame ground.

- Resistance is greater than 100 Ω; harness circuit is open. Go to Step 3.
- Resistance is less than 100 Ω; harness circuit resistance is correct. Replace the main display module, see the topic Module Replacement.

STEP 3. CHECK HARNESS – At the action lamp, disconnect wire 411-PK from the action lamp socket. Check for an open in circuit 411-PK between contact 13 of the main display module harness connector and the lamp socket. Also, check for an open in circuit 201-BK between the lamp socket and frame ground. Repair or replace the harness.

FMI 06

This service code is recorded when the main display module reads the voltage of the action lamp circuit (411-PK) as below normal (shorted to ground). The result of this fault condition is that the action lamp does not light.

STEP 1. CHECK LAMP – At the action lamp, disconnect wire 411-PK from the action lamp socket.

- Fault is NO longer present; the lamp or lamp socket is faulty. Replace the action lamp. (Note: For the purposes of this procedure, the correct resistance for a lamp is greater than 10 Ω.)
- Fault remains present. The action lamp is not causing the fault. Go to Step 2.

STEP 2. CHECK HARNESS – Turn the disconnect switch to the OFF position. Wire 411-PK remains disconnected from the action lamp. Disconnect the machine harness from the main display module. At the machine harness connector for the main display module, measure the resistance between contact 13 (411-PK) and frame ground.

- Resistance is less than 5000 Ω; harness is faulty. Repair or replace the machine harness.
- Resistance is greater than 5000 Ω; harness resistance is correct. Go to Step 3.

STEP 3. CHECK MODULE – Remove contact 13 from the machine harness connector for the main display module. Reconnect the harness connector to the main display module. Turn the disconnect and key start switches to the ON position. Place the same service code on-hold, check the fault present indicator.

- Fault remains present; the main display module is faulty. Replace the module; see the topic Module Replacement.
- Fault is NOT present; the main display module is not causing the fault. The fault is intermittent. The probable cause is poor electrical connection at the harness connectors or a damaged harness. Check the harness for damage and clean the harness connectors as required.

CID 600 Procedure (Hydraulic Oil Temperature Sender)

FMI 04

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced, find the connector contact of the main display module connector which corresponds to the current CID shown.

This service code is recorded when the main display module reads the sender signal as too low. The result of this fault condition is that the corresponding gauge indicates an abnormally high value. The possible causes are:

- Sender is faulty.
- Signal circuit in the machine harness is shorted to ground.
- Main display module is faulty.

NOTE: The main display module is unable to determine when a sender or sender signal harness is open (or resistance is too high). This condition is recognized as a gauge that always reads at the far left side of the scale.

STEP 1. CHECK MAIN DISPLAY MODULE AND HARNESS – Turn the disconnect and key start switch to the ON position. The fault present indicator should show "SERV CODE". Disconnect the machine harness from the sender causing the fault. Observe the fault present indicator.

- Fault present indicator turns OFF; sender is faulty. Replace the sender.
- Fault present indicator stays ON; harness wiring or main display module is faulty. Go to step 2.

STEP 2. CHECK SENDER WIRE FOR SHORT TO GROUND – Turn the disconnect and key start switch to the OFF position. Disconnect the machine harness from the sender. Turn the disconnect and key start switch to the ON position. Measure the voltage between frame ground and the sender signal wire.

- Voltage is 6.0 ± 0.5 DCV; voltage is correct. Check to see if the fault is still present. If the fault is still present, repeat steps 1 through 3. If the cause of the fault is still not found replace the main display module.
- Voltage is less than 0.5 DCV; harness wiring is faulty. There is an open circuit or a short to ground in the sender signal wire or a bad connector connection. Repair or replace the harness. If the cause of the fault is still not found replace the main display module.
- Voltage is NOT 6.0 ± 0.5 but greater than 0.5 DCV; harness is shorted to a power circuit. Repair or replace the harness. If the cause of the fault is still not found replace the main display module.

FMI 08

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced, find the connector contact of the main display module connector which corresponds to the current CID shown.

NOTE: The Sensor Voltage Test within the topic PWM Sensor Tests covers the troubleshooting of the sensor fault.

C **CID 601 Procedure (Brake Air Pressure Sensor)**

FMI 08

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced find the connector contact of the main display module connector which corresponds to the current CID shown.

NOTE: The Sensor Voltage Test within the topic PWM Sensor Tests covers the troubleshooting of the sensor fault.

CID 819 Procedure (Display Data Link)

FMI 02

This service code is recorded when the main display module does not receive expected information. When the main display module sends information to a display module, The display module sends a signal back to the main display module confirming that the information was received and was correct. When the main display module does not receive expected information, the service code is logged. The result of this service code is, while in Normal Mode (Mode 0), the display modules may not respond (gauges or readouts) to the information received. Check for loose or poor display data link connections. Check for opens or shorts in the display data link harness wiring.

CID 821 Procedure (Display Power Supply)

FMI 03

This service code is recorded when the main display module reads the voltage of the display power supply circuit as above normal. Normal display power supply voltage is 9.0 ± 0.5 DCV.

STEP 1. CHECK VOLTAGE AT MAIN DISPLAY MODULE – Using the 7X-1710 Cable probes, check the voltage at the main display module connector from contact 34 to 2. Do NOT disconnect the harness from the main display module.

- Voltage is 9.0 ± 0.5 DCV; the display power supply voltage is correct. Check the main display module for the same service code. If the fault present indicator is still ON, the main display module is faulty. Replace the main display module; see the topic Module Replacement.
- Voltage is NOT 9.0 ± 0.5 DCV; the display power supply voltage is NOT correct. Go to Step 2.

STEP 2. CHECK HARNESS FOR SHORT TO +BATTERY – Disconnect the machine harness from the main display module. At the machine harness connector for the main display module, measure the voltage from connector contact 34 to 2 (ground).

- Voltage is 0.0 ± 0.5 DCV; the voltage is correct. The main display module is faulty. Replace the main display module; see the topic Module Replacement.
- Voltage is NOT 0.0 ± 0.5 DCV; the harness is faulty. Repair or replace the harness.

FMI 04

This service code is recorded when the main display module reads the voltage of the display power supply circuit as below normal (shorted to ground). Normal display power supply voltage is 9.0 ± 0.5 DCV.

STEP 1. CHECK VOLTAGE AT MAIN DISPLAY MODULE – Using the 7X-1710 Cable probes, measure the voltage at the main display module connector from contact 34 to 2. Do NOT disconnect the harness from the main display module.

- Voltage is 9.0 ± 0.5 DCV; the display power supply voltage is correct. Check the main display module for the same service code. If the fault present indicator is still ON, the main display module is faulty. Replace the main display module; see the topic Module Replacement.
- Voltage is NOT 9.0 ± 0.5 DCV; the display power supply voltage is NOT correct. Go to Step 2.

STEP 2. DISCONNECT DISPLAY MODULES – Continue to measure the voltage at the main display module connector from contact 34 to 2. Disconnect a display module, one at a time, from the machine harness.

- Voltage is NOT 9.0 ± 0.5 DCV; the display power supply voltage is NOT correct. Repeat Step 2. If al display modules have been disconnected from the machine harness and the voltage is still NOT 9.0 ± 0.5 DCV, go to Step 3.
- Voltage is 9.0 ± 0.5 DCV; the display power supply voltage is correct. The display module that was just disconnected is faulty. Replace the module; see the topic Module Replacement.

STEP 3. CHECK FOR SHORT TO GROUND – Turn the disconnect and key start switch to OFF. Disconnect the machine harness from the main display module and the display modules. At the machine harness connector for the main display module, measure the resistance between connector contact 34 and 2.

- Resistance is less than 5000 Ω; the machine harness is faulty. Repair or replace the harness.
- Resistance is greater than 5000 Ω; harness circuit resistance is correct. The main display module is faulty. Replace the main display module: see the topic Module Replacement.

C **CID 830 Procedure (Brake Oil Temperature Sensor)**

FMI 08

Service Notes: Ensure that the desired service code (CID and FMI) is on-hold. Ensure that the fault present indicator shows "SERV CODE". Using the Electrical System Schematic for the machine being serviced, find the connector contact of the main display module connector which corresponds to the current CID shown.

NOTE: The Sensor Voltage Test within the topic PWM Sensor Tests covers the troubleshooting of the sensor fault.

Troubleshooting Faults Without Service Codes

Troubleshooting Switch Circuits

The main display module is unable to identify system errors in simple open/closed switch circuits, so there is no service code (MID/CID/FMI) information available to assist with troubleshooting. A possible fault exists when the operation of an alert indicator does not correspond to a known machine condition. For example; the alert indicator always FLASHES for the parameter engine oil pressure. Before troubleshooting, ensure that a fault does exist. For a description of what normal conditions cause these events, see the Operation & Maintenance Manual for the machine being serviced. Perform the following procedures only if a fault is suspected.

As observed during normal operation, the possible fault conditions for the indicator are:

- Alert indicator always FLASHING for same parameter; see the Alert Indicator Always FLASHING procedure.
- Alert indicator never FLASHES for a parameter; see the Alert Indicator Never FLASHES procedure.

NOTE: The indicator reflects the open or grounded condition of the switch inputs. When a switch input is open, the corresponding alert indicator FLASHES. When a switch input is grounded, the corresponding alert indicator is OFF. Therefore to check a circuit, the service person opens and grounds the corresponding switch wire while watching for the correct result on the alert indicator.

Alert Indicator Always FLASHING

This procedure is for the parameter that has the alert indicator FLASHING all the time. The always FLASHING condition is most likely caused by an undesired open circuit or a faulty main display module (unlikely).

Procedure

STEP 1. Locate the switch which corresponds to the parameter that always FLASHES the alert indicator. (If necessary, use the Electrical System Schematic to assist in locating the switch.)

STEP 2. CHECK HARNESS – Disconnect the signal wire from the switch. Place a jumper wire from the signal wire to the ground wire. (If a ground wire is not present, connect the signal wire to frame ground.)

- The alert indicator stops FLASHING; the circuit is operating correctly. The switch is faulty. Check or replace the switch.
- The alert indicator continues FLASHING; the machine harness is open or the control is faulty. Go to Step 3.

STEP 3. CHECK HARNESS – Turn the disconnect and key start switch to the OFF position. On the Electrical System Schematic trace the signal wire from the switch to the main display module. Determine the signal contact (connector contact) of the machine harness at the main display module. Disconnect the machine harness from the main display module. At the machine harness connector for the main display module, check for continuity between the signal contact and contact 2 or frame ground if a ground wire is not present at contact 2. (Jumper is still in place from Step 2.)

- Resistance is greater than 5.0 Ω; the harness is faulty. Repair or replace the harness.
- Resistance is less than 5.0 Ω; the harness is not causing the fault. The main display module is faulty. Replace the module; see the topic Module Replacement.

Alert Indicator Never Flashes

This procedure is for parameters that the alert indicator never FLASHES for. The never FLASHING condition is most likely caused by a short to ground or a faulty main display module (unlikely).

Procedure

STEP 1. Locate the switch which corresponds to the parameter that the alert indicator never FLASHES for. (If necessary, use the Electrical System Schematic to assist in locating the switch.)

STEP 2. CHECK HARNESS – Disconnect the signal wire from the switch.

- The alert indicator FLASHES; the circuit is operating correctly. The switch is faulty. Check or replace the switch.
- The alert indicator does NOT FLASH; the circuit is faulty. The signal wire is probably shorted to ground. Go to Step 3.

STEP 3. CHECK HARNESS – Turn the disconnect and key start switch to the OFF position. The signal wire remains disconnected from the switch; do not allow it to touch anything.

On the Electrical System Schematic trace the signal wire from the switch to the main display module. Determine the signal contact (connector contact) of the machine harness at the main display module. Disconnect the machine harness from the main display module. At the machine harness connector for the main display module, check for continuity between the signal contact and contact 2 or frame ground if a ground wire is not present at contact 2.

- Resistance is greater than 5000 Ω; the harness is not causing the fault. The main display module is faulty. Replace the module; see the topic Module Replacement.
- Resistance is less than 5000 Ω; the harness is faulty. The signal wire within the harness is shorted to ground. Repair or replace the harness.

Troubleshooting Harness Code Faults

HARNESS CODE TROUBLESHOOTING [1]						
Main Display Module Connector Contact	**31**	**3**	**12**	**22**	**16**	**6**
Wire Identification	**270-BK**	**271-BK**	**272-BK**	**273-BK**	**274-BK**	**275-BK**
Harness Code Plug Contact [2]	**1**	**2**	**3**	**4**	**5**	**6**
Machine Code	**Specified Status**					
03	O	O	G	G	O	G
09	O	G	G	O	G	G
27	O	O	G	O	O	G
28	G	G	O	O	O	G
34	G	O	G	G	G	O
35	O	O	G	G	G	O
39	O	O	O	G	G	O
40	G	G	G	O	G	O
43	O	O	G	O	G	O
45	O	G	O	O	G	O
46	G	O	O	O	G	O
47	O	O	O	O	G	O
48	G	G	G	G	O	O
49	O	G	G	G	O	O
61	O	O	G	G	O	O
53	O	G	O	G	O	O
58	G	O	G	O	O	O
60	G	G	O	O	O	O
Unknown [3]						

O = open, G = grounded
[1] Main display module is in Harness Code mode (mode 1).
[2] For machines so equipped. For machines without a harness code plug, permanent harness code connections are in the machine harness.
[3] See the Electrical System Schematic. Record the specified open (O) or grounded (G) status of the harness code circuits.

C NOTE: The preceding chart has changed from the former issue.

Before performing this procedure, always use the Harness Code mode to determine the machine code that is shown. Make sure the main display module has the correct part number for the machine it is installed on. If the machine code is not shown correctly this procedure determines which component is malfunctioning; faulty main display module, wrong harness code plug or faulty harness.

NOTE: Harness code and machine code are similar terms used to describe the particular machine that the main display module is installed on. Harness code is the status (open or ground) of the six harness code inputs (connector contacts 3, 6, 12, 16, 22 and 31) Machine code is the number that the main display module has assigned to a particular harness code for a particular machine. The machine code is shown during Harness Code mode. Each sales model has a specific harness code and therefore also a specific machine code. The specific machine code is listed in the topic Harness Code Mode. The specific harness code is given in the Electrical System Schematic module.

Procedure

STEP 1. Determine the machine code. The machine code is listed in the topic Harness Code Mode. After finding the machine code, use the Harness Code Troubleshooting chart to find the corresponding specified harness code.

If the machine code is NOT found (unknown), determine the harness code from the Electrical System Schematic in the machine Service Manual. Then record the specified open or grounded status into the row titled "Unknown" in the Harness Code Troubleshooting chart.

Go to Step 2.

STEP 2. CHECK HARNESS CODE CIRCUITS. The remaining steps check for incorrect harness code status on the main display module inputs by comparing the harness code status found in Step 1 to the actual status at the main display module inputs. The chart identifies the connector contacts and wire identification of the harness code circuits. For contacts specified as grounded on the chart check for opens in the harness. For contacts specified as open on the chart check for shorts in the harness.

STEP 3. CHECK FOR OPENS. Turn the disconnect to the OFF position. Disconnect the machine harness from the main display module. At the machine harness connector for the main display module, check for continuity between the corresponding connector contacts specified on the chart as grounded (3, 6, 12, 16, 22, and 31) and contact 2 (ground).

- Resistance is 5.0 Ω or less; the harness code circuit is not open. No defect was found in the harness code ground circuits. Go to Step 4.
- Resistance is greater than 5 Ω; the harness code circuit is open. Check the harness code plug on so equipped machines. Record the machine harness connector contact found to be open. Go to Step 4.

STEP 4. CHECK FOR SHORTS. The disconnect switch remains off and the machine harness to the main display module remains disconnected. At the machine harness connector for the main display module, measure the resistance between the corresponding connector contact specified on the chart as open (3, 6, 12, 16, 22, and 31) and contact 2 (ground).

- Resistance is 5000 Ω or greater; the harness code circuit is not shorted to ground. No defect was found in the harness code circuits.
- Resistance is less than 5000 Ω; the harness code circuit is shorted. Check the harness code plug on so equipped machines. Record the machine harness connector contact found to be shorted. Go to Step 5.

STEP 5. Repair the open and shorted harness code circuits found in Step 3 and 4 or replace the harness. Reconnect the harness connectors. Turn the disconnect and key start switch to the ON position. Recheck the machine code (see Step 1). If the main display module still shows an incorrect machine code, replace the module. See the topic Module Replacement.

Electrical System Tests

When an electrical system problem is present, the alert indicator for the electrical system FLASHES. These tests apply to warning category 1 or 3 problems. For a description of the warning indications for an electrical system problem, see the Operation And Maintenance Manual for the machine being serviced.

One of the following conditions cause the electrical system problem:

- The speed of the alternator is low; alternator "R" terminal frequency is less than 90 Hz. The probable cause is a slipping belt or an internal alternator malfunction.
- System voltage (+battery) is too low. The probable cause is an excessive electrical load (especially at low idle), alternator malfunction or faulty batteries.
- System voltage (+battery) is too high. The probable cause is a faulty alternator.

When engine speed is low, the operation of large electrical loads (such as air conditioning and/or lighting) places a great demand on the charging system. If operating under these conditions, increase the engine speed to high idle to generate more output from the alternator and then check the alert indicator.

- If the alert indicator turns OFF within about one minute, the charging system is probably overloaded while at low engine speed. To correct the problem, change the machine operation by increasing the engine speed and/or decreasing the electrical load (use medium or low fan speed instead of high).
- If the alert indicator remains FLASHING, there is a malfunction that requires service. Perform the Electrical System Troubleshooting procedures.

Electrical System Troubleshooting

Procedure

STEP 1. VISUAL CHECK – Check the alternator belt pulley and the belt tension.

- Pulley nut torque and belt tension are proper; go to Step 2.
- Pulley and belt are NOT proper; fix or adjust.

STEP 2. CHECK BATTERY VOLTAGE – Measure the battery voltage at the battery posts.

- Voltage is between 23.0 and 29.5 DCV; battery voltage is correct. Go to Step 3.
- Voltage is NOT between 23.0 and 29.5 DCV; there is a defect in the electrical system. Check the charging system, go to Charging System Test.

STEP 3. CHECK SYSTEM VOLTAGE HARNESS CIRCUIT – Turn the key start switch to the OFF position. Disconnect the machine harness from the main display module. Start the engine and run at high idle. At the machine harness connector for the main display module, measure the voltage between contact 1 (system voltage circuit) and contact 2 (ground).

- Voltage is between 23.0 and 29.5 DCV; system voltage is correct. Go to Step 4.
- Voltage is NOT between 23.0 and 29.5 DCV; there is a defect in the harness. Repair or replace the harness.

STEP 4. CHECK "R" TERMINAL HARNESS CIRCUIT – Start the engine and run at high idle. At the harness connector, measure the voltage between contact 30 (alternator "R" terminal circuit) and contact 2 (ground).

- Voltage is between 12.4 and 14.75 DCV; the "R" terminal voltage is correct. Replace the main display module; see the topic Module Replacement.
- Voltage is NOT between 12.4 and 14.75 DCV; there is a defect in the harness. Repair or replace the harness.

Charging System Test

FAULT CONDITIONS AND POSSIBLE CAUSES			
Current At Start-Up [1]	**Voltage After About 10 Min Is Below Spec.**	**Voltage After About 10 Min Is In Spec.**	**Voltage After About 10 Min Is Above Spec.**
Below Specification.	Repair alternator (faulty regulator, open stator phase, and/or rectifier).	Turn on all accessories. If voltage drops below spec., repair alternator (open rectifier and/or stator phase).	
Reached Specification and then tapered off.	Repair alternator (faulty regulator).	Alternator and battery in spec. Turn on all accessories to verify. Voltage must stay in spec.	Repair alternator (shorted regulator).
Exceeds Specification and stays high.	Check battery per Form SEHS7633. Do alternator test again if necessary.	Alternator in spec. Check battery per Form SEHS7633-01.	Repair alternator (shorted regulator). Also check battery for possible damage.

[1] All electrical accessories off.

Tools Needed		
9U-7330	Digital Multimeter or Equivalent	1
8T-0900	AC/DC Clamp-On Ammeter	1

Procedure

STEP 1. Put the multimeter positive (+) lead on the Bat terminal of the alternator. Put the negative (−) lead on the ground terminal or the frame of the alternator. Put the clamp-on ammeter around the positive output wire of the alternator.

STEP 2. Turn off all electrical accessories. With the fuel off, crank the engine for 30 seconds. Wait two minutes to let the starting motor cool. If it is believed that the batteries are fully charged, crank the engine again for 30 seconds.

NOTE: Cranking the engine for 30 seconds partially discharges the battery in order to do a charging test. If the battery is already low in charge, skip this step. Jump-start engine or charge as required.

STEP 3. Start the engine and run at full throttle.

STEP 4. Immediately check output current. For correct operation, this initial charging current is equal to or slightly greater than the full output current shown below:

9W-3043 Alternator 47A
5S-9088 Alternator 50A
8N-0999 Alternator 75A

STEP 5. For correct operation, within approximately 10 minutes at full throttle (possibly longer depending upon battery size, condition and alternator rating), the alternator output voltage is 26.5 to 29.0 DCV. See the Fault Conditions And Possible Causes chart.

STEP 6. The charging current during this period should taper off to less than approximately 10 amps with accessories turned OFF, depending again upon battery and alternator capacities. See the Fault Conditions And Possible Causes chart.

STEP 7. Turn on all electrical accessories. The alternator must maintain 26.5 to 29.0 DCV. The ammeter shows total charging current.

PWM Sensor Tests

Tools Needed		
9U-7330	Digital Multimeter or Equivalent	1
7X-1710	Cable Probes	1

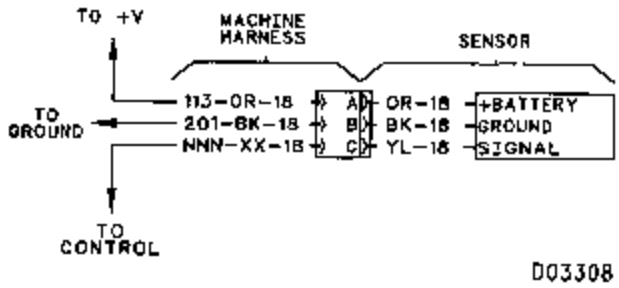
NOTE: In addition to these tests, Caterpillar Monitoring System diagnostics are helpful when troubleshooting sensors. Numeric readout mode shows a numeric value of the information from each sensor input. For a detailed explanation, see the topic Numeric Readout Mode in the Systems Operation section.

Troubleshoot sensor circuits in the following order.

1. Perform Sensor Signal Voltage Test. The test checks sensor voltages at the sensor with all circuits connected. DISCONNECT NOTHING. Troubleshoot "as is" before disconnecting any circuits. Disconnecting first may alter a poor connection and make proof-of-cause difficult or impossible.
2. Perform Sensor Dynamic Test if necessary.
3. If sensor and harness check correctly, the main display module is likely faulty. Replace the main display module, see the topic Module Replacement.

To identify sensor wires and connector contacts, refer to the following Sensor Wire And Contact Identification section. Otherwise proceed to Sensor Signal Voltage Test

Sensor Wire And Contact Identification



Typical PWM Sensor - Schematic Symbol

When testing a sensor, it is necessary to identify the connector contacts and the harness wires. The Electrical System Schematic shows the connector contact numbers which correspond to the wire numbers. See the Electrical System Schematic in the machine Service Manual.

On all machines, the wire numbers and connector contacts are identified by these general rules:

- The +V wire number (power) is between 100 and 199. The +V contact corresponds to this wire number.
- The ground wire number is between 200 and 299. The ground contact corresponds to this wire number.
- The signal wire number is between 400 and 499. The signal contact corresponds to this wire number.

For example, in the above Typical PWM Sensor illustration:

The +V wire is wire number 113.
The +V contact is contact A.

The ground wire is wire number 201.
The ground contact is contact B.

The signal wire is wire number 443.
The signal contact is contact C.

Testing And Adjusting

Sensor Signal Voltage Test (Main Display Module Connected)

100-3055 And 131-0427 Sensors

SENSOR VOLTAGE SPECIFICATIONS [1] For Sensor Voltage Test		
Temperature Sensor		
Temperature	Signal Voltage [2]	Duty Cycle
−40 to −20°C (−40 to −4°F)	1.0 to 1.1 DCV	10 to 11%
−20 to 0°C (−4 to 32°F)	1.1 to 1.4 DCV	11 to 15%
0 to 20°C (32 to 68°F)	1.4 to 2.0 DCV	15 to 23%
20 to 40°C (68 to 104°F)	2.0 to 3.1 DCV	23 to 37%
40 to 60°C (104 to 140°F)	3.1 to 4.5 DCV	37 to 55%
60 to 80°C (140 to 176°F)	4.5 to 5.7 DCV	55 to 71%
80 to 100°C (176 to 212°F)	5.7 to 6.6 DCV	71 to 82%
100 to 120°C (212 to 248°F)	6.6 to 7.2 DCV	82 to 89%
120 to 135°C (248 to 275°F)	7.2 to 7.4 DCV	89 to 93%

[1] If desired, use these specifications with Step 2 of the following procedure.

[2] These voltages are guidelines for troubleshooting and are not considered exact. The tolerance is ± 10%, depending on the condition of the harness. Most important is that the output voltage changes smoothly as the temperature changes.

3E-5370 And 131-0784 Sensors

SENSOR VOLTAGE SPECIFICATIONS [1] For Sensor Voltage Test		
Temperature Sensor		
Temperature	Signal Voltage [2]	Duty Cycle
−40 to −20°C (−40 to −4°F)	0.8 to 1.5 DCV	4 to 11%
−20 to 0°C (−4 to 32°F)	1.5 to 2.5 DCV	11 to 22%
0 to 20°C (32 to 68°F)	2.5 to 3.7 DCV	22 to 34%
20 to 40°C (68 to 104°F)	3.7 to 4.8 DCV	34 to 46%
40 to 60°C (104 to 140°F)	4.8 to 6.0 DCV	46 to 59%
60 to 80°C (140 to 176°F)	6.0 to 7.2 DCV	59 to 71%
80 to 100°C (176 to 212°F)	7.2 to 8.1 DCV	71 to 81%
100 to 120°C (212 to 248°F)	8.1 to 8.8 DCV	81 to 87%
120 to 135°C (248 to 275°F)	8.8 to 9.2 DCV	87 to 92%

[1] If desired, use these specifications with Step 2 of the following procedure.

[2] These voltages are guidelines for troubleshooting and are not considered exact. The tolerance is ± 10%, depending on the condition of the harness. Most important is that the output voltage changes smoothly as the temperature changes.

Procedure

Locate the suspect sensor. Identify the sensor wires and connector contacts; see Sensor Wire And Contact Identification. DO NOT DISCONNECT ANY HARNESS CONNECTORS AT THIS TIME. Turn the key start switch to the ON position. DO NOT START THE ENGINE.

STEP 1. CHECK SENSOR POWER – At the sensor connector, identify the +V and ground circuits. Push 7X-1710 Cable Probes in the back of the sensor connector along side of the +V and ground circuit wires. Measure the system voltage.

- Voltage is between 7.5 and 8.5 DCV; system voltage is present. Go to Step 2.
- Voltage is NOT between 7.5 and 8.5 DCV; there is an open circuit. Trace the +V and ground circuits in the machine harness. Repair or replace the harness.

STEP 2. CHECK SIGNAL VOLTAGE – At the sensor connector, identify the signal and ground circuits. Push 7X-1710 Cable Probes in the back of the sensor connector alongside of the signal and ground circuit wires. Measure and record the signal voltage.

NOTE: If more precise signal voltage specifications are necessary, use the specifications listed in the Sensor Voltage Specifications chart at the beginning of this test.

- Voltage is between approximately 1.0 and 7.0 DCV (9.0 DCV for 3E-5370); signal voltage at the sensor is correct. Go to Step 3.
- Voltage is NOT between approximately 1.0 and 7.0 DCV (9.0 DCV for 3E-5370); signal voltage is not correct.

  If voltage is greater than 7.0 DCV (9.0 DCV for 3E-5370), Go to Step 4.

  If voltage is less than 1.0 DCV, Go to Step 5.

STEP 3. CHECK MACHINE HARNESS SIGNAL CIRCUIT – At the machine harness connector for the main display module, identify the signal and ground circuits. DO NOT DISCONNECT THE HARNESS CONNECTOR. Push 7X-1710 Cable Probes in the back of the machine harness connector along side of the signal and ground circuit wires. Measure the signal voltage. Compare this measurement with the voltage measured in Step 2.

- Voltage is the same as in Step 2; the main display module is receiving a valid signal voltage. If the problem still persists, further testing is required; see Sensor Dynamic Test.
- Voltage is NOT the same as in Step 2; the machine harness has an open in the signal or ground circuits. Repair or replace the machine harness.

STEP 4. CHECK MACHINE HARNESS – Signal voltage is greater than 7.0 DCV (9.0 DCV for 3E-5370). The probable cause is a short to system voltage (+battery) in the machine harness or the sensor is faulty. Disconnect the machine harness from the sensor. At the machine harness connector for the sensor, measure the voltage between the signal contact and the ground contact.

- Voltage is greater than 6.0 ± 0.5 DCV; the voltage is not correct. The signal circuit of the machine harness is shorted to +battery. Repair or replace the machine harness. If the machine harness is not faulty, replace the main display module.
- Voltage is 6.0 ± 0.5 DCV; the voltage is correct for a good harness and main display module. The sensor is faulty. Replace the sensor.

STEP 5. CHECK MACHINE HARNESS – Signal voltage is less than 1.0 DCV. The probable cause is a short to ground in the machine harness or the sensor is faulty. Disconnect the machine harness from the sensor. At the machine harness connector for the sensor, measure the voltage between the signal contact and the ground contact.

- Voltage is less than 6.0 ± 0.5 DCV; the voltage is not correct. The signal circuit of the machine harness is shorted to ground. Repair or replace the machine harness. If the machine harness is not faulty, replace the main display module.
- Voltage is 6.0 ± 0.5 DCV; the voltage is correct for a good harness and main display module. The sensor is faulty. Replace the sensor.

Sensor Dynamic Test (Main Display Module Connected)

100-3055 And 131-0427 Sensors

SENSOR VOLTAGE SPECIFICATIONS [1] For Sensor Dynamic Test		
Temperature Sensor		
Temperature	Signal Voltage [2]	Duty Cycle
−40 to −20°C (−40 to −4°F)	1.0 to 1.1 DCV	10 to 11%
−20 to 0°C (−4 to 32°F)	1.1 to 1.4 DCV	11 to 15%
0 to 20°C (32 to 68°F)	1.4 to 2.0 DCV	15 to 23%
20 to 40°C (68 to 104°F)	2.0 to 3.1 DCV	23 to 37%
40 to 60°C (104 to 140°F)	3.1 to 4.5 DCV	37 to 55%
60 to 80°C (140 to 176°F)	4.5 to 5.7 DCV	55 to 71%
80 to 100°C (176 to 212°F)	5.7 to 6.6 DCV	71 to 82%
100 to 120°C (212 to 248°F)	6.6 to 7.2 DCV	82 to 89%
120 to 135°C (248 to 275°F)	7.2 to 7.4 DCV	89 to 93%

[1] If desired, use these specifications with Step 2 of the following procedure.

[2] These voltages are guidelines for troubleshooting and are not considered exact. The tolerance is ± 10%, depending on the condition of the harness. Most important is that the output voltage changes smoothly as the temperature changes.

3E-5370 And 131-0784 Sensors

SENSOR VOLTAGE SPECIFICATIONS [1] For Sensor Dynamic Test		
Temperature Sensor		
Temperature	Signal Voltage [2]	Duty Cycle
−40 to −20°C (−40 to −4°F)	0.8 to 1.5 DCV	4 to 11%
−20 to 0°C (−4 to 32°F)	1.5 to 2.5 DCV	11 to 22%
0 to 20°C (32 to 68°F)	2.5 to 3.7 DCV	22 to 34%
20 to 40°C (68 to 104°F)	3.7 to 4.8 DCV	34 to 46%
40 to 60°C (104 to 140°F)	4.8 to 6.0 DCV	46 to 59%
60 to 80°C (140 to 176°F)	6.0 to 7.2 DCV	59 to 71%
80 to 100°C (176 to 212°F)	7.2 to 8.1 DCV	71 to 81%
100 to 120°C (212 to 248°F)	8.1 to 8.8 DCV	81 to 87%
120 to 135°C (248 to 275°F)	8.8 to 9.2 DCV	87 to 92%

[1] If desired, use these specifications with Step 2 of the following procedure.

[2] These voltages are guidelines for troubleshooting and are not considered exact. The tolerance is ± 10%, depending on the condition of the harness. Most important is that the output voltage changes smoothly as the temperature changes.

This test is a quick check to determine if the sensor is functioning. It does not check the accuracy of the sensor. Perform this test only after successfully completing the Sensor Voltage Test.

To use the following procedure it is necessary to know the main display module connector contact that corresponds to the service code. Use the Electrical System Schematic in the machine Service Manual to determine the main display module connector contact that corresponds to the machine condition under test (engine coolant temperature, etc.). Use the 7X-1710 Cable Probe on the sensor signal wire connector contact on the main display module connector.

NOTE: The sensors are provided power from the main display module. Therefore the main display module must be connected for the sensors to function.

Two items are checked in this test:

- That a sensor signal is present at the main display module.
- That the signal voltage increases/decreases with a corresponding increase/decrease in the system being monitored.

Procedure

The required machine condition is:

- For temperature sensors, the coolant is below operating temperature.

STEP 1. SETUP – Ensure that the key switch is OFF and the sensor is connected to the machine harness. Turn the key switch to the ON position. DO NOT START THE ENGINE.

STEP 2. CHECK SIGNAL VOLTAGE – At the machine harness connector for the main display module, measure and record the voltage (DCV) between the signal contact and frame ground. For correct operation, the approximate voltage is between 1.0 and 7.0 DCV (9.0 DCV for 3E-5370).

NOTE: If more precise signal voltage specifications are necessary, use the specifications listed in the Sensor Voltage Specifications chart at the beginning of this test.

- Voltage is between approximately 1.0 and 7.0 DCV (9.0 DCV for 3E-5370); signal voltage to main display module is correct. Go to Step 4.
- Voltage is NOT between approximately 1.0 and 7.0 DCV (9.0 DCV for 3E-5370); signal voltage to the main display module is not correct. The probable cause is a faulty sensor. Replace the sensor.

STEP 3. CHANGE THE RELATED MACHINE CONDITION – Increase the temperature, pressure or fuel level of the system being tested. For example: run the engine to increase the engine coolant temperature, operate the implement controls to increase the hydraulic oil temperature, or add fuel to increase the fuel level. Go to Step 4.

STEP 4. CHECK SIGNAL VOLTAGE – At the machine harness connector for the main display module, measure the voltage (DCV) between the signal contact and frame ground. For correct operation, the voltage (DCV) is greater (and increases smoothly without step increases) than the voltage recorded in Step 2.

NOTE: The larger the change in the system being monitored (in Step 3), the greater the difference between Step 2 and Step 4 voltages.

- Voltage is greater and operates smoothly; the sensor is not faulty.
- Voltage is NOT greater; the probable cause is a faulty sensor. Replace the sensor.

Sender Tests

For the most accurate sender specifications, see the Resistor, Solenoid And Sender Specification chart on the Electrical System Schematic for the machine being serviced.

Temperature Sender

Disconnect the sender from the machine harness. Measure the resistance between the terminal and the case of the sender. The correct approximate resistance is:

54.4°C (130.0°F) ..... 850 to 1050 Ω
110°C (230.0°F) ..... 140 to 160 Ω

These values are not exact, but guidelines to use for troubleshooting.

Fuel Level Sender

Disconnect the sender from the machine harness. Measure the resistance between the two contacts of the sender. The correct approximate resistance is:

106-3535

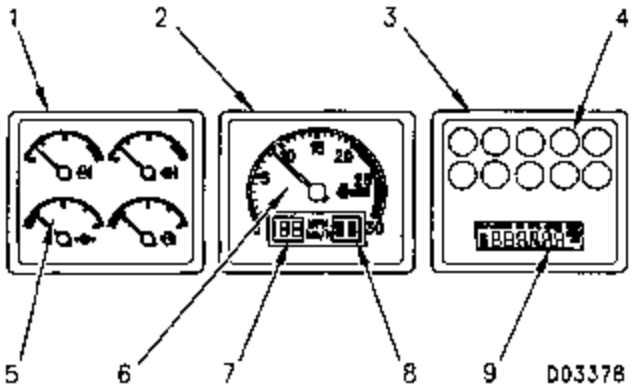
Empty tank ..... 240 to 260 Ω
Half tank ..... 97 to 118 Ω
Full Tank ..... 27 to 40 Ω

104 5546

Empty tank ..... 92 to 99 Ω
Full Tank ..... 0 to 5 Ω

If desired, check the sender further by removing the sender. Actuate the sender by hand while measuring the resistance. The resistance should change (similar to above) as the sender is actuated through the empty to full range.

Self Test Operation



Caterpillar Monitoring System
(1) Gauge cluster module. (2) Speedometer/tachometer module. (3) Main display module. (4) Alert indicators. (5) Gauges. (6) Tachometer gauge. (7) Speedometer readout. (8) Actual transmission gear readout. (9) Display area.

The self test verifies that the main display module and the display modules are operating properly. The main display module performs an automatic self test each time the key start switch is turned from the OFF to the ON position.

The internal circuits and the outputs (displays, action lamp and action alarm) are automatically checked. The operator must observe the outputs to determine whether or not the modules and the outputs are operating properly. The alert indicators and display area are tested for approximately one second:

- All alert indicators (4) FLASH.
- Display area (9) shows:
  All units indicators (°C, kPa, MILES, KM, RPM, LITERS).
  x10 indicator.
  Service meter symbol.
  888.X.8.8 on the six digit readout.

The display modules are tested for approximately three seconds:

- Tachometer gauge (6) and gauges (5) (on machines so equipped) jump to half scale, back to zero, then to full scale. After reaching full scale the tachometer and gauges return to showing current machine values.
- Transmission actual gear readout (8) turns on every segment of the readout. It looks like a "0" with an "X" and a "+" sign laid on top of the "0". There should be two of these side by side.

- Ground speed readout (8) turns on every segment of the readout. It looks like "188". MPH and km/h are both turned ON.
- The action lamp turns ON.
- The action alarm SOUNDS once.

The main display module then goes into the normal mode of operation (or scrolls the modes if the operator switch input or the service and clear switch inputs are grounded).

If the main display module operates as described; the module is operating properly. If the main display module does not operate as described; there is a harness code problem or the module is faulty. Check the harness code, see the topic Troubleshooting Harness Code Faults.

Module Replacement

Prior to replacement of a module, ensure that replacement is absolutely necessary. Rarely is a module the cause of a fault. Always check that the machine code is correct for the machine and that power is available to the main display module; system voltage is required between main display module connector contacts 1 and 2 of the machine harness. To check the machine code, see the topic Harness Code Mode under the subject Modes of Operation in the Systems Operation section.

Procedure

STEP 1. Turn the key start switch to the OFF position Disconnect the machine harness from the module.

STEP 2. Make sure the replacement module has the correct part number.

STEP 3. Install the replacement module.

NOTE: If the replacement main display module was previously removed from service, see the topic Initialization.

STEP 4. Connect the machine harness to the module. On so equipped machines, make sure the harness code plug is installed.

STEP 5. Turn the disconnect and key start switches to the ON position. Make sure the modules successfully complete the self test; see Self Test.

STEP 6. Setup the attachment display modules (on so equipped machines), see the topic Setup Mode under the subject Modes Of Operation in the Systems Operation section.

STEP 8. Set the units (English or Metric) to that desired, see the topic Units Mode under the subject Modes Of Operation in the Systems Operation section.

Initialization

Initialization is an internal process within the main display module. During Initialization, the main display module listens to the CAT data link and the harness code inputs. From this information, the module learns about the machine it is installed on. Information such as: engine oil pressure may come from an engine control or that actual transmission gear information is coming from the transmission control.

Normally initialization occurs when the main display module is replaced (the harness code changes). However, when a previously used main display module is used as a replacement, initialization is possibly necessary. Unexplainable faults with the CAT data link can occur if the main display module is not initialized correctly. The service person must activate the initialization process when the following condition exists or is suspected. The condition is:

The main display module to be installed was taken out of service from an application that had the same machine code as the main display module to be removed.

If this condition exists or is suspected, then perform the Initialization Procedure.

Initialization Procedure

This procedure causes the initialization process to occur on any main display module. Initialization basically requires that the main display module be powered up with a valid harness code that is different than the harness code when it was last powered down. For a list of valid harness codes, see Machine Code Chart under the topic Harness Code Mode (Mode 1), under the subject Modes Of Operation in the Systems Operation section.

STEP 1. Turn the key start switch to the OFF position. Determine whether the harness code inputs are hard wired in the machine harness or accessible at a harness code plug; use the Electrical System Schematic in the machine Service Manual.

- There is a harness code plug. Remove the harness code plug. Go to Step 4.
- The harness code inputs are hard wired in the machine harness. Go to Step 2.

STEP 2. Disconnect the machine harness from the main display module. At the machine harness connector, for the main display module, remove the wire for one of the following contacts which is grounded. 3, 6, 12, 16, 22 or 31. The connector contact that is removed must be connected to a ground wire in the machine harness.

STEP 3. With tape, secure the removed connector contact out of the way. Reconnect the machine harness to the main display module.

STEP 4. Turn the disconnect and key start switches to the ON position.

STEP 5. Various indicators in the Caterpillar Monitoring System display area illuminate. Wait 10 seconds.

STEP 6. Turn the key start switch to the OFF position. Depending on the previous procedure performed, either reinstall the harness code plug (from Step 1) or reinstall the grounded connector contact (from Step 2).

STEP 7. Make sure the main display module successfully completes the self test; see, Self Test. Check the machine code; see the topic Harness Code Mode (Mode 1), under the subject Modes Of Operation in the Systems Operation section.

Glossary Of Terms

+Battery – +Battery refers to any of the harness wiring which is part of the circuit that connects to the positive battery post. +Battery voltage is also referred to as system voltage.

+V – +V is a constant voltage that is supplied to a component to provide electrical power for its operation. +V is provided by an electronic control module or the battery.

Abnormal – Abnormal refers to a machine condition or signal that is not normal. The presence of an abnormal condition or signal means a problem exists and warning operation is activated which notifies the operator.

Alert Indicator – An alert indicator is an indicator on the top portion of the main display module which flashes red when a problem exists. The associated pictograph symbol identifies the abnormal machine system.

CID (Component Identifier) – The CID is a diagnostic code that tells which component or system is faulty. For example; transmission oil temperature, speed sensor, action lamp or engine boost pressure. The CID is a three digit code that is located in the digital readout area when in service mode.

Clear – Clear refers to removing diagnostic information from the memory of the main display module. Before clearing information, it is necessary that the information is on hold.

Connector Contact – A connector contact is the component of a harness connector that actually makes the electrical connection. Connector contacts are either pins or sockets.

Detected Fault – A detected fault is a fault that has been found by the main display module. A service code is recorded for the fault and diagnostic information is available when in service mode.

Diagnostic – Diagnostic refers to the showing, monitoring and/or recording of information other than normal. Diagnostic information is available from service, status, tattletale or numeric readout mode.

Display – Display refers to the gauges, indicators or readouts within the Caterpillar Monitoring System display area.

Fault – A fault is a failure of a component of the system. For example; open or shorted harness, faulty switch, sensor or control.

Floating – The status or the state of a control input that is not connected to a positive source or ground.

FMI (Failure Mode Identifier) – The FMI is a diagnostic code that tells what type of failure has occurred. For example; voltage above normal, current below normal or abnormal frequency. The FMI is a one or two digit code followed with the letter "F" that is located in the digital readout area when in service mode.

Hard Wired – Hard wired refers to electrical connections made within the harness that are permanent. These soldered or crimped connections are not meant to be altered.

Harness Code – Harness code refers to the grounded or open condition of the five harness code inputs (connector contacts 3, 6, 12, 16, 22 and 31). The harness code tells the main display module the characteristics of the machine it is installed on, such as: engine size, idle speed, tire size and attachments. The Caterpillar Monitoring System operates on different machines but it must know the characteristics of the machine it is installed on.

Hold or On-Hold – Hold or On-hold refers to holding (or locking) a set of diagnostic information that is shown in the digital display area when in service mode or numeric readout mode. It is necessary to hold the set of diagnostic information before troubleshooting or clearing.

Indicator – An indicator is any of the items within the Caterpillar Monitoring System display area which operate in an ON, FLASHING or OFF manner to bring attention to a machine condition.

Indicator Fault – An indicator fault is when the operation of an indicator does not correspond to a known machine condition.

Jumper – A jumper is a piece of wire used to make an electrical connection during troubleshooting.

Lamp – Lamp refers to a component of the machine lighting system.

MID (Module Identifier) – The MID is a diagnostic code that tells which electronic control module diagnosed the fault. For example; main display module, engine control module or transmission control module. The MID is a two digit code that is located in the digital readout area when in service mode.

Problem – Problem refers to the presence of an abnormal machine condition. For example; low engine oil pressure or high hydraulic oil temperature. When a problem exists, warning operation is activated and the main display module notifies the operator.

PWM (Pulse Width Modulated) – A PWM signal is a signal in which the duty cycle (time on verses time off) varies according to the machine conditions that are monitored. The frequency of a PWM signal is constant. The Caterpillar Monitoring System has sensors which provide a PWM signal to the main display module.

Scroll – Scrolling is the process of showing (within the digital display area) all available sets of diagnostic information, one set at a time. A set of diagnostic information is shown briefly and then the display automatically advances to the next set. After all sets are shown the sets are repeated.

Service Code – A code which describes a condition (sometimes a problem) in an electronic control system. This code is stored in the control for the service technician.

Show – Show refers to information within the Caterpillar Monitoring System display area that is viewed by the operator or service person.

Signal Wire – The signal wire is the harness wire which connects the sensor or switch to the main display module.

Switch Input – A switch input is any input of the main display module which is expecting only an open (floating) or grounded signal.

System Voltage – System voltage is the actual voltage that exists between the positive battery post and frame ground. System voltage is also referred to as +battery voltage.

Uncommitted Switch Input – Uncommitted switch inputs are switch inputs whose function varies according to the application. Information from the uncommitted switch inputs is typically used to operate the alert indicators.

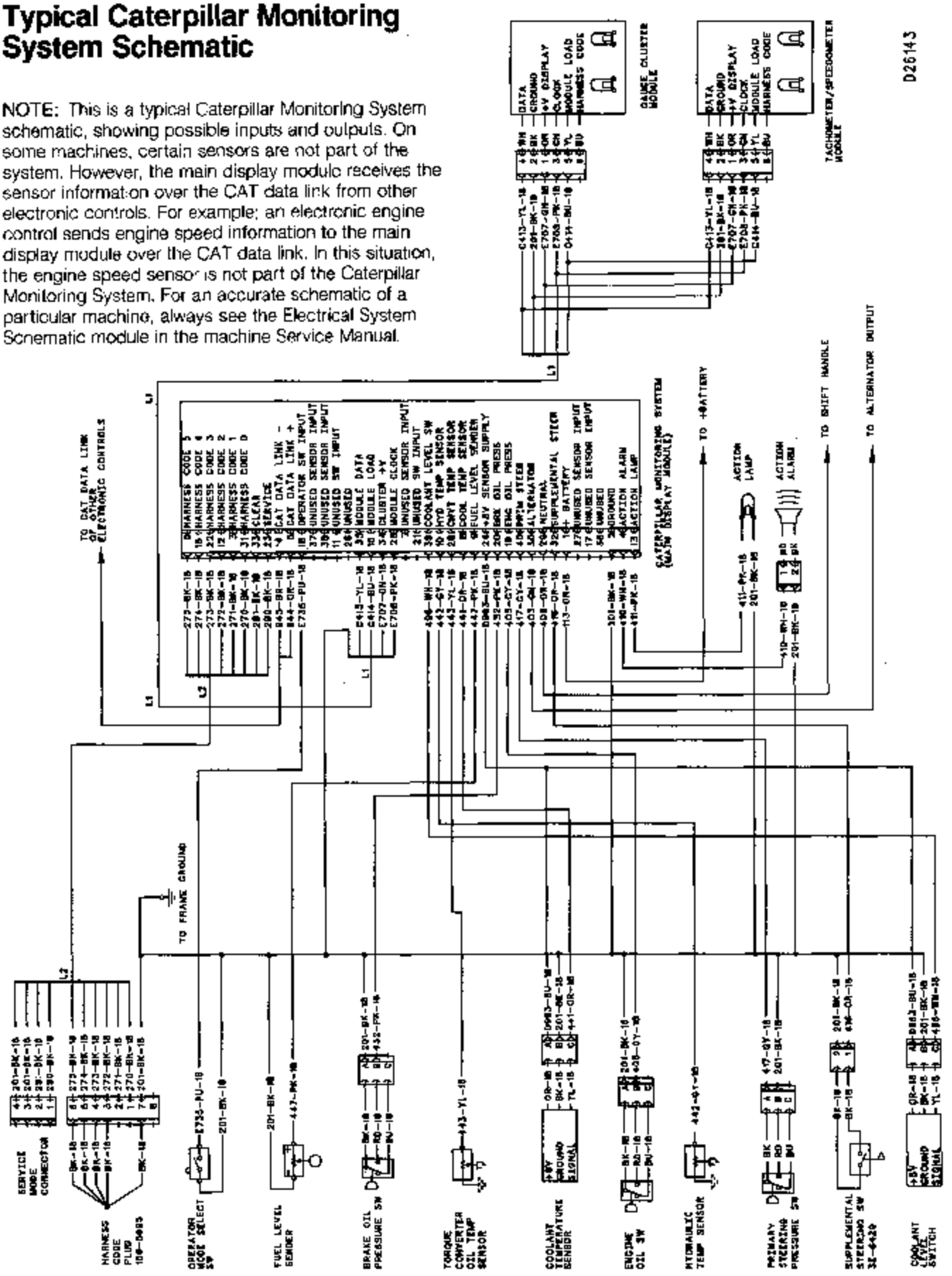
Undetected Fault – An undetected fault is a fault that exists and is not found by the main display module but is found by the operator or service person. The many diagnostic functions of the main display module assist with the troubleshooting of undetected faults.

Machine Code – The machine code is a two digit number that the main display module has assigned to a particular harness code for a particular machine. Each sales model has a specific harness code and therefore also a specific machine code.

Wring Out – Wring out refers to checking the continuity of a harness.

Typical Caterpillar Monitoring System Schematic

NOTE: This is a typical Caterpillar Monitoring System schematic, showing possible inputs and outputs. On some machines, certain sensors are not part of the system. However, the main display module receives the sensor information over the CAT data link from other electronic controls. For example; an electronic engine control sends engine speed information to the main display module over the CAT data link. In this situation, the engine speed sensor is not part of the Caterpillar Monitoring System. For an accurate schematic of a particular machine, always see the Electrical System Schematic module in the machine Service Manual.



CATERPILLAR®

SENR2947-01
May 1995

Systems Operation Testing & Adjusting

Starting and Charging Systems For Machines Equipped With Diagnostic Connector

Individual Circuit Description

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Introduction

The 6V-2150 Starting/Changing Analyzer Group works like a multi-channel voltmeter and reads out (displays) with a simple GO or NO GO indication.

It is used to troubleshoot the starting/changing system of all 24 Volt Caterpillar Earthmoving Machines Under the following conditions:

- Manufactured after July 1981.
- Equipped with automotive key type start.
- Equipped with diagnostic connector.

This new approach to troubleshooting makes it unnecessary to remove any machine sheet metal to find test points. The diagnostic connector is connected to the major test points of the machine starting/charging system, and is in an easily accessible location.

By using the 6V-2150 Analyzer Group with the diagnostic connector, this test operation can be done by one person, with no electrical experience.

Electrical experience may be necessary for replacement of a component.

The Analyzer can be used on All machines using the diagnostic connector.

Refer to the **Contents** section of this manual for the tool group usage.

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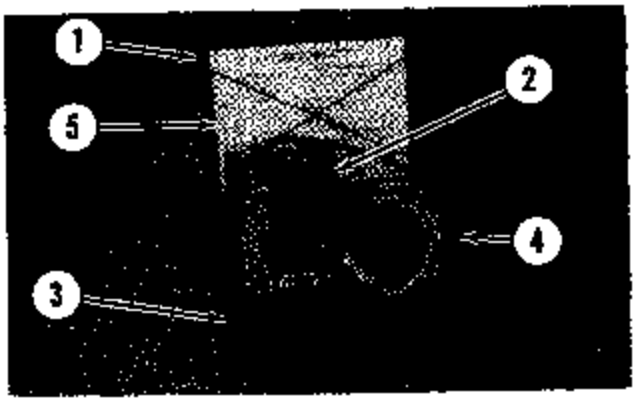
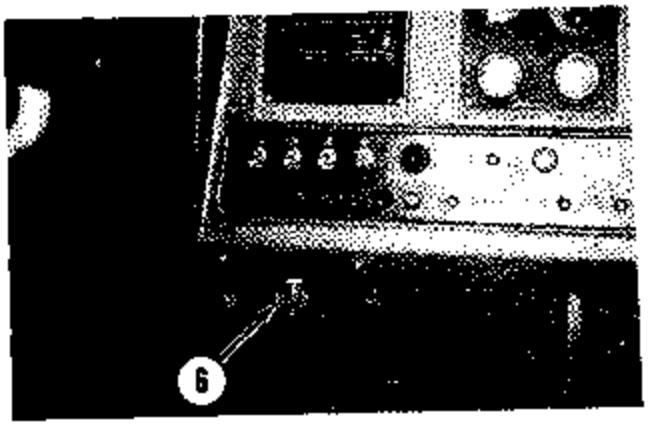
6V-2150 Starting/Charging Analyzer Group



1. 6V-3072 Case. 2. 6V-3112 Base. 3. 6V-4174 Packing Set. 4. 6V-3178 Cable Assembly. 5. SEES5548 Instruction.



6. Typical Location for the connector for the Starting/Charging Analyzer Group.

Features of the 6V-2150 Starting/Charging Analyzer Group

Adaptability: May be used on all 24 Volt Caterpillar earthmoving machines.

- Manufactured after July 1981.
- Equipped with automotive key type start.
- Equipped with a Diagnostic Connector.

Analyzer Connection: A plug from the 6V-2150 Analyzer fits into a diagnostic connector. This diagnostic connector is normally in the engine area, near the starter, but can also be inside the cab.

Operation: For a machine that will SELF START, less than five minutes are needed to connect the analyzer and make a complete test of the starting and charging system. More time will be needed to test a machine if it must be BOOST STARTED.

Power supply: Power to operate the analyzer comes through the diagnostic connector, from the vehicle electrical system.

Rugged: The design of the analyzer makes it possible to have good accuracy, in field service conditions.

Convenient: Analyzer operation is made easy since it is not necessary to:

- Remove any sheet metal.
- Look for components or test points in a circuit.
- Interpret (understand) a voltmeter reading.
- Have more than one person to test a machine.

Less Downtime: There will be less downtime since troubleshooting is made easier and faster. When used as part of PM or TA inspections, the analyzer can find marginal components (parts that have an unseen defect). Finding and correcting these defects early, can help to prevent future unscheduled downtime.

Specifications

Channels: The analyzer has fifteen channels (or readouts) that can check fifteen major components or circuits.

Accuracy: In field service conditions, this analyzer will keep and/or have the accuracy needed for diagnosis of failed or worn parts when used within the operating temperature range specification.

Temperature Range of Ambient Air During Analyzer Operation: Will maintain (keep) the needed accuracy from −18 to +60°C (0 to +140°F). The analyzer will operate outside this temperature range, but may not have the specified accuracy.

Temperature Range of Ambient Air During Analyzer Storage: −40 to 80°C (−40 to +176°F).

Power Required: 10 to 30 volts DC at approximately 250 mA using the 24 Volt vehicle electrical system as a source.

Cable Length: 5500 mm (217 in).

Operating Position: Any position.

Size:

Carrying Case: 394 x 311 x 102 mm (15.5 x 12.25 x 4 in)

Analyzer: 254 x 191 x 30 mm (10.0 x 7.5 x 1.18 in)

Weight:

Complete Group: 3.2 kg (7 lbs) Analyzer only: 1.8 kg (4 lbs)

Basic Operations

Sometimes the analyzer will give indication that a component, or components, has a defect, but the machine will start and seem to operate without any problems.

This normally indicates that the component (s) (including wiring harness and/or harness connectors) are at the point of being worn, and replacement is necessary.

Before making the component replacement, however, check for loose or corroded connectors in the circuit that shows a defect.

If replacement is still necessary, install the necessary new components to prevent any unexpected downtime for the machine.

NOTICE

Field service replacement of an original equipment wiring harness with wire of a different gauge can cause incorrect readings from the analyzer.

The complete test is made in the following four step procedure:

- Test Setup A–Hookup
- Test Step B–Crank
- Test Step C–Start Aid
- Test Step D–Hi Idle

Refer to *Analyzer Panel* in this manual

Test Setup A–Hookup

This is a test of the machine with the engine and all accessories at SHUT OFF, but with the key start switch in the ON position.

In this test step, the 6V-2150 Analyzer checks:

1. Batteries: Checks open circuit voltage as an indication of battery charge level.

2. Alternator Breaker: Checks for a tripped (activated) breaker.

3. Key Breaker: Checks for a tripped (activated) breaker.

4. Key Start Switch: Checks to find if the START half of the switch is OPEN.

5. Main Relay and/or Breaker: Checks for closed contacts on relay (if equipped) and that breaker (if equipped) is not activated.

6. Coolant Switch: Checks for a CLOSED coolant switch. [Switch will CLOSE at 27°C (80°F) during cool down. Switch will OPEN at 38°C (100°F) at warm-up.]

NOTE: It is possible that the machine does NOT have starting aid components.

7. Start Aid Switch/Solenoid: Checks to see if switch is OPEN, and/or if solenoid coil is NOT OPEN.

NOTE: For those machines that have dual (two) starter motors, Step(s) 8 and 9 that follow apply to both starter motors.

The #2 starter motor is always the attachment unless a dual starting system is standard equipment.

8. Start Relay: Checks to see if relay contacts are OPEN.

9. Starter Solenoid: Checks to see if solenoid contacts are OPEN.

NOTE: If all three lamps for #2 starter are OFF, it is an indication that the machine does NOT have a second starter motor.

Test Step B–Crank

Shut OFF the fuel supply to prevent the engine from starting during this step.

This step will activate all the cranking circuits so the 6V-2150 Analyzer can measure voltage, in relation to the components on circuits that follow, and checks:

1. Starter Ground Circuit: Checks for excessive voltage drop (voltage loss).

2. Batteries: Checks battery voltage, to see if it is within the expected range for cranking.

3. Alternator Breaker: Checks for excessive voltage drop, or for an activated breaker.

4. Key Breaker: Checks for excessive voltage drop, or for an activated breaker.

5. Key Start Switch: Checks for excessive voltage drop, or whether the switch and/or harness is OPEN.

6. Main Relay and/or Breaker: Checks for CLOSED relay contacts (if equipped) and that breaker (if equipped) is not activated.

7. Coolant Switch: Checks for CLOSED coolant switch. [Switch will CLOSE at 27°C (80°F) at cool down. Switch will OPEN at 38°C (100°F) at warm-up.]

NOTE: It is possible that the machine does NOT have starting aid components or may have an automatic starting aid system.

8. Start Aid Switch/Solenoid: Checks for OPEN switch and/or that solenoid coil is not an open circuit.

NOTE: If the machine has dual starter motors, Step(s) 9, 10 and 11 that follow apply to both starter motors.

9. Start Relay: Checks to see if the relay is CLOSED and if there is an excessive voltage drop across the contacts.

10. Starter Solenoid Power Circuit: Checks if there is excessive voltage drop in the solenoid power circuit.

11. Starter Solenoid: Checks to see if the solenoid contacts are CLOSED and if there is excessive voltage drop across the contacts.

Test Step C-Start Aid

NOTE: If the machine is NOT equipped with a START AID switch on the dash panel or has a 3500 Engine with an automatic ether injection system, it is NOT necessary to do Test Step C; proceed to *Test Step D-Hi Idle*.

If the machine IS EQUIPPED with a Start Aid switch on the dash panel, see the procedure that follows.

All lamp indications and test procedures are exactly the same as Test Step 1, UNTIL the Start Aid switch is pushed.

Then, the Analyzer measures voltages for the following components to check.

1. Coolant Switch: Checks if switch is CLOSED and if there is excessive voltage drop across the contacts.

2. Start Aid Switch/Solenoid: Checks if switch is now CLOSED and if there is excessive voltage drop across the contacts.

Test Step D-High Idle

All lamp indications and test procedures are exactly the same as *Test Setup A-Hookup* except as given here.

1. Alternator: This test measures battery voltage, to see if it is within the alternator charging limits.

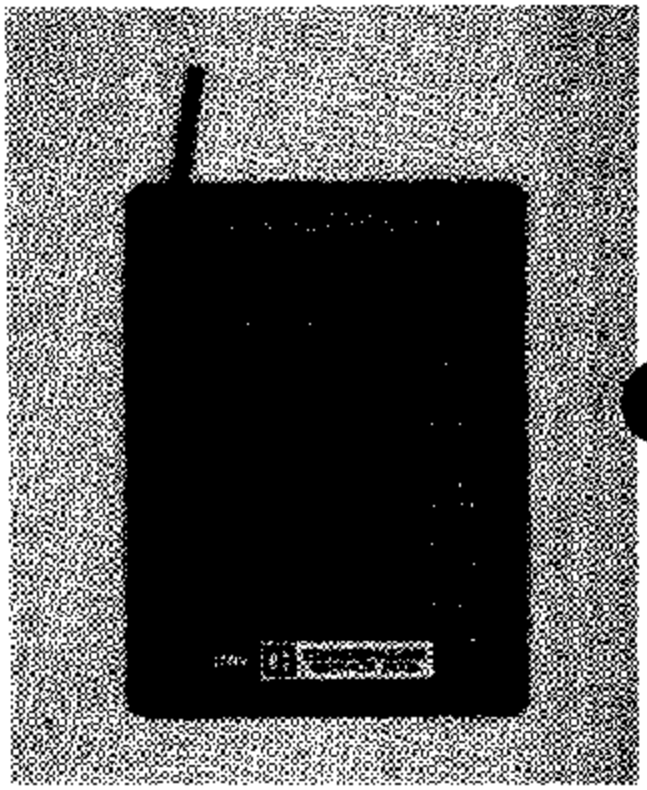
NOTE: Batteries sometimes need over two minutes to CHARGE up into this range, especially if the machine was jump started.

2. Main Relay and/or Breaker: If the alternator tests good, turn ON all electrical loads (lights, air conditioner, etc.). This will permit the analyzer to test for excessive voltage drop across the relay contacts and/or breaker (if equipped).

Alternator Breaker: Tests for excessive voltage drop across the breaker, caused by alternator charging current going through a defective breaker.

NOTE: Excessive alternator output voltage will completely SHUT OFF the analyzer. If, during Hi Idle, the alternator lamp comes ON normaly, goes OFF, and then the analyzer goes OFF (dead), alternator output is more than 30 volts, and this has put the analyzer in its safety SHUT-OFF position.

Analyzer Panel



Troubleshooting the 6V-2150 Starting/Charging Analyzer (During operation, if there is indication of a defect in the Analyzer).

If there is indication that the analyzer has a defect, the procedure that follows may possibly help to locate the problem.

1. Earlier repair or rework completed on the machine, such as engine removal, wiring harness replacement, etc., may be the cause of:

- Error in connection(s) of machine wiring harness.
- Error in wring of the diagnostic connector.

NOTE: When either of the above is thought to be the problem, use a 6V-3030 Digital Multimeter and refer to *Explanation of Analyzer Tests, in this manual, to troubleshoot the wiring from the Diagnostic Connector.*

2. If it is believed that the machine is wired correctly, but the analyzer still does NOT show the expected results, use another analyzer, one that is known to be good, and REPEAT the tests.

If the analyzer has a defect, refer to *Repair Information in this manual.*

Test of Machine That CANNOT Self-Start

To diagnose the problem(s) on a machine that has dead batteries, use the procedure that follows.

1. Connect the batteries of the DEAD machine to the batteries of the boost start machine.

NOTE: Refer to the *Boost Starting Procedure* in the Operation & Maintenance Manual for the machine that is to have the boost start.

2. Connect the 6V-2150 Analyzer to the Diagnostic Connector.

3. Complete analyzer Test Setup A–Hookup, Test Step B–Crank, and Test Step C–Start Aid to obtain the necessary diagnosis.

4. Start the engine of the DEAD machine, then disconnect the boost machine batteries, according to the *Boost Starting Procedure* in the *Operation & Maintenance Manual* for the machine that was boost started.

5. Complete *Test Step D-Hi Idle* to obtain the necessary diagnosis.

If the voltage of the former dead batteries starts to increase and the ALTERNATOR lamp comes ON, this indicates correct alternator operation; STOP the engine and REPEAT steps *Test Setup A–Hookup, Test Step B–Crank, Test Step C–Start Aid,* and *Test Step D–Hi Idle* to obtain the diagnosis of defect, according to test results.

NOTE: It is possible that the analyzer lamps for STARTER GROUND CIRCUIT, BATTERIES and ALTERNATOR will not give a correct indication while the boost machine batteries are connected to the dead machine.

Test For Machines That are Equipped with a 3208 Engine

The fuel system on 3208 Engines (613C) does NOT have a mechanical shutoff. These engines have an electrically operated shutoff solenoid on the fuel pump housing.

The electrically operated shutoff solenoid is AUTOMATICALLY activated for approximately 30 seconds (older models are seventy seconds), when the key start switch is turned to the OFF position.

To keep the engine from starting during *Test Step B-Crank,* use the following procedure.

1. Use a piece of 14 GA, 16 GA or 18 GA electrical wire approximately 2000 mm (79 in) long (preferably fused for 10 Amps) to make a jumper wire.

Install a #63 Mueller (or equivalent) clip on one end, and a Mueller 46-A (or equivalent) battery clip on the other end of the wire.

2. Connect the jumper wire from the MOTOR terminal of the starter solenoid, to the BATTERY terminal of the shutoff solenoid.

NOTE: The jumper wire will activate the shutoff solenoid ONLY while cranking and PREVENT the engine from starting during *Test Step B-Crank.*

NOTICE

Check starter cycle: Thirty seconds of cranking requires two minutes to cool.

Do NOT connect the shutdown solenoid directly to 24 volts. Coil damage MAY result.

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3. Connect the 6V-2150 Analyzer to the Diagnostic Connector, and complete steps *Test Setup A–Hookup, Test Step B–Crank,* and *Test Step C–Start Aid.* Use the test results for diagnostics of any machine problems.

4. Disconnect the jumper wire, and complete Test Step D–Hi Idle.

Test For Machines That Are Equipped With Energize-To-Run Fuel Shutoff Solenoids (Other Than 3208 Engines)

The fuel system on some of the later engines do NOT have a mechanical fuel shutoff. These engines have an electrically operated energize-to-run solenoid.

To prevent the engine from starting during Test Step B-Crank, disconnect the blue wire at the fuel solenoid on the fuel pump. Insulate the wire.

Be sure that the wire does NOT touch the chassis while performing the tests. If the solenoid connects through a 2 Pin connector, disconnect the connector.

NOTICE

Observe starter cranking cycle: Thirty seconds cranking time requires a two minute cool down time.

Connect the 6V-2150 Starting/Charging Analyzer to the Diagnostic Connector and complete Step(s) *Test Setup A–Hookup*, *Test Step B–Crank*, and *Test Step C–Start Aid*.

Reconnect the blue wire to the solenoid or connector and complete Test Step D–Hi Idle.

Explanation of Analyzer Tests

NOTE: All voltages listed in this manual are in volts direct current (DC).

With two exceptions, the basic schematic that follows is typical of all Caterpillar machines that have a Diagnostic Connector. The two exceptions are as follows.

1. Not all of the machines will be equipped with all of the components that are shown on the schematic (such as start aid, main relay, two starter motors, etc.).

If any of the components shown in the schematic are on a machine, the wire connections for those components will be the same as the wiring connections shown on this schematic.

2. Harness connectors, such as those used to connect to a cab, etc., are NOT shown on the schematic.

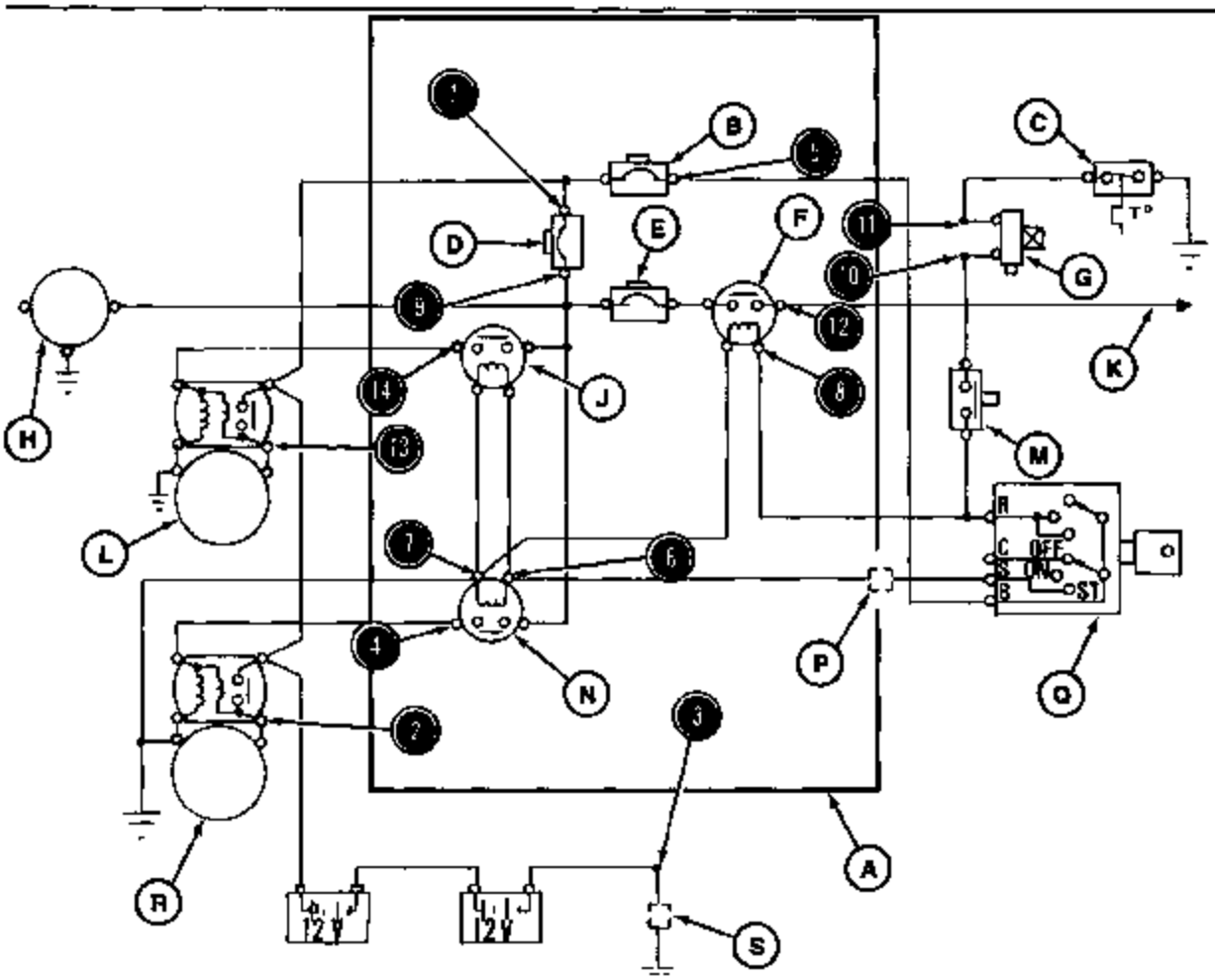
Although the connectors are not shown, they must be considered as a possible problem area when troubleshooting for machine defects since, many times, the analyzer tests include those connectors.

Make a comparison of this basic schematic with the wiring diagram of the machine that is to be tested, to determine which connectors and wiring harnesses are within the test points of the analyzer test step that is being conducted.

NOTE: All test point numbers on the schematic are the same as the numbers of the pins on the diagnostic connector. As an example, Test Point 1 on the schematic is Pin 1 on the connector.

In the topics that follow, a basic machine shows in detail each circuit test that is made by the 6V-2150 Starting/Charging Analyzer. The schematic with each topic shows only the circuit for that part of the test.

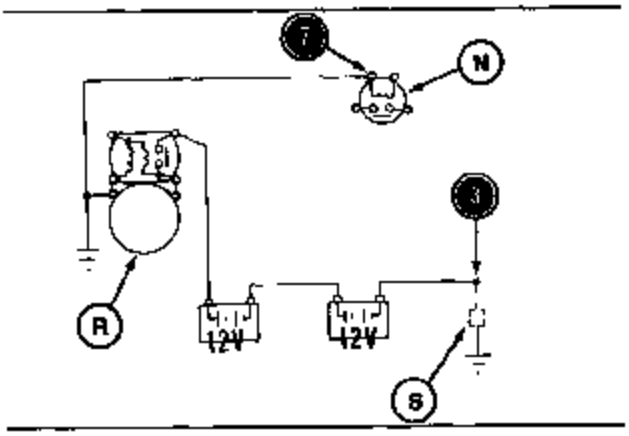
To see how the basic machine schematic is actually wired on the machine under test, reference must always be made to the vehicle wiring diagram.



A. Breaker/Relay Enclosure. B. Key Breaker. C. Coolant Switch. D. Alternator Breaker. E. Main Breaker. F. Main Relay. G. Start Aid Solenoid. H. Alternator. J. Start Relay #2. K. To Vehicle Loads. L. Starter Motor #2 (possibly an attachment). M. Start Aid Switch. N. Start Relay #1. P. Start Inhibit Switch(s) (if equipped). Q. Key Start Switch. R. Starter Motor #1. S. Disconnect Switch (if equipped).

NOTE: Test point location numbers (1) through (14) on the schematic are the same as the numbers of the diagnostic connector pins.

Starter Ground Circuit



Specification:

This test measures the voltage drop in the ground lead of starter (R), between Test Points (7) (positive) and (3) (negative).

A voltage drop between these two test points of more than 1.30 ± 0.15 volts causes the STARTER GROUND CIRCUIT lamp to come ON and indicate a defect.

A defect can be indicated only during Test Step B-Crank.

This condition may be caused by:

- A disconnect switch with excessive voltage drop.
- Cable to frame connections with excessive voltage drop.

If the machine being tested has a disconnect switch(s), it will also be tested as part of the starter ground circuit.

Other Circuit Information:

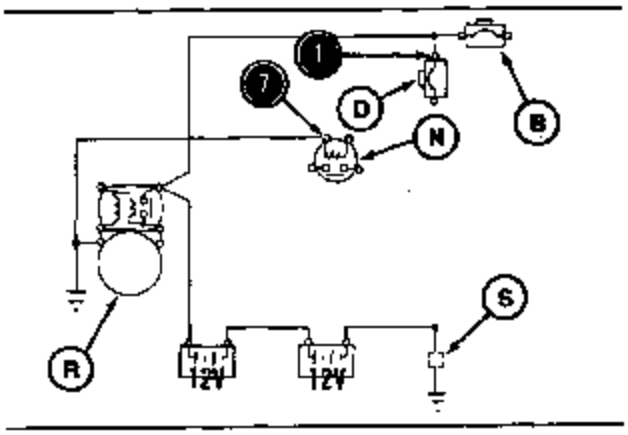
There are three ways that a starter ground circuit may be wired:

1. A single cable from the negative battery terminal, directly to the starter negative post. With this design, test point (3) is tied to test point (7), and the analyzer does NOT make a check of voltage drop. (Disconnect switch is not used).

2. In the second way, a disconnect switch will be found in the ground cable between the negative battery terminal and the negative starter terminal. The analyzer checks the disconnect switch and the disconnect switch-to-starter cable.

3. In the third way, the negative starter terminal is jumped to the frame, and the negative battery terminal is jumped to the frame, but in a different location. This type of hookup (connection) is CHECKED by the analyzer and typically includes a disconnect switch which the analyzer ALSO checks. Most often, cleaning cable-to-frame connections will correct this type of defect.

Batteries



Specification:

This test measures the TERMINAL voltage of the batteries, between test point (1) (positive) and test point (7) (negative).

At *Test Setup A-Hookup*, a voltage drop between these two test points below 23.10 ± 0.15 volts will cause the BATTERIES lamp to come ON and indicate a low state of charge.

In this condition, the batteries will not have enough power to crank the engine. A defect can be indicated during any Test Step.

This condition may be caused by:

- No alternator output.
- Worn out batteries that will not hold a charge.
- Light or accessory was left ON, with machine shut down, and this discharged batteries.

Specification:

During engine cranking, it is normal for the battery voltage to go below 23.1 volts and so the BATTERIES lamp will come ON.

However, if the battery voltage then goes below 12.50 ± 0.15 volts, the batteries will probably have cranked the engine only momentarily, and the BATTERIES lamp will go OFF to indicate very low voltage.

This condition may be caused by:

- Batteries (refer to *Specification* above).
- Starter motor (check for defect).
- Excessive engine drag or friction that will cause more power than normal to be used from the batteries.

Other Circuit Information:

To find which of the defects is the real cause of the problem, check the following:

No Alternator Output:

Boost start the machine to check alternator output.

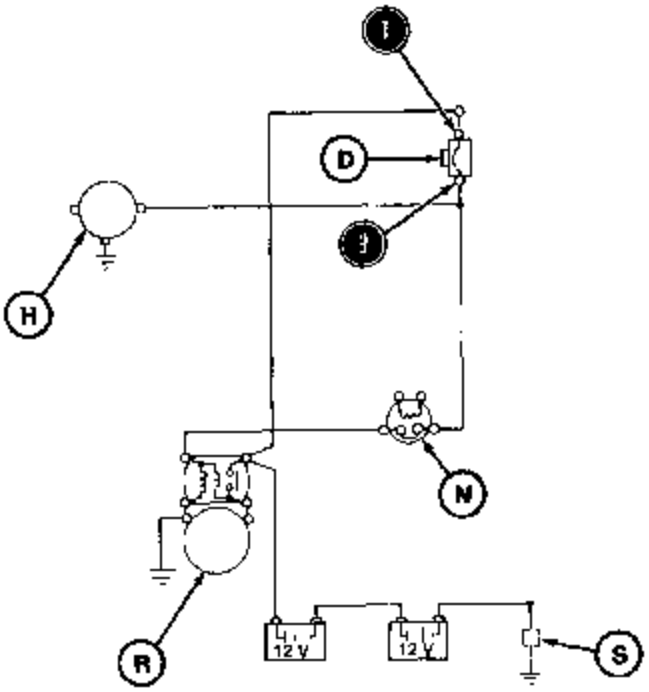
Refer to *Test Step D-Hi Idle.*

If the alternator is operating correctly, check, charge and/or replace batteries as necessary.

Refer to SEHS7633 .. *Battery Test Procedure* and than REPEAT the test with the 6V-2150 Analyzer

NOTE: Refer to the *Boost Starting Procedure* in the Operation & Maintenance Manual for the machine that is to have the boost start.

Alternator Breaker



Specification:

This test measures a voltage drop of either polarity across the alternator breaker between test point (1) and test point (9).

A voltage drop between these two test points of more than 0.45 ± 0.15 volts causes the ALTERNATOR BREAKER lamp to come ON and indicate a defect.

A defect may be indicated during any Test Step.

This condition may be caused by:

- Activated (tripped) breaker.
- Closed breaker with excessive voltage drop.

Other Circuit Information:

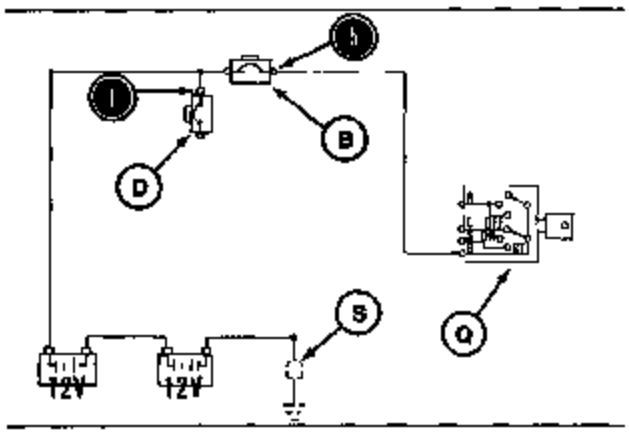
In the Step(s) *Test Setup A-Hookup*, *Test Step B-Crank*, and *Test Step C-Start Aid*, test point (1) will be positive and test point (9) will be negative since the battery is sourcing current through alternator breaker (D) to the cranking circuits.

During the *Test Step D-Hi Idle*, the voltage at Test Points (1) and (9) will have reverse polarity [test point (1) will be negative and test point (9) will be positive] since the battery is receiving current through alternator breaker (D) from alternator (H).

The batteries CANNOT get a full charge if the charging circuit has excessive voltage drop.

High charging current may cause the ALTERNATOR BREAKER lamp to blink or stay ON for a few seconds ONLY at engine startup, and then turn OFF before the ALTERNATOR lamp comes ON. This condition is acceptable.

Key Breaker



Specification:

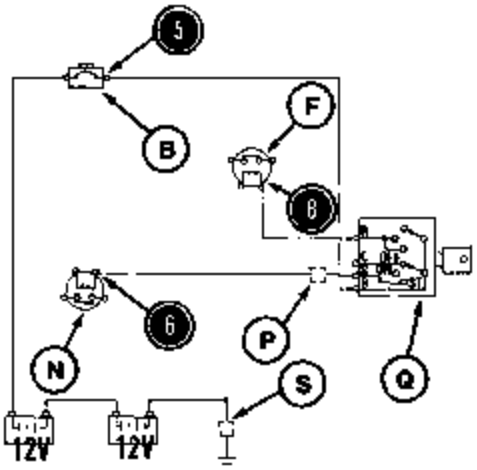
This test measures the voltage drop across the key breaker between test point (1) (positive) and test point (5) (negative).

A voltage drop between these two test points of more than 0.75 ± 0.15 volts causes the KEY BREAKER lamp to come ON and indicate a defect. A defect may be indicated during any Test Step.

This condition may be caused by:

- Activated (tripped) breaker.
- Closed breaker with excessive voltage drop.

Key Start Switch



Specification:

This test measures the voltage drop across both poles (switches) of the key start switch.

The voltage drop between Test Points (5) (positive) and (6) (negative) represents the STAR pole.

The voltage drop between test point (5) (positive) and (8) (negative) represents the RELAY pole.

A voltage drop between **EITHER** or **BOTH** of those two sets of test points more than 2.50 ± 0.15 volts causes the KEY START SWITCH lamp to come ON and indicate a defect. A defect may be indicated during any Test Step.

This Condition May Be Caused By:

- Open switch (pole).
- Closed switches, with excessive voltage drop.
- Switch (pole) with welded contacts.

NOTE: Start position of this switch is OPEN during *Test Setup A–Hookup, Test Step C–Start Aid,* and *Test Step D–Hi Idle* so it is correct when the KEY START SWITCH lamp is ON during these test steps.

Other Circuit Information:

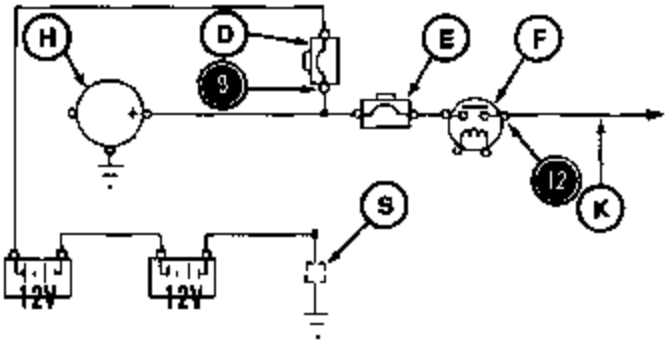
On machines that fail the *Key Start Switch* test during *Test Step B–Crank* (lamp is ON), the defect may be in any *Start Inhibit Switch* (such as the *Neutral Start Switch* on direct drive machines) instead of the *Key Start Switch.*

Start inhibit switches (P) are always installed between Test Points (5) and (6), and become part of the test for the *Key Start Switch.*

The wiring harness and the wiring harness connections are also checked in this test.

Refer to the machine's Wiring Schematic for location of these components, since an OPEN harness will show as a defect.

Main Relay and/or Breaker



Specification:

This test measures the voltage drop across the main relay and/or breaker between test point (9) (positive) and test point (12) (negative).

A voltage drop between these two test points of more than 1.30 ± 0.15 volts causes the MAIN RELAY and/or BREAKER lamp to come ON and indicate a defect. A defect may be indicated during any Test Step.

This condition may be caused by:

- Activated (tripped) breaker.
- Closed breaker with excessive voltage drop.
- Open relay contact, caused by burned contacts/open relay coil.
- Closed relay with excessive voltage drop.
- Relay with welded contacts.

NOTE: If a machine fails this test, it will be necessary to find which of the two components has the defect.

To find the defective part, use a 6V-3030 Digital Multimeter to check for excessive voltage drop across each component [main relay (F) and main breaker (E)].

Troubleshoot with the 6V-3030 Digital Multimeter under the exact conditions (Test Step) that caused the analyzer to show the fault.

Other Circuit Information:

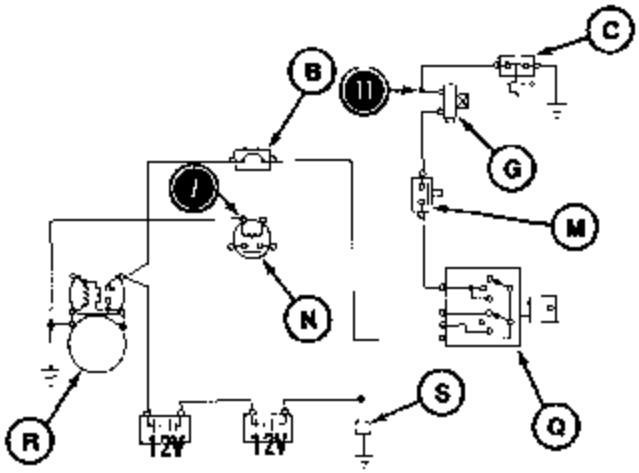
It is possible that a specific machine has both of these components, or does not have either one of them.

On machines that do not have either of these components, test point (12) is tied (connected) directly to test point (9) and will never indicate a defect on the analyzer.

On machines that do have either, or both, a MAIN RELAY and MAIN BREAKER, replace defective components as necessary.

Refer to the machine's wiring diagram to determine which components are used in the electrical system under test.

Coolant Switch



Specification:

This test measures the voltage drop across the coolant test point (11) (positive) and test point (7) (negative).

A voltage drop between these two test points of more than 1.30 ± 0.15 volts, causes the COOLANT SWITCH lamp to come ON and indicate a defect. A defect may be indicated during any Test Step.

This condition may be caused by:

- Open switch.
- Closed switch with excessive voltage drop.

• Switch with welded contacts (indicated by COOLANT SWITCH lamp OFF when coolant is above 38°C (100°F).

Other Circuit Information:

The coolant switch will OPEN when engine coolant temperature reaches 38°C (100°F).

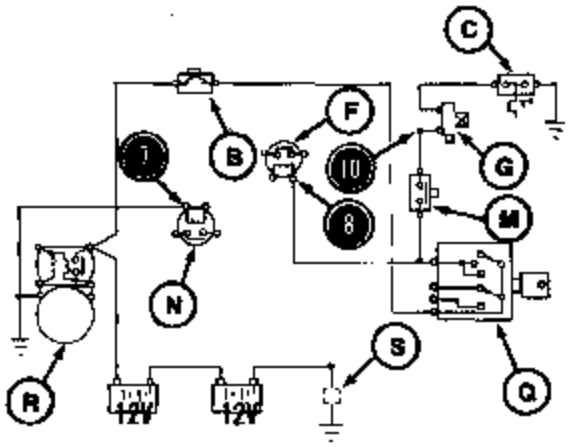
This switch prevents the use of a starting aid in a warm engine. Use of a starting aid in a warm engine may cause possible damage.

For this test to be valid, engine coolant must be below the 38°C (100°F) temperature.

In the case of a warm engine, it must first cool down to 27°C (80°F) to CLOSE the coolant switch.

The coolant switch will CLOSE when engine coolant temperature falls to 27°C (80°F) during engine cool down.

Start Aid Switch/Solenoid



Specification:

This test measures the:

• Voltage drop across the start aid switch between test point (8) (positive) and test point (10) (negative).

A voltage drop between these two test points of more than 2.5 ± 0.15 volts causes the START AID SWITCH/SOLENOID lamp to stay OFF and indicate a defect. A defect may be indicated during any Test Step.

• Resistance of the solenoid coil circuit between test point (10) and test point (7).

A resistance between these two test points of less than 300 Ohms will cause the START AID SWITCH/SOLENOID lamp to stay OFF.

A resistance between these two points of more than 3600 Ohms will cause the START AID SWITCH/SOLENOID lamp to come ON and indicate a defect. A defect may be indicated during the Test Setup A–Hookup, Test Step B–Crank, and Test Step D–Hi Idle tests.

This condition may be caused by:

Start Aid Switch:

• Open switch.

• Closed switch with excessive voltage drop.

• Switch with welded contacts.

Solenoid Coil Circuit:

• Open solenoid coil.

Other Circuit Information:

If the START AID SWITCH/SOLENOID lamp is ON and the START AID SWITCH is not activated, it is possible that the switch has a defect (welded contacts), or the START AID SOLENOID and/or harness may be OPEN.

Disconnect the 6V-2150 Analyzer and use a 6V-3030 Digital Multimeter to check continuity from test point (10) to test point (7), or the machine frame.

If resistance from test point (10) to test point (7) is less than approximately 8 Ohms, it is probable that the switch has a defect.

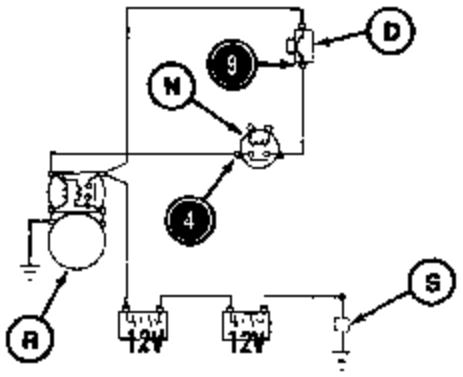
If the solenoid coil is OPEN, it is possible that switch failure (welded contacts) is the cause of solenoid coil failure.

This test includes the harness and the harness connectors. A defect in any of these parts will also cause the 6V-2150 Analyzer to indicate a START AID SWITCH/SOLENOID defect.

Refer to the machine's wiring diagram for more information.

NOTE: Engine coolant must be below 38°C (100°F) to perform this test [or 27°C (80°F) on engine cool down].

Start Relay (Starter No. 1)



Specification:

This test measures the voltage drop across the start relay contacts between Test Points (9) (positive) and test point (4) (negative).

A voltage drop between these two test points of more than 0.45 ± 0.15 volts, causes the START RELAY lamp to come ON and indicate a defect. A defect may be indicated during any Test Step, but most often in the *Test Step B–Crank Test.*

This condition may be caused by:

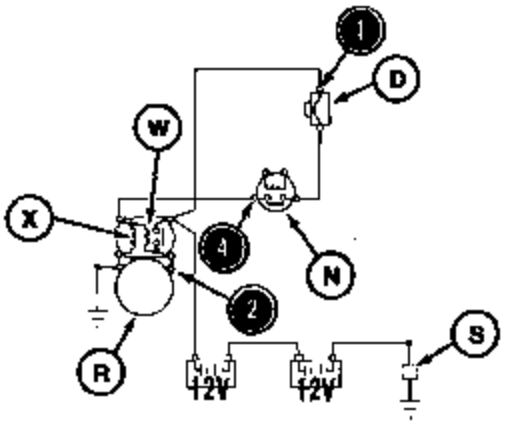
Open Relay Contacts:

- Caused by burned contacts/open relay coils.

Closed Relay Contact:

- With excessive voltage drop.

Starter Solenoid Power Circuit (Starter No. 1)



Specification:

This test measures the voltage drop across the starter solenoid PULL-IN coil (W) between test point (2) (positive) and test point (4) (negative).

A voltage drop between these two test points of more than 1.00 ± 0.15 volts causes the STARTER SOLENOID POWER CIRCUIT lamp to come ON and indicate a defect. A defect may be indicated ONLY during Test Step B–Crank test.

This condition may be caused by:

- Alternator breaker with excessive voltage drop (but may be in specification for the alternator breaker test alone).

- Start relay with excessive voltage drop (but may be in specification for the start relay test alone).

Other Circuit Information:

The starter solenoid has two coils. PULL-IN coil (W) and HOLD-IN coil (X).

The instant that start relay (N) closes, both coils (W and X) receive power

Battery voltage is applied to the HIGH end of both coils, at test point (4).

The LOW end of the HOLD-IN coil (X) is permanently grounded to the ground post of the starter motor.

Grounding for the LOW end, test point (2), of PULL-IN coil (W) is momentary, and takes place through the DC resistance of the starter motor.

As soon as magnetic force builds in both coils, the solenoid contacts close. This removes the temporary ground from PULL-IN coil (W), and puts battery voltage on both ends.

The instant that START RELAY (N) closes, HOLD-IN coil (X) gives assistance to PULL-IN coil (W). Together, they pull the solenoid switch CLOSED.

After this switch closes (during cranking), PULL-IN coil (W) is, basically, out of the circuit since battery voltage appears on both ends of the coil. This means the voltage across the PULL-IN coil is nearly zero (0). If Test Point (4) becomes MORE negative than Test Point (2) (By 1.0 or more volts), current will then flow BACKWARDS through the PULL-IN COIL and CAUSE the solenoid to DROP OUT (RELEASE).

As soon as it does, test point (2) will again ground the PULL-IN coil. Unless this problem is found, it will occur several times each second, and cause the starter solenoid contacts to burn to an OPEN condition.

Replacement of the solenoid will put the machine back to work, but the problem is NOT resolved and the machine will soon be down again.

Resolving the Problem

The voltage drop, during cranking, is greater from test point (1) to test point (4) than the voltage drop from test point (1) to test point (2).

Even if the analyzer shows that alternator breaker (D) and start relay (N) are within specifications, replacement of one, or both components can reduce the voltage drop enough, between test point (1) to test point (4), to be acceptable.

The harness and harness connectors can also have an effect on this circuit test.

Refer to the machine's wiring diagram for further information.

To indicate acceptable limits, the lamp for STARTER SOLENOID POWER CIRCUIT must be OFF.

For this test, the analyzer measures the voltage drop (ΔV) between test point (2) and test point (4) [using test point (1) as a reference]; that is, it looks at the result of the subtraction:

$V_2 - V_4 = \Delta V$

Or shown another way:

[voltage drop from test point (1) to test point (2)] −[voltage drop from test point (1) to test point (4)] = ΔV

If the result ΔV is greater than + 1.0 volts (disregard any negative result), the STARTER SOLENOID POWER CIRCUIT lamp comes ON and indicates a defect.

The voltage at V_2 is sourced through the starter solenoid contacts. The contacts of a good starter solenoid will typically produce a voltage drop of no more than 0.6 volts.

This voltage represents V_2 and assumes that no harness connections or wiring add any significant voltage drops.

When energized, if the voltage supplied the test loop [measured at test point (1)] is 24.0 volts, V_2 would be 23.4 volts.

The voltage at test point (4) is sourced [from test point (1)] through the alternator breaker (D) and the start relay (N).

The contacts of a good alternator breaker, or a good start relay, will typically produce a voltage drop no more than 0.4 volts each.

When taken in combination, then the typical maximum voltage drop from test point (1) to (4) is no more than 0.80 volts:

0.4 + 0.4 = 0.8 volts

This voltage represents V_4 and assumes that no harness connectors or wiring add any significant voltage drops. When energized, the voltage then at V_4 would be 23.2 volts.

For the typical system then:

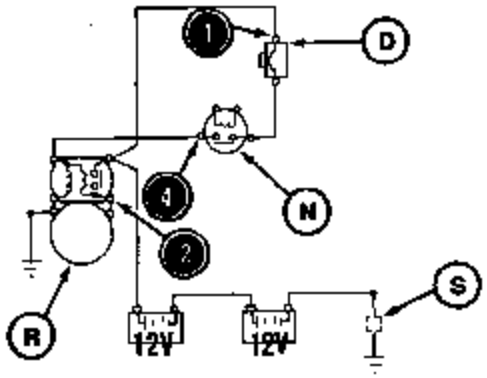
$\Delta V = V_2 - V_4 = 23.4 - 23.2 = +0.2$ volts

Any negative result in this equation is very satisfactory and the STARTER SOLENOID POWER CIRCUIT lamp remains OFF.

If, however, the voltage drop across the alternator breaker, starter relay, and associated wiring produced a voltage drop that was greater than 0.8 volts such that V_4 was made smaller (less than 22.6 volts):

ΔV could become greater than 1.00 and the STARTER SOLENOID POWER CIRCUIT lamp would come ON and indicate a defect.

Starter Solenoid (Starter No. 1)



Specification:

This test measures the voltage drop across the starter solenoid contacts between test point (1) (positive) and test point (2) (negative).

A voltage drop between these two test points of more than 0.75 ± 0.15 volts causes the STARTER SOLENOID lamp to come ON and indicate a defect.

A defect may be indicated during any Test Step but most often during the Test Step B–Crankin test..

This condition may be caused by:

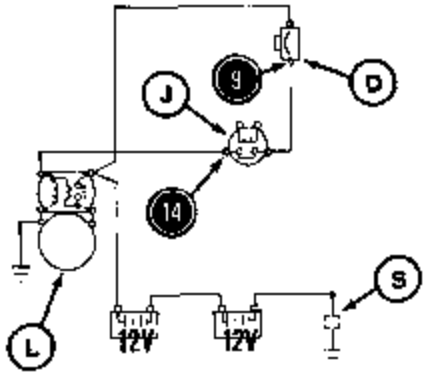
- Open solenoid contacts, caused by burned contacts/open solenoid coil.
- Closed solenoid contacts with excessive voltage drop.

Other Circuit Information:

An open wire from test point (4) to the starter solenoid will also give an indication of a defective solenoid.

Refer to the machine's wiring diagram for further information.

Start Relay (Starter No. 2)



Specification:

This test measures the voltage drop across the starter relay contacts between test point (9) (positive) and test point (14) (negative).

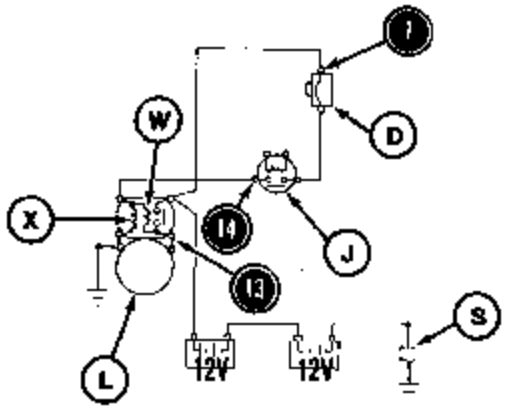
A voltage drop between these two test points of more than 0.45 ± 0.15 volts causes the START RELAY lamp to come ON and indicate a defect.

A defect may be indicated during any Test Step but most often during the Test Step B–Crank Test.

This condition may be caused by:

- Open relay contacts, caused by burned contacts/open relay coil.
- A closed relay, with excessive voltage drop.

Starter Solenoid Power Circuit (Starter No. 2)



Specification:

This test measures the voltage drop across PULL-IN Coil (W) between test point (13) (positive) and test point (14) (negative).

A voltage drop between these two test points of more than 1.00 ± 0.15 volts causes the STARTER SOLENOID POWER CIRCUIT lamp to come ON and indicate a defect. A defect may be indicated only during the Test Step B–Crank Test.

This condition may be caused by:

- Alternator breaker with excessive voltage drop (but may be in specification for the alternator breaker test alone).

- Start relay with excessive voltage drop (but may be in specification for the start relay test alone).

Other Circuit Information:

The starter solenoid has two coils, PULL-IN coil (W) and HOLD-IN coil (X).

The instant that start relay (J) closes, both coils (W and X) receive power.

Battery voltage is applied to the HIGH end of both coils, at test point (14).

The LOW end of HOLD-IN coil (X) is permanently grounded to the ground post of the starter motor.

Grounding for the LOW end, test point (13), of PULL-IN coil (W) is momentary and takes place through the DC resistance of the starter motor.

As soon as magnetic force builds up in both coils, the solenoid contacts close. This removes the temporary ground from PULL-IN coil (W), and puts battery voltage on both ends.

The instant that START RELAY (J) closes, HOLD-IN coil (X) gives assistance to PULL-IN coil (W). Together they pull the solenoid switch CLOSED.

After this switch closes (during cranking), PULL-IN coil (W) is, basically, out of the circuit since battery voltage appears on both ends of the coil. This means the voltage across the PULL-IN coil is nearly zero (0).

IF Test Point (14) becomes MORE Negative than Test Point (13) (By 1.0 or more volts), current will then flow BACKWARD through the PULL-IN COIL and cause the solenoid to drop OUT (RELEASE).

As soon as it does, test point (13) will again ground the PULL-IN coil. Unless this problem is located, it will continue several times each second, and cause the starter solenoid contacts to burn to an OPEN condition.

Replacement of the solenoid will put the machine back to work, but the problem is not resolved, and the machine will soon be down again.

Resolving the Problem

The voltage drop, during cranking, is greater from test point (1) to test point (14) than the voltage drop from test point (1) to test point (13).

Even if the analyzer shows that alternator breaker (D) and start relay (J) are within specifications, replacement of one, or both components may reduce the voltage drop enough, between test point (1) and test point (14), to be acceptable.

The harness and harness connectors may also have an effect on this circuit test.

Refer to the machine's wiring diagram for further information.

To indicate acceptable limits, the amp for STARTER SOLENOID POWER CIRCUIT must be OFF.

For this test, the analyzer measures the voltage drop (ΔV) between test point (13) and test point (14) (using test point (1) as a reference); that is, it looks at the result of the subtraction:

$V_2 - V_4 = \Delta V$

Or shown another way:

[voltage drop from test point (1) to test point (13)] – [voltage drop from test point (1) to test point (14)] = ΔV.

If the result ΔV is greater than 1.0 volts (disregard any negative result), the STARTER SOLENOID POWER CIRCUIT lamp comes ON and indicates a defect.

The voltage at V_2 is sourced through the starter solenoid contacts.

The contacts of a good starter solenoid will typically produce a voltage drop of no more than 0.6 volts.

This voltage represents V_2 and assumes that no harness connections or wiring add any significant voltage drops.

When energized, if the voltage supplied the test loop [measured at test point (1)] is 24.0 volts, V_2 would then be 23.4 volts.

The voltage at test point (14) is sourced [from test point (1)] through the alternator breaker and the start relay (J).

The contacts of a good alternator breaker, or a good start relay, will typically produce a voltage drop no more than 0.4 volts each.

When taken in combination, then the typical maximum voltage drop from test point (1) to (14) is no more than 0.8 volts:

(0.4 + 0.4 = 0.80 volts).

This voltage represents V_4 and assumes that no harness connectors or wiring add any significant voltage drops. When energized, the voltage then at V_4 would be 23.2 volts.

For the typical system then:

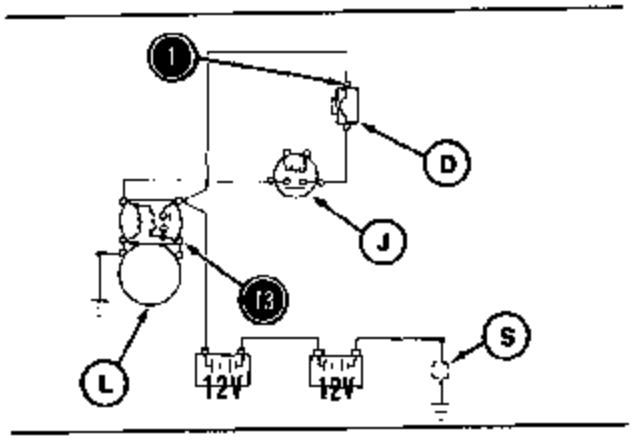
$\Delta V = V_2 - V_4 = 23.4 - 23.2 = +0.2$ volts

Any negative result in this equation is very satisfactory and the STARTER SOLENOID POWER CIRCUIT lamp remains OFF.

If, however, the voltage drop across the alternator breaker, starter relay, and associated wiring produced a voltage that was greater than 0.8 volts such that V_4 was made smaller (less than 22.6 volts):

ΔV could become greater than 1.00 and the STARTER SOLENOID POWER CIRCUIT lamp would come ON and indicate a defect.

Starter Solenoid (Starter No. 2)



Specification:

This test measures the voltage drop across the starter solenoid contacts between test point (1) (positive) and test point (13) (negative).

A voltage drop between these two test points of more than 0.75 ± 0.15 volts causes the STARTER SOLENOID lamp to come ON and indicate a defect.

A defect may be indicated during any Test Step but most often during the Test Step B–Crank test.

This condition may be caused by:

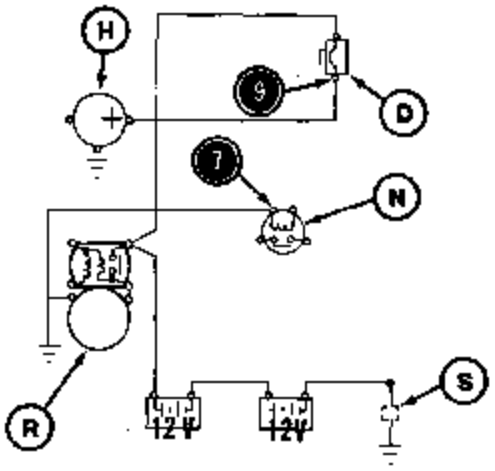
- Open solenoid contacts, caused by burned contacts/open solenoid coil.
- Closed solenoid contacts with excessive voltage drop

Other Circuit Information:

An open wire from test point (4) to the starter solenoid will also give an indication of a defective solenoid.

Refer to the machine's wiring diagram for further information.

Alternator



Specification:

This test measures the alternator output voltage between test point (9) (positive) and test point (7) (negative).

A voltage between these two test points of:

LESS Than 26.2 ± 0.15 volts

A voltage between these two test points of LESS than 26.2 ± .15 volts causes the ALTERNATOR lamp to stay OFF and indicate a defect (undercharge).

Undercharge is indicated when the ALTERNATOR lamp does not come ON after a minimum wait of two minutes.

MORE Than 28.9 ± 0.15 volts

A voltage between these two test points of MORE than 28.9 ± 0.15 volts causes the ALTERNATOR lamp to be OFF (after first being ON) and indicates a defective (overcharge).

Overcharge is indicated when the ALTERNATOR lamp comes ON shortly (less than one minute) after engine start up and then goes back OFF (may require ten or more minutes).

Correct alternator operation causes the ALTERNATOR lamp to be ON, and stay ON, with the engine at high idle.

This condition may be caused by :

Undercharge:

- Loose fan/alternator belts.
- Starter-to-engine block ground cable damaged, loose or missing.
- Defective alternator (or regulator which is internal to alternator).
- Defective batteries (will not accept a charge).

Refer to SEHS7633 .. *Battery Test Procedure.*

Overcharge:

- Alternator.

Other Circuit Information:

Undercharge

A marginal alternator (or sometimes batteries) is indicated when the ALTERNATOR lamp comes ON, but when all electrical loads (lights, heater, fans) are turned ON, the ALTERNATOR lamp goes back OFF, and stays OFF.

When such a condition exists use a 6V-4910 AC/DC Clamp On Ammeter to verify correct alternator output amperage.

For alternator output, refer to the Service Manual for the machine under test, or REGO1174 .. *Specifications Electrical Components.*

Overcharge

A severe overcharge may cause an alternator output so high (over 30 volts) that the 6V-2150 Analyzer goes into its safety shut down mode, indicated when all analyzer lamps go OFF.

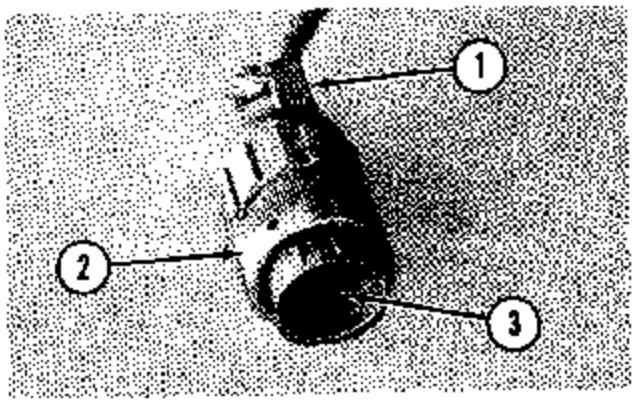
Overcharge may be confirmed in two ways:

- Slowly reduce engine speed to idle.

During this process, the analyzer should, first, come back ON (with the ALTERNATOR lamp OFF), then the ALTERNATOR lamp should also come back ON.
- Low water level in every cell of both batteries.

Repair/Replacement of 6V-3178 Cable Assembly

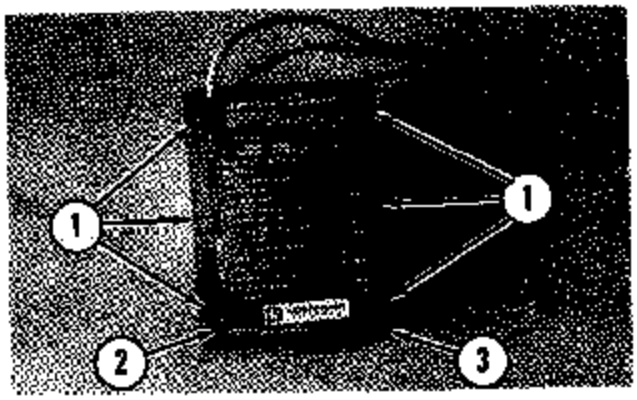
Repair of the connector



If it is necessary to repair the connector on the analyzer (the plug that connects to the diagnostic socket on the machine), use the 6V-4810 VE Connector Tool Group to make the repair. Parts of the connector are as follows:

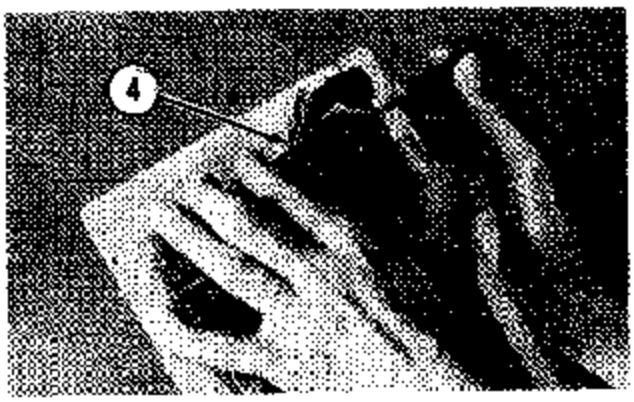
Parts Needed			
Item	Part No.	Description	Quan.
1	8N-1535	End Bell	1
2	3T-0203	Plug Assembly	1
3	8N-1538	Pin	14

Replacement of 6V-3178 Cable



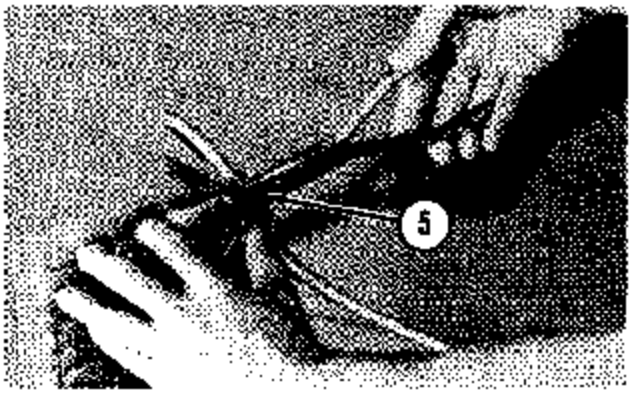
A cable that is damaged beyond repair can be replaced according to the procedure that follows:

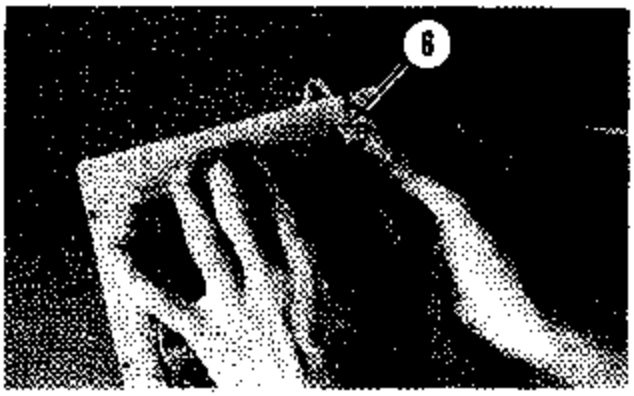
1. Remove six panel-to-base screws (1), then remove panel (2) from base (3).



2. Use a small screwdriver as shown to carefully separate connector (4), (one-half of the cable connector for the in-line PC board connector) from the part of the connector that is fastened to the PC board.

NOTE: Prior to disconnection of connector (4), be sure to look carefully at its installed position. When the new cable is installed, the new connector must be installed just like the original connector.





3. Use long nose pliers as shown to compress clamp/grommet (5) and push it out the front side of the panel, then push PC board connector (6) through the hole in the panel as shown.

4. Use the same tools to install the new cable. Be sure to install clamp/grommet (5), connector (4) etc., in the same position as they were with the former cable.

Repair Information

If the 6V-2150 Starting/Charging Analyzer needs repair, contact the Caterpillar Service Technology Group for information on obtaining the required service:

Telephone:

In Illinois 1-800-542-8665
Outside Illinois 1-800-541-8665
Canada 1-800-523-8665

Write:

Caterpillar Service Technology Group
600 W. Washington Street, LD-180
East Peoria, Il 61630

Telex:

Number 404435
Attn: Caterpillar Service Technology Group

6V-2150 Starting/Charging Analyzers less than one year old will be repaired under warranty (except for abuse). Cost of out-of warranty repairs will be charged to the owner

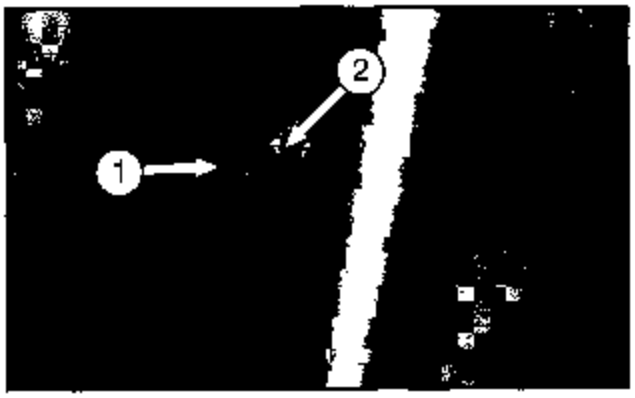
NATO-SPEC Slave Receptacle

Remove and Install NATO-SPEC Slave Receptacle

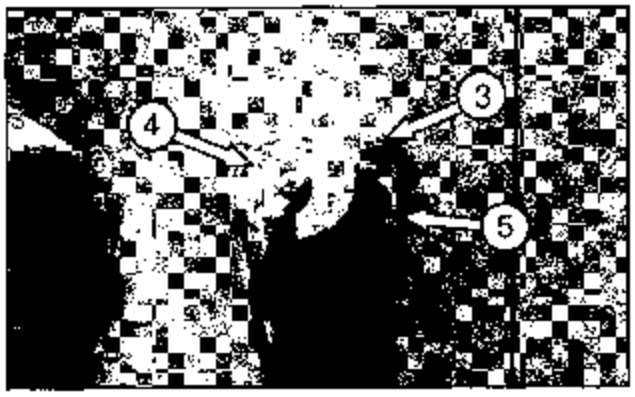
⚠ WARNING

Disconnect batteries before performance of any service work.

1. Turn the main battery switch to the "OFF" position.



2. Identify and disconnect positive and negative starter cables (1) from the slave receptacle (2).



3. Remove four screws, lockwashers, and nuts (3), cover and chain (4), and remove slave receptacle (5).

NOTE: The following steps are for the installation of the NATO-SPEC slave receptacle.

4. Install slave receptacle and cover and chain with four screws, lockwashers, and nuts.
5. Connect starter cables to slave receptacle.
6. Place main battery disconnect switch in position required for current operations.

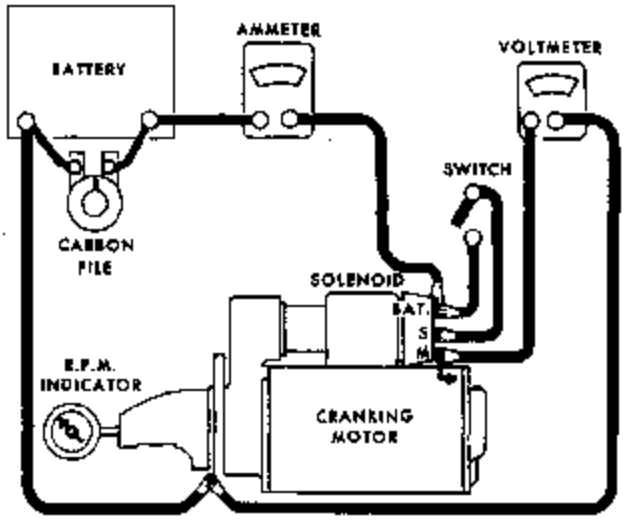
Electric Starting Motor

Disassemble and Assemble Electric Staring Motor

Start By:

a. remove electric starting motor

NOTE: With the cranking motor removed from the engine, the armature should be checked for freedom of rotation by prying the pinion with a screwdriver. Tight bearings, a bent armature shaft, or a loose pole shoe screw will cause the armature to not turn freely. If the armature does not turn freely the motor should be disassembled immediately. However, if the armature does rotate freely, the motor should be given a no-load test before disassembly.



No-Load Test Circuit

NO-LOAD TEST: As shown above, connect a voltmeter from the motor terminal to the motor frame, and use an rpm indicator to measure armature speed. Connect the motor and an ammeter in series with a fully charged battery of the specified voltage, and a switch in the open position from the solenoid battery terminal to the solenoid switch terminal. Close the switch and compare the rpm, current, and voltage reading with the specifications in Service Bulletins 1M-186, 1M-187, or 1M-188. It is not necessary to obtain the exact voltage specified in these bulletins, as an accurate interpretation can be made by recognizing that if the voltage is slightly higher the rpm will be proportionately higher, with the current remaining essentially unchanged. However, if the exact voltage is desired, a carbon pile connected across the battery can be used to reduce the voltage to the specified value. If more than one 12 volt battery is used, connect the carbon pile to only one of the 12 volt batteries. If the specified current draw does not include the solenoid, deduct from the ammeter reading the specified current draw of the solenoid hold-in winding. Make disconnections only with the switch open. Interpret the test results as follows:

INTERPRETING RESULTS OF NO-LOAD TEST:

1. Rated current draw and no-load speed indicates normal condition of the cranking motor.

2. Low free speed and high current draw indicate:

   a. To much friction; check for tight, dirty, or worn bearings; bent armature shaft; or loose pole shoes allowing armature to drag.

   b. Shorted armature. This can be further checked on a growler after disassembly.

   c. Grounded armature or fields. Check further after disassembly.

3. Failure to operate with high current draw indicates:

   a. A direct ground in the terminal or fields.

   b. "Frozen" bearings (this should have been determined by turning the armature by hand).

4. Failure to operate with no current draw indicates:

   a. Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.

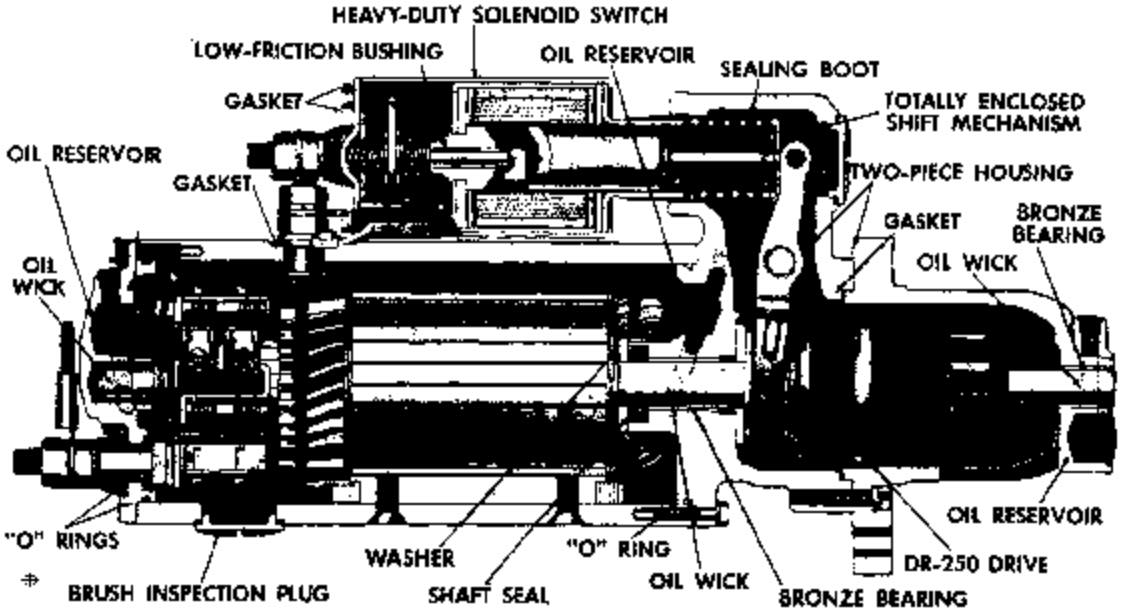
   b. Open armature coils. Inspect the commutator for badly burned bars after disassembly.

   c. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

5. Low no-load speed and low current draw indicate:

a. High internal resistance due to poor connections, defective leads, dirty commutator, and causes listed under No. 4.

6. High free speed and high correct draw indicate shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.



Cross Sectional View of Motor with DR-250 Heavy Duty Drive (50-MT)

Electric Starting Motor Disassembly

NOTE: Normally the cranking motor should be disassembled only as far as necessary to make repair or replacement of the defective parts. As a precaution, it is suggested that safety glasses be worn when disassembling or assembling the cranking motor.

1. Identify and disconnect field coil connector from solenoid motor terminal (M or MTR) and lead from solenoid ground terminal (G).

2. Remove the brush inspection plugs and remove the brush lead screws. This will disconnect the field leads from the brush holders.

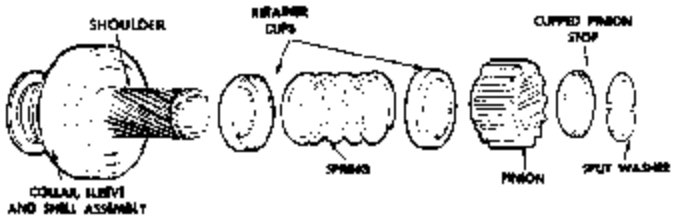
3. Remove six attaching bolts and separate the commutator end frame from the field frame.

NOTE: Make note of the relative position of the solenoid, lever housing, and drive nose housing so the motor can be reassembled in the same manner. The nose housing is designed so that it can be rotated to the desired position for different engine applications.

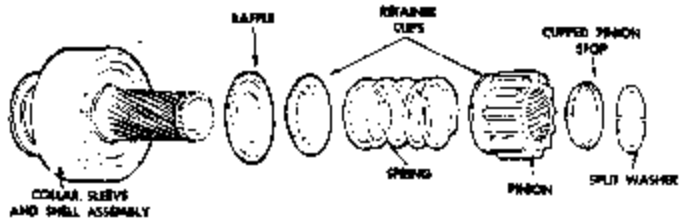
4. Separate the nose housing and field frame from the lever housing by removing six attaching bolts. .

5. Remove armature and drive clutch assembly from lever housing.

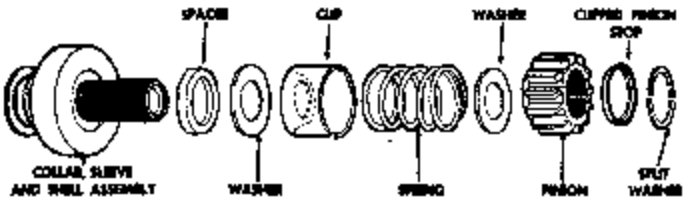
6. Separate solenoid from lever housing by pulling apart.



Disassembled view of early heavy duty sprag clutch drive assembly.



Disassembled view of late type heavy duty sprag clutch drive assembly.



Disassembled view of DR-250 drive.

7. Heavy Duty Sprag Clutch and DR-250 Drive Disassembly

   a. Remove the cupped pinion stop and split washer. In removing the cupped pinion stop, it will probably be damaged, a new one will be required at time of reassembly.

   b. Remove other parts in the order illustrated.

   c. Do not lubricate the sprags on heavy duty clutches, as they are lubricated for life with special oil at the factory.

   d. Assembly is the reverse order of disassembly, see starter motor assembly procedure steps 11 and 12 for installation of the pinion stop and washer/retainer.

8. Spline Drive and Positork Drives are serviced by complete replacement only.

CLEANING: The drive, armature, and fields should not be cleaned in any degreasing tank, or with grease dissolving solvents, since these would dissolve the lubricant in the drive and damage the insulation in the armature and field coils. All parts except the drive should be cleaned with mineral spirits and a brush. The drive can be wiped with a clean cloth. If the commutator is dirty it may be cleaned with No. 00 sandpaper. NEVER USE EMERY CLOTH TO CLEAN COMMUTATOR.

BRUSHES AND HOLDERS: Inspect the brushes for wear. If they are worn excessively when compared with a new brush, they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance. Check by hand to insure that the brush springs are giving firm contact between the brushes and commutator. If the springs are distorted or discolored, they should be replaced.

ARMATURE SERVICING: If the armature is worn, dirty, out of round, or has high insulation, the armature should be put in a lathe so the commutator can be turned down. The insulation should then be undercut 1/32 inch wide and 1/32 inch deep, and the slots cleaned out to remove any trace of dirt or copper dust. As a final step in this procedure, the commutator should be sanded lightly with No. 00 sandpaper to remove any burrs left as a result of the undercutting procedure. NOTE: The undercut operation must be omitted on cranking motors having Test Specifications 2412, 2415, 3501, 3564, 3574, and 3599 as listed in Delco Remy Service Bulletins 1M-186, 1M-187, and 1M-188. DO NOT UNDERCUT COMMUTATORS HAVING THESE SPECIFICATIONS.

ARMATURE CHECKS: The armature should be checked for opens, short circuits, and grounds as follows:

ARMATURE OPENS: Opens are usually caused by excessively long cranking periods. The most likely place for an open to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections. Poor connections cause arcing and burning of the commutator bars as the cranking motor is used. If the bars are not too badly burned, repair can often be effected by resoldering or welding the leads in the riser bars (using rosin flux), and turning down the commutator in a lathe to remove the burned material. The insulation should then be undercut, except as noted above.

ARMATURE SHORT CIRCUITS: Short circuits in the armature are located by use of a growler. When the armature is revolved in the growler with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short circuit is located. Shorts between bars are sometimes produced by brush dust or copper between the bars. These shorts can be eliminated by cleaning out the slots.

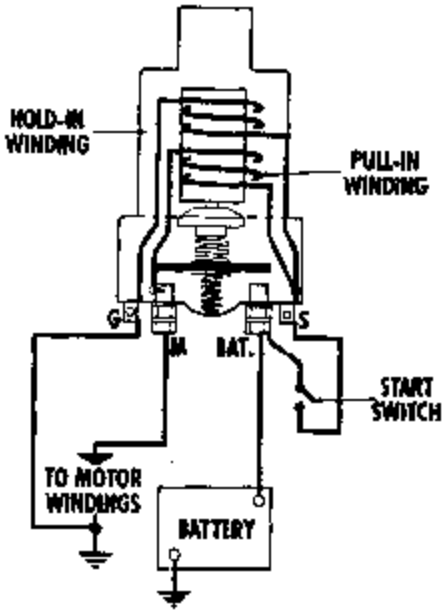
ARMATURE GROUNDS: Grounds in the armature can be detected by the use of a 110 volt test lamp and test points. If the lamp lights when one test point is placed on the commutator with the other point on the core or shaft, the armature is grounded. Grounds occur as a result of insulation failure which is often brought about by overheating of the cranking motor produced by excessively long cranking periods or by accumulation of brush dust between the commutator bars and the steel commutator ring.

FIELD COIL CHECKS: The field coils can be checked for grounds and opens by using a test lamp.

FIELD COIL GROUNDS: If the motor has one or more coils normally connected to ground, the ground connections must be disconnected during this check. Connect one lead of the 110 volt test lamp to the field frame and the other lead to the field connector. If the lamp lights, at least one field coil is grounded, which must be repaired or replaced. This check cannot be made if the ground connection cannot be disconnected.

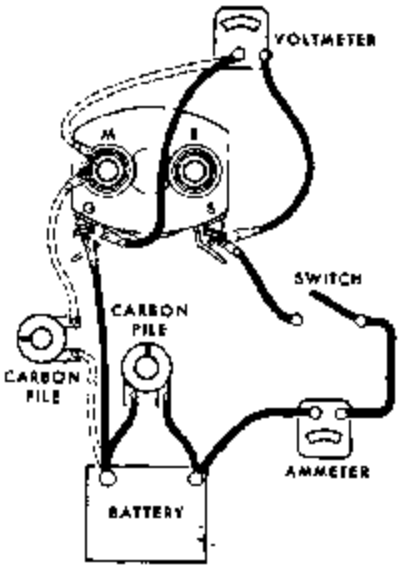
FIELD COIL OPENS: Connect test lamp leads to ends of field coils. If the lamp does not light, the field coils are open.

FIELD COIL REMOVAL: Field coils can be removed from the field frame assembly by using a pole shoe screw driver. A pole shoe spreader should also be used to prevent distortion of the field frame. Careful installation of the field coils is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place. Where the pole shoe has a long lip on one side and short lip on the other, the long lip should be assembled in the direction of armature rotation so it becomes the trailing (not leading) edge of the pole shoe.



Basic solenoid circuit.

SOLENOID CHECKS. A basic solenoid circuit is shown above. Solenoids may differ in appearance but can be checked electrically by connecting a battery of the specified voltage, a switch, and an ammeter to the two solenoid windings.



Solenoid hold-in and pull-in test circuit

NOTE: To prevent overheating, do not leave the pull-in winding energized more than 15 seconds. The current draw will decrease as the winding temperature increases.

With all leads disconnected from the solenoid, make test connections as shown above to the solenoid switch terminal (S) and the terminal (G) to check the hold-in winding. Use the carbon pile to decrease the battery voltage to the value specified in Service Bulletins 1S-180, 1S-186, 1S-187, and 1S-188 and compare the ammeter reading with specifications. A high reading indicates a shorted hold-in winding, and a low reading excessive resistance.

NOTE: If needed to reduce the voltage to the specified value, connect the carbon pile between the battery and the "M" terminal as shown by the dashed lines instead of across the battery as shown in solid lines. If the carbon pile is not needed, connect a jumper directly from the battery to the "M" terminal as shown by the dashed lines.

To check the pull-in winding connect from the solenoid switch terminal (S) to the solenoid motor (M or MTR) terminal. To check for grounds, move battery lead from "G" terminal to solenoid case, and from "M" terminal to solenoid case. Ammeter should read zero for both windings, if not, solenoid is grounded.

Electric Starting Motor Assembly

NOTE: The following steps are for the reassembly of the Electric Starting Motor.

LUBRICATION: All bearings, wicks, and oil reservoirs should be saturated with SAE No. 20 oil. Place a light coat of lubricant, Delco Remy No. 1960954 on the washer located on the shaft between the armature and shift lever housing.

Sintered bronze bearings used in these motors have a dull finish, as compared to the early type machined, cast bronze bearings which had a shiny finish.

Before pressing the bearing into place, dip it in SAE No. 20 oil. Also, tangent wicks should be soaked with SAE No. 20 oil. Insert the wick into place first, and then press in the bearing.

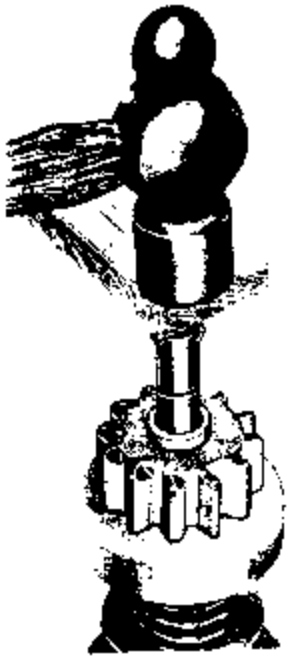
DO NOT DRILL, REAM, or MACHINE sintered bearings in any way! These bearings are supplied to size. If drilled or reamed, the inside diameter will be too large, also the bearing pores will be sealed over.

It is not necessary to cross-drill a sintered bearing when used with a tangent wick. Because the bearing is so highly porous, oil from the wick touching the outside bearing surface will bleed through and lubricate the shaft.

Middle bearings are support bearings and prevent armature deflection during cranking. As compared to end frame bearings, the clearance between the middle bearing and shaft is large and the clearance provides a loose fit when assembled.

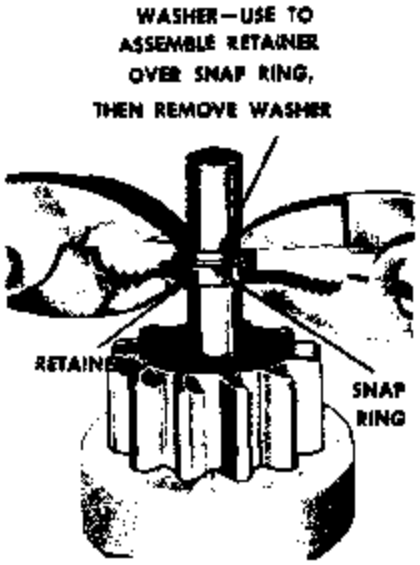
9. Reinstall solenoid into lever housing.

10. Reinstall armature and clutch assembly into lever housing.



Forcing snap ring over shaft.

11. Place the pinion stop snap ring, cup side up, over the end of the shaft and force the ring over the shaft with a block of wood and light hammer blow. Then slide the ring down into the shaft groove.



Forcing retainer over snap ring.

12. To force the retainer over the snap ring, place a suitable washer over the shaft and squeeze with pliers. REMOVE THE WASHER.

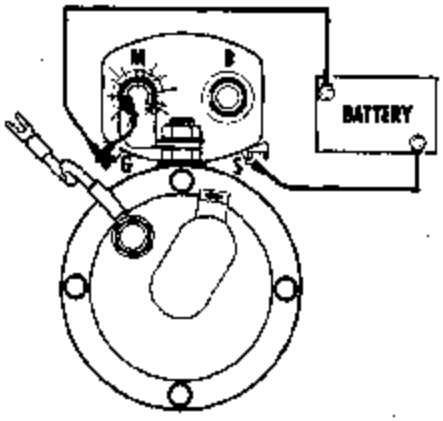
13. Attach nose housing and field frame to lever housing with six attaching bolts.

14. To assemble commutator end frame to field frame, pull the armature out of the field frame just far enough to permit the brushes to be placed over the commutator. Then push the commutator end frame and the armature back against the field frame and attach with six bolts.

15. Connect field leads to brush holders and reinstall brush inspection plugs.

16. Connect ground lead to solenoid ground terminal and field coil lead to solenoid motor terminal.

PINION CLEARANCE: After reassembly check the pinion clearance to make sure the clearance is within specifications.

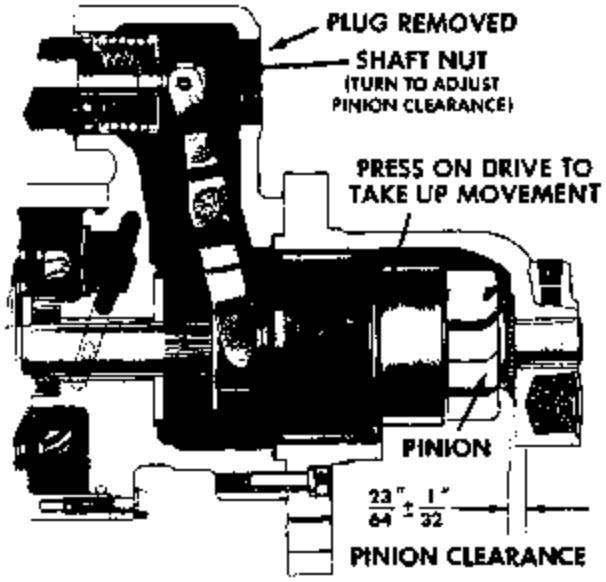


Circuit for checking pinion clearance.

1. Connect battery as shown above to the solenoid switch terminal (S) and ground terminal (G).

2. Momentarily flash a jumper lead between the ground terminal (G) and the motor terminal (M or MTR). The drive will now shift into cranking position and remain so until the battery is disconnected.

3. Push the pinion or drive back towards the commutator end to eliminate slack movement.



Checking pinion clearance on heavy duty motor.

4. Measure the distance between drive and drive stop.

5. Adjust clearance by removing plug and turning shaft nut. Although the typical specification is shown, always refer to 1M-188, 1M-187, or 1M-186 for specifications applying to specific models.

End By:

a. install electric starting motor

APPENDIX A

PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

F-1. GENERAL.

Preventive Maintenance Checks and Services (PMCS) mean systematically caring, inspecting, and servicing of equipment to keep it in good condition and to prevent breakdowns. As a unit level maintenance mechanic, your mission is to:

a. Be sure to do PMCS at the listed intervals. Always do PMCS in the same order, so it gets to be a habit. With some practice, you'll quickly spot anything wrong.

b. Do PMCS tasks that have more than one interval at the interval that occurs first. Intervals are:

(1) Monthly
(2) Quarterly
(3) Semiannual
(4) Annual
(5) Biennial
(6) Hours

c. Use DA Form 2404 (Equipment Inspection and Maintenance Worksheet) to record any faults that you don't immediately fix.

d. Ensure the operator helps with PMCS.

F-2. PMCS PROCEDURES.

a. Preventive Maintenance Checks and Services, Table 4-1, list inspections and care required to keep the compactor in good operating condition.

b. The "Item No." column of Table 4-1 provides number for each check or service. Use these numbers in the "TM ITEM NO." column on DA Form 2404 when recording faults that you don't immediately fix.

c. The "Interval" column of Table 4-1 tells when to do a certain check or service. Do PMCS tasks that have more than one interval at the interval that occurs first.

d. The "Location" column gives the location of the item to check. This column and the "Item to Check/Service" column is together.

e. The "Item to Check/Service" column lists the item to check or service. This column and the "Location" column is together.

f. The "Procedure" column tells how to do the check or service or list a reference to find the required check or service. Carefully follow these instructions. If tools aren't available, or if directed by procedure, notify your supervisor.

g. The "Not Fully Mission Capable If:" column tells you when you can't use the compactor. Don't use the compactor if any of these conditions exist.

h. If anything looks wrong and you can't fix it, write it on your DA Form 2404 and IMMEDIATELY report it to your supervisor.

F-2. PMCS PROCEDURES (CONT).

I. When doing PMCS, you will always need a rag or two. Following are checks and services that are common to the entire compactor:

WARNING

- DO NOT use diesel fuel, gasoline, or benzene (benzol) for cleaning.
- Dry cleaning solvent P-D-680 is toxic and flammable. Wear protective goggles and gloves and use in a well-ventilated area. Avoid contact with skin, eyes, and clothes and DO NOT breathe vapors. Do not use near open flame or excessive heat. Never smoke around solvent. The flash point for type III solvent is 200 degrees F. (93 degrees C.).
- If you become dizzy while using dry cleaning solvent, get fresh air immediately and get medical aid. If solvent gets in your eye, immediately flush the eye with water and get medical aid.

(1) **Keep it Clean**. Dirt, grease, oil, and debris only get in the way and may cover up a serious problem. Clean as you work. Use dry cleaning solvent (P-D-680, Type III; Military Symbol SD-3) on all greasy or oily metal surfaces. Use soap and water when you clean rubber or plastic material.

(2) **Rust and Corrosion.** Check compactor body and frame for rust and corrosion. If any bare metal or corrosion exists, clean and apply a thin coat of oil. Report corrosion problems using Standard Form (SF) 368, Product Quality Deficiency Report (PQDR) per DA Pam 738-750.

(3) **Bolts, Nuts, and Screws.** Check them all for obvious looseness, missing, bent, or broken condition. You can't try them all but look for chipped paint, bare metal, or rust around bolt heads. If you find a bolt, nut, or screw you think is loose, tighten it.

(4) **Welds.** Look for loose or chipped paint, rust, or gaps where parts are welded together. If you find a bad weld, report it to your supervisor.

(5) **Electrical Wires and Connectors**. Look for craked, frayed, or broken insulation, bare wires, and loose or broken connectors. Tighten loose connectors. Replace any damaged wires or connectors.

(6) **Hoses and Fluid Lines**. Look for wear, damage, and leaks, and make sure clamps and fittings are tight. Wet spots show leaks, but a stain around a fitting or connector can also mean a leak. If a leak comes from a loose fitting or connector, thighten it. If something is broken or worn out, replace it.

j. When checking for "operating condition," look at the component to see if it's serviceable.

F-3. LUBRICATION.

a. **Grease Fittings**. Clean grease fittings with clean dry rag before lubricating.

F-3. LUBRICATION (CONT).

b. **Lube Oil Filters.** Replace oil filters at prescribed hardtime intervals and when:

(a) clogged or contaminated.

(b) AOAP laboratory analysis recommends servicing.

c. **AOAP Sampling.** Follow hardtime oil service intervals while the compactor is under warranty. Active Army units shall sample engine and transmission oil, every 50 hours or 90 days, whichever comes first. Reserve and National Guard activities shall sample engine and transmission oil every 50 hours or 180 days, whichever comes first. All units shall sample hydraulic fluid once a year. Sampling procedures are in DA Pam 738-750. Apply hardtime intervals if AOAP laboratory support isn't available.

F-4. FLUID LEAKAGE DEFINITIONS FOR UNIT PMCS.

Following are types/classes of leakage an operator needs to know to be able to determine the status of the compactor. Learn these leakage definitions and remember - when in doubt, notify your supervisor. Excluding fuel leaks, you can continue to operate with Class I and II leaks. Of course, you must consider the fluid capacity of the item leaking.

a. **Class I** - Seepage of fluid (as indicated by wetness or discoloration) not great enough to form drops.

b. **Class II** - Leakage of fluid great enough to form drops but not great enough to cause drops to drip from the item being checked/inspected.

c. **Class III** - Leakage of fluid great enough to form drops that fall from the item being checked/inspected. Hydraulic systems (other than brake systems) may have class III leakage that isn't cause for deadlining. Components, such as actuating cylinders, are designed to allow a certain amount or fluid to pass by the ram seal to lubricate the seal and ram. You could interpret this as a Class III leak. Use good mechanical knowledge and common sense in the decision about whether to deadline the compactor.

UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
1	QUARTERLY OR 100 HRS	Rear Axle Trunnion	**CAUTION** Wipe all fittings before lubricating. Open the engine access door on the left side of the machine. Lubricate two remote fittings in the lube fitting block for the rear axle trunnion.	
2	QUARTERLY OR 100 HRS	Steering Cylinder Bearings	Open the access door on the left side of the machine. Lubricate two remote fittings located on the lube fitting block for the head end of the steering cylinders. Lubricate one fitting on each eye of the rod end of the steering cylinders (two fittings).	
3	QUARTERLY OR 100 HRS	Bulldozer Stabilizer	Lubricate one fitting on the bulldozer stabilizer.	
4	QUARTERLY OR 100 HRS	Bulldozer Cylinder Trunnion Bearing	Lubricate two fittings on the bulldozer cylinder trunnion bearing.	
5	QUARTERLY OR 100 HRS	Bulldozer Cylinder Rod Bearing	Lubricate one fitting on the bulldozer cylinder rod bearing.	
6	QUARTERLY OR 250 HRS	Fan Bearing Spline	Open the right engine access door. Lubricate one fitting on the fan bearing. Close the engine access door.	
7	QUARTERLY OR 250 HRS	Drive Shaft Spline	Start the engine, raise the dozer blade, release the parking brake, and articulate the machine full right or left. Lower the dozer blade to the ground, engage the parking brake, and stop the engine. Lubricate one fitting on the drive shaft spline.	
8	QUARTERLY OR 250 HRS	Fan and Alternator Belts	**NOTE** The alternator and fan belts must be replaced in sets.	
			Check fan and alternator belt adjustment. The belts should deflect 9/16 to 13/16 of an inch (14 to 20 mm) under 25lbs (110 N) of force midway between the pulleys.	Fan/alternator belt out of adjustment.
			Check alternator mount for security.	Alternator mount loose.

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
8	QUARTERLY OR 250 HRS CONT.	Fan and Alternator Belts cont.	Check wires and connectors.	Wires frayed, cracked, worn. Loose connectors.
9	ON CONDITION QUARTERLY OR 250 HRS	Engine Crankcase Breather	**WARNING** Cleaning solvent, P-D-680, Type III, is TOXIC and flammable. Wear protective goggles and gloves. Use only in a well ventilated area. Avoid contact with skin, eyes, and clothes. Do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for Type III cleaning solvent is 200° Fahrenheit (93.3° Celsius). Failure to do so may result in injury or death to personnel.	
			Clean the breather. Loosen the breather outlet hose clamp and remove the hose from the breather cover. Loosen the breather bolt and remove the breather.	
			Check the condition of the cover seal. Replace if damaged. Wash the element and cover assembly in cleaning solvent. Shake or user compressed air to dry the element.	Cover seal damaged, worn.
			Inspect the hose, replace if necessary. Install the breather element cover assembly. Install the hose and clamps. Close the engine access doors.	Hose damaged.
10	QUARTERLY O 250 HRS. DURING WARRANTY PERIOD FOR ALL. ACTIVE OR RESERVE ARMY UNITS: QUARTERLY O 50 HRS. NATIONAL GUARD: SEMIANNUALL OR 50 HRS.	Engine Oil and Filter Change	**WARNING** Engine oil is hot. Oils can burn when in contact with very hot surfaces or if ignited when released as a spray. **NOTE** •Refer to DA Pam 738-750 for sampling requirements. •Intervals for sampling as well as draining and refilling lubricants may be changed by an AOAP laboratory. •If AOAP laboratory support is not available, use UARTERLY/250HRS. interval.	

UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES FOR HIGH SPEED, SELF-PROPELLED, COMPACTOR

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
10	QUARTERLY O 250 HRS. DURING WARRANTY PERIOD FOR ALL. ACTIVE OR RESERVE ARMY UNITS: QUARTERLY O 50 HRS. NATIONAL GUARD: SEMIANNUALL OR 50 HRS. Cont.	Engine Oil and Filter Change Cont.	Take engine oil sample for AOAP analysis.	
			Remove the filter element. Clean the filter housing base, ensuring the entire old filter gasket is removed. Apply a light coat of engine oil to the gasket of the new filter.	
			Install the new filter by hand. When the gasket contacts the filter base, tighten the filter three-quarters of a turn more. Fill the crankcase with new oil (7.28 gal). Clean and install the fill plug. Start the engine and allow the oil to warm. Check for leaks.	Any leaks.
			With the engine running, maintain the oil on the dipstick between the marks on the low idle side of the dipstick. Add oil if necessary. Stop the engine. Close the engine access covers.	Oil level below the "ADD" mark.
11	ON CONDITION SEMIANNUAL OR 500 HRS	Transmission Oil Filter	**WARNING** Cleaning solvent, P-D-680, Type III, is TOXIC and flammable. Wear protective goggles and gloves. Use only in a well ventilated area. Avoid contact with skin, eyes, and clothes. Do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for Type III cleaning solvent is 200° Fahrenheit (93.3° Celsius). Failure to do so may result in injury or death to personnel.	
			The transmission filter is located at the center of the machine.	
			Remove and discard the used element from the filter housing. Clean the filter housing with cleaning solvent. Clean the housing base. Insert a new filter element in the housing. Inspect the filter housing seal and replace if damaged. Install the filter housing into the housing base.	Filter housing seal damaged.
			Start the engine. Apply the service brakes. Slowly operate the transmission controls to circulate the transmission oil. Move the transmission control lever into NEUTRAL. Engage the parking brake. Inspect for leaks.	Any leaks.

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
11	ON CONDITION SEMIANNUAL OR 500 HRS	Transmission Oil Filter Cont.	Maintain the oil level between the marks on the dipstick located on the right side of the machine. Add oil through fill tube if necessary. Stop the engine.	Transmission oil level is not between "ADD" and "FULL".
			Inspect oil lines, hoses, and connectors for damage.	Damaged lines, hoses, connectors
12	ON CONDITION SEMIANNUAL OR 500 HRS.	Hydraulic System Filters	Remove two bolts and swing the platform away from the hydraulic tank. Remove the oil filler cap slowly to relieve tank pressure.	
			Loosen the filter housing cover retaining bolts. Remove the covers and filter element. Discard the filter elements.	
			Clean the covers and inspect the condition of the o-ring seals. Replace, if necessary. Install new filter elements. Install the covers. Tighten the cover retaining bolts to 43 plus or minus 3-ft. lb. (58 plus or minus 4 N-m).	O-ring seals damaged.
			Maintain the hydraulic oil to the "FULL" mark in the sight gauge. Add hydraulic oil, if necessary, through the fill tube.	Hydraulic oil not between "ADD" and "FULL" mark.
			Inspect filler cap gasket. Replace the gasket if it's damaged. Install the oil filler cap. Close the platform and install the two bolts.	Filler cap gasket damaged.
13	ON CONDITION SEMIANNUAL OR 500 HRS	Fuel Filters	**WARNING** Fuel is very flammable and can explode easily. To avoid serious injury or death, always wear safety glasses and keep fuel away from open flame or any spark (ignition source). **CAUTION** DO NOT fill fuel filters with fuel before installing them. Contamination of fuel will cause accelerated wear to fuel system parts.	

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
13	ON CONDITION SEMIANNUAL OR 500 HRS CONT	Fuel Filters Cont.	**WARNING** Cleaning solvent, P-D-680, Type III, is TOXIC and flammable. Wear protective goggles and gloves. Use only in a well ventilated area. Avoid contact with skin, eyes, and clothes. Do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for Type III cleaning solvent is 200° Fahrenheit (93.3° Celsius). Failure to do so may result in injury or death to personnel.	
			Clean and change filters. a. Wash the primary filter element: Loosen the filter housing retaining bolt. Remove the housing element. Remove the element from the case. Wash the element and housing in cleaning solvent. Dry the element with compressed air. Clean the filter case base. Inspect the seal. Replace, if damaged. Insert the clean element. Install the element and case into housing. Retighten the retaining bolt to a torque of 18 plus or minus 3lb. ft. (24 plus or minus 4 N-m).	Damaged seal.
			b. Change secondary fuel filter: Remove and discard the filter. Clean the filter mounting base, ensuring all of the old seal is removed. Coat the seal of a new filter with clean fuel. Install the new filter by hand. When the seal contacts the base, tighten three-quarters of a turn more. There are rotational-index marks 90° apart on the filter. Use them as a guide for proper tightening. Prime fuel system.	
			c. Priming the fuel filters: Turn the priming pump plunger counterclockwise and pull out the plunger. Operate the plunger to fill the new filter elements with fuel. Continue pumping until a resistance is felt, indicating the elements are full of fuel. Push in and turn clockwise to lock the priming pump plunger. Start the engine and check for leaks. Stop the engine.	Any fuel leaks.

UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
			CAUTION The fuel injection nozzles can be damaged if only one wrench is used to loosen or tighten the fuel line nuts. Use one wrench to hold the nozzle and another to loosen the nut.	
			NOTE The injection pumps and high pressure lines must be primed if the engine will not start, or runs rough, after priming the filters and pump housing. Each injection pump has a reverse flow check valve. There cannot be opened with hand priming pump pressure. Use the following procedures to prime the injection pump and lines:	
			d. Priming the fuel system: Loosen the fuel injection lines at the cylinder head of the engine. Move the governor control level to the LOW IDLE position. Turn the start switch key to START. Crank the engine until the fuel flows free of air bubbles from all fuel lines. then stop cranking the engine. Tighten the fuel line nuts to a torque of 30 plus or minus 5lb. ft. (40 plus or minus 7 N-m). Use a second wrench on the nozzle to prevent damaging it. Start the engine and check for leaks.	Any fuel leaks.
14	ON CONDITION SEMIANNUAL OR 500 HRS	Fuel Tank Cap and Filf Screen	**WARNING** Cleaning solvent, P-D-680, Type III, is TOXIC and flammable. Wear protective goggles and gloves. Use only in a well ventilated area. Avoid contact with skin, eyes, and clothes. Do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for Type III cleaning solvent is 200° Fahrenheit (93.3° Celsius). Failure to do so may result in injury or death to personnel.	

UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
14	ON CONDITION SEMIANNUAL OR 500 HRS CONT.	Fuel Tank Cap And Fill Screen Cont.	Clean the cap and screen. Lift and turn the lever counterclockwise until it stops. Lift cap straight up to remove.	
			Inspect the seal for damage, replace if necessary.	Damaged seal.
			Remove screws; filter assembly, valve, and gaskets. Wash the cap in cleaning solvent. Install new filter kit. Remove and wash the fill screen in cleaning solvent. Install fill screen. Install fuel cap.	
15	ANNUAL OR 1000 HRS	Drive Shaft Universal Joints	**CAUTION** Wipe all fittings before lubricating.	
			Lubricate five fittings on the drive shaft universal joints.	
16	ANNUAL OR 1000 HRS	Drive Shaft Support Bearing	**CAUTION** Wipe all fittings before lubricating.	
			Lubricate one remote fitting for the drive shaft support bearing.	
17	ANNUAL OR 1000 HRS	Frame Pivot Bearings	**CAUTION** Wipe all fittings before lubricating.	
			Lubricate one fitting in the upper pivot bearing and lubricate one fitting in the lower pivot fitting.	
18	ANNUAL OR 1000 HRS	Engine Air Intake System	Loosen the clamp and remove the air intake hood assembly. Inspect and clean the screen for accumulated dirt and debris. Loosen clamp and remove body assembly. Clean all parts with compressed air or wash in warm water. Dry all parts.	
			Install body assembly and tighten clamp. Torque the bolt to 18±5lb ft (24±7 N-m).	

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
19	ON CONDITION ANNUAL OR 1000 HRS	Transmission Oil Change	**WARNING** Transmission oil can be moderately flammable and can be an irritant to skin, eyes, and respiratory system. Avoid prolonged exposure. Eye protection and rubber gloves must be worn when working with transmission oil. **WARNING** Cleaning solvent, P-D-680, Type III, is TOXIC and flammable. Wear protective goggles and gloves. Use only in a well ventilated area. Avoid contact with skin, eyes, and clothes. Do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for Type III cleaning solvent is 200° Fahrenheit (93.3° Celsius). Failure to do so may result in injury or death to personnel. **CAUTION** Do not drop or bump the magnets against any hard object/surface. Operate the engine long enough to warm the oil. The machine must be level. Lower the dozer blade to the ground with slight down pressure. Engage the parking brake and the transmission neutral lock. Stop the engine. Remove the transmission drain plug and allow the oil to drain into a suitable container. Change the filter element. *Refer to PMCS item 11.* Remove magnetic strainer cover located at the rear of the transmission transfer gear housing. Remove the retainer, the tube and the screen from the housing.	

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
19	ON CONDITION ANNUAL OR 1000 HRS CONT.	Transmission Oil Change Cont.	Remove the tube and magnets from the screen. Inspect magnets for damaged. Wash the tube and the screen in a clean, nonflammable solvent.	Damaged magnets.
			Clean the magnets with a cloth, a stiff bristle brush or pressure air.	
			Clean cover and inspect the seal. Replace seal if damaged.	Damaged seal.
			Insert the tube and magnets in the screen. Insert the screen, tube and magnets in the housing. Install the cover. Tighten the cover bolts.	
			Clean and install the transmission drain plug. Install the access cover on the transmission guard.	
			Fill the transmission with oil through the fill tube (15.3 gallons).	
			Remove the transmission breather located on the oil fill tube. Install a new transmission breather.	
			Start the engine. Apply the service brake. Slowly operate the transmission controls to circulate the oil. Engage the transmission neutral lock.	
			Maintain the oil level between the ADD and FULL marks on the dipstick. Add oil if necessary. Stop the engine.	Transmission not between "ADD" and "FULL" mark
20	ON CONDITION ANNUAL OR 1000 HRS	Hydraulic Oil Change	**WARNING** Cleaning solvent, P-D-680, Type III, is TOXIC and flammable. Wear protective goggles and gloves. Use only in a well ventilated area. Avoid contact with skin, eyes, and clothes. Do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for Type III cleaning solvent is 200° Fahrenheit (93.3° Celsius). Failure to do so may result in injury or death to personnel.	

UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
20	ON CONDITION ANNUAL OR 1000 HRS CONT.	Hydraulic Oil Change Cont.	**WARNING** Hydraulic oil can be moderately flammable and can be an irritant to the skin, eyes, and respiratory system. Avoid prolonged exposure. Eye protection and rubber gloves must be worn when working with hydraulic oil.	
			CAUTION Operate the engine long enough to warm the oil. The machine must be level. Lower the dozer blade to the ground with slight down pressure.	
			Engage transmission neutral lock and the parking/secondary brake. Stop the engine.	
			Open the access cover located on the right of the machine in the operator's platform. Slowly remove the hydraulic oil tank filter cap to relieve pressure.	
			Remove the tank drain plug located under the hydraulic tank. Unseat the drain valve. Allow the oil to drain into a suitable container. Dispose of oil IAW local procedures. Change the hydraulic filter (refer to PMCS Item No. 12).	
			Remove the fill screen. Clean the screen in cleaning solvent. Shake or blow dry. Install the fill screen.	
			Remove the drain pipe nipple. Clean the tank drain plug. Inspect the drain plug, and replace the seal if damaged. Install the drain plug.	Damaged seal.
			Fill the hydraulic oil tank (22.6 gallons). Clean hydraulic tank cap. Inspect the tank cap seal and replace if damaged. Install hydraulic tank cap.	Damaged seal.
			Start and run the engine for a few minutes. Maintain the oil level to the "FULL" mark on the sight gauge. Add oil if necessary. Cover the access cover. Stop the engine.	Hydraulic oil level not between "ADD and "FULL" mark.

UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
21	ON CONDITION BIENNIAL OR 2000 HRS	Differential Oil Change	**WARNING** Differential Oil can be moderately flammable and can be an irritant to the skin, eyes, and respiratory system. Avoid prolonged exposure. Eye protection and rubber gloves must be worn when working with differential oil. **CAUTION** Wipe covers and surfaces around openings before checking or adding oil. Change the oil in the front/rear differentials. Remove the drain plugs for the front and rear differentials and allow the oil to drain into a suitable container. Dispose of oil IAW local procedures. Clean and install the drain plugs. Remove the front and real differential fill plugs. Fill and maintain the oil to the bottom of the fill plug (12.2 gallons for rear differential and 12.2 for front differential). Clean and install the fill plugs. Operate the machine a few minutes to allow the oil to flow through the entire axles. Remove the fill plugs and check the oil level. Add oil, if necessary. Clean and install the fill plugs.	
22	BIENNIAL OR 2000 HRS	Engine Valve Lash and Injector Fuel Timing	Check that engine valve lash and injector fuel timing are set to specifications (notify DS maintenance).	Engine valve lash and injector fuel timing are out of adjustment.
23	BIENNIAL OR 2000 HRS	Engine Valve Rotators	**WARNING** When inspecting the valve rotators, wear protective goggles (or a face shield) and protective clothing to prevent being burned by hot oil spray. Open the engine access cover. Start the engine and run at low idle. Watch the top surface of each valve rotator. Each valve rotator should turn slightly each time the valve closes. Stop the engine. Close the engine access cover.	One or more valve rotators fail to rotate, notify DS maintenance.

UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

ITEM NO.	INTERVAL	ITEM TO BE CHECKED OR SERVICED	PROCEDURE	NOT FULLY MISSION CAPABLE IF:
24	ANNUAL OR 2000 HRS	Wet Disc Brakes	Inspect the disc wear. Remove the inspection ports on the front axle. Remove the inspection ports on the rear axle. Measure the depth of the oil grooves on both sides of the brake disc. Refer to the chart found in the maintenance, under WET DISC BRAKES, for the remaining brake disc life based on oil groove depth and disc thickness.	Less than 40% of disc life remaining. Notify DS maintenance.

APPENDIX B

MAINTENANCE ALLOCATION CHART (MAC)

SECTION I. INTRODUCTION

B-1. GENERAL.

a. This introduction (Section I) provides a general explanation of all maintenance and repair functions authorized at various maintenance levels under the standard Army Maintenance System Concept.

b. The Maintenance Allocation Chart (MAC) in Section II designates overall authority and responsibility for the performance of maintenance functions on the identified end item or component. The application of the maintenance functions to the end item or component will be consistent with the capabilities of the designated maintenance levels which are shown on the MAC in column (4) as:

Unit - includes two subcolumns, C (operator/crew) and O (unit) maintenance;

Direct Support - includes an F subcolumn;

General Support - includes an H subcolumn;

Depot - includes a D subcolumn.

c. Section III lists the tools and test equipment (both special tools and common tool sets) required for each maintenance function as referenced from Section II.

d. Section IV contains supplemental instructions and explanatory notes for a particular maintenance function.

B-2. MAINTENANCE FUNCTIONS.

Maintenance functions will be limited to and defined as follows:

a. **Inspect.** To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination (e.g., by sight, sound, or feel).

b. **Test.** To verify serviceability by measuring the mechanical, pneumatic, hydraulic, or electrical characteristics of an item and comparing those characteristics with prescribed standards.

c. **Service.** Operations required periodically to keep an item in proper operating condition; e.g., to clean (includes decontaminate, when required), to preserve, to drain, to paint, or to replenish fuel, lubricants, chemicals fluids, or gases.

d. **Adjust.** To maintain or regulate, within prescribed limits, by bringing into proper position, or by setting the operating characteristics to specified parameters.

e. **Align.** To adjust specified variable elements of an item to bring about an optimum or desired performance.

f. **Calibrate.** To determine and cause corrections to be made or to be adjusted on instruments or test, measuring, and diagnostic equipment used in precision measurement. Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust in the accuracy of the instrument being compared.

B-2. MAINTENANCE FUNCTIONS (CONT).

g. **Remove/Install.** To remove and install the same item when required to perform service or other maintenance functions. Install may be the act of emplacing, seating, or fixing into position a spare, repair part, or module (component or assembly) in a manner to allow the proper functioning of an equipment or system.

h. **Replace.** To remove an unserviceable item and install a serviceable counterpart in its place. "Replace" is authorized by the MAC and is shown as the 3rd position code of the SMR code.

i. **Repair.** The application of maintenance services[1], including fault location/troubleshooting[2], removal/installation, and disassembly/assembly[3] procedures, and maintenance actions[4] to identify troubles and restore serviceability to an item by correcting the specific damage, fault, malfunction, or failure in a part, subassembly, module (component or assembly), end item, or system.

j. **Overhaul.** That maintenance effort (service/action) prescribed to restore an item to a completely serviceable/operational condition as required by maintenance standards in appropriate technical publications (i.e., DMWR). Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

k. **Rebuild.** Consist of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with the original manufacturing standards. Rebuild is the highest degree of materiel maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (e.g., hours/miles) considered in classifying Army equipment/components.

B-3. EXPLANATION OF COLUMNS IN THE MAC, SECTION II.

a. **Column 1, Group number.** Column 1 lists functional group code numbers, the purpose of which is to identify maintenance significant components, assemblies, subassemblies, and modules with the next higher-assembly. End item group number shall be "00."

b. **Column 2, Component/Assembly.** Column 2 contains the names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. **Column 3, Maintenance Function.** Column 3 lists the functions to be performed on the item listed in column 2.

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[1]Services - Inspect, test, service, adjust, align, calibrate, and/or replace.

[2]Fault location/troubleshooting - The process of investigating and detecting the cause of equipment malfunctioning; the act of isolating a fault within a system or unit under test (UUT).

[3]Disassembly/Assembly - The step-by-step breakdown (taking apart) of a spare/functional group coded item to the level of its least component, that is assigned an SMR code for the level of maintenance under consideration (i.e., identified as maintenance significant).

[4]Actions - Welding, grinding, riveting, straightening, facing, machining, and/or resurfacing.

d. **Column 4, Maintenance Level.** Column 4 specifies, by listing of a work time figure in the appropriate subcolumn(s), the level of maintenance authorized to perform the function listed in Column 3. This figure represents the active time required to perform that maintenance function at the indicated level of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different levels, appropriate work time figures will be shown for each level. The work time figure represents the average time required to restore an item (assembly, subassembly, component, module, end item, or system) to a serviceable condition under typical field operating conditions. This time includes preparation time (including any necessary disassembly/assembly time), troubleshooting/fault location time, and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation chart. The symbol designations for the various maintenance level are as follows:

C ..... Operator or crew maintenance	L ..... Specialized Repair Activity (SRA)[5]
O ..... Unit maintenance	H ..... General support maintenance
F ..... Direct support maintenance	D ..... Depot maintenance

e. **Column 5, Tools and Test Equipment Reference Code.** Column 5 specifies, by code, those common tool sets (not individual tools), common TMDE, and special tools, special TMDE, and special support equipment required to perform the designated function. Codes are keyed to tools and test equipment in Section III.

f. **Column 6, Remarks.** When applicable, this column contains a letter code, in alphabetical order, which is keyed to the remarks contained in Section IV.

B-4. EXPLANATION OF COLUMNS IN TOOL AND TEST EQUIPMENT REQUIREMENTS, SECTION III.

a. **Column 1, Reference Code.** The tool and test equipment reference code correlates with a code used in the MAC, Section II, Column 5.

b. **Column 2, Maintenance Level.** The lowest level of maintenance authorized to use the tool or test equipment.

c. **Column 3, Nomenclature.** Name or identification of the tool or test equipment.

d. **Column 4, National Stock Number.** The National Stock Number of the tool or test equipment.

e. **Column 5, Tool Number.** The manufacturer's part number, model number, or type number.

B-5. EXPLANATION OF COLUMNS IN REMARKS, SECTION IV.

a. **Column 1, Remarks Code.** The code recorded in column 6, Section II.

b. **Column 2. Remarks.** This column list information pertinent to the maintenance function being performed as indicated in the MAC, Section II.

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[5]This maintenance level is not included in Section II, column (4) of the Maintenance Allocation Chart. Functions to this level of maintenance are identified by a work time figure in the "H" column of section II, column (4), and an associated reference code is used in the Remarks column (6). This code is keyed to Section IV, Remarks, and the SRA complete repair application is explained there.

SECTION II, MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Dir Spt	Gen Spt	Depot		
Group Number	Component/Assembly	Maintenance Function	C	O	F	H	D	Tools and Equipment Ref Code	Remarks Code
01	ENGINE								
0100	Engine Assembly:								
	Engine, Caterpillar 3306B	Test		1.5				5	
		Service		0.5				1,3	P
		Replace			16.0			1,2,3,7,8, 9,10,12,13	
		Repair			51.2			1,2,3,6,7, 8,9,10,12, 13	
0101	Crankcase, Block, Cylinder Head:								
	Crankcase Breather	Service		0.2				1	P
	Cylinder Block	Replace				32.5		1,7	
		Repair				40.0		1,7	
	Cylinder Head Gasket	Replace			3.0			1,7	
	Cylinder Head Assembly	Replace			4.0			1,6,7	
		Repair			6.7			1,7	
0102	Crankshaft:								
	Crankshaft	Replace				16.0		1,7	
	Drive Pulley	Replace			3.0			1,7	
	Oil Seals	Replace			3.0			1,7	
	Bearings	Replace				6.0		1,7	
0103	Flywheel Assembly:								
	Flywheel Assembly	Replace			8.0			1,6	
		Repair			2.0			1	

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1) Group Number	(2) Component/Assembly	(3) Maintenance Function	(4) Maintenance Level: Unit C	Unit O	Dir Spt F	Gen Spt H	Depot D	(5) Tools and Equipment Ref Code	(6) Remarks Code
0104	Pistons, Connecting Rods:								
	Piston Assembly	Replace				2.0		1,7,12	
		Repair				1.5		1,7,12	
	Connecting Rod Assembly	Replace				2.0		1,7	
		Repair				1.5		1,7	
	Piston Rings	Replace				1.0		1,7,12	
0105	Valves, Camshaft, and Timing System:								
	Valve Cover	Replace		1.5				1,7	
	Valves, Intake and Exhaust	Adjust			2.0			1,2	
		Replace			12.0			1,7,10	
		Repair			5.0			1,7	
	Valve Rotators	Inspect		0.8					P
		Replace			11.0			1,7	
		Repair			5.0			1,7	
	Camshaft	Replace				4.0		1,7	
		Repair				6.0		1,7	
	Rocker Arm Assembly	Replace			2.0			1,7	
		Repair			3.0			1,7	
0106	Engine Lubrication System:								
	Engine Oil System	Service	0.2	0.7					P
	Oil Filter	Replace		0.5				1	P
	Oil Pan	Replace			1.0			1,7	
	Oil Pressure Regulator	Replace			0.5			1,7	
	Oil Cooler Core	Replace			1.0			1,2,3,4	

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Dir Spt	Gen Spt	Depot		
Group Number	Component/Assembly	Maintenance Function	C	O	F	H	D	Tools and Equipment Ref Code	Remarks Code
0108	Manifolds:								
	Air Intake	Service		1.0				1,2	P
		Replace			1.5			1,2,3	
	Exhaust	Replace			1.5			1,2,3	
03	FUEL SYSTEM								
0301	Carburetor and Fuel Injector:								
	Fuel Injector Assembly	Test			0.5			1,7,14	
		Adjust			1.0			1,7,14	
		Replace			1.0			1,7,14	
		Repair				2.0		1,7,14	
0302	Fuel Pumps:								
	Fuel Injection Pump	Test				7.5		1,2,6,7	
		Replace			6.0			1,2,6,7	
		Repair				11.0		1,2,6,7	
	Fuel Transfer Pump	Replace		0.5				1	
0304	Air Cleaner:								
	Air Cleaner Assembly	Replace		1.2				1	
		Repair		1.0				1,2	
	Air Cleaner Filter Element	Inspect	0.1						P
		Service	1.0						
		Replace	0.5						
0305	Supercharger, Blower Turbocharger or Altitude Compensator:								
	Turbocharger	Inspect			1.0				
		Replace			1.3			1,2	

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1) Group Number	(2) Component/Assembly	(3) Maintenance Function	(4) Maintenance Level: Unit C	Unit O	Dir Spt F	Gen Spt H	Depot D	(5) Tools and Equipment Ref Code	(6) Remarks Code
0305	Turbocharger (con't)	Repair				8.4		1,2,6,7	
0306	Tanks, Lines, Fittings, Headers:								
	Fuel Tank	Service		0.5					
		Replace		1.5				1,6,7	
		Repair		2.0				1,6	
	Fuel Tank Drain Valve	Service	0.1						P
		Replace		0.5				1	
	Fuel Tank Cap and Fill Screen	Inspect		0.3					P
		Replace		0.6				1	
	Lines, Fittings, and Hoses	Replace		1.0				1,6	
		Repair		2.0				1	
0308	Engine Speed Governor and Controls:								
	Governor	Test			0.5			1,7	
		Replace			1.8			1,7,11,15	
		Repair				2.0		1,7,11,15	
0309	Fuel Filters:								
	Fuel Filter Assembly	Service		1.4				1,2	P
		Replace		0.9				1,2	
	Fuel Filter Elements	Replace		0.5				1,2	P
04	EXHAUST SYSTEM								
0401	Muffler and Pipes:								
	Muffler and Pipes	Inspect	0.1						P
		Replace		1.5				1,2	
		Repair		2.0				1,2	

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1) Group Number	(2) Component/Assembly	(3) Maintenance Function	(4) Maintenance Level: Unit C	Unit O	Dir Spt F	Gen Spt H	Depot D	(5) Tools and Equipment Ref Code	(6) Remarks Code
05	COOLING SYSTEM								
0501	Radiator, Evaporative Cooler, or Heat Exchanger:								
	Radiator Assembly	Inspect	0.2						F
		Service	0.5	1.0					P
		Replace		3.0				1	
		Repair			2.0				A
	Radiator Shield	Replace		1.2				1	
		Repair			1.0			1	
0503	Water Manifold, Headers, Thermostats, and Housing Gasket:								
	Thermostat	Test		0.5					
		Replace		1.0				1,2	
	Hoses and Clamps	Replace		1.2				1	
0504	Water Pump:								
	Water Pump	Replace		2.0				1,2	
		Repair			2.5			1,7	
0505	Fan Assembly:								
	Fan Assembly	Replace			1.0			1,2	
	Fan Belts	Inspect	0.1	0.1					P
		Adjust		0.4				1,2,3	
		Replace		1.0				1,2,3	
	Fan Bearing	Service		0.1					P

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Dir Spt	Gen Spt	Depot		
Group Number	Component/Assembly	Maintenance Function	C	O	F	H	D	Tools and Equipment Ref Code	Remarks Code
06	ELECTRICAL SYSTEM								
0601	Alternator, Generator								
	Alternator	Test		0.5					
		Replace		0.6				1,3,4	
		Repair			1.5			1,2,6,7	
	Alternator Drive Belt	Inspect	0.1	0.1					P
		Adjust		0.4				1,2,3	
		Replace		0.5				1,2,3	
0603	Starting Motor:								
	Starter Assembly	Test		0.5					
		Replace		1.0				1,2	
		Repair			1.6			1,6,7	
0607	Instrument or Engine Control Panel:								
	Instrument Panel Group	Replace		0.5				1	
		Repair		0.5				1	
	Gauge Panel Lights	Inspect	0.1						P
		Replace		0.8				1	
	Gauge Group	Inspect	0.2						P
		Replace		1.6				1	
0609	Lights:								
	Worklights	Inspect	0.2						P
		Replace		1.3				1	
		Repair		1.3				1	

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Dir Spt	Gen Spt	Depot		
Group Number	Component/Assembly	Maintenance Function	C	O	F	H	D	Tools and Equipment Ref Code	Remarks Code
0609	Lights (con't):								
	Signal Lights	Inspect	0.2						P
		Replace		0.2				1	
		Repair		0.5				1	
0610	Sending Units and Warning Switches:								
	Coolant Temperature Sender	Replace		0.5				1	
	Engine Oil Temperature Sender	Replace		0.5				1	
	Hydraulic Oil Temperature Sender	Replace		0.5				1	
	Backup Warning Switch	Replace		0.5				1	
	Backup Alarm	Test	0.1						P
		Replace		0.5				1	
0611	Horn, Siren:								
	Air Horn	Test	0.1						P
		Replace		0.5				1	
0612	Battery, Storage:								
	Battery	Inspect	0.2						P
		Service	0.3						
		Replace		0.5					
	Cables	Inspect	0.3						P
		Replace		0.4				1	
		Repair		0.5				1	
	Battery Box	Inspect	1.0						P
		Replace		1.0				1	
		Repair		0.5				1	

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1) Group Number	(2) Component/Assembly	(3) Maintenance Function	(4) Maintenance Level: Unit C	Unit O	Dir Spt F	Gen Spt H	Depot D	(5) Tools and Equipment Ref Code	(6) Remarks Code
0613	Wiring Harness								
	Wiring Harness	Replace			2.0			1,2,6	
		Repair		1.0				1,2,6	
07	TRANSMISSION								
0700	Transmission Assembly	Test			3.0				
		Service	0.2	1.0					P
		Replace			12.0			1,2,6,7,18	
		Repair			16.0			1,2,6,7,18	
0703	Control Valve	Replace			0.5			1,7	
		Repair			1.0			1,7	
0708	Torque Converter	Replace			8.0			1,7	
		Repair			8.0			1,7	
0721	Transmission Oil Filter	Service		0.5				1	
		Replace		1.0				1	
		Repair			1.0			1	
	Transmission Oil Filter Element	Replace		0.5				1	P
10	FRONT AXLE								
1000	Front Axle Assembly	Service		1.0					P
		Replace			10.0			1,2,3,6,7, 16	
		Repair			10.0			1,2,3,6,7, 16	
1002	Front Differential	Service		0.2					P
		Replace			10.0			1,2,3,6,7	
		Repair			10.0			1,2,3,6,7	

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Dir Spt	Gen Spt	Depot		
Group Number	Component/Assembly	Maintenance Function	C	O	F	H	D	Tools and Equipment Ref Code	Remarks Code
1003	Planetary/Final Drive	Service		1.0					P
		Replace			9.0			1,2,3,6,7, 16	
		Repair			8.0			1,2,3,6,7, 16	
1004	Steering and Leaning Wheel Mechanism:								
	Drive Shaft Spline	Service		0.1					P
	Drive Shaft Support Bearing	Service		0.1					P
		Replace		1.0				1	
	Drive Shaft Universal Joints	Service		0.3					P
		Replace		1.5				1	
11	REAR AXLE								
1100	Rear Axle Assembly	Service		0.1					P
		Replace			10.0			1,2,3,6,7, 16	
		Repair			10.0			1,2,3,6,7, 16	
1102	Rear Differential	Service		0.2					P
		Replace			10.0			1,2,3,6,7	
		Repair			10.0			1,2,3,6,7	
12	BRAKE SYSTEM								
1201	Parking Brake	Test	0.2						P
	Parking Brake Linkage	Adjust		0.2				1,7	
		Replace		1.0				1,7	
		Repair		1.0				1,7	
1202	Service Brakes	Test	0.2						P
		Replace		2.0				1,7	
		Repair		3.0				1,7	

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Dir Spt	Gen Spt	Depot		
Group Number	Component/Assembly	Maintenance Function	C	O	F	H	D	Tools and Equipment Ref Code	Remarks Code
1204	Accumulator	Test	0.2						P
		Repair		0.5				1	B
	Lines and Fittings	Replace		2.0				1,2,3,6	
		Repair		1.0				1	
1209	Air Compressor Assembly			0.5				1	
13	WHEELS								
1311	Wheel Assembly:								
	Wheel Assembly	Inspect		0.5				1,2,17	
		Replace			4.0			1,2,17	
	Tamping Tips	Inspect	0.1						P
		Replace		1.0				1,2	
	Cleaner Bar and Scraping Tips	Inspect	0.1						P
		Adjust		0.5				1,2	
		Replace		1.0				1,2	
14	STEERING								
1401	Steering Wheel	Replace		1.0				1	
1410	Steering Pump	Replace			2.0			1,2	
		Repair			2.0			1,2	
1411	Hoses, Lines, and Fittings	Replace			1.0			1	
		Repair			1.0			1,2,3,5	
1412	Steering Cylinder	Service		0.1					P
		Replace			1.5			1,2	
		Repair			2.0			1,2	
1414	Valve Assembly	Replace			2.0			1,2	
		Repair			1.5			1,2	

SECTION II, MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Dir Spt	Gen Spt	Depot		
Group Number	Component/Assembly	Maintenance Function	C	O	F	H	D	Tools and Equipment Ref Code	Remarks Code
15	FRAME								
1501	Frame Assembly:								
	Frame Assembly	Repair				4.0		1,7	
	Frame Pivot Bearing	Service Replace		0.2 1.0				 1	P
18	HOOD, FENDERS, PANELS, AND PLATES								
1801	Hood Assembly	Replace Repair		1.0	 1.5			1,6	
1802	Fenders	Replace Repair		0.5	 1.0			1,6	
1806	Seat Assembly	Replace Repair		1.0	 1.0			1	
	Seat Belt	Inspect Replace	0.1	 0.8				 1	P
1808	Tool Box	Replace		1.0					
21	BUMPERS, GUARDS, AND MARINE FENDERS								
2101	Bumpers, Brackets, Guards, and Protective Devices								
	ROPS	Inspect Replace	0.2	 1.2				 1,2	P

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Dir Spt	Gen Spt	Depot		
Group Number	Component/Assembly	Maintenance Function	C	O	F	H	D	Tools and Equipment Ref Code	Remarks Code
22	BODY CHASSIS OR HULL AND ACCESSORY ITEMS								
2210	Data Plates and Instruction Holders:								
	Decals and Data Plates	Inspect	0.2						P
		Replace		0.3				1	
24	HYDRAULIC LIFT COMPONENTS								
2406	Hydraulic Lines and Fittings	Replace		1.5				1,2,3,6	
		Repair		1.0				1,2,3,6	
2408	Liquid Tanks or Reservoirs:								
	Hydraulic Tank	Service	0.2						P
		Replace		4.0				1,2,3	
		Repair			2.0			1,2,3,7	
	Hydraulic Oil Filter Element	Replace		0.8					P
74	EARTH MOVING EQUIPMENT COMPONENTS								
7435	Moldboard Assembly:								
	Blade Assembly	Replace		1.0				1,2	
		Repair			1.0			1,3	
	Cutting Edge	Inspect	0.1						P
		Replace		1.0				1,2	

SECTION II. MAINTENANCE ALLOCATION CHART (MAC)
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Dir Spt	Gen Spt	Depot		
Group Number	Component/Assembly	Maintenance Function	C	O	F	H	D	Tools and Equipment Ref Code	Remarks Code
7435	Moldboard Assembly (con't):								
	End Bits	Inspect	0.1						P
		Replace		1.0				1,2	
	Bulldozer Stabilizer	Service		0.1					P
	Bulldozer Cylinder Trunnion Bearing	Service		0.1					P
	Bulldozer Cylinder Rod Bearing	Service		0.1					P

SECTION III, TOOLS AND TEST EQUIPMENT
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

TOOL OR TEST EQUIPMENT REFERENCE	MAINTENANCE LEVEL	NOMENCLATURE	NSN	TOOL NUMBER
1	O,F,H	Tool Kit, General Mechanics Automotive (SC 5180-90-N26)	5180-00-177-7033	W33004
2	O	Shop Equipment, Organizational Repair, Light, Truck Mounted (SC 4940-95-CL-B03)	4940-00-294-9516	T13152
3	O	Shop Equipment, Automotive Maintenance and Repair: OM Common No. 1, Less Power (SC 4910-95-CL-A74)	4910-00-754-0654	W32593
4	O	Shop Equipment, Automotive Maintenance and Repair: OM Supplemental No. 1, Less Power (SC 4910-95-CL-A73)	4910-00-754-0653	W32867
5	O and H	Simplified Test Equipment for Internal Combustion Engines - Reprogrammable (STE/ICE-R) TM 9-4910-571-12&P	4910-01-222-6589	A56243
6	O,F	Shop Equipment, Contact Maintenance, Truck Mounted (SC 4940-95-CL-B04)	4940-00-294-9518	T10138
7	F,H	Shop Equipment, General Purpose Repair, Semitrailer Mounted (SC 4940-95-CL-B02)	4940-00-287-4884	T10549
8	F,H	Tool Outfit Hydraulic Systems Test and Repair (HSTRU) (SC 4940-95-CL-B07)	4940-01-036-5784	T30377
9	F,H	Shop Equipment, Automotive Maintenance and Repair: Field Maintenance Basic, Less Power (SC 4910-95-A31)	4910-00-754-0705	T24660
10	F,H	Shop Equipment, Automotive Maintenance and Repair: Field Maintenance, Supplemental Set No. 2, Less Power (SC 4910-95-A63)	4910-00-754-0707	T25756

SECTION III. TOOLS AND TEST EQUIPMENT
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

TOOL OR TEST EQUIPMENT REFERENCE	MAINTENANCE LEVEL	NOMENCLATURE	NSN	TOOL NUMBER
11	F,H	Tool, Governor Adjustment P/N (11083) 6V2017	5120-01-376-0389	
12	F,H	Gage Set, Inspection P/N (11083) 1U6432	5280-01-K64-9359	
13	F,H	Tool Kit, Internal Combustion Engine, P/N (11083) 6V2105	5180-01-K64-9360	
14	F,H	Adapter, Fuel Injection P/N (11083) 5P7448	5120-01-K64-9361	
15	F,H	Driver, Armature Wedge P/N (11083) 6V2054	5120-01-K64-9362	
16	O,F,H	Installer P/N (11083) 1U6436	5120-01-K65-1319	
17	O,F,H	Spanner Wrench P/N (11083) 4C8500	5120-01-K65-1320	
18	O,F,H	Transmission Service Tool P/N (11083) 9U6665	5120-01-K65-1321	

SECTION IV REMARKS
FOR
HIGH SPEED, SELF-PROPELLED, COMPACTOR

REMARKS CODE	REMARKS
A	Repair radiator in accordance with TM 750-254, Cooling System: Tactical Vehicles.
B	Repair is by replacement of the accumulator.
P	Preventive Maintenance Checks and Services (PMCS).

APPENDIX C

APPROVED FUELS, LUBRICANTS, GREASES, AND OILS FOR HIGH SPEED, SELF-PROPELLED, COMPACTOR

NSN	NOMENCLATURE	UM/UI
	Oil, Lubricating, ICE, Tactical Service (MIL-PRF-2104G) (OE/HDO-30) (12 F to 120 F) (ENGINE)	
9150-01-178-4726		1 Quart Can
9150-00-188-9858		5 Gallon Can
9150-00-189-6729		55 Gallon Drum
	Oil, Lubricating, ICE, Arctic (MIL-L-46167) (OEA) (-50 F to 35 F) (ENGINE - COLD WEATHER)	
9150-00-402-4478		1 Quart Can
9150-00-402-2372		5 Gallon Can
9150-00-491-7197		55 Gallon Drum
	Oil, Lubricating, Gear, Multipurpose (MIL-L-2105) (GO-80/90) (10 F to 120 F) (DIFFERENTIAL)	
9150-01-035-5392		1 Quart Can
9150-01-035-5393		5 Gallon Can
9150-01-035-5394		55 Gallon Drum
	Oil, Lubricating, Gear, Multipurpose (MIL-L-2105) (GO-75) (-60 F to 45 F) (DIFFERENTIAL - COLD WEATHER)	
9150-01-035-5390		1 Quart Can
9150-01-048-4593		5 Gallon Can
9150-01-035-5391		55 Gallon Drum

Oil, Lubricating, Internal
Combustion Engine (ICE), Tactical
Service (MIL-L-2104) (OE/HDO-10)
(-15 F to 120 F) (HYDRAULIC)

9150-00-189-6727	1 Quart Can
9150-00-186-6668	5 Gallon Can
9150-00-191-2772	55 Gallon Drum

Oil, Lubricating, ICE, Arctic
(MIL-L-46167) (OEA)
(-50 F to 120 F)
(HYDRAULIC - COLD WEATHER)

9150-00-402-4478	1 Quart Can
9150-00-402-2372	5 Gallon Can
9150-00-491-7197	55 Gallon Drum

TRANSMISSION
(35 F to 95 F)

Caterpillar Oil, Part Number (11083) 2P9869, MUST be used when adding oil/changing the oil in the transmission. DO NOT use the Military Equivalent (MIL-L-2104) in the transmission. It will cause damage to the transmission, which will not be covered under the commercial warranty.

Oil, Lubricating, ICE, Arctic
(MIL-L-46167) (OEA)
(-50 F to 120 F)
(TRANSMISSION - COLD WEATHER)

9150-00-402-4478	1 Quart Can
9150-00-402-2372	5 Gallon Can
9150-00-491-7197	55 Gallon Drum

Grease, Automotive, and
Artillery (MIL-G-10924)
(-50 F to 120 F)

9150-01-197-7688	2.25 Ounce Tube
9150-01-197-7690	1.75 Pound Can
9150-01-197-7689	6.5 Pound Can
9150-01-197-7692	35 Pound Can

	Coolant, Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty (MIL-A-46153)	
6850-00-181-7933		5 Gallon Can
6850-00-181-7940		55 Gallon Drum
	Fuel, Aviation, Turbine, JP-8, NATO F-34 (MIL-T-83133)	
9130-01-305-5597		Gallon

By Order of the Secretary of the Army:

ERIC K. SHINSEKI
General, United States Army
Chief of Staff

Official:

JOEL B. HUDSON
Administrative Assistant to the
Secretary of the Army
9921706

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DATE SENT:

PUBLICATION NUMBER	PUBLICATION DATE	PUBLICATION TITLE
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BE EXACT...PINPOINT WHERE IT IS

PAGE NO.	PARA-GRAPH	FIGURE NO.	TABLE NO.	IN THIS SPACE, TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:
1-3	1-6			Tank unit illustration shows suction hose item 3 as two hoses coupled together. Reason: suction hose is now one hose.
3-1	3-3			Text refers to cleaning solvent item 7, App. D in Expendable Supplies Section. Reason: Should be item 10, App. D.
3-18	3-10			Blender hose illustration is not accurate as shown. Reason: Blender hose should show quick-disconnect couplings at both ends.

SAMPLE

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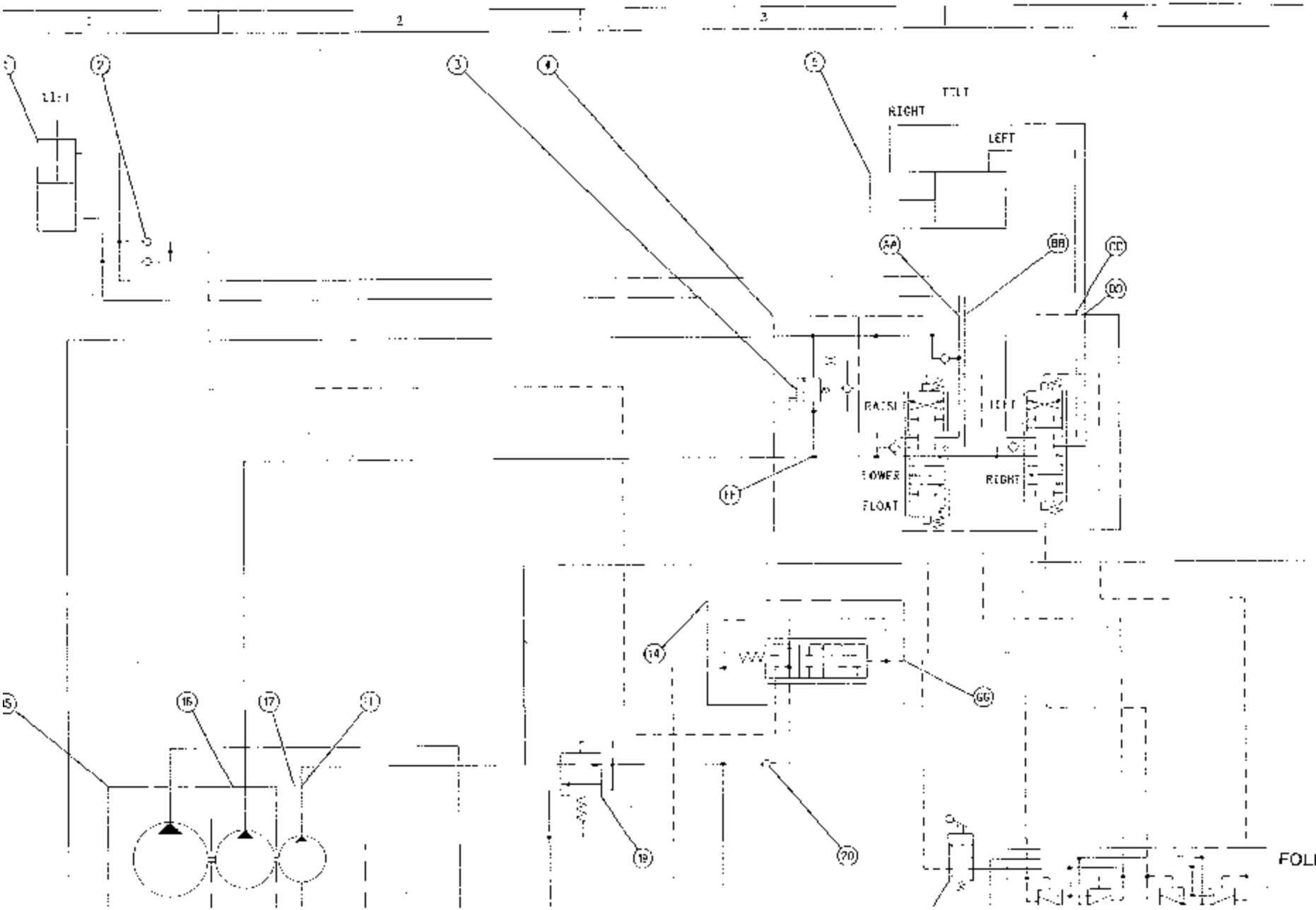
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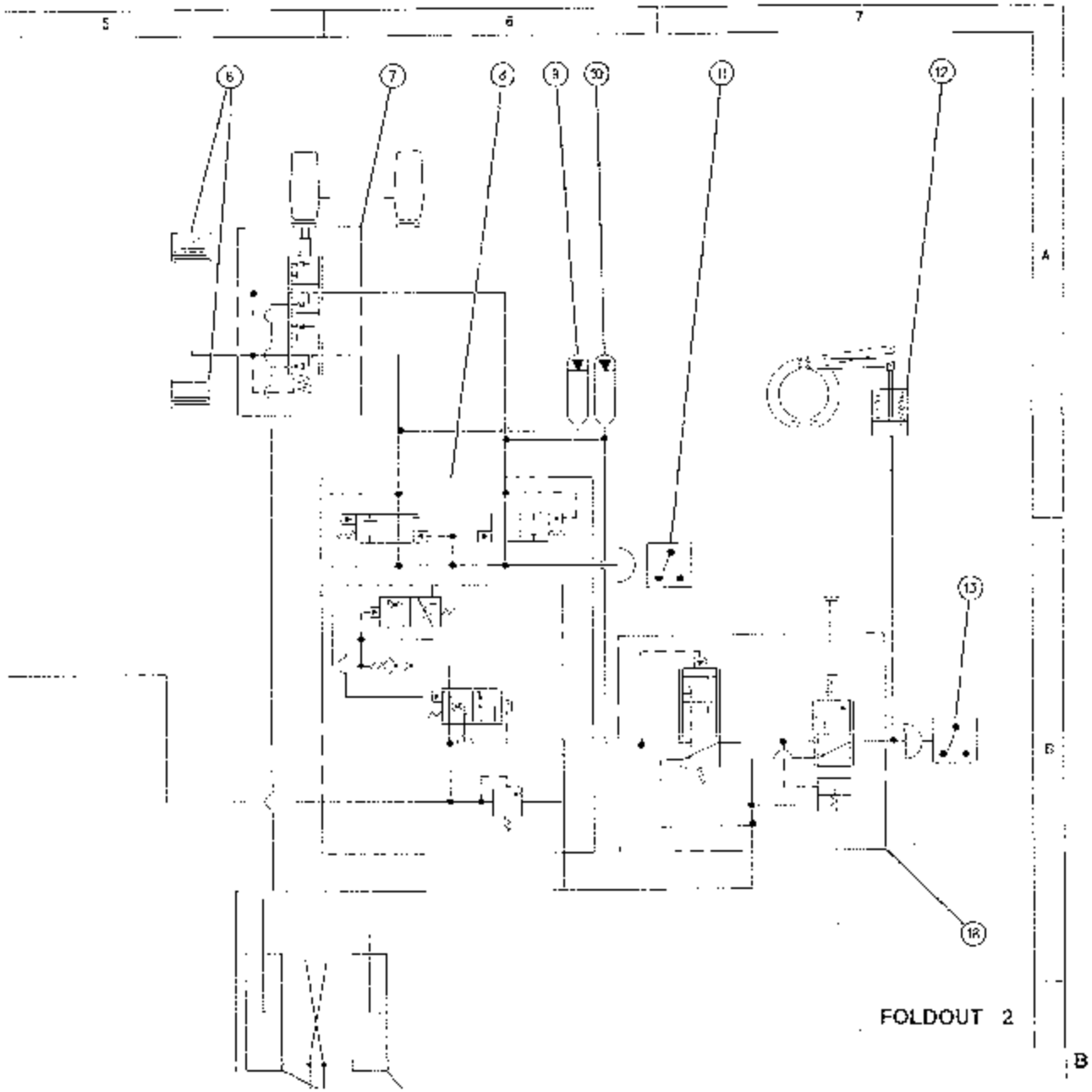

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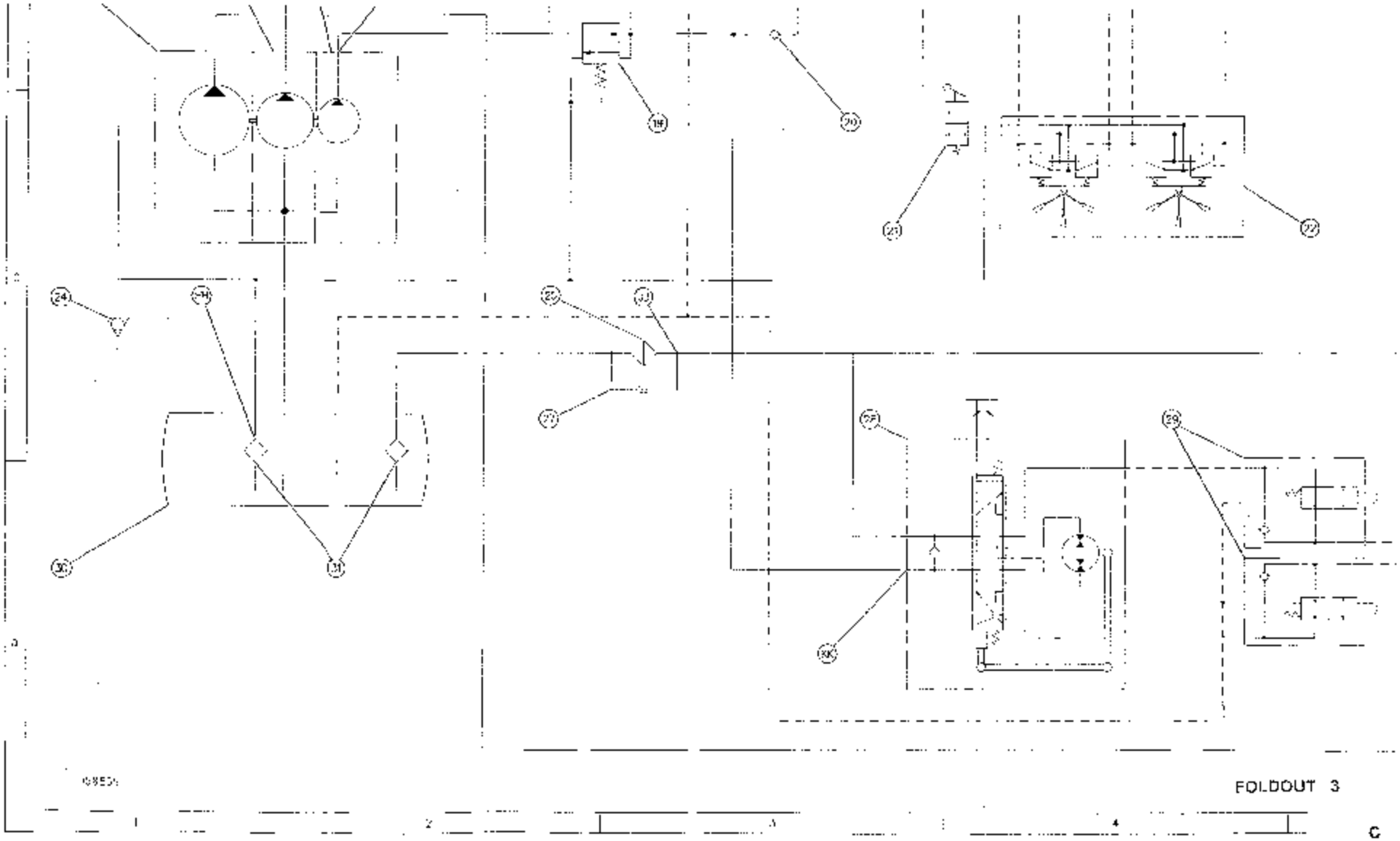
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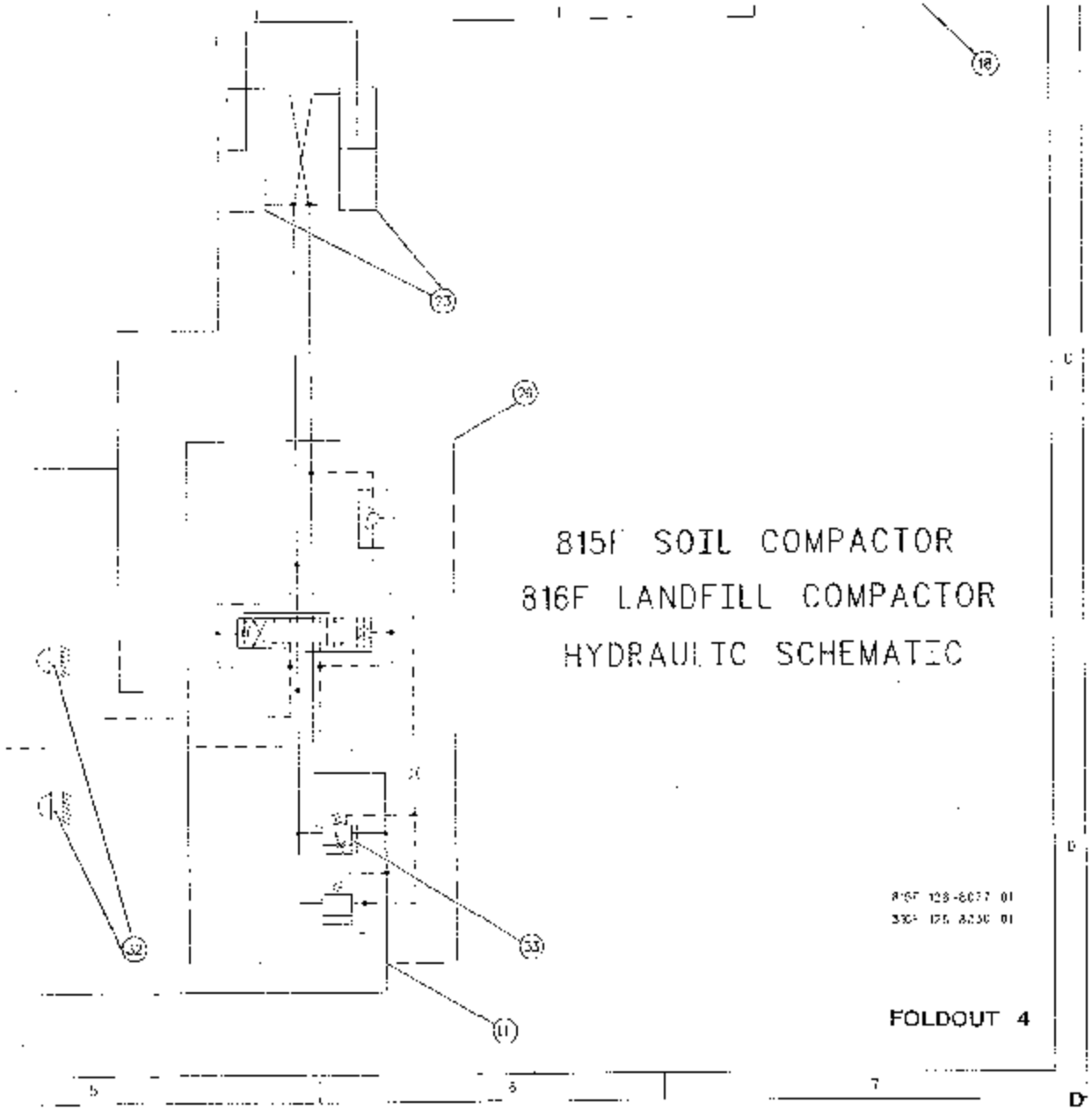
815F SOIL COMPACTOR
816F LANDFILL COMPACTOR
HYDRAULIC SCHEMATIC
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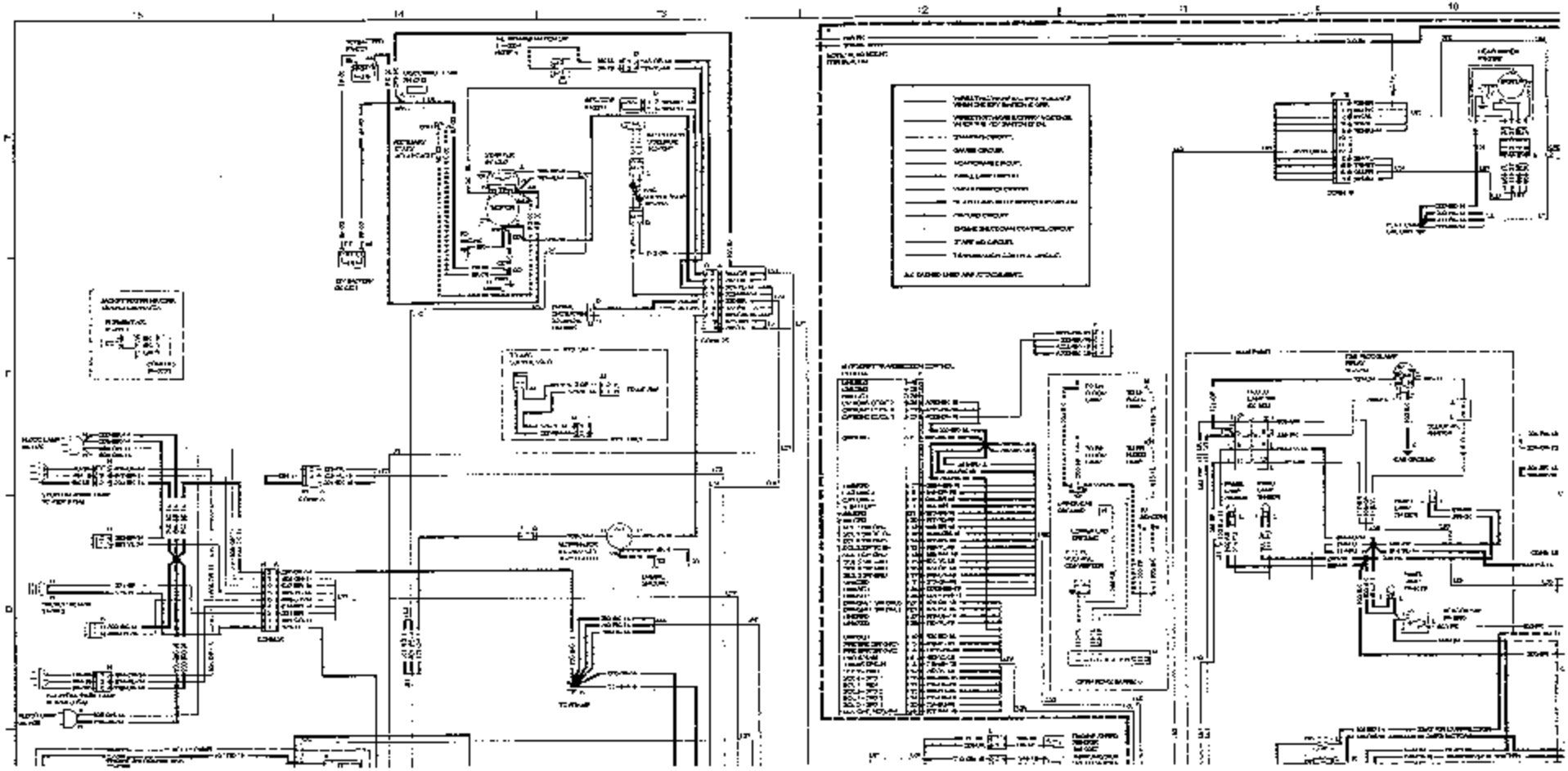
D	E	F

Schematic SENR 1319 Section A

815F Electric System



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A	B	C
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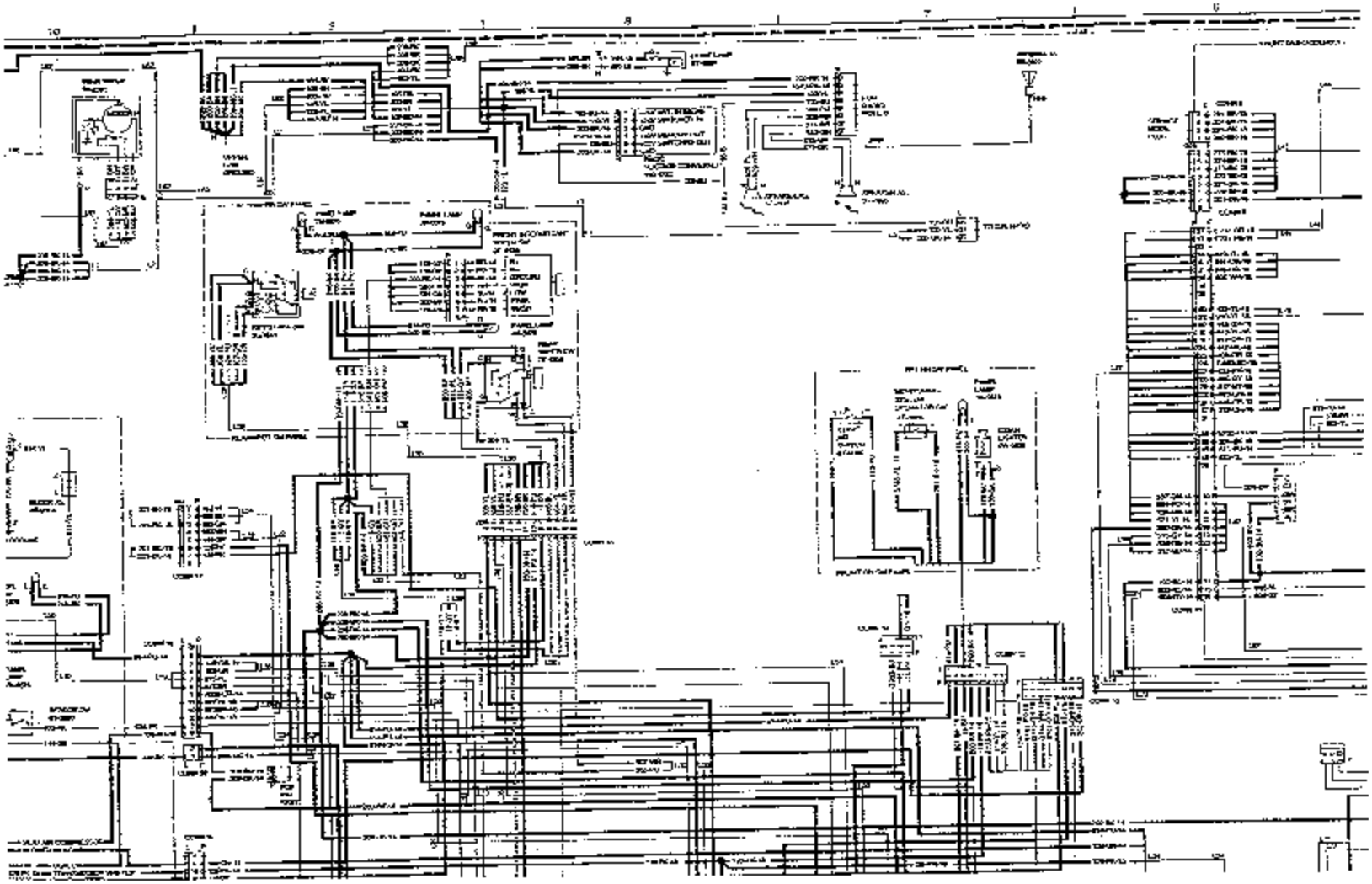
Schematic SCNR 1319 Section B

816F Electric System



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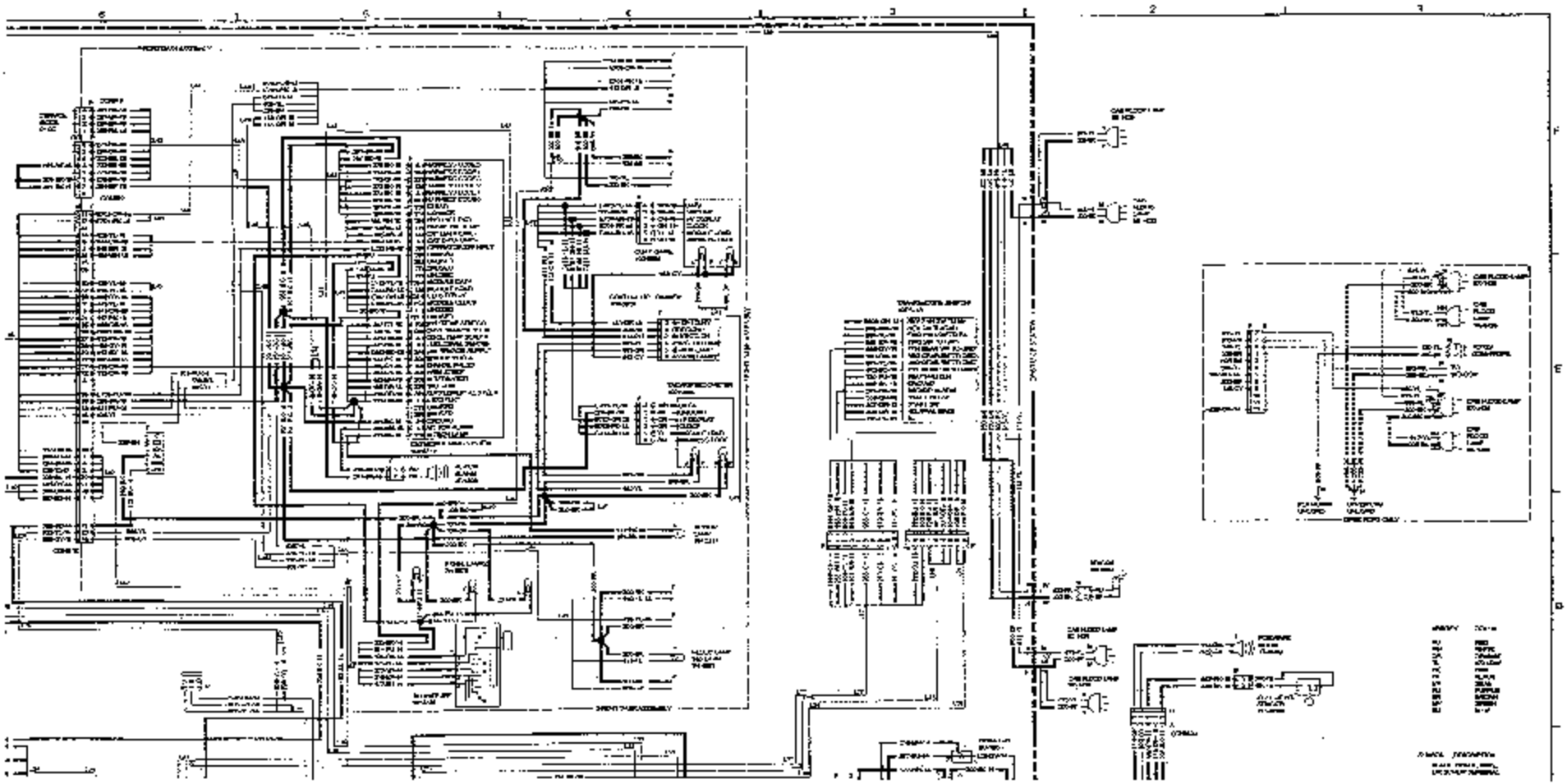
Schematic SENR 1319 Section C
819F Electric System



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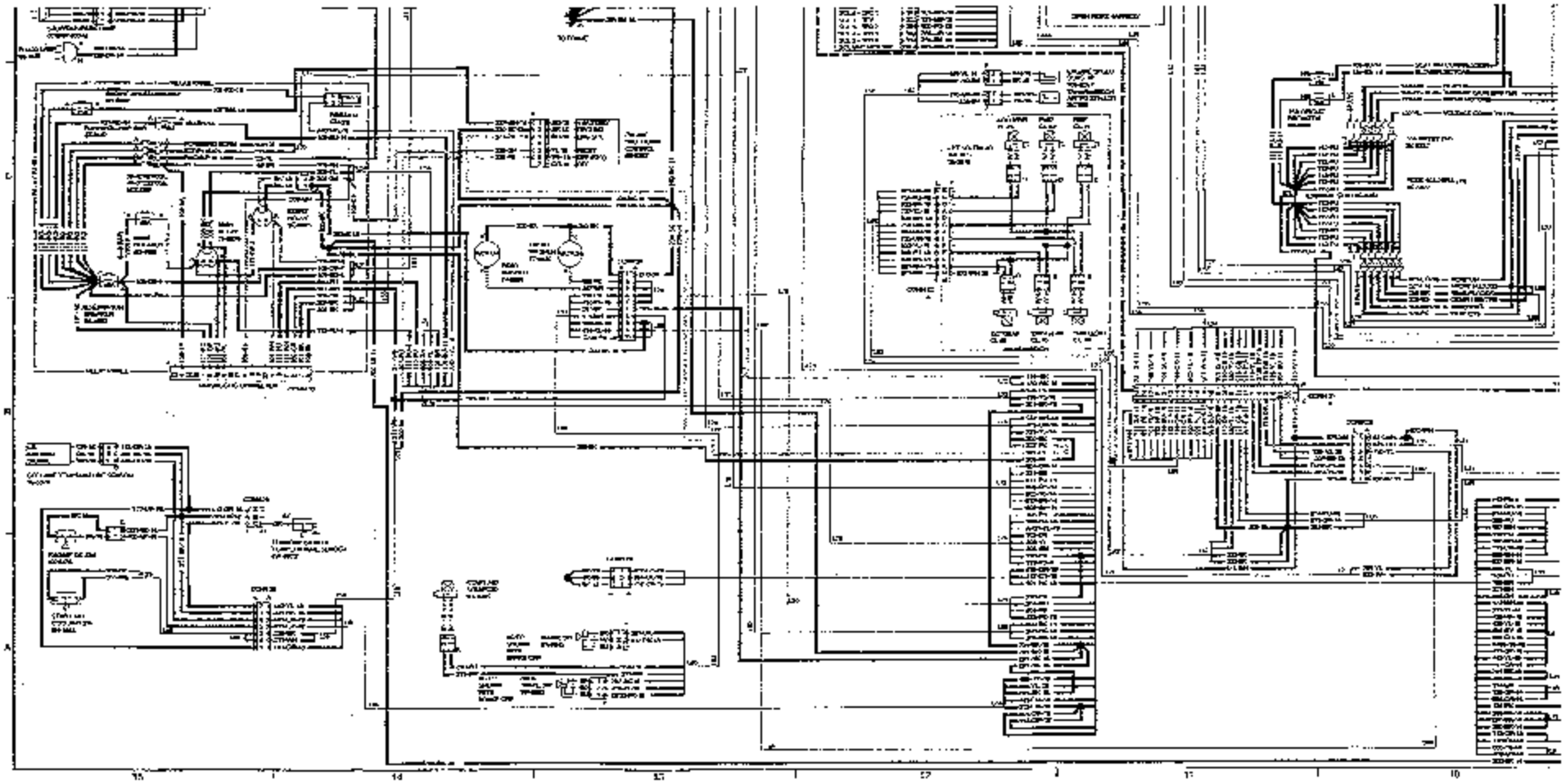
Schematic SENR 1319 Section D

815F Electric System



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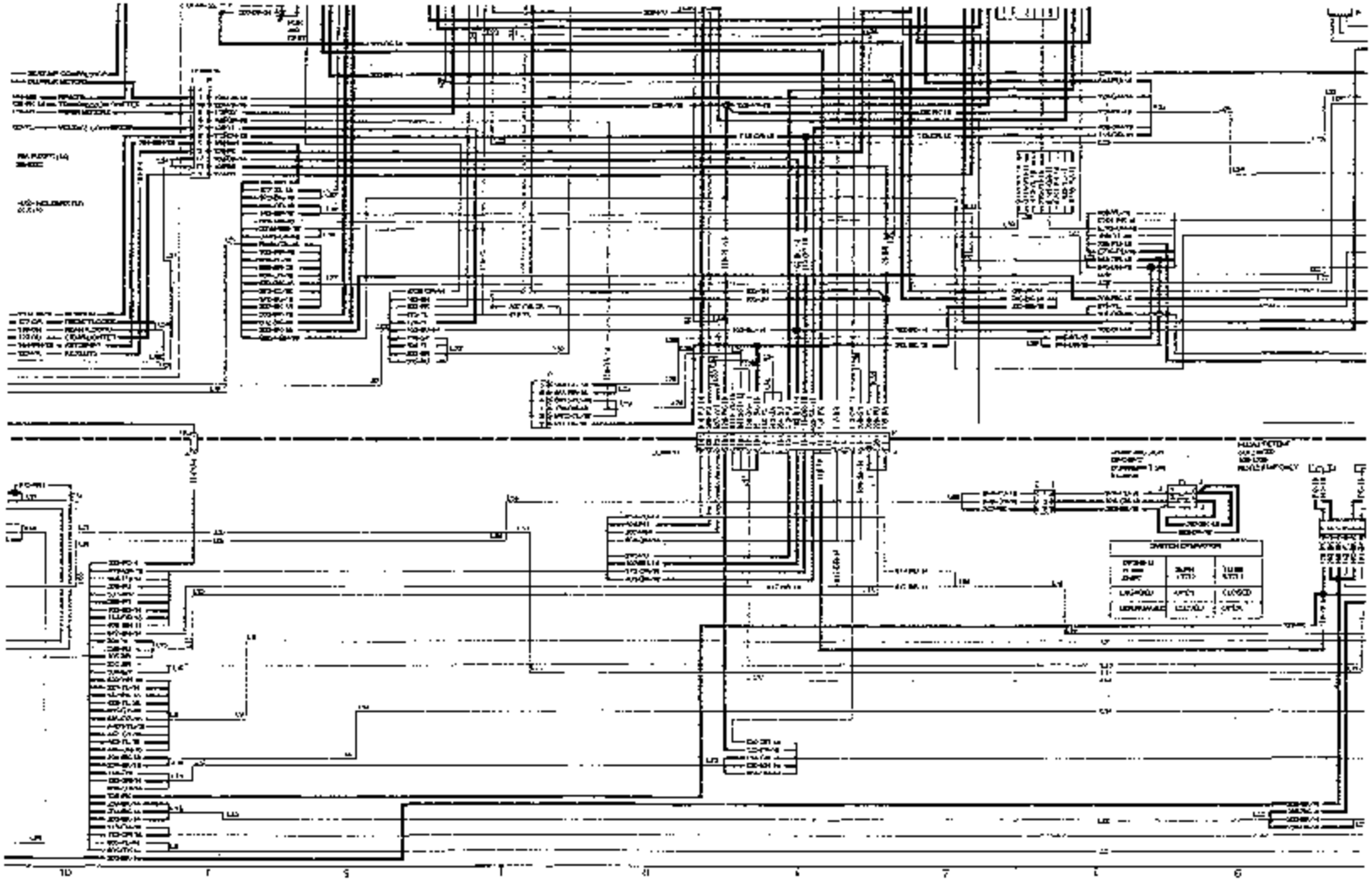

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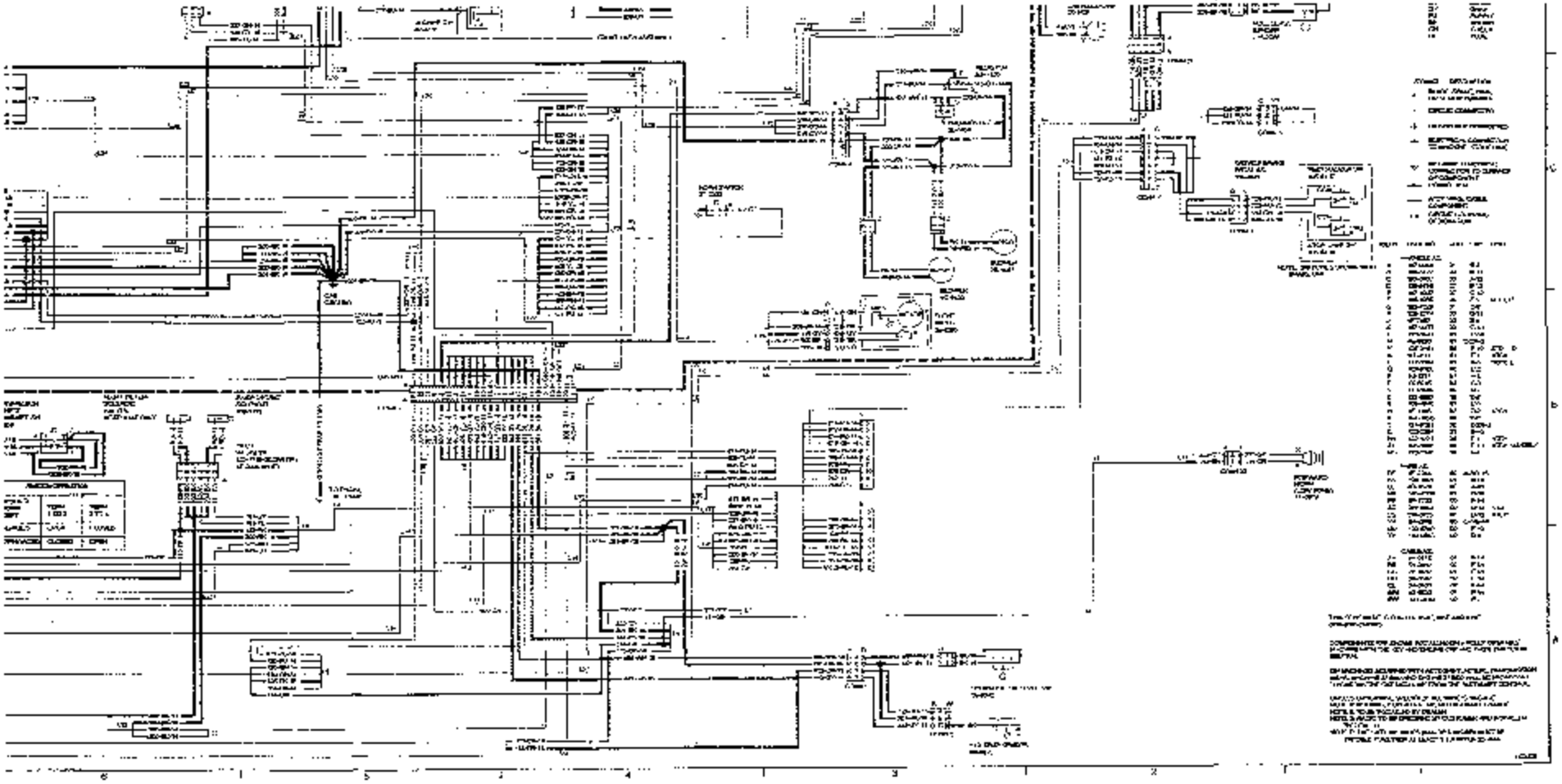
Schematic SENR 1319 Section F

815F Electric System



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