

# Shuttlelift CD5515-2 Grove YB5515-2

## Service/Maintenance Manual



Reference Only

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# SERVICE MANUAL

This Manual has been prepared for and is considered part of -

**CD5515-2/YB5515-2**

Crane Model Number

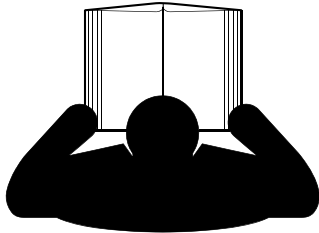
This Manual is Divided into the following Sections:

SECTION 1	INTRODUCTION
SECTION 2	SAFETY PRACTICES
SECTION 3	ELECTRIC SYSTEM
SECTION 4	HYDRAULIC SYSTEM
SECTION 5	PREVENTATIVE MAINTENANCE
SECTION 6	ENGINE AND ENGINE SYSTEMS
SECTION 7	TRANSMISSION AND TORQUE CONVERTER
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SECTION 11	STRUCTURALS
SECTION 12	SCHEMATICS/WIRING DIAGRAMS

## NOTICE

The crane serial number is the only method your Grove distributor or Crane Care Customer Service at Grove has of providing you with correct parts and service information.

The crane serial number is identified on the builder's decal attached to the operator's cab. **Always furnish crane serial number** when ordering parts or communicating service problems with your Grove distributor or Crane Care Customer Service at Grove.



## ⚠ DANGER

**An untrained operator subjects himself and others to death or serious injury. Do not operate this crane unless:**

- You are trained in the safe operation of this crane. Manitowoc is not responsible for qualifying personnel.
- You read, understand, and follow the safety and operating recommendations contained in the crane manufacturer's manuals and load charts, your employer's work rules, and applicable government regulations.
- You are sure that all safety signs, guards, and other safety features are in place and in proper condition.
- The Operator Manual and Load Chart are in the holder provided on crane.

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 **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.

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 **CALIFORNIA  
PROPOSITION 65 WARNING**

Battery posts, terminals, and related accessories contain chemical lead and lead compounds, chemicals known to the State of California to cause cancer, birth defects or other reproductive harm. Wash hands after handling.

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The original language of this publication is English.

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## SECTION 1 INTRODUCTION

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This manual contains information on maintenance, service and repair of the Models CD5515-2 & YB5515-2 cranes. Major components and systems are included, except service on the engine. This information will be found in the engine manufacturer's service manual.

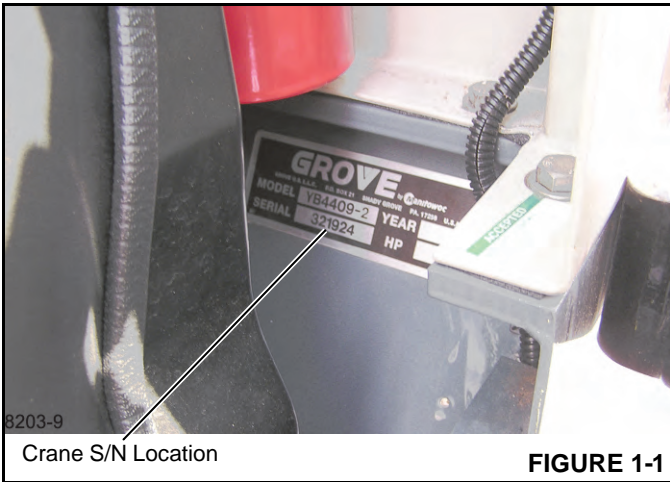
### DIRECTIONAL REFERENCE

All directional references in this manual, unless otherwise noted, are viewed from the normal operator's working

position at the main controls. "LEFT" is the operator's left and "RIGHT" is the operator's right.

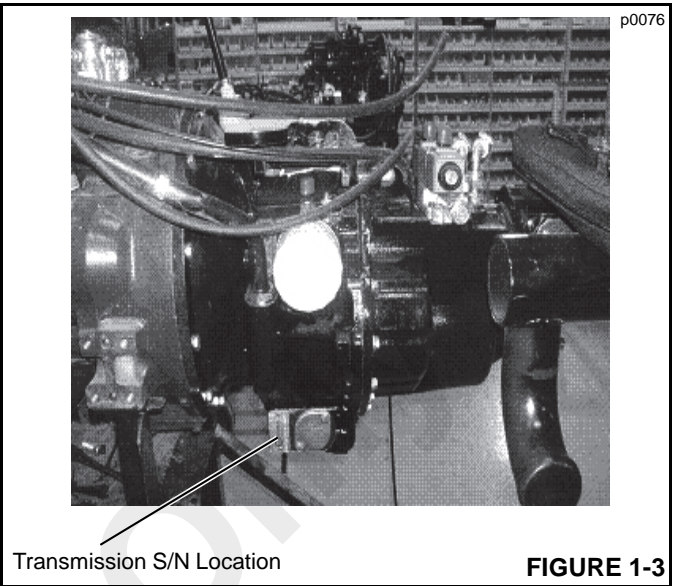
### IDENTIFICATION PLATES

When assistance is required for parts and service, be sure to include the model number and serial number of the crane in the correspondence. Location of serial number plates are shown below.



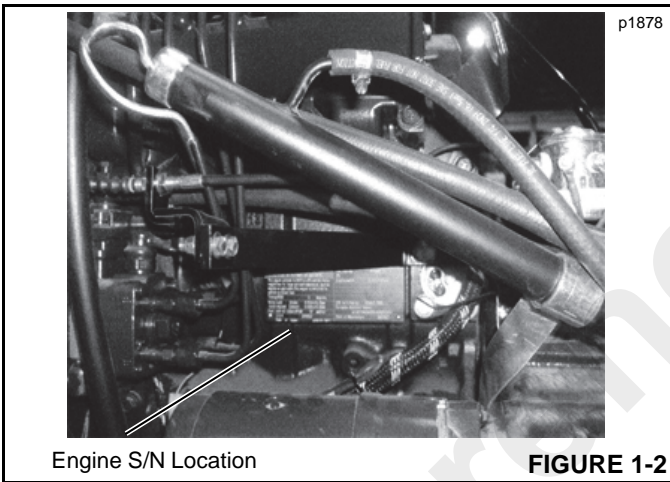
Crane S/N Location

FIGURE 1-1



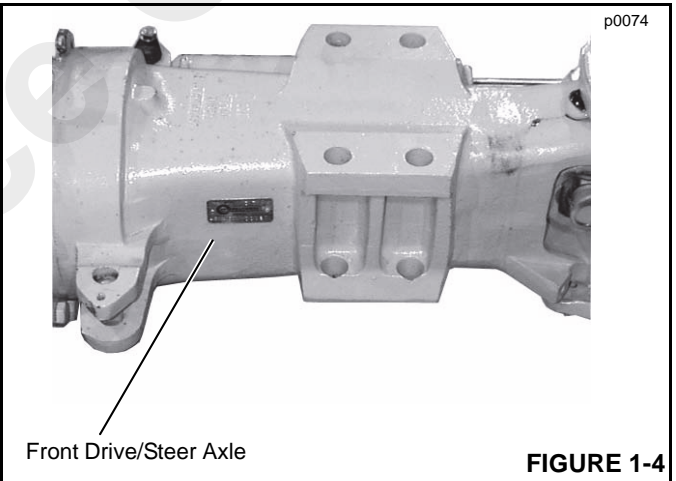
Transmission S/N Location

FIGURE 1-3



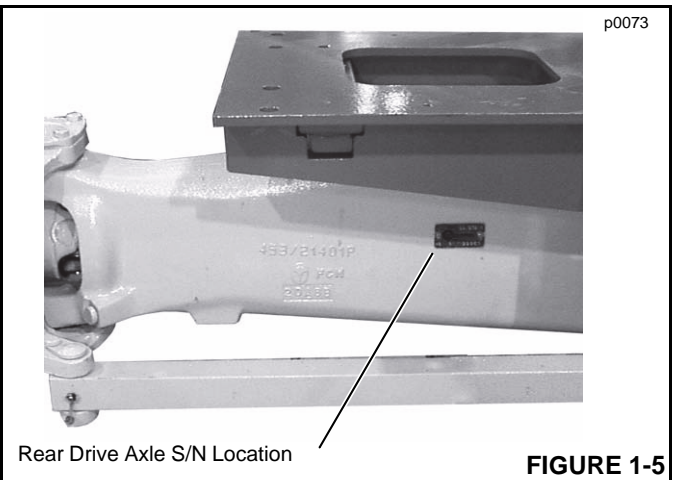
Engine S/N Location

FIGURE 1-2



Front Drive/Steer Axle

FIGURE 1-4



Rear Drive Axle S/N Location

FIGURE 1-5

## GENERAL SPECIFICATIONS

### Engine

Make and model.....	Cummins QSB3.3L -4 Cyl. Diesel Tier 4i
Type of Aspiration .....	Turbocharged
Horsepower.....	100 hp @ 2600 rpm
Low idle speed .....	900 rpm
Intermediate Speed Control (ISC) Idle Speed .....	1200 rpm - Coolant Temperature is less than 71° C (160° F)
Maximum engine speed.....	2600 rpm

### Tires

Size .....	12.00R20
Type .....	Radial
Air pressure.....	896 kPa (135 psi)
Wheel nut torque.....	680 Nm (500 lb-ft)

### Electrical System

Rating.....	12 VDC negative ground
Number and type of batteries:	
Standard Battery .....	One-maintenance free
Battery (Two with cold weather start) .....	150 amp/hr each
Battery rating.....	150 amp/hr
Alternator .....	120 amps

### FUEL TANK

Capacity .....	151 L (40 gal)
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### HYDRAULIC SYSTEM

Primary Pump.....	Piston, 60 cc - CCW
Swing Motor .....	Single section, gerotor-type
Hoist Motor .....	Gear
Hydraulic Filters.....	One 3-micron filter in line from valves One 30- mesh suction filter inside hydraulic tank
Hydraulic Cylinders .....	Double-acting cylinders for lift, telescope, steering and outriggers
Hydraulic Tank.....	123 L (32 gal.) capacity, steel construction with internal baffles

### Boom

Reach (from center line of rotation)	
3 Section Boom.....	12.50 m (41' 0")
4 Section Boom.....	15.24 m (50')
Boom Extension - Fixed (optional) .....	4.6 m (15 ft)

Boom Elevation ..... 0° to 69°

**MAST ROTATION - 360°**

Mast Bearing (Diameter) ..... 860.6 mm (33.884 in)  
 Swing Drive Mechanism ..... Hydraulic motor driven gearbox  
 Swing Speed ..... 2.1 rpm

**Wire Rope**

Wire Rope (Main Hoist):

**Domestic**

**Size** ..... **14.3 mm (9/16") 6 x 19 EIPS-IWRC**

**Length** ..... **97.5 m (320 ft)**

**CE**

Diameter ..... 14 mm

Type ..... 8 x 25 EIPS-IWRC

Length ..... 97.5 (320 ft)

**Wire Rope (Optional Below Deck Winch):**

Diameter ..... 11.1 mm (7/16 in)

Length ..... 35.1 m (115 ft)

**Hydraulic System**

Filters ..... 10 micron return line filter  
 ..... 30 mesh suction filter in tank

**Weight**

Crane Gross Vehicle Weight ..... 13,488 kg (29,735 lb)

**Travel Speeds**

**Two-Wheel Steer**

**1st gear** ..... **6.4 km/hr (4 mph)**

**2nd gear** ..... **11.3 km/hr (7 mph)**

**3rd gear** ..... **21 km/hr (13 mph)**

**4th gear** ..... **34 km/hr (21 mph)**

Crane Gross Vehicle Weight ..... 13,488 kg (29,735 lb)

**FRONT AXLE DRIVE**

**Type** ..... **International Transmissions Limited**

**Model** ..... **SD80 - Center Drive Head**

**REAR AXLE DRIVE**

**Type** ..... **International Transmissions Limited**

**Model** ..... **SD80 - Offset Drive Head**

**REAR AXLE NON-DRIVE**



Type ..... International Transmissions Limited  
 Model ..... SD80 - Offset with No Drive Head

**Operating Dimensions**

**Two-Wheel Steer**

- Outside turning radius  
 (center line outside tires) ..... 6.09 m (19' 10.5")
- Outside turning radius  
 (end of boom extension, 41' boom) ..... 7.75 m (25' 5")  
 (end of boom extension, 50' boom) ..... 7.66 m (25' 2")

**Four-Wheel Steer**

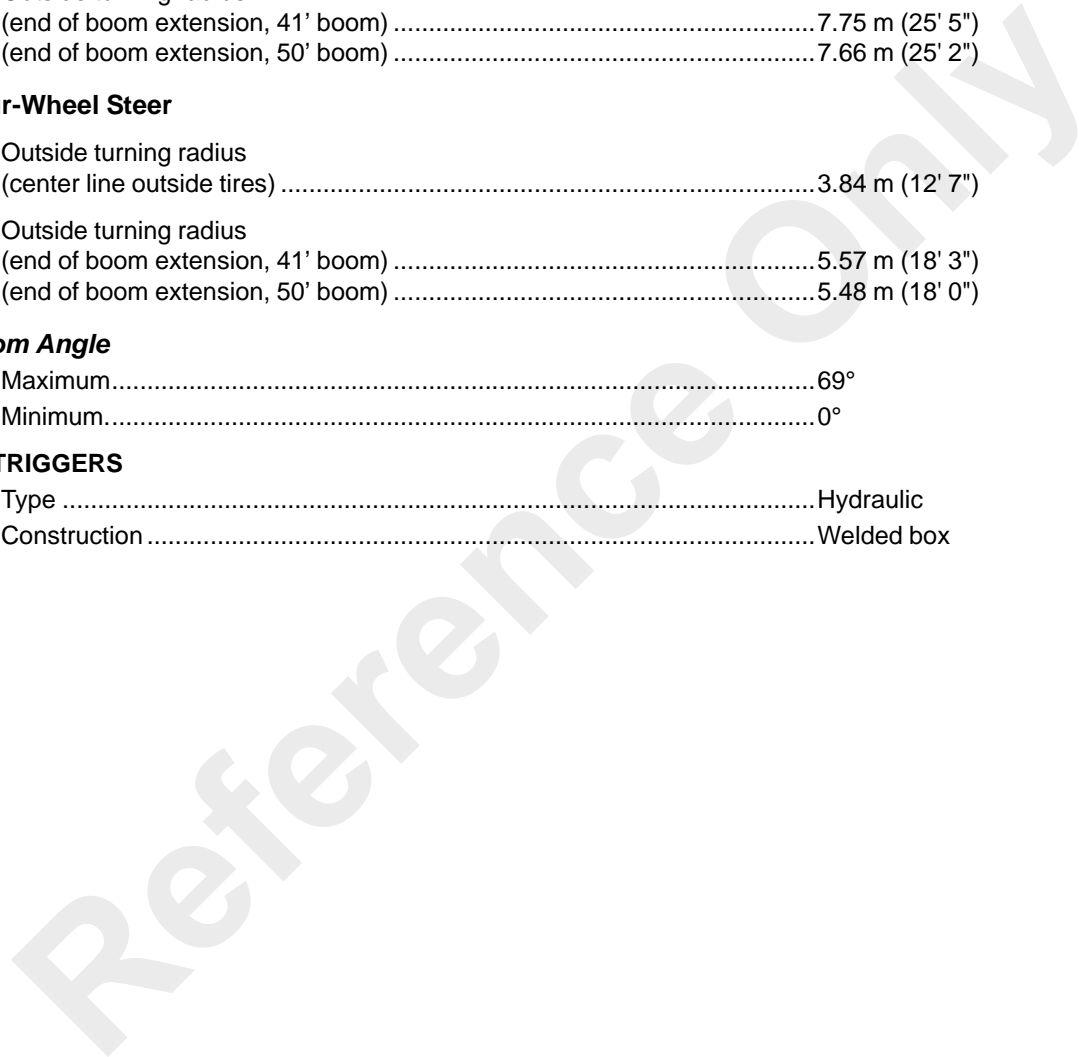
- Outside turning radius  
 (center line outside tires) ..... 3.84 m (12' 7")
- Outside turning radius  
 (end of boom extension, 41' boom) ..... 5.57 m (18' 3")  
 (end of boom extension, 50' boom) ..... 5.48 m (18' 0")

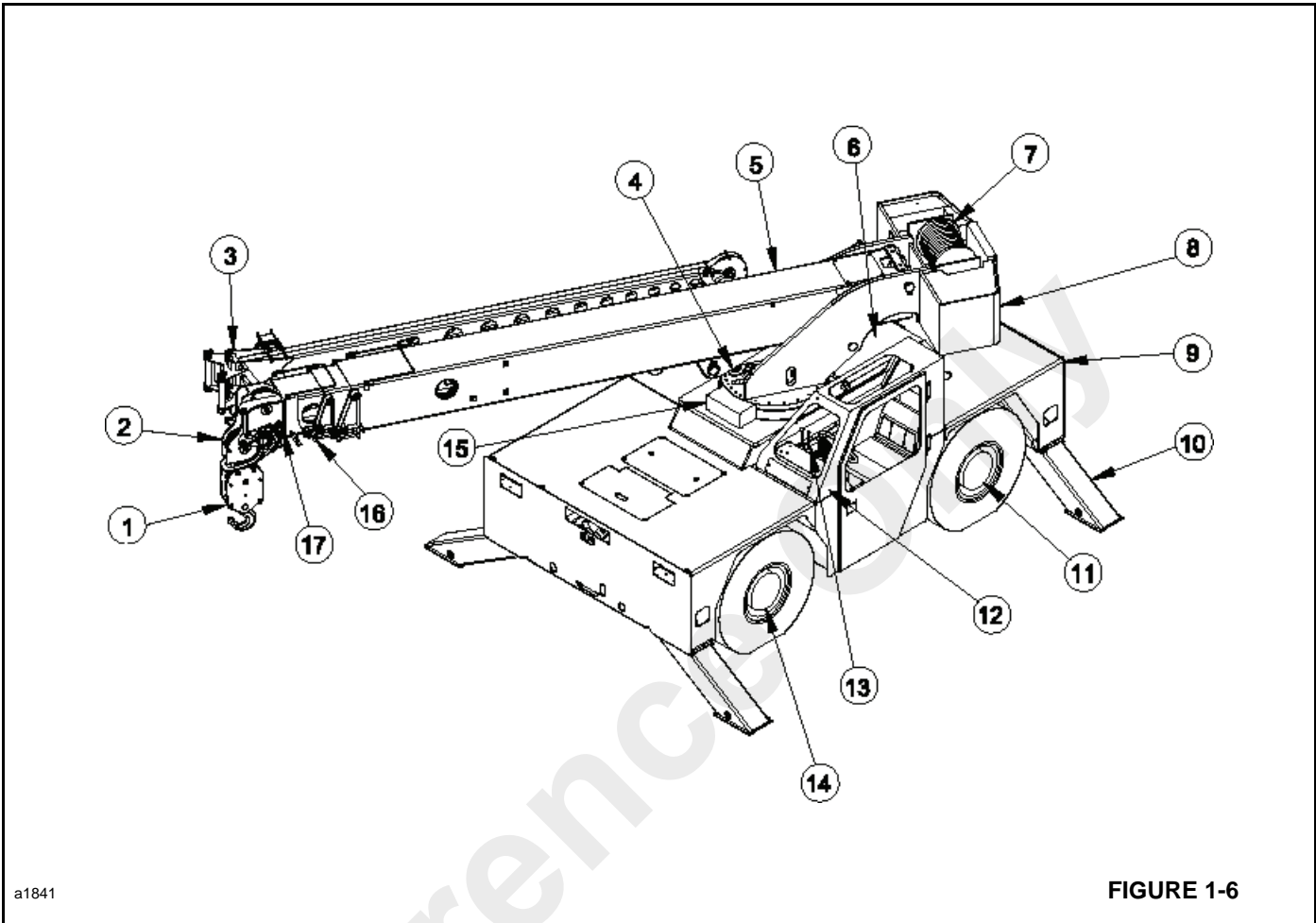
**Boom Angle**

Maximum ..... 69°  
 Minimum ..... 0°

**OUTRIGGERS**

Type ..... Hydraulic  
 Construction ..... Welded box





a1841

FIGURE 1-6

Item	Description	Item	Description
1	Hook Block	11	Rear Axle
2	Boom Nose	12	Operator's Cab
3	Boom Extension	13	Operator Controls
4	Lift Cylinders (2)	14	Front Axle
5	Boom	15	Swing Motor and Gearbox
6	Engine Location	16	Second Boom Section
7	Main Hoist	17	Third Boom Section
8	Mast and Counterweights		
9	Chassis		
10	Outriggers		

## GENERAL MAINTENANCE

These general suggestions should be helpful in following the instructions in this manual. In analyzing a system malfunction, use a systematic approach to locate and correct the problem.

**NOTE:** Your safety and that of others is always the number one consideration when working around machines.

Safety is a matter of thoroughly understanding the job to be done and the application of good common sense. It is not just a matter of do's and don'ts. Stay clear of all moving parts.

1. Determine the problem.
2. List possible causes.
3. Devise checks.
4. Conduct checks in a logical order to determine the cause.

5. Consider the remaining service life of components against the cost of parts and labor necessary to replace them.
6. Make the necessary repair.
7. Recheck to ensure that nothing has been overlooked.
8. Functionally test the failed part in its system.

## Cleanliness

An important item in preserving the long life of the crane is keeping dirt out of working parts. Enclosed compartments, seals, and filters have been provided to keep the supply of air, fuel, and lubricants clean. It is important that these enclosures be maintained.

Whenever hydraulic, fuel, lubricating oil lines, or air lines are disconnected, clean the adjacent area, as well as, the point of connection. As soon as the disconnection is made, cap, plug, or tape each line or opening to prevent entry of foreign material. The same recommendations for cleaning and covering apply when access covers or inspection plates are removed.

Clean and inspect all parts. Be sure all passages and holes are open. Cover all parts to keep them clean. Be sure parts are clean when they are installed. Leave new parts in their containers until ready for assembly.

Clean the rust preventive compound from all machined surfaces of new parts before installing them.

## After Cleaning

Remove all water or solvent from the parts immediately after cleaning. Use compressed air or a clean cloth. Make sure the parts are completely dry and clean. DO NOT use compressed air on bearings. Spinning bearings without lubricant will cause damage to the bearing, and could cause the bearing to fly apart.



### CAUTION

#### Eye Injury Hazard!

When using compressed air use only low air pressure and keep air stream from direction of face.

Always wear eye and face protection when using compressed air. Injury to eyes could occur.

## Removal and Installation

When performing maintenance, do not attempt to manually lift heavy parts when hoisting equipment should be used. Never locate or leave heavy parts in an unstable position. When raising a crane or portion thereof, ensure the crane is

blocked securely and the weight is supported by blocks or jack stands rather than by lifting equipment.

When using hoisting equipment, follow the hoist manufacturers recommendations and use lifting devices that will allow you to achieve the proper balance of the assemblies being lifted and to ensure safe handling. Unless otherwise specified, all removals requiring hoisting equipment should be accomplished using an adjustable lifting attachment or straps designed for that purpose. All supporting members (straps, chains and cables) should be parallel to each other and as near perpendicular as possible to the top of the object being lifted.

**NOTE:** The capacity of an eyebolt diminishes as the angle between the supporting members and the object becomes less than 90°. Eyebolts and brackets should never be bent and should only have stress in tension

Some removals require the use of lifting fixtures to obtain proper balance. The weights of some components are given in their respective sections of the manual.

If a part resists removal, check to be certain all nuts and bolts have been removed and that an adjacent part is not interfering.

## Disassembly and Assembly

When disassembling or assembling a component or system, complete each step in turn. Do not partially assemble one part and start assembling another. Make all adjustments as recommended. Always check the job after it is completed to see that nothing has been overlooked. Recheck the various adjustments by operating the machine before returning it to service.

## Pressing Parts

When pressing one part into another, use an anti-seize compound or a molybdenum disulfide base compound to lubricate the mating surfaces.

Assemble tapered parts dry. Before assembling parts with tapered splines, be sure the splines are clean, dry, and free from burrs. Position the parts together by hand to mesh the splines before applying pressure.

Parts which are fitted together with tapered splines are always very tight. If they are not tight, inspect the tapered splines and discard the part if the splines are worn.

## Locking Devices

Lockwashers, flat metal locks, or cotter pins are used to lock nuts and bolts.

Flat metal locks must be installed properly to be effective. Bend one end of the lock around the edge of the part. Bend the other end against one flat surface of the nut or bolt head.

Always use new locking devices on components which have moving parts.

When installing lockwashers on housings made of aluminum or thin sheetmetal, use a flat washer between the lockwasher and the housing.

## Wires and Cables

Batteries should always be disconnected prior to working on the electrical system.

When removing or disconnecting a group of wires or cables, tag each one to ensure proper identification during assembly.

## Shims

When shims are removed, tie them together and identify them as to location. Keep shims clean and flat until they are reinstalled.

## Hoses and Tubes

### **▲ DANGER**

#### **High Pressure/Temperature Hazard!**

Exercise extreme care around pressurized hydraulic hoses or tubes. **DO NOT** work on a hydraulic system while it is in operation or until all pressure is released. Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

Stay clear of all hydraulic oil leaks. Relieve system pressure and use a piece of cardboard or paper to check for leaks. Do not use your hands.

Fluid injected into skin must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene will result.

### **Inspection**

Check hoses carefully. Do not use your bare hands to check for leaks.

Tighten all connections to recommended torque.

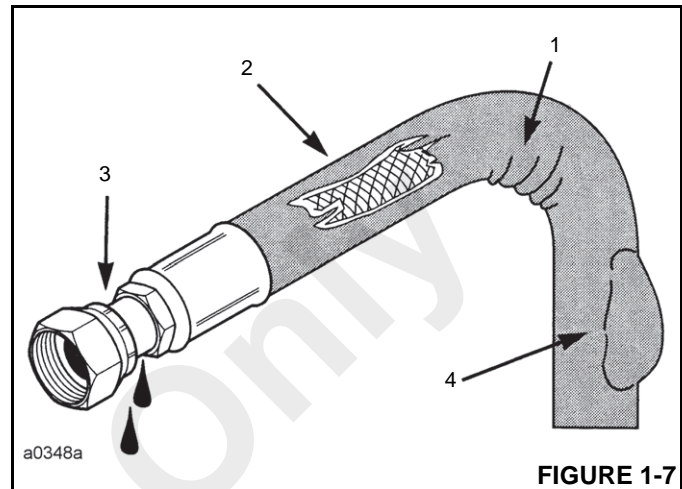
If the hose end connections are damaged, always replace the hose or tube. Damaged, dented, crushed, or leaking hose fittings restrict oil flow and the operation of the parts being served. Fittings showing signs of movement from their original position have failed and must be replaced.

Be sure hoses are in good condition. If in doubt, replace them.

Replace hoses if any of the following is evident Figure 1-7:

- Evidence of kinking or crushing (1)

- Chaffing or cuts; wire is exposed (2)
- Damaged or leaking fittings (3)
- Localized ballooning (4)



### **Installation**

1. When installing a new hose, loosely connect each end and make sure the hose takes up the designed position before tightening the connection. Clamps should be tightened sufficiently to hold the hose without crushing and to prevent chafing.
2. If a hose is replaced on a part that moves during operation, be sure it moves freely by moving the part through its complete range of movement.
3. Be sure any hose which has been installed is not kinked or twisted.

Free moving, unsupported hoses must never rub on each other or related work surfaces. This causes chafing and reduces hose life.

## Bearings

### **Antifriction Bearings**

When an antifriction bearing is removed, cover it to keep out dirt and abrasives. Wash bearings in non-flammable cleaning solution and allow them to drain dry. The bearing may be dried with compressed air but do not spin the bearing. Discard the bearings if the races and balls or rollers are pitted, scored, or show signs of heat damage. If the bearing is serviceable, coat it with oil and wrap it in clean waxed paper. Do not unwrap new bearings until time of installation. The life of an antifriction bearing will be shortened if not properly lubricated. Dirt in an antifriction bearing can cause the bearing to lock resulting in the shaft turning in the inner race or the outer race turning within the cage.

**Double Row, Tapered Roller**

Double row, tapered roller bearings are precision fit during manufacture and components are not interchangeable. The cups, cones, and spacers are usually etched with the same serial number and letter designator. If no letter designators are found, wire the components together to assure correct installation. Reusable bearing components should be installed in their original positions.

**Heating Bearings**

Bearings which require expansion for installation should be heated in oil not to exceed 250°F (121°C). When more than one part is heated to aid in assembly, they must be allowed to cool and then pressed together again. Parts often separate as they cool and contract.

**Installation**

Lubricate new or used bearings before installation. Bearings that are to be preloaded must have a film of oil over the entire assembly to obtain accurate pre-loading. When installing a bearing, spacer, or washer against a shoulder on a shaft, be sure the chamfered side is toward the shoulder.

When pressing bearings into a retainer or bore, uniformly apply pressure to the outer race. If the bearing is pressed on the shaft, uniformly apply pressure on the inner race.

**Preload**

Preload is an initial load placed on the bearing at the time of assembly. Whether a tapered roller bearing should have preload could depend on any of several conditions: rigidity of the housings and shaft, bearing spread, speed of operation, etc.

To determine whether a bearing requires preload or end clearance, consult the disassembly and assembly instructions pertaining to that bearing.

Care should be exercised in applying preload. Misapplication while preloading bearings requiring end clearance can result in bearing failure.

**Sleeve Bearings**

Do not install sleeve bearings with a hammer. Use a press and be sure to apply the pressure directly in line with the bore. If it is necessary to drive a bearing into place, use a bearing driver or a bar with a smooth flat end. If a sleeve bearing has an oil hole, align it with the oil hole in the mating part.

**Gaskets**

Be sure the holes in the gaskets correspond with the passages in the mating parts. If it is necessary to make gaskets, select material of the proper type and thickness. Be

sure to cut holes in the right places. Blank gaskets can cause serious damage.

When removed, always install new cylinder head and manifold gaskets using recommended gasket compound on head gaskets to allow uniform sealing.

**Batteries**

Clean batteries by scrubbing them with a solution of baking soda and water. Rinse with clear water. After cleaning, dry thoroughly and coat terminals and connections with an anti corrosion compound or grease.

If the crane is to be stored or not used for an extended period of time, the batteries should be removed. Store the batteries in a cool (not subfreezing), dry place, preferably on wooden shelves. Never store on concrete. A small charge should be introduced periodically to keep the specific gravity rating at recommended level.

**Hydraulic Systems****▲ DANGER****High Pressure/Temperature Hazard!**

Exercise extreme care around pressurized hydraulic systems. DO NOT work on a hydraulic system while it is in operation or until all pressure is released.

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

Stay clear of all hydraulic oil leaks. Relieve system pressure and use a piece of cardboard or paper to check for leaks. Do not use your hands.

Fluid injected into skin must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene will result.

**Cleanliness**

Contaminants in a hydraulic system affect operation and will result in serious damage to the system components. Dirty hydraulic systems are a major cause of component failures.

**Keep the System Clean**

When removing components of a hydraulic system, cover all openings on both the component and the crane.

If evidence of foreign particles is found in the hydraulic system, flush the system.

Disassemble and assemble hydraulic components on a clean surface.

Clean all metal parts in a nonflammable cleaning fluid. Then lubricate all components to aid in assembly.

### **Sealing Elements**

Inspect all sealing elements (O-ring, gaskets, etc.) when disassembling and assembling the hydraulic system components. Installation of new elements is always recommended.

### **Hydraulic Lines**

When installing metal tubes, tighten all bolts finger-tight. Then, in order, tighten the bolts at the rigid end, the adjustable end, and the mounting brackets. After tubes are mounted, install the hoses. Connect both ends of the hose with all bolts finger-tight. Position the hose so it does not rub on the crane or another hose and has a minimum of bending and twisting. Tighten both couplings.

Due to manufacturing methods there is a natural curvature to a hydraulic hose. The hose should be installed so any bend is with this curvature.

### **Visual Inspection of Hoses and Fittings**

1. Visually inspect hoses and fittings once a month or every 250 hours for the following:
  - Leaks at hose fitting or in hose
  - Damaged, cut, or abraded cover
  - Exposed reinforcement

- Kinked, crushed, flattened, or twisted hose
- Hard, stiff, heat cracked, or charred hose
- Blistered, soft, degraded, or loose cover
- Cracked, damaged, or badly corroded fittings
- Fitting slippage on hose
- Other signs of significant deterioration

If any of the above conditions exist, evaluate hose assemblies for correction or replacement. For replacement of hose assemblies, refer to your Manitowoc Crane Care Parts Manual.

2. At the same service interval, visually inspect all other hydraulic components and valves for the following:
    - Leaking ports.
    - Leaking valve sections or manifolds and valves installed into cylinders or onto motors.
    - Damaged or missing hose clamps, guards, or shields.
    - Excessive dirt and debris around the hose assemblies.
- If any of these conditions exist, address them appropriately.
3. All hydraulic hose assemblies are recommended to be replaced after 8000 hours of service life.

Table 1-1

Zone	Classification
A	Tropical Moist: All months average above 18°C. Latitude 15° - 25° North and South
B	Dry or Arid: Deficient precipitation most of the year. Latitude 20° - 35° North and South
C	Moist Mid-Latitude: Temperature with mild winters. Latitude 30° - 50° North & South
D	Moist Mid-latitude: Cold winters. Latitude 50° - 70° North & South
E	Polar: Extremely cold winters and summers. Latitude 60° - 75° North & South

4. Hydraulic hose assemblies operating in a temperature climate zone “C” Table 1-1 are recommended to be replaced after 8000 hours of service life.
5. Hydraulic hose assemblies operating in climate zones “A” and “B” with high ambient temperatures, could see hose service life reduced by 40 to 50%, therefore, it is recommended to replace these hoses after 4000 to 5000 hours of service life.
6. Hydraulic hose assemblies operating in climate zones “D” and “E” should expect a degradation of mechanical properties such as elasticity, therefore, it is recommended these hoses be inspected and addressed accordingly.

**Electrical System**

**Harnesses, Wires, and Connectors**

Visually inspect all electrical harnesses, cables, and connectors every month or 250 hours for the following:

- Damaged, cut, blistered, or cracked insulation.
- Exposed bare wires.
- Kinked or crushed wires and cables.
- Cracked or corroded connectors, battery terminals, and ground connections.

If any the above conditions exist, evaluate, clean and replace as necessary.

The climate in which the crane operates affects the service life of the electrical components. The climate zones are defined in Table 1-1. Recommended replacement of harness and cables is as follows:

- Climate zone C after 10,000 hours of service.
- Climate zones A and B with high ambient temperatures and duty cycles after 8000 hours of service.
- Climate zones D and E after 5,000 hours of service.
- Salt water conditions after 8,000 hours of service.

**Fatigue of Welded Structures**

Experience has shown that highly stressed welded structures when repeatedly subjected to varying stresses caused by twisting, shock, bending, and intentional and/or unintentional overloads, often become subject to weld cracking which may be attributed to fatigue of the welded joint. This condition is not uncommon in construction equipment.

Equipment should be periodically inspected for evidence of weld fatigue. The frequency of these inspections should increase with the age of the equipment and the severity of the application. The following are known high stress areas applicable to Grove cranes, and a visual inspection of these areas should be made part of an owner’s planned preventive maintenance program:

- Telescopic Boom: wear pad retaining structures, hydraulic cylinder attaching points, boom pivot shaft retaining structures.
- Outrigger pads, beams, boxes and attachment structures.
- Main frame: generally in the area of doubler plates and crossmembers; at the junction of front and rear frame members on truck cranes.
- Turntable bearing connection—where bearing is welded to the crane superstructure or chassis.
- Counterweight support structures.
- Chassis axle and suspension mounting structures.
- Hydraulic cylinder end connections.

The above is provided only as a guide, and your inspection plan should not be limited to the areas listed. A thorough visual inspection of all weldments is good practice.

Anyone requiring more detailed inspection instructions and/or repair procedures may request same by contacting your local Manitowoc distributor.

**Loctite®****⚠ CAUTION****Skin and/or Eye Hazard!**

Loctite type adhesives contain chemicals that may be harmful if misused. Read and follow the instructions on the container.

Always follow the directions on the Loctite container, as not all Loctite types are suitable for all applications. Various types of Loctite are specified throughout the Service Manual. The following types of Loctite brand adhesives are available from the Parts Department of the local Manitowoc distributor.

**Application of Medium Strength Loctite**

**NOTE:** The fastener may be re-used; the adhesive may be re-applied over cured adhesive residue.

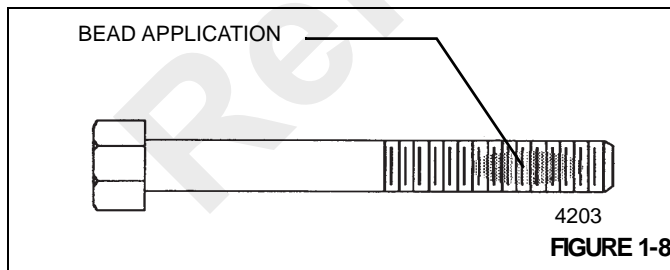
The following procedure covers the proper application and curing method for medium strength Loctite adhesive/sealant (Loctite #242) and primer (Locquic® Primer T7471).

**Primer Application**

**NOTE:** Primer is not required with Loctite #243.

**NOTE:** It is not necessary to bathe the threads in primer.

1. Ensure the threaded surface, both male and female, is clean and free of dirt and oil. Apply a light spray coating of primer to both male and female parts to be joined to clean and accelerate the curing process.
2. Allow the part to dry prior to adhesive/sealant application.

**Adhesive/Sealant Application**

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 1-8).
2. In a blind hole application, a bead of several drops of adhesive should be applied into the bottom of the hole to be hydraulically forced up during engagement.
3. After application and engagement of mated threads, fixturing will occur within five (5) minutes if primed prior

to engagement. Fixturing may take up to 30 minutes on unprimed parts.

4. Time required to achieve full strength is 24 hours. Maximum ultimate strength is achieved using no primer with this specific threadlocking adhesive.

**Fasteners and Torque Values**

Use bolts of the correct length. A bolt which is too long may bottom before the head is tight against the part it is to hold. If a bolt is too short, there may not be enough threads engaged to hold the part securely. Threads can be damaged. Inspect them and replace fasteners, as necessary.

Torque values should correspond to the type bolts, studs, and nuts being used.

The torque tables are provided by Manitowoc for reference when performing maintenance.

Use of proper torque values is extremely important. Improper torquing can seriously affect performance and reliability.

Identification of fastener grade is always necessary. When marked as a high strength bolt (grade 5, 8, etc.), the mechanic must be aware that he/she is working with a highly stressed component and the fastener should be torqued accordingly.

**NOTE:** Some special applications require variation from standard torque values. Reference should always be made to component overhaul procedures for recommendations.

Special attention should be given to the existence of lubricant, plating, or other factors that might require variation from standard torque values.

The use of lubricants on zinc-flake coated parts shall be prohibited since this will change the required torque value.

When maximum recommended torque values have been exceeded, the fastener should be replaced.

Previously installed bolts and nuts of Grade 8 or Class 10.9 and higher may not be reused.

When referring to the applicable torque charts, use values as close as possible to the torque values shown to allow for wrench calibration tolerance.

**Torque Wrenches**

Flexible beam type wrenches, even though they might have a pre-set feature, must be pulled at right angle and the force must be applied at the center of the handle. Force value readings must be made while the tool is in motion. Rigid handle type, with torque limiting devices that can be pre-set to required values, eliminate dial readings and provide more reliable, less variable readings.



**NOTE:** If multipliers and/or special tools are used to reach hard to get at areas, ensure torque readings are accurate.

Torque wrenches are precision instruments and must be handled with care. To ensure accuracy, calibrations must be made on a scheduled basis. Whenever there is a possibility that a torque wrench may have been either overstressed or damaged, it should immediately be removed from service until recalibrated. When using a torque wrench, any erratic or jerking motion can result in the application of excessive or improper torque. ALWAYS use a slow, even movement and STOP when the predetermined value has been reached.

When using step wrenches, calculated wrench settings are valid only when the following conditions are met:

- Torque wrenches must be those specified and forces must be applied at the handle grip. The use of handle extensions will change applied torque to the bolt.

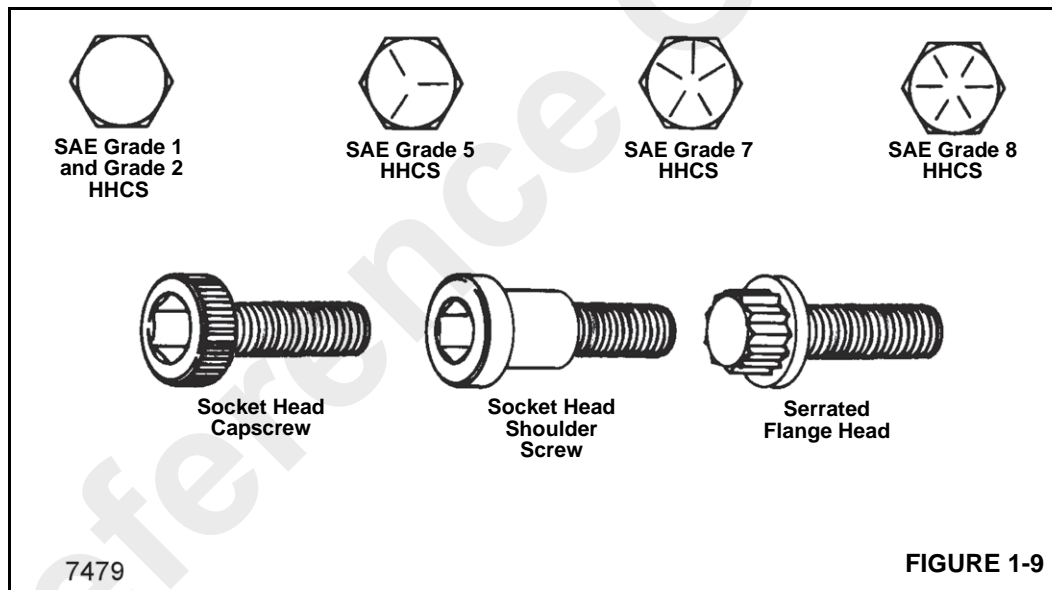
- All handles must be parallel to the step wrench during final tightening. Multiplier reaction bars may be misaligned no more than 30 degrees without causing serious error in torque.
- Multiplier bar handles must be propped or supported within the outer 1/4 of the handle length, or serious under or over tightening will occur.

To convert pounds-foot (lb-ft) of torque to newton meters (Nm), multiply the pounds-foot quantity by 1.3558.

To convert pounds-inch (lb-in) of torque to newton meters (Nm), multiply the pounds-inch quantity by 0.11298.

**Torque Values**

The following tables list the torque values for both ASME standard and metric fasteners. The tables list the values for grade 5 and grade 8 zinc-flake coated, untreated (black) finish and stainless steel fasteners.



**Table 1-2: UNC (Course) Thread: Torque Values for Zinc-Flake Coated and Untreated Fasteners**

		Bolt Diameter - Inches													
		Torque Values (Pounds-Foot, Maximum/Minimum)													
	SAE Grade	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2	
Zinc-Flake	5	7	14	25	40	61	88	121	213	342	512	636	884	1532	
	8	10	20	36	57	86	124	171	301	483	723	1032	1433	2488	
Untreated	5	9.0	19	32	52	78	114	156	270	416	606	813	1141	2028	
		7.7	17	30	48	72	106	144	249	384	560	751	1053	1865	
	8	12.5	26	48	73	120	161	234	385	615	929	1342	2043	3276	
		11.5	24	44	67	110	143	216	355	567	857	1234	1885	3024	

**NOTE:** Studs shall be torqued using capscrew values when grade is known.

Table 1-3: UNF (Fine) Thread: Torque Values for Zinc-Flake Coated and Untreated Fasteners

Bolt Diameter - Inches														
Torque Values (Pounds-Foot, Maximum/Minimum)														
	SAE Grade	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2
Zinc-Flake	5	8	15	28	44	66	95	132	229	364	543	785	944	1654
	8	11	22	39	61	94	134	186	323	514	766	1109	1530	2682
Untreated	5	10	21	36	57	88	126	182	312	458	658	882	1251	2288
		9	19	34	53	81	116	167	287	421	606	814	1155	2105
	8	14.5	26	53	85	125	177	250	425	672	1009	1500	2092	3640
		13.5	24	49	79	115	163	230	393	620	931	1380	1925	3360

NOTE: Studs shall be torqued using capscrew values when grade is known.

Table 1-4: Metric Fasteners, Coarse Thread, Zinc-Flake Coating

Bolt Diameter - Metric																
Torque Values (Nm)																
Grade	M4	M5	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24	M27	M30	M33	M36
8.8	2.6	5.2	9.0	21.6	42.4	73.1	116	178	250	349	467	600	877	1195	1608	2072
10.9	3.7	7.5	12.5	31.5	62.0	110	170	265	365	520	700	900	1325	1800	2450	3150
12.9	4.3	9.0	15.0	36.0	75.0	128	205	315	435	615	830	1060	1550	2125	2850	3700

Table 1-5: Metric Fasteners, Coarse Thread, Untreated

Bolt Diameter - Metric																
Torque Values (Nm, Maximum/Minimum)																
Grade	M4	M5	M6	M7	M8	M10	M12	M14	M16	M18	M20	M22	M24	M27	M30	
8.8	3.1	6.5	11	19	27	53	93	148	230	319	447	608	774	1134	1538	
	2.8	5.9	10	17	25	49	85	136	212	294	413	562	714	1046	1420	
10.9	4.5	9.2	16	26	38	75	130	212	322	455	629	856	1089	1591	2163	
	4.1	8.5	14	24	35	69	120	195	298	418	581	790	1005	1469	1997	
12.9	5.4	11	19	31	45	89	156	248	387	532	756	1029	1306	1910	2595	
	4.9	10	17	28	42	83	144	228	357	490	698	949	1206	1763	2395	

Table 1-6: Metric Fasteners, Fine Thread, Zinc-Flake Coating

Bolt Diameter - Metric														
Torque Values (Nm)														
Grade	M8x1	M10x1	M10x1.25	M12x1.5	M14x1.5	M16x1.5	M18x1.5	M20x1.5	M22x1.5	M24x2	M27x2	M30x2	M33x2	M36x3
8.8	23	46	44	75	123	185	270	374	496	635	922	1279	1707	2299
10.9	34	71	66	113	188	285	415	575	770	980	1425	2025	2500	3590
12.9	41	84	79	135	220	335	485	675	900	1145	1675	2375	2900	4200

Table 1-7: Metric Fasteners, Fine Thread, Untreated

Bolt Diameter - Metric														
Torque Values (Nm, Maximum/Minimum)														
Grade	M8x1	M10x1	M10x1.25	M12x1.5	M14x1.5	M16x1.5	M18x1.5	M20x1.5	M22x1.5	M24x2	M27x2	M30x2	M33x2	M36x3
8.8	29	57	57	100	160	248	345	483	657	836	1225	1661	—	—
	27	53	53	92	147	229	318	446	607	771	1130	1534	—	—
10.9	41	81	81	1140	229	348	491	679	924	1176	1718	2336	—	—
	38	75	75	130	211	322	451	627	853	1085	1587	2157	—	—
12.9	49	96	96	168	268	418	575	816	1111	1410	2063	2800	—	—
	45	90	90	156	246	386	529	754	1025	1302	1904	2590	—	—

Table 1-8: UNC (Coarse) Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

Size	Torque Value	
	lb-in	lb-ft
#5 (0.125)	6.9	—
#8 (0.164)	18	—
#10 (0.190)	21	—
1/4	68	—
5/16	120	10
3/8	210	17.5
7/16	340	28
1/2	—	39
5/8	—	74
3/4	—	114

**NOTE:** Stainless steel fasteners tend to gall while being tightened. To reduce this risk, lubricate the threads with oil or molybdenum disulfide and torque at low speeds without interruptions. Do not use excessive pressure. Impact wrenches are not recommended.

Table 1-9: Metric Coarse Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

Size	Torque Value Nm
M2.5	0.4
M3	0.9
M4	1.5
M5	3.1
M6	5.3
M8	13.0
M10	27.0
M12	45.0
M14	71.1
M16	109
M18	157
M20	220

**NOTE:** Stainless steel fasteners tend to gall while being tightened. To reduce this risk, lubricate the threads with oil or molybdenum disulfide and torque at low speeds without interruptions. Do not use excessive pressure. Impact wrenches are not recommended.

**WELD STUDS (TABLE 1-10)**

Unless otherwise specified the following grade 2 torque values (+/- 10%) apply.

**Table 1-10  
Weld Stud Torque Values**

T-2-4

STUD SIZE	TORQUE
#10	20 lb in
1/4"	4 lb ft
5/16"-18	9 lb ft
5/16"-24	10 lb ft
3/8"	14 lb ft
1/2"	35 lb ft
5/8"	70 lb ft

**Hydraulic Fitting**

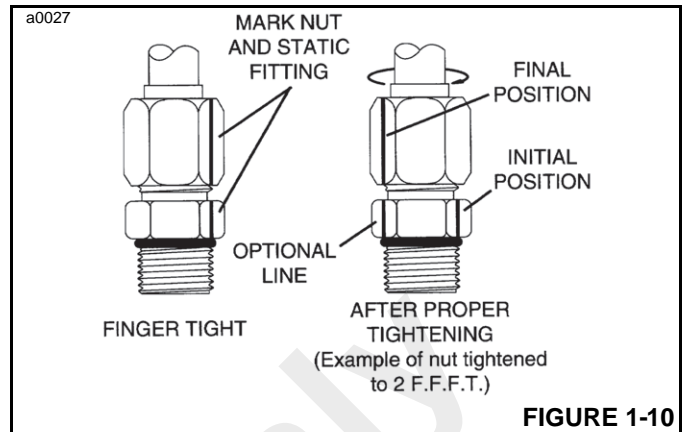
**F.F.F.T. METHOD (Flats from Finger Tight)**

Manitowoc Cranes, Inc. recommends that the F.F.F.T. tightening method described here be used when assembling all hydraulic fittings. This method will minimize the risk of fitting damage or failure due to under or overtightening.

It will also reduce the chance of a leaky connection which is caused normally by different plating combinations of fittings. This method is particularly useful when plating type of fitting is unknown and during maintenance or repair when a joint may be oily.

Follow these steps when tightening all fitting connections:

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Align tube or hose to the mating fitting and check to see that the flare seats properly on the nose of the fitting.
3. Finger tighten the nut onto the fitting. If necessary, a wrench should be used to seat the nut snugly against the fitting. This is considered the "FINGER TIGHT" condition.
4. Using a permanent-type ink marker, make a mark on one of the flats of the nut and continue it onto the hex of the static fitting or port



5. Tighten the joint by the number of flats (F.F.F.T.) as specified in Table 1-11 and 1-12 for size and type of fitting.
6. Optional for future tightening of the same connection.) Extend the line from the nut at its new location onto the hex of the static fitting or port (Figure 1-10).

**37° Flared Steel Fitting - Tube or Hose to Fitting**

1. Follow F.F.F.T. method, see F.F.F.T. METHOD (Flats from Finger Tight).

**Table 1-11**

T-2-5

SAE SIZE	TUBE CONN. (F.F.F.T.)	SWIVEL NUT/ HOSE CONN. (F.F.F.T.)
2	—	—
3	—	—
4	2	2
5	2	2
6	1.5	1.25
8	1.5	1
10	1.25	1
12	1.25	1
14	1	1
16	1	1
20	1	1
24	1	1
32	1	1

**Adjustable Straight**

**Table 1-12**

**Adjustable Straight Thread O-ring**

T-2-6

ADJUSTABLE STEEL STR. THREAD O-RING FITTINGS	
SAE SIZE	(F.F.F.T.)
2	1.0 ± 0.25
3	1.0 ± 0.25
4	1.5 ± 0.25
5	1.0 ± 0.25
6	1.5 ± 0.25
8	1.5 ± 0.25
10	1.5 ± 0.25
12	1.5 ± 0.25
14	1.5 ± 0.25
16	1.5 ± 0.25
20	2.0 ± 0.25
24	2.0 ± 0.25
32	2.0 ± 0.25

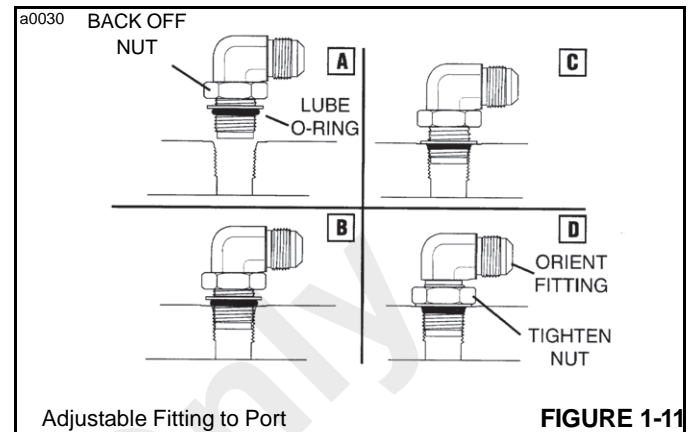
**Thread O-ring Fitting - Fitting to Port (Table 1-12)**

1. Inspect both mating parts for burrs, nicks, scratches, or foreign particles.
2. Lubricate O-ring with a light coat of clean oil (Figure 1-11A).
3. Back off locknut as far as possible (Figure 1-11A).
4. Screw fitting into port by hand until the backup washer contacts face of port and is pushed all the way towards the locknut (Figure 1-11B).
5. To orientate the fitting, unscrew the fitting the required amount, but not more than one full turn (Figure 1-11C).
6. Hold the fitting in the desired position and tighten the nut (Figure 1-11D) following the F.F.F.T. method, See F.F.F.T. METHOD (Flats from Finger Tight) starting with step 4.

**Nonadjustable Straight Thread O-ring Fitting - Fitting to Port (Table 1-13)**

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Lubricate O-ring with clean oil (Figure 1-12).
3. Turn fitting until finger tight.

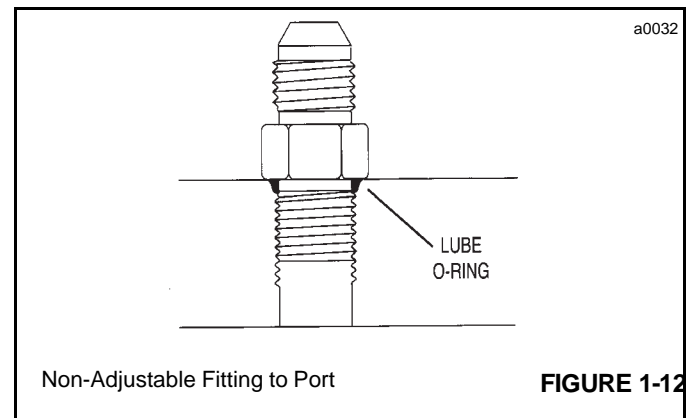
4. Using the assembly torque method, tighten to given torque for size from Table 1-13.



**Table 1-13**

T-2-7

SAE SIZE	NON-ADJUSTABLE STEEL STR. THREAD O-RING FITTINGS	
	TORQUE (lb in)	TORQUE (lb ft)
2	90 ± 5	7.5 ± 0.5
3	170 ± 10	14 ± 1.0
4	220 ± 15	18 ± 1.0
5	260 ± 15	22 ± 1.0
6	320 ± 20	27 ± 2.0
8	570 ± 25	48 ± 2.0
10	1060 ± 50	90 ± 5.0
12	1300 ± 50	110 ± 5.0
14	1750 ± 75	145 ± 6.0
16	1920 ± 25	160 ± 6.0
20	2700 ± 150	225 ± 12.0
24	3000 ± 150	250 ± 12.0
32	3900 ± 200	325 ± 15.0



## WIRE ROPE

### General

The following compendium of information is from various wire rope manufacturers and includes inspection, replacement, and maintenance guidelines for wire rope as established by ANSI/ASME B30.5, federal regulations, and Manitowoc. The inspection interval shall be determined by a qualified person and shall be based on such factors as expected rope life as determined by experience on the particular installation or similar installations, severity of environment, percentage of capacity lifts, frequency rates of operation, and exposure to shock loads. Periodic inspections need not be at equal calendar intervals and should be performed at shorter time intervals as the wire rope approaches the end of its useful life. A periodic inspection shall be performed at least once a year. The following provides inspection and maintenance procedures for wire ropes used on Grove products (e.g. wire rope used as load lines [hoisting cables], boom extension and retraction cables, pendant cables, tow winch cables, and hook block tie down cables).

### Environmental Conditions

The life expectancy of wire rope may vary due to the degree of environmental hostility and other conditions to which these mechanical devices are subjected. Variation in temperature, continuous excessive moisture levels, exposure to corrosive chemicals or vapors or subjecting the wire rope to abrasive material may shorten normal wire rope life. Frequent/periodic inspections and maintenance of your wire rope is recommended for preventing premature wear and to insure long-term satisfactory performance.

### Dynamic Shock Loads

Subjecting wire rope to abnormal loads beyond the endurance limit will shorten the wire ropes life expectancy. Examples of this type of loading are listed below.

1. High velocity movement e.g.; hoisting or swinging of a load followed by abrupt stops.
2. Suspending loads while traveling over irregular surfaces such as railroad tracks, potholes, and rough terrain.
3. Moving a load that is beyond the rated capacity of the lifting mechanism, i.e.; overloading.

### Lubrication

A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added throughout the life of a rope to replace factory lubricant which is used or lost. It is important that lubricant applied as part of a maintenance program shall be compatible with the original lubricant, and to this end, the rope manufacturer should be consulted. Lubricant applied

shall be of the type which does not hinder visual inspection. Those sections of rope which are located over sheaves or otherwise hidden during inspection and maintenance procedures require special attention when lubricating rope. The object of rope lubrication is to reduce internal friction and to prevent corrosion.

During fabrication, ropes receive lubrication; the kind and amount depends on the rope's size, type, and anticipated use. This in-process treatment will provide the finished rope with ample protection for a reasonable time if it is stored under proper conditions. But, when the rope is put into service, the initial lubrication may be less than needed for the full useful life of the rope. Because of this possibility, periodic applications of a suitable rope lubricant are necessary.

The following are important characteristics of a good wire rope lubricant:

- It should be free from acids and alkalis.
- It should have sufficient adhesive strength to remain on the rope.
- It should be of a viscosity capable of penetrating the interstices between wires and strands.
- It should not be soluble in the medium surrounding it under the actual operating conditions (for example, water).
- It should have a high film strength.
- It should resist oxidation.

Before applying lubrication, accumulations of dirt or other abrasive material should be removed from the rope. Cleaning can be accomplished by using a stiff wire brush and solvent, compressed air, or live steam. Immediately after the wire rope is cleaned, it should be lubricated. Many techniques may be used; these include bath, dripping, pouring, swabbing, painting or pressure spray methods. Whenever possible, the lubricant should be applied at the top of a bend in the rope, because at that point the strands are spread by bending and are more easily penetrated. There should be no load on the rope while it is being lubricated. It should be noted, the service life of wire rope will be directly proportional to the effectiveness of the method used and amount of lubricant reaching the working parts of the rope.

### Precautions and Recommendations During Inspection or Replacement

1. Always lock out equipment power when removing or installing wire rope assemblies.
2. Always use safety glasses for eye protection.
3. Wear protective clothing, gloves, and safety shoes as appropriate.

4. Use supports and clamps to prevent uncontrolled movement of wire rope, parts, and equipment.
5. When replacing fixed length cable assemblies (for example, pendants) having permanently attached end fittings use only pre-assembled lengths of wire rope as supplied from Manitowoc. Do not build lengths from individual components.
6. Replace an entire wire rope assembly. Do not attempt to rework damaged wire rope or wire rope ends.
7. Never electroplate wire rope assemblies.
8. Do not weld any wire rope assembly or component unless welding is recommended by the wire rope manufacturer. Welding spatter shall never be allowed to come in contact with the wire rope or wire rope ends. In addition, be sure that the wire rope is not an electrical path during other welding operations.
9. Wire ropes are manufactured from special steels. If heating a wire rope assembly is absolutely necessary for removal, the entire wire rope assembly shall be discarded.
10. On systems equipped with two or more wire rope assemblies operating as a matched set, they shall be replaced as an entire set.
11. Do not paint or coat wire ropes with any substance except approved lubricants.
12. Measure the rope's diameter across crowns (1) of the strands when determining if rope has become damaged (Figure 1-13).

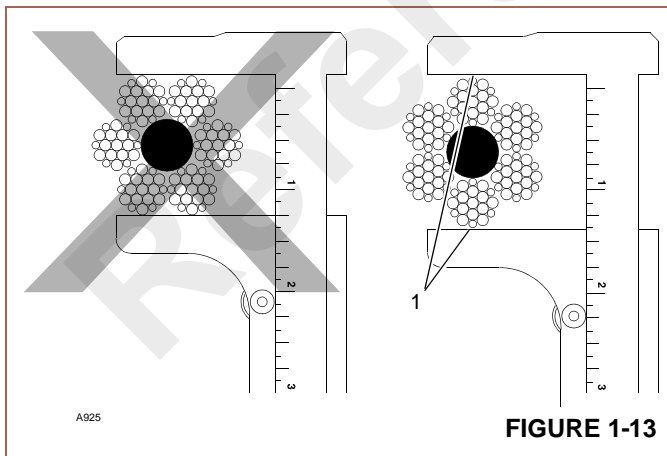


FIGURE 1-13

13. When checking for broken wires (5) Figure 1-14 relax the rope, move it off "pick-up points". Defect in the rope is in relation to "Lay Length" (2) which is the distance measured along rope in which one strand (3) makes one complete revolution around the core (4).

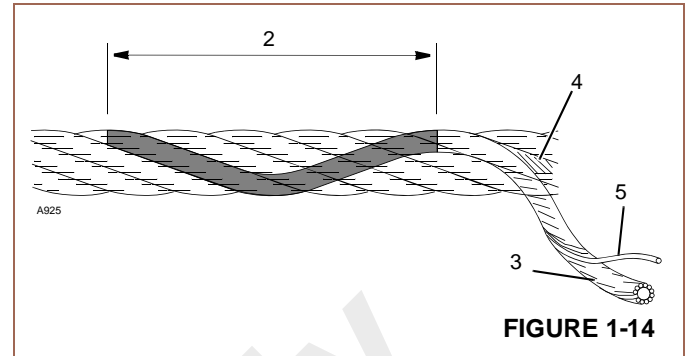


FIGURE 1-14

### Wire Rope Inspection (Running Ropes and Pendant Cables)

Wire rope should be inspected frequently/daily and periodically/yearly in accordance with the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies. Recommended inspection intervals may vary from crane to crane and may vary based on environmental conditions, frequency of lifts, and exposure to shock loads. The inspection time intervals may also be predetermined by state and local regulatory agencies.

**NOTE:** Wire rope may be purchased through Manitowoc Crane Care.

Any deterioration observed in the wire rope should be noted in the equipment inspection log and an assessment concerning wire rope replacement should be made by a qualified person.

### Keeping Records

A signed and dated report of the wire rope's condition at each periodic inspection must be kept on file at all times. The report must cover all inspection points listed in this section. The information in the records can then be used to establish data which can be used to determine when a wire rope should be replaced.

It is recommended that the wire rope inspection program include reports on the examination of wire rope removed from service. This information can be used to establish a relationship between visual inspection and the rope's actual internal condition at the time of removal from service.

### Frequent Inspection

A frequent daily visual inspection is recommended for all running ropes in service. This inspection should be made on all wire rope which can be expected to be in use during the day's operation. This inspection should be used to monitor progressive degradation and to discover severe damages necessitating wire rope replacement such as:

- Distortion, kinking, crushing, un-stranding, birdcaging, reduction of diameter, etc.

- General corrosion.
- Broken or cut strands.
- Number, distribution and type of broken wires.
- Evidence of core failure.
- End fitting wear/abrasion.

Pay particular attention to areas of the rope where wear and other damage is likely to occur:

- Pick-up Points: Sections of wire rope that are repeatedly stressed during each lift, such as those sections in contact with sheaves.
- End Attachments: The point where a fitting is attached to the wire rope or the point where the wire rope is attached to the drum.
- Abuse Points: The point where the wire rope is subjected to abnormal scuffing and scraping.

### **Periodic Inspection**

Wire rope should be inspected periodically/annually or at a shorter time interval if necessitated by environmental or other adverse conditions, and shall cover the entire length of the wire rope. Only the outer surface of the wire rope need be inspected, and no attempt should be made to open the rope. Periodic inspection should include all items listed under frequent inspection plus the following:

- Inspect for reduction of rope diameter below nominal diameter.
- Inspect for severely corroded or broken wires at end connections.
- Inspect for severely corroded, cracked, bent, worn, or improperly applied end connections.
- Inspect wire rope in areas subjected to rapid deterioration such as:
  - Sections in contact with saddles, equalizer sheaves, or other sheaves where wire rope travel is limited.
  - Sections of wire rope at or near terminal ends where corroded or broken wires may protrude.
- Inspect boom nose sheaves, hook block sheaves, boom extension/jib sheaves, auxiliary boom nose sheaves, and hoist drums for wear. Damaged sheaves or hoist drums can accelerate wear and cause rapid deterioration of the wire rope.

## **Wire Rope Inspection (Boom Extension and Retraction Cables)**

### **Periodic Inspection**

It is recommended that a periodic inspection of all boom extension and retraction cables be performed using the

following guidelines. This inspection shall cover the entire length of the extension and retraction cables. This inspection should be used to monitor progressive degradation and to discover severe damages necessitating wire rope replacement or equipment repair. Inspection criteria are as follows:

- Inspect for reduction of rope diameter below nominal diameter.
- Inspect for severely corroded or broken wires at end connections.
- Inspect for severely corroded, cracked, bent, worn, or improperly applied end connections.
- Inspect wire rope in areas subjected to rapid deterioration such as:
  - Sections in contact with saddles, equalizer sheaves, or other sheaves where wire rope travel is limited.
  - Sections of wire rope at or near terminal ends where corroded or broken wires may protrude.
  - Sections of wire rope in contact with stationary surfaces where abrasion or chafing may take place as a result of equipment vibration.
- Inspect for damaged or wobbly boom extension and retraction sheaves that may cause rapid deterioration of the wire rope.
- Inspect for unusual cable sag/stretch and be sure cables used in sets all have an equal tension applied. Repeated need for adjustment of an individual cable is evidence of cable stretch and indicates the need for additional and more thorough inspection in order to determine and correct the cause.

## **Wire Rope Inspection/Replacement (All Wire Rope)**

No precise rules can be given for determination of the exact time for replacement of wire rope since many variable factors are involved. Determination regarding continued use or replacement of wire rope depends largely upon the good judgement of an appointed and qualified person who evaluates the remaining strength in a used rope after allowance for any deterioration disclosed by inspection.

Wire rope replacement should be determined by the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies and as recommended by Manitowoc. All wire rope will eventually deteriorate to a point where it is no longer usable. Wire rope shall be taken out of service when any of the following conditions exist:

- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.



- Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than 5%.
- In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.
- In rotation resistant rope, two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
- Severe corrosion as evidenced by pitting.
- Manitowoc recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
- Manitowoc recommends for cable extended booms, that boom extension cables be replaced every seven (7) years.

**Seizing Wire Rope**

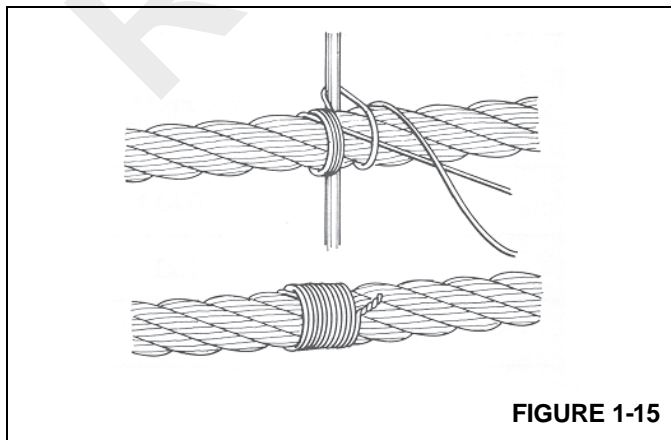
It is important to seize the ends of rotation resistant wire ropes to prevent the displacement and unraveling of the individual wires and strands at the ends. All preformed and non-preformed styles of wire rope should be seized prior to cutting. Seizings must be placed on both sides of the point where the wire rope is to be cut.

The two preferred methods for seizing wire ropes are:

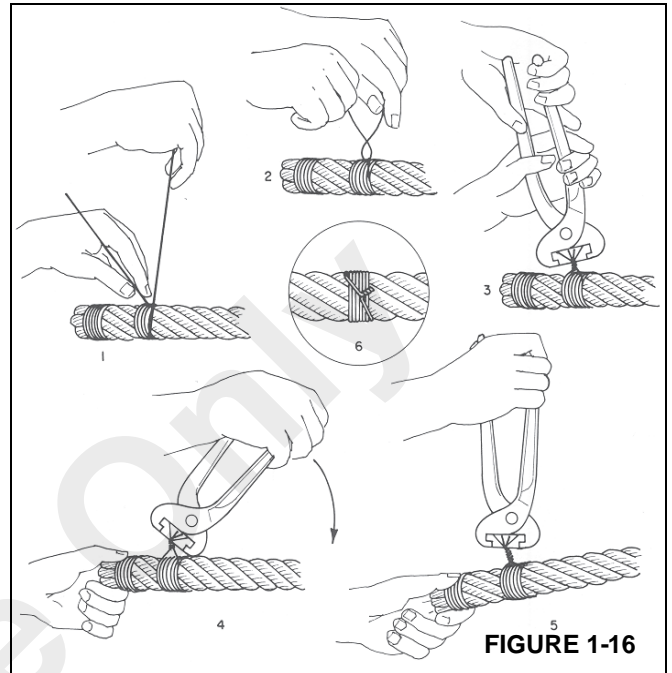
**Method 1**

Using a length of soft annealed wire Figure 1-15, place one end in the groove between two strands of the wire rope. Turn the long end of the annealed wire at right angles to the wire and wrap it tightly over the portion in the groove.

The two ends of the annealed wire should be twisted together tightly. Cut off the excess wire and pound the twist flat against the wire rope.

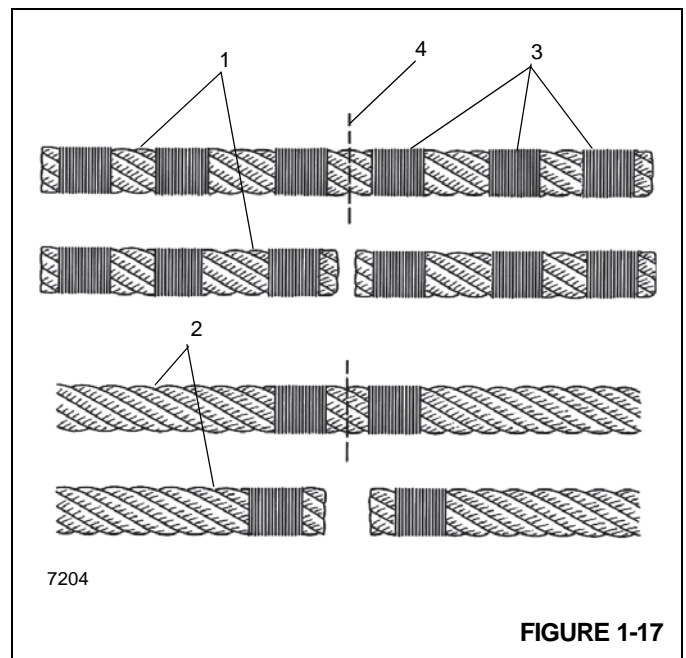


**Method 2**



Wind a length of soft annealed wire Figure 1-16 around the wire rope at least seven times. The two ends should be twisted together in the center of the seizing. Tighten the seizing by alternately prying and twisting. Cut off both ends of the wire and pound the twist flat against the rope.

**NOTE:** Non-preformed wire rope (1) Figure 1-17 should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).



### O-RING, SEAL AND ELASTIC NUT REPLACEMENT

Replace O-rings and gaskets whenever they are disturbed. Never mix new and old seals or O-rings regardless of condition. Always lubricate new seals and O-rings (unless stated otherwise) with 10W30 oil or petroleum jelly before installation. Replace all used elastic locknuts with new parts.

### HYDRAULIC PRESSURE TESTING

Prior to pressure testing, be sure all hoses are in good condition and all fittings are tight.

Use a pressure gauge with a range that is high enough to measure the specific pressure.

Comply with the correct procedure to inhibit damage to the system or the equipment and eliminate the possibility of injury.

Reference Only

## SECTION 2 SAFETY PRACTICES

### SECTION CONTENTS

<p><b>Introduction</b> ..... 2-1</p> <p><b>Signal Words</b> ..... 2-1</p> <p style="padding-left: 20px;">Signal Word ..... 2-1</p> <p style="padding-left: 20px;">Personal Considerations ..... 2-2</p> <p style="padding-left: 20px;">Equipment Considerations ..... 2-2</p>	<p>General Considerations ..... 2-3</p> <p>Operational Considerations ..... 2-3</p> <p><b>Environmental Protection</b> ..... 2-4</p> <p><b>Final Word</b> ..... 2-4</p>
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### INTRODUCTION

Some of the SERVICE work involves the need to drive the crane. The operator’s manual supplied with each crane contains the detailed safety practices relating to driving and operating. These practices apply to the service technician and should be read, understood and practiced.

Prior to performing any service on the crane, considerations should be given to factors that may have an effect upon safety; not only for the mechanic; but also the bystanders.

### SIGNAL WORDS



This safety alert symbol means **ATTENTION!** Become alert - **your safety is involved!** Obey all safety messages that follow this symbol to avoid possible death or injury.

### Signal Word

It is a distinctive word on safety decals and throughout this manual that alerts the viewer to the existence and relative degree of the hazard.



### DANGER

Identifies **hazards** that will result in death or serious injury if the message is ignored.



### WARNING

Identifies **hazards** that could result in death or serious injury if the message is ignored.



### CAUTION

Identifies **hazards** that could result in minor or moderate injury if the message is ignored.

### CAUTION

Without the safety alert symbol, identifies **hazards** that could result in property damage if the message is ignored.

### Important

*The information in this manual does not replace any safety rules and laws used in your area. Before operating the crane, learn the rules and laws for your area. Make sure the crane has the correct equipment according to these rules and laws.*

**Your safety and the safety of others in the work area depend significantly upon your knowledge and understanding of all correct operating and service practices and procedures for this machine.**

## Personal Considerations

	What to do	Why
Clothing	Check to see that you are suitably clothed. For certain work it may be necessary to wear flame or acid resistant clothing.	The wrong cloths or carelessness in dress can cause accidents and injury.
Eye Protection	Wear eye protection when chiseling, grinding, dazing, welding, painting, etc.	The smallest eye injury may cause loss of vision.
Breathing Protection	Wear respiratory protection.	Fume, dust and paint spray are unpleasant and harmful.
Hearing Protection	Use ear protection if noise is excessive.	A loud noise may damage your hearing. The greater the exposure, the worse the damage.
Hand Protection	Use protective cream before work and clean hands thoroughly after.	Prevents irritation and skin contamination.
Foot Protection	Wear protective footwear with reinforced toe caps and oil-resistant soles.	Protects feet from falling objects and to avoid slipping.
Lifting	Make sure you are capable of lifting the object. If in doubt, get help.	Avoids injury through incorrect handling of components.

## Equipment Considerations

	What to do	Why
Operator's Cab	Before using the crane, be sure there are no loose items in operator's cab.	Inhibits operator injury from parts of operator's body or clothing being caught on objects when leaving the cab.
Lifting Equipment	Ensure that lifting equipment (chains, brackets, hooks etc.) is checked before use. If in doubt, select stronger equipment. Replace worn or damaged equipment.	Prevents serious injury or death due to falling objects.
Compressed Air	Never stand under a suspended load. Never use compressed air to blow dust, filings, dirt, etc., from work area unless the correct type of nozzle is used.	Prevents serious injury or death. Prevents serious injury to operator and/or bystanders.
Hand Tools	Look around before using an air hose. Warn others. Never use the wrong tool for the job. Always use the recommended tool. Always keep tools clean and in good working condition.	Yourself and bystanders may get grit into their eyes, ears or skin. Many cuts, abrasions and injuries are caused by defective or wrong tools. These tools will reduce work, labor and cost.

**General Considerations**

	<b>What to Do</b>	<b>Why</b>
Solvents	Use only cleaning fluids and solvents that are known to be safe.	Certain types of fluids cause damage to components and can cause skin irritations.
Housekeeping	Clean and remove all hazards from the area.	Improves surroundings and daily environment for everybody.
First Aid	Do not overlook any cut, abrasion or burn. Have it cleaned and dressed properly.  <i>Make sure you know the location of the First Aid Box.</i>	What appears at first trivial could become painful and injurious.  Results in quick application of aid procedures.
Cleanliness	Plug all hose ends and connections.  Clean exterior of all parts before repairing.	Ensures optimum performance.  Dirt and abrasive dust can reduce the efficiency and working life of a component and lead to costly replacement.

**Operational Considerations**

	<b>What to do</b>	<b>Why</b>
Engine	Stop the engine and engage parking brake before performing any service.  Place a warning sign in cab to warn others that service is being performed on the crane. Disconnect the battery leads if leaving the crane unattended.  Do not attempt to start the engine while standing beside it.	Inhibits serious injury and/or death.  Inhibits serious injury and/or death.  Inhibits serious injury and/or death.
Hoists	Do not remove any hoist component unless the drop block or hook and ball are lowered to the ground.	Inhibits serious injury and/or death.
Radiator Cap	Always remove the radiator cap only when the engine cooling system is cool. Turn the radiator cap slowly to first stop to relieve pressure.	Escaping coolant will burn.
Supports	Make sure safe and stable supports are installed before removing any component or structural item.  Be sure to remove the ignition key before working underneath the machine. Always apply the parking brake.	Inhibits serious injury and/or death.  Inhibits accidental start and movement of the machine which could cause serious injury or death.
Oil Pressure	Before loosening hoses or tubes, make sure all hydraulic pressure is relieved.	A pressure explosion will cause serious injury.

	What to do	Why
Pressure Testing	<p>Make sure all test equipment is in good condition.</p> <p>Use only specified gauges.</p> <p>Comply with test procedures specified.</p>	Inhibits damage to the system or the equipment and inhibits the possibility of personal injury.
Parking	Do not park or attempt to service the crane on an incline. If unavoidable block the tires.	Inhibits serious injury and/or death.
Wheels and Tires	Do not overinflate the tires.	Over-inflation can cause tires to burst and could result in injury.

## ENVIRONMENTAL PROTECTION

**Dispose of waste properly!** Improperly disposing of waste can threaten the environment.

Potentially harmful waste used in Manitowoc cranes includes — but is not limited to — oil, fuel, grease, coolant, air conditioning refrigerant, filters, batteries, and cloths which have come into contact with these environmentally harmful substances.

Handle and dispose of waste according to local, state, and federal environmental regulations.

When filling and draining crane components, observe the following:

- Do not pour waste fluids onto the ground, down any drain, or into any source of water.
- Always drain waste fluids into leak proof containers that are clearly marked with what they contain.
- Always fill or add fluids with a funnel or a filling pump.
- Immediately clean up any spills.

## FINAL WORD

Safety precautions are very seldom the figment of someone's imagination. They are the result of sad experiences—most likely personal injury. Heed these precautions and you will protect yourself and others accordingly. Disregard them and you may duplicate the sad experiences of others.

## SECTION 3 ELECTRIC SYSTEM

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### GENERAL

To aid in the understanding and troubleshooting of an electrical system, review the terms and information that follows.

#### CAUTION

Know the electrical circuit before connecting or disconnecting an electrical component. A wrong connection can cause personal injury or damage to the component and/or system.

**Electrical Energy** - power which comes from the movement of electrons. Electrons are particles with a negative charge. Electrons will collect around particles with a positive charge, called protons, until an electrical imbalance occurs.

**Amperage** - rate of flow of electrons (CURRENT), measured in amperes.

**Voltage** - the electromotive force (EMF) which causes electrons to move through an electrical circuit, measured in volts.

**Resistance** - any resistance to flow of electrons in an electrical circuit, measured in Ohms.

**Ohm's Law** - "Electric current increases in direct relation to the voltage and decreases in relation to the amount of resistance in any circuit."

To Find:

- **EMF (Voltage)** - Multiply CURRENT (amps) by RESISTANCE (Ohms).
- **RESISTANCE (Ohms)** - Divide EMF (voltage) by CURRENT (amps).
- **CURRENT (Amps)** - Divide EMF (voltage) by RESISTANCE (Ohms).

Consider the following when trying to find trouble in an electrical system:

1. Current always flows from (+) positive to (-) negative, or from the point of highest voltage.
2. Because the system used on this machine is a negative ground system, current that leaves the supply (battery) returns to the supply (battery).

3. In series circuit arrangements, the voltage is completely used in the circuit when the current is flowing. In parallel circuit arrangements, the voltage is constant.
4. When the voltage is constant, resistance controls the rate of current (amps) in the circuit. Refer to Ohm's Law.

### Comparing Electrical System to a Hydraulic System

The electrical system is in many ways similar to a hydraulic system. Both systems need a "pump" to cause the flow which generates the energy. Each system needs a complete circuit so the flow can return to storage or supply. Both systems need "valves" to control the flow through the system. See Table 3-1.

**Table 3-1**  
**Comparing Electrical System and Hydraulic System**

ELECTRICAL SYSTEM	HYDRAULIC SYSTEM
Alternator	Pump
Battery	Reservoir
Switches	Valves
Wires and Cables	Tubes and Hoses
Diodes	Check Valves
Volts	PSI or bar
Amps	gpm or L/min
Ohms	Resistance

### Magnetism

When electrical current passes through a conductor it creates a magnetic field around the conductor. This magnetic field can be used to induce current into a second conductor. This is the principle behind generators, coils, relays and solenoids, which are the working components of

the electrical system. These components will be covered further in the discussion of the electrical system.

## MAIN ELECTRICAL SYSTEM

### General

The electrical system used on this machine is a 12 volt, direct current (DC) system with a (-) negative ground. The power is supplied by one (two with diesel engine cold start) 12 volt battery.

An alternator supplies the necessary current (amps) for system operation, and charging of the batteries, when the engine is running. A voltage regulator on the alternator controls the voltage in the charging system. A warning light in the dash indicates when the alternator is not charging the battery.

### Wire Harnesses

Five wire harnesses connect the electrical system components:

- Dash Wire Harness
- Main Frame Wire Harness
- Engine Wire Harness
- Boom Wire Harness
- Cab Wire Harness

### Fuses

The fuses are located for easy access directly below the instrument panel. See Figure 3-1.

Another fuse box is located in the battery/relay compartment. Its fuses are identified in Figure 3-4.

Identification of the fuse ratings and the circuits protected is shown in Table 3-2. Always replace the fuse with one of the same rating.



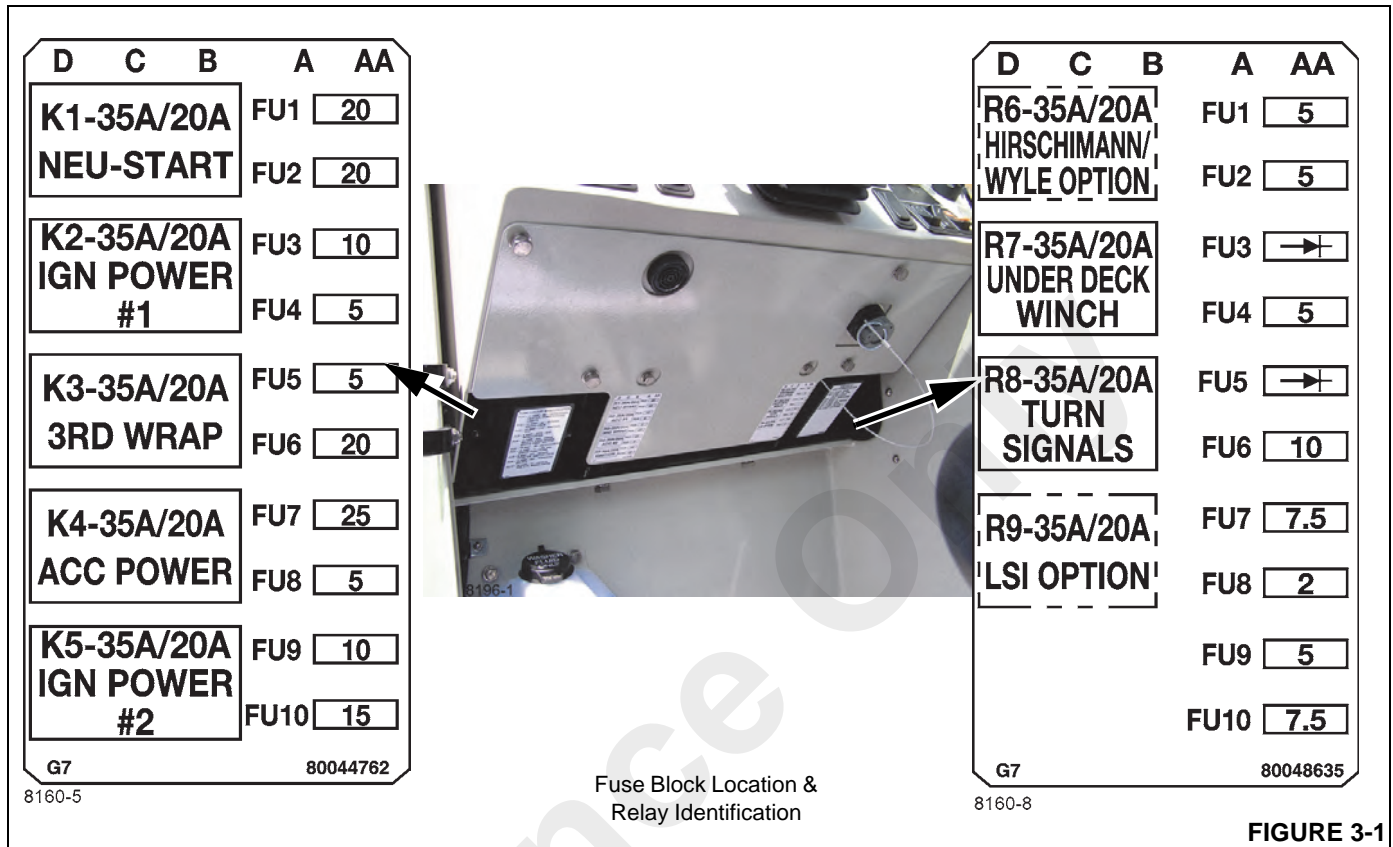


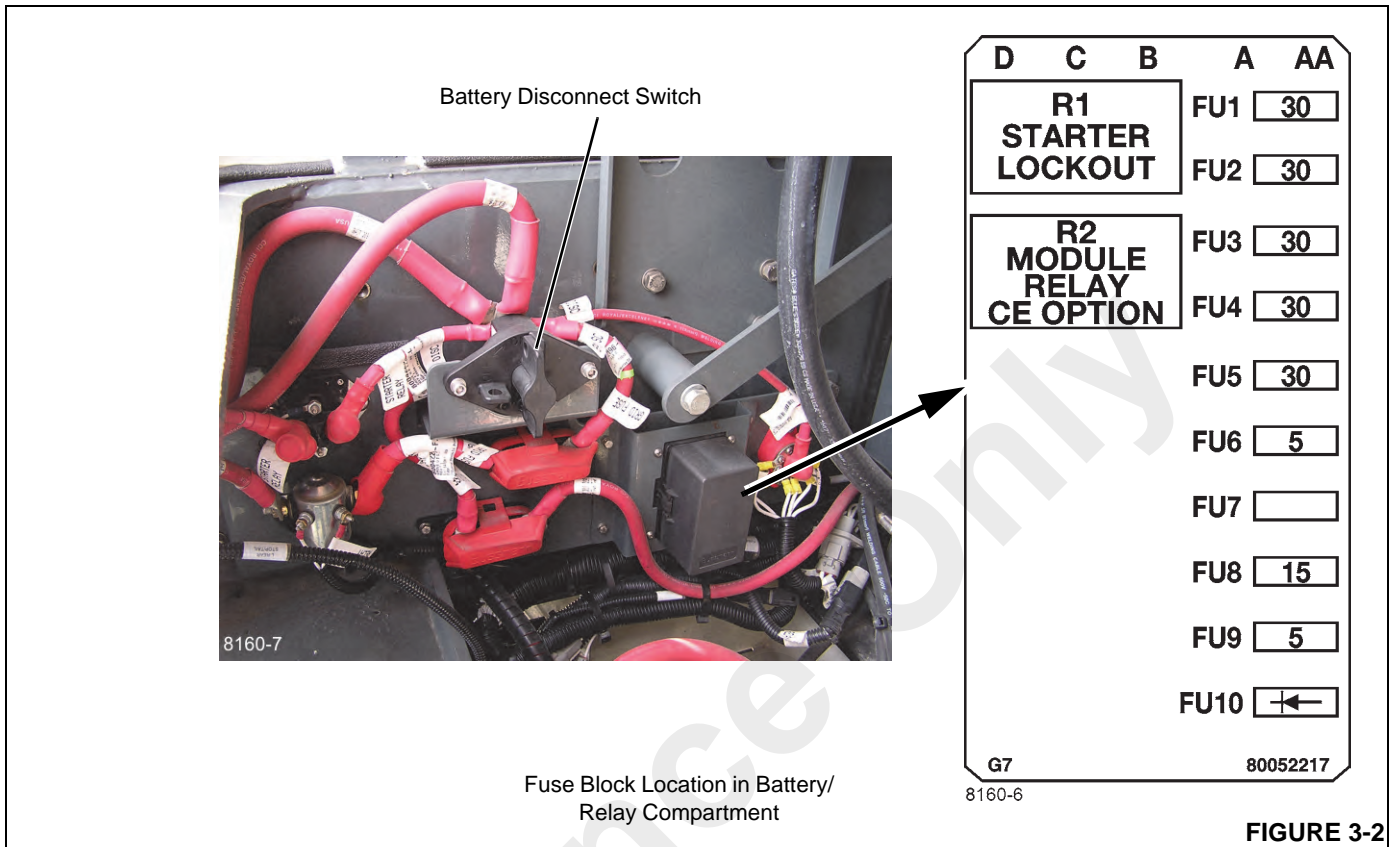
FIGURE 3-1

Fuse Box #1 Circuit Identification

Fuse	Amps	Circuit
FU1	20	Defroster, Heater, Dome/Strobe Lts.
FU2	20	Wipers, Washer, Swing Lock
FU3	10	Shifter, TCU, Trans Oil Cooler, Back Up Alarm
FU4	5	Outrigger Monitoring
FU5	5	Park Brake, Brake Light Switch
FU6	20	Outriggers, Winch
FU7	25	RCL, DRI, Crane Functions
FU8	5	Gauge Cluster, Switch LEDs
FU9	10	Steering Select
FU10	15	Head & Tail Lts., Worklights, Turn Signals/4 Way Flashers

Fuse Box #2 Circuit Identification

Fuse	Amps	Circuit
FU1	5	Hoist Down Solenoid
FU2	5	1195, ECM Power, E-Stop
FU3	Diode	Buzzer
FU4	5	Diagnostic Connector
FU5	Diode	RCL Override
FU6	10	Spare
FU7	7.5	RCL Power
FU8	2	RCL Power
FU9	5	Ignition
FU10	7.5	ACC



Fuse Box #3 Circuit Identification

Fuse	Amps	Circuit
FU1	30	ACC Power Relay
FU2	30	IGN Power Relay
FU3	30	ECM Power
FU4	30	Headlights
FU5	30	IGN Power Relay #2

Fuse	Amps	Circuit
FU6	5	Starter Lockout Signal from Engine ECM
FU7	-	Empty
FU8	15	Module Power
FU9	5	Swing Valves (360° Swing Lock Opt)
FU10	Diode	

## CHARGING SYSTEM

The purpose of the charging system is to give power for operation of the lights, instruments, electrical accessories and controls, and to keep a full charge on the batteries. The charging circuit includes the alternator, voltage regulator, warning light, battery, and wiring.

### Alternator and Voltage Regulator

The alternator changes the mechanical energy from the engine into electrical energy. The alternator has a "Rotor Assembly," which rotates inside a series of windings called the "Stator." The field windings on the rotor receive controlled current from the voltage regulator, which causes a magnetic field around the winding. When the rotor turns, an alternating current (AC) voltage occurs in the windings of the stator. This alternating current is changed to direct current by diodes in the alternator. The alternator has an internal voltage regulator, which controls the output voltage of the alternator by controlling the amount of current through the field windings of the alternator. When the voltage on the line is 14.6 volts, current through the field winding is zero. Below 12 volts, the current is maximum. The voltage regulator keeps the voltage on the line to approximately 14 volts.

### Batteries

The batteries are a maintenance-free, lead-acid type battery. The battery has four functions:

1. To provide adequate power for starting the engine.
2. To be a stabilizer for voltage in the system.
3. To give power to the system when the electrical loads are greater than the output of the alternator.
4. Store power.

#### **Battery Disconnect Precautions**

When disconnecting the battery use the following procedure:

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove the negative battery cables.
5. Remove the positive battery cables.

Use the following procedure when connecting the battery:

1. Connect leads to the battery terminals starting with the positive terminals.
2. Install the ECM power fuse.

3. Turn the battery disconnect switch to ON.

### Battery Disconnect Switch

The battery disconnect switch, Figure 3-2, is located in the battery/relay compartment. Turn the switch to OFF to disconnect the battery from the electrical system.

### Voltmeter

The voltmeter is in the cab instrument panel and is connected to the battery. The voltmeter indicates the voltage (charge) on the battery.

### Pressure Switch

The pressure switch, when closed by engine oil pressure, energizes the hourmeter in the cab instrument panel.

### Special Precautions

1. Never cause a short circuit or ground in the output or field wires of the alternator. These wires are always hot (charged). A short circuit can cause damage to the alternator diodes.
2. An alternator is not the same as a generator. Never try to change the polarity of the alternator. The diodes keep the correct polarity.
3. Always connect the positive (+) cable from the starter to the positive (+) terminal of the battery. Connect the ground cable from the engine to the negative (-) terminal of the battery. Never change these connections.
4. Never operate the alternator on an open circuit or disconnect the battery when the alternator is operating. A high voltage condition will occur and cause damage to the diodes.
5. When a booster battery is used, make sure the battery is connected correctly (positive terminal to positive terminal; negative terminal to negative terminal).
6. Never use a battery charger as a booster for battery output.
7. Heat can cause damage to the diodes. Keep all sources of heat away from the alternator.

## Battery Maintenance and Charging

### **Battery**

A maintenance-free battery is used on this crane. A limited amount of maintenance is required on the battery. See Section 5, Preventative Maintenance.

### Charging the Battery



#### WARNING

Batteries produce explosive gases. Keep sparks, flame and lit smoking materials away. Ventilate when charging or using batteries in an enclosed place. Always wear eye protection when working near batteries.

1. Always connect the positive wire (normally red) of the battery charger to the positive (+) terminal of the battery first.
2. Connect the negative wire (normally black) of the battery charger to the engine or frame, far enough away from the battery to inhibit explosion should a spark occur.

**NOTE:** Sparks occur when current moves from the positive to the negative terminals of the charger. If you disconnect either of the connections, the current in both wires is stopped.

3. When disconnecting the charger, always remove the negative (-) or ground connection first. Wait approximately one minute after the charger has stopped before disconnecting the charger's positive (+) wire. This procedure will decrease the possibility of explosion of hydrogen gas around the battery.

### STARTING CIRCUIT

The starting circuit includes the battery, starter motor and solenoid, auxiliary start solenoid, starter relay, park brake switch, and the ignition switch.

#### General Inspections

Many starting problems can be found by making the following checks:

1. Check that the parking brake is engaged.
2. Check battery condition. Charge or replace the battery as necessary. Clean battery posts and cable connectors.
3. Inspect wiring for worn insulation or other damage. Inspect all connections at the starter motor, starter solenoid, starter relay, and wire harness plugs. Clean and tighten all connections and replace any bad wiring.
4. If the starter still does not operate after correcting the circuit, perform the Starting Circuit Check.

#### Starting Circuit Check

**NOTE:** If the starter will not crank the engine, the following checks will help find a faulty component in the starting circuit. Use a test lamp or voltmeter to perform the checks.

#### CAUTION

The ignition switch must be in the OFF position when performing steps 1 and 2. If the switch is in the ON position, the engine may start if the parking brake is engaged. Personal injury is possible.

1. Place the ignition switch in the OFF position and **disengage** the parking brake.
2. See the electrical schematic at the end of this manual. Momentarily connect a jumper cable to the "B" and "S" terminals on the starter solenoid.
  - a. If the starter operates, the starter and solenoid are good. The problem is somewhere between the solenoid and the ignition switch. Go to step 3.
  - b. If the starter does not operate, connect the jumper cable to the "B" and "M" terminals on the starter solenoid. If the starter operates correctly, the problem is in the starter solenoid. Replace the solenoid. If the starter still does not operate, the starter is bad and must be repaired or replaced.
3. Check the voltage at the "BAT" terminal of the ignition switch. If no voltage is indicated, there are wrong connections or damage to the wiring between the starter and the ignition switch. If voltage is indicated, go to step 4.
4. Turn the ignition switch to the START position and check voltage at the start "ST" terminal. Go to step 5 if voltage is indicated. If no voltage is indicated, replace the ignition switch.
5. Make sure that the parking brake is engaged. Have someone hold the key switch in the START position, check for voltage at wires 156 and 2 on the neutral start relay located under the instrument panel. If voltage is indicated at the relay wire 2, go to step 6. If there is no voltage at wire 156, check the wire to the ignition switch. If there is voltage at wire 156 and no voltage at wire 2, replace the relay.
6. Turn the ignition switch to the START position. Connect a jumper wire between wires 2 and "B" on the starter solenoid. If the starter operates, the starter relay is defective and must be replaced. If the starter did not operate, go to step 7.
7. With the ignition switch in the START position, check for voltage at the switch "S" terminal of the starter solenoid. If there is no voltage, the problem is in the wire from the starter relay to the starter solenoid. Repair or replace the wiring. If voltage is indicated, the problem is in the starter solenoid.

## INSTRUMENT AND LIGHT CIRCUITS

### General

Power is available to the light switch from a 20 amp fuse on the fuse block. The light switch has three positions. The upper position illuminates the work lights, head lights, tail lights, gauge lights and the instrument panel light. The center position turns all lights off. The lower position illuminates the head and tail lights, as well as, the instrument panel lights.

### Light Bulbs

**Table 3-2**  
**Light Bulbs**

Location	Trade No.
Head Lights	4411 Sealed
Tail Lights	1157
Turn Signal	1156
Work Lights	4411 Sealed
Mast Lights	4411 Sealed

### Gauges and Indicators

The gauges are 12 volt components. Power is available to the gauges through a 5 amp fuse when the ignition switch is in the ON position.

#### Fuel Gauge

The fuel gauge connects to a sending unit in the fuel tank. This sending unit puts a variable resistance in the circuit and causes a corresponding indication on the fuel gauge, representing fuel level.

#### Engine Oil Pressure Indicator

This indicator connects to the engine ECM. The ECM connects to a sending unit in the engine lubrication system. When the oil pressure is below a predetermined value the sending unit signals the ECM indicating engine oil pressure is too low.

#### Engine Temperature Gauge

This gauge connects to the engine ECM. The ECM connects to a sending unit in the engine cooling system. The variable resistance caused by the sending unit gives a corresponding indication of the temperature of the engine coolant.

### Voltmeter Display

The voltmeter is connected in parallel with the charging circuit. The voltmeter gives an indication of electrical charging system problems that can not be seen with an ammeter.

Normally, when the engine is stopped (ignition switch in the ON position) or when the engine is running at low idle, the voltmeter will indicate 11-14 volts. When the engine is running above low idle, the voltmeter will normally indicate 14-16 volts. More than 16 volts indicates an overcharging condition Table 3-3.

### Hour Meter

Power is available through the oil pressure switch on the engine by way of the engine ECM. The hour meter operates only when the engine is running.

### ECM Display Toggle Switch



**FIGURE 3-3**

The Display Toggle Switch is used to display engine ECM error codes. With the engine running, press the button and no engine codes are present the display cluster will read "No Errors Detected". If a single error code is present, it will be displayed when the button is pressed. If multiple error codes are present, the display will list in the parentheses the number of error codes and will scroll through them in order of occurrence each time the button is depressed.

Table 3-3: Voltage Level Conditions

Voltage Measured	Engine Speed	Condition of Charging System
0-10 volts	Stopped or low idle	Battery discharged. Low battery charge.
11-12 volts	Above low idle. Stopped or low idle.	Problem in charging system. See Troubleshooting - Charging System. Normal battery charge.
12-14 volts	Above low idle.	Problem in charging system. See Troubleshooting - Charging System. Battery fully charged - no load.
14-16 volts	Stopped or low idle.	If needle is between 14 and 15 volts, the battery is newly charged. Overcharged battery.
More than 16 volts	Above idle.	Overcharge. See Troubleshooting - Charging System

## WIRE HARNESSES

### Engine Wire Harness

The engine wire harnesses Figure 3-4 or Figure 3-5 and supply electrical current from the battery to the charging circuit, starting circuit, and senders attached to the engine. It also supplies the current to the main frame wire harness.

### Main Frame Wire Harness

The main frame wire harness Figure 3-6 supplies electrical current to operate the electrical components attached to the main frame. It also connects to the instrument panel and engine wire harnesses.

### Dash Wire Harness

The dash wire harness Figure 3-7 supplies electrical current to the gauges, lights and switches in the instrument panel. It connects to the main frame wire harness.

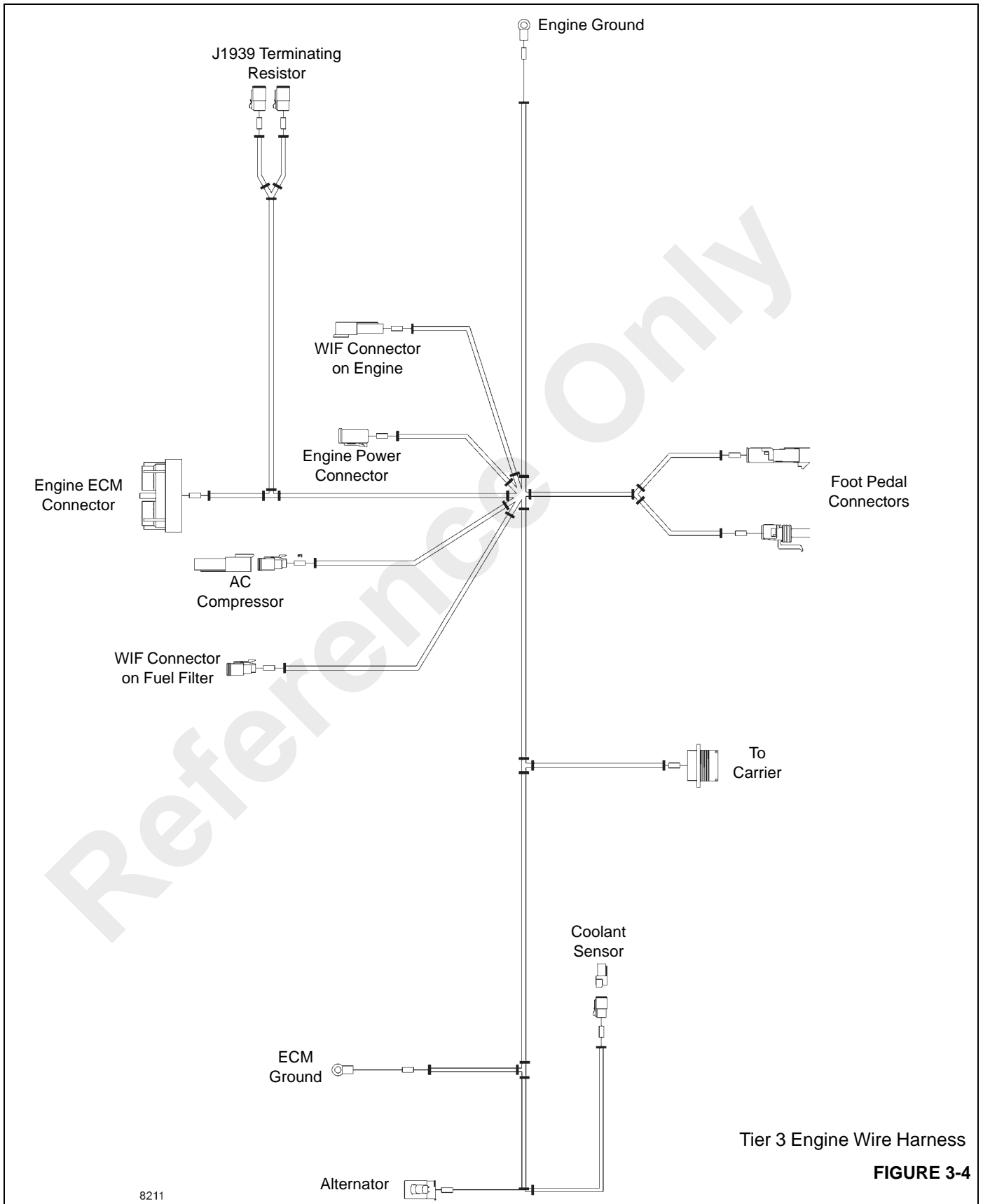
### Cab Wire Harness

The cab wire harness Figure 3-8 supplies electrical current to the components in the cab not connected to the dash wire harness.

### Boom Wire Harness

The boom wire harness Figure 3-9 supplies electrical current to the components mounted on the boom.

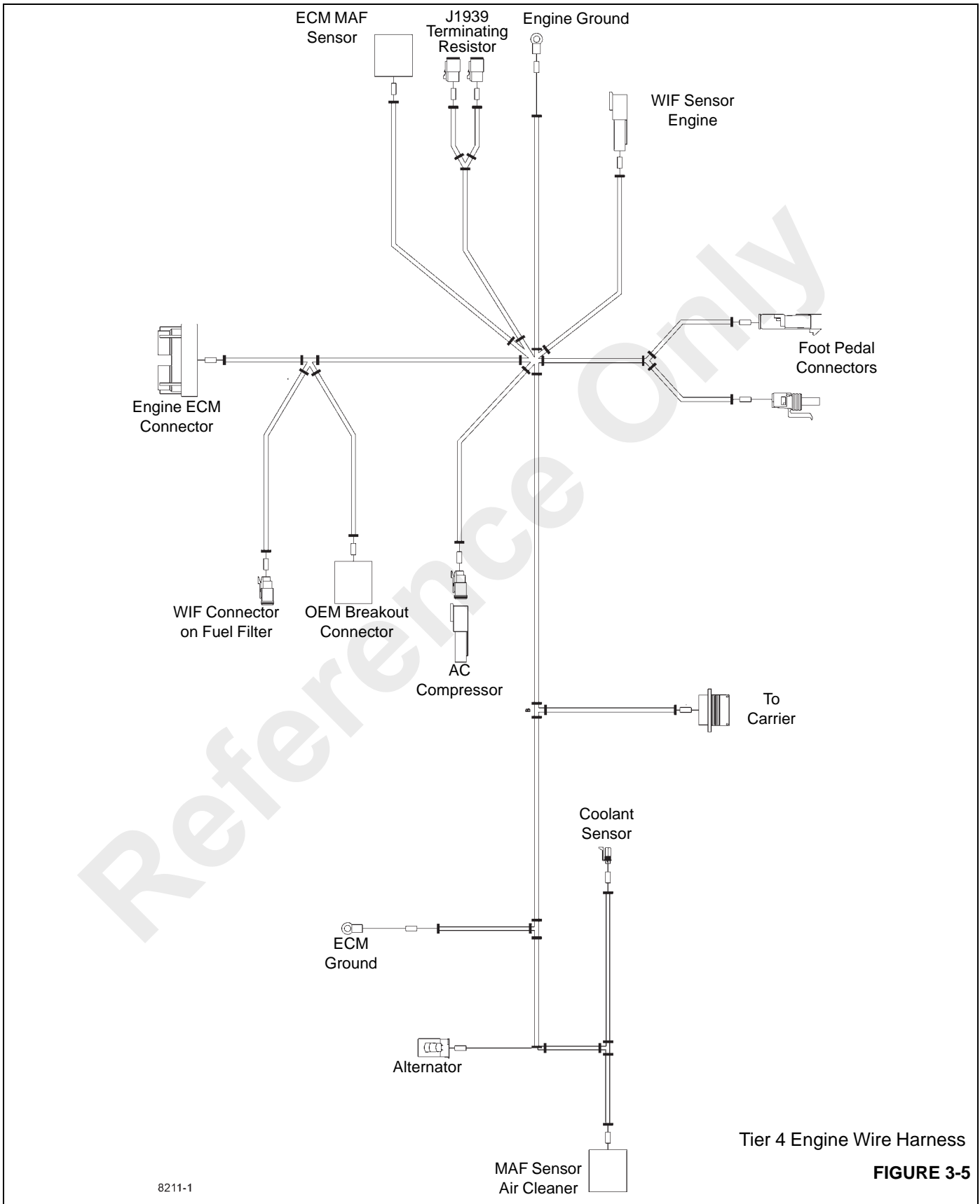
**NOTE:** For wire harness wiring diagrams, see *Schematics/Wiring Diagrams* at the end of this manual.



Tier 3 Engine Wire Harness

FIGURE 3-4

8211

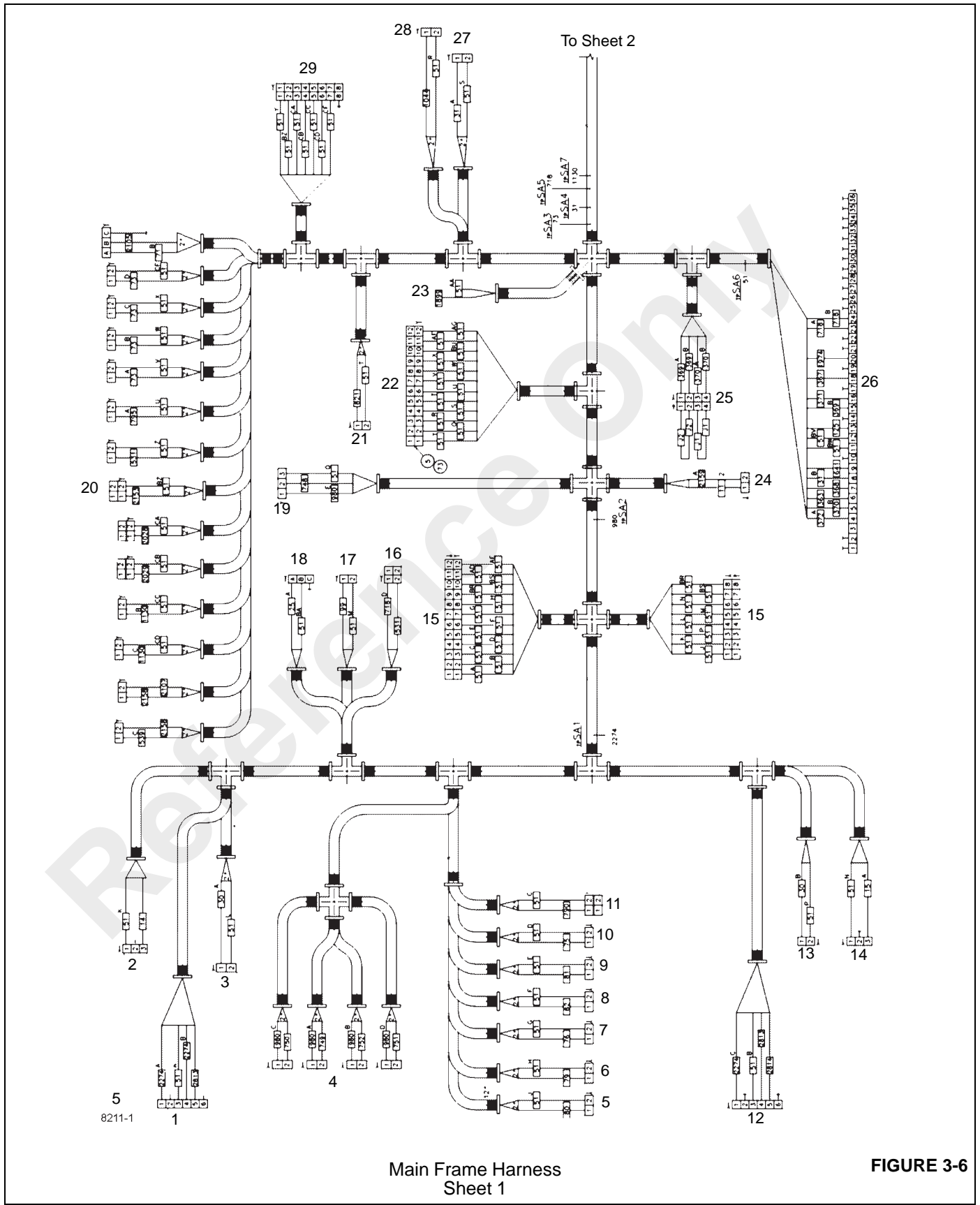


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Tier 4 Engine Wire Harness

FIGURE 3-5





Main Frame Harness Sheet 1

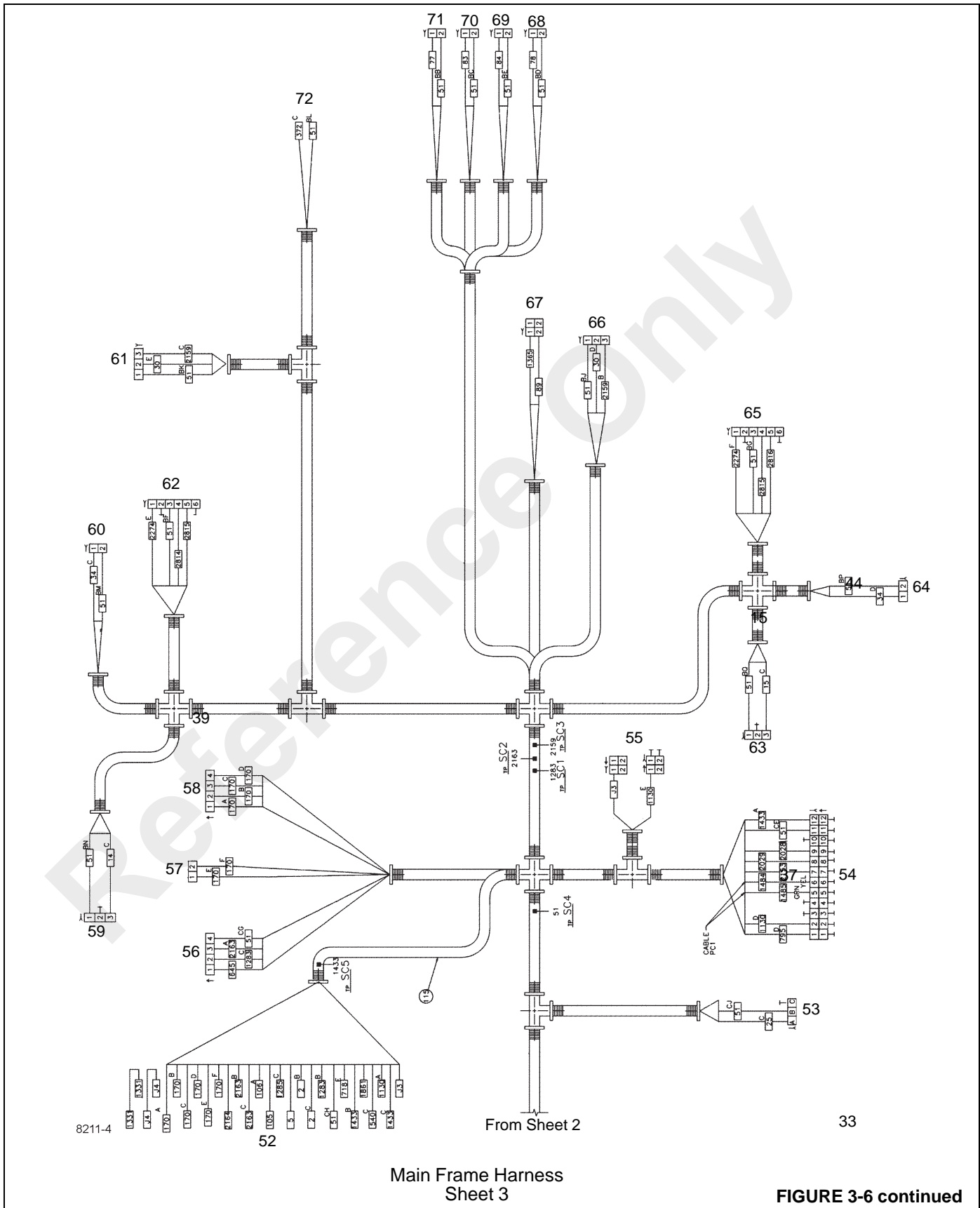
FIGURE 3-6

Item	Description Sheet 1
1	Right Front OMS
2	Right Front Turn Indicator
3	Right Front Headlight
4	Steer Solenoids
5	Outrigger Return
6	Outrigger Extend
7	Left Front Outrigger Beam
8	Left Front Jack
9	Right Front Jack
10	Right Front Outrigger Beam
11	Winch
12	Left Front OMS
13	Left Front Headlight
14	Left Front Turn Indicator
15	Ground Splice
16	Transmission Cooler Temperature Switch
17	Horn
18	Transmission Temperature Switch
19	Front Steering Proximity Switch
20	Main Control Valve
21	Hoist Down
22	Ground Splice
23	Outrigger Alarm Option
24	Brake Light Pressure Switch
25	Transmission Gear Shifter
26	Transmission Module
27	Park Brake
28	Brake Low Pressure Switch
29	Ground Splice



Item	Description Sheet 2
30	To Dash Harness
31	To Dash Harness
32	Ground Splice
33	360° Swing Lock
34	360° Swing Lock
35	To Cab
36	To Cab
37	Frame Grounds
38	To Dash Harness
39	To Dash Harness
40	To Dash Harness
41	PC1
42	Slew Proximity
43	Swivel
44	Ground Splice
45	Hydraulic Oil Temperature
46	Unloader Valve
47	2WD/4WD Solenoid
48	Fuel Level Sending Unit
49	Ground Splice
50	To Engine
51	Rear Steer Proximity Switch

Reference Only



Item	Description Sheet 3
52	Fuse/Relay Box
53	Transmission Temperature Switch, Tier 3
54	Module Connector
55	360° Swing Lock Option
56	Relays
57	Power Post (B)
58	Power Post (A)
59	Right Rear Turn Signal
60	Right Rear Work Light
61	Right Rear Stop/Tail Light
62	Right Rear OMS
63	Left Rear Turn Signal
64	Left Rear Work Light
65	Left Rear OMS
66	Left Rear Stop/Tail Light
67	A/C Binary Switch
68	Left Rear Outrigger Beam
69	Left Rear Outrigger Jack
70	Right Rear Outrigger Jack
71	Right Rear Outrigger Beam
72	Backup Alarm

Reference Only

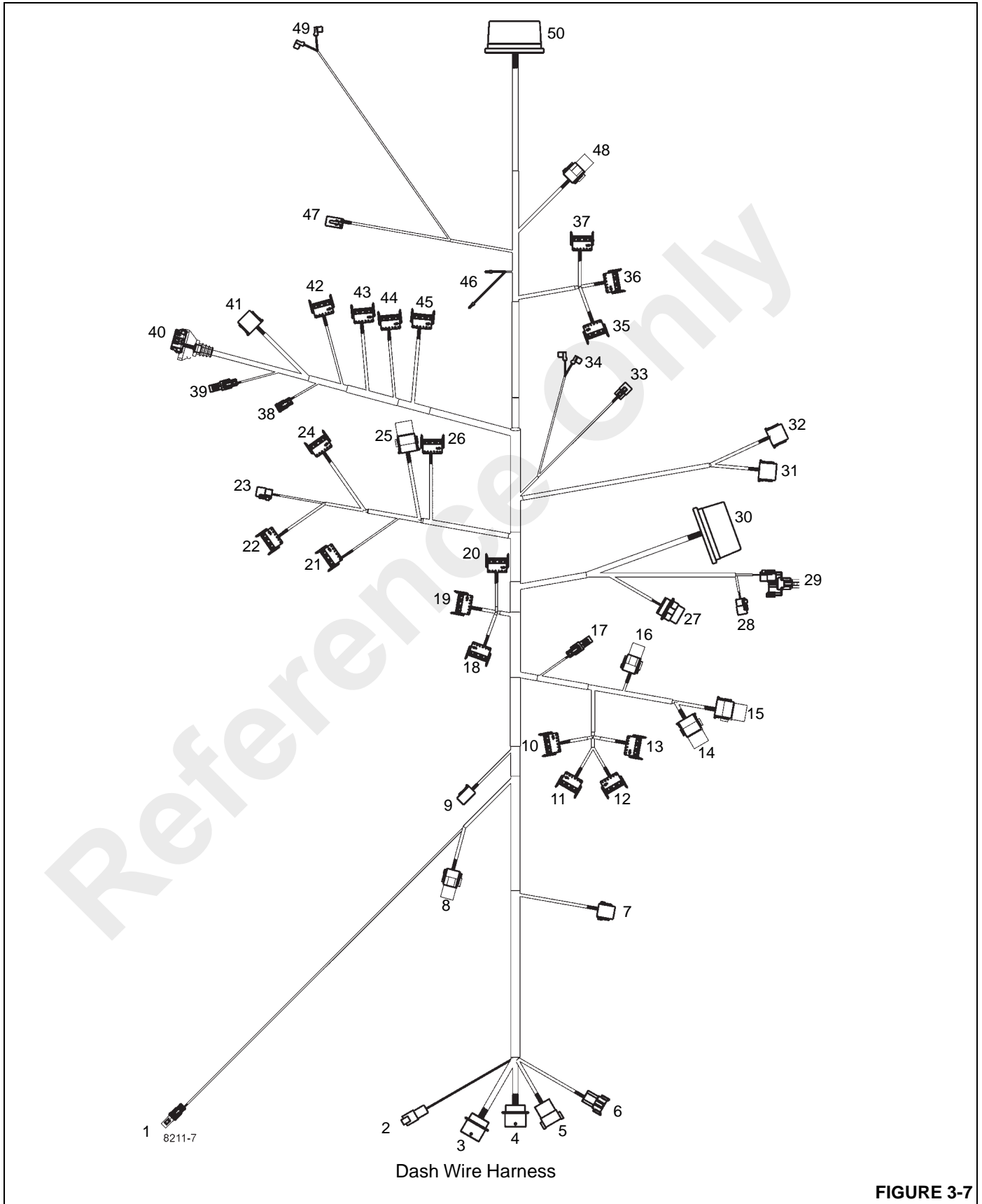
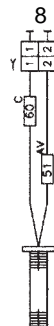


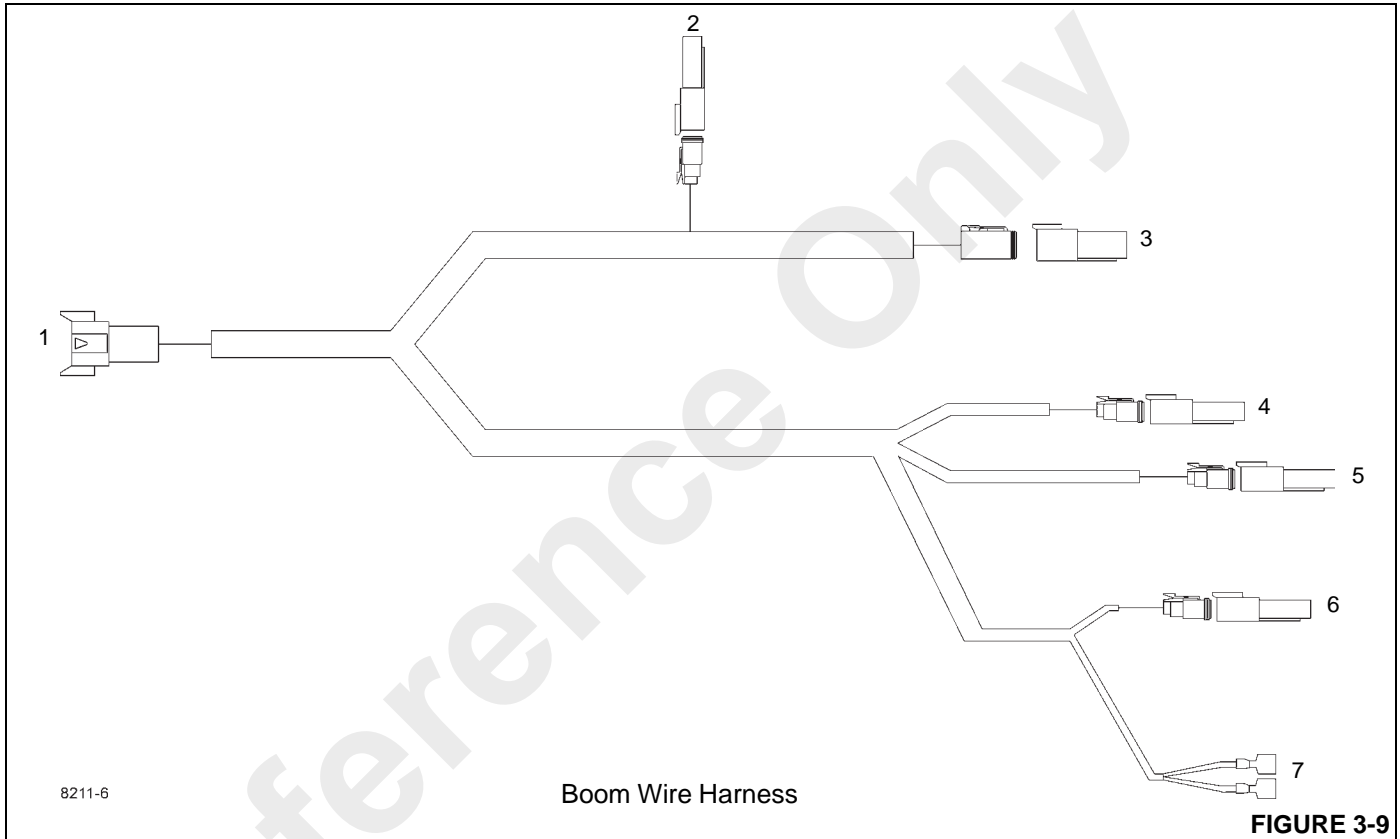
FIGURE 3-7

Item	Description
1	Skylight Wiper
2	Carrier P6
3	Carrier P1
4	Carrier P2
5	Carrier P3
6	Carrier P5
7	Steering Return to Center
8	46 Splice
9	Ignition Switch
10	Outrigger Left Front
11	Outrigger Right Rear
12	Outrigger Right Front
13	Outrigger Left Rear
14	Ground Splice 2
15	Ground Splice 1
16	Ground Splice 3
17	Thumb Thumper
18	Park Brake
19	Crane Power
20	Hazard Switch
21	Locked Indicator
22	RCL Override
23	LSI Display
24	Winch Switch
25	71 Splice
26	Swing Lock Switch
27	Diagnostic
28	J1939 Blue
29	J1939 Orange
30	Fuse Box #2
31	Shift/Turn Right B
32	Shift/Turn Left A
33	Flasher
34	Transmission Pressure Alarm
35	Steering Select Switch
36	2WD/4WD Select Switch
37	Work/Headlights
38	Screen Toggle Switch
39	Defroster Fan
40	Cluster Gauge
41	RCL Display
42	Defroster Switch
43	Heater Switch
44	Hoist Speed Switch
45	Outrigger Extend/Retract Switch
46	Emergency Stop Switch
47	Windshield Wiper
48	221 Splice
49	Windshield Washer
50	Fuse Box #1





Item	Description
1	To Carrier Harness
2	Heater/Air Conditioning
3	Seat Switch
4	RCL A
5	RCL B
6	RCL C
7	Dome Light
8	Strobe Light



Item	Description
1	To Swivel
2	Hoist High Speed
3	Hoist Rotation Indicator
4	Left Hand Boom Lights
5	Right Hand Boom Lights
6	RCL Warning Light (CE Option)
7	RCL Warning Alarm (CE Option)

3

## ACCESSORY CIRCUITS

### Anti-Double Blocking System

#### General

This mechanism (Figure 3-10) prevents the hook block from being pulled into the boom head during extension of the booms and during hoist operation. When the hook block actuates the limit switch on the boom head, oil flow to the telescope cylinder, lift cylinder and hoist motor is stopped. An alarm is activated to give a warning to the operator in all cases. To move the hook block away from the boom head, the operator must retract the boom, raise the boom or lower the hoist.



FIGURE 3-10

#### Circuit Description

See the wiring diagrams in *Schematics/Wiring Diagrams*. Power is made available through a 25 amp fuse to the circuit relay under the console in the cab and to the limit switch on the boom head. When the hook block reaches the upper limit, the limit switch closes, energizing the relay. The energized relay activates the three anti-double blocking solenoid valves in the lift, telescope and hoist circuits.

#### Electric Swivel

An electrical swivel is installed at the center of the mast rotation. The swivel gives electric current continuity through full rotation of the mast.

### Rated Capacity Limiter (RCL) System

#### Description

The rated capacity limiter (RCL) is a length, load, angle, radius, lifting capacity and anti-double block indicator. A display in the cab provides information to assist the operator in operating the crane.

The Wylie I4500 system, available as a CE option, can be set with limits by the operator to warn of approach into undesired areas of angle, length or height.

For more information on the RCL system, see the Owner's Manual furnished with the crane.

See wiring diagram in *Schematics/Wiring Diagrams*.

### Optional Engine Shutdown

#### General Description

Cranes can be furnished with an automatic engine shutdown, to protect the engine when the engine oil pressure is too low or the engine water temperature is too high. The electrical circuit includes a mag relay switch located behind the cab dash panel, two diodes in the instrument panel wire harness, the engine water temperature and oil pressure senders, and the fuel shut off valve.

#### Circuit Function

When the engine oil pressure drops below a safe operating pressure or the water temperature rises above a safe operating temperature, the sending unit sends a signal to the indicator light, illuminating the light. It also, sends a signal to the mag relay switch under the dash panel. Both senders are connected to the "S" terminal of the relay. To prevent current from one sender (oil pressure), illuminating the other indicator light (water temperature) the circuit has two diodes installed, which allow current to travel in one direction only. The relay is activated and cuts current from the "NC" terminal to the fuel shut off valve, closing the valve and shutting off the engine.

### Heater

The heater is a hot water heater and is connected into the cooling system of the engine. An electric blower pushes air through the heater core and into the cab. A defroster fan blows air onto the windshield.

See the electrical wiring diagrams in *Schematics/Wiring Diagrams*. Power is available through a 20 amp fuse to the heater/defroster switch in the instrument panel when the ignition switch is in the ON position. The switch is a three position switch (HI, LO and OFF).

**TROUBLESHOOTING**

Finding a problem in the electrical system is not difficult if you know basic electricity and understand the arrangement of the electrical system. Use the wiring diagrams at the end of this manual as your guide.

Accurate testing equipment is also necessary. The instruments normally used are a voltmeter, ammeter, ohmmeter and test light.

Many times the problem can be found by visual inspection of the components in the circuit. Corrosion on terminals, loose connections or bad wiring are the causes of many problems.

Each circuit in the system has a fuse for protection against overloads. Remember that a burnt fuse is an indication of an overload or **SHORT** circuit, not an **OPEN** circuit.

If you did not find the cause of the problem during the visual inspection, use a voltmeter to check the voltage at several points in the circuit, or measure voltage drop across the component. Normally, the best method is to start at the furthest component in the circuit and move backwards toward the power supply. An ohmmeter can be used to measure the resistance in any component. Remember to disconnect the component from the power supply before you connect the ohmmeter.

**Table 3-4  
Charging System Troubleshooting**

Problem	Possible Cause	Solution
Alternator does not charge.	<ol style="list-style-type: none"> <li>1. Alternator belt loose or broken.</li> <li>2. Worn brushes or open brush leads or connections.</li> <li>3. Open circuit, short circuit or ground stator winding.</li> <li>4. Fault in voltage regulator.</li> <li>5. Short circuit or open circuit in rectifier diodes.</li> <li>6. Open circuit or short circuit in rotor (field) winding.</li> <li>7. Wires connected wrong, loose, or broken.</li> <li>8. Dirty slip rings or bad slip ring connections.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace and/or tighten to specification.</li> <li>2. Replace or repair alternator.</li> <li>3. Replace alternator.</li> <li>4. Replace voltage regulator.</li> <li>5. Replace or repair alternator.</li> <li>6. Replace alternator.</li> <li>7. See wiring diagram. Repair or replace wires.</li> <li>8. Inspect slip rings. Clean or repair as required.</li> </ol>
High charging rate (battery at full charge).	<ol style="list-style-type: none"> <li>1. Low electrolyte level in battery.</li> <li>2. Fault in wiring system.</li> <li>3. Loose or dirty connections.</li> <li>4. Malfunction in voltage regulator.</li> </ol>	<ol style="list-style-type: none"> <li>1. Add distilled water.</li> <li>2. Repair or replace faulty wiring.</li> <li>3. Clean and tighten connections.</li> <li>4. Replace voltage regulator.</li> </ol>
Low charging rate.	<ol style="list-style-type: none"> <li>1. Loose or worn alternator belt.</li> <li>2. Bad alternator.</li> <li>3. Bad battery.</li> <li>4. Low electrolyte level.</li> <li>5. Short circuit in system.</li> <li>6. Worn alternator.</li> <li>7. Malfunctioning voltage regulator.</li> <li>8. Low engine speed.</li> </ol>	<ol style="list-style-type: none"> <li>1. Adjust or replace belt.</li> <li>2. Replace or repair.</li> <li>3. Replace battery.</li> <li>4. Add distilled water.</li> <li>5. Check and repair.</li> <li>6. Test, replace or repair alternator.</li> <li>7. Replace the voltage regulator.</li> <li>8. Run engine at higher speed.</li> </ol>

Problem	Possible Cause	Solution
Alternator Noise.	<ol style="list-style-type: none"> <li>1. Badly worn belt.</li> <li>2. Pulleys out of alignment.</li> <li>3. Loose pulley.</li> <li>4. Worn bearings.</li> <li>5. Short in rectifier diodes.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace belt and adjust.</li> <li>2. Align fan and alternator pulleys.</li> <li>3. Check for broken key or worn keyway, if used. Tighten pulley nut.</li> <li>4. Replace or repair alternator.</li> <li>5. Replace or repair alternator.</li> </ol>
Starter motor does not turn.	<ol style="list-style-type: none"> <li>1. Open circuit, dirty or loose connections.</li> <li>2. Bad starter relay.</li> <li>3. Bad ignition switch.</li> <li>4. Worn starter motor, bad starter solenoid, or internal problem in engine.</li> <li>5. Dead battery.</li> <li>6. Parking brake not engaged.</li> <li>7. Bad neutral start relay.</li> </ol>	<ol style="list-style-type: none"> <li>1. Clean and tighten connections at battery and starter. Check wiring and connections between ignition switch and starter solenoid.</li> <li>2. Replace starter relay.</li> <li>3. Replace switch.</li> <li>4. Repair or replace starter, replace solenoid, or see engine manual.</li> <li>5. Recharge or replace battery.</li> <li>6. Engage parking brake.</li> <li>7. Replace relay.</li> </ol>
Winch motor runs in only one direction.	<ol style="list-style-type: none"> <li>1. Defective solenoid or stuck solenoid.</li> <li>2. Defective control switch.</li> </ol>	<ol style="list-style-type: none"> <li>1. Jar solenoid to free contacts. Check by applying 12 volts to coil terminal (should hear an audible click when energized). Replace solenoid.</li> <li>2. Check and replace if necessary.</li> </ol>
Winch motor runs extremely hot.	<ol style="list-style-type: none"> <li>1. Long period of operation.</li> <li>2. Insufficient battery power.</li> <li>3. Bad connection.</li> </ol>	<ol style="list-style-type: none"> <li>1. Cooling-off periods are essential to prevent overheating.</li> <li>2. Check battery terminal voltage under load. If 10 volts or less, replace the battery.</li> <li>3. Check battery cables for corrosion, clean and grease.</li> </ol>
Winch motor runs but with insufficient power, or with slow line speed.	<ol style="list-style-type: none"> <li>1. Insufficient battery power.</li> <li>2. Bad connection.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check battery terminal voltage under load. If 10 volts or less, replace the battery.</li> <li>2. Check battery cables for corrosion, clean and grease.</li> </ol>
Winch motor runs but drum does not rotate.	<ol style="list-style-type: none"> <li>1. Clutch not engaged.</li> <li>2. Clutch engaged.</li> </ol>	<ol style="list-style-type: none"> <li>1. Engage clutch.</li> <li>2. Disassemble the hoist to determine cause and repair.</li> </ol>

Problem	Possible Cause	Solution
Winch motor will not operate.	<ol style="list-style-type: none"> <li>1. Defective solenoid or stuck solenoid.</li> <li>2. Defective control switch</li> <li>3. Defective motor.</li> <li>4. Loose connections.</li> </ol>	<ol style="list-style-type: none"> <li>1. Jar solenoid to free contacts. Check by applying 12 volts to coil terminal (should hear an audible click when energized). Replace solenoid.</li> <li>2. Check and replace if necessary.</li> <li>3. If solenoids operate, check voltage at armature post. Replace motor if defective.</li> <li>4. Tighten connections on bottom side of hood and on motor.</li> </ol>

Reference Only

## SECTION 4 HYDRAULIC SYSTEM

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### GENERAL DESCRIPTION

#### General

A hydraulic system uses liquid to make a transfer of force. Any force on a confined liquid is applied to any point in the system that the liquid reaches. Oil is used as the hydraulic liquid for this system because the liquid must be a lubricant for the components of the system.

There are several main components in a hydraulic system. Each component has a specific function in the system.

The **pump** moves the oil through the system. It is important to remember that the pump causes the flow, not the pressure in the system. Pressure is caused by resistance to the flow. This resistance can be **external** (for example, a load on a cylinder or motor), or **internal** (the resistance of the components of the system). Pressure increases as the resistance to the flow increases. The pump will continue to push more oil into the system until the resistance is overcome or the relief valve opens (fixed displacement pumps) or the pump compensator setting is reached (variable displacement pumps).

**Valves** are used to control the flow, pressure, direction, and volume of the oil in the system. There are many different types of valves. An explanation of the different valves used on this machine is given in the description of each circuit.

**Filters** remove dirt and particles of foreign materials from the oil in the system. The oil in the system must be kept clean to inhibit damage to the pumps, cylinders, valves, and other components of the system.

**Motors and Cylinders** are the actuators or working tools of the system. In the motors and cylinders, hydraulic energy is changed into mechanical force (rotary or straight line movement).

The **Hydraulic Oil Tank** has three important functions: storage, cooling, and supply of oil to the pumps. Because piston rods take space in the cylinders, the level of the oil in the tank will be higher when all the cylinders are retracted.

To understand how a hydraulic system works, it is important to understand the following words:

**Flow** - The flow through the system is caused by the pump. The amount of fluid which is sent to a circuit or actuator generally controls the speed of that function. The flow is measured in gallons per minute (gpm) or liters per minute (L/min).

**Pressure** - is caused by any resistance to the flow of the oil. Pressure is normally measured in pounds per square inch (psi) or bar. There are four general types of pressure.

- **High Pressure**, which is normally the result of an external load on the system.
- **Low Pressure**, normally the result of the internal resistance of the components in the system.
- **Static Pressure**, where the oil is closed in a circuit between two components. There is no movement of the oil, but there is pressure on the oil, normally because there is an external load on the circuit.
- **Series Pressure**, which is found where oil is confined between two components in a series arrangement, for example when the rod port of one cylinder is connected to the base port of another cylinder. Movement of either cylinder will cause movement in the other cylinder.

## Hydraulic System

There are four hydraulic systems on this machine. Information on the hydraulic system for the transmission, brakes, and steering is found in Sections 7, 9, and 10 respectively. Only the main hydraulic system is included in this section. The main hydraulic system gives hydraulic power to:

- The swing motor
- The boom cylinders; lift and telescope

- The front and rear outrigger cylinders
- The main hoist motor

The hydraulic components on the boom and mast are connected to the hydraulic components on the lower structure through a hydraulic swivel. The hydraulic swivel is at the center of rotation of the mast. The design of the hydraulic swivel permits operation of the hydraulic functions through full rotation of the mast.

## TROUBLESHOOTING

To find a problem in the hydraulic system with minimum loss of time, use the following aids and procedures.

### Troubleshooting Aids

- **Hydraulic schematics** — an exact illustration of the arrangement of the system. The schematic shows all the components in relation to the system. The ability to understand the schematic is important to good troubleshooting. The schematic can be found at the end of this manual.
- **Flowmeter** — an instrument that can be connected into the system to measure the flow of the oil in the system. The flow is measured in gallons per minute (gpm) or liters per minute (Lpm). Normally, the flowmeter is used to check the output of the pump. The flowmeter can also be used to find the location of leakage or restriction in the system. Instructions for installation of the flowmeter and the use of the flowmeter are normally included with the flowmeter.
- **Pressure Gauge** — an instrument for measurement of the pressure in the system. This indication is normally given in pounds per square inch (psi) or bar. On this crane, quick couplers are installed in the pressure lines from the pumps. Pressure taken at these locations will give an indication of operating pressure or relief pressure.

### Troubleshooting Procedures

For good troubleshooting, a step by step analysis of the problem and the possible cause is necessary. First, find the symptoms.

- Check with the operator. Learn if there was a loss of power (crane did not move the load) or a loss of speed (slow cycle time).
- Learn if the problem is common to all circuits or is found in one or two circuits.
- Make a visual inspection. Look for a restriction in the linkages, low level of hydraulic oil, bent tubes, collapsed or ballooned hoses, leakage around the hydraulic components, etc.

Second, make an analysis of symptoms. The function of each component in the system must be known before a correct analysis can be made.

Remember:

- If a problem is common to all circuits, the component which is causing the problem must also be common to all circuits. Examples are: the engine, pump, hydraulic tank and filters.
- If the problem is common to only two or three circuits, the component which is causing the problem must be common to those two or three circuits. Examples are: pump section, relief valve, hydraulic swivel, etc.
- If a problem is in only one circuit, then the component which is causing the problem must be in that circuit. Examples are: valve section, cylinder, motor.

Again, use the schematic. Find which components are in the circuit or circuits. What component can cause the problem

with these symptoms? Make a list of the possible causes. Start at the source of the flow in that circuit. If the problem is in all circuits, start at the pump. Know the direction of oil flow through each circuit.

Use the flowmeter and pressure gauge to check your diagnosis of the problem. Start at the source of the flow and check each component in sequence until the exact location of the problem is found.

If the problem is in two or three circuits, check each circuit separately. After a circuit is checked, use caps or plugs to remove that circuit from the system. Continue to next circuit down the line until the problem is found.

**NOTE:** Do not remove the main relief valve from the circuit. The relief valve must be kept in the circuit to prevent damage to the pump and other components.

### TROUBLESHOOTING GUIDES

**Table 4-1**  
**General Hydraulic System Troubleshooting**

Problem	Possible Cause	Remedy
Noise (above normal).	Air in system.	With engine at low rpm, operate all control functions several times to return the air to atmosphere through the tank breather.
	Low oil supply.	Add recommended oil.
	Restriction in pump inlet line.	Remove and clean inlet line to pump.
	Dirty oil.	Change oil and filters.
	Loose clamps, vibration of hydraulic lines.	Check and tighten.
	Dirt or foreign material in a relief valve.	Clean or replace the relief valve.
	Broken control valve spool.	Replace the control valve section.
	Pump bearings worn.	Replace the bearings or pump.



Problem	Possible Cause	Remedy
Slow operating speeds (All functions).	Low engine rpm.	Increase engine rpm.
	Air leak in pump inlet line.	Tighten pump inlet line. Replace O-ring in inlet flange.
	Air in oil (foam in tank).	Check oil level, look for leaks in the system.
	Leakage in the load sense relief valve.	Remove and clean or replace the relief valve.
	Improper load sense relief valve setting.	Replace the relief valve.
	Leakage in hydraulic swivel.	Replace seals on swivel shaft.
	Control valve not fully actuated.	Check spool travel.
	Improper primary pump.	Check and adjust pump pressure settings. See <i>Checking and Adjusting Hydraulic Pressure Settings</i> , page 4-15.
	Faulty pump.	Overhaul or replace pump.
No movement when system is first started.	Low oil level.	Check and add oil.
	Air or restriction in inlet line to pump pressure.	Check and tighten inlet line. Clear restriction.
	Cold oil or wrong weight of oil.	Use correct oil, follow normal warming procedure.
Loss of movement during operation.	Low oil level.	Check and add oil.
	Vacuum in hydraulic tank.	Clean tank filler/breather cap.
	Restriction or leakage in the relief valve.	Clean or replace the relief valve.
	Broken hydraulic line.	Replace.
	Bad seal in hydraulic swivel.	Replace seals.
	Broken gear or shaft in pump.	Overhaul or replace.
Overheating of hydraulic oil.	Wrong operation (running over the load sense relief pressure setting for long periods).	Change procedure of operation.
	Dirty filters.	Change filter.
	Oil too light.	Use correct oil.
	Low oil level.	Check and add oil.
	Dirty oil.	Change oil and filters. See Chapter 5, 1.
Foam in hydraulic oil tank.	Leak in system.	Check O-ring on pump inlet. Check for leak in system and correct.
	Wrong type of oil.	Use correct oil.
	Low oil level.	Check and add oil.
	Bad seal in pump, motor or cylinder.	Overhaul or replace.
Short life of pump bearings, shafts, etc.	Dirt in oil.	Change oil and filter more frequently.
	Wrong type of oil.	Use correct oil.
Pump leakage (external).	Bad seal on pump shaft.	Replace shaft seal.
	Bad seals between pump sections (Swing & Steering).	Replace seals.

Problem	Possible Cause	Remedy
Difficult to engage valve spools.	Dirt or foreign material between spool and valve bore.	Remove and clean valve spool and bore.
	Broken spring (spool return).	Replace spring.
	Distortion or damage to valve spool.	Replace valve section.

**Table 4-2  
Lift Circuit Troubleshooting**

Problem	Possible Cause	Remedy
Lift cylinder does not extend or retract.	Control valve not actuated. Not enough oil from pump to operate the cylinder. Bad leak in hydraulic swivel. Load sense relief valve held open by dirt on valve seat.	See Difficult to Engage Valve Spools. See Loss of Movement During Operation. Replace seals. Disassemble and clean or replace the load sense relief valve.
Cylinder extends, but does not retract.	Malfunction in holding valve. Restriction in hose to control valve.	Replace the holding valve. DO NOT ADJUST. Check and correct.
Cylinder retracts but does not extend.	Malfunction in anti-double blocking electrical system. Bad cartridge in anti-double blocking solenoid valve. Restriction in pilot control line to control valve. Faulty controller.	See Electric System. Replace cartridge. Locate and repair. Repair or replace.
Boom moves slowly downward when control valve is in NEUTRAL position.	Internal leakage in cylinder. Leakage in holding valve. Faulty controller. Broken centering spring in control valve section.	Replace piston seals. Replace holding valve. DO NOT ADJUST. Repair or replace. Replace broken spring.

**Table 4-3  
Telescope Circuit Troubleshooting**

Problem	Possible Cause	Remedy
Cylinder will not extend the boom under load.	Restriction in boom sections. Load too heavy. Faulty pump. Leakage in hydraulic swivel. Load sense relief valve malfunction. Dirt or restriction in main relief.	Clean and apply lubricant to boom slides. See Chapter 5, 1. Reduce load. Overhaul or replace. Replace seals in the swivel. Check load sense relief pressure. Disassemble the relief valve and clean.
Boom extends, but will not retract.	Restriction in hose to the control valve. Malfunction in the holding valve.	Check and correct. Replace the holding valve. DO NOT ADJUST

Problem	Possible Cause	Remedy
Boom retracts but will not extend	Malfunction in anti-double blocking electrical system. Bad cartridge in anti-double blocking solenoid valve. Restriction in pilot control line to control valve. Faulty controller.	See Electric System. Replace the cartridge Check and correct. Repair or replace control valve.
Boom slow at extending.	Restriction in boom sections.	Clean and lubricate boom slides. See Chapter 5, 1.

**Table 4-4**  
**Outrigger Circuit Troubleshooting**

Problem	Possible Cause	Remedy
No movement all cylinders	Electrical problem. Dirt or restriction in the dump valve. Dirt in relief valve keeping the valve off the valve seat. Relief valve setting too low. Faulty pump section.	See Chapter 3, 1. Clean or replace the dump valve. Clean the relief valve. Check and adjust the relief valve setting. Overhaul or replace the pump.
Slow movement all outriggers.	Low engine rpm. Solenoid valve on outrigger valve section not fully actuating the valve spool. Leakage in relief valve.	Increase engine speed. Check for restriction or binding in the solenoid valve. Clean or replace the relief valve.
Slow movement, one cylinder.	Internal leakage in the cylinder	Replace piston seals.
Outrigger lowers but will not raise.	Problem in electrical circuit. Faulty lock valve in base of the cylinder.	See Chapter 3, 1. Replace counterbalance valve.
Outrigger cylinder does not hold under load.	Leakage in counterbalance valve in base of cylinder. Internal leakage in cylinder.	Clean or replace counterbalance valve. Replace piston seals.
Outriggers only on one side.	Faulty control valve section. Faulty solenoid valve or open circuit to solenoid valve. Faulty selector valve. Restriction or dirt between the outrigger valve spool and housing.	Repair or replace valve section. See Chapter 3, 1. Replace selector valve. Remove and clean the outrigger valve spool.

**Table 4-5  
Main Hoist Circuit Troubleshooting**

Problem	Possible Cause	Remedy
Hoist will not lift maximum (rated) load, considerable reduction in line speed.	Faulty load sense relief valve. Dirt in load sense relief valve, keeping the valve off the valve seat. Not enough oil from the pump.  Improper primary pump pressure. Malfunction or damage to hoist components.  Internal leakage in the hoist motor.	Replace the relief valve. Remove and clean the relief valve. See Main Relief and Port Relief Valves. Check hoses and lines for restrictions to or from pump. Check and adjust pressures. Check and overhaul the hoist, if necessary. See Chapter 11, 1. Check for binding or damaged sheaves. Replace the hoist motor.
Raise speed is slower than lowering speed.	Restriction in hose to control valve. Faulty counterbalance valve.	Check and repair. Replace the counterbalance valve.
Motor will not hold the load when the control lever is in neutral — load drops rapidly.	Overload condition. Faulty counterbalance valve.	Decrease the load. Replace the counterbalance valve.
Motor will not hold the load when the control lever is in neutral — load drifts down slowly.	Overload condition. Faulty counterbalance valve.	Decrease the load. Replace the counterbalance valve.
Hoist does not move.	Restriction in holding valve cartridge.  Brake not releasing.  Low pilot pressure.	Clean or replace the holding valve cartridge.  Check condition of the brake. Repair as necessary. Check and adjust.
Hook block lowers, but will not raise.	Malfunction in anti-double blocking electrical system. Bad cartridge in anti-double blocking solenoid valve. Faulty controller. Restriction in pilot control line to control valve.	See Chapter 3, 1.  Faulty controller.  Repair or replace. Locate and correct.

**Table 4-6  
Swing Circuit Troubleshooting**

Problem	Possible Cause	Remedy
Mast will not rotate when the swing control is actuated.	Damaged or broken motor shaft. Damaged or broken gearbox shaft or gear. Faulty pump. Leakage in hydraulic swivel. Main relief valve malfunction. Dirt or restriction in swing relief. Low pilot pressure. Faulty controller.	Repair or replace the swing motor. Overhaul or replace the gearbox. See Chapter 11, 1. Overhaul or replace the pump. Replace seals in the swivel. Check main relief pressure. Clean the relief valve. Check and adjust. Repair or replace.
Difficult or slow swing.	Friction or restriction in mast bearing. Faulty swing motor or gearbox.	See Chapter 11, 1. Repair or replace.

**HYDRAULIC SYSTEM**

**System Description**

The hydraulic system is a closed-center hydraulic system with pressure compensated load sensing characteristics driven by a variable displacement axial piston pump.

**Hydraulic Pump**

**Description**

The hydraulic pump is a variable displacement axial piston pressure compensated pump. The pump generates a fluid flow and imparts to that fluid the necessary pressure forces to obtain the hydraulic system pressure.

The pump basically consists of the housing (1, Figure 4-1), piston (2), shoes (3), port plate (4), drive shaft (5), swash plate (6), shaft seal (7), compensator (8) and valve plate (9).

Rotation of the drive shaft (5) and control piston (not shown) causes a linear piston movement as the piston shoe (3) slides along the tilted swash plate (6). As the piston retracts in the cylinder bore, hydraulic oil from the hydraulic oil tank fills the developing vacuum cavity by way of the suction kidney in the valve plate (9). At maximum retraction of the piston, shaft rotation causes the piston to go beyond the suction kidney and begin communication with the pressure kidney. Continuing rotation then extends the piston into the

cylinder bore, forcing oil into the pressure port and out to the hydraulic system.

**Test - Pump Output**

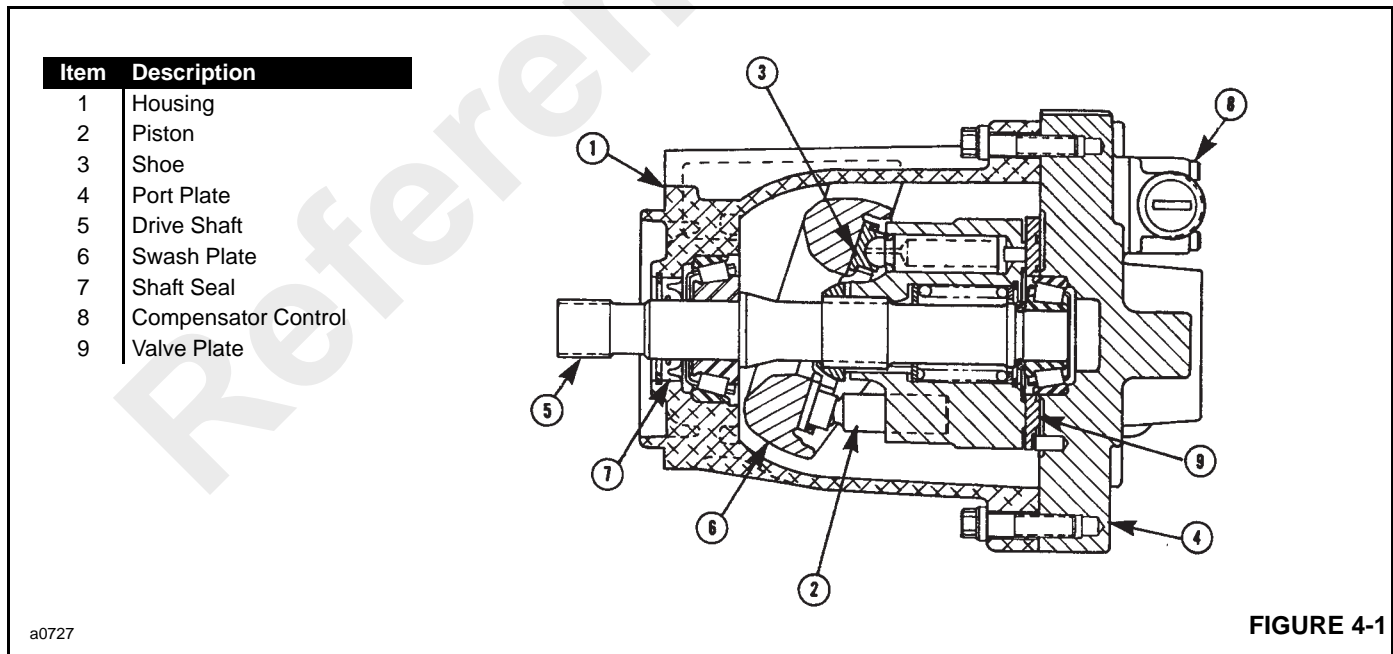
The hydraulic pump output can not be checked using a flowmeter. The efficiency of the pump must be checked by using function cycling speeds.

**Pressure Regulation**

System pressure is working on the pressure compensator against a setting spring. When system pressure overcomes the spring force, the spool shifts allowing system pressure into the control piston. This causes the pump to stroke to a regulating point sufficient to maintain the increased compensator setting (system pressure) and the lubrication fluid flow required.

When the system pressure setting is reached, only the amount of fluid necessary to satisfy the load conditions is delivered. If the load condition is such that no flow is required, only cooling and lubricating fluid is delivered. Power usage and heating of the fluid are kept to a minimum.

When the system pressure falls below the compensator spring setting, spring force returns the spool back to the normal position, which drains the control piston (2, Figure 4-1) to the pump case drain. This causes the pump to de-stroke, reducing the fluid flow to the level required.



**Description of Operation**

**Hydraulic System**

The hydraulic system is a closed-center hydraulic system. Which means that hydraulic oil is blocked from returning to

tank when the valves spools are in the neutral position. The control valve sections used in the hydraulic system of the main control valve are pressure compensated valve sections incorporating a flow divider principle in their operation. This provides the ability to control multifunction operation when flow demand exceeds pump capacity though slowed down proportionally. This means that all circuits will continue to

function regardless of differences in their load and regardless of the pump flow. The flow relationships specified between functions are maintained over the full range of the pump.

Figure 4-2 illustrates the interrelationship of the load sense shuttle (1), the compensator (2), the directional spool or variable orifice (3), combined with the variable displacement load sense pump (4).

After the spool is activated the work port load pressure is transmitted to the bridge (5). The load sense shuttle (1), in turn, transmits the highest work port pressure to the load sense port of the pump (4) and all compensators (2) within the valve assembly. Pump (4) responds to the load sense signal with load sense pressure plus pump margin or differential pressure. It is this margin or differential pressure that overcomes the compensators (2) and permits flow to bridge (5) and work port A (16) or B (17). This system establishes a constant pressure differential across a variable orifice spool (3). At full stroke of spool (3) the maximum orifice can be determined, thus creating spool flow ranges

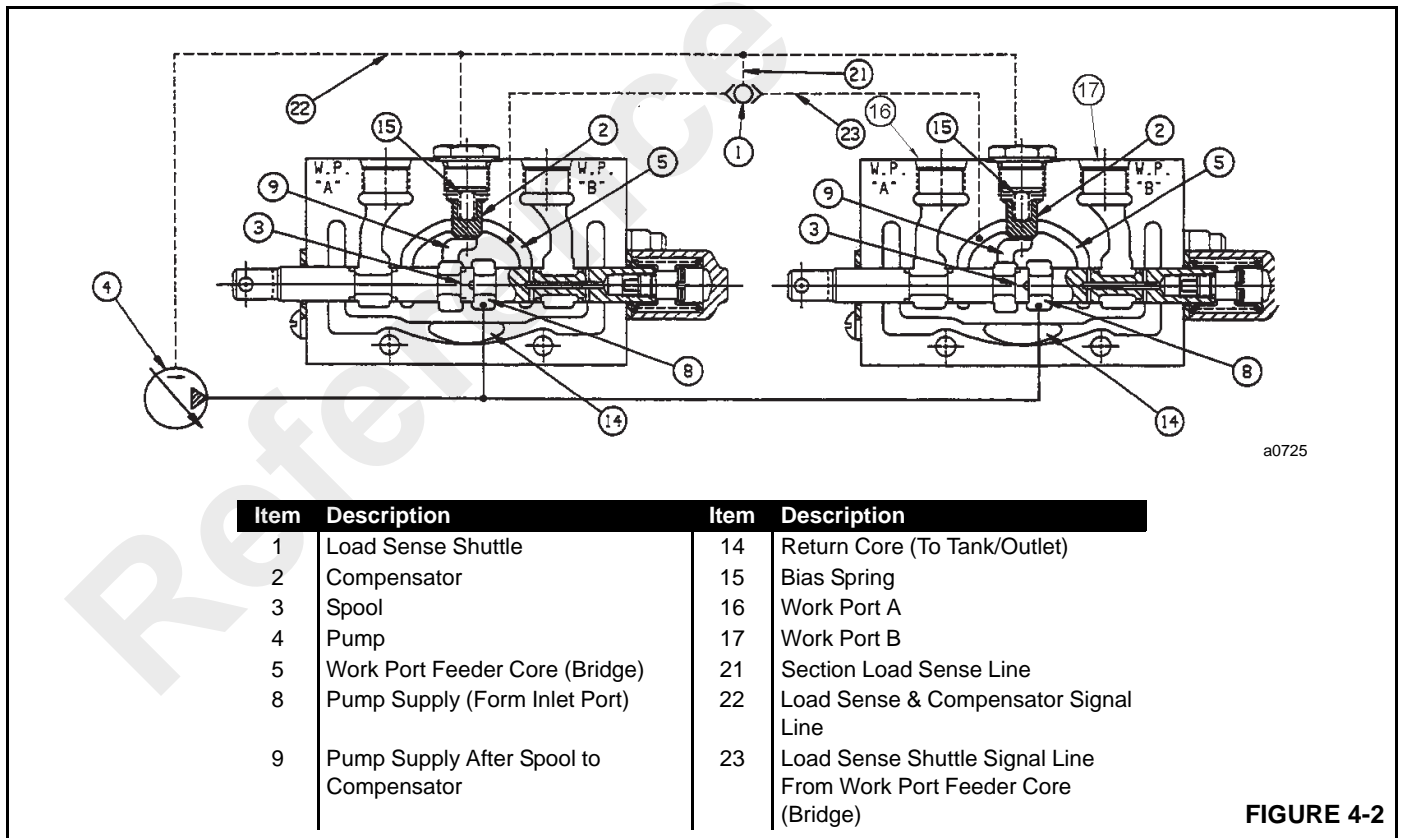
(i.e. 76, 114, 151 Lpm [20, 30, 40 gpm]) at a predetermined pressure differential at spool (3). It is the working combination of the components that sets up the flow dividing principle.

**Inlet Section**

The inlet section (Figure 4-2) is connected to the pressure side of the variable displacement load sense pump by a hydraulic hose. There is a load sense relief valve installed in the inlet section.

**Working Valve Sections**

There are four working sections (Figure 4-2) of the main control valve that receive hydraulic oil from the variable displacement load sense pump. These sections control the hoist, telescope, lift and swing functions. They are closed-center sections, blocking any return of oil back to tank until the valve spool is actuated to operate a function. Flow is then directed through the return core (14, Figure 4-2) to the outlet port of the inlet/outlet section and then to tank.



**HYDRAULIC SWIVEL**

**General**

The hydraulic swivel is at the center of rotation of the mast. The purpose of the hydraulic swivel is to permit the flow of oil between the hydraulic components on mast and boom and

the components on the lower structure during any rotation of the mast.

The hydraulic swivel has seven passages Figure 4-3. Grooves and ports in the shaft align with ports in the housing. Seals between the grooves of the shaft prevent leakage between the passages. The seals fit tightly against the

housing. The housing rotates with the mast and the shaft is stationary.

**Functions**

The numbers of each port is stamped on the housing and on the lower end of the shaft.

**Port No. 1**

Hydraulic oil under pressure flows through this port when the hoist block is being raised. When lowering the hoist block the hydraulic oil under low pressure flows through this port.

**Port No. 2**

Hydraulic oil under pressure flows through this port when the hoist block is being lowered. When raising the hoist block the hydraulic oil under low pressure flows through this port.

**Port No. 3**

Hydraulic oil under pressure flows through this port when the boom is being lowered. When raising the boom the hydraulic oil under low pressure flows through this port.

**Port No. 4**

Hydraulic oil under pressure flows through this port when the boom is being raised. When lowering the boom the hydraulic oil under low pressure flows through this port.

**Port No. 5**

Hydraulic oil under pressure flows through this port when the boom is being retracted. When extending the boom the hydraulic oil under low pressure flows through this port.

**Port No. 6**

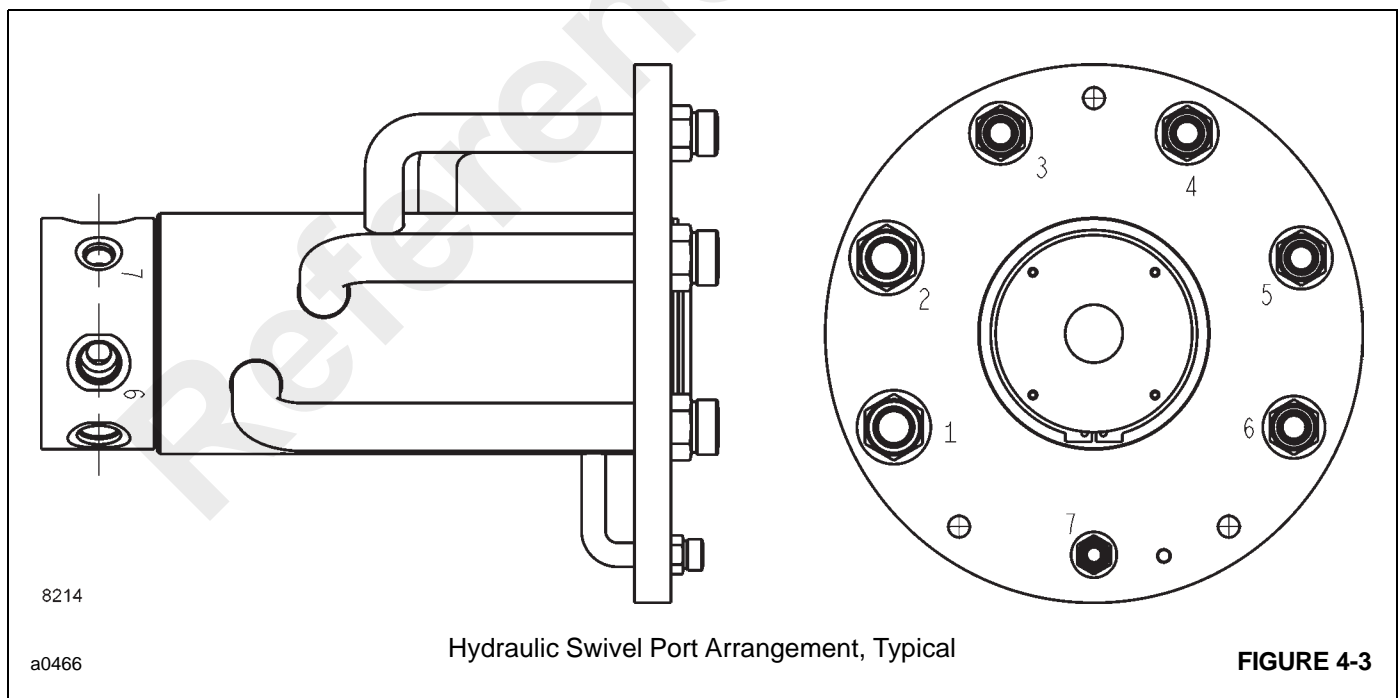
Hydraulic oil under pressure flows through this port when the boom is being extended. When retracting the boom the hydraulic oil under low pressure flows through this port.

**Port No. 7**

Hydraulic oil under low pressure flows through this port from the hoist motor drain.

**Troubleshooting**

Leakage between the passages of the hydraulic swivel will cause loss of power or possible wrong operation of one of the circuits. It is important to know the arrangement of the passages in the hydraulic swivel. Remember that the oil will always follow the path of least resistance.



**LIFT CIRCUIT**

Use the hydraulic schematic in Section 12 along with the following text to understand how the lift circuit functions.

**General**

The lift hydraulic circuit includes two lift cylinders, two holding valves, Ports 3 and 4 in the hydraulic swivel, an anti-double

block cutout solenoid valve, a valve section of the four-spool control valve (Figure 4-4), and the hydraulic lines.

### Oil Flow

When the valve spool is in the neutral position, both A and B ports are closed and oil is held in the circuit to prevent movement of the lift cylinders.

#### *Raising the Booms*

Pulling the joystick towards the operator connects the pump passage A in the control valve. Oil leaves Port B of the control valve section and passes through Port 4 of the hydraulic swivel and enters the base end of the lift cylinders through the holding valves. In this direction, the oil flows freely through the holding valves and into the base end of the cylinder. The cylinder rod starts to extend, pushing oil ahead of the piston out the rod end port. The oil returns through Port 3 of the hydraulic swivel to Port A of the control valve section. From here, the oil is routed to the tank passage of the control valve assembly and returns through the return filter to the hydraulic oil tank.

The anti-double block valve will shut off the oil supply to the cylinders in the event the hook block comes in contact with the boom head. In this case, the operator must let out more rope on the hoist before the boom can be raised.

#### *Lowering the Booms*

Pushing the joystick away from the operator sends oil in the opposite direction and causes the cylinder to retract. The holding valve lets the cylinder retract only if there is oil under pressure available to the rod port of the cylinder. See Holding Valve.

### Holding Valve

The holding valve has three functions:

1. Inhibit cavitation of the cylinder,
2. Give full control of the lowering of the boom,
3. Hold the load in event of a hydraulic failure.

Pilot pressure from the rod side of the piston opens the holding valve. If the cylinder starts to retract faster than the pump can fill the cylinder, there will be a decrease in the pilot pressure. The holding valve will close and interrupt the flow of oil from the cylinder. The holding valve will interrupt the flow as often as necessary to keep the cylinder filled. Also, if there is a failure of the pump or a hydraulic line, the holding valve will hold the boom in position.

Engine speed is important for good lowering of the boom. At low engine speed, normally there will not be enough oil from the pump to keep the cylinder filled. As a result, the boom will move down in a movement that is not regular.



### WARNING

Do not adjust the holding valve setting. The valve is adjusted by the manufacturer.

### Lift Cylinder Leakage Check

If internal leakage in one or both of the cylinders is suspected, check for leakage as follows:

1. Remove the suspected cylinder from the machine. See page 4-33.
2. Mount the cylinder in a suitable cylinder stand.
3. Connect a portable hydraulic system to the cylinder base end.
4. Apply pressure to extend the cylinder rod.
5. Check the amount of leakage from the rod port of the cylinder. If the cylinder leaks more than a few drops of oil per minute, replacement of the piston seals is necessary, See page 4-33.



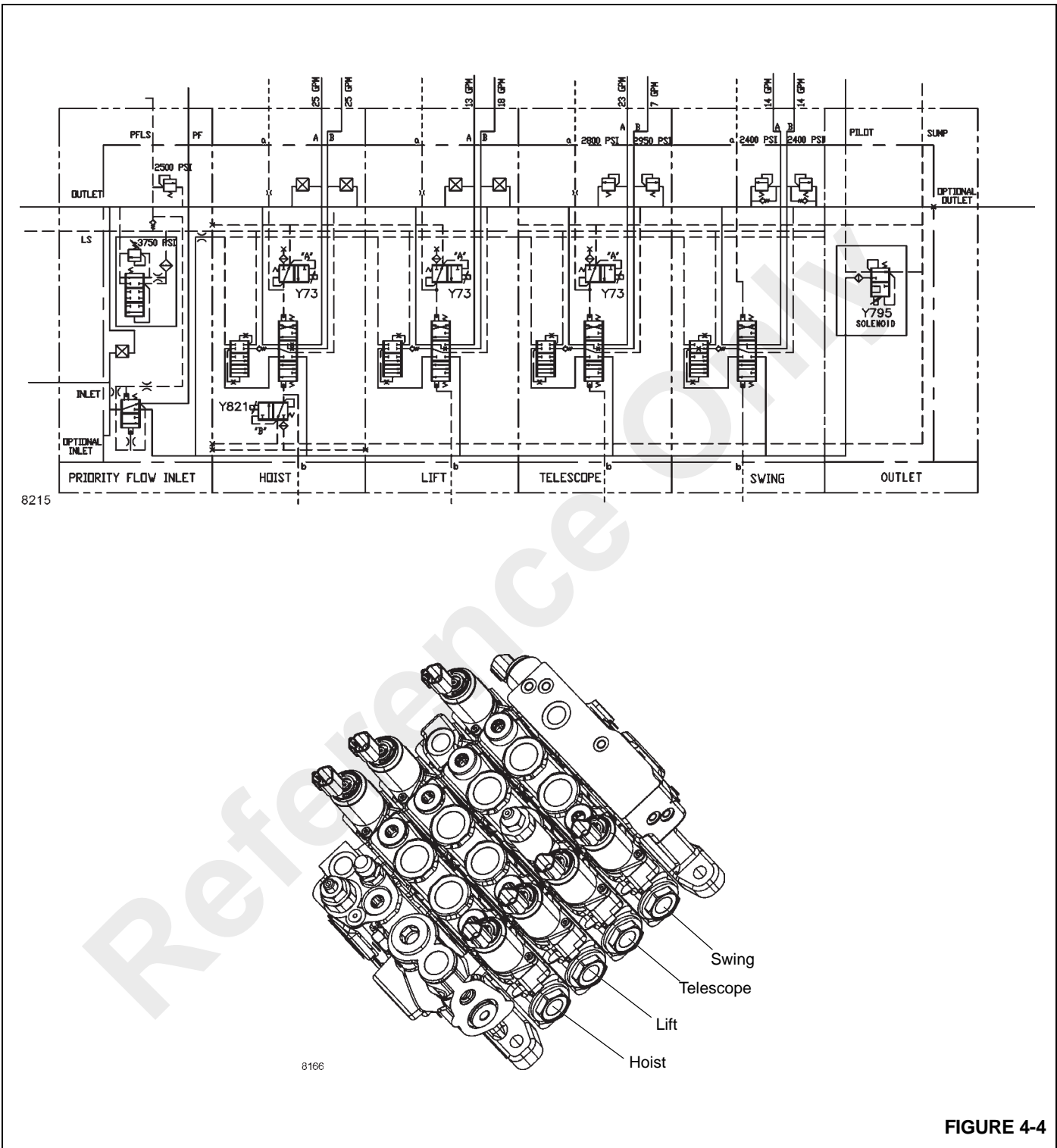


FIGURE 4-4

## TELESCOPE CIRCUIT

Use the hydraulic schematic in Section 12 along with the following text to understand how the telescope circuit functions.

### General

The telescope circuit includes the telescope cylinder, a holding valve, ports 5 and 6 of the hydraulic swivel, an in-line relief valve, an anti-double block cutout solenoid valve, the first section of the four-spool main control valve, and the hydraulic lines.

### Oil Flow

#### *Telescope Out*

Pushing joystick away from operator connects the supply from the pump to port B of the control valve section (Figure 4-4). Oil leaves Port B and is routed through the anti-double block solenoid valve and hydraulic swivel port 6 to the holding valve on the base end of the cylinder to port E.

In the extending direction, oil flows freely through the holding valve and into the base end of the cylinder. The cylinder extends and pushes oil ahead of the piston through the rod end port of the cylinder. The oil returns through swivel port 5 and Port A of the control valve. From here, the oil is routed into the tank passage and returns through the return filter to the hydraulic tank.

The anti-double block valve will shut off the oil supply to the telescope cylinder in the event the hook block comes in contact with the boom head. In this case the operator must let out more wire on the main hoist before he can extend the boom.

#### *Telescope In*

Pulling the joystick towards operator, routes oil out of valve port A and through the port 5 of the hydraulic swivel to the rod port ('R') of the holding valve mounted on the hydraulic cylinder. The cylinder starts to retract but meets resistance from the oil held in the cylinder base end by the holding valve. This restriction causes an increase in pressure as the pump continues to push more oil into the rod port of the cylinder. When the pressure is high enough to open the holding valve, the cylinder retracts. See Holding Valve.

The relief valve in the circuit protects the telescope cylinder. If the pressure should ever reach 203.40 bar (2950 psi) to the rod port or 193.05 bar (2800 psi) to the piston port the relief valve will open and return oil to tank, stopping any movement of the telescope cylinder and its cable mechanism.

Oil from the rod end of the cylinder returns through port 6 of the hydraulic swivel to the control valve. From here, the oil is routed through the return filter to the hydraulic tank.

## Holding Valve

The holding valve has three functions:

1. Inhibit cavitation of the cylinder.
2. Give full control of the lowering of the boom.
3. Hold the load in event of a hydraulic failure.

Pilot pressure from the rod side of the piston opens the holding valve. If the cylinder starts to retract faster than the pump can fill the cylinder, there will be a decrease in the pilot pressure. The holding valve will close and interrupt the flow of oil from the cylinder. The holding valve will interrupt the flow as often as necessary to keep the cylinder filled. Also, if there is a failure of the pump or a hydraulic line, the holding valve will hold the boom in position.

Engine speed is important for smooth operation. At low engine speed, normally there will not be enough oil from the pump to keep the cylinder filled. As a result, the boom will move down in a movement that is not regular.



### WARNING

Do not adjust the holding valve setting. The valve is adjusted by the manufacturer.

## Port Relief Valve

The port relief valve installed in the telescope circuit is used to protect the telescope mechanism (cables, sheaves, etc.) from damage caused by high hydraulic oil pressure.

The relief valve for the telescope circuit is located in the telescope section of the four-section control valve and is connected to Port B and Port A.

### *Checking Relief Valve Pressure*

1. Install a 0 - 344.50 bar (0 - 5000 psi) pressure gauge on the quick-coupler for pump section No.2.
2. Accelerate the engine to maximum RPM.
3. Fully retract the booms. Continue to hold the control in position after the boom has stopped moving.
4. Read the pressure indicated on the pressure gauge when the relief valve opens. It should be  $134.45 \pm 3.45$  bar ( $1950 \pm 50$  psi).
5. Release the control lever.
6. Fully extend the booms. Continue to hold the control in position after the boom has stopped moving.
7. Read the pressure indicated on the pressure gauge when the relief valve opens. It should be  $124.02 \pm 3.45$  bar ( $1800 \pm 50$  psi).

8. If the pressure readings are correct, stop the engine and remove the pressure gauge.
9. If the pressure readings are incorrect, adjust the pressure setting of the relief valve.

### Telescope Cylinder Leakage Test

If the cylinder does not hold the load, the problem is normally internal leakage in the cylinder. This problem can also be caused by leakage in the control valve or the holding valve. To check for leakage in the cylinder:

1. Raise the boom a little above the horizontal position.
2. Fully extend the boom.
3. Stop the engine. Move the control lever several times in each direction to release any hydraulic pressure in the circuit.
4. Disconnect the hydraulic hose from bulkhead elbow Figure 4-7 which connects to the rod port of the telescope cylinder. A little oil will drain from the elbow.
5. Start the engine. Actuate the control lever in the direction to extend the boom. Check the amount of leakage from the bulkhead elbow. If the leakage is more than a few drops per minute, replacement of the piston seals is necessary.

### Hydraulic Swivel

See page 4-9 for hydraulic swivel information.

### HOIST CIRCUIT

Use the hydraulic schematic in Section 12 along with the following text to understand how the hoist circuit functions.

#### General

The hoist circuit includes the hoist motor, a brake, a brake holding valve, ports 1 and 2 of the hydraulic swivel, an anti-double block solenoid valve, the control valve (Figure 4-4) and the hydraulic lines.

### Oil Flow

When the valve spool is in the neutral position, both A and B ports are closed. Oil is held in the hoist circuit, inhibiting movement of the hoist motor.

#### Hoist Up

Pulling the joystick towards the operator routes oil from the pump to cylinder port A of the control valve (Figure 4-4). From here the oil is routed through the anti-double block solenoid valve, and swivel port 2 to the brake holding valve. In this direction, the oil flows freely through the brake holding valve to the hoist motor.

During this operation the brake is not released, since the load is driven through a one-way cam clutch in the hoist, bypassing the brake. When the hoist comes to a stop, the cam clutch locks up and the load is prevented from moving by the brake.

The anti-double block solenoid valve will shut off the oil supply to the hoist motor in the event the hook block comes in contact with the boom head. In this case the operator must lower the hook block before the boom can be raised or extended.

The oil turns the motor and returns through swivel port 1 to the control valve. From here, the oil is sent back through the filter to the hydraulic tank.

#### Hoist Down

Pushing the joystick away from the operator sends oil from cylinder port B of the single spool control valve through swivel port 1 to the hoist motor. The motor starts to turn, and the increase in pressure on the up stream side of the motor causes the brake holding valve to open and also the hoist brake to disengage. The oil then returns through swivel port 2 to the control valve and back to the tank.

#### Drain Line

A drain line is connected to the hoist motor and returns drain oil from the motor through swivel port 7 back to the hydraulic tank.

## Brake Holding Valve

The holding valve has three functions:

1. Inhibit cavitation of the motor.
2. Give full control of the lowering of the load.
3. Hold the load in event of a hydraulic failure.

Pilot pressure from the down stream side of the motor opens the holding valve. If the motor starts to turn faster than the pump can supply oil to the motor, there will be a decrease in the pilot pressure. The holding valve will close and interrupt the flow of oil from the motor. The holding valve will interrupt the flow as often as necessary to keep the flow constant to the motor. Also, if there is a failure of the pump or a hydraulic line, the holding valve will hold the load in position.

Engine speed is important for smooth operation. At low engine speed, normally there will not be enough oil from the pump to keep the motor turning. As a result, the load will move down in a movement that is not regular.



### WARNING

Do not adjust the holding valve setting. The valve is adjusted by the manufacturer.

## Hydraulic Swivel

See page 4-9 for hydraulic swivel information.

## SWING CIRCUIT

### General

The swing motor is controlled by the fourth section of the four-spool control valve (Figure 4-4). In the neutral position, oil is held in the circuit and the motor is prevented from turning. The gear/pinion is protected by a port relief valve set at 159.96 bar (2320 psi) in both swing directions.

### Oil Flow

#### Swing Right

Pushing the joystick away from the operator sends oil through motor port A of the valve section to the swing motor. The motor rotates clockwise and causes the mast to rotate to the right. Oil from downstream side of the motor returns

through the B port and sent back to tank through the return filter.

#### Swing Left

Pulling the joystick towards the operator sends oil through motor port B of the valve section to the swing motor. The motor rotates counter clockwise and causes the mast to rotate to the left. Oil from downstream side of the motor returns through the A port and is sent back to the tank through the return filter.

## PILOT CONTROL SYSTEM

### General

The pilot control system is used to actuate the spools of the main control valve using hydraulic pressure. The system includes a relief valve, two remote control valves and the hydraulic hoses and fittings.

### Oil Flow

The pilot control system receives its hydraulic flow from the pilot port of the Main Control Valve. The pilot control circuit is protected by a 34.48 bar (500 psi) relief valve.

Oil under pressure is routed to the four remote control valves, where it is directed by the remote control valves to actuate the spools of the main control valve.

Oil from the remote control valves is routed back to the hydraulic tank.

### Pilot System Relief Valve

The relief valve maintains the 34.48 bar (500 psi) system pressure by opening and returning oil to the hydraulic tank when the pressure setting is exceeded.

## PRESSURE SETTING PROCEDURES

### Checking and Adjusting Hydraulic Pressure Settings

In the valve bank assembly compartment are the following two valve assemblies: the brake/steering manifold (1, Figure 4-5), and the main control valve (2, Figure 4-5).

Check all pressures with hydraulic fluid at normal operating temperature, 60°-71°C (140°-160°F)—check hydraulic fluid temperature at the bottom of the hydraulic tank. Also, the engine must be at maximum RPM.

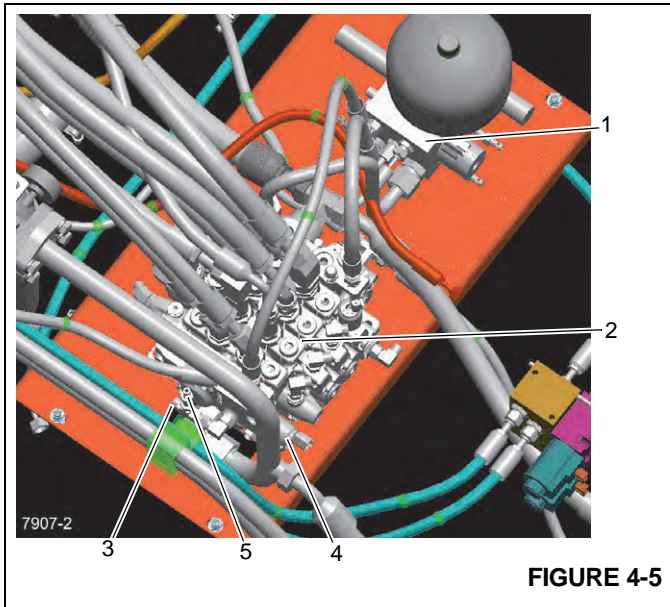


FIGURE 4-5

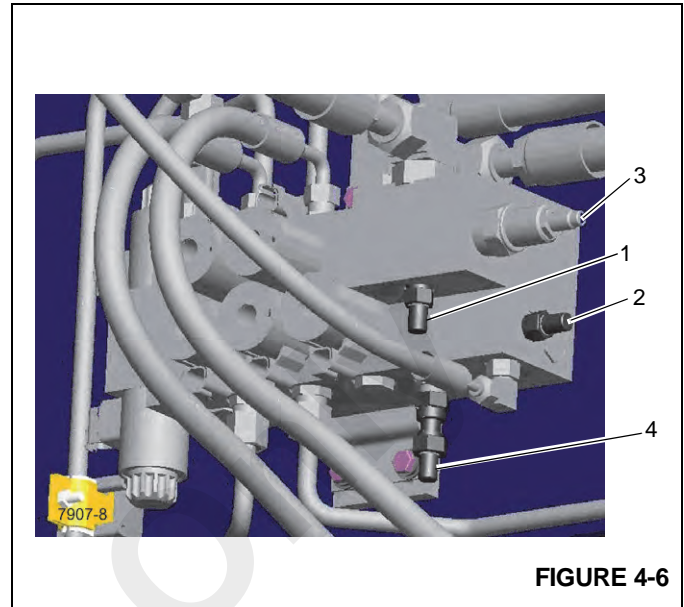


FIGURE 4-6

### Pump Margin Pressure Setting

1. With the engine shut off, install a 0 - 344.73 bar (0-5000 psi) pressure gauge on the test port G1 (1, Figure 4-6).
2. Start engine and read the pressure gauge while at engine idle. A reading of  $24.13 \pm 0.35$  bar ( $350 \pm 5$  psi) should be observed.
3. If pressure reading is correct, shut off the engine, and disconnect the pressure gauge.
4. If pressure is incorrect, loosen the margin set screw from the pump compensator valve (4, Figure 4-7). A 4 mm hex wrench is required for the set screw.
5. Adjust the margin pressure setting by turning the margin adjusting screw (1, Figure 4-7) until  $24.13 \pm 0.35$  bar ( $350 \pm 5$  psi) pressure is obtained on the gauge; clockwise increases pressure, counterclockwise reduces the pressure. A 6 mm hex wrench is required for the adjusting screw.
6. Tighten the margin set screw.
7. Shut off the engine and disconnect the pressure gauge.

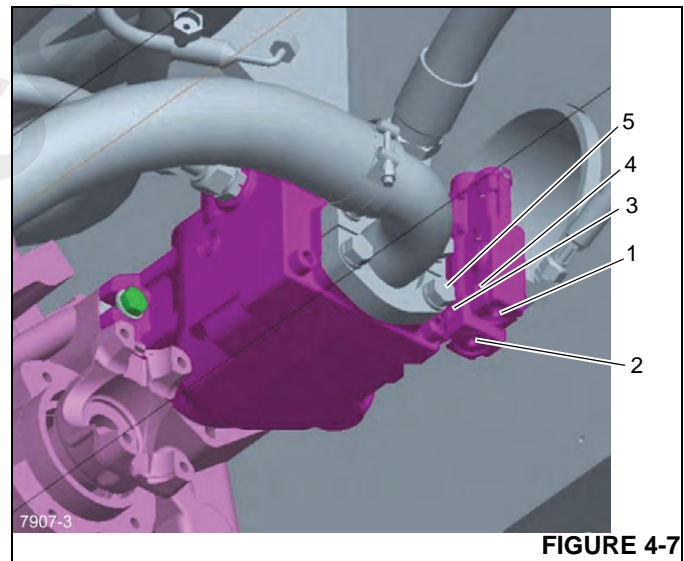


FIGURE 4-7

### Pump Compensator Pressure Setting

The pump compensator pressure is the main hydraulic system pressure. It is regulated by a pressure compensating valve located on the main hydraulic pump.

**NOTE:** Always set the pressures on the pump compensator and load sense relief valves together.

1. With the engine shut off, install a 0 - 344.73 bar (0-5000 psi) pressure gauge on the test port (1, Figure 4-6).
2. On the control valve, remove the cap on the load sense relief valve (1, Figure 4-8) and turn the adjusting screw fully in. A 19 mm open end wrench is required for the jam nut and a 3 mm wrench is required for the adjusting screw.

3. Start the engine.
4. Ensure the boom is all the way down. Activate the boom down function at full engine throttle. The pressure gauge should read  $289.57 \pm 3.45$  bar ( $4200 \pm 50$  psi).

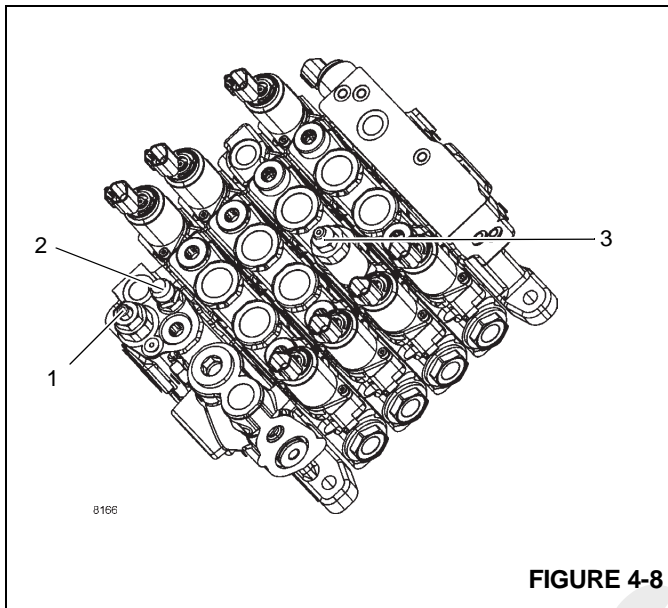


FIGURE 4-8

5. If pressure reading is correct:
  - a. Shut off the engine, and disconnect the pressure gauge.
  - b. Replace the cap nut on the load sense relief valve.
  - c. Set the pressure on the load sense relief valve, refer to *Load Sense Relief Valve Pressure Setting*.
6. If pressure reading is incorrect:
  - a. Remove the bolt on the suction hose split flange by the compensator set screw (5, Figure 4-7).
  - b. Loosen the set screw from the pump compensator valve (3, Figure 4-7). A 4 mm hex wrench is required for the set screw.
  - c. While engaging the boom down function with the engine at full throttle, adjust the pump max pressure setting by turning the compensator adjusting screw (2, Figure 4-7) until  $289.58 \pm 3.45$  bar ( $4200 \pm 50$  psi) pressure is obtained on the gauge; clockwise increases pressure, counterclockwise reduces the pressure. A 6 mm hex wrench is required for the adjusting screw.
  - d. Tighten compensator set screw.
  - e. Install and tighten the split flange bolt.
  - f. Shut off the engine, and disconnect the pressure gauge.

Set the pressure on the load sense relief valve, refer to *Load Sense Relief Valve Pressure Setting*

#### **Load Sense Relief Valve Pressure Setting**

**NOTE:** Always set the pressures on the pump compensator and load sense relief valves together.

1. Install a 0 - 344.73 bar (0-5000 psi) pressure gauge on the load sense test port (2, Figure 4-6) located on the front outrigger manifold.
2. Start the engine.
3. Loosen the jam nut on the relief valve (1, Figure 4-8). A 19 mm open end wrench is required for the jam nut.
4. Ensure the boom is all the way down. Activate the boom down function at full engine throttle, adjust the load sense relief setting by turning the relief valve adjusting screw (1, Figure 4-8) until  $258.55 \pm 3.45$  bar ( $3750 \pm 50$  psi) pressure is obtained on the pressure gauge; clockwise increases pressure, counterclockwise reduces the pressure. A 4 mm hex wrench is required for the adjusting screw.
5. Tighten the jam nut on the load sense relief valve.
6. Shut the engine off and disconnect the pressure gauge.
7. Set the pressure on the priority flow load sense valve, refer to *Priority Flow Load Sense Relief and Accumulator Relief Setting*, page 4-17.

#### **Priority Flow Load Sense Relief and Accumulator Relief Setting**

1. Install a 0 - 344.73 bar (0-5000 psi) pressure gauge on the G1 port (1, Figure 4-9) located on the brake/steering manifold.
2. With the park brake on start the engine. Set crane up on a level surface with outrigger jacks fully extended.
3. Remove the cap nut on the priority flow load sense relief valve (2, Figure 4-8) located on the main control valve. A 18 mm wrench is required for the cap nut. Turn steering wheel all the way to one side until the steer cylinder bottoms out while another person adjusts the priority flow load sense relief setting by turning the relief valve adjusting screw (2, Figure 4-8) until  $172.37 \pm 3.45$  bar ( $2500 \pm 50$  psi) is obtained on the pressure gauge; clockwise increases pressure, counterclockwise reduces the pressure. A 3mm hex wrench is required for the adjusting screw.
4. Replace the cap nut on the priority flow load sense relief valve.

5. Shut down the engine and remove the pressure gauge.
6. Install a 0 - 344.73 bar (0-5000 psi) pressure gauge on the G2 port (3, Figure 4-9) located on the brake/steering manifold.
7. With the park brake on start the engine. Loosen jam nut on the UP10 pilot unloading valve (2, Figure 4-9). A 19 mm open end wrench is required for the jam nut.
8. Pump the brakes to lower the accumulator pressure below 110.32 bar (1600 psi). Keep pumping the brakes while another person adjusts the accumulator relief setting by turning the relief valve adjusting screw (2, Figure 4-9) until  $137.90 \pm 3.45$  bar (2000 psi  $\pm$  50 psi) is obtained on the pressure gauge; clockwise increases pressure, counterclockwise reduces the pressure. A 7mm hex wrench is required for the adjusting screw.
9. Tighten the jam nut against the valve body.
10. Shut down the engine and remove the pressure gauge.

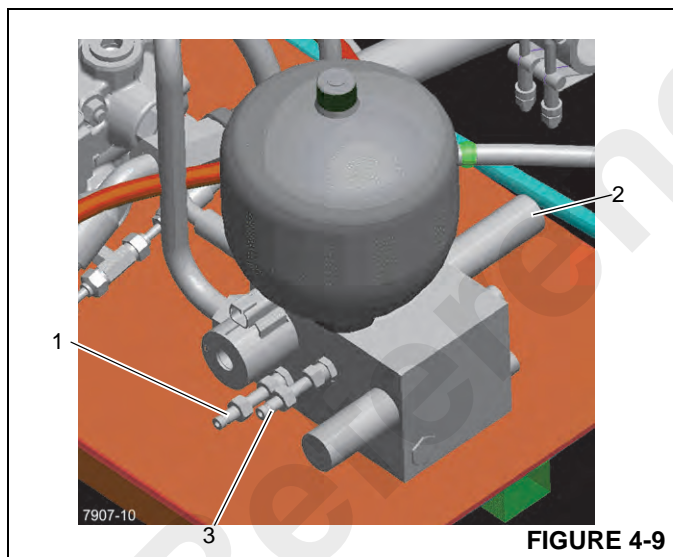


FIGURE 4-9

### Boom Telescope Extend Pressure Setting

**NOTE:** Always check/set the pressure on the load sense relief valve before checking the pressure on the other valves.

1. With the engine off, install a 0 - 344.73 bar (0-5000 psi) pressure gauge on the load sense test port (2, Figure 4-6).
2. Extend pressure setting procedure:
  - a. Set the crane up on outriggers.
  - b. Operate the extend boom function to fully extend the boom and hold while another person observes the pressure gauge, the pressure should be  $193.05 +3.45/-0$  bar (2800 +50/-0 psi).

- c. If the pressure is incorrect, adjust the extend work port relief valve (3, Figure 4-8) on the control valve until the pressure reads  $193.05 +3.45/-0$  bar (2800 +50/-0 psi); clockwise increases pressure, counterclockwise reduces the pressure. A 3mm hex wrench is required for the adjusting screw.

3. Retract the boom and outriggers.
4. Shut the engine off.
5. Remove the gauge.

### Outrigger Circuit Pressure Setting

1. Shut off the engine. Install a 0 - 344.73 bar (0-5000 psi) pressure gauge to the front outrigger manifold test point (4, Figure 4-6).
2. Start and accelerate the engine to maximum rpm.
3. Actuate the outrigger enable switch to the extend position while another person observes the pressure gauge. The pressure should be  $172.37 \pm 3.45$  bar (2500 psi  $\pm$  50 psi).
4. Return the control to the neutral position.
5. If the pressure reading is correct, stop the engine and remove the pressure gauge.
6. If the pressure reading is incorrect:
  - a. Loosen the jam nut on the outrigger relief valve (3, Figure 4-6) at the front of the machine on the front outrigger housing weldment. A 19 mm open end wrench is required for the jam nut.
  - b. Start and accelerate the engine to maximum RPM.
  - c. Actuate the outrigger enable switch to the extend position.
  - d. Turn the adjusting screw in or out to obtain  $172.37 \pm 3.45$  bar (2500 psi  $\pm$  50 psi). In will increase pressure; out will decrease pressure. A 3mm hex wrench is required for the adjusting screw.
  - e. Tighten the jam nut against the relief valve body.
  - f. Shut down the engine and remove the pressure gauge.

### Pilot Pressure Setting

1. With the engine shutdown and the parking brake set, install a 0 - 344.73 bar (0-5000 psi) pressure gauge onto the pilot test port (5, Figure 4-5) of the control valve.
2. Start the engine and actuate the crane power switch and read the pressure indicated on the pressure gauge. The gauge should read  $25.00 \pm 1.72$  bar (362  $\pm$  25 psi). If the pressure setting is correct shutdown the engine and remove the pressure gauge. If the pressure setting is incorrect, verify the supply current to the crane power solenoid. The pilot pressure setting is not adjustable.

## ANTI-DOUBLE BLOCKING SYSTEM

### General

The anti-double block circuit protects the hoist, telescope and lift circuits from damage in the event that the hoist block comes in contact with the boom head causing a double blocking situation. The anti-double block system includes an anti-double block mechanism Figure 4-10 at the end of the boom head, a valve block with three normally closed solenoids, and a check valve in the main control valve sections for lift, telescope and hoist functions.



FIGURE 4-10

### System Function

The main control valve sections for the hoist, telescope and lift functions each have a check valve installed internally. This check valve is connected to the return passage in the valve section and to port A of the valve section. Its primary function is to release hydraulic oil back to tank whenever the anti-double block solenoid valves are open (de-energized).

During normal operation the solenoid valves are in the closed (energized) position (Figure 4-7). In the closed position oil under pressure is stopped by the solenoid valve from returning to tank. The blocked fluid under pressure passes through a restriction in the valve section to the check valve. The check valve is held closed by a combination of the check valve spring and oil pressure from the closed solenoid valve. In combination, the oil pressure and spring pressure is greater than the return oil pressure and the check valve is kept closed. Return oil is then directed through the valve spool to the outlet port of the control valve.

When the hoist block comes in contact with the anti-double blocking bracket at the end of the boom head, the bracket raises and actuates a switch. This switch, when actuated, closes an electrical signal to the three solenoid valves opening them Figure 4-8. With the solenoid valves open, oil supply to the check valve is reduced. The check valve spring

alone is not enough to hold the check valve closed, therefore, the check valve opens. With the check valve open, hydraulic oil which would normally flow to the lift cylinder, telescopic cylinder or hoist motor through port A of the valve section is returned through the check valve to the outlet of the control valve, or through the open solenoid valve, back to tank.

Lowering the hoist block will deactivate the switch to close the solenoid valves and return flow through port A to the function.

## OUTRIGGER AND AXLE LOCK OUT CIRCUITS

### Independently Controlled Outrigger Hydraulic System

The independently controlled outrigger hydraulic system includes a priority flow control valve, an accumulator charging valve, a dump valve, the first eight solenoid valves of the outrigger valve, four horizontal outrigger cylinders and four vertical outrigger cylinders with holding valves.

#### Oil Flow

Oil from the fourth pump section flows at a rate of 60.5 L/min (16 gpm) to the priority flow control valve. The priority flow control valve reduces the flow rate to 45.4 L/min (12 gpm) to the accumulator charging valve. It then passes through the accumulator charging valve to the dump valve. If the dump valve is energized (actuation of an outrigger switch) the oil flows to the outrigger valve. Depending upon which outrigger function is activated (solenoid valve energized), the oil flows through outrigger valve section to the outrigger. The cylinder extends or retracts and pushes oil ahead of the piston through one of the ports of the cylinder. The oil returns through outrigger control valve back to tank through the return filter.

### Outrigger Valves

#### Description

The front outrigger valve consists of a manifold, relief valve, and five solenoid valves. The fifth solenoid valve is used to control the optional under deck winch.

The rear outrigger valve consists of a manifold, relief valve, and five solenoid valves, the fifth valve is used to control the axle oscillation cylinders.

Each solenoid valve has a closed-center passage, blocking oil at the valve and preventing oil from returning to tank unless the spool is shifted. Oil from the manifold inlet flows directly to each valve section where it stops. When a section solenoid is activated, the spool moves allowing oil to flow through the solenoid valve section and manifold to the outrigger cylinder. Return oil from the cylinder flows through the valve section back to tank.



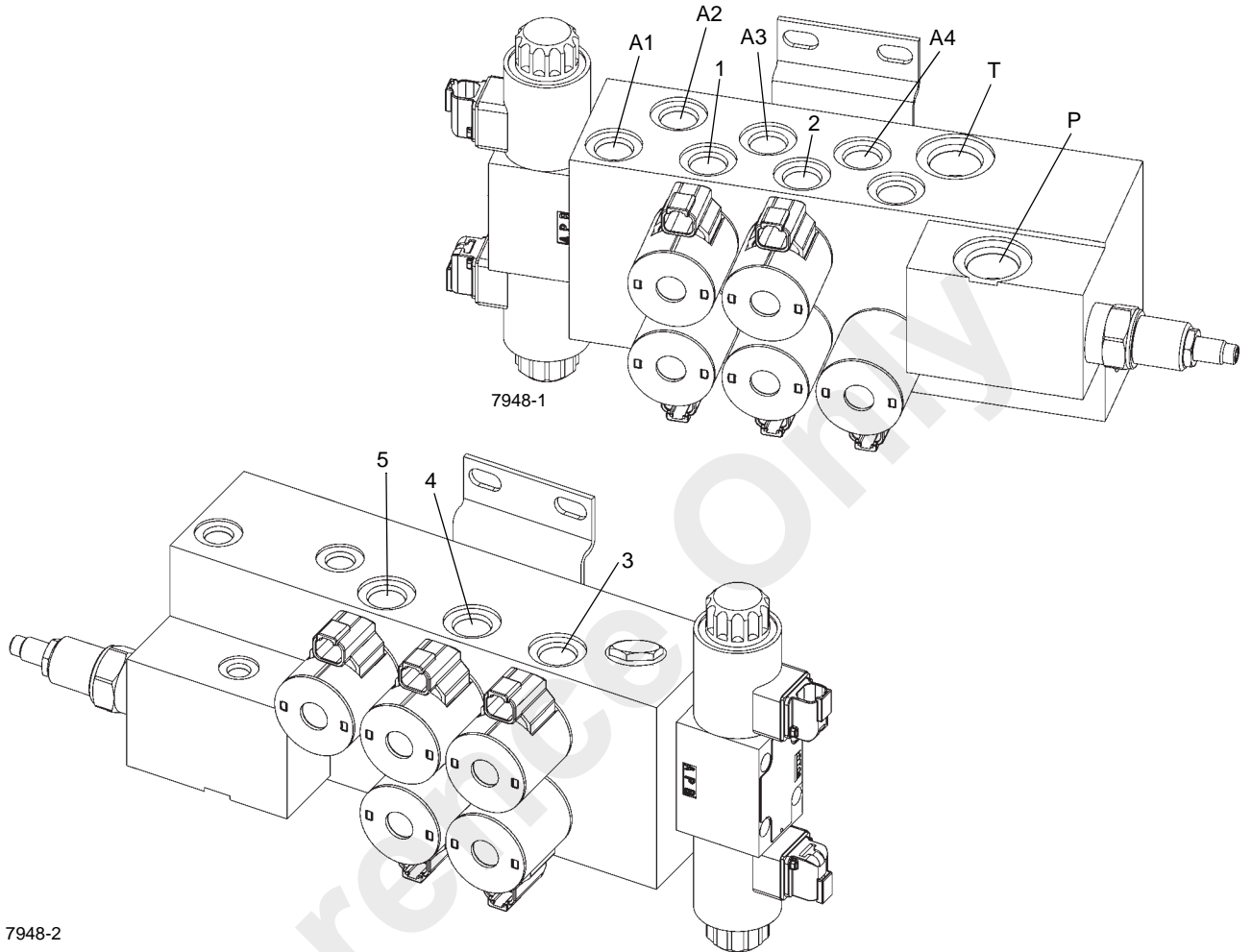
A relief valve set at  $144.79 \pm 3.45$  bar ( $2100 \pm 50$  psi) is installed in the inlet of the manifold, protects the outrigger circuits from high pressure buildup.

#### **Outrigger Valve Ports**

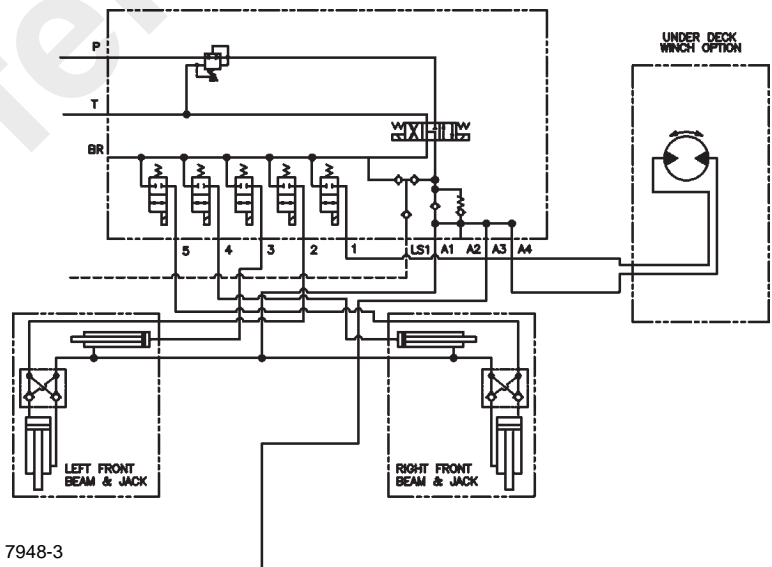
For easy identification, the ports of the outrigger valve are stamped on the valve manifold.

**Table 4-7: Port Identification Figure 4-11**

Port	Function
1	Under Deck Winch
2	Left Front Jack Cylinder
3	Left Front Beam Cylinder
4	Right Front Beam Cylinder
5	Right Front Jack Cylinder
A1	Front Outrigger Beam and Jack Return
A2	Not Used
A3	Rear Outrigger Manifold Return
A4	Under Deck Winch Return
P	From Pump
T	To Tank



7948-2



7948-3

FIGURE 4-11

## Load Holding Valves

The vertical (jack) cylinders have load holding valves installed in the cylinder base. The purpose of these valves is to inhibit the cylinder from retracting if a hydraulic line or hose breaks. The load-holding valve will hold the oil in the base of the cylinder until there is oil from the pump available to the rod side of the cylinder.

Oil flows freely through the load-holding valve and into the cylinder base when the cylinder is being extended. To retract the cylinder, oil is sent to the rod port of the cylinder. As the cylinder starts to retract, the piston meets resistance of the oil held in the cylinder base by the load-holding valve. Pressure increases as the pump tries to overcome the resistance.

When the pressure on the oil from the pump is high enough to overcome the spring in the load-holding valve plus the pressure of the oil in the cylinder base, the load-holding valve opens and the cylinder retracts.

If the cylinder starts to retract too rapidly, for example because of a heavy load on the cylinder, pilot pressure from the rod side decreases and the load holding valve closes. The cylinder stops retracting temporarily until enough oil is again available to the rod side of the cylinder. In this way, cylinder cavitation is prevented and the load is held.

**NOTE:** The engine must be running to retract the outrigger cylinders. The load-holding valves prevent retracting the outrigger jacks simply from the weight of the machine.

## Vertical Outrigger Cylinder Leakage Check

If one of the outrigger vertical cylinders will not hold under load, the problem is either the holding valve or the cylinder piston packings. To check for internal leakage in the cylinder:

1. Start the engine and engage the parking brake.
2. Fully lower the outrigger.
3. Shut off the engine.
4. Remove the hydraulic line from the rod port of the vertical cylinder being checked.
5. Start the engine and actuate the control switch in the direction to lower the outrigger. Check the amount of leakage from the open port. If the leakage is more than a couple of drops per minute, replacement of the piston seals is recommended.

## COMPONENT REPAIR

### Hydraulic Pump Repair

#### Removal

1. Drain the hydraulic tank.
2. Remove the secondary pump from the primary pump. See removal instructions.
3. Disconnect the suction line and pressure line from the primary pump. Disconnect the load sense and drain lines from the pump. Cap and plug all hoses and ports.
4. The pump is heavy. Use an overhead crane and a sling or a support to hold the pump in position.
5. Remove the pump mounting bolts and lockwashers. Remove the pump and gaskets from the transmission.

#### Disassembly and Repair

The hydraulic pump is not a field repairable component. The pump must be sent back to the pump manufacturer for repair. Contact your distributor for return information.

#### Installation

1. Attach the pump fittings to the pump before installing the pump to transmission. Check the O-rings on the inlet and outlet hose fittings. If damaged replace the O-rings.
2. Align the spline of the pump shaft with the spline of the pump coupler on the transmission. Position the pump with the three gaskets. Install the mounting hardware.
3. Install the secondary pump to the primary pump. See installation instructions.
4. Attach the suction and pressure hoses to the primary pump.
5. If a new pump is being installed, remove the two lower hex-socket capscrews from the rear of the piston pump. Discard the capscrews.
6. Connect the load sense line to the pump compensator.
7. Connect the pump drain line to the pump.
8. Fill the hydraulic tank with clean filtered hydraulic oil.

**NOTE:** The variable displacement pump and all other components require clean, filtered hydraulic oil for proper operation. Contaminated hydraulic oil may cause damage to the pump and other components. Before adding any oil to the hydraulic tank, be sure it is filtered through a 10 micron (absolute) or less filter.

9. The pump will fill with hydraulic oil when the tank is filled. The air in the pump will work itself back to tank.
10. Perform pump start-up. See below.

**Pump Start-up**

1. Start the engine and let it idle. Do not allow the engine to surge or run excessively fast during the initial start-up. **DO NOT OPERATE ANY HYDRAULIC FUNCTION AT THIS TIME.**
2. Let the pump run for about 60 seconds to release any air that might be in the hydraulic system. Check the suction hose connections for loose clamps, fittings, etc.
3. Adjust the pump to deliver system pressures. Follow the instruction under *Checking and Adjusting Hydraulic Pressure Settings*, page 4-15.
4. Check the level of hydraulic oil in the hydraulic oil tank. If low, add only pre-filtered hydraulic oil.

**NOTE:** The variable displacement pump and all other components require clean, filtered hydraulic oil for proper operation. Contaminated hydraulic oil may cause damage to the pump and other components. Before adding any oil to the hydraulic tank, be sure it is filtered through a 10 micron (absolute) or less filter.

**Outrigger Control Valve****Removal**

1. Stop the engine and engage the parking brake. Place chocks under the wheels.
2. Disconnect the battery using the battery disconnect switch.
3. Remove the access cover over the control valves.
4. Individual valve sections can be removed from the manifold block without removing the complete valve. Disconnect the electrical leads from the outrigger valve solenoids. Remove the four socket head capscrews securing the valve section to the manifold block. Remove the valve section.
5. If the complete valve assembly must be removed, tag all hydraulic lines for correct assembly. Clean the valve and connecting lines. Disconnect the hydraulic lines from the valve ports. Put caps on lines to keep dirt out of the hydraulic system. Remove the valve mounting screws and remove the valve.

**Solenoid Replacement**

1. The solenoids on the valve section can be removed without removing the valve section from the manifold block.
2. Stop the engine and engage the parking brake. Place chocks under the wheels.
3. Disconnect the battery using the battery disconnect switch.

4. Open the access cover over the control valves and remove the cover plate.
5. Disconnect the wire leads from the solenoid valve.
6. Remove the plastic nut from the solenoid shaft. Slide the solenoid off of the shaft.
7. Place a new solenoid over the solenoid shaft and install the plastic nut.
8. Connect the wire leads to the solenoid valve.
9. Connect the battery using the battery disconnect switch.
10. Start the engine and test outrigger function.
11. Install the cover plate and close the access cover.

**Installation**

1. If the complete valve assembly is being installed, put the valve assembly in position and secure it with four mounting screws. Connect the hydraulic lines to the manifold block.
2. If only a valve section is being installed, place the valve section in position and install the socket head capscrews.
3. Connect the wire leads to the solenoid valves.
4. Connect the battery using the battery disconnect switch.
5. Start the engine and check the outriggers for correct operation. Stop the engine, check for leaks and add hydraulic fluid if necessary.

**Swing Motor****Removal**

1. Shut off the engine and release any hydraulic pressure in the swing motor circuit by moving the control lever in both directions.

**CAUTION**

The swing motor can only be reached from under the machine. Shut off the engine and remove the ignition key to prevent accidental starting and moving of the crane while working under it. Block all tires.

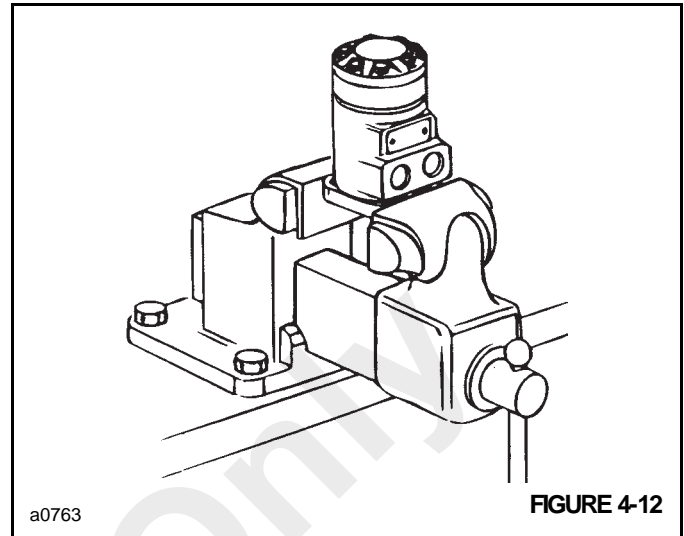
2. Before disconnecting the hydraulic lines, clean the port area of the swing motor thoroughly. Disconnect the hydraulic lines from the swing motor. Put caps and plugs on the lines and motor ports to keep dirt out.
3. Remove the two mounting bolts from the swing motor. Remove the swing motor.

**Disassembly****CAUTION**

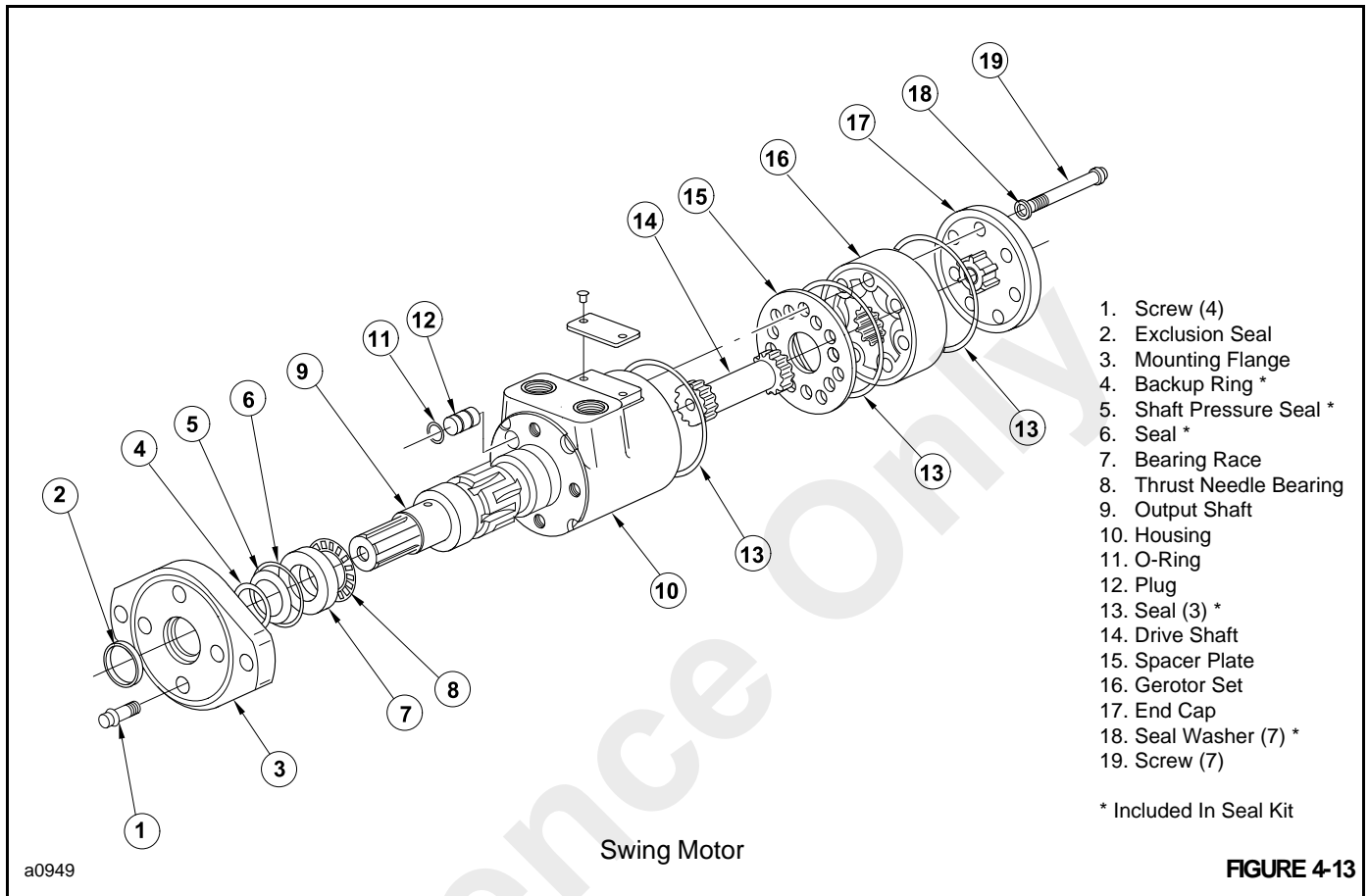
Cleanliness is extremely important when repairing the swing motor. Work in a clean area. Plug the ports then use a wire brush to remove foreign material and debris from around the external joints of the motor. Check the shaft and key slot, remove all nicks, burrs or sharp edges that might damage seals during installation. Before starting the disassembly procedures, drain any remaining oil from inside the motor.

1. Place the motor in a vice and clamp across the edges of the flange Figure 4-12 with the output shaft facing down. When clamping use protective devices on the jaws, such as soft jaws, pieces of rubber or wood.

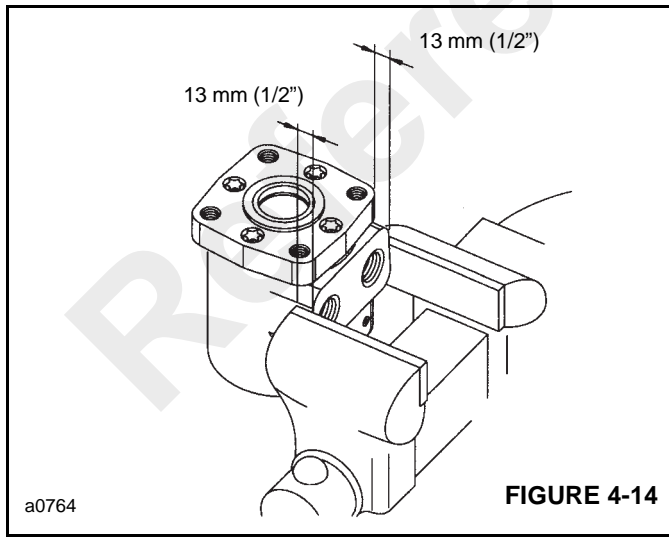
**NOTE:** Although not all drawings show the motor in a vice, it is recommended that you keep the motor in the vice during disassembly and assembly. Follow the clamping procedure explained in Step 1.



2. Remove seven capscrews (19) Figure 4-13 and seal washers (18).
3. Remove end cap (17). Remove and discard seal (13) from the end cap.
4. Remove gerotor (16). Remove and discard seal (13) from the gerotor.
5. Remove drive spacer, if applicable.
6. Remove drive shaft (14).
7. Remove spacer plate (15).
8. Remove seal 13 from housing (10).
9. Remove output shaft (9) from housing (10).
10. Remove needle thrust bearing (8) from shaft or housing.
11. Reposition the motor in the vice. Clamp across ports Figure 4-14. DO NOT clamp on housing. Excessive clamping pressure on side of housing causes distortion.



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12. Remove four capscrews (1) from mounting flange (3). These screws were installed with Loctite® to hold them in place.

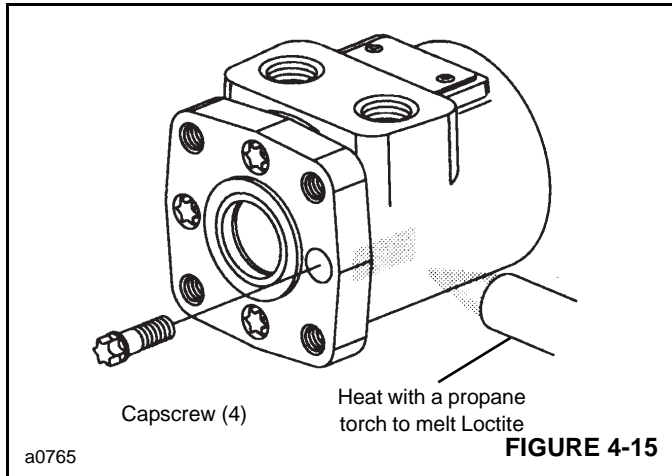
The screws will require 35 - 45 Nm (300 - 400 lb-in) of torque to break loose and 11 Nm (100 lb-in) torque to remove. Do not use an impact wrench on the screws. This could result in rounded heads or broken sockets.

**NOTE:** If a torque higher than given above is required to break the capscrews loose, apply heat according to the following:

When heated, Loctite partially melts. This reduces the torque required to remove screw. Use a small flame propane torch to heat a small area of the housing where the screws enter. Figure 4-15. **Be careful not to overheat the housing** and damage the motor. Gradually apply torque to the capscrew with a socket wrench as heat is applied for 8 to 10 seconds. As soon as the screw breaks loose, remove the heat from the housing. Continue turning the screw until it is completely removed. Repeat for other capscrews.

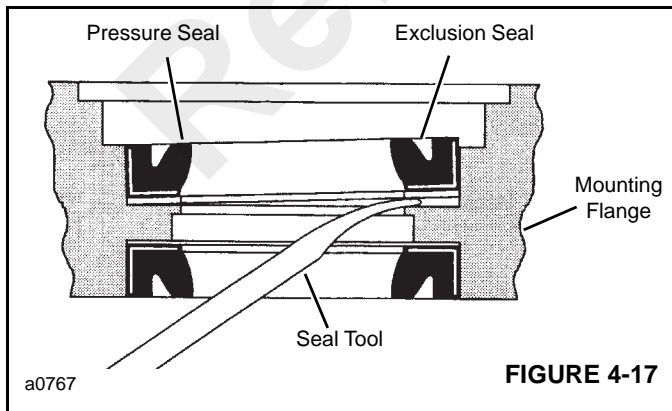
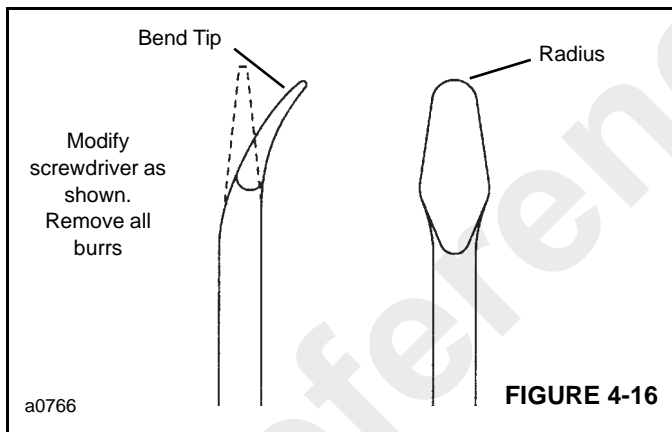
13. Carefully remove flange (3) Figure 4-13 from housing (10).

**NOTE:** Important: Some motors may have a quad seal and back-up ring in place of the pressure seal. The quad seal and back-up ring are no longer available and are replaced by the pressure seal. They are interchangeable, but some precautions must be taken to insure proper installation. Follow the reassembly instructions.



14. Exclusion seal (2), backup ring (4), shaft pressure seal (5) and seal (6) will come off with flange (3). Use the seal removal tool to remove the exclusion and pressure seals Figure 4-16 and Figure 4-17.

**NOTE:** Important: Be careful not to scratch the seal cavity outside diameter. This could create a leak path.



15. A metal plug (12) Figure 4-13, with O-ring (11), plugs a machined hole in the housing. It is not necessary to remove the plug and replace the O-ring unless leakage

occurs around the plug. To remove the plug, insert a 5 mm (0.187 in) hex key through the port opening and push it out. The model 009 plug is not interchangeable with the 007 and 008 plugs.

**Inspection/Cleaning**

Check all mating surfaces. Replace any parts with scratches or burrs that could cause leakage or damage. Clean all metal parts in a suitable solvent. Blow dry with air. Do not wipe parts with a cloth or paper towels, because lint or other matter could get into the hydraulic system and cause damage.

Check around the key slot and chamfered area of the shaft for burrs, nicks or sharp edges that could damage seals during assembly. Remove nicks or burrs with a hard smooth stone. Do not file or grind motor parts.

**NOTE:** Lubricate all seals with petroleum jelly. Use new seals when assembling the motor. **DO NOT stretch the seals before installing them.**

Cleanliness is extremely important in the successful application of Loctite. Before Loctite can be applied, the parts should be cleaned as follows:

**NOTE:** Fully cured Loctite resists most solvents, oils, gasoline and kerosene and is not affected by cleaning operations. It is not necessary to remove cured Loctite that is securely bonded in tapped holes; however, any loose particles of cured Loctite should be removed.

1. Wash the housing with a suitable solvent to remove oil, grease and debris. Pay particular attention to the four tapped holes on the flange end.
2. Blow dry with compressed air. Clean and dry the tapped holes.
3. Wire brush the screw threads to remove cured Loctite and other debris. Discard any screws that have damaged threads or rounded heads.
4. Wash the screws with a non-petroleum base solvent. Blow dry with compressed air.

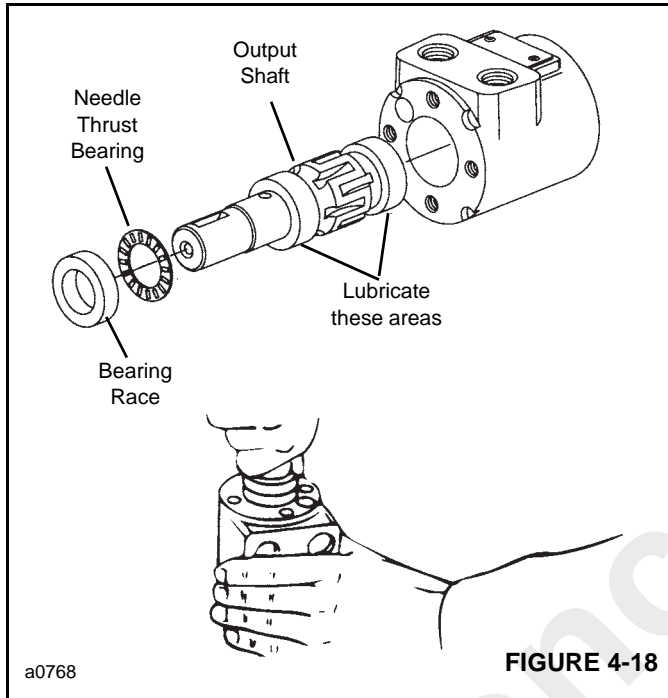
**Assembly**

**Shaft End**

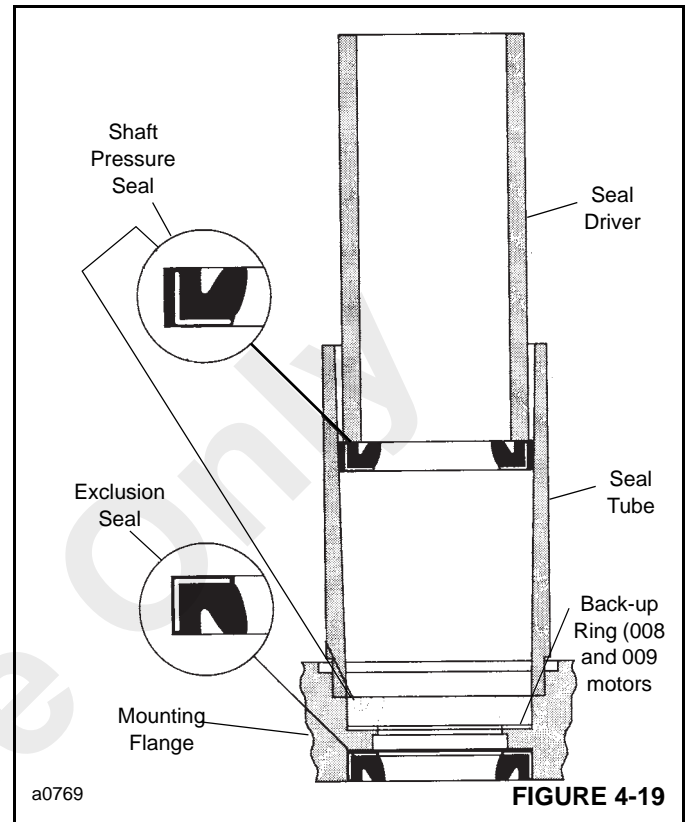
1. If plug (12) Figure 4-13 was removed, lubricate the new O-ring (11) and install on the plug. The plug has two O-ring grooves, but requires only one O-ring in the groove closest to the end of the plug. Push the plug into the housing (10) until it is flush with the housing. Be careful not to damage the O-ring.
2. Lubricate output shaft (9) with hydraulic oil and install the shaft into housing (10).

**CAUTION**

Do not permit oil to get into the four tapped holes of housing (10).

**FIGURE 4-18**

3. Install needle thrust bearing (8), then bearing race (7) on shaft (9). Pull shaft partially out of housing. Push all three parts in housing (10) together Figure 4-18. The bearing race must rotate freely when in position.
4. Install exclusion seal (2) Figure 4-13 in flange (3) with the lips of the seal facing out Figure 4-19. Carefully press the exclusion seal in place.
5. Visually check seal seats in the mounting flange for scratches or other marks that might damage the seals (5). Check for cracks in flange (3) that could cause leakage.

**FIGURE 4-19**

6. Lubricate inside diameter of seal tube and outside diameter of shaft pressure seal with light film of clean petroleum jelly. Align small inside diameter end of seal tube with seal seat in mounting flange (3). Install back-up ring (4) and pressure seal (5) in tube with lips of seal face up Figure 4-19. Insert seal driver in tube and firmly push seal seat with a rotating action.

**NOTE:** After installing the seal in the flange, examine the seal condition. If damaged or improperly installed, replace the seal before continuing with assembly.

7. Install O-ring (6) Figure 4-13 into groove in flange (3).
8. It is recommended to apply a light coat of Loctite® Primer NF in tapped holes of housing 10. Allow the primer to air dry for at least 1 minute. Do not force dry with air jet; the primer will blow away.

Use of primer is optional. With primer, Loctite® curing time is approximately 15 minutes. Without the primer the curing time is approximately 6 hours.

9. Apply 3 or 4 drops of Loctite sealant at the top of the threads for each of the four holes in the housing Figure 4-20. Do not allow parts with Loctite to come in contact with any metal parts other than those for assembly. Wipe off excess Loctite from housing face, using a non-petroleum base solvent.

Do not apply Loctite to threads more than 15 minutes before installing screws. If the housing stands for more



than 15 minutes, repeat application. No additional cleaning or removal of previously applied Loctite is necessary.

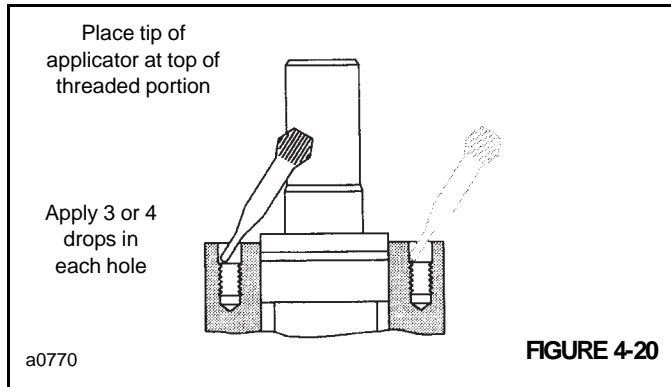


FIGURE 4-20

- Before installing the flange and seal assembly over shaft (9) Figure 4-13, place a protective sleeve or bullet over the shaft. Then lubricate the space between exclusion seal (2) and pressure seal (5), as well as the lips of both seals Figure 4-21.

Install flange. Rotate flange slowly while pushing down over the shaft. Be careful not to invert or damage the seals.

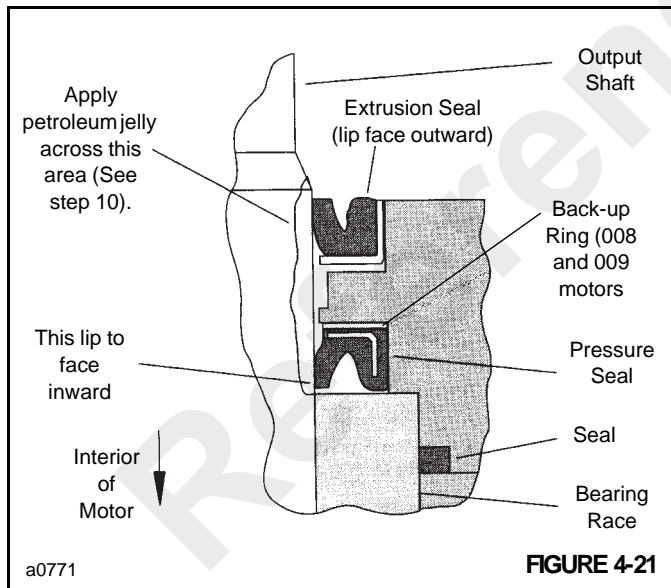


FIGURE 4-21

- After removing the protective sleeve or bullet, clamp the motor in a vise. Make sure the shaft cannot fall out. Install dry screws and alternately torque them immediately to 28 Nm (250 lb-in). If you use primer, allow to cure for 10 to 15 minutes. Without primer, allow 6 hours curing before subjecting the motor to high torque reversals.

**NOTE:** If you use new screws, make sure they are the correct length: 22 mm (0.875 in) under head length.

**Gerotor End**

- Reposition the motor in the vise with gerotor end up. Clamp across the ports. Do not clamp on side of housing.

**NOTE:** To aid installation of seals, apply a light coat of clean petroleum jelly to seals. Do not stretch the seals before installing them in a groove.

- Pour approximately 30 cc (1 ounce) of clean hydraulic oil in the output shaft cavity.
- Install O-ring (13) Figure 4-13 in the housing groove. Avoid twisting the seal.

**Timing Procedure**

- Install drive shaft (14) Figure 4-13. Use a felt tip pen to mark one drive tooth. Align this mark with the timing dot on the output shaft Figure 4-22.

**NOTE:** If drive shaft (14) is not symmetrical, install larger splined end into output shaft (9).

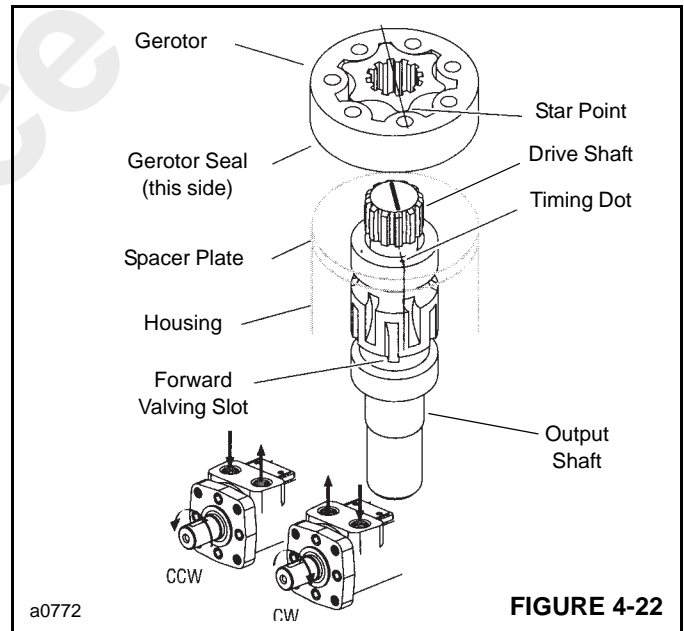


FIGURE 4-22

- Install spacer plate (15).
- Install seal (13) in gerotor seal groove. Carefully place gerotor on spacer plate, seal side toward the spacer plate. Align any star point with tooth marked on drive shaft Figure 4-22.
- Rotate gerotor (16) to line up with bolt holes. Be careful not to disengage star from drive or disturb the gerotor seal.
- Install drive spacer if applicable.
- Install seal (13) in end cap (17). Carefully place the end cap on gerotor (16).

21. Install capscrews (19) and seal washers (18) in end cap (17). Tighten the capscrews to 7.4 Nm (40 lb-in). Make sure the seal washers are properly seated. Then, tighten the capscrews to a torque of 27-28 Nm (235-250 lb-in) in the sequence shown Figure 4-23.

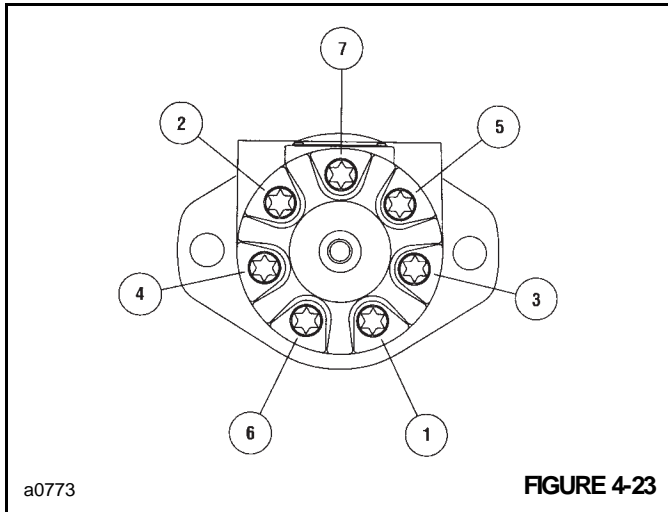


FIGURE 4-23

**Installation**

1. Place a new gasket on the face of the swing motor mounting flange.
2. Align the splines of the swing motor shaft with the splines of the worm gear shaft of the swing gear box.

Install the swing motor to the gearbox with two socket head capscrews and lockwashers.

3. Connect the hydraulic lines and fittings to the swing motor.
4. Start the engine and slowly rotate the mast to remove any air in the swing hydraulic circuit. Check for leaks.

**Hoist Motor**

**Removal**

1. Shut off the engine, set the parking brake.
2. Before disconnecting the hydraulic lines, clean the port area of the hoist motor thoroughly. Disconnect the hydraulic lines from the hoist motor. Put caps and plugs on the hoses and ports to keep dirt out.
3. Loosen and remove the two capscrews and lockwashers securing the motor to the hoist. Remove the hoist motor and gasket. Discard the gasket.
4. Remove hoses, fittings, the adapter flanges, spacer block and line mount body Figure 4-24 from the pump. Discard all O-rings.

**Disassembly**

The hoist motor is not field serviceable. It must either be replaced or returned to your distributor for repair.

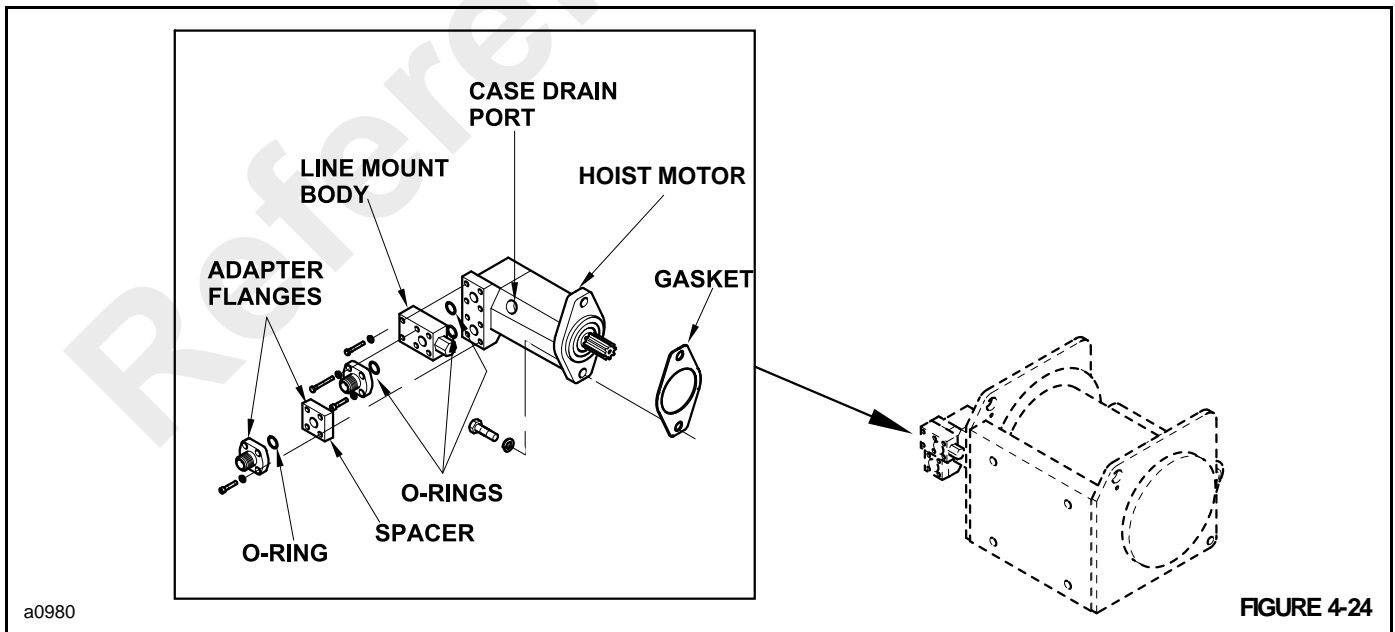


FIGURE 4-24

**Installation**

1. Install the line mount body Figure 4-24, spacer and adapter flanges to the hoist motor. Be sure to use new O-ring seals.

2. Install the hoist motor and new gasket to the hoist using two capscrews and lockwashers.

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**CAUTION**

To inhibit cavitation and damage to the motor due to lack of lubricating hydraulic oil, DO NOT start the motor without first filling the motor with hydraulic oil.

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3. Fill the hoist motor with clean hydraulic fluid through the case drain port Figure 4-24 to the bottom of the fill plug.
4. Connect all the hydraulic hoses and fittings to the motor.
5. Start the engine and slowly run the hoist through several cycles to remove any air in the system. Check for hydraulic leaks.

**Hydraulic Swivel***Removal*

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**CAUTION**

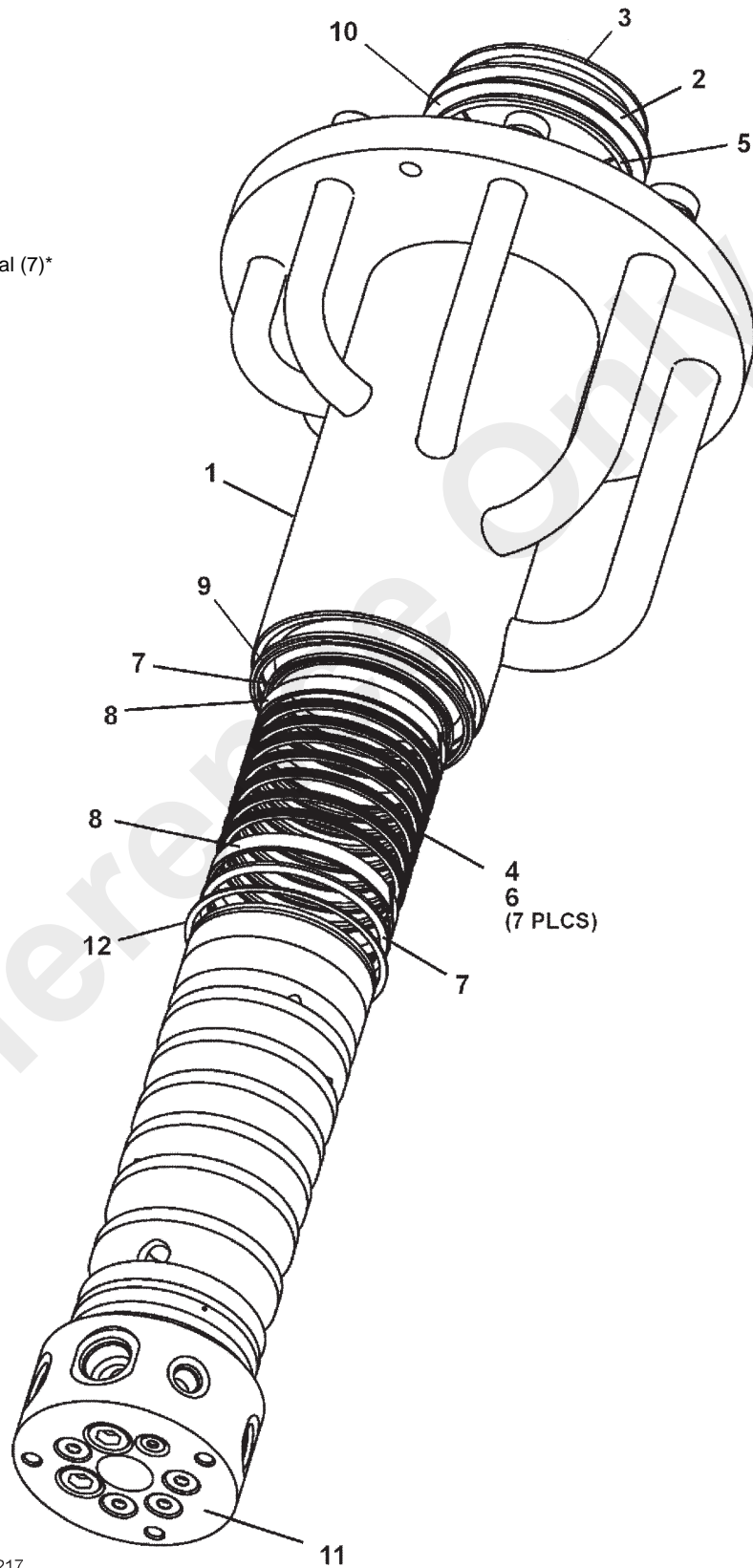
The area around the swivel and the swivel must be completely cleaned before removing the swivel from the machine.

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1. Stop the engine and engage the parking brake. Move the controls in both directions to release any pressure in the hydraulic circuits.
2. Put tags on the hydraulic lines with the number of the hydraulic port to which the line connects.
3. Disconnect the hydraulic lines from the upper and lower swivel ports. Be prepared to collect the hydraulic oil in the lines. Put caps or plugs on the fittings and hydraulic lines.
4. Remove the stop from the bottom of the swivel.
5. Put a support under the swivel. Remove the three bolts and lockwashers securing the swivel to the mast.
6. Remove the hydraulic swivel.

- 1. Housing Assembly
- 2. Washer Ring
- 3. Retainer Ring
- 4. Piston Seal (7)\*
- 5. Wiper Ring \*
- 6. Energizer Square Seal (7)\*
- 7. U-cup Seal (2)\*
- 8. Wear Ring (2)\*
- 9. Wiper Ring \*
- 10. Thrust Washer \*
- 11. Spool Assembly
- 12. Thrust Washer \*

\* Included In Seal Kit



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FIGURE 4-25

**Disassembly**

1. Remove retaining ring (3) Figure 4-25 and washer ring (2). Remove and discard thrust washer (10) and wiper ring (5).
2. Carefully pull the swivel spool (11) from swivel housing (1). If the swivel spool can not be pulled from the swivel housing, hit the top of the swivel shaft with a soft hammer.
3. Remove and discard thrust washers (10, 12) and all seals and wear rings from spool (11).

**Inspection**

Wash the housing and spool in a suitable solvent. Check the housing for damage. If there is scoring or deep grooves, the housing must be replaced.

Use compressed air to remove foreign materials from the passages in the swivel spool. Check the spool for rough edges that could cause damage to the seals during installation.

Install new seals, wear rings and thrust washers.

**Assembly**

**NOTE:** The hard rubber square seal (6) Figure 4-25 must be warm before installation. Heat the seal with a trouble lamp. Do not apply lubricant to the loader before installation.

1. Place the spool on the work bench in the vertical position.
2. Walk one seal (7) down each groove until it reaches the last groove. Then slide seal down the spool until it seats in groove on the spool.

**CAUTION**

Take care not to damage any of the seals and O-rings during installation.

3. Install a piston seal (4) into each of the seven grooves on the spool.

4. Install one heated square seal (6) over each piston seal.
5. Install the two wear rings (8) into their appropriate grooves.
6. Install wiper ring (9) into its groove.
7. Place the swivel housing (1) on the work bench with the bottom of housing facing up. Lubricate the lower 1/4 of the swivel bore with hydraulic fluid.
8. Place seal (7) on the end of the swivel housing (1) and then insert the assembled spool into the housing until it is seated. Be careful not to pinch or cut seal (7).
9. Turn the swivel over and install thrust washer (10) and wiper ring (5). Install washer ring (2) and secure with retaining ring (3).

**Test**

Pressure test the hydraulic swivel to 344.75 bar (5000 psi).

Test each port individually. No leakage past seals is permitted.

**Installation**

1. Put the hydraulic swivel in place on the machine. Fasten the hydraulic swivel to the brackets in the mast using three bolts and lockwashers.
2. Install the swivel stop to the bottom of the hydraulic swivel using three bolts and lockwashers.
3. Connect the hydraulic lines to the lower ports of the hydraulic swivel.
4. Fill the lower hydraulic system by adding recommended hydraulic oil through the upper ports of the hydraulic swivel.
5. Connect the hydraulic lines to the upper ports.
6. Start the engine and move the hydraulic oil through the swivel. Visually, check for leaks.

**CAUTION**

Do not rotate the mast until the oil has moved through the hydraulic swivel for several minutes.

## Hydraulic Cylinders

### Removal

**NOTE:** The following removal instructions are general and should be modified to suit the cylinder being removed. Telescope cylinder removal instructions will be found in *Structurals*, page 11-1. Steering cylinder removal instructions can be found in *Steering System*, page 10-1.

1. Put a support under the component to which the cylinder is fastened. Make sure the component can not fall after the cylinder is removed.
2. Stop the engine. Release the pressure in the cylinder circuit by moving the control back and forth several times.
3. Disconnect the hydraulic lines from the cylinder. Put caps on the hydraulic lines to keep dirt out of the system.
4. Connect a hoist to lift the weight of the cylinder.
5. Remove the cylinder mounting pins. Remove the cylinder.

### Disassembly

**NOTE:** The following procedures gives general instructions for repair of the hydraulic cylinders. Refer to illustrations for relation of the component parts.

Steering cylinder repair instructions can be found in Steering System Section 10.

1. Put the ports of the cylinder down to drain the oil from the cylinder.
2. Fasten the base of the cylinder in a vise with soft jaws. Place a support under the rod so the cylinder is level.
3. Use a spanner wrench to loosen and remove the head gland. Slide the head gland forward on the cylinder rod.
4. Pull the rod and piston straight out of the cylinder tube. If necessary, use compressed air applied to the base port of the cylinder to push the piston and rod out of the cylinder tube.
5. Fasten the eye of the rod in a vise with soft jaws. Put a support under the opposite end of the rod to hold the rod level. Use care not to cause damage to the chrome surface of the rod.
6. The piston is fastened to the rod either by internal threads or with a locking nut. To remove the piston:
  - a. On pistons with internal threads, remove the set screw from the piston. Use a spanner wrench to loosen and remove the piston.

- b. On pistons which are fastened with a locking nut, use a socket wrench and extension to loosen the nut.

7. Remove and discard the seals and wear rings from the piston.
8. Remove and discard all seals, backup rings, wear rings, etc. from the head gland.

### Inspection

Wash the parts in a suitable solvent. Use compressed air to remove all residue.

Check the bore of the cylinder tube for damage or distortion. Move the piston through the full length of the cylinder and check the clearance between the piston and the bore of the cylinder. If there is damage or distortion, replace the cylinder tube.

Look for damage to the chrome surface of the rod. The rod must be smooth and straight. A bent rod indicates possible loss of strength in the rod and replacement is necessary. If the chrome surface has damage, completely remove the old chrome and apply new chrome 0.03 mm (0.001 inch) thick.

Remove any rough edges on the piston to prevent damage to new rings during installation.

### Assembly

1. Install new rings, rod wiper and seals on the head gland. See cylinder illustrations for location and correct installation.
2. Apply hydraulic oil to the rod and slide the assembled head gland on the rod.
3. Assemble the rings and seals on the piston.
4. Fasten the piston to the rod with locking nut and tighten to specified torque. Be sure O-ring is installed between the piston and the rod. On pistons with internal threads, screw piston onto cylinder rod and install the set screw to secure the piston on the rod.
5. Apply hydraulic oil to the bore of cylinder and the rings on the piston. Carefully slide the piston and rod into the cylinder tube. Keep the rod straight during installation. Use care not to damage the piston rings when you install the piston through the threads in the bore of the cylinder tube.
6. Slide the head gland into the cylinder tube and tighten to specified torque. See illustrations. If equipped, install the set screw to secure the gland head in the cylinder.

### Test

1. Fill the cylinder with clean hydraulic oil. To test the piston seal rings, continue to push oil into the rod end after the cylinder has hit bottom. Test to pressure indicated in

Table 4-8 in both directions as directed in steps 2 through 5.

**Table 4-8: Cylinder Test Pressures**

CYLINDER	TEST PRESSURE
Lift	324.05 bar (4700 psi)
Telescope	344.74 bar (5000 psi)
Horizontal Outrigger	344.74 bar (5000 psi)
Vertical Outrigger	344.74 bar (5000 psi)

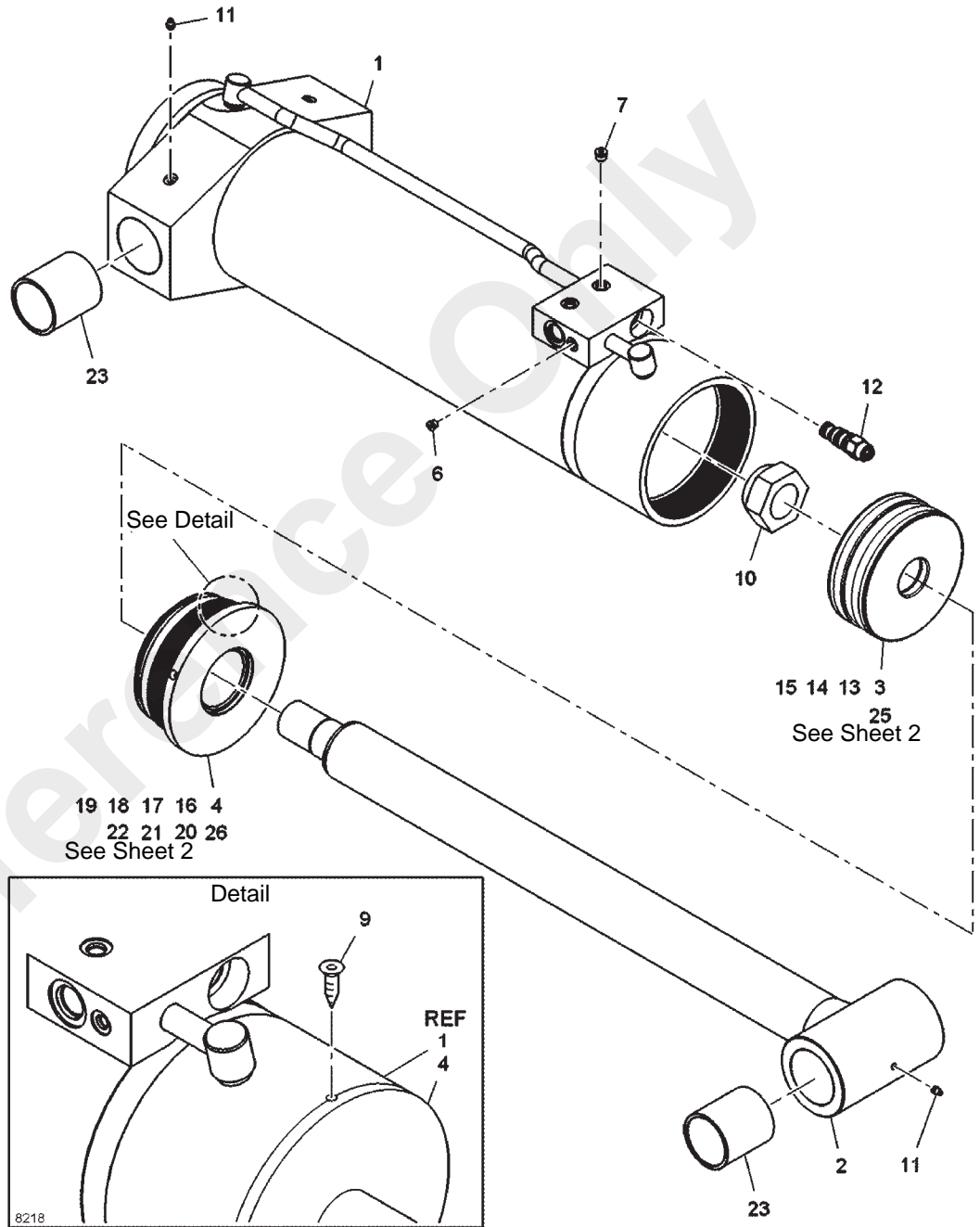
2. Move the cylinder rod through two complete strokes at 55.10 bar (800 psi) to remove air from the cylinder. Look for external leaks. If the pressure difference between cylinder ports is more than 6.89 bar (100 psi) during the second stroke, the cylinder assembly is not acceptable. Disassemble and inspect for foreign materials or wrong assembly.
3. Wipe the cylinder rod clean, then move the cylinder through four complete strokes at 55.10 bar (800 psi), but do not permit the cylinder to hit bottom on each stroke. After four strokes, extend the cylinder rod just far enough to see how much oil has collected during the four strokes. Inspect the cylinder rod for indication of rod seal leakage. A thin layer of oil on the cylinder rod is normal.
4. Fully retract the cylinder rod. Keep the base port open. Apply test pressure in Table 4-8 to the rod port. Hold this

pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No internal or external leakage is permitted.

5. Fully extend the cylinder rod. Keep the rod port open. Apply test pressure in Table 4-8 to the base port. Hold this pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No internal or external leakage is permitted.
6. Put plugs in the cylinder ports to keep out dirt during installation.

#### **Installation**

1. Install the cylinder on the machine using the correct mounting hardware.
2. Connect the hydraulic lines.
3. Lubricate the cylinder grease fittings with recommended grease.
4. Check hydraulic oil level in the hydraulic oil reservoir. Add oil if necessary.
5. Start the engine and operate the cylinder(s) through several complete cycles to remove air. Check for leaks. Operate cylinders slowly and do not let the cylinders hit bottom until movement is positive in both directions. After the circuit is filled with oil, the cylinders can be operated normally.
6. Check oil level in the hydraulic tank and fill if necessary.



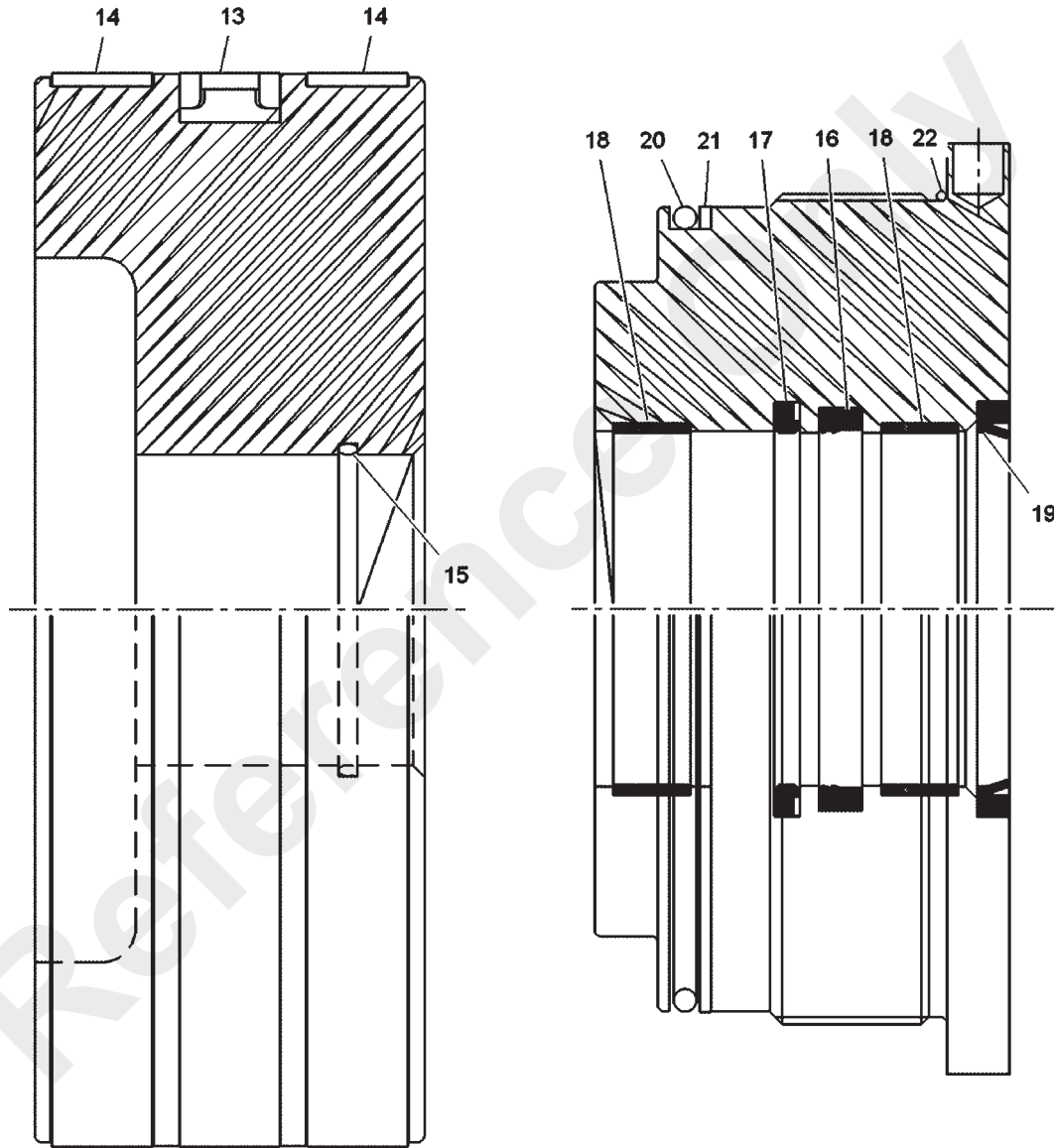
- 1. Barrel Assembly
- 2. Rod Assembly
- 3. Piston Assembly includes item 25
- 4. Head Assembly includes item 26
- 5. Not Used
- 6. O-Ring Plug
- 7. Metal Plug (2)
- 8. Not Used
- 9. Screw
- 10. Locknut
- 11. Grease Fitting
- 12. Counterbalance Valve
- 13. Piston Seal\*
- 14. Wear Ring (2)\*
- 15. O-Ring\*
- 16. Rod Seal\*\*
- 17. Buffer Seal\*\*
- 18. Wear Ring (2)\*\*
- 19. Wiper Ring\*\*
- 20. O-Ring\*\*
- 21. Backup Ring\*\*
- 22. O-Ring\*\*
- 23. Bushing (4)
- 24. Not used
- 25. Seal Kit, Piston
- 26. Seal Kit, Head

\* = Repair Kit

Lift Cylinder Sheet 1

FIGURE 4-26





8218-1

Detail Item 25

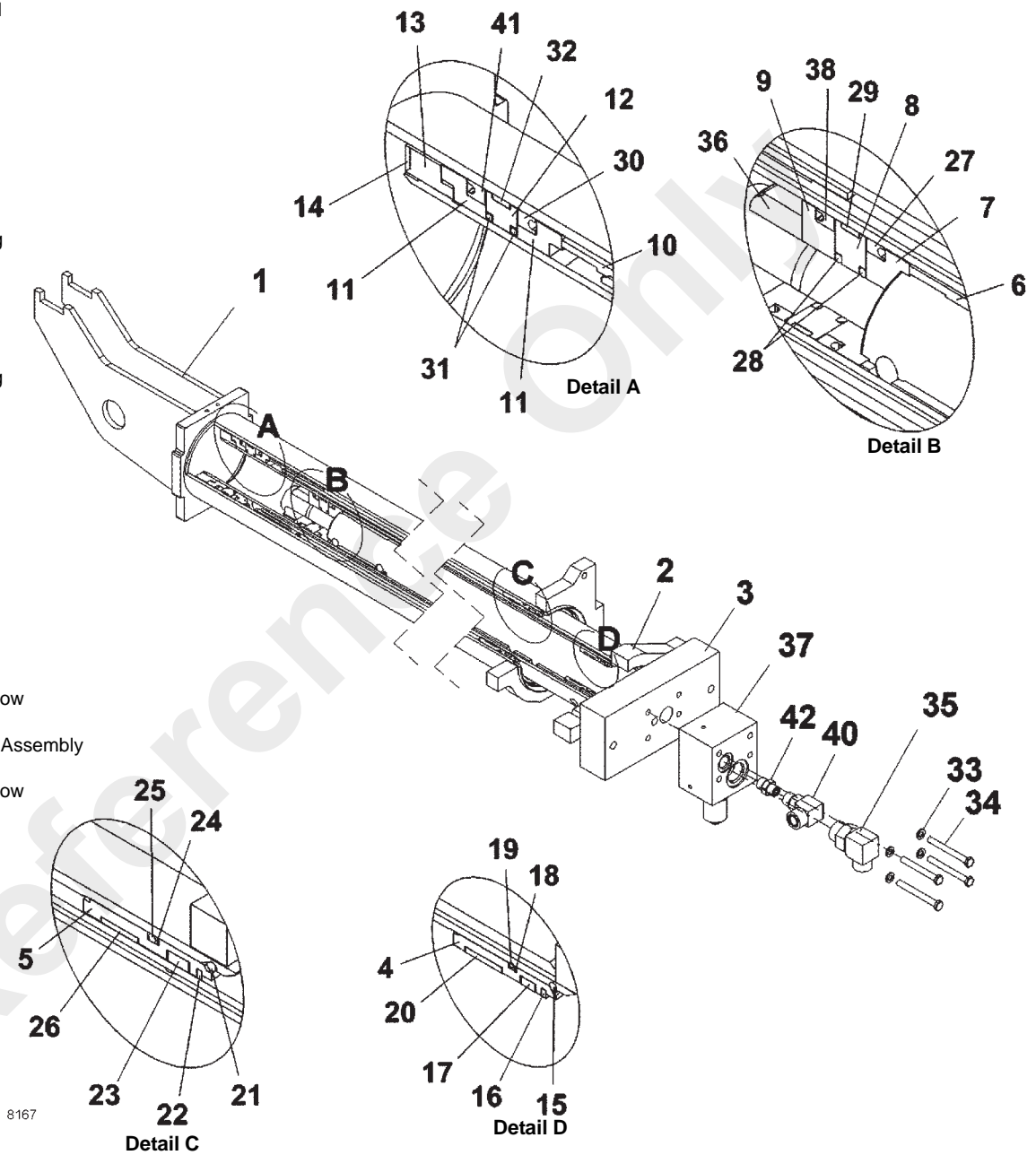
Detail Item 26

a0432

Lift Cylinder Sheet 2

FIGURE 4-26 continued

1. Barrel Assembly
2. Outer Shaft Assembly
3. Inner Shaft Assembly
4. Packing Gland
5. Packing Gland
6. Stop Tube
7. Mandrel
8. Piston
9. Mandrel
10. Stop Tube
11. Mandrel
12. Piston
13. Round Nut
14. Screw
15. Retaining Ring
16. Rod Wiper
17. Rod Seal
18. Backup Ring
19. O-ring
20. Wear Ring
21. Retaining Ring
22. Rod Wiper
23. Rod Seal
24. Backup Ring
25. O-ring
26. Wear Ring
27. Piston Seal
28. O-ring
29. Wear Ring
30. Piston Seal
31. O-ring
32. Wear Ring
33. Lockwasher
34. Capscrew
35. 45 Degree Elbow
36. Locknut
37. Holding Valve Assembly
38. Piston Seal
40. 90 Degree Elbow
41. Piston Seal
42. Strait Adapter



4

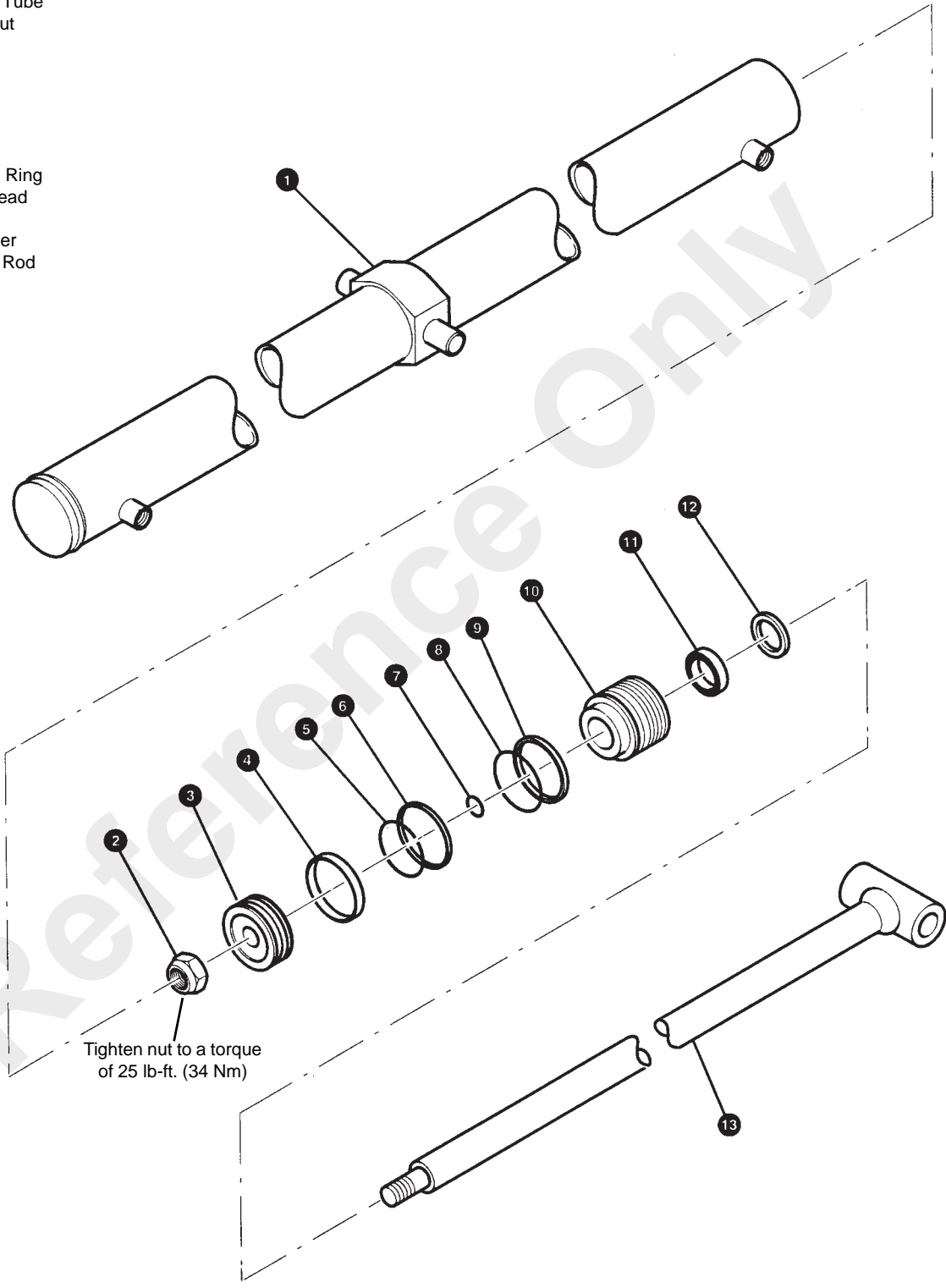
Telescope Cylinder

FIGURE 4-27

a0434

- 1. Cylinder Tube
- 2. Piston Nut
- 3. Piston
- 4. Wiper\*
- 5. O-Ring\*
- 6. Seal\*
- 7. O-Ring\*
- 8. O-Ring\*
- 9. Back-Up Ring
- 10. Gland Head
- 11. Seal\*
- 12. Rod Wiper
- 13. Cylinder Rod

\*= Seal Kit



Tighten nut to a torque of 25 lb-ft. (34 Nm)

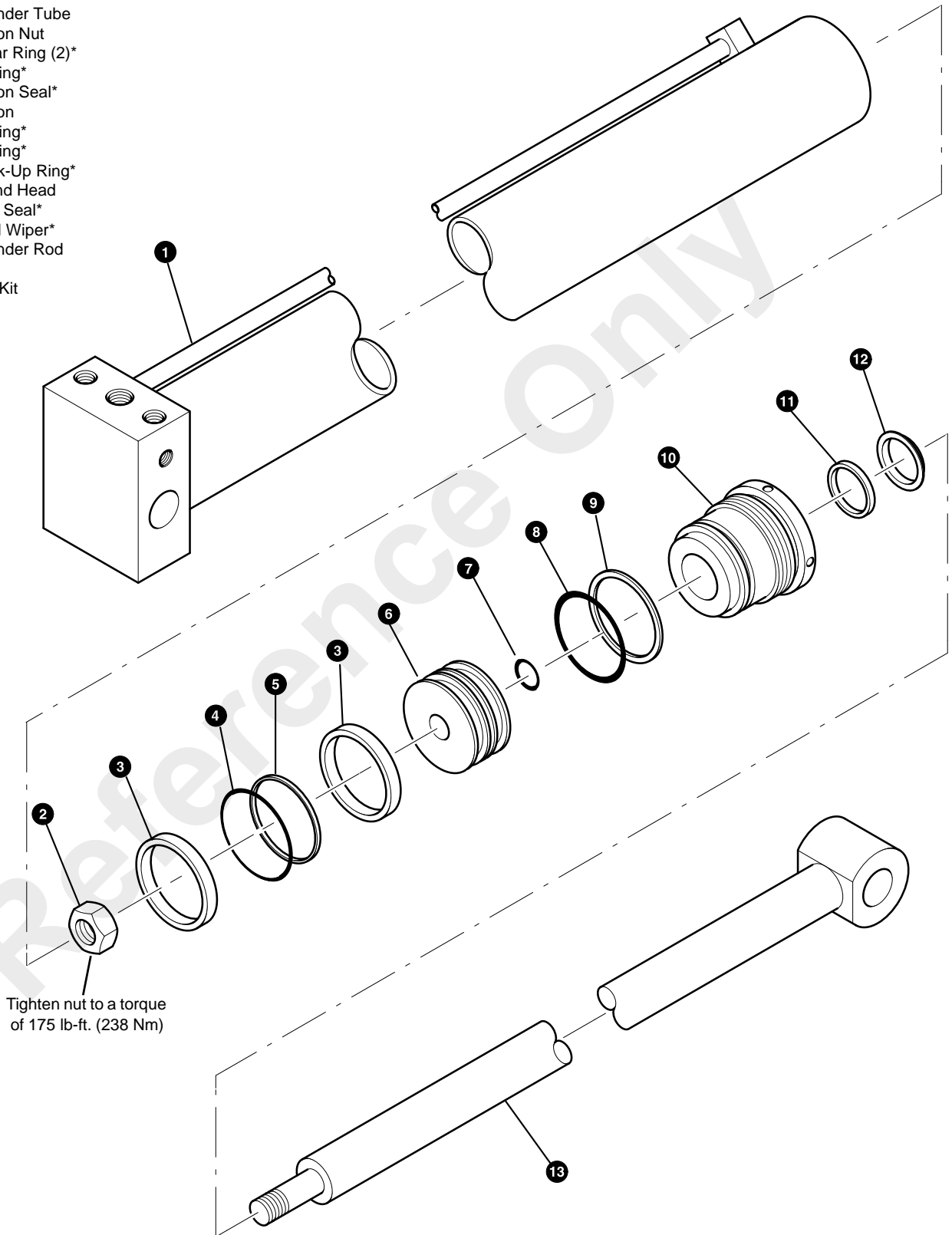
Horizontal Outrigger Cylinder

FIGURE 4-28

a0440

- 1. Cylinder Tube
- 2. Piston Nut
- 3. Wear Ring (2)\*
- 4. O-Ring\*
- 5. Piston Seal\*
- 6. Piston
- 7. O-Ring\*
- 8. O-Ring\*
- 9. Back-Up Ring\*
- 10. Gland Head
- 11. Rod Seal\*
- 12. Seal Wiper\*
- 13. Cylinder Rod

\*= Seal Kit



Tighten nut to a torque of 175 lb-ft. (238 Nm)

Vertical Outrigger Cylinder

FIGURE 4-29

**UNDER DECK WINCH**

The under deck winch is connected to the front outrigger control manifold. Hydraulic oil flows through an electrically activated three position directional control valve to provide

directional control and a two-position control valve to supply oil flow.

Reference Only

## SECTION 5 PREVENTATIVE MAINTENANCE

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### INTRODUCTION

**NOTE:** Do not use gasoline or other flammable fluids to clean component parts. Fire or explosion may occur causing bodily burns.

Use eye protection when performing service or maintenance tasks. Propelled and/or dropped items can cause eye injury.

If maintenance or adjustments must be performed with the engine running, have a person at the controls while another person performs the work to prevent accidental movement which could cause injury or death.

Preventive maintenance is necessary to keep the crane in good condition as long as possible. Adjust the maintenance schedule to your operation, according to the type of work, size of loads, temperature conditions and frequency of equipment use.

The intervals in the Maintenance Schedule are for average operating conditions, and must be understood as the **MINIMUM** maintenance necessary for the crane. Decrease these intervals if the crane is operated in conditions that are

below average (for example, in dust, in high or low temperatures, with heavy loads or frequent starting and stopping).

Use the hourmeter and a calendar to make sure that all necessary maintenance is done according to the schedule.

**NOTE:** When performing service on the crane, put a tag on the key switch or remove the key to prevent operation of the crane.

### Spark Arresting Mufflers

**NOTE:** Codes of some states or provinces may require that this crane be equipped with a **SPARK ARRESTING MUFFLER**. The State of California, as an example, is one state which has such regulations for agricultural and forestry application, plus a regulation for construction applications in forest covered, brush covered, or grass covered lands.

### Safety List

Inspect the following safety equipment daily:

**SAFETY BELT** - Check for frayed or cut webbing, damaged buckles or loose mounting hardware.

**SAFETY DECALS** - Check condition of decals. Replace if worn, damaged or missing. See Section 2.

**COVERS** - Keep all protective covers in place.

**PARKING BRAKE** - Check operation. Have unit repaired if required.

**ENGINE** - Check operation. Remove all dirt or debris, and all flammable materials before running engine.

## LUBRICANTS

### *Cummins Oil Registration List*

Cummins has a program that lists engine oils that it has tested to meet its engineering specifications. Listing of recommended oils is on QuickServe® Online. Log on to quickserve.cummins.com and login with a current username and password or create a new account by selecting "Create an Account" under information, choose Limited Owners Plan and register. Once logged in, click on the "Service" Tab in the top red bar, "Service Tools" mini-tab and "Oil Registration Lists" link within the Service Tools list. This will load a list of the different Cummins Engineering Specification numbers. Select the one that applies to your engine to view the registered oils.

It is not the policy of Manitowoc Cranes, Inc. to publish lists of approved lubricants or guarantee lubricant performance. The responsibility for the quality of the lubricant rests completely with the distributor or manufacturer of the lubricant.

In various paragraphs in this maintenance section, statements may be found, "use (lubricant brand name) or equivalent." This statement does not constitute an unconditional guarantee of performance of the brand of lubricant mentioned. It is intended only as a guide to the type of lubricant recommended for a given application.

## MAINTENANCE RECORDS

Dated records must be kept for inspection of critical components such as, brakes, crane hooks, wire ropes, hydraulic cylinders and relief valve pressure settings. These records must be kept where they can be easily obtained and reviewed.

## MAINTENANCE

### Preparation

Before maintenance, adjustments and repairs are started on a crane, the following precautions shall be taken as applicable:

- Place a warning tag in a conspicuous location at the controls stating that the machine requires adjustment or repair before it can be operated.
- Park the crane where it will cause the least interference with other equipment or operations in the area.
- Place all controls at the off position and set the brakes to prevent inadvertent motion.
- Disable all methods used to start the crane's engine.
- Lower the boom to the ground or otherwise secured against dropping.
- Lower the hook block to ground or otherwise secured against dropping.
- Relieve the hydraulic pressure from all hydraulic circuits before loosening or removing hydraulic components.

After maintenance, adjustments and repairs have been made, do not return the crane to service until all guards have been reinstalled, trapped air removed from the hydraulic system if required, safety devices reactivated, and maintenance equipment and all warning tags removed.

Maintenance, adjustments and repairs shall be done only by designated personnel who are properly trained. Use only Manitowoc supplied parts to repair the crane.

### Hydraulic System Maintenance Precautions

Contaminants in a hydraulic system affect operation and result in serious damage to the system components. Dirty hydraulic systems are a major cause of component failures.

If evidence of foreign particles is found in the hydraulic system, flush the system.

Disassemble and reassemble hydraulic components on a clean surface.

Clean all metal parts in a nonflammable cleaning fluid. Then lubricate all components to aid in assembly.

Inspect all sealing elements (O-ring, gaskets, etc.) when disassembling and assembling the hydraulic system components. Installation of new sealing elements is always recommended.

When installing metal hydraulic tubes, tighten all bolts finger tight. Then, in order, tighten the bolts at the rigid end, the adjustable end, and the mounting brackets. After tubes are mounted, install the hoses. Connect both ends of the hose with all bolts finger tight. Position the hose so it does not rub the machine or another hose and has a minimum of bending and twisting. Tighten bolts in both couplings.

Due to manufacturing methods, there is a natural curvature to a hydraulic hose. The hose should be installed so any bend is with this curvature.

In case of replacement hoses with angled stem reusable fittings, the hose curvature must be taken into consideration when assembling and positioning the angled stem.

### Label Parts when Disassembling

When removing or disconnecting a group of wires or cables, tag each one to ensure proper identification during re-assembly.

When shims are removed, tie them together and identify them as to location. Keep shims clean and flat until they are reinstalled.

### Hydraulic Oil Recommendations

For the hydraulic oil specifications, Reference *Replace the Hydraulic Oil*, page 5-29.

### Draining and Flushing

If a component has been changed because of a failure that might allow metal or abrasive particles to enter the system, all systems must be thoroughly checked, drained, and flushed.

1. Remove the reservoir drain plug. Allow about three minutes after hydraulic oil stops flowing from the drain port for the side walls to drain.
2. Clean and install the reservoir plug and fill the reservoir with a 50/50 mixture of fuel oil and clean hydraulic oil.
3. Cycle the crane through all functions several times. Then return the crane to its stowed position and turn the front and rear wheels to the extreme left. Shut down the engine.
4. Remove the reservoir drain plug and drain the reservoir. Clean and install the drain plug and fill the reservoir with clean hydraulic oil.

**NOTE:** Hydraulic oil supply lines must be connected to the cylinders when flushing the system.

Draining the various components will be aided by connecting a drain line in place of the disconnected return line.

5. Disconnect the return line from the lift cylinder and raise the boom to maximum elevation.
6. Connect the cylinder return line and lower the boom to its stowed position. Replenish the reservoir hydraulic oil level as required.
7. Disconnect the return line from an outrigger extension cylinder and fully extend the outrigger.
8. Connect the outrigger return line and retract the outrigger. Replenish the reservoir hydraulic oil level as necessary.
9. Repeat Steps 7 and 8 for the remaining outriggers.

### CAUTION

When draining the outrigger cylinders, always operate either both front or both rear cylinders together to prevent twisting the crane.

10. Disconnect the return lines from a pair of outrigger jack cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger jack cylinders to the stowed position. Replenish the reservoir hydraulic oil level as necessary.
12. Repeat Steps 10 and 11 for the remaining two outrigger cylinders.
13. Disconnect the return line from the telescope cylinder and fully extend the boom.
14. Connect the return line and retract the boom. Replenish the reservoir hydraulic oil level as necessary.
15. Disconnect the return lines from steer cylinders and turn the wheels to the extreme right.
16. Connect the return lines and turn the wheels to the extreme left and then back to center. Replenish the reservoir hydraulic oil level as necessary.
17. Raise the crane on outriggers.
18. Disconnect the return line from the main hoist motor and fully hoist up the hoist.
19. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the reservoir hydraulic oil level as necessary.
20. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
21. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

### CAUTION

When hydraulic oils are changed or added, ensure that hydraulic oils of different manufacturers are of the same specifications, however, discoloration (milky) may occur. Mixing incompatible hydraulic oils may result in improper operation or damage to the machine.

When hydraulic oils are changed, recheck the reservoir hydraulic oil level after brief system operation and add hydraulic oil as required. Ensure the crane is level and in the travel mode of operation when the hydraulic system is being filled. The system must be filled with all cylinders retracted. Fill the reservoir to the full mark on the reservoir sight gauge.



After the reservoir is filled, operate all circuits and recheck the reservoir sight gauge. Add hydraulic oil as required.

## Removing Air From the Hydraulic System

Air entering the hydraulic oil will normally be removed automatically by passage of the hydraulic oil over the baffles in the hydraulic reservoir. If a component has been replaced, the reservoir level is too low, or a leak develops in the suction lines to the pumps, air can enter the system. If air becomes entrapped in the hydraulic oil, it may be detectable in pumps and motor operated components such as the swing mechanism and hoist(s), because it can cause these units to become noisy during operation. If noisy operation occurs, first check the level of the hydraulic reservoir and replenish as necessary. Then inspect for leaks in the suction lines leading to the pumps.

Minute leaks may be hard to locate. If a leak is not readily detectable, use the following way to check for it:

- Seal all normal openings in the hydraulic system and the reservoir. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to 0.138 to 0.276 bar (2 to 4 psi) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the reservoir after completing any repairs or service. Operate all hydraulic circuits several times in both directions.
- This action should return any entrapped air to the reservoir where it can be removed from the hydraulic oil by the baffles.



### CAUTION

Always locate the machine on a firm supporting surface, extend the outriggers and level the machine and position the boom over the front to extend the boom at low angles. Injury or damage to the machine may result if this caution is not followed.

- To remove entrapped air from telescope cylinders, lower the boom to below horizontal and fully telescope the boom in and out several times.
- If the air is not readily removed, lower the boom to below horizontal, extend the telescope cylinders as far as practicable, and allow the boom to remain in this position overnight. This should allow entrapped air to find its way to the holding valve so that telescoping the boom IN the next morning should force the air back to the reservoir. Ensure the boom is first telescoped IN (not OUT) in the

morning. Telescoping OUT may cause air to be forced back into the cylinder.



### CAUTION

Do not attempt to loosen fittings in pressurized lines or while the hydraulic pumps are in operation.

Extreme care must be used when removing any plugs or restrictions from a hydraulic system suspected to have entrapped air that may be pressurized. Moderate to minor injury may result from pressurized air in a hydraulic system.

- Entrapped air may be removed from cylinders having wet rods by cycling. On certain cylinders, a plugged port is provided on the rod end to bleed off entrapped air.
- In the event that air entrapment should persist, bleeding of air by loosening various clamp and screw type fittings may become necessary.
- If the above procedures fail to eliminate air entrapment, contact your authorized Manitowoc distributor.

## Parts Replacement

Parts found damaged or out of tolerance when maintenance is being performed should be replaced. Refer to the Grove Parts Catalog for proper replacement parts.

## SPECIAL MAINTENANCE

### Delivery Inspection

#### Fuel Tank

- Fill with correct fuel.

#### Engine

- Check oil in crankcase. Fill if level is low.
- Remove water from fuel filters and sediment bowl.

#### Cooling system

- Check coolant level. Fill if level is low.

#### Hydraulic Tank

- Check oil level. Fill if level is low.

#### Drive Axles

- Check axle housing lubricant level and wheel hub lubricant level. Fill if levels are low.

#### Hoist Gearbox

- Check oil level. Fill if level is low.

#### Tires

- Check for correct air pressure.

Wire rope cable clamps and connections

- Check for loose or missing parts.

Anti-Double Blocking System

- Check that the system is working properly.

Controls

- Check that all controls are working properly.

**After First 50 Hours of Operation (New Cranes)**

Engine

- Change the engine oil and filter.

Transmission

- Change the transmission oil filter.

Swing Gearbox

- Check and tighten mounting bolts.

Hoist Gearbox

- Check and tighten mounting bolts.

Swing Gear Pinion and Swing Gear

- Lubricate.

Grease Fittings

- Apply grease to all grease fittings.

Boom Slides

- Lubricate.

Wheel Mounting Nuts

- Check Torque.

**Cranes Not In Regular Use**

A crane which has been idle for a period of one month or more, but less than six months, must be given an inspection by a qualified person. This person should use the daily through monthly inspections.

A crane which has been idle for a period of over 6 months must be given a complete inspection covering all inspections through one year, by a qualified person.

Standby cranes must be inspected using the daily through monthly inspection, by a qualified person.

**PREVENTIVE MAINTENANCE**

**Maintenance Schedule and Checklist**

**NOTE:** Hour intervals in each maintenance chart show the correct time for service. The hourmeter located in the operator's cab indicates the total hours the crane has been running.

In addition to the following scheduled maintenance, perform the scheduled maintenance suggested in the engine manual furnished with the crane.

When performing maintenance, do the required maintenance interval as well as all previous interval maintenance. For example, when performing the 250 hour (monthly) maintenance interval, perform all the tasks required for daily, 50 hour and 100 hour maintenance.

Service Check	Daily before operation	50 Hours Weekly	100 Hours Two Weeks	250 Hours Monthly	500 Hours Three Months	1000 Hours Six Months	2000 Hours Yearly
Inspect the anti-double blocking system	X						
Inspect the wire rope	X						
Inspect reeving, clamps and connections	X						
Inspect the lifting hook	X						
Inspect safety devices	X						
Check controls operation	X						
Check engine crankcase oil level	X						
Check transmission oil level	X						
Check engine coolant level	X						
Check fuel level	X						
Check tire pressure	X						

Service Check	Daily before operation	50 Hours Weekly	100 Hours Two Weeks	250 Hours Monthly	500 Hours Three Months	1000 Hours Six Months	2000 Hours Yearly
Drain water from engine fuel filter	x						
Check air cleaner restriction indicator	x						
Check hydraulic oil level	x						
Inspect wire rope and sheaves		x					
Apply grease to all lubrication fittings		x					
Lubricate the boom slides		x					
Lubricate the boom sheaves		x					
Clean air cleaner duct cup		x					
Lubricate parking brake fitting		x					
Inspect engine fan belts			x				
Check wheel nut torque			x				
Lubricate the swing gear and pinion				x			
Lubricate the wire rope				x			
Inspect the boom sheaves				x			
Inspect all hydraulic hoses				x			
Replace engine crankcase oil *				x			
Replace engine oil filter *				x			
Clean radiator fins and core				x			
Clean battery and connections				x			
Torque critical bolts				x			

Service Check	Daily before operation	50 Hours Weekly	100 Hours Two Weeks	250 Hours Monthly	500 Hours Three Months	1000 Hours Six Months	2000 Hours Yearly
Check axle wheel hub lubricant level (4)					X		
Check axle housing lubricant level (2)					X		
Check hoist gearbox and brake lubricant level					X		
Lubricate the outrigger slides					X		
Add grease to swing gearbox					X		
Replace fuel filter elements					X		
Inspect the parking brake pads					X		
Inspect tires for damage					X		
Add rust inhibitor to engine cooling system					X		
Replace the air cleaner element *					X		
Check swing gear to pinion backlash						X	
Replace the transmission oil and filter						X	
Replace the axle wheel hub lubricant						X	
Replace the axle housing lubricant						X	
Replace the hoist gearbox lubricant						X	
Replace the hydraulic oil						X	
Replace the hydraulic oil filter						X	
Replace the engine coolant							X
Inspect the crane structure and booms for damage							X
Test the Rated Capacity Indicator (RLI)							X

-Maintenance should be performed using either the hourly or calendar dates, whichever occurs first.

-Under extremely dusty conditions, (\*) items may require replacement more frequently.

**Lubrication Points**

Apply grease to the following fittings after the first 20 hours of operation, thereafter every 50 hours of operation or weekly, whichever occurs first. Use a Lithium Base, E.P. No. 2

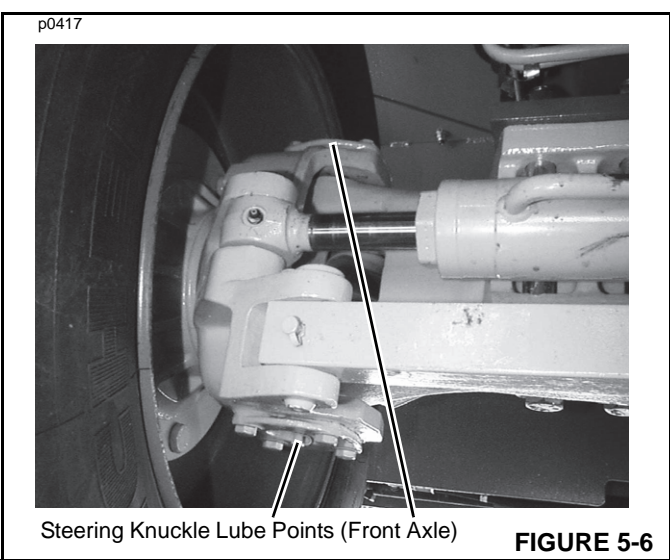
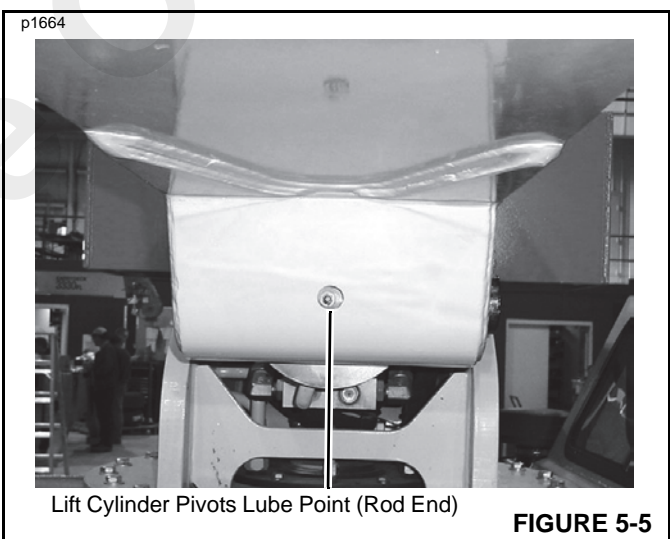
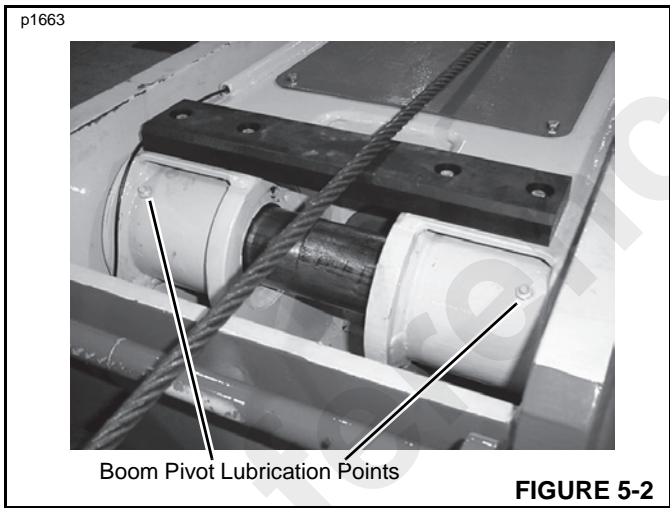
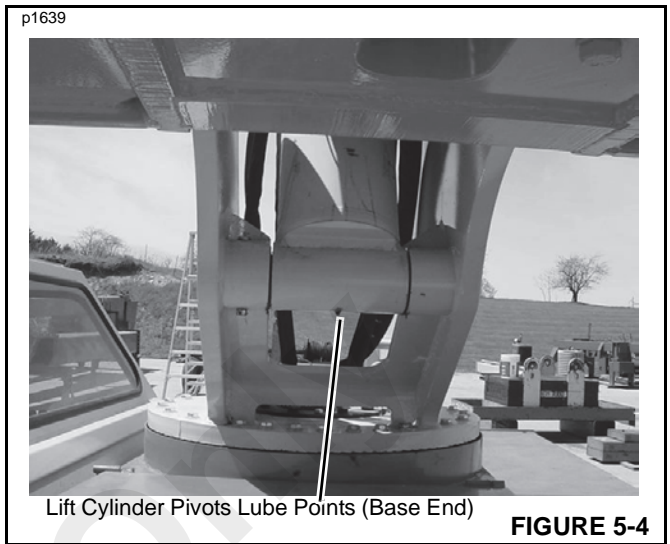
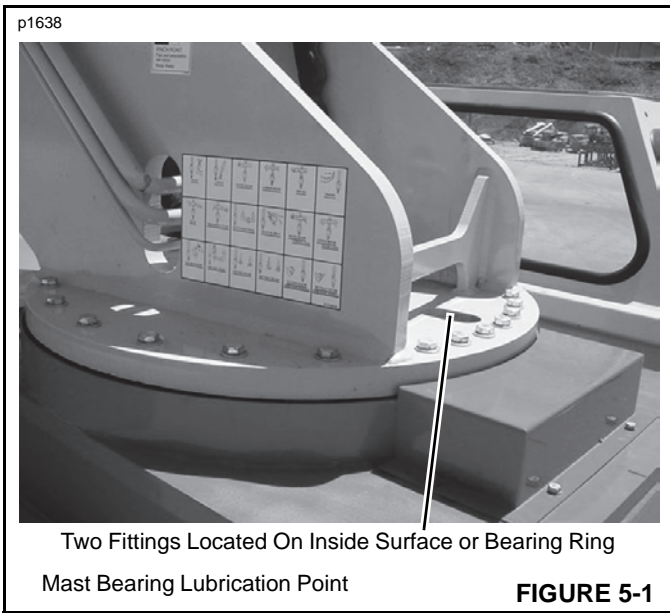
bearing grease or equivalent. Apply enough grease to remove the old grease.

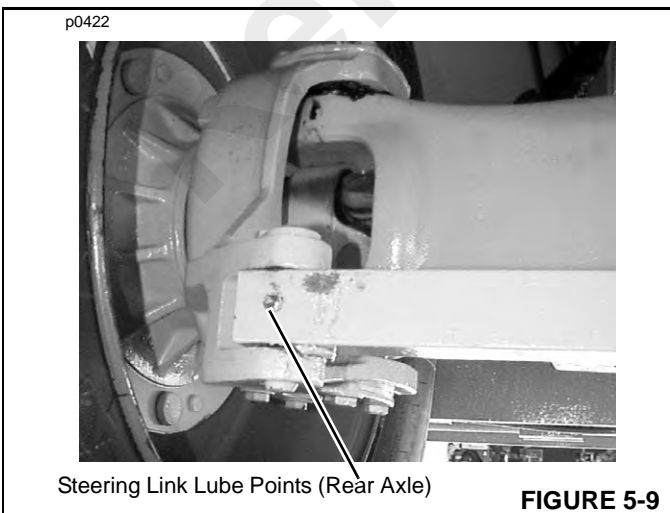
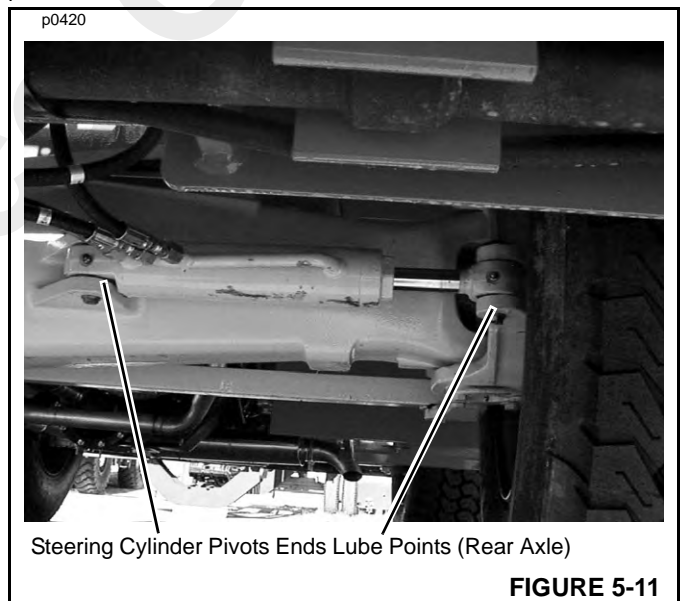
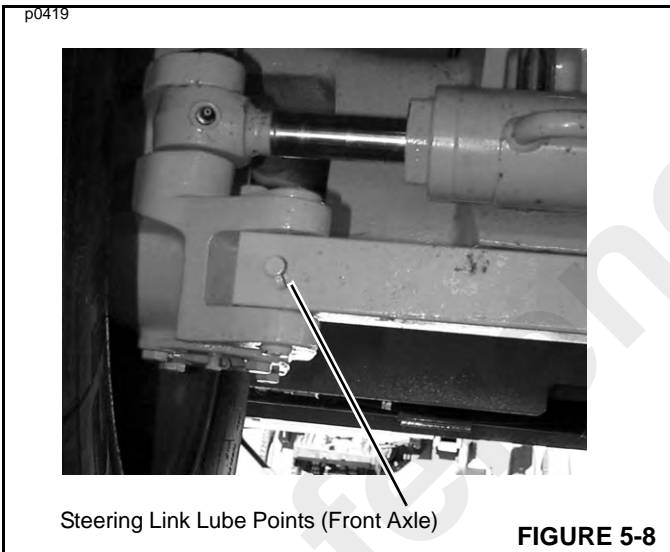
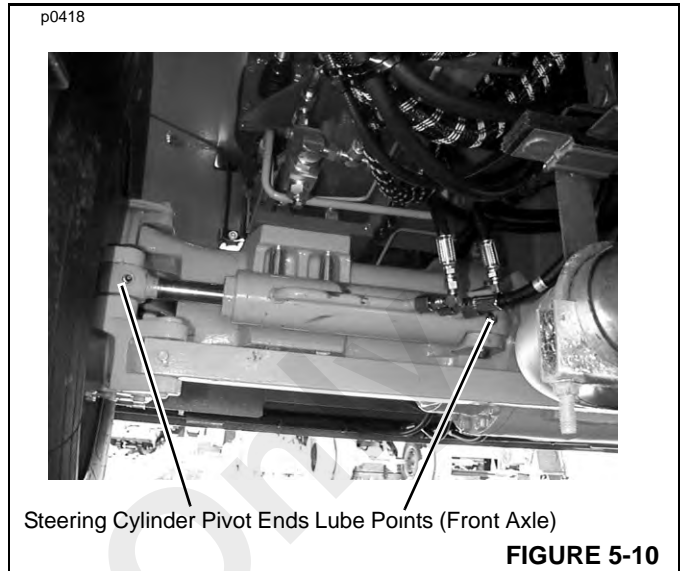
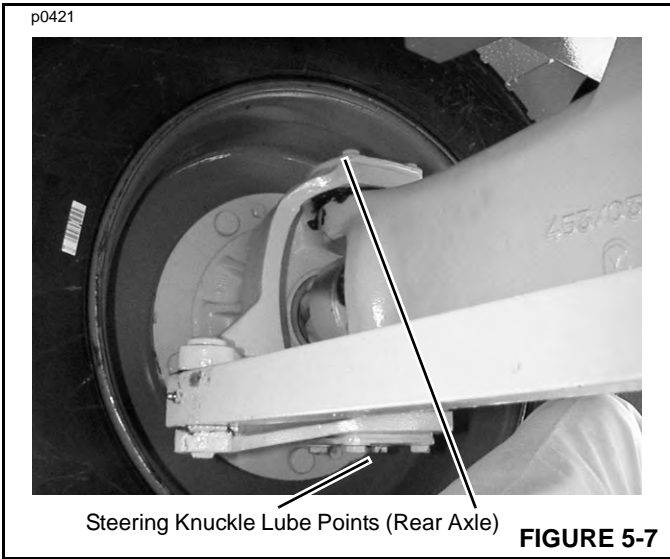
**NOTE:** \*Drive shaft u-joints do not require routine lubrication. Lubricate only after major overhaul.

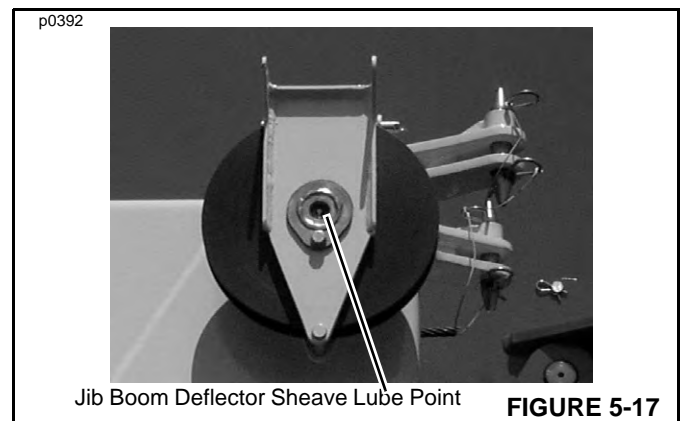
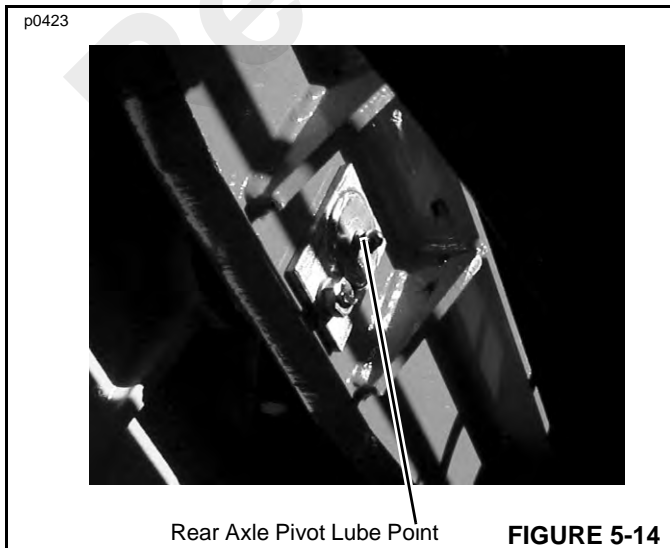
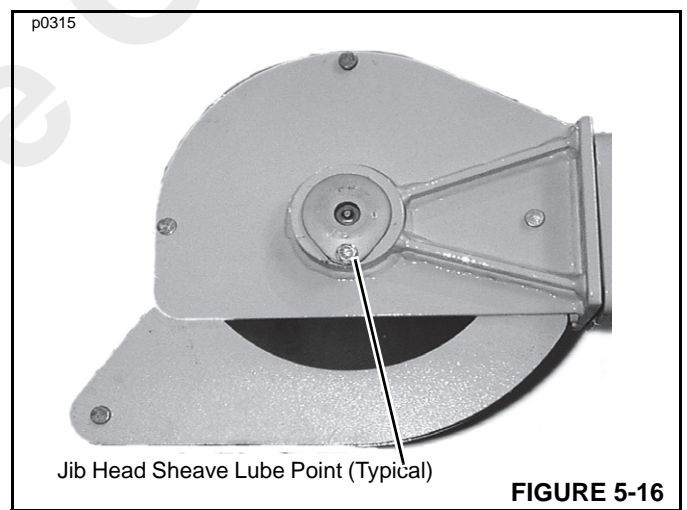
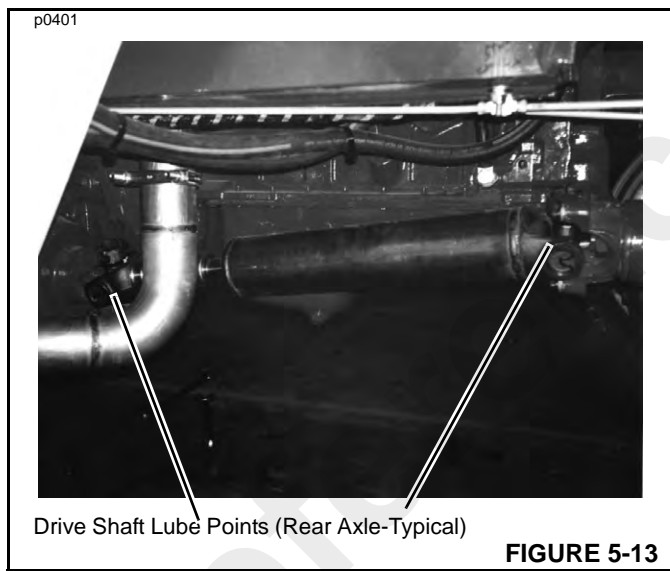
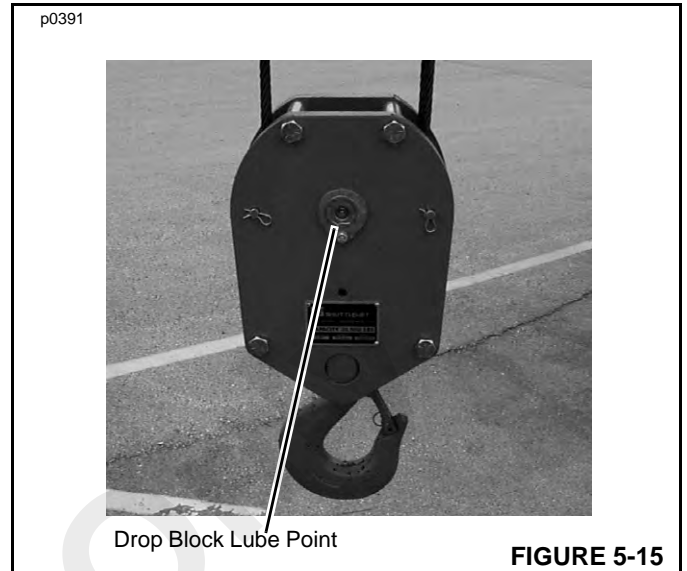
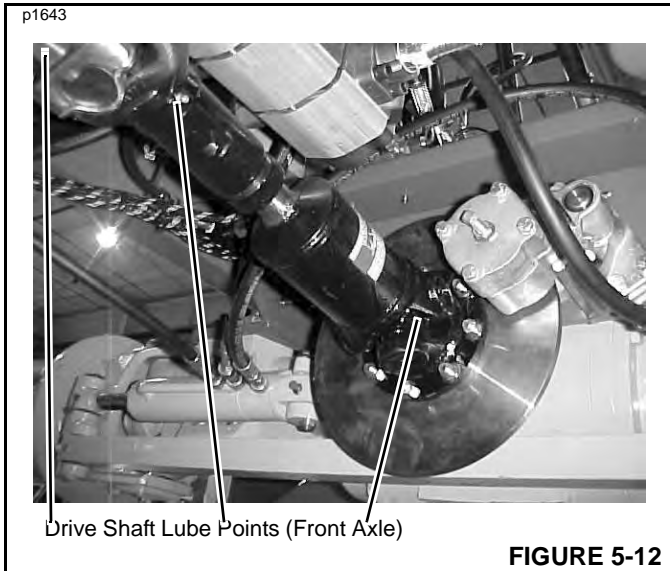
<b>Booms and Main Frame</b>	
<b>Location</b>	<b>QTY</b>
Mast Bearing (see Figure 5-1)	2
Boom Pivot (see Figure 5-2)	2
Boom Head Sheaves and Pivot (see Figure 5-3)	2
Lift Cylinder Pivots (see Figure 5-5)	2

<b>Drive Train</b>	
<b>Location</b>	<b>QTY</b>
Steering Knuckles- front axle (see Figure 5-6)	4
Steering Knuckles- rear axle (see Figure 5-7)	4
Steering Link- front axle (see Figure 5-8)	2
Steering Link- rear axle (see Figure 5-9)	2
Steering Cylinder Pivot Ends- front axle (see Figure 5-10)	2
Steering Cylinder Pivot Ends- rear axle (see Figure 5-11)	2
Drive Shaft- front axle (see Figure 5-12)*	2
Drive Shaft- rear axle (see Figure 5-13)*	2
Rear Axle Pivot (see Figure 5-14)	2

<b>Optional Equipment and Accessories</b>	
<b>Location</b>	<b>QTY</b>
Drop Block (see Figure 5-15)	2
Jib Boom Head Sheave (see Figure 5-16)	1
Jib Boom Deflector Sheave (see Figure 5-17)	1









## SCHEDULED MAINTENANCE

### Daily (Walk-around) Inspection

**NOTE:** You must read and understand the warnings and basic safety rules, found in Section 2 of this manual, before performing any operation or maintenance procedures.

For additional engine maintenance guidelines, see the engine manual furnished with this crane.

#### Inspections

##### Inspect the Anti-Double Blocking System

Test the anti-double block system daily before beginning operation to make sure it is functioning properly.

Raise the drop block until it hits the anti-double blocking bracket under the boom head. An alarm should sound and the raising of the hoist block should stop.

Lower the hoist block and the alarm will stop.

If there is a malfunction in the system, **DO NOT** operate the crane. Have the malfunction corrected.

##### Inspect the Wire Rope

Each day before beginning operation, visually inspect the wire rope for damage. See "50 Hours of Operation (Weekly)" on page 5-17, for examples of damage that can be visually inspected for. If any damage is found, do not operate the crane. The wire rope must be replaced with a new rope before operation can resume.

##### Inspect Reeving, Clamps and Connections

Each day before beginning operation, inspect for correct reeving of the boom and drop block. Inspect the terminal ends of the wire rope for damaged parts, loose clamps or wrong installation.



#### WARNING

Loads may fall if the wedge and socket is not installed properly or has damage. A falling load can injure or kill.

**DO NOT** operate the crane if any of the above are found. Only after correcting the problem should the crane be put back in service.

##### Inspect the Lifting Hook



#### WARNING

Loads may fall if the lifting hook is damaged or loose. A falling load can injure or kill.

Daily before beginning operation, inspect the lifting hook for damage; cracks, deformation, loose retaining hardware, etc. If any damage is found, **DO NOT** operate the crane until the damage is repaired.

##### Inspect All Safety Devices

Daily before beginning operation, check all safety devices for proper operation. Examples of safety devices include, backup alarms, horn and beacon lights.

If any is found to be malfunctioning, correct the problem before placing the crane in service.

##### Check Controls Operation

Each control should be checked for proper operation after the above inspections have been completed. Do not place the crane in service if any control is not functioning properly.

##### Component/System Checks

##### Check Fuel Level

Check the fuel supply daily before operation. Turn the ignition key to the ON position and view the fuel gauge on the instrument panel. If necessary, fill the tank with recommended fuel.

Engine fuel is **flammable** and can cause a fire and/or explosion. Avoid personal injury or death by keeping sparks, open flames, and smoking materials away from the crane and fuel during refueling or fuel system servicing. Know the location of the fire extinguishers on the job site and how to use them.



Maintain control of the hose nozzle when filling the fuel tank. Do not allow fuel to spill. Clean up spilled fuel immediately. Dispose of clean up materials properly.



**DO NOT** fill the fuel tank to capacity. Allow room for fuel expansion.

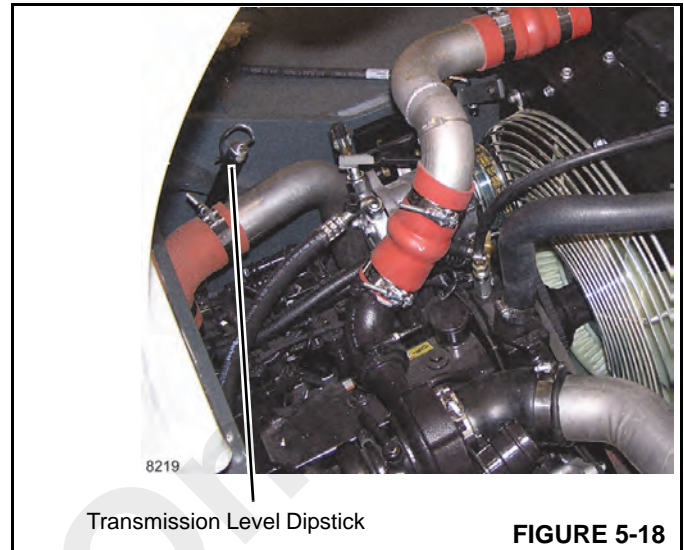
Tighten the fuel cap securely. If the cap is lost, replace only with original equipment.

### Check the Engine Crankcase Oil Level

1. Level the crane, engage the parking brake and shut off the engine.
2. Lift the engine compartment cover and support in place using the furnished prop rod.
3. Remove the engine oil dipstick and check oil level. Oil should be visible within the crosshatched mark area on the dipstick.
4. If the oil is low, add recommended oil to bring the level up to the crosshatch area of the dipstick. When full, install the dipstick and close the engine compartment cover.

### Check the Transmission Oil Level

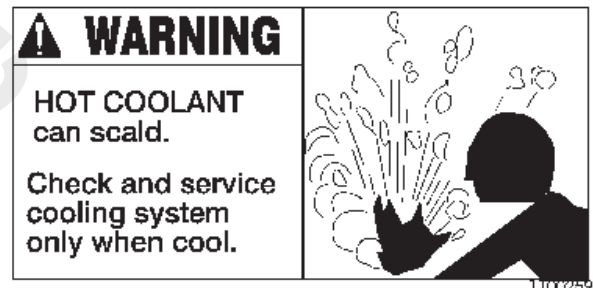
1. Check the oil level when the oil is cold. Level the crane, engage the parking brake and shut off the engine.
2. Lift the engine compartment cover and support in place using the furnished prop rod. Remove the dipstick (Figure 5-18) and check the oil level. Oil should be visible on the dipstick between the minimum and maximum marks with the oil cold.
3. If oil is low, add recommended oil to bring the level between the marks. **DO NOT OVERFILL.** Install the dipstick. Close the cover.



Transmission Level Dipstick

FIGURE 5-18

### Check Engine Coolant Level



**NEVER** remove the radiator cap while the cooling system is hot. Check coolant level only when the coolant temperature is below 50°C (120°F). The system is under pressure and the coolant can cause severe burns or eye injury. Wear protective clothing and safety glasses. Always turn the cap slowly to the first stop and allow the pressure to escape before removing the cap completely.

1. Level the crane, engage the parking brake and shut off the engine.
2. Check that the overflow bottle (Figure 5-19) is at least half full. If coolant is low, fill the overflow bottle half way with a 50/50 mixture of glycol antifreeze and water. Do not add only water as this could cause rust to form in the radiator and engine.
3. If the bottle is empty, **BE SURE THE ENGINE IS COOL** to below 50°C (120°F), then slowly loosen the radiator cap to the first stop. Allow all pressure to release. Remove the radiator cap and check the fluid level. Coolant should be visible in the radiator.
4. If level is low, add a 50/50 mixture of glycol antifreeze and water, do not add only water as this could cause rust to form in the radiator and engine.

**NOTE:** For more details on proper radiator checking and maintenance procedures, see the engine manual furnished with the crane.

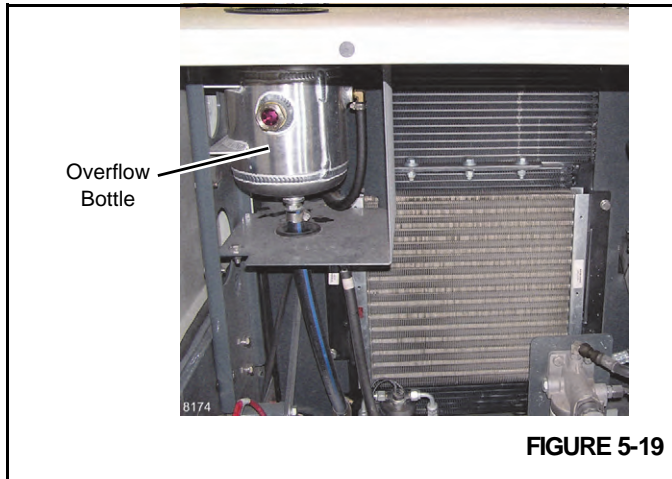


FIGURE 5-19

**Drain Water from Engine Fuel Filter**

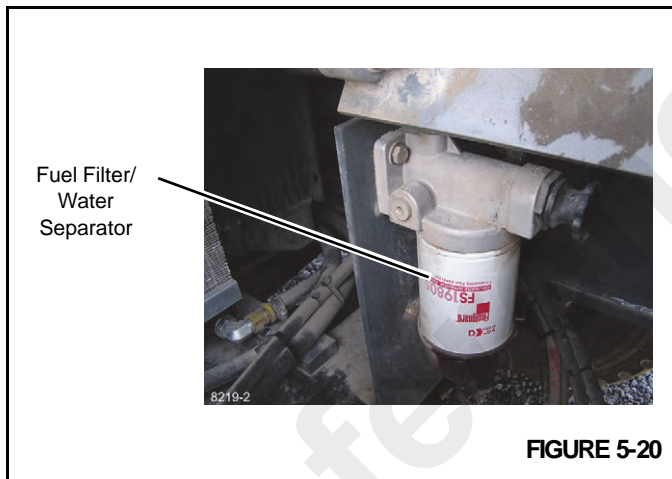
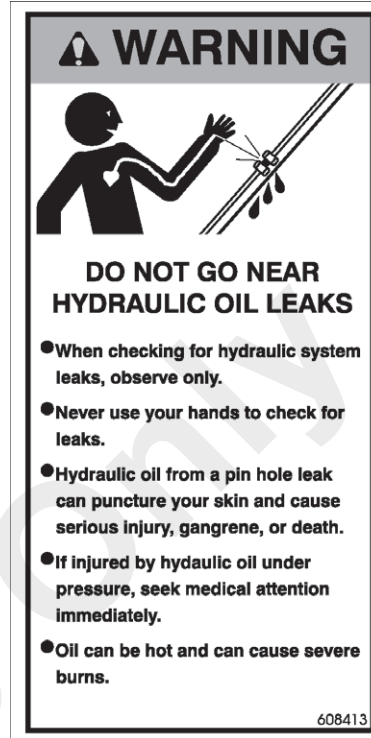


FIGURE 5-20

1. Shut off the engine and engage the parking brake.
2. See the engine manual furnished with the crane and follow the water draining instructions.

**Check Hydraulic Oil Level**

If the hydraulic oil is consistently low, check for leaks in the hydraulic system.



1. Be sure the boom is fully retracted and lowered and the outriggers are retracted and up.
2. Level the crane, engage the parking brake and shut off the engine.
3. Visually check the oil level on the hydraulic oil level sight gauge (Figure 5-21). The hydraulic oil should be visible in the sight gauge. If low, fill tank with clean recommended hydraulic oil.

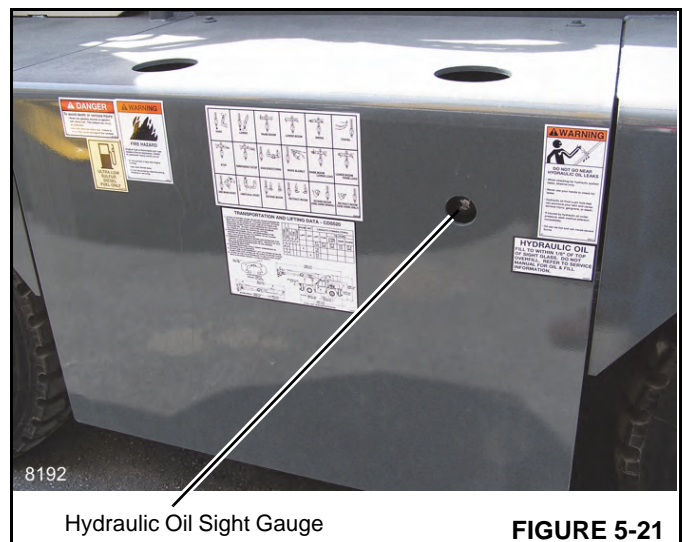


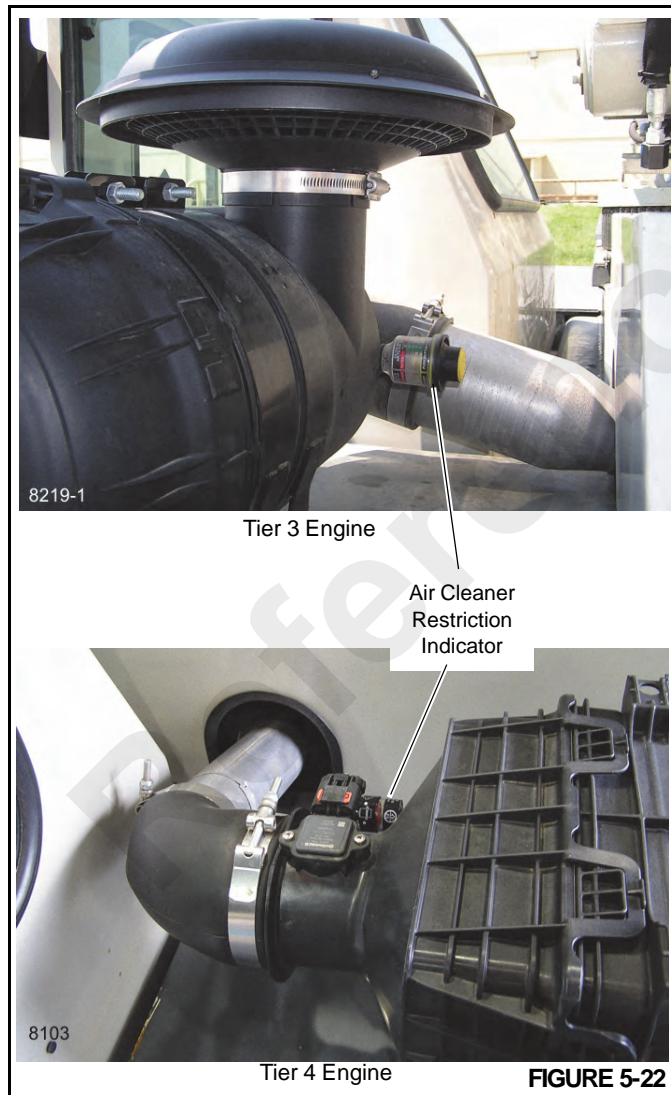
FIGURE 5-21

**Check the Air Cleaner Restriction Indicator**

The air cleaner is equipped with a filter restriction indicator (Figure 5-22). The air cleaner element needs cleaning or replacing if the indicator's colored piston has popped out and is visible when the engine is running at high idle.

To check the visual indicator the engine must be running. The filter restriction indicator is visible through the rear cab window.

Don't remove the element for inspection. Such a check always does more harm to your engine than the good your inspection can do. Ridges of dirt on the gasket sealing surface can drop on the clean filter side when the gasket is released.



**Remove the Element**

**NOTE:** Service the air cleaner only with the engine shut down. Dirt and debris can enter the engine and

cause damage if the engine is operated with the air cleaner element removed.

1. Remove the housing cover.
2. Remove the element as gently as possible until you get it outside of housing. Accidentally bumping it while it is still inside the housing means dropped dirt and dust that may contaminate the clean side of the air cleaner housing, before the new or cleaned filter element has a chance to do its job.
3. Remove the safety element.
4. Clean the inside of the housing carefully. Any dirt left inside the housing could cause damage to the engine. Use a clean, water-dampened cloth to wipe every surface clean. Check it visually to make sure it is clean before installing a cleaned or new element.
5. Always clean the gasket sealing surfaces of the housing. An improper gasket seal is one of the most common causes of engine contamination. Make sure that all hardened ridges are completely removed, both on the bottom and top of the housing.

**Inspect the Element**

1. Don't be fooled by the appearance of the element, it should look dirty.
2. Check the element for uneven dirt patterns. The dirty element is a valuable clue to dust leakage of gasket sealing problems. A dust trail or pattern on the element clean side is a sign that the element was not firmly sealed or that a dust leak exists. Make sure the cause of the leak is identified and rectified before replacing the element.

**Clean the Element**

**NOTE:** To prevent personal injury, always wear safety glasses when using compressed air.

Air cleaner elements must be replaced after six cleanings, every three months or after every 500 hours of operation, whichever occurs first.

1. Clean the filter element with compressed air. Use compressed air with 2.07 bar (30 psi) maximum pressure at the nozzle.
2. Direct the air inside the element and then move the nozzle up and down while rotating the element.

**Install the Element**

1. Install the safety element over the stud in the housing and slide it all the way in.
2. Install the element over the stud in the housing and slide it all the way in.
3. Make sure the gasket is seating evenly. If you don't feel the gasket is seating evenly for a perfect seal, you won't

have protection. Recheck to see if the sealing surface in the housing is clean, or if the element is the right model number. It may be too short for the housing.

4. Install the air cleaner housing cover.
5. Reset the air cleaner restriction indicator by pushing in the reset button (Figure 5-33).
6. If a cleaned air cleaner element was installed, start the engine and run at high idle. If the air cleaner restriction

indicator's colored piston pops out and is visible again, shut down the engine and replace the air cleaner element with a new element.

#### **Check Tire Pressure**

Check the air pressure in the crane's four tires. Correct pressure is 9.31 bar (135 psi).

Also, check for broken studs, rim damage, loose nuts, cracks and other tire damage.

Reference Only

**50 Hours of Operation (Weekly)**

**NOTE:** You must read and understand the warnings and basic safety rules, found in Section 2 of this manual, before performing any operation or maintenance procedures.

For additional engine maintenance guidelines, see the engine manual furnished with this crane.

**Clean the Air Cleaner Dust Cup**

Squeeze the dust cup to remove any accumulation of dust or debris.

**Wire Rope Inspection**

All wire ropes wear out eventually and lose work capability throughout their service life. That's why periodic inspections are critical. SAE J959, Lifting Crane, Wire-Rope Strength Factors, requires that a thorough inspection be performed and recorded on the wire rope not less often than weekly when the crane is in continuous service.

Regular inspection of wire rope and equipment should be performed for three good reasons:

- It reveals the rope's condition and indicates the need for replacement.
- It indicates if you are using the most suitable type of rope.
- It makes possible the discovery and correction of faults in equipment or operation that can cause costly accelerated rope wear.

**Inspection**

Inspections should be carried out by a person who has learned through special training or practical experience what to look for, and who knows how to judge the importance of any abnormal conditions they may discover. It is the inspector's responsibility to obtain and follow proper inspection criteria for each application inspected.

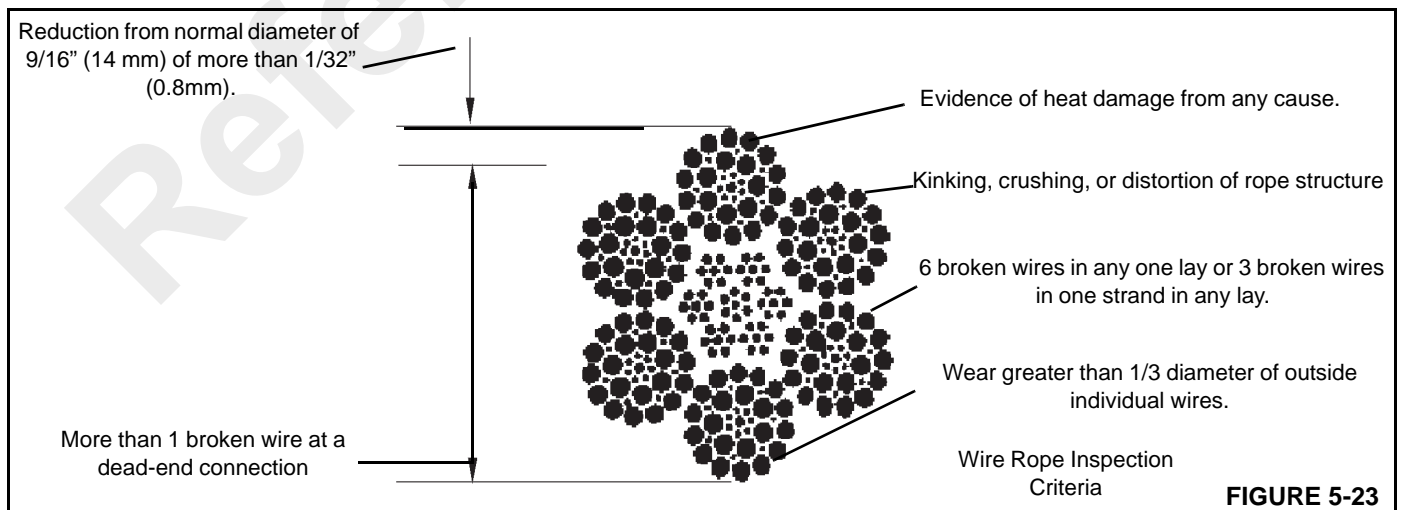
If you are not familiar with wire rope inspection, information on how to inspect wire rope, sheaves and drums is available from your distributor. Order Wireco Report No. 107.

**General Inspection**

**NOTE:** Always wear gloves when working with wire rope to prevent hand injuries.

1. **Wire Rope** - Inspect for damage, rust or wear to the wire rope. Keep a record of each inspection. Replace the wire rope if any of the conditions in Figure 5-23 are present.
2. **Sheaves** - Inspect sheaves for damage and/or wear. The sheave grooves must be smooth and a little larger than the wire rope. Use a sheave gauge to check the size of the sheave groove. Rough edges, narrow or worn grooves will cause damage to the wire rope. Replace any worn or damaged sheaves.

**NOTE:** As a sheave wears, the groove for the wire rope becomes smaller. The tracks on the sheave are caused by the wire rope. Yet, the wire rope will continue to engage these tracks, for example a chain engaging a sprocket. As the wire rope turns and twists on the sheave, the wire rope will move out of the worn track. This will cause increased wear on the wire rope.



**FIGURE 5-23**

**Grease Fittings**

Lubricate all points indicated under the heading "Lubrication Points".

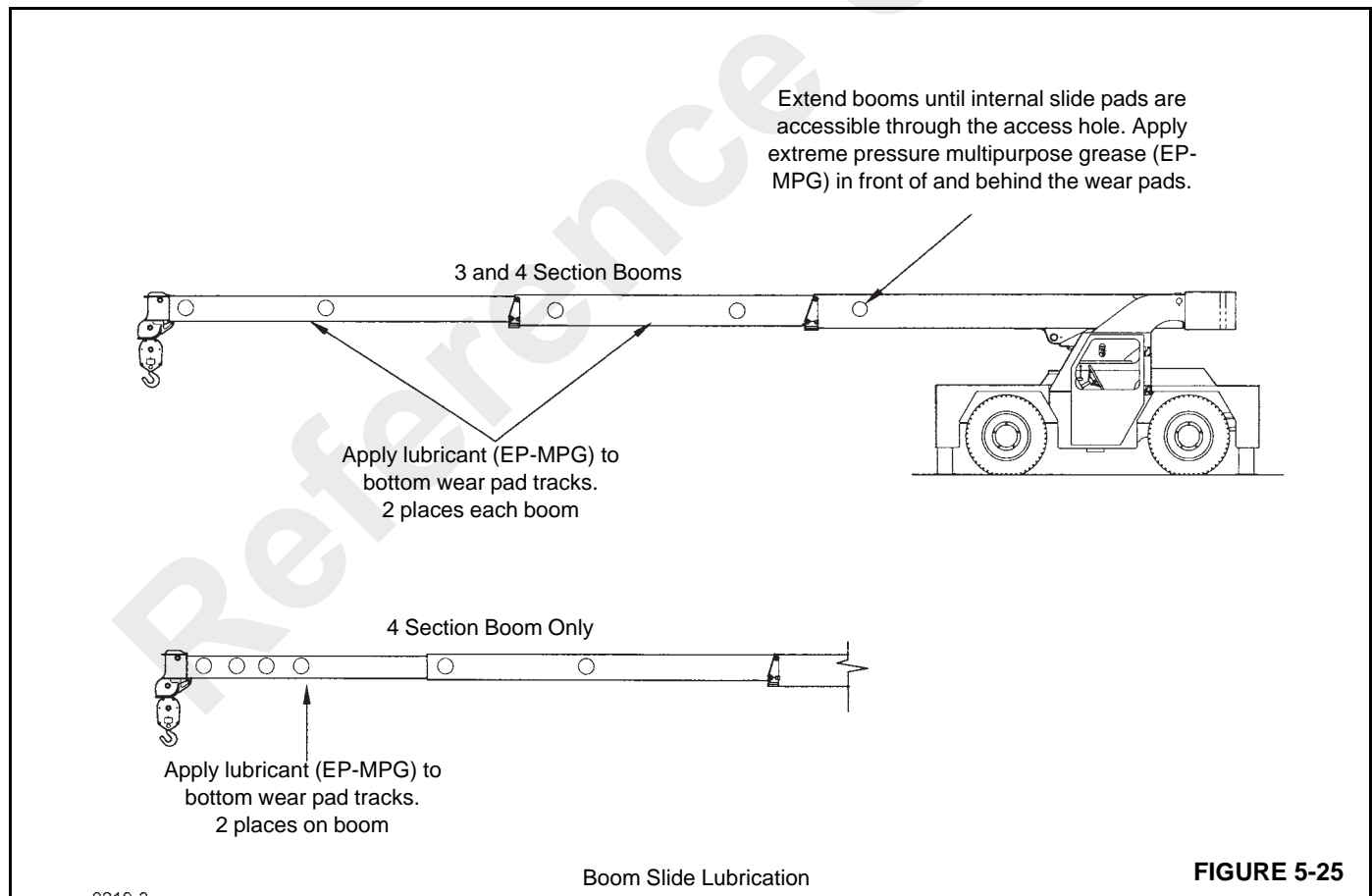
**Lubricate Parking Brake**

Apply grease to the fitting on the parking brake (Figure 5-24).



**Lubricate the Boom Slides**

1. Extend the outriggers. Lower the boom and then extend it to its maximum out position.
2. Engage the parking brake and shut off the engine.
3. Clean the old lubricant from the booms.
4. Apply extreme pressure multipurpose grease, or equivalent, to the boom sliding surfaces (Figure 5-25) on the boom sections. Only use a small amount of lubricant for best results.
5. On four-section booms only, align the boom access holes (Figure 5-25) to gain access to the telescope cylinder rod end slide pad.
6. Apply extreme pressure multipurpose grease, or equivalent, to the inner boom surface in front of and behind the slide block. Only use a small amount of lubricant for best results. Extend and retract the booms to distribute the lubricant along the slide path.



**100 Hours of Operation (Two Weeks)**

**NOTE:** You must read and understand the warnings and basic safety rules, found in Section 2 of this manual, before performing any operation or maintenance procedures.

For additional engine maintenance guidelines, see the engine manual furnished with this crane.

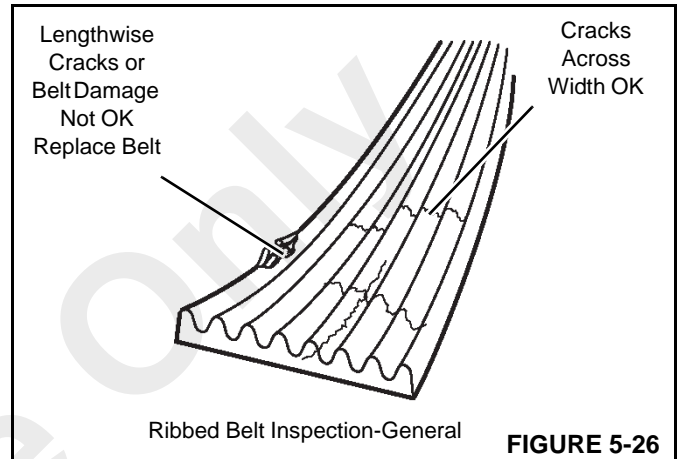
**Inspect the Fan Belts**

Keep the engine and accessory belts properly tensioned for maximum engine performance and fuel economy. Proper belt tension minimizes slippage and increases belt life.



A belt that is too loose will see excessive vibration and increased wear. A belt that is too tight produces wear on the belt and the bearings of the pulleys it travels around.

Check ribbed belts for intersecting cracks. Cracks across the belt are acceptable. Cracks along the length of a ribbed belt are not acceptable. Ribbed belts with cracks along their length should be replaced. See Figure 5-26.



Any ribbed belt showing signs of wear or that has material missing should be replaced. When a belt is replaced, check its tension again after 30 minutes of operation. New belts will stretch with use.

**Check Wheel Nut Torque**

Check the torque on each wheel nut in crisscross pattern. Wheel nut torque should be 680 Nm (500 lb-ft).



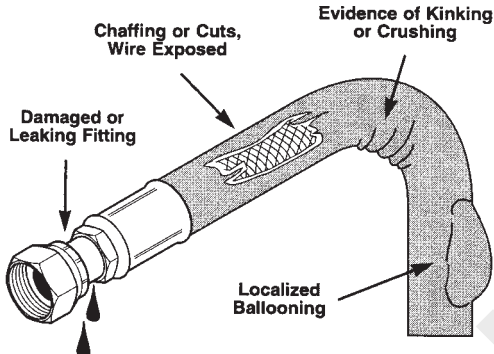
**250 Hours of Operation (Monthly)**

**NOTE:** You must read and understand the warnings and basic safety rules, found in Section 2 of this manual, before performing any operation or maintenance procedures.

For additional engine maintenance guidelines, see the engine manual furnished with this crane.

**Inspect the Hydraulic Hoses**


Inspect hydraulic hose assemblies for leaks, damaged fittings and worn exterior. Do not use your hands to check for hydraulic leaks. Hydraulic oil under pressure can cause serious injury or possible death. Use a piece of cardboard or other material as a deflector to detect leaks. Replace any problem hose before beginning work.



**Check hoses carefully. Do not use your bare hands to check for leaks. Tighten all connections to recommended torque. Replace if any of the following are found:**

- End fittings damaged or leaking.
- Outer covering chafed or cut and wire reinforcing exposed.
- Outer covering ballooning locally.
- Hose shows evidence of kinking or crushing.

**WARNING**



**DO NOT GO NEAR HYDRAULIC OIL LEAKS**

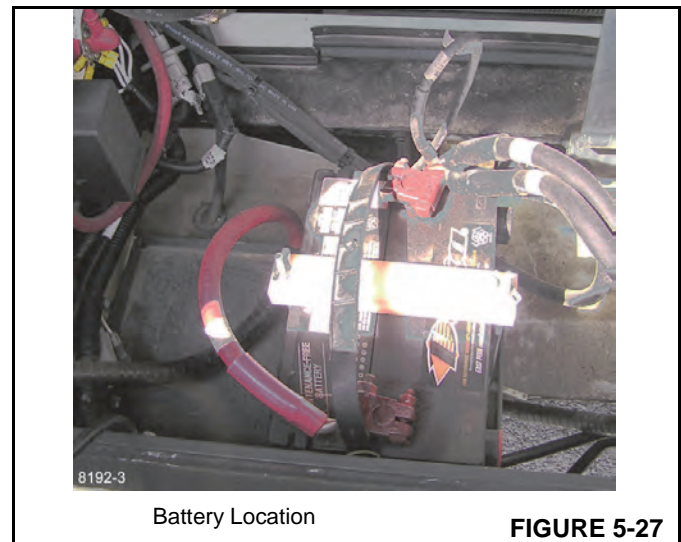
- When checking for hydraulic system leaks, observe only.
- Never use your hands to check for leaks.
- Hydraulic oil from a pin hole leak can puncture your skin and cause serious injury, gangrene, or death.
- If injured by hydraulic oil under pressure, seek medical attention immediately.
- Oil can be hot and can cause severe burns.

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**Clean Battery and Cables**

1. Remove the battery compartment cover.

	<p><b>WARNING</b></p> <p>EXPLOSIVE GASES can cause serious injury.</p> <p><b>Keep sparks, Flames, and Lighted Materials away from Batteries.</b></p>	<p><b>When jump starting:</b></p> <ul style="list-style-type: none"> <li>● Wear safety glasses.</li> <li>● Be certain that machines do not touch and batteries are not frozen.</li> <li>● Follow jump starting directions contained in Operator's Manual.</li> </ul>
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2. Tighten all battery hardware to keep the battery securely in place.
3. Disconnect the battery cables.
4. Sprinkle the battery with baking soda to neutralize the acid. Rinse with water. Be careful not to get water inside the battery.
5. Coat the battery posts with petroleum jelly and reinstall the battery cables.
6. Install the battery box cover.

**Clean the Radiator**

**NOTE:** To prevent personal injury, always wear safety glasses when using compressed air.

Clean the radiator fins by using compressed air or a water hose to remove all foreign materials. If these materials are not removed, the engine may over heat due to blocked air through the radiator fins and core.

**Lubricate the Wire Rope**

Apply lubricant to the hoist wire rope to inhibit rust, corrosion and wear.

1. Unwind the wire rope from the hoist drum.
2. Thoroughly clean the wire rope prior to application of any lubricant. Use a wire brush and compressed air to remove all foreign matter and old lubricant.

**NOTE:** To prevent personal injury from compressed air, always wear safety glasses when using compressed air for cleaning.

3. After cleaning the wire rope, apply a good grade of wire rope lubricant, to the entire length of the wire rope. Or, apply a light weight oil that has been preheated to a temperature between 18° to 36°C (60° to 100°F). Use a brush or cloth to apply the oil.

**NOTE:** Be sure the lubricant enters the strands of the wire rope for proper lubrication. Do not use grease to lubricate the wire rope.

**Lubricate the Swing Gear and Pinion**

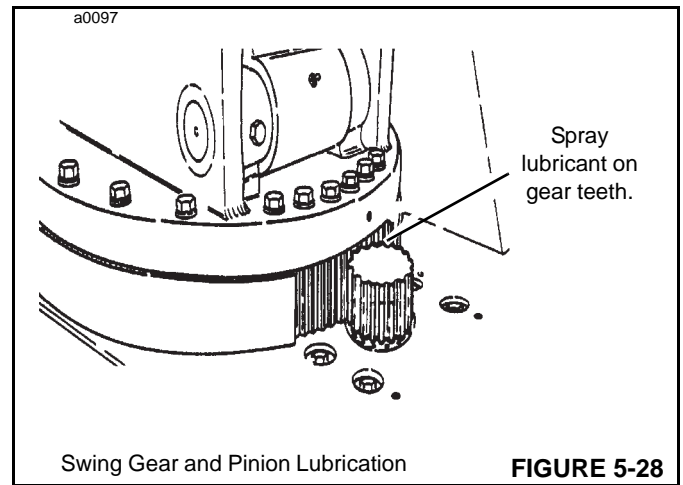
1. Engage the parking brake and shut off the engine.
2. Remove the guard covering the swing pinion.

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Rotating gears can cause injury. Keep hands clear of rotating pinion and gear while the mast is rotating.

3. Using a brush, apply open gear lube to the pinion and swing gear teeth (Figure 5-28).



4. Start the engine and rotate the mast until a non-lubricated portion of the swing gear is exposed. Keep hands away from rotating pinion and gear.
5. Shut off the engine.
6. Apply Ceplattyn spray lube to the swing gear teeth.
7. Repeat steps 4, 5 and 6 until the complete swing gear is lubricated.

**Replace the Crankcase Oil and Filter**

Change the engine oil more frequently if operating under difficult conditions, for example in high or low temperatures, dusty surroundings or frequent starting and stopping.

**NOTE:** If it is necessary to climb under the crane to change the engine oil and replace the engine oil filter, be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.

Drain the engine oil only when it is hot and the contaminants are in suspension.

Hot oils can cause personal injury.

1. Operate the engine until the water temperature reaches 60°C (140°F).
2. Shut off the engine
3. Place a suitable container under the engine drain plug. Remove the oil drain plug.
4. Clean the area around the engine oil filter head.
5. Remove the filter and clean the gasket surface of the filter head.

**NOTE:** The O-ring can stick on the filter head. Make sure it is removed before installing the new filter.

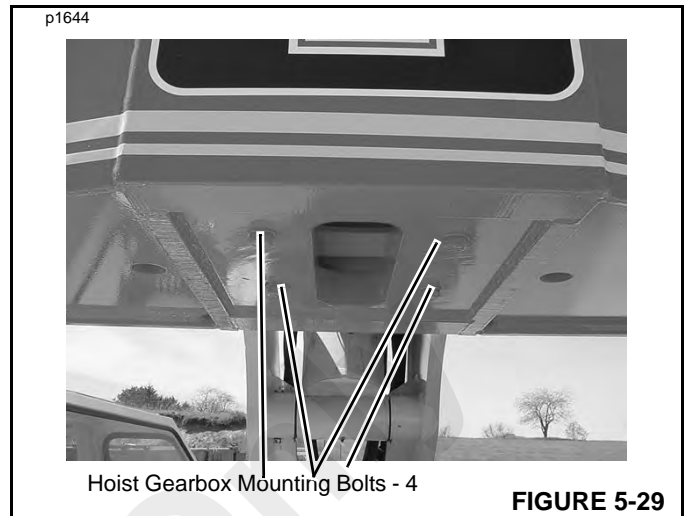
6. Fill the new filter with clean recommended lubricating oil (See engine operator’s manual furnished with the crane).
7. Apply a small amount of clean engine oil to the gasket of the new oil filter. Turn the filter clockwise to tighten it until the gasket makes contact. Then, tighten the filter 1/2 to 3/4 turn to get correct seal.
8. Fill the engine crankcase with clean recommended lubricating oil.
9. Operate the engine at idle and inspect for leaks at the filter and drain plug

**Torque Critical Bolts**

**NOTE:** Maintain correct torque on all bolts. Failure to do so may result in severe damage to the crane.

**Hoist Gearbox Mounting Bolts**

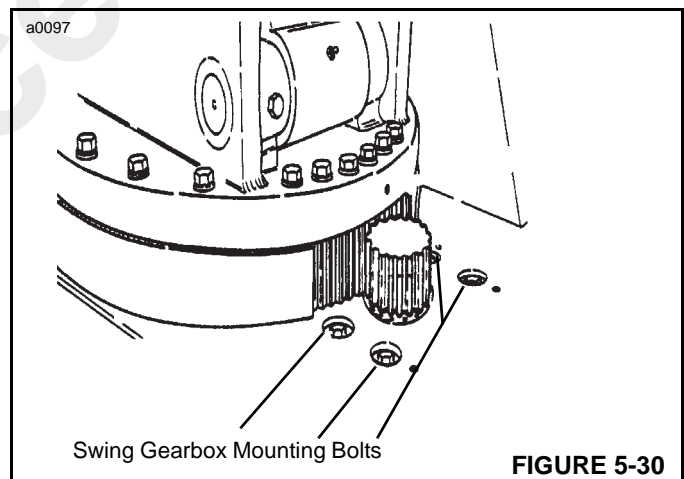
Torque the M16 mounting bolts (4) to 298-322 Nm (220-238 lb-ft). See Figure 5-29.



**FIGURE 5-29**

**Swing Gearbox Mounting Bolts**

Torque the 3/4” gearbox mounting bolts (4) to 289 Nm (213 lb-ft). See Figure 5-30. If the bolts are loose, check gear backlash.



**FIGURE 5-30**

**Mast Mounting Bolts**

Because of the cyclic loading on the mast bolts, it is important that these bolts be checked at regular intervals.

Make a record of any loose bolts. If any bolt does not hold to correct torque after the second check, remove and replace the bolt. A loose bolt indicates possible failure of the bolt.

The correct torque on each outside unplated bolt (mast to swing bearing) should be 698-756 Nm (515-558 lb-ft). The correct torque on each inside unplated bolt (swing bearing to frame) should be 698-756 Nm (515-558 lb-ft).

Use the torque sequence shown in Figure 11-20 when checking the torque on the bolts.

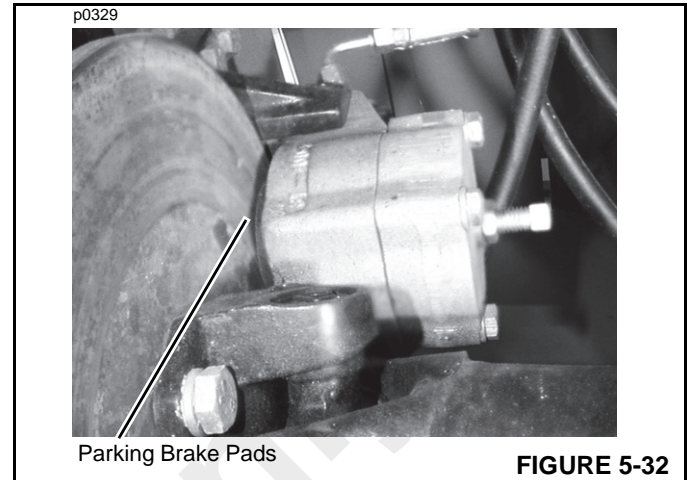
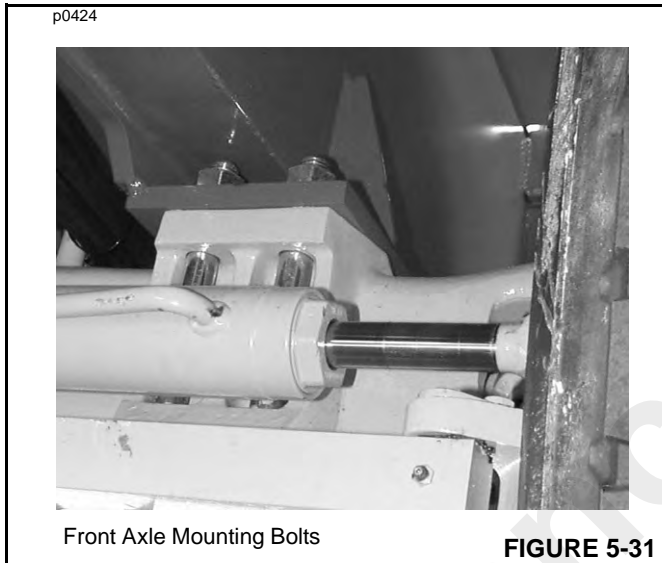
**NOTE:** Use only special Class 12.9 unplated bolts for replacement of the mast bolts. Order the bolts from your distributor, see your parts manual.

If a broken bolt is found, replace the bolt and also replace the bolt on each side of the broken bolt.

The proper bolt torque will not be obtained without the hardened steel washers under the bolt heads on the outer (mast) bolt circle.

### Front Axle Mounting Bolts

Torque the 1" axle mounting bolts (8) to 782 Nm (575 lb-ft). See Figure 5-31.



### Replace Fuel Filter

See the engine operator's manual furnished with the crane and follow the replacement procedures.

**NOTE:** If the filter is not filled with fuel prior to installation, the engine will not start due to air in the fuel system. The fuel system will have to be bled as instructed in the engine operator's manual furnished with the crane.

### Replace Air Cleaner Element

**NOTE:** Service the air cleaner only with the engine shut down. Dirt and debris can enter the engine and cause damage if the engine is operated with the air cleaner element removed.

1. Remove the housing cover.
2. Remove the element as gently as possible until you get it outside of housing. Accidentally bumping it while it is still inside the housing means dropped dirt and dust that may contaminate the clean side of the air cleaner housing, before the new element has a chance to do its job.
3. Remove the safety filter.
4. Clean the inside of the housing carefully. Any dirt left inside the housing could cause damage to the engine. Use a clean, water-dampened cloth to wipe every surface clean. Check the housing visually to make sure it is clean before installing a cleaned or new element.
5. Always clean the gasket sealing surfaces of the housing. An improper gasket seal is one of the most common causes of engine contamination. Make sure that all hardened ridges are completely removed.
6. Install the safety element. Make sure it is seated all the way.

**NOTE:** The safety element must be replaced after two main element replacements.

## 500 Hours of Operation (3 Months)

**NOTE:** You must read and understand the warnings and basic safety rules, found in Section 2 of this manual, before performing any operation or maintenance procedures.

For additional engine maintenance guidelines, see the engine manual furnished with this crane.

### Inspect the Tires

Inspect the tires for any signs of damage, such as cracks, large gouges, deterioration, etc. If damage is found, it must be carefully analyzed to determine if the tire is safe to use. Replace all tires that are unsafe.

### Inspect Parking Brake Pads

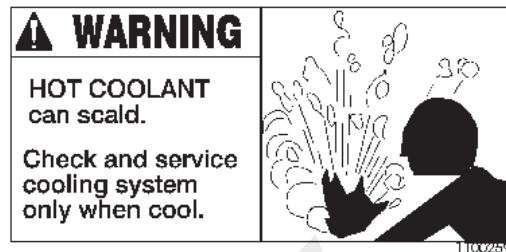
**NOTE:** It is necessary to climb under the crane to check the parking brake pads. Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.

Inspect the thickness of the brake pads (Figure 5-32). Replace the brake pads if they are 0.71 mm (0.028 in) thick or less.

Check the surface condition of the brake disc. Replace the disc if badly warped, pitted or out of tolerance.

7. Install the new element over the opening in the housing and slide it all the way in.
8. Make sure the gasket is seating evenly. If you don't feel the gasket is seating evenly for a perfect seal, you won't have protection. Recheck to see if the sealing surface in the housing is clean.
9. Install the air cleaner housing cover.
10. Reset the air cleaner restriction indicator by pushing in the reset button (Figure 5-33).

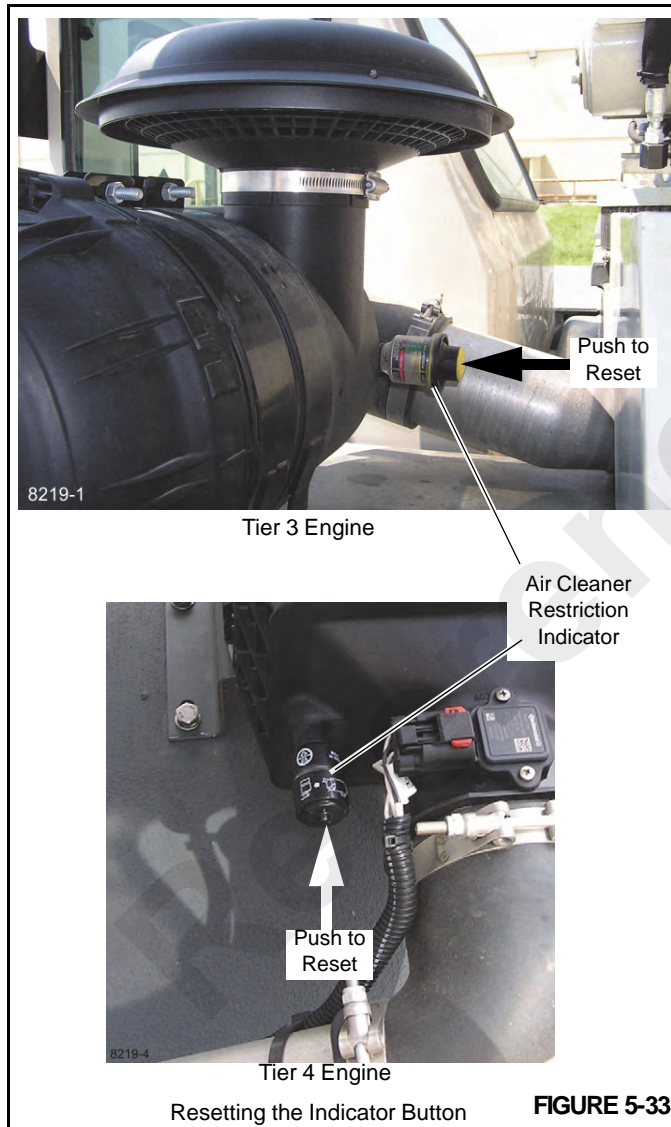
**Add Rust Inhibitor to Engine Cooling System**



For maximum protection of the engine cooling system, add a corrosive inhibitor to the radiator. When the engine is cold, remove the radiator cap and pour the inhibitor in the radiator reservoir, following manufacturer's instructions.

**Lubricate the Outrigger Slides**

1. Lower the outriggers.
2. Clean the tops of the outriggers with a suitable solvent.
3. Apply Mobil EP grease, or equivalent, to the areas shown in Figure 5-34. Do not over lubricate. Raise and lower the outriggers several times to spread the grease.



**FIGURE 5-33**



**FIGURE 5-34**

**Add Grease to the Swing Gearbox**

**NOTE:** It is necessary to climb under the crane to add grease to the swing gearbox. Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.

The grease fitting for adding grease to the swing gearbox can only be reached from under the crane. It will be necessary to use a light to see the fitting.

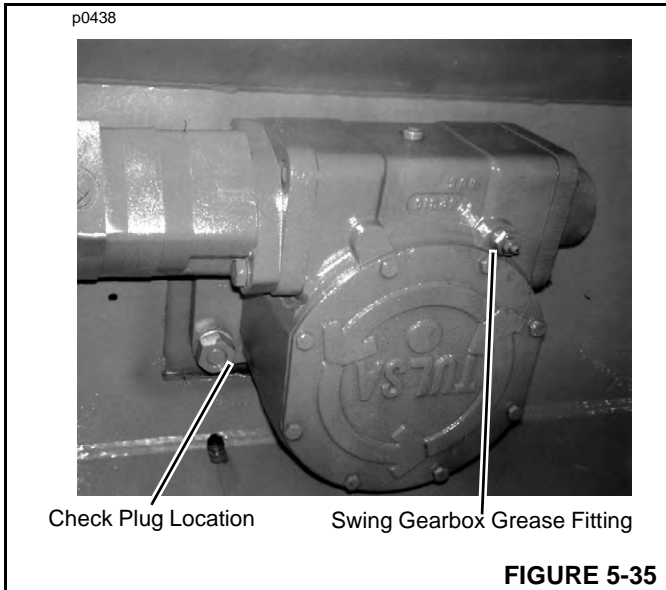


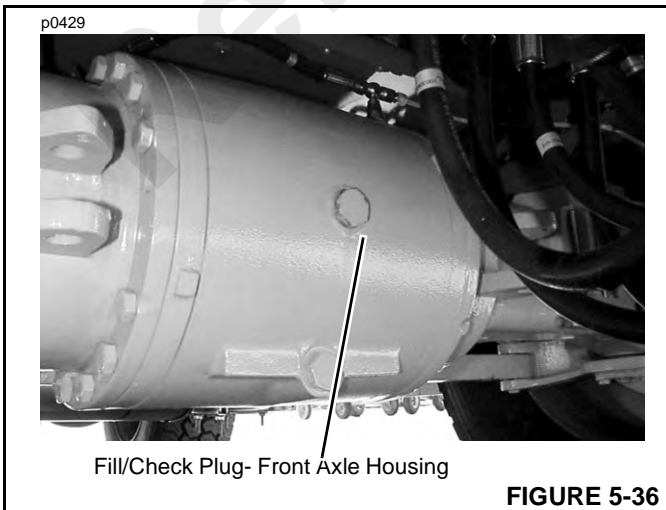
FIGURE 5-35

1. Engage the parking brake and shut off the engine. Remove the ignition key.
2. Clean the grease fitting and check plug (Figure 5-35).
3. Remove the check plug.
4. Apply Lithium Base, E.P. No. 2 bearing grease to the fitting. Fill gear box until grease exits the check plug hole. Install the check plug.

**Check Axle Housing Lubricant Level**

It is necessary to climb under the crane to check the axle housing lubricant. Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.

1. Clean around the axle housing fill/check plug (Figure 5-36 and Figure 5-37) and remove the plug.



Fill/Check Plug- Front Axle Housing

FIGURE 5-36



Fill/Check Plug- Rear Axle Housing

FIGURE 5-37

2. Check the lubricant level, which should be even with the bottom of the fill/check hole.
3. If necessary, add Mobil Fluid 424 to fill the housings until oil is level with the bottom of the fill/check hole.

**Check Wheel Hub Lubricant Level**

1. Using the outriggers, raise the tires slightly off of the ground.
2. Place the transmission in neutral and release the parking brake.
3. Turn one of the wheel hubs until the fill/check plug is horizontal with the ground (Figure 5-38).



Fill/Check Plug- Wheel Hub

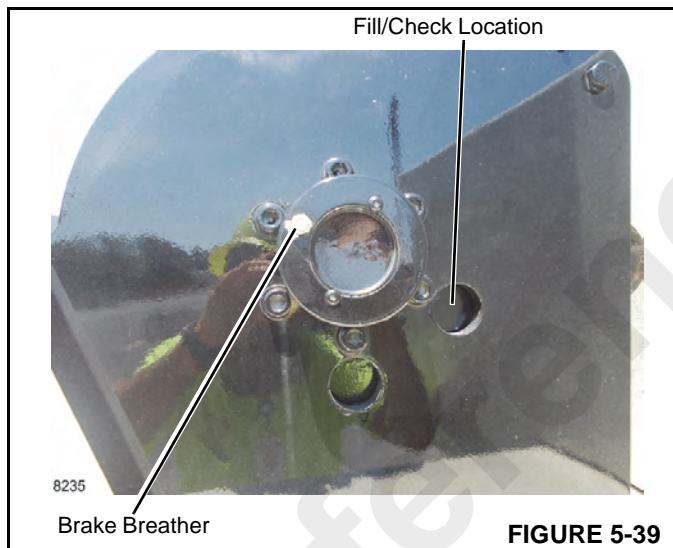
FIGURE 5-38

4. Clean around the plug and then remove it.
5. Check the lubricant level, which should be even with the bottom of the hole.

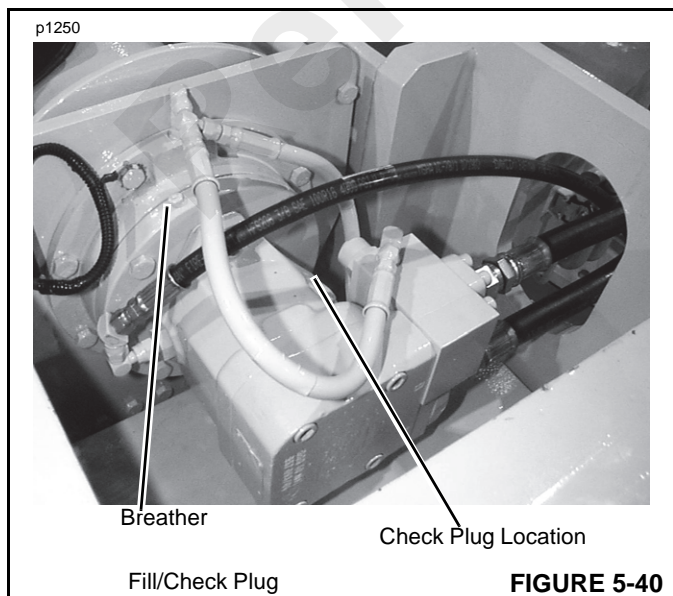
6. If necessary, add Mobil Fluid 424 to fill the hub to the recommended level.
7. Repeat Steps 1 through 6 for the other wheel hubs.

**Check Hoist Gearbox and Brake Lubricant Levels**

1. Lower the boom to its lowest position.
2. Engage the parking brake and shut off the engine.
3. Clean around the gearbox fill/check plug (Figure 5-39) and then remove the plug.
4. Check the lubricant level, which should be to the bottom of the fill/check hole.
5. If necessary, add SAE 90 EP gear lube to gearbox until it reaches the bottom of the fill/check plug hole.
6. Clean around the area of the brake breather and check plug (Figure 5-40). Remove the check plug.



**FIGURE 5-39**



**FIGURE 5-40**

7. Check the lubricant level which should be level with the bottom of the check plug hole.

**! WARNING**

**DO NOT** use EP type gear lubes in the brake section of this hoist. EP lubes may prevent the clutch from locking up, causing the load to fall and resulting in property damage, personal injury or death.

8. If necessary, add Mobil 424 hydraulic oil through breather hole until oil is level with the bottom of the check plug hole.
9. Install the breather and check plug

**1000 Hours of Operation (6 Months)**

**NOTE:** You must read and understand the warnings and basic safety rules, found in Section 2 of this manual, before performing any operation or maintenance procedures.

For additional engine maintenance guidelines, see the engine manual furnished with this crane.

**Replace the Transmission Oil and Filter**

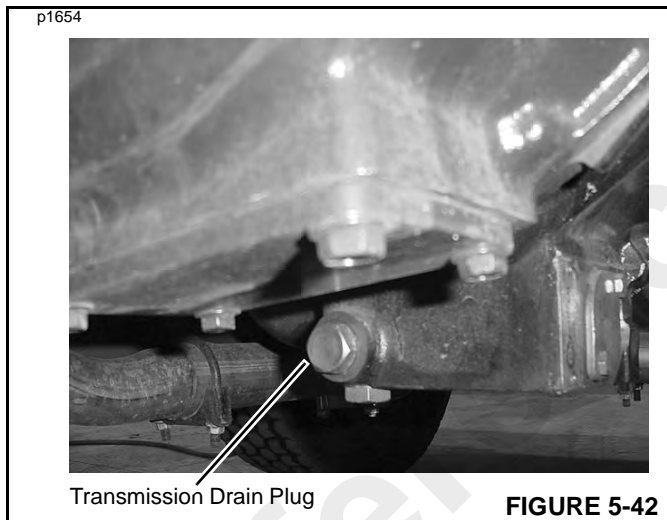
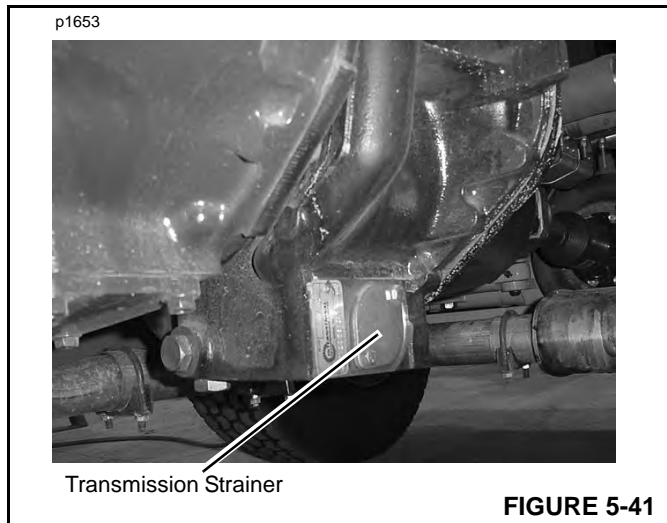
1. Engage the parking brake and shut off the engine. Remove the ignition key.

**NOTE:** It is necessary to climb under the crane to drain the transmission oil. Be sure engine is shut off, the ignition key is removed, parking brake is engaged and chock blocks are in place before climbing under the crane.

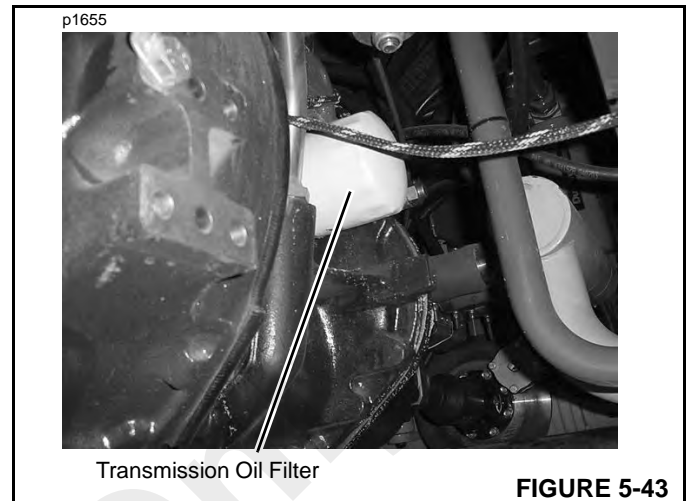
When the strainer is loosened/removed, oil will gush out. Keep to one side when you remove the strainer.

**NOTE:** Before removing the strainer, be sure you have a new strainer gasket. The old strainer gasket will be damaged during removal of the strainer, and if it is installed with the strainer, leakage will occur. It is recommended that three gaskets be kept in supply at all times. This will cover a years maintenance and one for emergency maintenance.

2. Place a suitable container under the strainer (Figure 5-41). Remove the strainer and gasket and drain the oil into the container. Discard the gasket.
3. Place the container under the drain plug and remove the drain plug (Figure 5-42). Drain any oil left in the transmission into the container. Install the drain plug.



4. Clean the strainer in a suitable solvent.
5. Install the cleaned strainer and new gasket. Tighten the strainer mounting bolts to a torque of 10 Nm (7.4 lb-ft).
6. Remove the transmission oil filter by unscrewing it from the transmission housing (Figure 5-43). Properly discard the filter.
7. Coat the seal of the new filter with clean transmission oil.
8. Screw on the transmission filter until it touches the filter head. Then, turn the filter another 3/4 of a turn minimum to seat the seal.



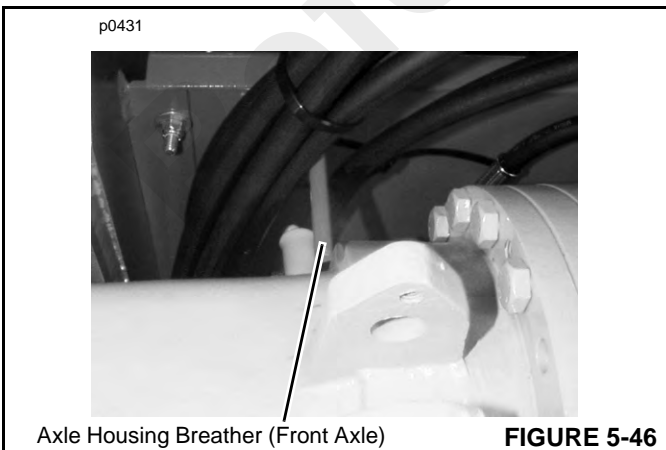
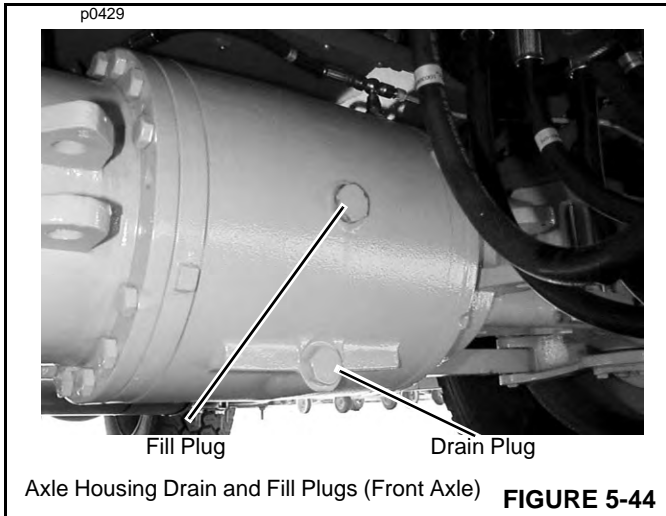
9. Fill the transmission with Mobil ATF 210, or equivalent, transmission fluid to the upper mark on the dipstick (approximately 13 liters [3.43 gallons]).
10. Start the engine and let it run at idle speed for a period not exceeding five minutes. This allows the oil to fill the transmission filter, torque converter and hoses.
11. Stop the engine, wait approximately one minute and then check oil level. If low, add oil to the upper mark on the transmission dipstick. **DO NOT OVERFILL.**

#### **Replace the Axle Housing Lubricant**

**NOTE:** It is necessary to climb under the crane to drain the axle housing lube. Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.

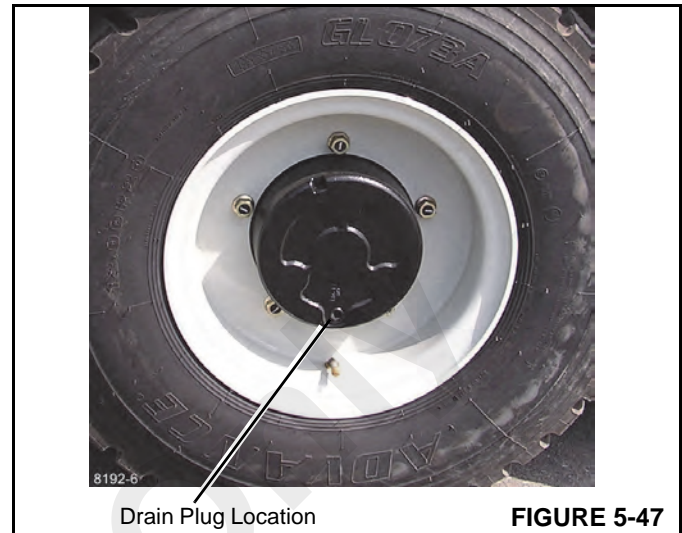
1. Clean around the fill plug in the axle housing (Figure 5-44 and Figure 5-45). Remove the plug.
2. Place a container under the axle housing drain plug (Figure 5-44 and Figure 5-45). Remove the drain plug and drain the fluid into the container. Install the drain plug.
3. Clean the front axle breather (Figure 5-46) with a suitable solvent. If the breather is removed, be sure that the hole in the breather tube is facing toward the axle hub (toward the right).



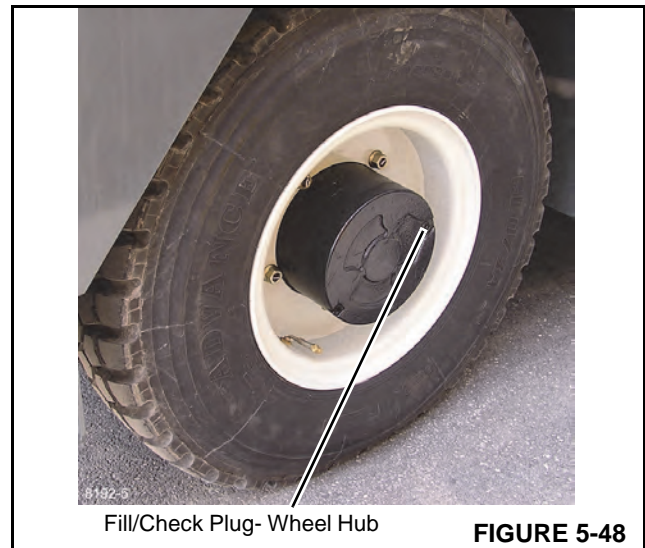


4. Fill the axle housing with recommended lubricant through the fill plug hole. Fill until the oil reaches the bottom of the fill hole.
5. Install the fill plug.

**Replace Axle Wheel Hub Lubricant**



1. Using the outriggers, raise the tires slightly off of the ground.
2. Place the transmission in neutral and release the parking brake.
3. Turn one of the axle wheel hubs until the drain plug is located at the bottom of the wheel hub (Figure 5-47).
4. Clean around the drain plug and then remove it. Drain the wheel hub oil into a suitable container.



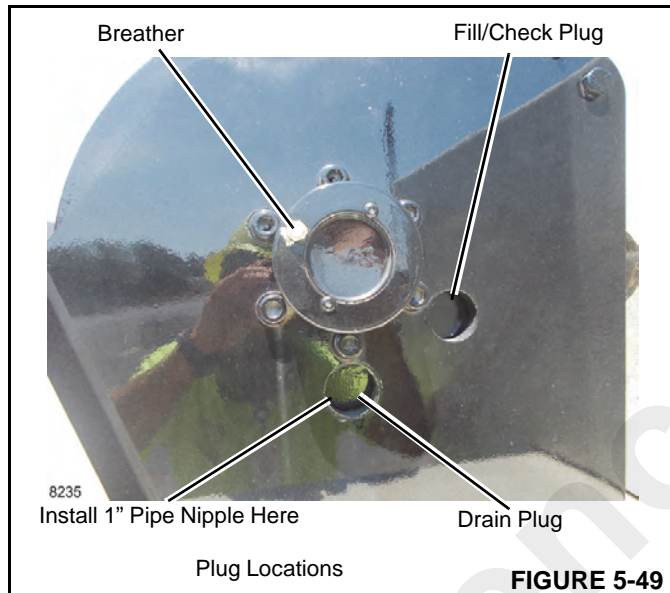
5. Turn the wheel hub until the drain hole is horizontal (Figure 5-48).
6. Fill the wheel hub with the recommended lubricant through the fill hole until the oil reaches the bottom of the hole.
7. Install the plug.

- Repeat the above procedure for the other three wheel hubs.

### Replace the Hoist Gearbox and Brake Lubricant

#### Hoist Gearbox

- Lower the boom to lowest position, engage the parking brake. Leave the engine running.
- Rotate the drum until the drain plug is visible in the hole in the side of the mounting bracket.



**FIGURE 5-49**

- Clean around the gearbox breather and the fill/check plug hole. Remove the gearbox breather (Figure 5-49) and clean it in a suitable solvent. After it is cleaned, install the breather.
- Clean around the fill/check plug (Figure 5-49) and remove the plug.
- Place a suitable container under the drain plug.
- Screw a 1 inch pipe nipple into the hole in the mounting bracket (Figure 5-49). Using a ratchet wrench with an extension and a 3/8" hex wrench attached, remove the drain plug through the pipe nipple. Allow the fluid to drain into the container. Examine the oil for signs of significant metal particles. If any particles are found, the gearbox may require disassembly and repair.
- Install the drain plug and remove the nipple.

- Fill the gearbox through the fill hole until the fluid is even with the bottom of the fill hole. Fill with SAE 90 EP gear lube.
- Install the fill/check plug.

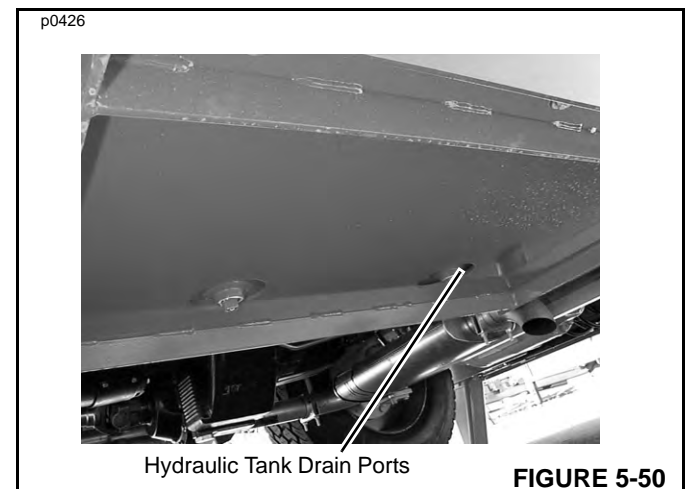
### Replace the Hydraulic Oil

**NOTE:** ISO (International Standards Organization) #46/68 Hydraulic Oil (Mobil Fluid #424) is recommend for year-round use in the hydraulic system.

In very cold temperatures, SAE 5W or SAE 5W-20 oils can be used if the viscosity of the oil will not be less than 60 SUS (Saybolt Universal Seconds) at maximum operating temperature. It may be necessary to use a pre-heater and a longer than normal warming period at low operating speed to heat the oil to operating temperature.

To change the hydraulic oil:

- Fully retract and lower the booms.
  - Retract all outriggers.
  - Operate the hydraulic system until the hydraulic oil is warm.
- NOTE:** It is necessary to climb under the crane to drain the hydraulic oil. Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.
- Level the crane, engage the parking brake, shut off the engine and remove the ignition key.
  - Place a suitable container under the hydraulic tank drain ports (Figure 5-50).



Hydraulic Tank Drain Ports

**FIGURE 5-50**

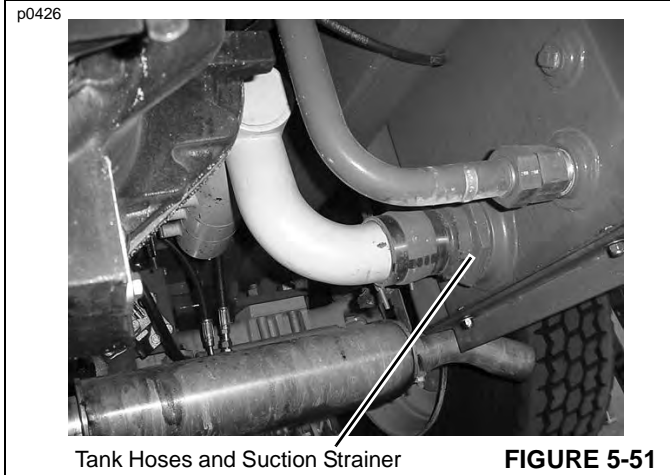


FIGURE 5-51

6. When the tank is empty, disconnect the two hydraulic lines from the rear of the hydraulic oil tank (Figure 5-51). Remove the suction strainer from the suction port and clean it in a suitable solvent.
7. Clean the inside of the hydraulic tank and remove any sediment.
8. Install the fill strainer, suction strainer, suction hose and return line to the hydraulic tank.
9. Replace the hydraulic oil filter. See "Replace the Hydraulic Oil Filter."
10. Fill the hydraulic tank with Mobil Fluid 424 hydraulic oil to the level of the sight glass.
11. After the tank is filled, start the engine and operate each function until all the cylinders and lines are filled.
12. Fully retract and lower the boom and retract the outriggers. Check the hydraulic oil level. Oil must be to the level of the sight glass. Add hydraulic oil if necessary.
13. Visually check for leaks.

### Replace the Hydraulic Oil Filter



FIGURE 5-52

1. Engage the parking brake and shut off the engine.

**NOTE:** It is necessary to climb under the crane to replace the hydraulic oil filter. Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.

2. Locate the hydraulic oil filter under the machine (Figure 5-52).
3. Remove the filter:
  - a. Using a filter wrench, turn the filter counterclockwise to loosen and remove the filter. Properly discard the removed filter.
  - b. Clean the mounting surface on the filter head for the filter.
4. Install the filter:
  - a. Apply a small amount of clean hydraulic oil to the gasket of the new hydraulic filter. Install the filter. Install the filter to the filter head by turning it clockwise until the filter gasket makes contact. Then, tighten the filter 1/2 to 3/4 turn to achieve a tight seal.
  - b. Start the engine and check for leaks around the filter.

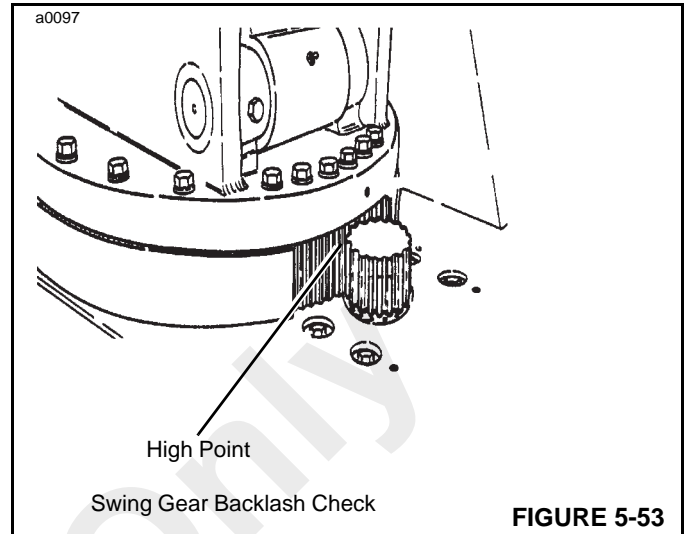
**Check Swing Gear/Pinion Backlash**

1. Remove the cover to expose the swing pinion and ring gear.



Rotating gears can cause injury. Keep hands clear of rotating pinion and gear while the mast is rotating. Start the engine and rotate the mast until the high point on the swing gear is in alignment with the pinion. The high point is either punch-marked or painted on the gear teeth (Figure 5-53).

2. Using a 0.013 mm (0.005 in) feeler gauge, check the backlash between the gear and pinion. If there is any other clearance, adjust the backlash. See *Swing Gearbox and Pinion*, page 11-26.



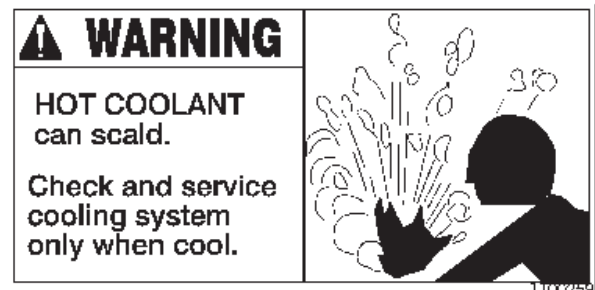
**FIGURE 5-53**

**2000 Hours of Operation (Yearly)**

**NOTE:** You must read and understand the warnings and basic safety rules, found in Section 2 of this manual, before performing any operation or maintenance procedures.

For additional engine maintenance guidelines, see the engine manual furnished with this crane.

**Replacing the Engine Coolant**



1. Open and prop in place the engine compartment cover.
2. **BE SURE THE ENGINE IS COOL** and follow the cooling system draining and filling procedures in the Engine Operation and Maintenance Manual furnished with the crane.
3. After the coolant is replaced, close the engine compartment cover.

**Inspect the Crane Structure and Booms for Damage**

Thoroughly inspect the crane structure and booms for the following:

- Inspect for loose mounting hardware. Tighten any loose hardware.
- Inspect for cracked or broken welds. Do not operate the crane if a critical weld is cracked or broken until the weld is repaired. Contact your Grove distributor or Manitowoc Crane Care.
- Inspect for missing or unreadable warning decals. Replace if necessary.
- Inspect for excessive rust or corrosion on crane structure and booms. Paint any areas with excessive rust or corrosion.
- Inspect for missing items. Replace if necessary.
- Inspect the crane for any damage that might inhibit safe operation of the crane. Repair any damage.

**Testing the Rated Capacity Limiter (Optional)**

See the Rated Capacity Limiter manual furnished with this crane and test the limiter according to instructions in the manual.

**MISCELLANEOUS MAINTENANCE**

**Batteries/Charging System**

**NOTE:** Lead-acid batteries produce flammable and explosive gases. To avoid personal injury, when checking, testing or charging batteries:

- **DO NOT** use smoking materials near batteries.
- Keep arcs, sparks and flames away from batteries.
- Provide ventilation and wear safety glasses.
- Never check battery charge by placing a metal object across the posts. The sparks could explode battery gases and cause injury or death. Use a voltmeter or hydrometer.

	<p><b>WARNING</b></p> <p>EXPLOSIVE GASES can cause serious injury.</p> <p><b>Keep sparks, Flames, and Lighted Materials away from Batteries.</b></p>	<p><b>When jump starting:</b></p> <ul style="list-style-type: none"> <li>• Wear safety glasses.</li> <li>• Be certain that machines do not touch and batteries are not frozen.</li> <li>• Follow jump starting directions contained in Operator's Manual.</li> </ul>
	<small>T100263</small>	

**Checking the Charging System**

Check the voltmeter reading on the instrument panel. Normal voltmeter readings are as follows:

Engine above idle - 14 to 16 volts

Engine stopped - 10 to 14 volts

A reading of less than 10 volts with the engine at low idle indicates a low battery charge.

A reading of less than 14 volts with the engine speed above low idle indicates a problem in the charging system. The system should be checked out by a qualified service technician.

**Charging the Battery**

Under normal conditions, the engine's alternator will have no problem keeping a charge on the batteries. The only condition in which the battery(s) may cause a problem is when they have been completely discharged for a long period of time. Under this condition the alternator may not be able to recharge the battery(s) and a battery charger will be required for charging the battery(s).

Before using a battery charger, an attempt can be made to recharge the battery using the engine alternator by first jump starting the crane (See Jump Starting, in Section 3) and letting the engine run.

**DO NOT** charge a frozen battery; it may explode and cause injury. Let the battery warm up before attaching a charger.

Charging rates between 3 to 50 amperes are satisfactory if no excessive gassing or spewing of electrolyte occurs or the battery does not feel excessively warm (over 52°C [125°F]). If spewing or gassing occurs or temperatures exceed 52°C (125°F), the charging rate must be reduced or temporarily stopped to permit cooling.

**Replacing the Battery**

**NOTE:** The fluid in electric storage batteries contains sulfuric acid, which is **POISON** and can cause **SEVERE CHEMICAL BURNS**. Avoid all contact of fluid with eyes, skin or clothing. Use proper protective gear when handling batteries. **DO NOT** tip any battery beyond a 45° angle in any direction. If fluid contact does occur, follow the First Aid suggestions that follows.

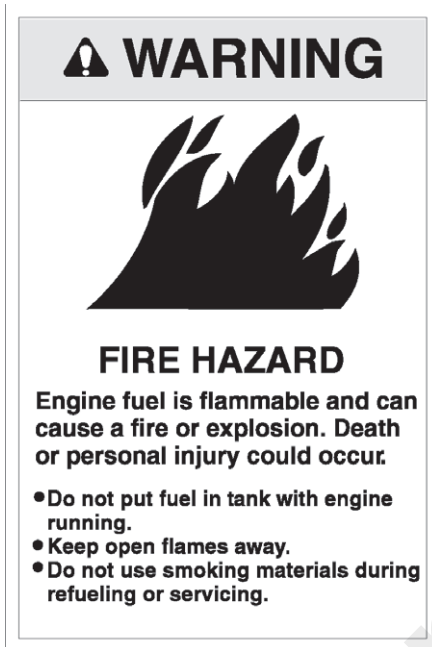
**Battery Electrolyte First Aid**

- **External Contact** - Flush with water.
- **Eyes** - Flush with water for at least 15 minutes and get immediate medical attention.
- **Internal** - Drink large quantities of water. Follow with milk of magnesia, beaten egg or vegetable oil. Get immediate medical attention.

**NOTE:** In case of internal contact, **DO NOT** give fluids that would induce vomiting.

Remove the battery very carefully to avoid spillage of battery fluid. Properly dispose of the battery.

## Fuel System



### Fuel Storage

Storage of fuel for an extended period causes accumulation of sediment, dirt, water and other foreign materials in the fuel. Many engine problems are caused by dirty fuel and long storage periods.

Keep fuel in an outside location. Use a shelter to keep the fuel as cool as possible. The water from condensation must be removed at regular intervals from the storage tank.

## CARWELL® RUST INHIBITOR

### Protecting Cranes From Rusting

Manitowoc Crane Group's cranes are manufactured to high quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, we are also doing our part to help prevent premature corrosion of cranes.

Grove cranes will be treated with a rust inhibitor called Carwell T32-CP-90. While a rust inhibitor cannot guarantee that a crane will never rust, this product will help protect against corrosion on Grove cranes that are treated with this product.

Carwell is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as

hazardous under OSHA Regulation 29CFR-19-10.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents.

Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

Once applied, treatment can appear to leave a slightly "oily" residue on painted surfaces and until the red tinting fades could initially be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it must be removed using standard steam-cleaning techniques.

This treatment works in various ways: (1) it eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface; (2) the film creates a barrier to repel further moisture from coming in contact with the metal; and (3) it penetrates crevices.

In addition to the factory-applied treatment, Grove crane owners must provide proper maintenance and care to help ensure long-term protection of their crane against corrosion. This procedure provides information and guidelines to help maintain the paint finish on Grove cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

While the surfaces of the crane that are easily seen have the biggest impact on the appearance of the crane, particular attention should be given to the undercarriage of the crane to minimize the harmful effects of corrosion.

Exercise special care and increase the frequency of cleanings if the crane is operated:

- on roads where large quantities of salt or calcium are applied to treat icy and snowy road surfaces;
- in areas that use dust control chemicals;
- anywhere there are increased levels of wetness - especially near salt water;
- during prolonged periods of exposure to damp conditions (e.g., moisture held in mud), where certain

crane parts may become corroded even though other parts remain dry; or

- in high humidity, or when temperatures are just above the freezing point.

## Cleaning Procedures

To help protect against corrosion of Grove cranes, Manitowoc Crane Care recommends washing the crane at least monthly to remove all foreign matter. More frequent cleanings may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.



### CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

**NOTE:** Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

## Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.

- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

**NOTE:** Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.



### CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

For scratches and marks in highly visible areas:

- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat of paint using accepted blending techniques. Use of original paint colors is recommended to insure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

## Application

Depending upon the environment in which a crane is used and/or stored, the initial factory application of Carwell T32-CP-90 should help inhibit corrosion for up to approximately 12 months.

It is recommended that the treatment be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments (such as islands, coastal regions, industrial areas, areas where winter road salt is regularly used, etc.), reapplication of treatment is recommended sooner than 12 months, e.g., repeat treatment in 6-9 months.

- Do not apply to recently primed and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

**NOTE:** Crane must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Crane should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged on the crane.
- Use of pressure pots to apply the treatment to the crane being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

## Areas of Application

Refer to Figure 5-54

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; valves, hose end and fittings, swivel, pumps, axles, drivelines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose ends and fittings, wire rope on hoist roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.
- Boom application areas are; pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, headache ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.







FIGURE 5-54

Item	Description
1	Hoist Tension Spring
2	Hoist Hose Connections
3	Pivot Shaft
4	Wire Rope
5	Hose Connections inside turntable
6	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
7	Boom Nose Pins, Clips
8	Headache Ball/Hook Block

Item	Description
9	Turntable Bearing Fasteners
10	O/R Pins, Clips
11	Hook block Tiedown Cable
12	O/R Hose Connections
13	Entire underside of unit
14	Powertrain Hardware inside compartment
15	Boom Extension Pins, Clips - Option
16	Boom Extension Hanger Hardware - Option

Reference Only

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## SECTION 6 ENGINE AND ENGINE SYSTEMS

### SECTION CONTENTS

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### GENERAL

These instructions are written for worldwide use. In territories where legal requirements govern engine smoke emissions, noise, safety factors, etc., then all instructions, data and dimensions given must be applied in such a way that, after maintaining or repairing the engine, it does not contravene regulations when in use.

**NOTE:** These instructions cover only the routine maintenance of the engine. See the engine manual furnished with the crane for engine diagnosis, repair and component replacement.

### ENGINE TYPES

Two and four wheel drive units use a Cummins 4B3.3 turbo-charged diesel engine.

### ENGINE PERFORMANCE

Engine performance is very important to the operation of the crane, The engine is the drive for the hydraulic pump, which supplies power to operate the work functions of the crane. For maximum power the engine must be kept in good working condition.

### ENGINE RPM

To check the engine speed, follow the instructions in the engine operator’s manual. Maximum and minimum speeds

are controlled by a governor installed on the engine. The throttle gives variable control of the engine speed within the limits set by the governor.

### GOVERNOR

The governor is preset at the factory and is very unlikely that it should ever have to be adjusted.

**NOTE:** Restrictions or wrong adjustment of the throttle linkage can be a possible cause of wrong engine RPM. Make sure the throttle linkage moves the engine throttle lever through a full stroke. If necessary, disconnect the throttle linkage and move the throttle by hand. Check the engine speed with the throttle linkage disconnected and compare results.

### ENGINE CRANKCASE SYSTEM

The engine crankcase system must be well lubricated to inhibit damage to the engine. The correct type of oil must be used, as well as proper maintenance at regular intervals. For correct intervals, see Preventative Maintenance, page 5-1.

### Crankcase Oil Data

Use oil viscosity based upon the expected air temperature range during the period between oil changes.



**Oil Performance Recommendations**

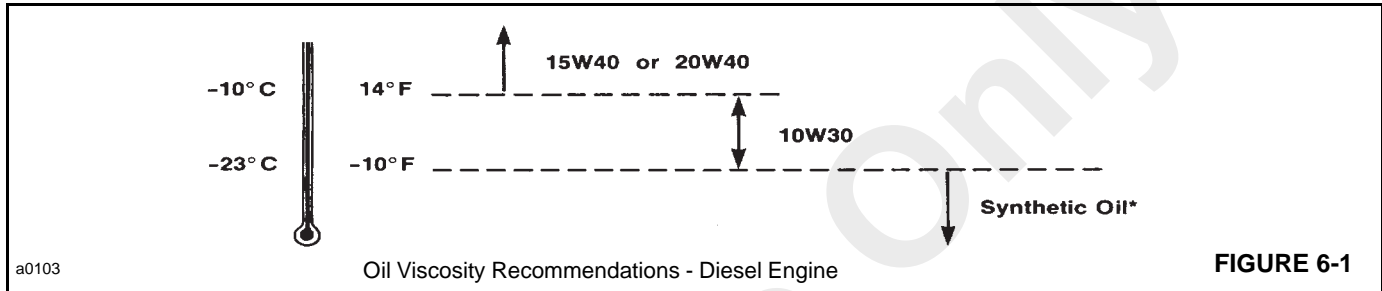
**CC/SF** for use in naturally aspirated engines and in engines that operate in light duty service including standby and emergency operation (equivalent to MIL-L-2104B).

**Sulfated Ash Limit** of 1.85% by weight is recommended. Oils with higher ash count may produce deposits on valves that can progress to guttering and valve burning.

Do not use “break-in” lubricating oils in new or rebuilt engines. Only use lubricating oils specified for normal engine operation.

**Oil Viscosity Recommendations**

The use of a multigrade lubricating oil improves oil consumption control and improves engine cranking in cold temperatures while maintaining lubrication at high operating temperatures. A multigrade oil is therefore recommended with the viscosity grades shown in the Figure 6-1. The use of single grade lubricating oils is not recommended, except for synthetic oils used in Arctic conditions.



**Arctic Operation**

**NOTE:** SAE 5W viscosity grade synthetic oil may be used when operating the engine in ambient temperatures below -23°C (-10°F) provided it meets the minimum viscosity at 100°C (212°F).

When there is no provision to keep the engine warm when operating in ambient temperatures consistently below -23°C (-10°F), use a lubricating oil that meets the following requirements:

**Table 6-1: Arctic Oil Recommendations**

Parameter (Test Method)	Specification
Performance	API Classification CC -Naturally Aspirated API Classification CC/CD - Turbocharged
Viscosity Maximum	10,000 mPa·s at -35°C (-31°F) 0.16 inch (3.1 mm) Squared Minimum at 100°C (212°F)
Pour Point (ASTM D-97)	Maximum of 5°C (41°F) Below the Lowest Expected Ambient Temperature
Sulfated Ash Content	Maximum of 1.85% by weight (ASTM D-874)

**ENGINE COOLING SYSTEM**

The engine cooling system consists of the coolant passages in the engine, a thermostat, water pump, hoses and radiator.

The engine is cooled by the circulation of coolant through the passages in the engine block and head. Circulation is by a thermo-siphon action assisted by a water pump driven by a belt from the crankshaft pulley.

The water pump bearings are packed with a special grease during assembly and do not require attention in maintenance.

**Coolant Requirements**

The quality of coolant will determine the efficiency and life of the cooling system.

1. Check the antifreeze concentration several weeks before the beginning of the cold season or hot season. The antifreeze must have an ethylene glycol (ethanediol) base. Use a low silicone antifreeze that conforms to one of the standards below, or which contains no more than 0.1% anhydrous alkali metasilicate.

**U.S.A.** - Engineering Standard GM6038-M.

**U.K.** - BS3151: 1959: Ethandiol antifreeze type B with sodium nitrate inhibitors.

**Australia** - AS 2108-1977: Antifreeze compounds and corrosive inhibitors for engine cooling systems.

2. There is an advantage to using antifreeze even when frost protection is not necessary. Antifreeze protects against corrosion and also raises the boiling point of the coolant. A 50% concentration of antifreeze is preferred, but if this much protection is not preferred, a 33% concentration can be used. Never use more than a 65% concentration under any conditions. Where frost

protection will never be required, use a **non-chromate corrosion inhibitor** and clean soft water. Change the water/corrosion inhibitor every 12 months, or 500 hours, or to manufacturer's recommendation.

**Do not use hard water** in the cooling system. Hard water, or water with high levels of calcium and magnesium ions, encourages silica gel formations, especially after a number of heating and cooling cycles. These gel formations can result in loss of cooling or heating in radiators and cab heater cores by coating and plugging the tubes. The formations usually deposit in the cooler sections of the cooling system, such as the radiator bottom tank.

**Use soft water, distilled water or deionized water** to reduce the potential and severity of silicate dropouts.

**NOTE:** If you use water without a corrosion inhibitor, rust will form and plug the small holes in the head gasket. These holes are orifices and their size is critical. Do not enlarge the size of the orifices. To do so will disturb the coolant flow and will not solve any overheating problem. If you use water without a corrosion inhibitor for even a short period, the cup plugs will rust through, allowing coolant leakage. An incorrect or malfunctioning radiator cap can result in the loss of coolant and engine running hot. Any sudden loss of coolant from a heavily loaded engine can result in severe damage to the pistons and cylinder bore.

**NOTE:** Some corrosion inhibitor mixtures contain soluble oil which can have an adverse effect on some types of water hoses.

## Radiator Cap and Overflow Bottle

The cooling system is designed to use a radiator cap to prevent the boiling of coolant. The radiator cap is set to open at 0.97 bar (14 psi). When it does open it allows coolant to be expelled into the overflow bottle and as soon as the engine cools the overflow fluid is sucked back into the radiator. An incorrect radiator cap can result in a great loss of coolant and the engine running hot.

Keep the overflow bottle at least half full of coolant at all times.

## Thermostat

A malfunctioning thermostat can result in the engine running hot or cold. If it becomes necessary to replace the thermostat see the engine manual furnished with the crane.

## ENGINE ELECTRICAL SYSTEM

The engine electrical system, the charging and starting circuits, as well as the sending units, are described in this section.

## ENGINE FUEL SYSTEM

### Diesel Engine Fuel System Description

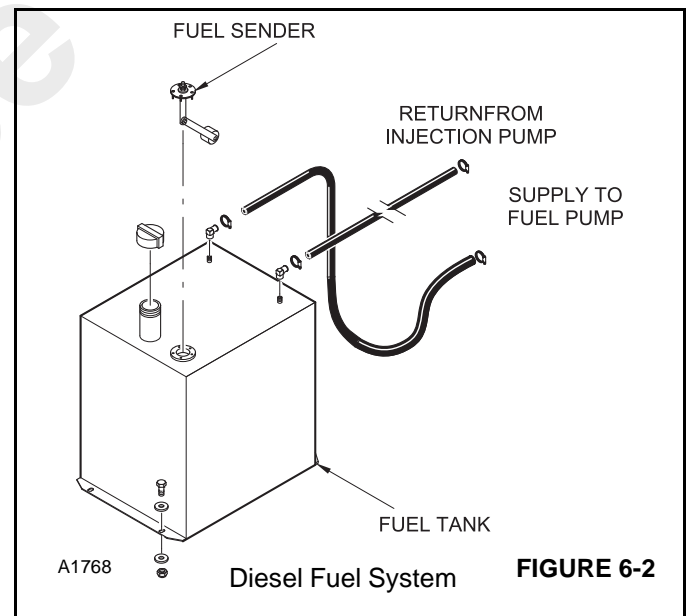
The diesel engine fuel system is a closed-loop fuel system which includes a fuel tank, an engine fuel filter, an engine fuel pump and the fuel lines.

A fuel supply line carries fuel from the bottom of the fuel tank to the engine fuel pump Figure 6-2. A line carries the fuel from the engine fuel pump to the engine fuel filter. Fuel that has been filtered flows to the fuel injector pump.

Fuel is distributed to the fuel injectors from the fuel injector pump. Excess fuel from the fuel injector pump is returned to tank.

### Fuel Tank

The fuel tank is located on the right side of the crane. It is a welded box construction with a suction tube installed in the fuel support port. The tube inhibits sediment and water from being picked up off the bottom and sent to the engine.



### Fuel Level Sender and Gauge

The fuel level sender and gauge are described in the Section 11, Electrical System.

### Fuel Pump

The fuel pump is installed internally in the engine and is used to pump fuel from the fuel tank and send it under pressure to the fuel filters and injection pump.

The fuel pump includes a priming button. This button is used to bleed the fuel system if one of the following should occur:

- The fuel filter is not filled prior to installation.
- The injection pump is replaced.

- High pressure fuel line connections are loosened or lines are replaced.
- Initial start up or start up after an extended period of time.
- The fuel tank has run empty.

Refer to the diesel operator's manual furnished with this crane for bleeding procedures.

### Fuel Filter

The filter is used to collect contaminants and water that has accumulated in the fuel and is not picked up by the sediment bowl. It must be serviced at regular intervals. See Section 5, Preventive Maintenance for maintenance intervals.

### Fuel Injection Pump

The fuel injection pump is a distributor-type pump with a mechanical flywheel-type governor. The pump is flange mounted and is driven from the engine timing case.

### Fuel Injectors

Fuel injectors should be taken out and examined at regular intervals. Refer to the engine operator's manual.

## QSB Engine Electronic Controlled Fuel System Units

Refer to the Engine Manual Furnished with this unit for a description of the Electronic Controlled Fuel System.

## Types of Fuel to Use

Fuel represents the major portion of the crane's operating costs. Therefore, it is important to use it efficiently. Don't let cost tempt you to use an inferior diesel fuel. The savings is a false economy when you consider the damage poor fuel can do to your crane's engine.



### WARNING

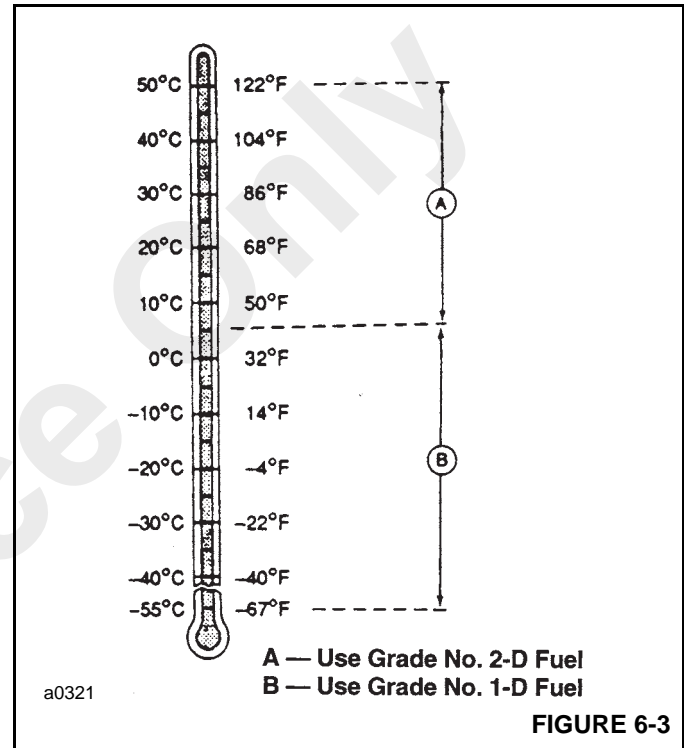
Do not mix gasoline or alcohol with diesel fuel. This mixture can cause an explosion.

**NOTE:** Use only diesel fuel designed for diesel engines. Some heating fuels contain harmful chemicals which can seriously affect engine efficiency and performance.

Due to precise tolerances of diesel fuel injection systems, it is extremely important that the fuel be kept clean and free of dirt and water. Dirt or water in

the system can cause severe damage to both the injection pump and the injection nozzles.

Use either a Grade No. 1 or a Grade No. 2 ultra low sulfur diesel fuel as defined by ASTM Designation D-975 for diesel engines. In European countries, use ISO 1585 commercial diesel fuel. Find expected air temperature at time of start up on the thermostatic scale Figure 6-3. Correct diesel fuel grade (A, B) is shown next to the scale.



**NOTE:** If engine is operating at temperatures  $-40^{\circ}\text{C}$  to  $-57^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$  to  $-70^{\circ}\text{F}$ ), Grade DF-A arctic fuel is recommended. Also consult the engine distributor for special lubricants and starting aids.

Cetane number should be a minimum of 40 to assure satisfactory starting and overall performance. At low temperatures and/or high altitudes, minimum cetane number of 45 is recommended.

**NOTE:** Excessive white smoke at start up could be a result of low cetane fuel.

Use low sulfur content fuel with a cloud point of at least  $6^{\circ}\text{C}$  ( $10^{\circ}\text{F}$ ) below the lowest expected air temperature at time of starting. The cloud point is temperature at which wax crystals begin to form in diesel fuel.

**NOTE:** When using diesel fuel with a sulfur content above 0.5%, the engine oil change interval must be reduced by 50%. DO NOT use a fuel with more than 1% sulfur.

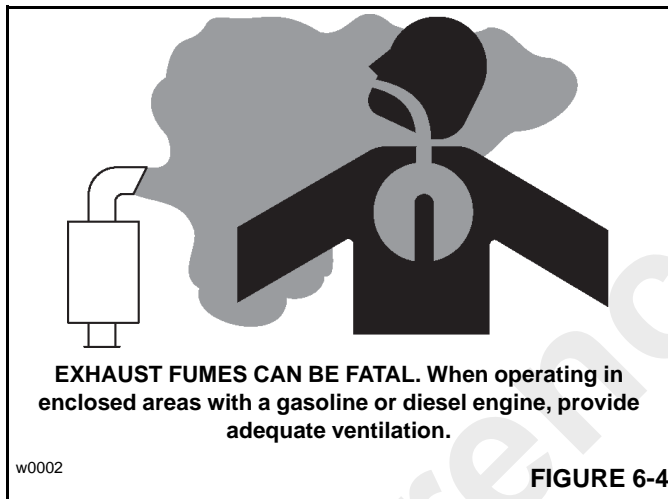
## ENGINE AIR INTAKE SYSTEM

Air for combustion is pulled through an air filter by the engine. Dust and foreign materials are removed from the air by the air filter.

Replace or clean the air filter at the intervals given in Preventative Maintenance, Section 5. Make sure all clamps on the intake tube and filter are tight. If dust or foreign materials enter the engine, permanent damage can be caused to the engine.

**NOTE:** NEVER run the engine without an air cleaner installed.

## ENGINE EXHAUST SYSTEM



Exhaust system components get very hot and can cause severe burns.

The exhaust system is installed under the frame to minimize the transfer of noise and vibration into the operator's compartment.

Annoying rattles and noise vibrations in the exhaust system are usually caused by misalignment of parts. When aligning the system, leave all bolts and nuts loose until all parts are properly aligned, then tighten working from top to bottom.

When installing exhaust parts, make sure there is sufficient clearances between the hot exhaust parts and parts that would be adversely affected by heat.

When installing an exhaust system, allow for expansion when the system is hot.

Periodic maintenance of the exhaust system is not required, However, it is advisable to check the condition of the system when performing other maintenance on the crane.

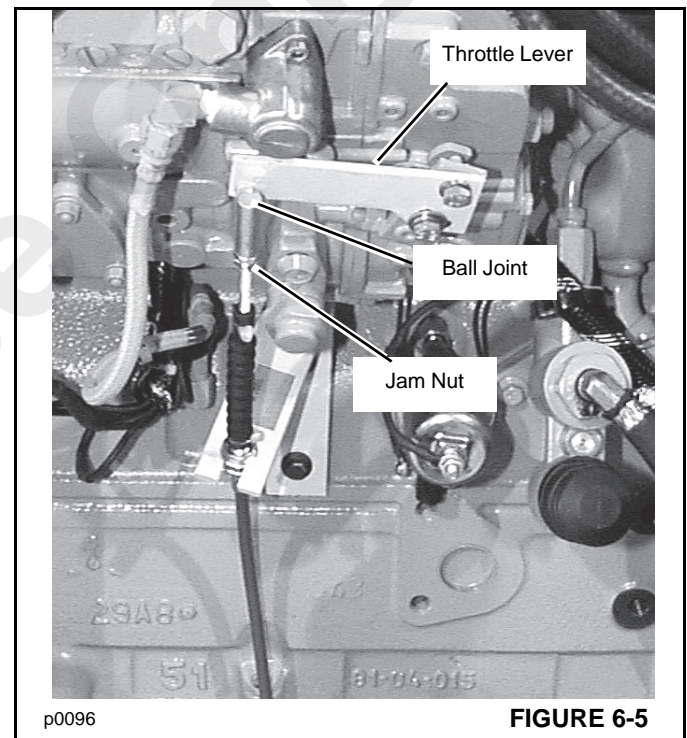
Check the complete exhaust system for broken, damaged, missing or mispositioned parts, open seams, holes, loose connections and other deterioration which could cause exhaust fumes to seep into the operator's compartment. Any damaged areas must be corrected.

## CHECKS AND ADJUSTMENTS

### Throttle Linkage Adjustment

Adjustment of the throttle linkage is made by adjusting the travel distance of the throttle cable.

1. Remove the ball joint Figure 6-5 from the throttle control lever.



2. Loosen the jam nut and turn the ball joint clockwise to increase throttle speed and counterclockwise to decrease throttle speed.
3. Connect the ball joint to the throttle lever and then tighten the jam nut.

**NOTE:** Maximum speed for the engine is 2500 rpm. Main hydraulic pump damage could occur from a higher RPM setting. Never set engine speed higher than 2500 rpm.



Table 6-2: Engine Troubleshooting Chart

Problem	Probable Cause	Action
Engine hard to start or will not start.	<ol style="list-style-type: none"> <li>1. Improper starting procedure.</li> <li>2. No fuel.</li> <li>3. Air in fuel line.</li> <li>4. Crankcase oil too heavy.</li> <li>5. Improper type of fuel.</li> <li>6. Water, dirt or air in fuel system.</li> <li>7. Clogged fuel filter.</li> </ol>	<ol style="list-style-type: none"> <li>1. Review starting procedure in Engine Operator's Manual.</li> <li>2. Check fuel gauge.</li> <li>3. Bleed the fuel line.</li> <li>4. Use oil with proper viscosity.</li> <li>5. User proper fuel for operating conditions.</li> <li>6. Drain, flush, fill and bleed system.</li> <li>7. Replace the filter element.</li> </ol>
Engine runs irregularly or stalls frequently.	<ol style="list-style-type: none"> <li>1. Low coolant temperature.</li> <li>2. Clogged fuel filter.</li> <li>3. Water dirt or air in fuel system.</li> <li>4. Dirty or faulty fuel injection nozzles.</li> <li>5. Clogged air filter.</li> </ol>	<ol style="list-style-type: none"> <li>1. Remove and check thermostat.</li> <li>2. Replace filter element.</li> <li>3. Drain, flush, fill and bleed.</li> <li>4. Have authorized distributor or distributor check the nozzles.</li> <li>5. Replace the filter elements.</li> </ol>
Below normal engine temperature.	<ol style="list-style-type: none"> <li>1. Defective thermostat.</li> <li>2. Defective temperature gauge.</li> </ol>	<ol style="list-style-type: none"> <li>1. Remove and check thermostat.</li> <li>2. Check gauge, sender and all connections.</li> </ol>
Lack of power.	<ol style="list-style-type: none"> <li>1. Engine overload.</li> <li>2. Intake air restriction.</li> <li>3. Clogged fuel filters.</li> <li>4. Overheated engine.</li> <li>5. Below normal engine temperature.</li> <li>6. Faulty engine.</li> </ol>	<ol style="list-style-type: none"> <li>1. Reduce the load.</li> <li>2. Service air cleaner.</li> <li>3. Replace fuel filters.</li> <li>4. Refer to Engine Operator's Manual. Check for plugged radiator/oil cooler fins.</li> <li>5. Remove and check thermostat.</li> <li>6. Refer to Engine Operator's Manual.</li> </ol>
Low oil pressure.	<ol style="list-style-type: none"> <li>1. Low oil level.</li> <li>2. Faulty gauge or sender.</li> <li>3. Improper type of oil.</li> </ol>	<ol style="list-style-type: none"> <li>1. Add oil.</li> <li>2. Check gauge, sender and connections.</li> <li>3. Drain and fill crankcase with proper viscosity and quality.</li> </ol>
Engine overheats	<ol style="list-style-type: none"> <li>1. Engine overloaded.</li> <li>2. Low coolant level.</li> <li>3. Plugged radiator/oil cooler fins.</li> <li>4. Faulty radiator cap.</li> <li>5. Cooling system needs flushing.</li> <li>6. Defective thermostat.</li> <li>7. Defective temperature gauge or sender.</li> </ol>	<ol style="list-style-type: none"> <li>1. Reduce the load.</li> <li>2. Fill radiator to proper level, check radiator and hoses for loose connections or leaks.</li> <li>3. Clean fins.</li> <li>4. Replace radiator cap.</li> <li>5. Flush cooling system.</li> <li>6. Replace thermostat.</li> <li>7. Check and replace.</li> </ol>

## REMOVAL AND INSTALLATION

### Removal



#### WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

1. Raise and support the frame far enough to remove the rear axle assembly.
  2. Remove the engine cover and rear deck cover plate.
  3. Disconnect the ground cable and battery cable from the battery.
  4. Disconnect the frame electrical wire harness from the engine electrical wire harness.
  5. Disconnect the transmission high temperature switch from the frame electrical wire harness.
  6. Disconnect the transmission electrical wire harness from the instrument panel wire harness.
  7. Drain the radiator. Disconnect the upper and lower hoses from the radiator.
  8. Disconnect the transmission cooling lines from the radiator. Put plugs and caps on all lines to keep dirt out of the system.
  9. Disconnect the hot water heater hoses from the engine.
  10. Remove the radiator.
  11. Remove the air cleaner and intake hose(s).
- NOTE:** Have a fire extinguisher handy and know how to use it before performing the next step.
12. Disconnect the fuel lines from the fuel tank. Plug or cap the lines to prevent leakage.
  13. Disconnect the drive shaft(s) from the transmission. See Section 7.
  14. Disconnect the exhaust pipe from the exhaust manifold of the engine.
  15. Drain the hydraulic tank.
  16. Disconnect the hydraulic hoses from the four sections of the hydraulic pump.
  17. Disconnect the suction hose from the hydraulic tank and the hydraulic pump suction manifold.
  18. Disconnect the throttle linkage from the engine.
  19. If equipped, remove the optional cold start kit from the bracket inside the chassis frame.
  20. Disconnect the engine ground cable from the engine or the engine flywheel.
  21. Remove the rear axle.
    - a. Attach a chain to the front engine lifting lug and attach to a hoist. Use the hoist to support the engine while the rear axle is removed.
    - b. Loosen and remove the wheel lug nuts and remove both rear wheels.
    - c. Disconnect and plug the hydraulic hoses at the steering cylinders.
    - d. Disconnect and cap and plug the brake hoses from the axle.
    - e. Support the axle on a trolley jack.
    - f. Remove the front engine mounting hardware.
    - g. With the engine and rear axle both supported, remove the eight bolts and flat washers securing the engine/axle mounting bracket to the chassis.
    - h. Lower and remove the axle clear of the chassis.
  22. Remove the rear engine support mounting bolts, washers, rubber mounts and nuts.
  23. Using a trolley jack, raise the transmission so it can be removed out the rear of the chassis.
  24. Using the hoist, slowly pull the engine and transmission rearward enough to attach a sling around the torque converter housing. At the same time, check that all items are free for engine removal. Attach a pull jack to the sling and hoist.
  25. Slowly raise the engine and check that all lines and components which can possibly cause interference with the engine removal have been removed. Carefully lift the engine and transmission out the rear of the frame at about a 30° angle.
  26. If a new engine is to be installed, remove all parts from the old engine not provided with the new engine and install them on the new engine.

## Installation

1. Attach a hoist to the engine the same way removal was accomplished.
  2. Lift the engine into place over the chassis. Tilt the engine at about a 30° angle to insert the engine into the chassis. Lower the engine into the chassis and set the transmission on a trolley jack. Remove the sling and pull jack.
  3. Move the engine and transmission into the chassis until the rear mounting bolts, washers, rubber mounts and nuts can be installed and tightened.
  4. Install the rear axle.
    - a. Locate the rear axle under its mounting location. Raise the axle and mounting bracket into position and install the eight mounting bolts and flat washers.
    - b. Install the front engine mounting hardware.
    - c. Connect the brake lines to the axle.
    - d. Connect the hydraulic hoses to the steering cylinders.
  5. Connect the suction hose to the hydraulic tank and the hydraulic pump suction manifold.
  6. Connect the hydraulic hoses to the four sections of the hydraulic pump.
  7. Fill the hydraulic tank.
  8. Connect the engine ground cable to the engine.
  9. If equipped, install the cold start kit.
  10. Connect the throttle linkage to the engine.
  11. Connect the exhaust pipe to the engine manifold. If a gasket is used, install a new gasket.
  12. Connect the drive shaft(s) to the engine. See Axles/ Drive Shafts/Wheels and Tires, Section 8.
  13. Connect the fuel lines to the fuel tank.
- NOTE:** The diesel fuel supply fuel line must be bled of air before engine can be started. Refer to the engine operator's manual furnished with this crane, for bleeding procedure.
14. Install the air cleaner and intake hose.
  15. Install the radiator in place on the chassis.
  16. Connect the transmission cooling lines to the radiator. Connect the upper and lower radiator hoses.
  17. Connect the hot water heater hoses to the engine.
  18. Fill the radiator with recommended coolant.
  19. Connect the transmission wire harness to the instrument panel wire harness.
  20. Connect the transmission high temperature switch lead to the switch.
  21. Connect the engine wire harness to the frame wire harness.
  22. Install the engine cover and rear cover plate.
  23. Connect the battery cables to the battery.
  24. Check complete installation to be sure all components are installed and secure.
  25. Fill the engine and transmission with recommended oil.
  26. Start the engine. Continue to add transmission fluid until transmission cooling lines are full. Add fluid as needed to fill the cooling system.
  27. Adjust the throttle control, if necessary.
  28. Steer the rear wheels in both directions several times to remove air from the steering circuit.
  29. Bleed air from brake lines. Refer to Section 9.
  30. Stop the engine and check for leaks. Tighten fittings if necessary.

## SECTION 7 TRANSMISSION AND TORQUE CONVERTER

### SECTION CONTENTS

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### TECHNICAL DATA

#### General Technical Data

Description:

Two-Wheel Drive .....	Full electrohydraulic transmission unit with input, reverse, and mainshaft clutch packs. Torque converter is integral.
Four-Wheel Drive .....	Full electrohydraulic transmission unit with input, reverse, four wheel drive and mainshaft clutch packs. Torque converter is integral.

Designation:

Two-Wheel Drive .....	PS752
Four-Wheel Drive .....	PS754

Weight (dry):

Two-Wheel Drive .....	220 kg (484 lb)
Four-Wheel Drive .....	236 kg (520 lb)

Number of Teeth:

Transfer Gear .....	46
Layshaft .....	16

Gear Ratios:

1st .....	6.58:1
2nd .....	3.71:1
3rd .....	1.77:1
4th .....	1.00:1

Torque Converter Dia. .... 11 in. (279 mm)

Torque Converter at Stall ..... 2.40:1

Torque Converter Color Code Identification:

Color Coded Dots .....	2 Orange
	1 Green

## Minimum Engine RPM at Converter Stall:

2 <sup>nd</sup> Gear . . . . .	2075 rpm
3 <sup>rd</sup> Gear . . . . .	2050 rpm

## Converter IN pressure (neutral) at 50°C (122°F)

1000 rpm . . . . .	2.8 – 4.1 bar (40 – 60 psi)
2000 rpm . . . . .	4.8 – 6.2 bar (70 – 90 psi)

## Converter OUT pressure (neutral) at 50°C (122°F)

1000 rpm . . . . .	1.9 – 2.3 bar (27 – 33 psi)
2000 rpm . . . . .	2.3 - 2.7 bar (33 – 39 psi)

## Converter Inlet Relief Valve Pressure (Max.) . . . . .

6.5 bar (95 psi)

## Converter Inlet Relief Valve Lubrication Pressure (in neutral) at 50°C (122°F)

1000 rpm . . . . .	0.14 - 0.28 bar (2.0 – 4.0 psi)
2000 rpm . . . . .	0.28 – 0.55 bar (4.0 – 8.0 psi)

## Converter Mainline Pressure (in neutral) at 122° F (50° C)

1000 rpm . . . . .	9.0 - 10.0 bar (135 – 145 psi)
2000 rpm . . . . .	9.7 – 11.0 bar (140 – 160 psi)

## Flow Rates (in neutral) at 122° F (50° C)

Cooler (1000 rpm) . . . . .	10.4 – 13.6 bar (2.8 – 3.6 psi)
Cooler (2000 rpm) . . . . .	14.5 – 20.0 bar (3.8 – 5.3 psi)
Pump (1000 rpm) . . . . .	11.0 – 15.0 bar (2.9 – 4.0 psi)
Pump (2000 rpm) . . . . .	22.5 – 29.5 bar (6.0 – 7.8 psi)

The following clutch pressures should be the same as the Mainline Pressure to within 7 bar (10 psi):

- Input Clutch Pressure (high and low ratio)
- Forward Clutch Pressure (high and low ratio)
- Layshaft Clutch Pressure
- Mainshaft Clutch Pressure

**Clutch Solenoid Technical Data**

Type . . . . .	4 way, 3 position, directional control
Operating Flow . . . . .	40 L/min (9.85 gpm)
Operating Pressure . . . . .	10 bar (145 psi)
Leakage (maximum) . . . . .	50 cc/min @ 40° C, 10 bar (14 in./min. @ 104° F, 145 psi)
Fluid Type . . . . .	ATF 210
Fluid Cleanliness . . . . .	ISO 22/17
Waterproof Specification . . . . .	IP 67
Coil Operating Voltage . . . . .	+12 V DC nominal (10.8 to 13.2 V)
Pull-in Voltage . . . . .	+10.5 V (max.) @ 25°C (77°F) air, after energized for 10 minutes at 16 V and off for 10 seconds
Dropout Voltage . . . . .	+1.5 V (min.) at 20°C (68°F) air
Peak Voltage . . . . .	+26 V DC for 5 minutes at 0°C (32°F)
Coil Resistance . . . . .	4.9 ohms ± 5% @ 20°C (68°F)
Operating Temperature Range:	
Air . . . . .	-40°C to +43°C (-40°F to +109°F)
Oil . . . . .	-40°C to +100°C (-40°F to +212°F)
Diode Protection . . . . .	3 amps minimum, 50 ns maximum reverse recovery time

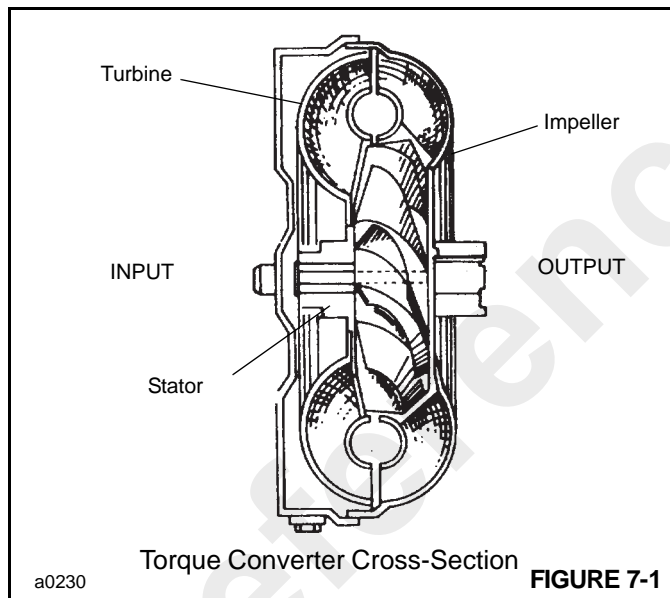
## DESCRIPTION OF OPERATION

### Torque Converter

The torque converter Figure 7-1 is the hydraulic link between the engine and the drive train. There are three main components in the torque converter:

- A turbine
- An impeller (pump)
- A stator and One-Way Clutch

The **impeller** is the pump for the torque converter. This component starts the movement of the oil to the other components. The impeller is connected to the engine flywheel through the torque converter and a drive plate. The impeller rotates at engine speed. Similar to a centrifugal pump, the impeller takes oil at the inner diameter and releases the oil at the outer diameter.



The **turbine** is opposite the impeller and is connected by splines to the input shaft of the Powershift Transmission. The turbine receives oil at the outer diameter and releases the oil to the stator at the inner diameter. The movement of oil from the impeller to the turbine makes a multiplication of torque possible. The torque converter gives maximum torque when the turbine is at zero (0) rpm.

The **stator** is between and at the center of the impeller and turbine. The stator changes the direction of the oil which leaves the turbine so the oil will enter correctly again into the impeller.

The torque converter and transmission have a common hydraulic system. Figure 7-3 shows the arrangement of the system.

### CAUTION

Normal operating temperature is 82° - 88°C (180° - 190°F). High temperatures will cause damage and leakage in the seals and gaskets of the torque converter. Do not continue operation if the temperature increases above 82° - 88°C (180° - 190°F). A warning light on the cab instrument panel will illuminate when the temperature rises above a safe temperature. Put the transmission in "neutral" position and let the engine run at low RPM until the temperature returns to normal and the warning light goes out. If temperature does not return to normal, check for restriction in the lubrication and cooling lines of the torque converter.

### Transmission

The Powershift Transmission is an electro-hydraulic transmission unit. Gear shifting and direction selection are controlled using multi-disc clutch packs.

Electrically operated solenoid valves divert pressurized oil (provided by pump **Q** Figure 7-2) to the selected clutch packs.

A combined lever/swivel switch (travel select lever) on the steering column actuates both gear ratio and direction solenoids.

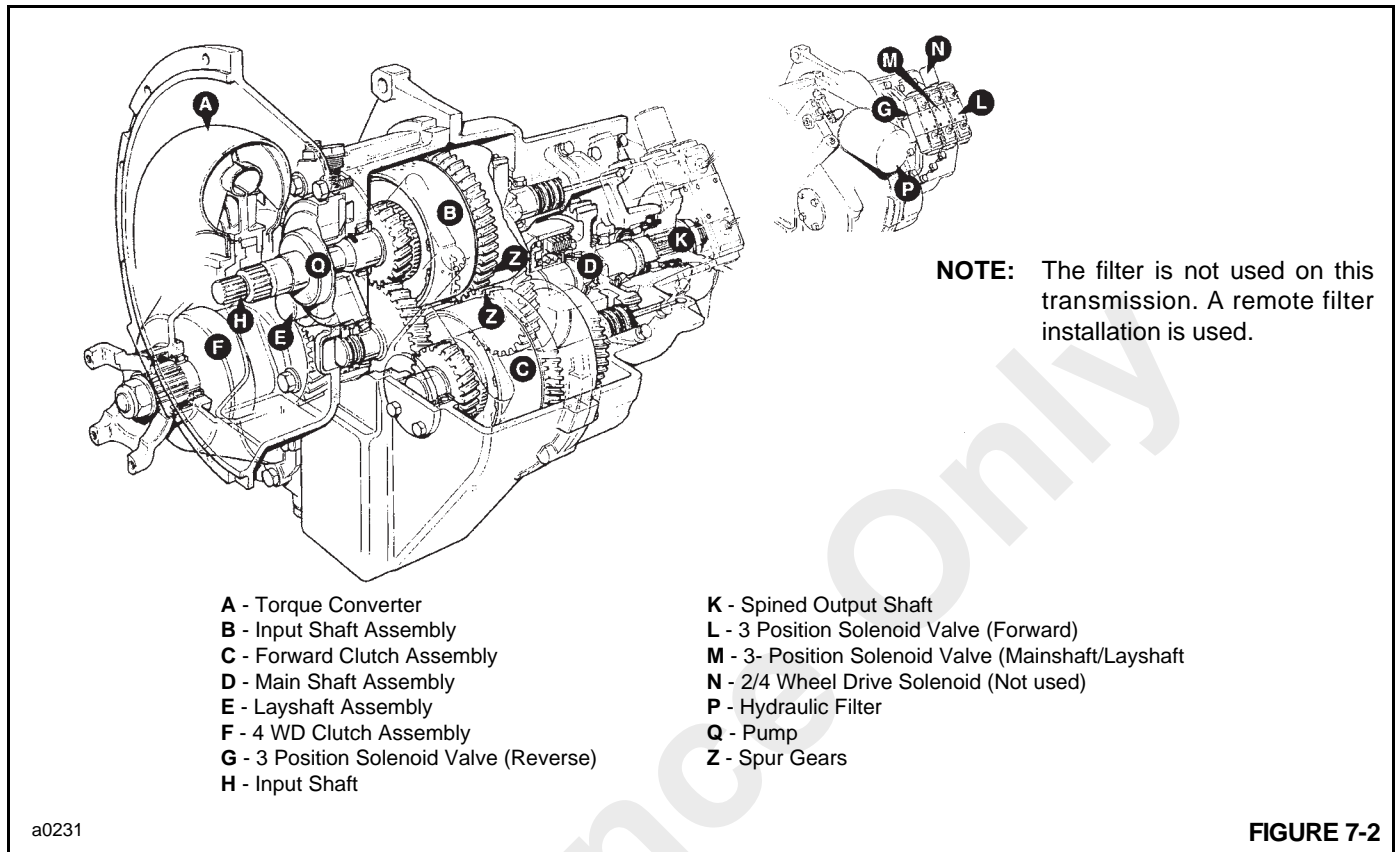
The Powershift transmission consists of a torque converter **A** Figure 7-2, input clutch assembly **B**, forward clutch **C**, layshaft assembly **E**, and a mainshaft assembly **D**.

The torque converter is a fluid coupling bolted to a drive plate which is bolted to the engine flywheel. As the engine crankshaft begins to rotate, the torque converter gives a smooth power takeoff gradually increasing the torque transmitted. This torque is transferred from the torque converter assembly to the clutch/gear assemblies via the input shaft **H**.

The input clutch assembly **B** contains two hydraulically operated clutches; one clutch provides reverse low ratio drive and other a reverse high ratio drive. The three-position solenoid **G**, when energized, directs pressurized oil to either the reverse low or reverse high clutch.

The forward clutch assembly **C** is similar to the input clutch assembly. It contains two hydraulically operated clutches; one clutch provides forward low ratio drive and the other forward high ratio drive. The three-position solenoid valve **L**, when energized, directs pressurized oil either to the forward low or forward high clutch.

Forward drive is transmitted via constant meshing of spur gears **Z**.



Both the mainshaft and the layshaft assemblies have a single clutch each. The three-position solenoid **M**, when energized, directs pressurized oil to either the mainshaft clutch or the layshaft clutch.

The 4 wheel drive unit (used on four-wheel drive cranes) has a single clutch **F**. In normal operation the clutch is spring loaded and therefore engages to give four-wheel drive. The 2/4 wheel drive solenoid **N** is not used on this crane.

### Hydraulic Operation – Two-Wheel Drive

When the Powershift Transmission Figure 7-3 is operated, multi-disc clutch packs are pressurized and engaged. The engaged clutch packs then transfer drive from the engine to the road wheels (via the torque converter **A**, input shaft **H** and the drive shafts).

Different combinations of engaged clutches give four gear ratios in forward and reverse drive. There must always be two clutches engaged before the crane will drive: 1. a direction ratio clutch (i.e., forward low) and 2. a drive clutch (i.e., layshaft or mainshaft).

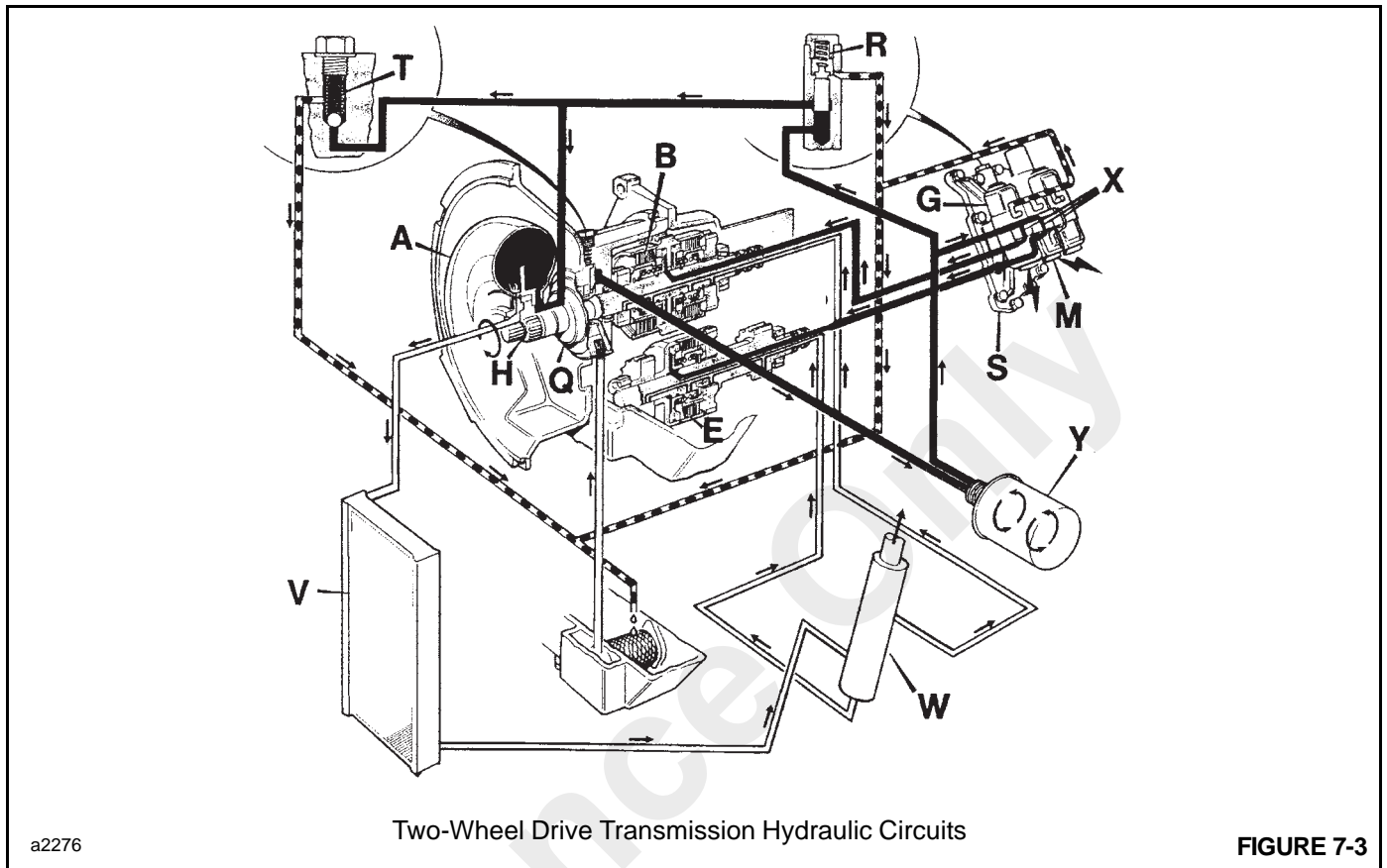
Figure 7-3 shows 1st gear reverse selected, therefore, the two engaged clutches will be reverse low ratio clutch **B** and layshaft drive clutch **E**.

For purpose of this description, clutches not used when 1st gear reverse is selected are not shown.

Oil from the pump **Q** is fed through an internal passage by way of the filter **Y** to pressure the maintaining valve **R**, which maintains a constant pressure to the solenoid valve adapter block **S**.

The solenoid adapter block houses the solenoid valves, which are used to divert oil to the clutch packs.

Excess oil from the maintenance valve flows through the casing to the torque converter. Oil enters the converter between the converter hub and stator support, and leaves between the stator and the input shaft. Pressure in the converter is controlled by relief valve **T** which dumps oil from the converter line back to the sump.



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FIGURE 7-3

Oil from the torque converter flows out of the transmission unit to the external oil cooler **V**. From the cooler, the oil flows to pipe cluster **W** (the pipe cluster is only used on earlier transmissions, on later transmissions oil flow is incorporated within the casing, which distributes the oil to pass through the center of all clutches for lubrication purposes).

In neutral the flow of pressurized oil is blocked at the solenoid valves.

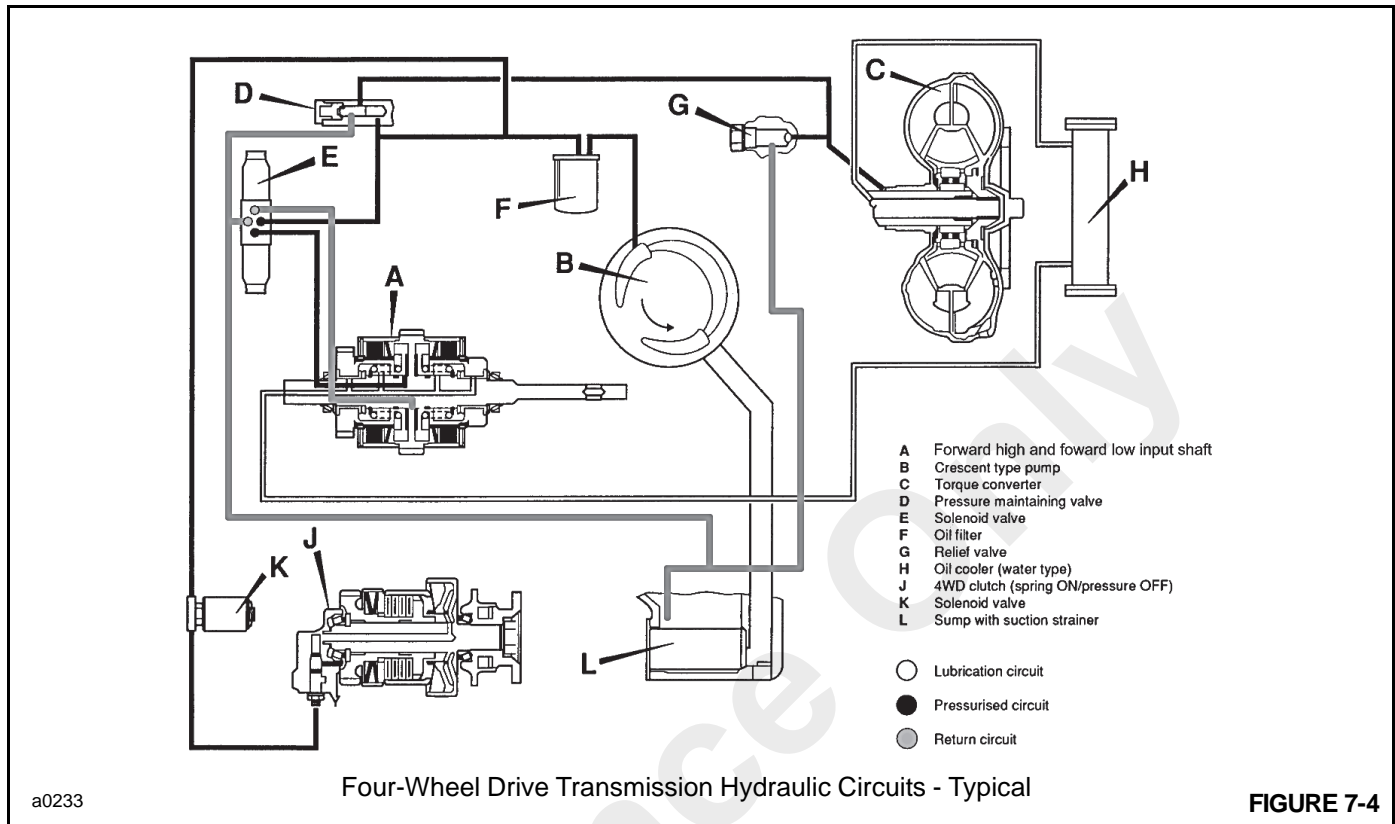
Restrictor orifice **X** in the feed lines to the solenoid valves modulates the pressure to the clutches. This ensures a

smooth clutch engagement. Pressure from the clutches not engaged will vent back to the sump by way of internal passages and the solenoid spools.

When 1st gear forward is selected valves **G** and **M** are energized. The energized valves cause internal spools to move, which then divert pressurized oil to clutch packs **B** and **E** by way of internal passages.

The drive from the engine is then transferred by way of the engaged clutches and gears to the output flange and finally to the road wheels.

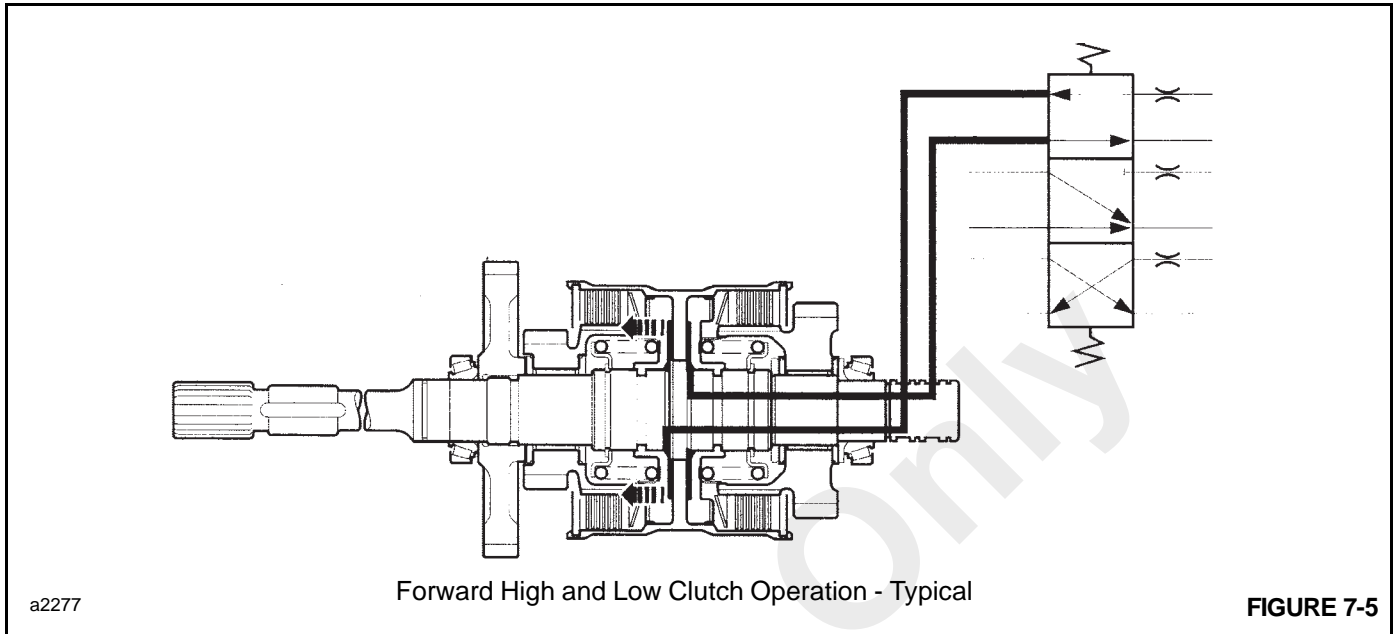




### Hydraulic Operation - Four- Wheel Drive

The solenoid adapter block also houses a solenoid valve **K** for the four-wheel drive clutch Figure 7-5. Oil under pressure is directed to the solenoid where it stopped. The purpose of the solenoid is to change the transmission from four-wheel drive mode to two-wheel drive mode. In four-wheel drive mode the solenoid valve is not actuated and the clutch pack

**J** is spring applied. In two-wheel drive mode the solenoid is actuated and hydraulic oil is directed to the clutch pack releasing the clutch. **Although the solenoid is furnished with the cranes with four-wheel drive, the two-wheel drive option is not available** and the transmission is always in four-wheel drive.



## Clutch Operation

The transmission reverse high and reverse low clutch assemblies (Figure 7-5) are operated by the double solenoid valve.

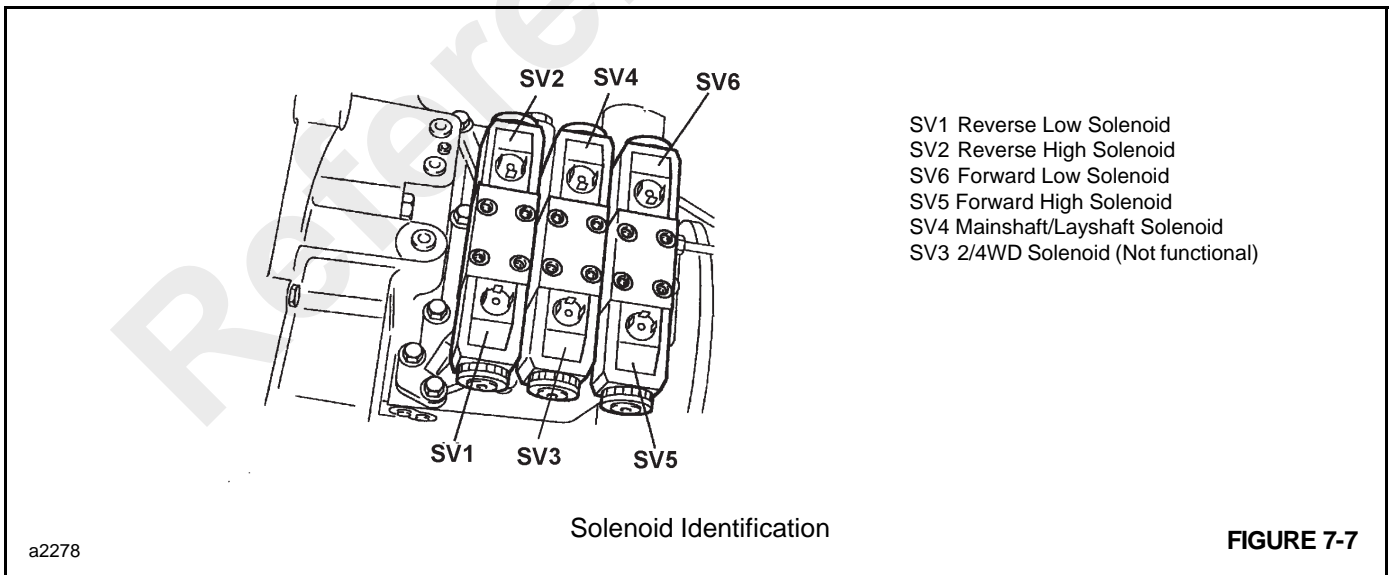
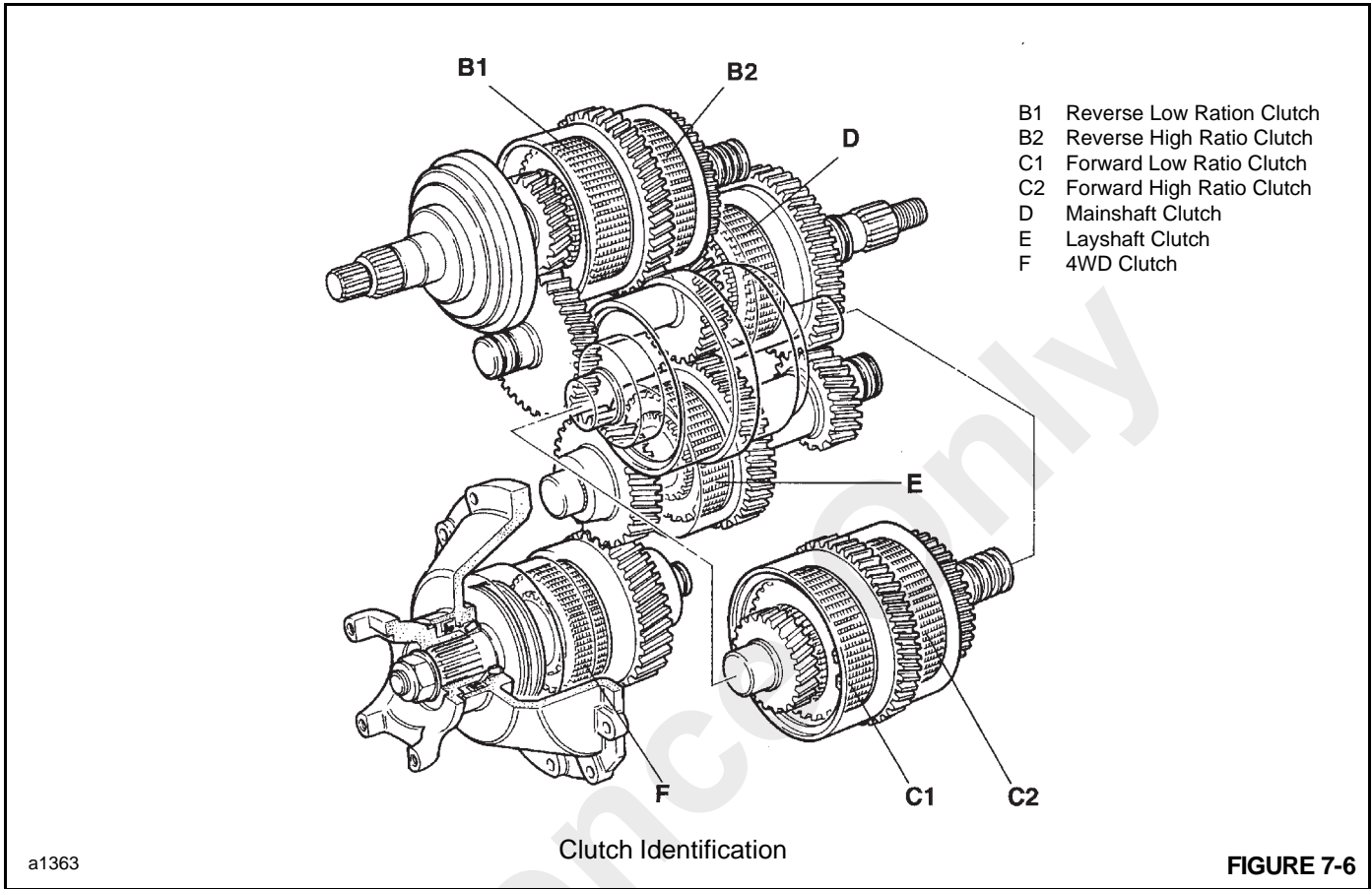
In neutral, the solenoid valve blocks the flow of pressurized oil to the clutches.

When energized, the solenoid valve, depending on which coil is energized, diverts pressurized oil by way of the shaft to the appropriate clutch in the unit. Pressure from the other

clutch is vented to the sump by way of the solenoid valve spool.

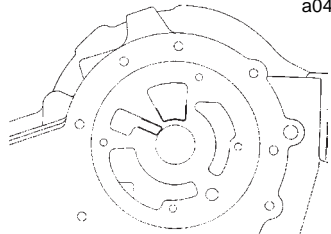
**NOTE:** The forward high and forward low clutch unit operates in a similar manner.

The mainshaft and layshaft assemblies each have a single clutch. The principle of operation similar to the forward/reverse, high/low clutch assemblies i.e., the mainshaft/layshaft solenoid valve diverts oil to either the mainshaft clutch or the layshaft clutch.



Troubleshooting

Problem	Possible Cause	Remedy
Lack of Power.	<ol style="list-style-type: none"> <li>1. Poor engine condition.</li> <li>2. Low oil level.</li> <li>3. Worn pump.</li> <li>4. Torque converter damaged.</li> <li>5. Low mainline pressure.</li> <li>6. Clutches slipping.</li> <li>7. Internal leakage.</li> <li>8. High stall speeds.</li> <li>9. Low stall speeds.</li> <li>10. Overheating.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check and if necessary repair the engine.</li> <li>2. Add oil to transmission.</li> <li>3. Check, repair or replace the pump.</li> <li>4. Check, repair or replace the torque converter.</li> <li>5. See fault "Low Mainline Pressure."</li> <li>6. Check clutch pressures, check clutch piston rings.</li> <li>7. Check internal cored passages and the casting for porosity.</li> <li>8. See fault "High Stall Speeds" (on all clutches).</li> <li>9. See fault "Low Stall Speeds" (on all clutches).</li> <li>10. See fault "Overheating."</li> </ol>
Low Mainline Pressure.	<ol style="list-style-type: none"> <li>1. Worn pump.</li> <li>2. Blocked suction strainer.</li> <li>3. Pressure maintaining valve sticking or leaking.</li> <li>4. Foaming oil.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check, repair or replace the pump.</li> <li>2. Clean suction strainer.</li> <li>3. Free sticking valve or replace valve.</li> <li>4. Internal leakage (cored passages) - inspect transmission.  Dirty suction strainer - clean strainer.  High oil level - drain to proper level.  Incorrect grade of oil - drain and refill with correct oil.</li> </ol>
High Stall Speed (on all clutches).	<ol style="list-style-type: none"> <li>1. Damaged torque converter blades.</li> <li>2. Clutches slipping clutch friction/counter.</li> <li>3. Internal leakage.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check, repair or replace the torque converter.</li> <li>2. Remove, inspect and install new plates.</li> <li>3. Check internal passages and casing for porosity.</li> </ol>
Low Stall Speeds (on all clutches).	<ol style="list-style-type: none"> <li>1. Poor engine condition.</li> <li>2. Torque converter reaction member clutch slipping.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check and repair engine.</li> <li>2. Check and repair the torque converter.</li> </ol>

Problem	Possible Cause	Remedy
Low Converter Out Pressure.	<ol style="list-style-type: none"> <li>1. Low mainline pressure.</li> <li>2. Converter internal leakage.</li> <li>3. Converter relief valve faulty.</li> </ol>	<ol style="list-style-type: none"> <li>1. See fault "Low Mainline Pressure."</li> <li>2. Check and replace the torque converter.</li> <li>3. Check and replace the relief valve.</li> </ol>
Low Pump Flow.	<ol style="list-style-type: none"> <li>1. Low oil level.</li> <li>2. Blocked suction strainer.</li> </ol>	<ol style="list-style-type: none"> <li>1. Add oil to transmission.</li> <li>2. Clean suction strainer.</li> </ol>
High Converter Out Pressure.	<ol style="list-style-type: none"> <li>1. Oil cooler/lines blockage.</li> </ol>	<ol style="list-style-type: none"> <li>1. Clean cooler, remove blockage.</li> </ol>
Low Lubrication Pressure.	<ol style="list-style-type: none"> <li>1. Low mainline pressure.</li> <li>2. Oil cooler/lines blockage.</li> <li>3. Ruptured lubrication lines.</li> <li>4. Converter internal leakage.</li> <li>5. Converter relief valve faulty.</li> </ol>	<ol style="list-style-type: none"> <li>1. See fault "Low Mainline Pressure."</li> <li>2. Clean cooler, remove blockage.</li> <li>3. Repair line.</li> <li>4. Check and replace the torque converter.</li> <li>5. Check, repair or replace the relief valve.</li> </ol>
Overheating.	<ol style="list-style-type: none"> <li>1. Low oil level.</li> <li>2. High oil level.</li> <li>3. Trapped or kinked hoses in cooler system.</li> <li>4. Low converter out pressure relief valve.</li> <li>5. Oil cooler blockage.</li> <li>6. Operating in wrong gear ranges.</li> <li>7. Engine cooling system overheating.</li> <li>8. Foaming oil.</li> <li>9. Clutch pistons sticking on return stroke.</li> <li>10. Passages on front housing pump mounting face are the wrong depth (indicated with an excessively low pressure and flow on the converter out cooling line).</li> <li>11. Leakage across pump mounting face and front case.</li> </ol>	<ol style="list-style-type: none"> <li>1. Add oil to transmission.</li> <li>2. Drain oil to correct level.</li> <li>3. Repair or replace hoses.</li> <li>4. Repair or replace the torque converter and flow rate.</li> <li>5. Clean the oil cooler.</li> <li>6. Select correct gears to suit working conditions.</li> <li>7. Find and repair engine cooling problems.</li> <li>8. See fault "Low Mainline Pressure."</li> <li>9. Check and repair clutch piston(s) and seal(s).</li> <li>10. Replace front housing (or repair existing housing).</li> <li>11. Check for damaged surface on both components and loose pump mounting bolts.</li> </ol> <div style="text-align: right; margin-top: 20px;">  <p style="margin-top: 5px;"><b>FIGURE 7-8</b></p> </div>

**Electrical Troubleshooting**

**System Operation**

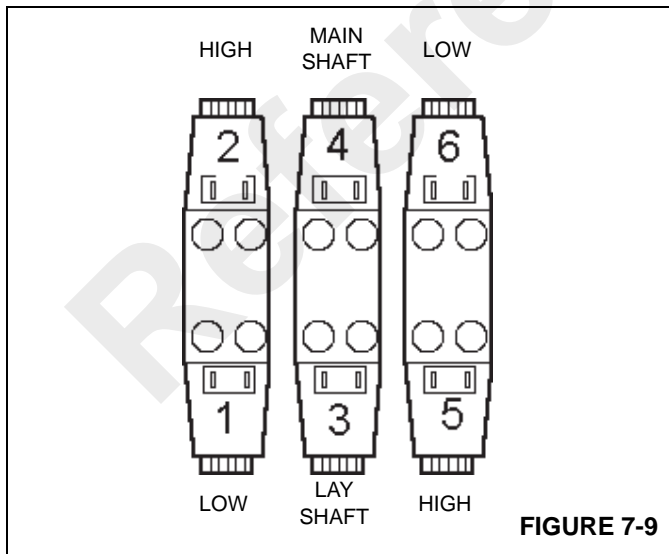
Each powershift transmission is provided with electrical safety locks which inhibit inadvertent operation of the crane while in an unsafe condition.

When the parking brake is ENGAGED the crane is prevented from moving by “dumping” oil in the transmission’s oil system to the internal oil reservoir. No oil is directed to any of the drive mechanisms, thereby inhibiting crane movement. When DISENGAGED the crane will only start when the shift control lever is in the NEUTRAL position.

Change of crane travel direction is accomplished by moving the shift control lever, located on the steering column, from Neutral (center) position up to the FORWARD position or down to the REVERSE position. Change of speed range is accomplished by rotating the shift control handle COUNTERCLOCKWISE to increase the travel speed range or CLOCKWISE to decrease the travel speed range.

Movement of the shift control lever and rotation of the shift control handle energizes combinations of solenoid valves through the ECU, which are connected to two shafts located in the transmission (See Table 7-1).

Transmissions are furnished with six solenoid valves (SV1, SV2, SV3, SV4, SV5 and SV6) See arrangement in Figure 7-9. Two of the solenoid valves control speed ranges while the remaining four control speed and the direction of travel.



The solenoids are controlled by the transmission Electronic Control Unit (ECU) and are connected through the wire harness.

Table 7-1 shows which solenoid valves are energized for the four speeds and two directions of travel.

**Table 7-1: Solenoid Valve Energizing Sequence**

GEAR	DIRECTION	VALVES
First	Forward	SV6 and SV3
Second	Forward	SV5 and SV3
Third	Forward	SV6 and SV4
Fourth	Forward	SV5 and SV4
First	Reverse	SV1 and SV3
Second	Reverse	SV2 and SV3
Third	Reverse	SV1 and SV4
Fourth	Reverse	SV2 and SV4

**Electronic Control Unit (ECU)**

The Electronic Control Unit (ECU) is designed to do two things Figure 7-10:

- To control the selection of gears and direction of travel.
- To protect the gearbox from damage due to incorrect use of the controls.

It is a microprocessor controlled unit which is mounted in the battery compartment. A wire harness connects the ECU to the transmission harness, which connects to the solenoids, the oil pressure switch and a speed sensor, on the transmission. A second harness connects the unit to various switches and selectors in the cab.

The unit receives signals from the gear/direction and other switches in the cab and operates the appropriate transmission solenoids accordingly. Built-in software prevents potentially damaging (and dangerous) selections from being made. The control features provided by the ECU software are listed below:

1. **Downshift Inhibit** - prevents too low of a gear being selected for a given speed.
2. **Kickdown** - operated by a button on the shift lever in the cab - changes down a gear (from 2nd, 3rd or 4th) for a period of 6 seconds before reverting to the selected gear.
3. **Reverse Inhibit** - prevents directional changes if the speed is too high.
4. **Neutral Start** - the machine will only start with the shift control handle in neutral, irrespective of gear selection (speed) position.

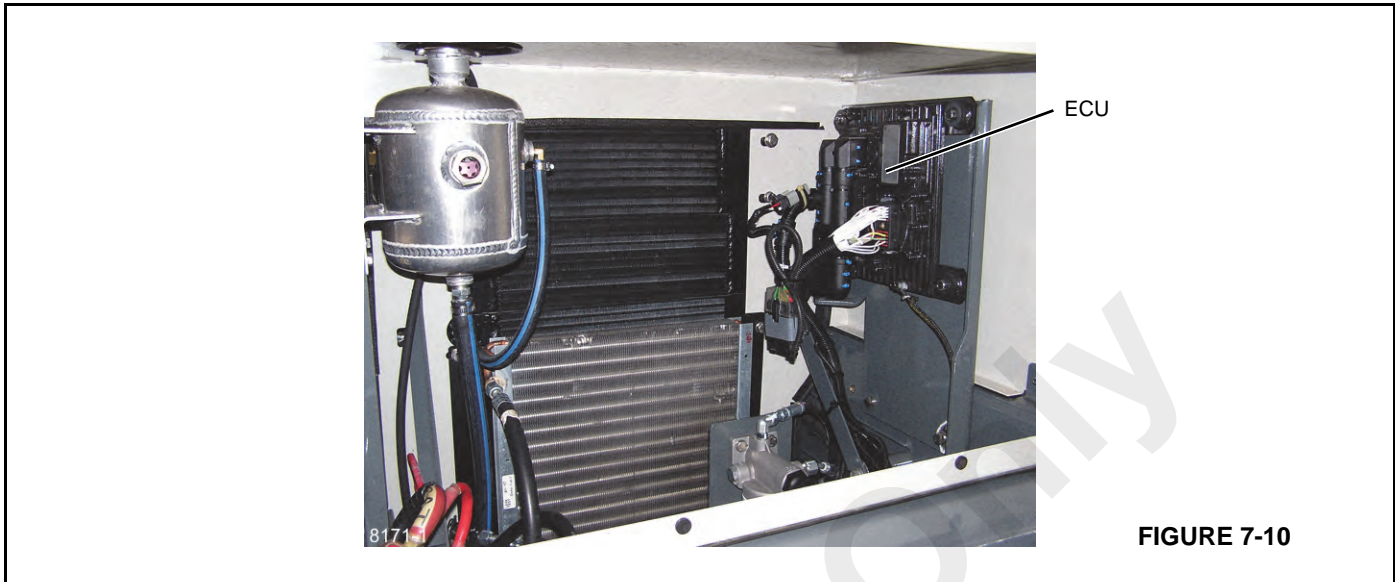


FIGURE 7-10

**Electrical Troubleshooting Chart**

Problem	Possible Cause	Remedy
No drive at engine start up	<ol style="list-style-type: none"> <li>1. Blown ECU fuse.</li> <li>2. ECU connector loose.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check ECU fuse (also check fuse to shift lever).</li> <li>2. Check that connector is mating correctly with ECU.</li> </ol>
No drive and continuous warning buzzer.	<ol style="list-style-type: none"> <li>1. Attempting to select drive with parking brake engaged.</li> </ol>	<ol style="list-style-type: none"> <li>1. Release parking brake.</li> </ol>
No drive.	<ol style="list-style-type: none"> <li>1. Faulty shift control.</li> <li>2. Parking brake sticking.</li> <li>3. Faulty transmission harness.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check control and wiring.</li> <li>2. Check parking brake assembly.</li> <li>3. Check harness continuity and connector.</li> </ol>
Missing gears.	<ol style="list-style-type: none"> <li>1. Faulty solenoid(s).</li> <li>2. Faulty shift control.</li> <li>3. Low oil pressures.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check solenoid(s) and wiring.</li> <li>2. Check control and wiring.</li> <li>3. Check clutch pack and mainline pressures.</li> </ol>
No 4th gear.	<ol style="list-style-type: none"> <li>1. Faulty speed signal.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check speed sensor and wiring.</li> <li>2. Check speed sensor installation (i.e., distance from transfer case).</li> </ol>
Down speed protection does not seem to be working.	<ol style="list-style-type: none"> <li>1. Faulty speed signal.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check speed sensor and wiring.</li> </ol>
Will not downshift and repeating double beep sounded.	<ol style="list-style-type: none"> <li>1. Speed too high for selected downshift.</li> </ol>	<ol style="list-style-type: none"> <li>1. Slow crane with brakes. Deselect downshift.</li> </ol>
Lower gear than lever selected.	<ol style="list-style-type: none"> <li>1. Kickdown engaged.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check kickdown switch and wiring.</li> </ol>
Kickdown will not engage and double beep sounded.	<ol style="list-style-type: none"> <li>1. Speed too high to engage lower gear.</li> </ol>	<ol style="list-style-type: none"> <li>1. Slow crane and try kickdown again.</li> </ol>
Kickdown not operating.	<ol style="list-style-type: none"> <li>1. Faulty kickdown input.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check kickdown switch and wiring.</li> </ol>

Problem	Possible Cause	Remedy
Machine will not perform a reversal of direction and repeating double beep sounded.	1. Speed too high for reversal of direction.	1. Slow crane with brakes. Deselect reversal.
Sporadic gear changes.	1. Moisture in ECU connectors.	1. Check that connector seals are installed and are in good condition.

**Finding Electrical Problems**

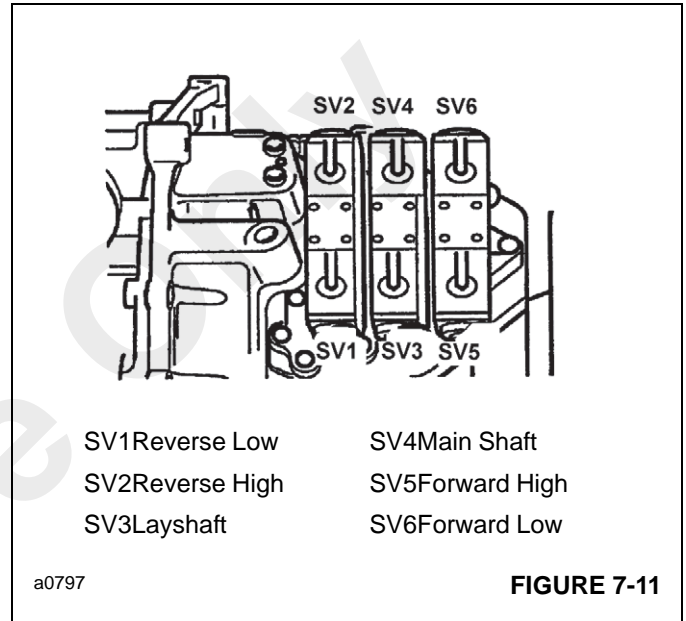
It is possible to carry out a large portion of the ECU diagnostics with basic workshop tools, such as a test lamp and/or voltmeter.

**CAUTION**

Never check for voltage directly across any pins on the ECU. Internal damage can result from shorting pins.

**Checking Solenoid Operation**

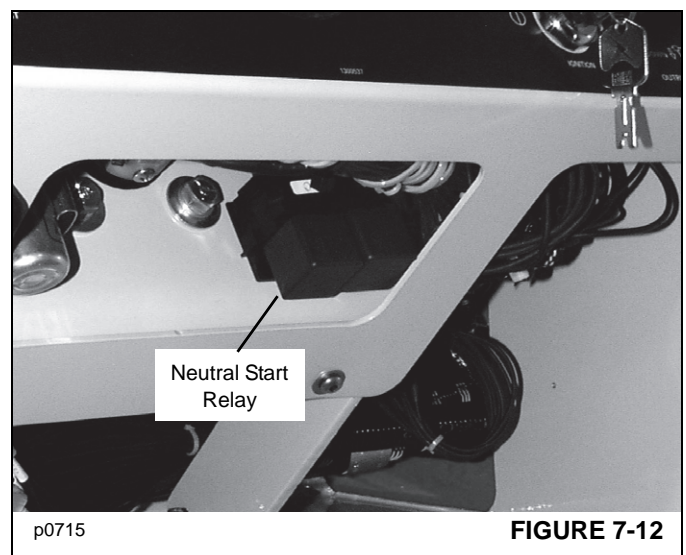
Gear Selection	Solenoids
Forward 1st	Forward Low (SV6) and Layshaft (SV3)
Forward 2nd	Forward High (SV5) and Layshaft (SV3)
Forward 3rd	Forward Low (SV6) and Mainshaft (SV4)
Forward 4th	Forward High (SV5) and Mainshaft (SV4)
Reverse 1st	Reverse Low (SV1) and Layshaft (SV3)
Reverse 2nd	Reverse High (SV2) and Layshaft (SV3)
Reverse 3rd	Reverse Low (SV1) and Mainshaft (SV4)
Reverse 4th	Reverse High (SV2) and Mainshaft (SV4)



**FIGURE 7-11**

The correct operation can be confirmed as follows:

1. Check the wheels.
2. Disable the crane neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located beneath the dash Figure 7-12.



**FIGURE 7-12**



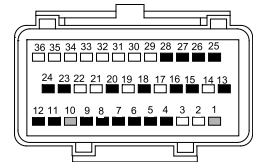
3. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
4. Select the desired gear on the shifter control lever.
5. Identify the two solenoids which give the required gear Figure 7-11.
6. Check the magnetic attraction on the ends of the solenoid using a feeler gauge or small screwdriver.
7. If solenoid(s) are not being energized, check that they are receiving power.
8. If the wrong solenoids are being energized for the gear selection check the wire harness for proper connections.

9. If the solenoids are being energized correctly and the problem persists, the problem may be in the transmission itself or a stuck spool in the solenoid.

If the problem seems to be intermittent (e.g. transmission dropping to neutral), select a gear and place a small washer on the ends of the energized solenoids. The washers will be held in place by the magnetic attraction. Drive the crane around without changing gear or direction. If the problem reappears examine the washers. If one or both of the washers have dropped off, it is a good indication that there is an electrical problem. In this case, examine the wire harness and ECU further. If both washers are still in place the problem lies elsewhere (possibly in the transmission itself).

Table 7-2: Instrument Panel Wire Harness Check

**Key**  
 ✓ Full Battery Charge  
 - No voltage measured with key ON  
 NC Pin not connected



Pin No.	Function	Forward Gears				Reverse Gears			
		F1	F2	F3	F4	R1	R2	R3	R4
1	Jumps To 1	-	-	-	-	-	-	-	-
2	NC								
3	NC								
4	Reverse	-	-	-	-	✓	✓	✓	✓
5	4th Gear	-	-	-	✓	-	-	-	✓
6	Kickdown	-	-	-	-	-	-	-	-
7	2nd Gear	-	✓	-	-	-	✓	-	-
8	Parking Brake	-	-	-	-	-	-	-	-
9	Alarm Buzzer	-	-	-	-	-	-	-	-
10	Jumps to 1	-	-	-	-	-	-	-	-
11	GND	-	-	-	-	-	-	-	-
12	GND	-	-	-	-	-	-	-	-
13	Low Oil Pressure Switch	✓	✓	✓	✓	✓	✓	✓	✓
14	NC								
15	3rd Gear	-	-	✓	✓	-	-	✓	✓
16	Forward	✓	✓	✓	✓	-	-	-	-
17	NC								
18	1st Gear	✓	-	-	-	✓	-	-	-
19	NC								
20	Neutral	-	-	-	-	-	-	-	-
21	NC								
22	NC								
23	+12V	✓	✓	✓	✓	✓	✓	✓	✓
24	+12V	✓	✓	✓	✓	✓	✓	✓	✓
25	GRN Pison	Factory Use Only							
26	RX Pison	Factory Use Only							
27	TX Pison	Factory Use Only							
28	CTS Pison	Factory Use Only							
29	NC								
30	NC								
31	NC								
32	NC								
33	NC								
34	NC								
35	NC								
36	NC								

1. ECU operation - The application of the parking brake de-energizes all solenoids except when in 4th gear (to enable stall testing).
2. ECU Operation - Pressing the kickdown button places the transmission in the next lowest gear, i.e., 4th gear goes to 3rd, 3rd goes to 2nd, 2nd goes to 1st. This lasts until the timer runs out or another gear or direction is selected.

### Checking for (+ V) Supply to Solenoids

1. Check all four tires, or lower all outriggers.
2. Disable the machine neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located beneath the dash Figure 7-12.
3. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
4. Select the desired gear on the shift control lever.
5. Identify the two solenoids which give the required gear Figure 7-11.
6. Remove the electrical connector on the solenoids relating to gear selection.
7. Test across the connector terminals with a test lamp or voltmeter.

When using a voltmeter for the above check, the following results can be seen.

- Energized solenoid (ON) = full battery charge.
- De-energized solenoid (OFF) = reduced voltage (Typically 5 - 9 V).

This reduced voltage should not be interpreted as a problem. When an electrical load is placed across the terminals this voltage drops to zero.

### Checking the Main Frame Harness

**NOTE:** The following checks should be carried out with the parking brake DISENGAGED.

1. Check the four tires, or lower all outriggers.
2. Disable the crane neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located beneath the dash Figure 7-12.
3. Disconnect the main frame wire harness from the ECU. The main frame wire harness connector is the larger of the two ECU connectors.
4. Check the condition of the connector and socket for signs of water entry. Check the condition of the rubber seal in the instrument panel wire harness connector.
5. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
6. Test the voltages on the pins in the harness connector (**DO NOT check the ECU pins**) using a test lamp or voltmeter. Refer to Table 7-2 for pin identification.
7. If the lamp illuminates, or the voltmeter shows full battery charge, where indicated in the table, then the

integrity of the harness and power supply to the ECU is verified.

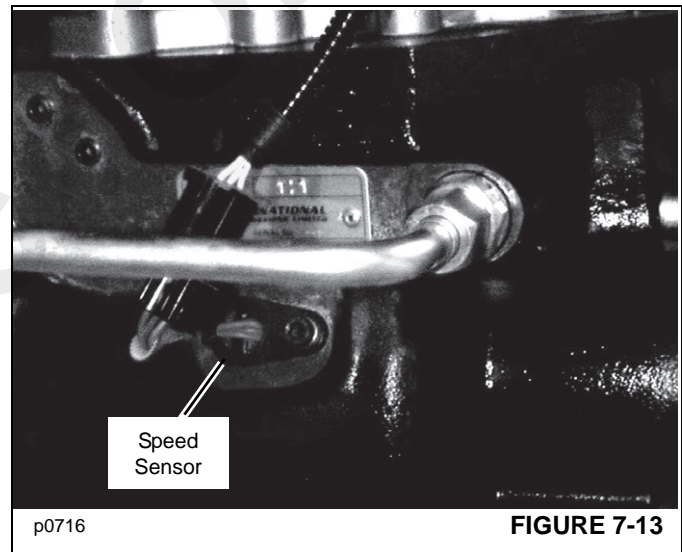
### Checking Parking Brake Switch

The correct operation of the parking brake can be checked using either of the following tests:

1. Check continuity between **pin 8** and ground (**pin 11** or **12**) when parking brake is applied.
2. Connect a test lamp between **pin 23** or **24** and **pin 8**. The lamp will illuminate when the parking brake is applied.

### Checking Sensor Operation

The speed sensor Figure 7-13 detects the speed of rotation of the output shaft for the transfer gear and sends this information to the ECU.



p0716

**FIGURE 7-13**

The ECU requires a speed signal to determine the operating speed of the crane. Some gear selections will not be permitted if the speed signal is too high (i.e. downshifts).

**NOTE:** The ECU is designed to inhibit 4th gear selection if the speed sensor fails to send a signal.

A test lamp should be used to check operation of the speed sensor, as follows:

1. Park the crane on a firm, level ground. Engage the parking brake and set the forward/reverse lever to the neutral position.
2. Turn off the engine and remove the ignition key.
3. Disconnect the speed sensor from the wire harness.
4. Remove the speed sensor from the transmission. Place a suitable container underneath to catch the oil.
5. Check that the sensor is working by connecting a volt/ohm meter to the pins in the speed sensor connector and checking the voltage reading. Connect the positive

(+) meter lead to the pin for the RED wire and the negative (-) meter lead to the pin for the BLUE wire. Move a piece of metal in front of the sensor. When the metal passes the front of the sensor, the meter should be registering 12 VDC. If it does not register 12 VDC, replace the speed sensor.

6. While the sensor is removed, check the sensor for damage.
7. If the sensor is working properly, the problem is most likely in the harness itself. Repair or replace the harness.

### Speed Sensor Depth

The speed sensor depth is not adjustable and is set at time of manufacturing during case machining.

### Tips On Common Problems

#### ECU Mounting

If the ECU mounting capscrews are overtightened the ECU and internal components can be damaged. Hand tighten the capscrews only.

#### Speed Sensors

Generally speed sensors do not fail. Most problems seen are caused by physical damage due to transit, installation or faulty wiring.

Occasionally sensors are out of tolerance or installed incorrectly.

#### Harnesses

By far the most troublesome cause of ECU inoperability are the wire harnesses. The integrity of the electrical connectors and components is paramount to problem free operation.

It has been noticed that water entry into the shift control assembly can occur if the control is damaged (replace the control). This is particularly important on open cab cranes. It is possible that the water can short internal switches providing false signals to the ECU. If water is trapped in the control it can corrode internal switch contacts making them stick on or off.

Moisture or contamination trapped in connectors is a probable cause of many faults.

However effective an electrical connector, it can not be expected to sustain direct steam cleaning using high pressure hoses. It is recommended that operators should make themselves aware of connectors which are vulnerable to a direct jet from a steam cleaner and avoid continued contact.

Poor ground of electrical components can cause problems. Check that the grounding to the ECU, shift control and other switches is sound.

#### No 4th Gear

There are two main causes for this problem:

- The speed sensor is inoperable (Check speed sensor and installation).
- Shift control switch contact or wiring problems.

#### Erratic/Sticking Gears

It is possible that a mechanical issue is the cause of this problem. A known problem is if the transmission has at some point suffered coolant failure and water has entered the transmission. If the original plastic clutch pistons are still being used then there is a risk that they will stick.

TESTING

Solenoid Identification

When testing individual clutch pressures page 7-19, it is necessary to isolate the clutch being tested. For instance, to check the layshaft clutch, you could select 1st gear forward. This would energize the layshaft and forward low clutches. Because we only want to check the layshaft clutch pressure and not the forward low clutch pressure, remove the electrical connector to the forward low clutch BEFORE selecting 1st gear.

Use the tables below to determine which solenoid electrical connectors should be removed when pressure-testing individual clutches. Table 7-3 identifies the solenoid connectors and Table 7-4 and Figure 7-14 identifies which clutches are engaged when the various gears are selected.

**NOTE:** Travel directions as described are the actual travel directions of the crane.

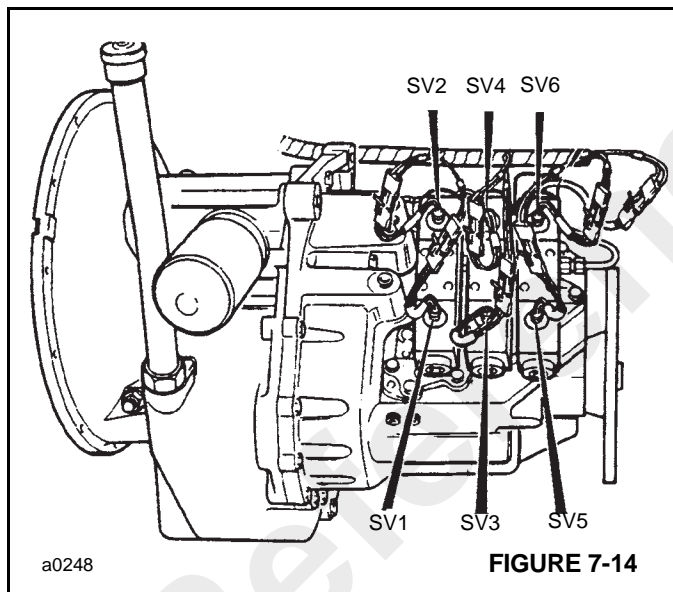


Table 7-4: Solenoid Valve Energizing Sequence

Gear	Direction	Clutches Engaged Solenoids
First	Forward	Forward Low & Layshaft SV6 and SV3
Second	Forward	Forward High & Layshaft SV5 and SV3
Third	Forward	Forward Low & Mainshaft SV6 and SV4 (SV4 only used on six solenoid transmissions)
Fourth	Forward	Forward High & Mainshaft SV5 and SV4 (SV4 only used on six solenoid transmissions)
First	Reverse	Reverse Low & Layshaft SV3 and SV1
Second	Reverse	Reverse High & Layshaft SV3 and SV2
Third	Reverse	Reverse Low & Mainshaft SV4 and SV1
Fourth	Reverse	Reverse High & Mainshaft SV4 and SV2

Test for Clutch Leakage



**WARNING**

**DO NOT** go under the crane with the engine running. Turn off the engine, apply the parking brake, chock the wheels and remove the ignition key before going underneath the crane.

Isolating A Suspect Clutch

Stop the engine, connect a 0-20 bar (0-300 psi) pressure gauge to the test connector A Figure 7-15 (mainline pressure test point).

Make sure that both sides of all four wheels are chocked. Apply the foot brake and the parking brake.

Start the engine and run at 1000 rpm. Engage 1st gear forward. Record the pressure reading. Repeat the test for all rear ratios in forward drive and record the pressure readings as shown below.

Table 7-3: Solenoid Descriptions

Item	Solenoid Description
SV1	Reverse Low
SV2	Reverse High
SV3	Layshaft
SV4	Mainshaft
SV5	Forward High
SV6	Forward Low

Example Only:

Gear Selected	Ratio Clutch	Mainshaft or Layshaft Clutch	PSI	Bar
First	Forward Low	Layshaft	140	9.62
Second	Forward High	Layshaft	125	8.62
Third	Forward Low	Mainshaft	140	9.65
Fourth	Forward High	Mainshaft	125	8.62

Readings should not vary between clutches by more than 0.7 bar (10 psi). In the example shown, we can see that pressure is low when 2nd and 4th gear forward is selected, indicating clutch leakage.

From the example you can see that the forward clutch high is used for selection of both 2nd and 4th gear forward. We know from the table that the mainshaft and layshaft clutches are working normally (1st and 3rd gear selection shown normal operating pressures). So it can be assumed that the forward high clutch is leaking.

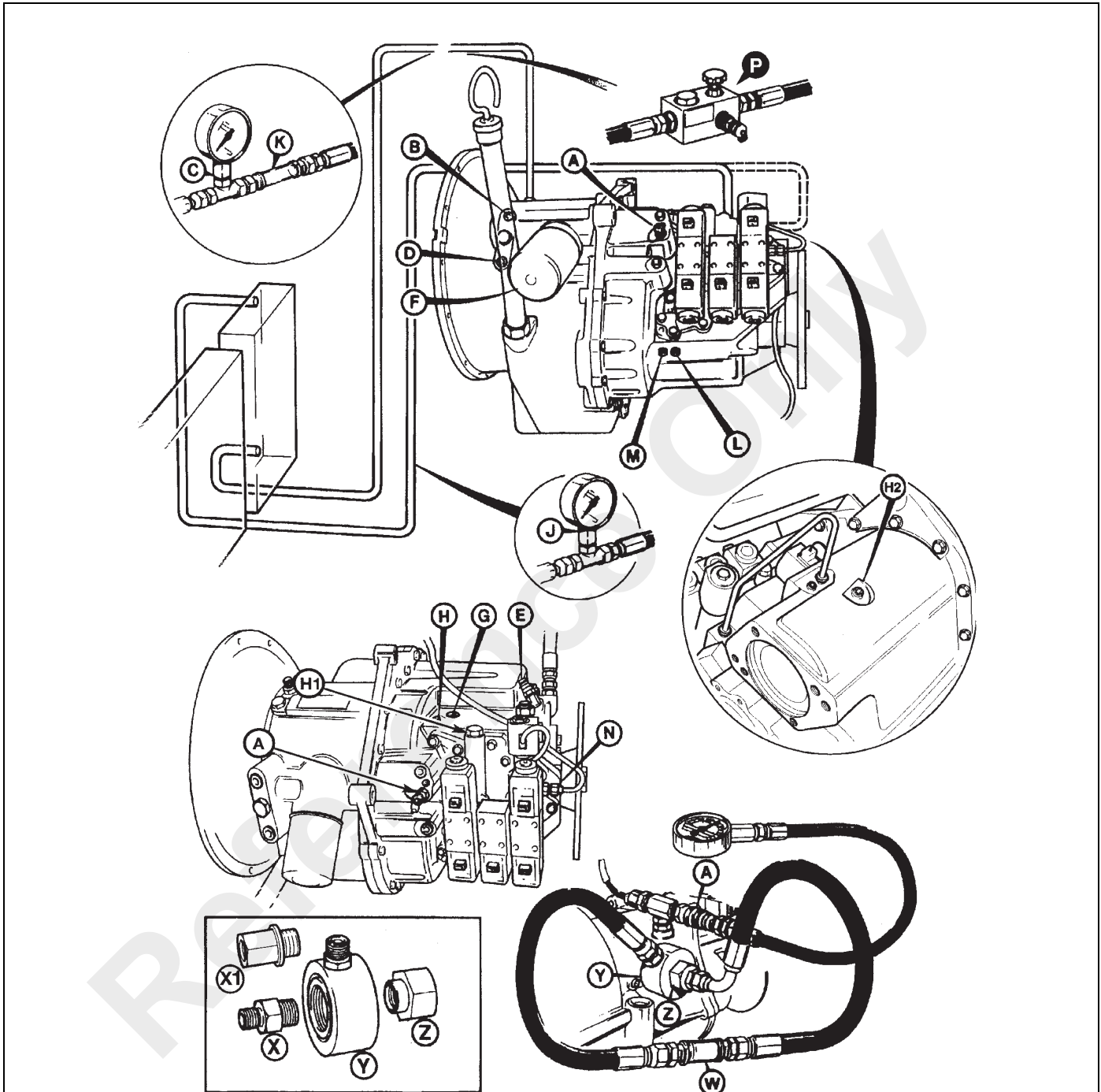
We can now confirm the forward reverse clutch is leaking by completing an "Individual Clutch Leakage Test."

**NOTE:** Repeat the above procedure using reverse ratios if necessary.

**Individual Clutch Leakage Test**

In the following procedures the forward high clutch is tested, therefore, in Step 2 a pressure gauge is connected to the forward high clutch test point.

Reference Only



TEST POINTS

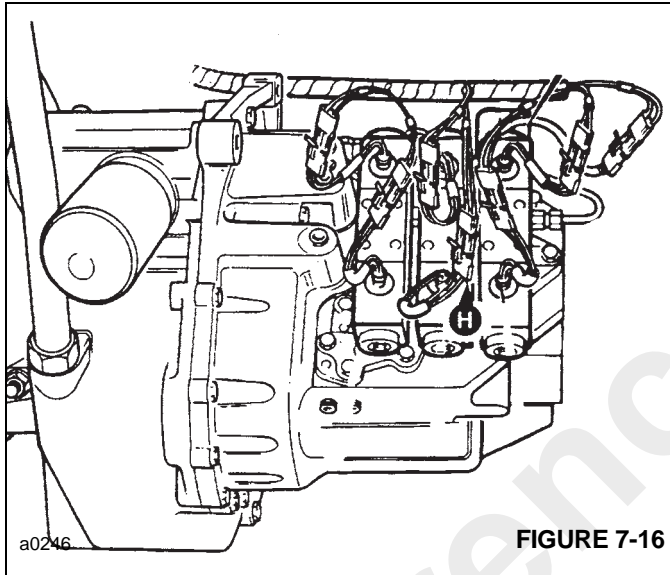
- |   |   |
|---|---|
| A - Mainline Pressure                               | J - Lubrication Pressure  |
| B - Converter inlet/converter relief valve pressure | K - Cooler flow (flowmeter in line from cooler to transmission) |
| C - Converter outlet pressure                       | L - Forward high ratio clutch pressure                          |
| D - Mainshaft clutch pressure                       | M - Forward low ratio clutch pressure                           |
| E - Layshaft clutch pressure                        | N - 5- wheel drive clutch pressure                              |
| F - Pump flow (remove filter and fit adapters)      | P - Load valve  |
| G - Reverse high ratio clutch pressure              |   |
| H - Reverse low ratio clutch pressure               |   |

a2279

FIGURE 7-15

When testing other suspect clutches, connect a gauge to the relevant suspect clutch pressure test point. See Figure 7-15 for position of individual clutch pressure test points. Because the forward high clutch is suspect, a gear must be selected that will use the forward high clutch, in this instance 2nd gear forward.

1. Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to test connector **A**, Figure 7-15 (mainline pressure test point).
2. Connect a 0-20 bar (0-300 psi) pressure gauge to test connector **L** (forward high ratio clutch test point).



**FIGURE 7-16**

3. Remove the layshaft clutch solenoid feed connector **H**, Figure 7-16. This ensures only the forward high clutch is energized when 2nd gear forward is selected.

**NOTE:** See Figure 7-15 for identification and position of solenoid feed connectors when testing other suspect clutches.

4. Make sure that both sides of all four wheels are chocked. Apply foot brake and parking brake.
5. Start the engine and run at 1000 rpm, select 2nd gear forward. Note the pressure readings on both gauges, which should not vary more than 0.7 bar (10 psi). If the difference on the gauges is greater than 0.7 bar (10 psi) do the following:
  - a. Stop the engine and interchange the gauges.
  - b. Start the engine and run at 1000 rpm. Select 2nd gear forward. If the difference on the gauges is still greater than 0.7 bar (10 psi), service the forward high clutch.

- c. If after interchanging the gauges, the readings are different than in step 4, have the gauges calibrated and repeat the test procedure.

### Converter Stall Test

**NOTE:** Engine speed must be recorded during this test. This machine is not equipped with a tachometer. One must be installed to perform this test.

### CAUTION

**DO NOT** stall the converter longer than 10 seconds or the transmission fluid will overheat. Make sure that the oil level is correct and at normal operating temperature.

Before completing the following test, remove the transmission dipstick. If there is any sign of smoke emitting from the dipstick tube, **STOP THE TEST IMMEDIATELY** and service the transmission.

1. Ensure that the engine and transmission are at normal working temperatures. Run the engine at maximum speed and check the **No Load Speed (High Idle Specs)**. See Engine Technical Data in the engine operator's manual.
2. Apply the parking brake and the foot brake firmly. If necessary, set the machine against a fixed obstruction.
3. Select 2nd gear forward and run engine at maximum rpm. Record the engine speed from the tachometer. Repeat the test for 3rd gear forward and record the speed reading.
4. Repeat step 3, except this time select 2nd gear reverse and 3rd gear reverse respectively. Record the speed readings.

**NOTE:** Using 2nd and 3rd gears in forward and reverse will ensure that all clutches are energized during the test.

5. All recorded readings should be as specified in Torque Converter Stall in technical data.

If the engine speed is below the stated figures, either the engine is losing power and should be serviced/overhauled or the torque converter reaction member clutch is slipping.

To check the engine, select Neutral, open the throttle fully, and raise the booms fully to bring the main relief over relief. The engine speed should fall slightly above the Maximum Governed Speed. If engine speed is correct, the torque converter reaction member is slipping.

If engine speed is higher than the Maximum Governed Speed, check the transmission for clutch slippage or internal leakage. To isolate a suspected clutch, tabulate the recorded readings as shown in the example below.



Gear Selected	Direction Clutch	Mainshaft or Layshaft Clutch	RPM
Second	Forward High	Layshaft	2060
Third	Forward Low	Mainshaft	1990
Second	Reverse High	Layshaft	1985
Third	Reverse Low	Mainshaft	1980

In the example shown, the engine speed is abnormally high when 2nd gear forward is selected, indicating a slipping clutch.

From the example, it is evident that the layshaft clutch is working normally (2nd gear reverse indicates 1985 rpm). Therefore, it follows that the suspect clutch is the forward high. Assuming all other possible faults have been eliminated (see Troubleshooting), this clutch should be serviced.

## Pressure and Flow Tests



### WARNING

Fine jets of hydraulic oil at high pressure can penetrate the skin. Do not use your hand to check for hydraulic leaks. Do not put your face close to suspected leaks. Hold a piece of cardboard close to suspected leaks and inspect the cardboard for signs of hydraulic oil. If hydraulic oil penetrates your skin, get medical help immediately.

If the machine to be raised has a 4WD transmission installed, make sure all four wheels are off the ground. If only the front or rear tires are raised, the crane could still drive through the wheels on the ground.

Take care when disconnecting hydraulic hoses and fittings. The oil will be hot and could cause burns.

**DO NOT** go under the crane with the engine running. Turn the engine off, apply the parking brake and remove the ignition key before going underneath the crane.

Before completing any transmission pressure/flow tests, make sure that the oil level is correct and is at normal operating temperature.

### Pump Flow

**NOTE:** Special adapters are required to perform the following test. Contact Manitowoc Crane Care.

Stop the engine. Remove the filter adapter from the transmission. Install a special test adapter **X** or **X1** (depending on the filter head adapter) onto the threaded spigot Figure 7-15. Install special test adapter **Y** and secure with adapter **Z**. Connect flowmeter **W**.

Start the engine and run at 1000 rpm. With the transmission in neutral, the flowmeter will show the pump flow. Compare this reading with the pump flow specification on page 7-2. A low reading indicates a worn pump or blocked suction strainer.

Repeat the test and note the gauge reading with the engine running at 2000 rpm.

Stop the engine and remove all test adapters. Install the filter or the adapter.

### Mainline Pressure

Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to the test connector **A** Figure 7-15.

Start the engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will show the mainline pressure. Compare this pressure reading with the one listed on page 7-2. Either a faulty pressure maintenance valve or a worn pump can cause a low reading. A high reading may indicate a faulty pressure maintenance valve.

Repeat the test and note gauge reading with engine running at 2000 rpm.

Stop the engine and remove the test gauge.

### Converter Out Pressure/Oil Cooler Flow Rate

Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge and flowmeter into the converter out line as shown at **C** and **K** respectively Figure 7-15.

Run the engine at 1000 rpm with the transmission in neutral. The pressure gauge indicates the converter out pressure and the flowmeter indicates the oil cooler flow rate. Compare both readings with the specifications on page 7-2. A blocked oil cooler could cause a high pressure together with a low flow.

Repeat step 2 and note the gauge reading with engine running at 2000 rpm.

Stop the engine, remove the test gauge and flowmeter and install hoses to original position.

### Converter In Pressure

1. Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to test point **B** Figure 7-15.
2. Start the engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will show "Converter In Pressure". Compare the gauge reading with the figures listed in the General Technical Data on

page 7-1. A high or low reading could indicate a faulty converter relief valve.

3. Remove the pressure test gauge.

#### Converter Relief (Safety) Valve Pressure

1. Connect a 0-20 bar (0-300 psi) pressure gauge to test point **B** Figure 7-15.
2. Install a load valve **P** into the converter out line.

**NOTE:** Make sure the load valve is in the OPEN position (the adjusting knob screwed fully out) before starting the following pressure test. If the load valve is not fully open, damage to the converter seals will occur.



#### CAUTION

DO NOT allow the pressure to exceed 10.34 bar (150 psi) or damage to the converter seals will occur.

---

3. Start the engine and run at 1000 rpm. With the transmission in neutral, slowly screw down the load

valve **P** while observing the gauge reading which should rise to the converter relief valve setting specified on page 7-1.

4. If the reading is higher than specified the converter relief valve is faulty. A low reading indicates a leaking pump seal or faulty converter relief valve.
5. Stop the engine and remove the test gauges and install hoses to original position.

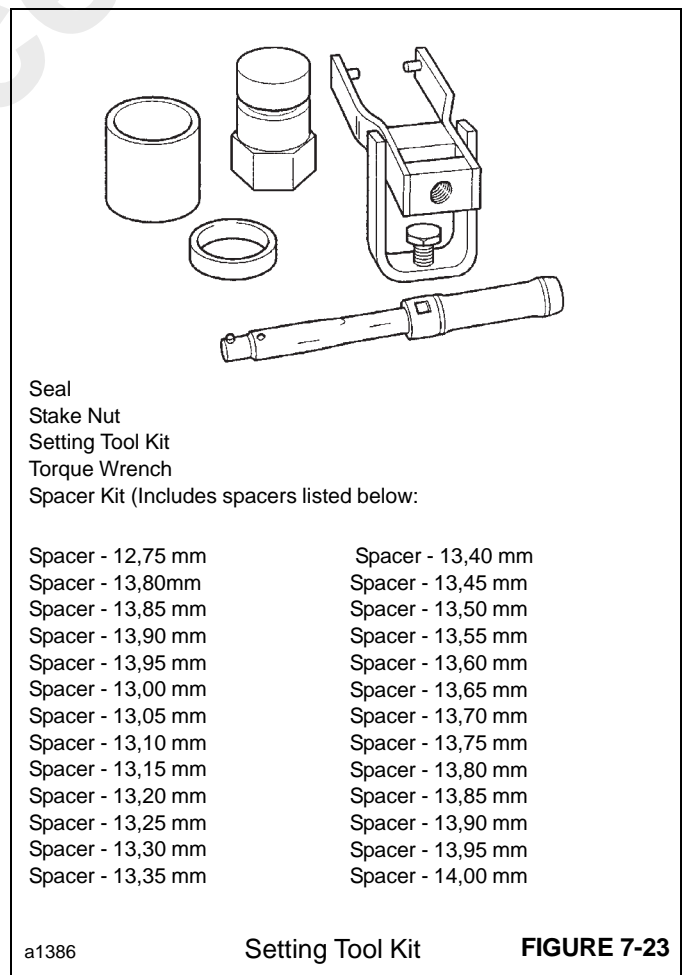
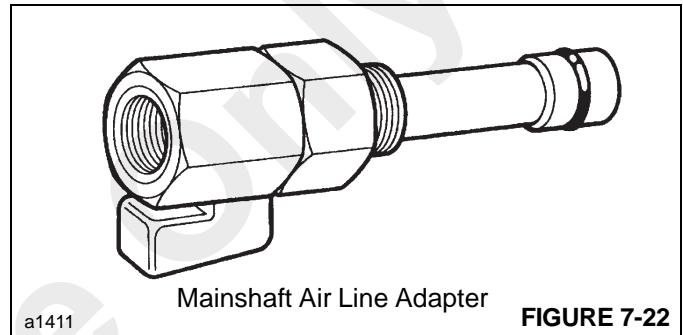
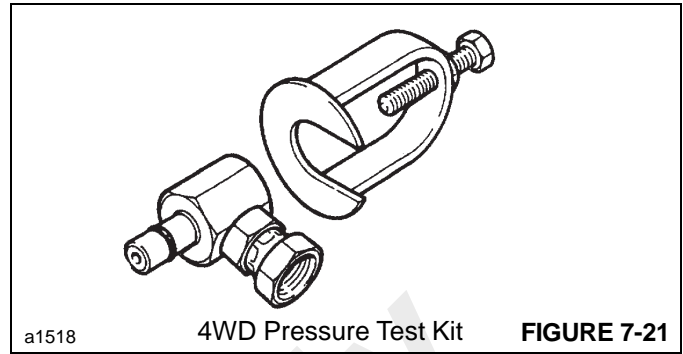
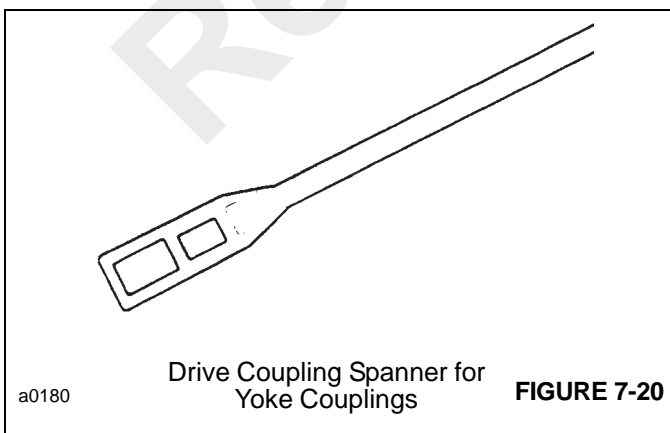
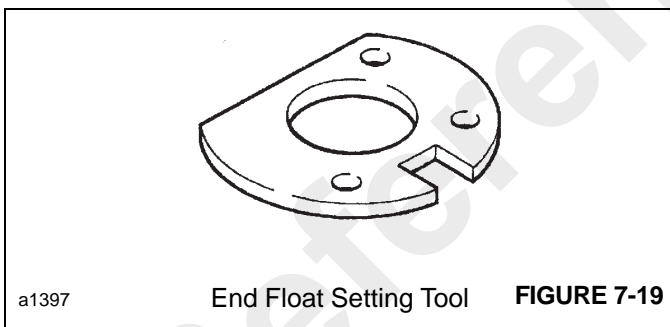
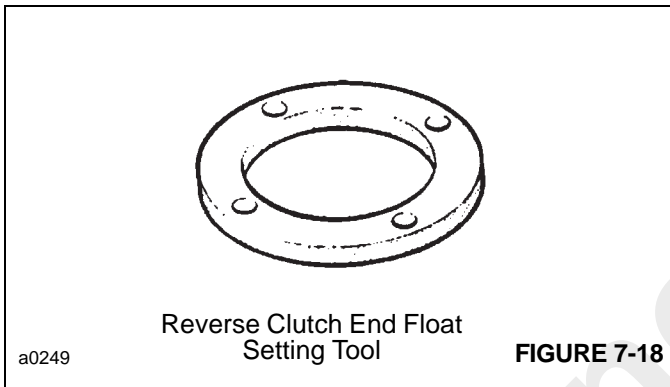
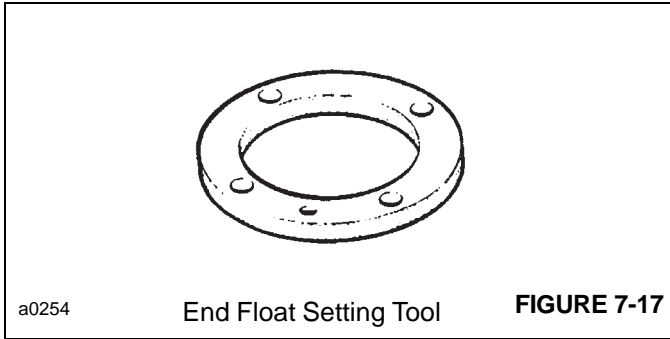
#### Lubricating Pressure

1. Stop the engine and connect a suitable pressure gauge into the return line from the oil cooler to the transmission as shown in **J** Figure 7-15.
2. Start the engine and run at 1000 rpm. With the transmission in neutral, the pressure gauge will indicate the lubricating pressure. Compare the pressure reading with the specification on page 7-1.
3. Repeat step 2 and note the pressure with the engine running at 2000 rpm.
4. Stop the engine and remove the pressure gauge.

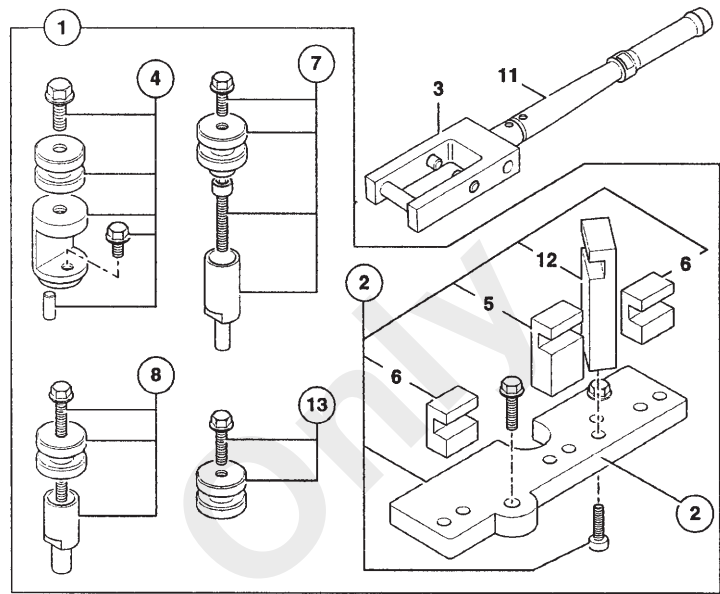
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TRANSMISSION REPAIR

Special Service Tools



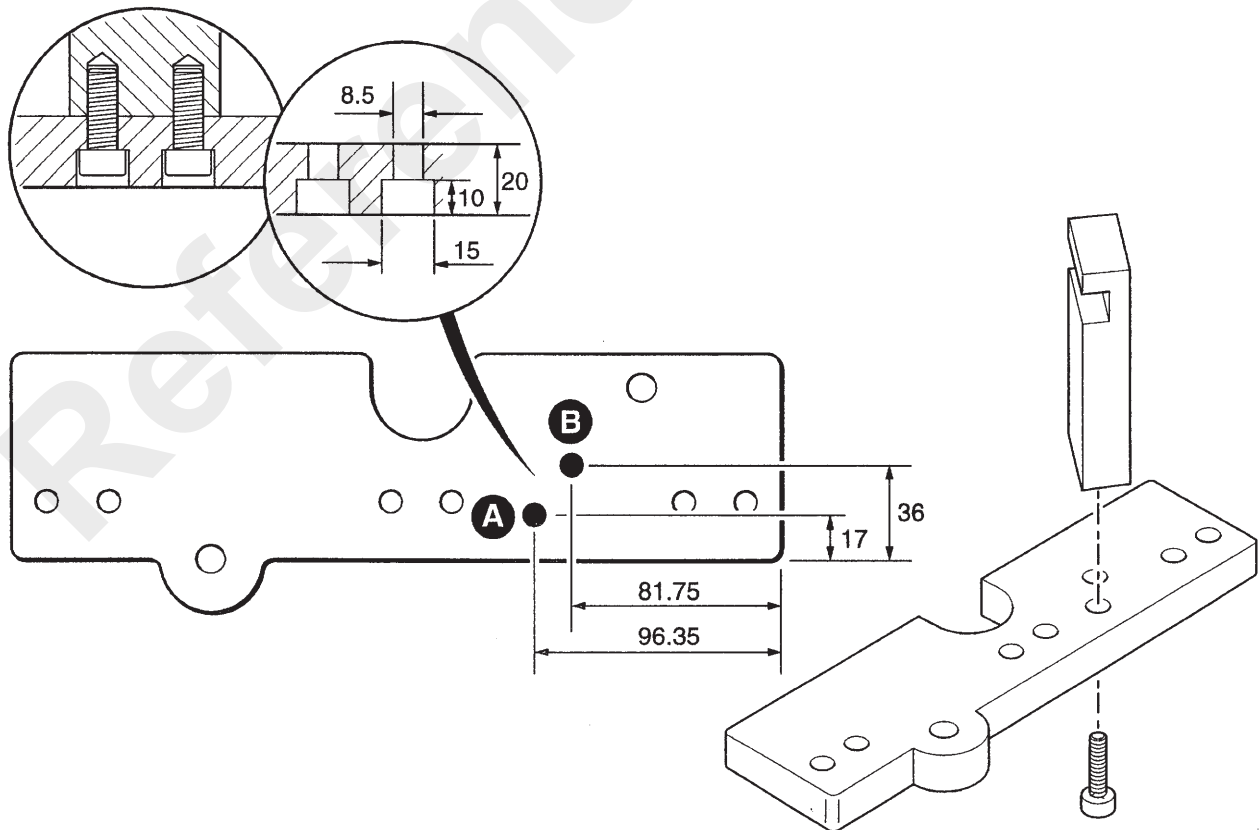
- 1. End Play Checking Kit (Includes Items 2 - 13)
- 2. Base Plate and Bolts
- 3. Yoke
- 4. Mainshaft Adapter
- 5. Pillar (20,75 mm)
- 6. Pillar (45,75 mm)
- 7. Setting Body (54 mm)
- 8. Setting Body (64 mm)
- 9. Setting Tool (12 mm)
- 10. Setting Tool (10 mm)
- 11. Setting Wrench - 0 - 74 lb-ft. (0-100 Nm)
- 12\* Pillar, Input Shaft
- 13\* Setting Body



Torque Converter Removal/Installation

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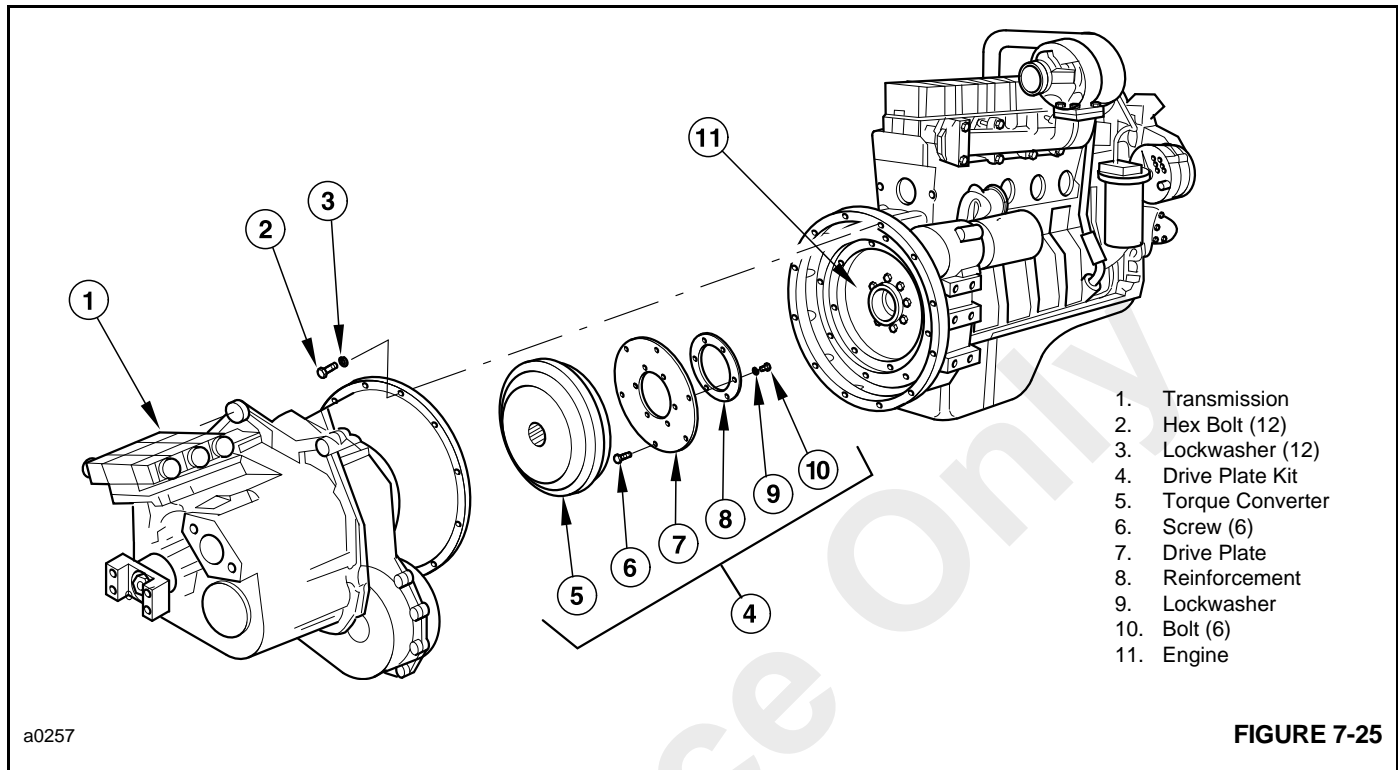
\* If these items are not in your kit, they may be ordered separately, but base plate 2 will have to be drilled to secure item 12, see A and B. Dimensions in mm.



End Play Checking Kit

FIGURE 7-24

a1399



## Servicing the Torque Converter

### Removal

1. Remove complete power unit. See Section 6.
2. Fasten engine to an engine stand.
3. Use a hoist and chains to support the weight of the transmission, which must be removed to gain access to the torque converter.



### CAUTION

The transmission is very heavy and could cause personal injury if not supported properly when it is removed.

4. Remove the 12 bolts **2** Figure 7-25 and lockwashers **3** that fasten the transmission/torque converter housing **1** to the engine flywheel housing **11**. Remove the transmission and torque converter assembly **4** and place in a clean, work area where the torque converter can be removed. It is recommended that the transmission be mounted in the service fixture.
5. The torque converter assembly **4** is fastened to the engine flywheel **11** through a drive plate **7**. Remove the

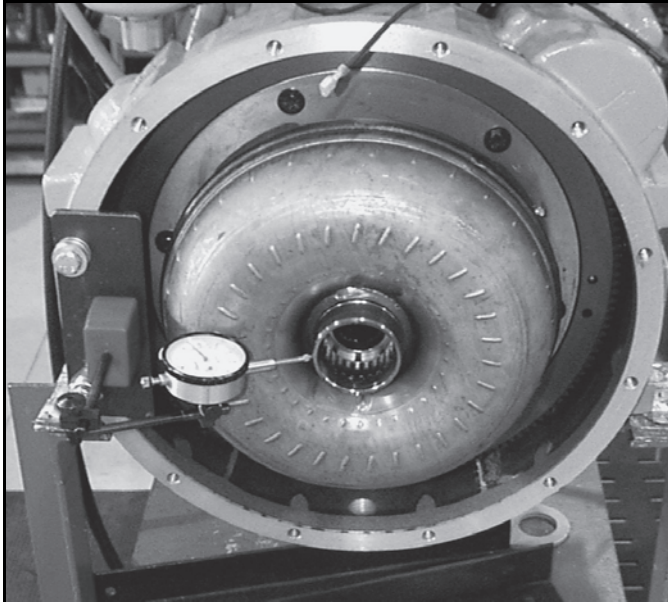
six drive plate mounting screws **6** to remove the torque converter and drive plate.

6. Remove the six bolts **10** and lockwashers **9** securing torque converter **5** to drive plate **7** and remove the drive plate and its reinforcement **8**.
7. Replace the complete torque converter. The parts are not serviced separately. Replace drive plate if there is distortion or damage.

**NOTE:** It is recommended that the torque converter be replaced any time system contamination occurs. It is not possible to completely clean the torque converter by flushing to remove the contamination. Replacement of the complete assembly is necessary to prevent early failure of other components in the system.

### Installation

1. Assemble the drive plate **7** Figure 7-25 and reinforcing plate **8** to the torque converter **5** using bolts **10** and lockwashers **9**. Apply Loctite® 243 to threads of bolts **10** and tighten to a torque of 40 Nm (30 lb-ft).
2. Clean the pilot bore of the engine flywheel.



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Checking Centering

FIGURE 7-26

dial indicator held in position against the converter hub Figure 7-26. The torque converter must be centered on the flywheel within 0.15 mm (0.006 in).

**NOTE:** If the alignment should exceed 0.15 mm (0.006 in), remove the torque converter and check the spline shaft for burrs, remove the drive shaft and rotate it 180° on the torque converter and repeat step 3.

4. Apply Loctite® 243 to drive plate mounting bolts **6** and tighten to a torque of 19 Nm (14 lb-ft).
  5. Clean and lubricate the splines of the transmission input shaft.
  6. Align the transmission input shaft splines with the splines of the torque converter impeller and assemble the transmission/torque converter housing to engine flywheel housing. Install the 12 bolts and lockwashers and tighten to proper torque of 39 Nm (28 lb-ft).
  7. Install the power unit into the crane.
  8. Connect all removed hydraulic lines, electrical harnesses, cables, etc. Fill the transmission with recommended transmission fluid. Refer to Section 5, Preventive Maintenance.
3. Install the torque converter and drive plate assembly **4** to the engine flywheel using six bolts **6**. Check the alignment of the torque converter to the flywheel using a

Reference Only

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## SECTION 8 AXLES/DRIVE SHAFTS/WHEELS AND TIRES

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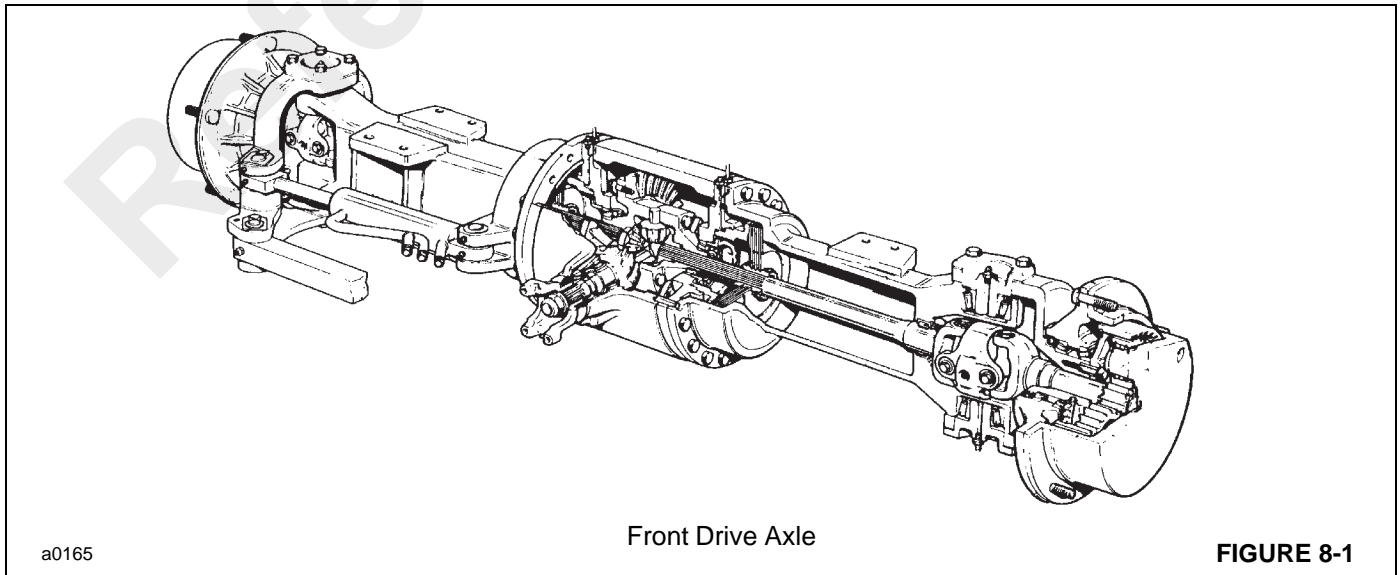
### DESCRIPTION

#### Front Axle

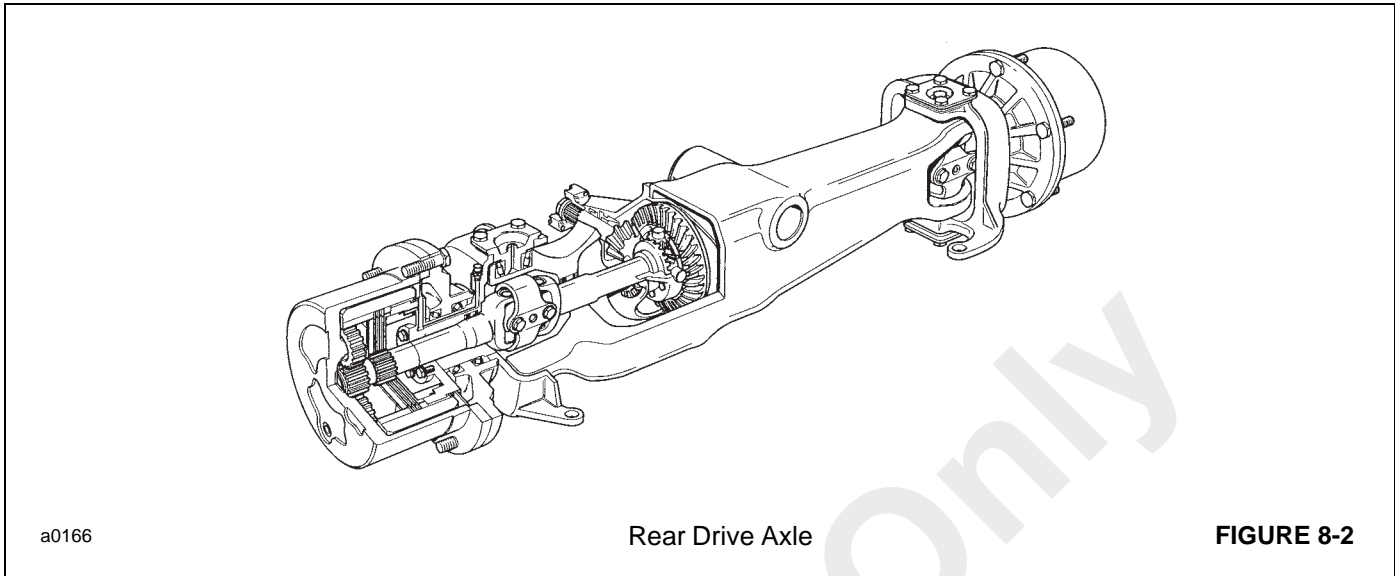
The front axle Figure 8-1 is a rigid-mounted drive axle, attached to the frame of the crane by eight bolts, washers and nuts. The axle includes a 3 piece spiral bevel input, two reduction drive hubs and inboard brakes.

#### Rear Axle

The crane may be equipped with either a rear drive axle or rear non-drive axle. Figure 8-2 shows only the drive axle. The axle is pin mounted to the frame of the crane, allowing it to pivot in both directions. The axle will pivot 1-1/2° in both directions. The drive axle includes spiral bevel input, two reduction drive hubs and brakes in the drive hubs. The non-drive axle does not have a 3 piece spiral input.







**TECHNICAL DATA**

**Front Drive Axle**

Type . . . . .	3 piece spiral bevel input with epicyclic hub reduction and inboard braking
Installation . . . . .	Rigid pad mount
Number of steering cylinders . . . . .	2
Weight (dry, with no steering cylinders and without wheels) . . . . .	420 kg (926 lb) approximate
Half (Axle) shaft braking/type . . . . .	5 plate (each half shaft). Standard retraction type.
Input type . . . . .	1480 half yoke
Toe-in . . . . .	0°
Caster angle . . . . .	0°
Camber angle . . . . .	1°
King pin inclination . . . . .	0°
Hub reduction . . . . .	5.4:1
Overall ratio . . . . .	13.7:1
Crownwheel and pinion ratio . . . . .	2.538:1
Number of teeth:	
Crownwheel . . . . .	33
Pinion . . . . .	13

**Rear Drive Axle**

Type . . . . .	Spiral bevel input with epicyclic hub reduction
Installation . . . . .	Pin mount
Number of steering cylinders . . . . .	2
Weight (dry, with no steering cylinders and without wheels) . . . . .	450 kg (992 lb) approximate
Hub brakes . . . . .	3 plate (each hub) standard retraction type.

Input type	1480 half yoke
Oscillation (Both Directions)	1-1/2°
Toe-in	0°
Caster angle	0°
Camber angle	1°
King pin inclination	0°
Hub reduction	5.4:1
Overall ratio	24.975:1
Crownwheel and pinion ratio	4.625:1
Number of teeth:	
Crownwheel	37
Pinion	8

**Rear Non-Drive Axle**

Type	Spiral bevel input with epicyclic hub reduction
Installation	Pin mount
Number of steering cylinders	2
Weight (dry, with no steering cylinders and without wheels)	424 kg (931 lb) approximate
Hub brakes	3 plate (each hub) standard retraction type.
Input type	1480 half yoke
Oscillation (Both Directions)	1-1/2° (Oscillation lockouts engaged)
Toe-in	0°
Caster angle	0°
Camber angle	1°
King pin inclination	0°
Hub reduction	5.4:1

Reference Only

## FRONT DRIVE AXLE REPAIR

### Removal



#### WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Loosen the wheel lug nuts then raise and support the crane on axle stands or blocks positioned under the chassis frame. Remove the wheels.
2. Disconnect the drive shaft from the axle by removing the eight bolts, lockwashers and nuts securing the drive shaft to the parking brake disc plate.
3. Disconnect parking brake hydraulic line from the parking brake. Plug and cap hose and fitting.
4. Disconnect and plug the hydraulic hoses to the steering cylinders.
5. Disconnect the brake lines from the front axle.
6. Support the axle on a trolley jack.

7. Loosen and remove the eight mounting bolts and nuts.
8. Remove the axle from the machine.

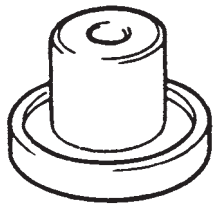
### Installation

1. Place the axle on a trolley jack.
2. Position the axle and trolley jack under the crane frame.
3. Install the eight bolts and nuts with the nuts on top of the axle. Tighten the bolts to the proper torque, see *Fasteners and Torque Values on page 1-12*.
4. Connect the brake line or hose to the axle.
5. Connect the hydraulic hoses to the steering cylinder.
6. Connect the hydraulic line to the parking brake.
7. Connect the front drive shaft to the parking brake disc plate using eight bolts, lockwashers and nuts.
8. Bleed the air from both service and parking brake system. See Section 9.
9. Bleed the air from the steering circuit. See Section 10.
10. Install the wheels to the axle. Lower the crane. Torque the lug nuts to 680 Nm (500 lb-ft).

### Special Tools

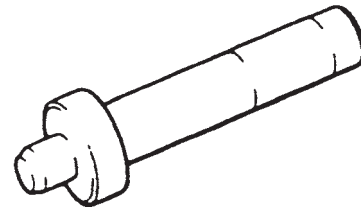
To completely disassemble and assemble the front drive axle, special service tools are required. Unless you have these or similar tools DO NOT service the axle.

The tools illustrated on the next page are available from your Grove distributor.



a0167

Driver - Crownwheel Bearing and Differential Bearing Cones



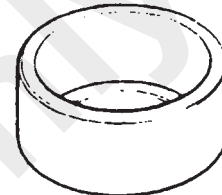
a0174

Bearing Pad Driver



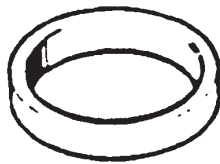
a0168

Adapter - Steer/Drive Axle Pinion Bearing Cone



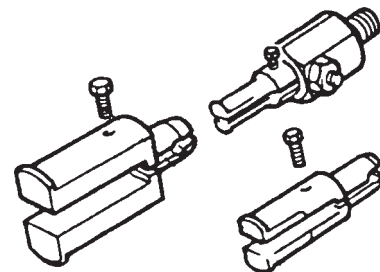
a0171

Measuring Cup - Pinion Head Bearing



a0169

Spacer - Pinion Bearing Pre-load



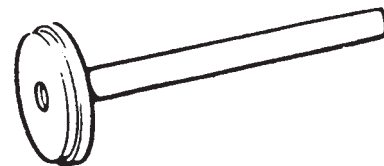
a0172

Adapter - Impulse Extractor  
Small - 17 to 25 mm  
Medium - 25 to 45 mm  
Large 45 to 80 mm



i0173

17 mm A/F x 3/4 in. square drive



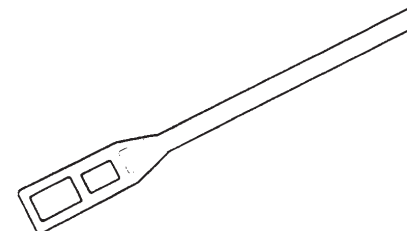
a0175

Driver - Pinion Head Bearing Cup



a0179

Impulse Extractor Set for Hub Bearing Seals



a0180

Drive Coupling Spanner for Axle York Couplings

FIGURE 8-3

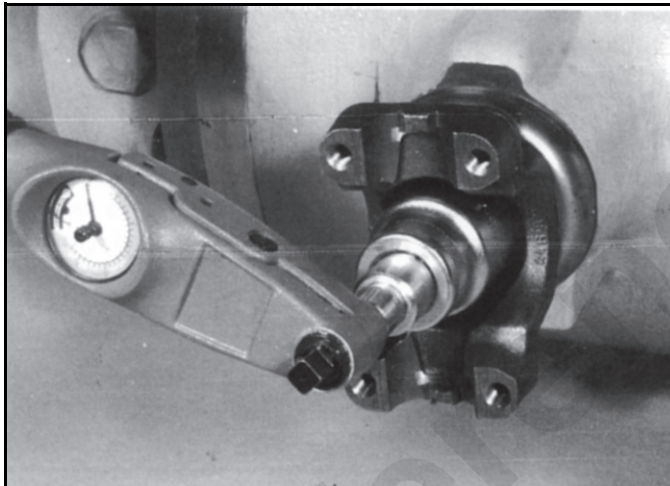
Replacing the Pinion Oil Seal

**! WARNING**

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Remove the wheel and tires and disconnect the axle drive shaft. Measure the axle rolling torque and record the reading Figure 8-4.

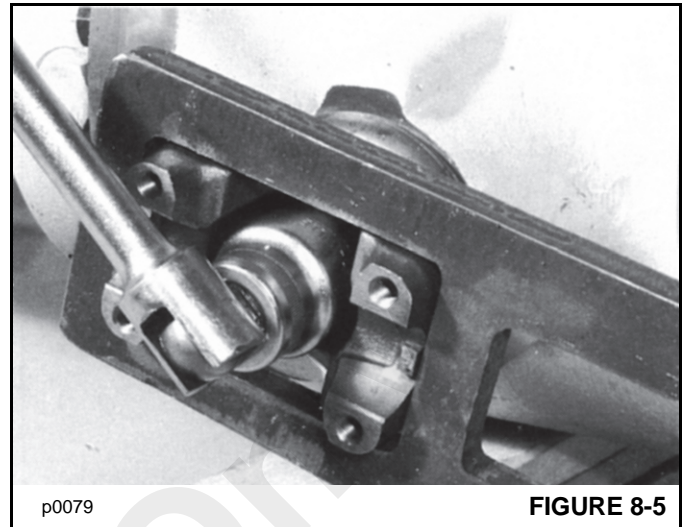


p0078

FIGURE 8-4

2. Mark the position of the coupling yoke on the splined shaft. Using the drive coupling spanner, remove the coupling yoke Figure 8-5 together with its stake nut and washer.

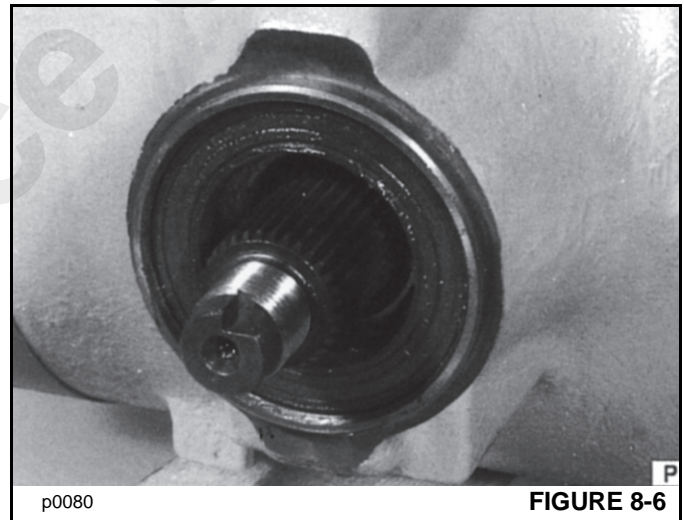
**NOTE:** On later axles, the stake nut and washer are combined. The separate nut and washer should be discarded and replaced with the new combined nut and washer.



p0079

FIGURE 8-5

3. Remove the seal Figure 8-6 and install a new one. Pack the lips of the new seal with grease before installing.



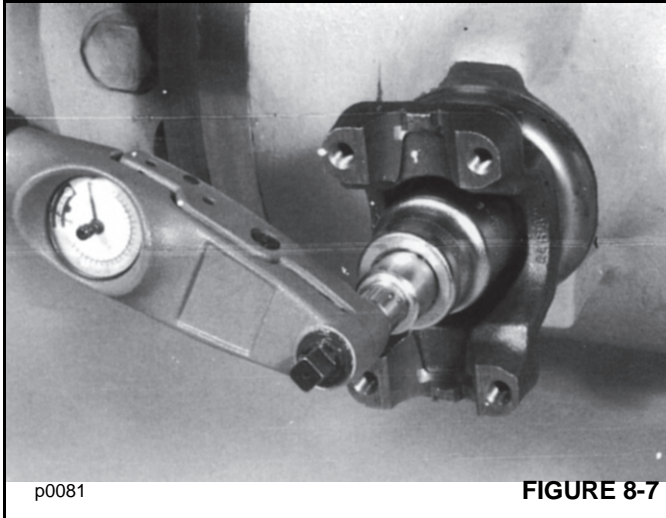
p0080

FIGURE 8-6

**NOTE:** Take care not to damage the housing when removing the old oil seal.

4. Align the locating marks on the yoke and the splined shaft. Install the coupling yoke and a new combined stake nut and washer.
5. Using the drive coupling spanner Figure 8-10, tighten the nut to a torque of 250 Nm (184 lb-ft).
6. Measure the rolling axle torque Figure 8-9. The reading should be the 0.5 to 1 Nm (0.37 to 0.74 lb-ft) more than that recorded in Step 1.

If necessary, progressively tighten the nut to achieve the correct rolling torque.



p0081

FIGURE 8-7

### CAUTION

If the rolling torque value (new pinion seal installed) exceeded the reading in Step 1 by 1 Nm (0.74 lb-ft) or more, then the collapsible spacer mounted on the axle pinion **MUST** be replaced.

7. Stake the nut using a square ended staking tool.

## Axle Hub Repair

### Disassembly

**NOTE:** The axle does not have to be removed to disassemble the axle hub.

1. Drain the oil from the axle hub.
2. Remove screws **24** Figure 8-8.
3. Using a soft-faced mallet, tap the planet gear carrier **18** to "crack" the joint between the carrier and the bearing carrier **8**. Then pry the planet gear carrier from the bearing carrier. Remove and discard O-ring **23**.
4. Remove a planet gear **19** only if it is defective. A planet gear can only be replaced as an assembly, which consists of the pinion, a bearing and two "L" shaped retaining rings. To remove a planet gear, first remove the retaining ring **4**, then pull off the planet gear.
5. The drive shaft thrust pad **17** is drilled and taped M6 for removal purposes. Remove the drive shaft thrust pad from planet gear carrier.

6. Remove the external retaining ring **22** and sun gear **20**.
7. Remove the Verbus Ripp bolts **16**. These bolts are very tight and care must be taken not to distort the bolt heads. Use as short of an extension as possible. Discard the Verbus Ripp bolts.
8. Using two metric bolts jack the annulus assembly **12, 13 & 14** off bearing carrier **8**.

**NOTE:** Be sure annulus ring position is marked for reassembly.

Fretting between the hub swivel and annulus carrier mating surfaces might be evident. This condition is normal, do not attempt to repair.

If the hub swivel and annulus carrier are to be replaced, they must be replaced as a pair not individually.

9. Remove internal retaining ring **14** to separate the annulus ring **12** from the annulus carrier **13**.
10. Pull off bearing carrier **8** together with the outer wheel bearing cone **10** and cup **11**. Remove combination seal **9**. Remove the inner bearing cup **7** from the inboard side of the carrier.

11. Pull off inner wheel bearing **6**.

**NOTE:** Earlier type axles may have an O-ring and wear ring installed in place of combination seal **9**. These parts should be discarded.

12. On later units, remove and discard combination seal **9**.
13. Disconnect the track rod and steering cylinder from the axle steering knuckles.

**NOTE:** If the track rod is removed completely, identify R.H. and L.H. ends to ensure correct assembly.

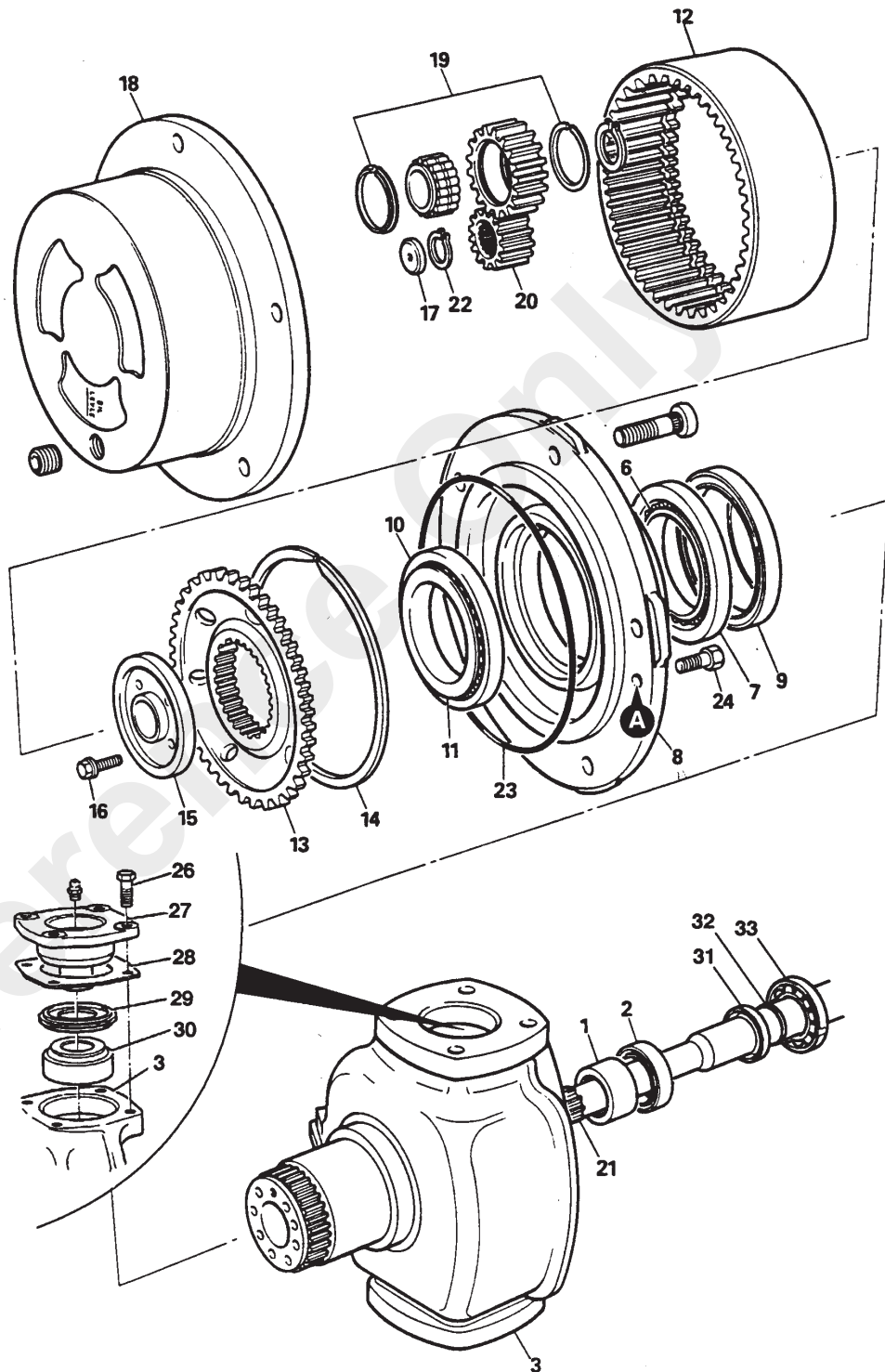
The top and bottom trunnions are very similar (bottom trunnion not shown), the only difference being that shims **28** are installed to the top trunnion only.

14. Mark the position of the top and bottom trunnions **27**, remove bolts **26** and remove the trunnions. Retain shims **28** with top trunnion. Remove hub swivel **3**.

**NOTE:** Trunnions may be removed easily and without damage to the shims by pumping grease through the grease fitting.

15. Remove top and bottom trunnion seals **29** and bearings **30**.

1. Bearing
2. Oil Seal
3. Hub Swivel
4. Snap Ring
6. Wheel Bearing Cone
7. Wheel Bearing Cup
8. Bearing Carrier
9. Combination Seal
10. Wheel Bearing Cone
11. Wheel Bearing Cup
12. Annulus Ring
13. Brake Carrier
14. Retaining Ring
15. Retainer Plate
16. Verbus Ripp Bolts (4)
17. Thrust Pad
18. Planetary Gear Carrier
19. Planet Gear Assembly (3)
20. Sun Gear
21. Drive Shaft
22. Snap Ring (3)
23. O-Ring
24. Capscrew (2)
26. Trunnion Bolts (8)
27. Trunnion (2)
28. Shim
29. Seal (2)
30. Bearing (2)
31. Oil Seal
32. Retaining Ring
33. Bearing



a0181

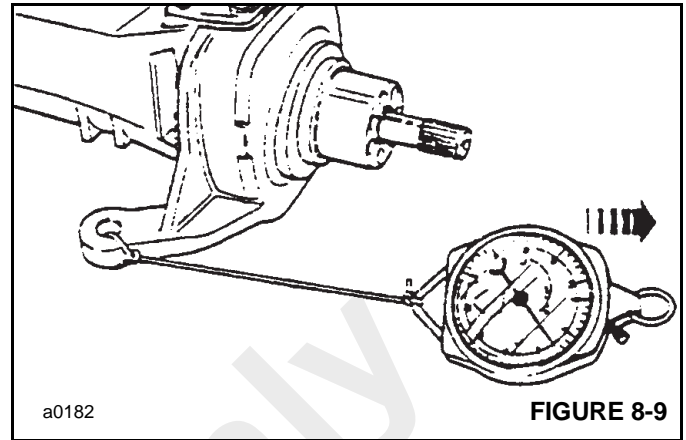
FIGURE 8-8

16. Remove drive shaft **21** from the axle casing.
17. Pry out drive shaft inner oil seal **2**.
18. Using a bearing puller, remove bearing **1**.
19. Pry out drive shaft inner seal **31B**.
20. Remove retaining ring **32**.
21. Using a bearing puller, remove bearing **33**.
22. If there has been a component failure, remove all traces of debris and clean the magnetic drain plug.

### Assembly

**NOTE:** The top and bottom trunnions are very similar (bottom trunnion not shown), the only difference being that shims **28** are installed to the top trunnion only.

1. Tap the drive shaft inner bearing **33** Figure 8-8 into position in the hub swivel drive shaft bore. Secure with retaining ring **32**.
2. Install a new oil seal **31** Pack grease between lips of the seal.
3. Install drive shaft **21**, taking care to locate inner end into the splines of the differential gears.
4. Tap drive shaft outer bearing **1** into position in the hub swivel.
5. Install new oil seal **2**. Pack grease between the lips of the seal.
6. Press new top and bottom oil seals **29** into position followed by bearings **30**. Grease bearings and oil seal before installing in axle.
7. Locate hub swivel **3** and install bottom trunnion **27**. Apply Loctite® 243 to the threads of the bottom trunnion bolts **26** and then tighten to a torque of 56 Nm (42 lb-ft). Install top trunnion **27** with normal 0.25 mm (0.10 in) shim **28** and leave top trunnion bolts **26** finger tight).
8. Attach a spring balance (Figure 8-9) to track rod swivel and turn the swivel. Tighten the top trunnion bolts **26** to eliminate end float but without bearing pre-load, that is, no increase in spring balance reading.



9. Measure the gap at the top trunnion and subtract 1 mm (0.040 inches) to give shim thickness (bearing pre-load). For example:

Gap = 1.55 mm (0.061 inches)

less = 1.00 mm (0.040 inches)

Shim = 0.55 mm (0.021 inches)

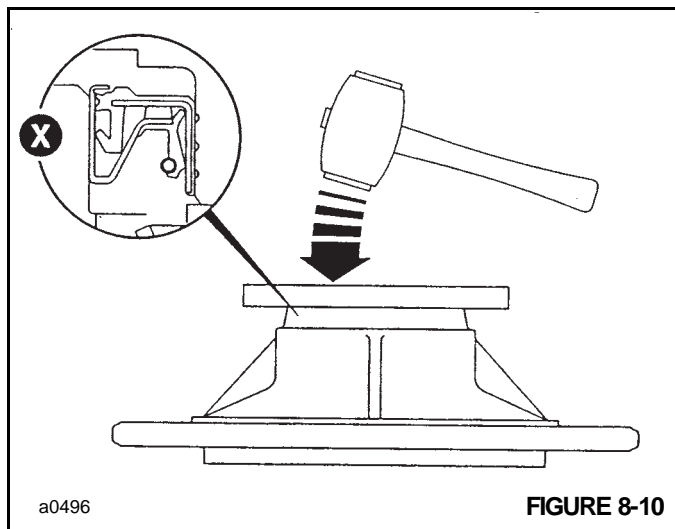
**NOTE:** If the gap measures 1 mm (0.040 inches), then no shim is required.

If after installing the shims, the bearing pre-load is not attainable, install new bearings.

10. Reinstall the top trunnion. Apply Loctite® 243 to the top trunnion bolt threads, install and tighten to a torque of 56 Nm (42 lb-ft).  
Check the spring balance reading which should be 4.5 kg (10 lb) more than the reading recorded in step 8.
11. Connect the track rod and steering cylinder to the axle steering knuckle. Tighten the track rod nut to a torque of 135 Nm (100 lb-ft), then continue to tighten to next castellation and insert the pin.
12. Lightly oil the inner wheel bearing **6** and its cup **17**. Then install them into bearing carrier **8**.
13. Install a new combination seal **9** into the bearing carrier **8**.

Do not lubricate before installing. Drive the seal squarely into the bearing carrier **8** until the locating lip is flush, as shown in **X** Figure 8-10.





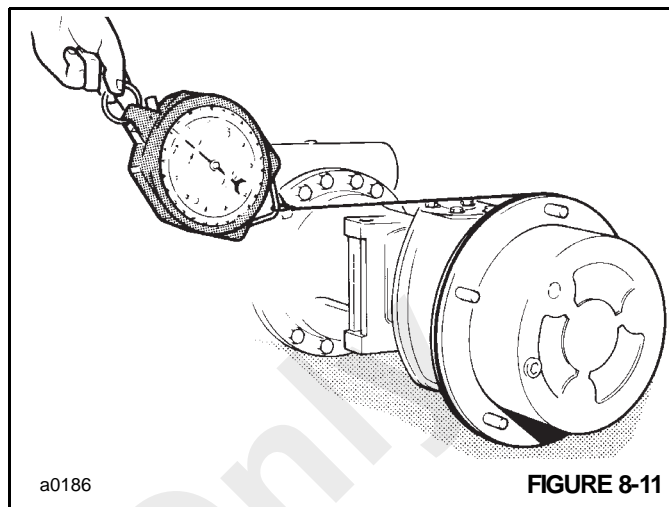
**NOTE:** After assembling the bearing carrier to the swivel hub, make sure that there is sufficient clearance between the hub and seal.

14. Install the cup of outer wheel bearing **10** Figure 8-8 into the bearing carrier **8**. Grease the bore of the combination seal **9** and the surface of the hub.
15. Install the bearing carrier **8** onto hub swivel **3**.
16. Lightly oil the bearing race of outer wheel bearing **11**. Install the bearing onto the axle arm. Rotate the carrier **8** (and therefore the bearing) during installation.
17. Assemble annulus ring **12** to annulus carrier **13**. Secure with retaining ring **14**.
18. Install the annulus assembly in the same angular position as removal (see Note after step 9 on page 8-7) using new Verbus Ripp bolts **16**. Do not fully tighten the bolts but allow the bearing carrier to rock slightly.

### CAUTION

Verbus Ripp bolts must **NOT** be reused.

19. Check the bearing carrier rolling force:
  - a. Use a spring balance and cord wrapped around the planet carrier bolts Figure 8-8. Pull the spring balance so that the hub rotates. Do this several times to set the seal and then record the reading.
  - b. Remove the planet gear carrier **18** Figure 8-8 and tighten the new Verbus Ripp bolts **16** to 166 Nm (122 lb-ft).



- c. Repeat steps 19 and 19A and record the reading.
- d. To get the rolling force, subtract the seal drag rolling force (Step 19 A) from reading obtained at step 19C. The result should be 1.4 to 15.3 kg (3 to 34 lb).

If the resulting force is outside these limits check that seal **19** is installed correctly and/or replace bearings (**6** and **11**).

- NOTE:** A high rolling force reading may indicate that the oil seal was damaged during installation.
20. Press the drive shaft thrust pad **17** (chamfered side down) into the recess in planet gear carrier **18**.
  21. Install new planet gears **19** in place of any that were removed (see Step 4 in Disassembly). Secure with retaining ring **4**.
- NOTE:** Large radius end of the bearing core installs onto the pin first.
22. Slide sun gear **20** onto the drive shaft and secure with retaining ring **22**.
  23. Install a new O-ring **23**.
  24. Install planet gear carrier **18** onto bearing carrier **8** turning it slightly to engage the gear teeth and aligning the two tapped holes **A** Figure 8-8 in the planet gear carrier. (The tapped holes are diametrically opposite one another). Ensure that the gear carrier butts fully against the bearing carrier.
- NOTE:** Do not strike the center of planet gear carrier **18** when installed, as this may dislodge drive shaft thrust pad **17**.
25. Install screws **24** and tighten to a torque of 56 Nm (41.3 lb-ft).
  26. Fill the axle hub with oil. See *Preventative Maintenance* on page 5-1.

## Drive Head Repair

The following procedures can only be carried out with the axle removed from the crane. See "Removal", on page 8-4.

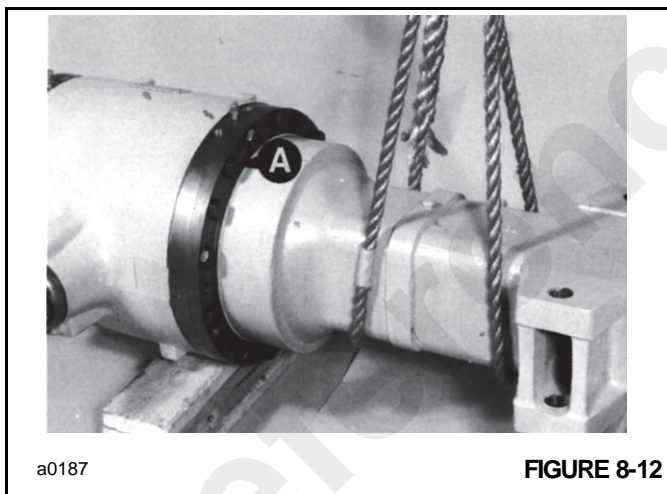
It will be necessary to provide a suitable stand to support the axle after removal.

The crownwheel and pinion are a matched set and should be replaced together if either is damaged or excessively worn.

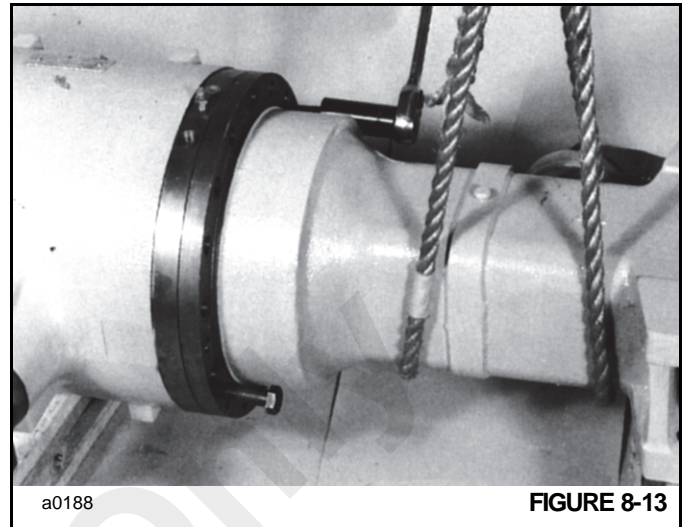
The differential case halves are also a matched set as are the differential side gears and planet gears. Do not use unmatched case halves and gears.

### Disassembly

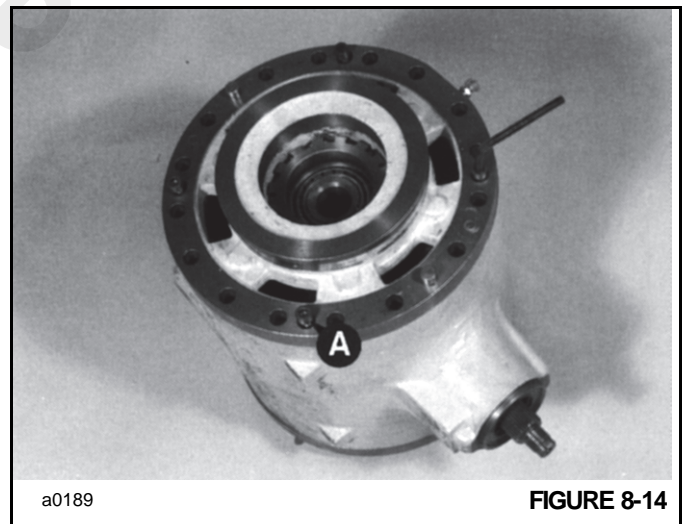
1. Before disassembling the axle, drain the oil from the axle into a suitable container.
2. Remove the steering cylinders and track rod.
3. Remove both axle arms.
  - a. Support the axle arm and remove bolts **A** Figure 8-12.



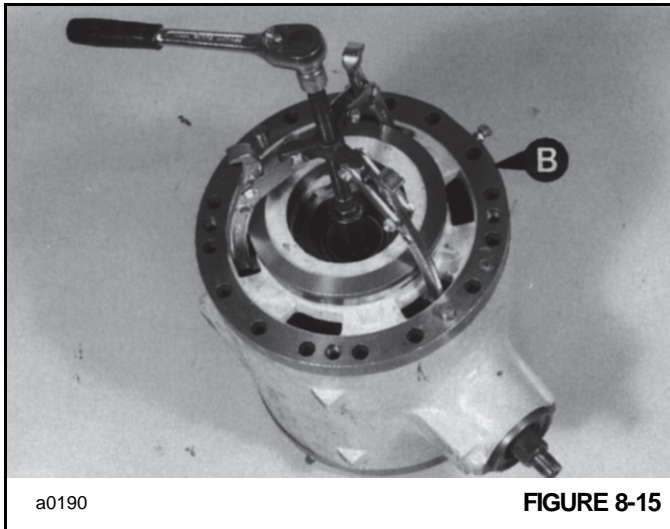
- b. Jack the axle arm off of the drive head, using the drive head securing bolts Figure 8-13. Remove all traces of gasket material from the mating surfaces.



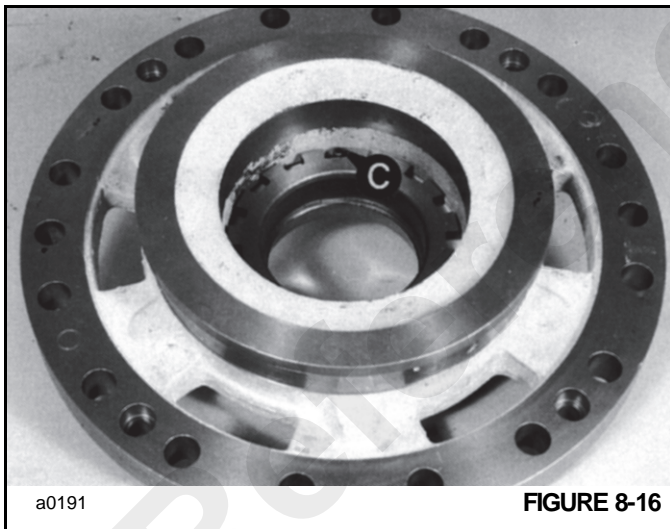
4. Remove the drive shaft coupling. See Replacing the Pinion Oil Seal on page 8-6.
5. Position the drive head as shown in Figure 8-14, with the crownwheel at the top. Remove capscrews **A**.



6. Match - mark the brake piston housing **B** Figure 8-15 and the drive head. Pull off the brake piston housing.



7. Drive out the differential side nut locking pin **C** Figure 8-16, to allow readjustment upon assembly. Remove the other brake piston housing only if damaged, but remove its locking pin **C** regardless (to allow side load adjustment upon assembly).

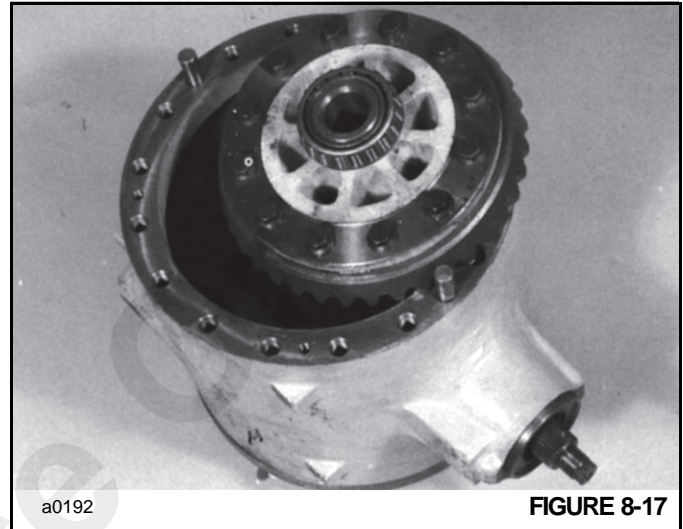


**CAUTION**

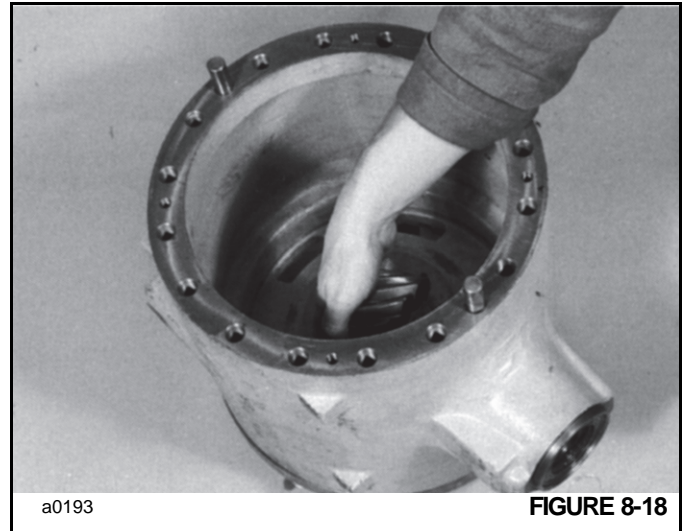
**METAL SPLINTERS.** You can be injured by flying metal splinters when driving metal pins in and out. Use a soft faced hammer or drift to remove and install metal pins. Always wear safety glasses.

8. Lift out the crownwheel/differential assembly Figure 8-17.

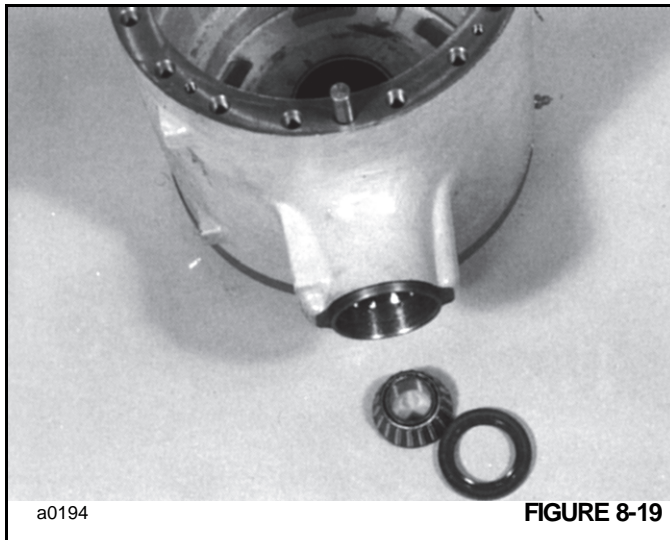
**NOTE:** If both brake piston housings are removed, put a mark on the crownwheel end of the drive head casing to ensure that the assembly is returned to its original position.



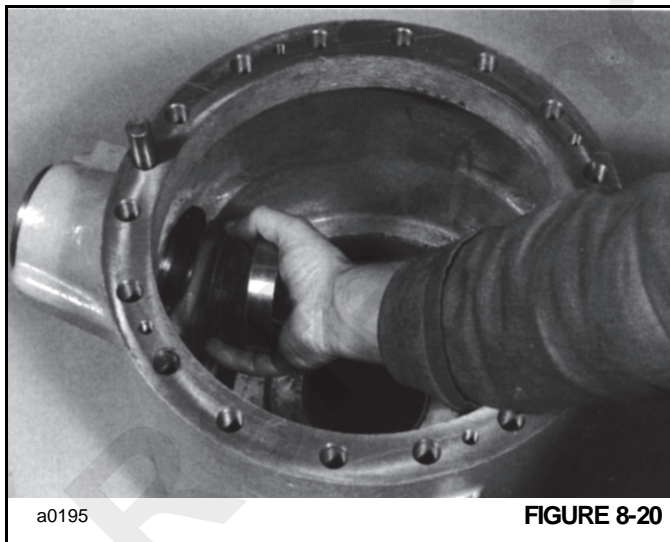
9. Using a soft hammer, hit the pinion end shaft until the pinion is free from its front bearing. Remove the pinion Figure 8-18.



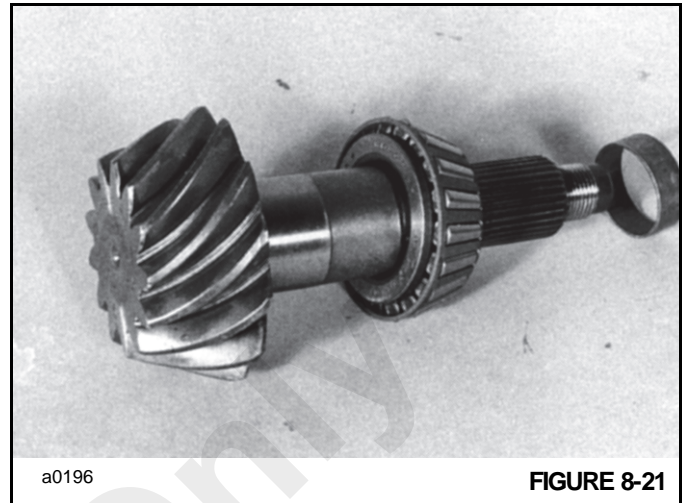
10. Remove the pinion seal and outer bearing cone Figure 8-19.



11. If necessary, drive out the pinion inner bearing cup and shims Figure 8-20. Discard the shims. Repeat for the outer bearing cup, if required. There are no shims for the outer bearing cup.

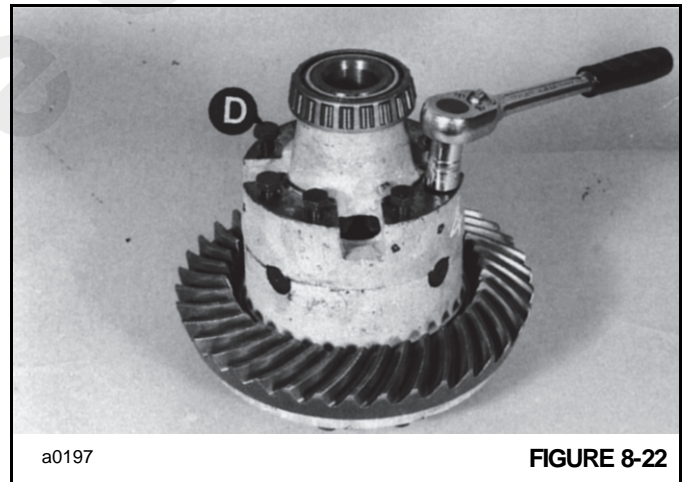


12. Remove and discard the pinion collapsible spacer Figure 8-21. Pull off the bearing cone.

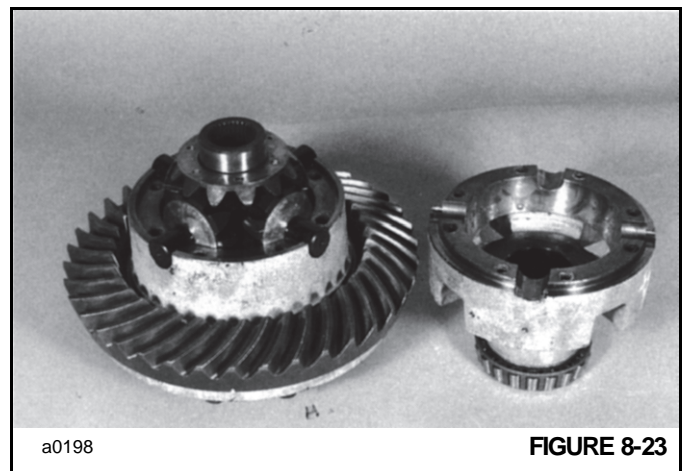


13. To dismantle the differential assembly:

a. Remove bolts **D** Figure 8-22.

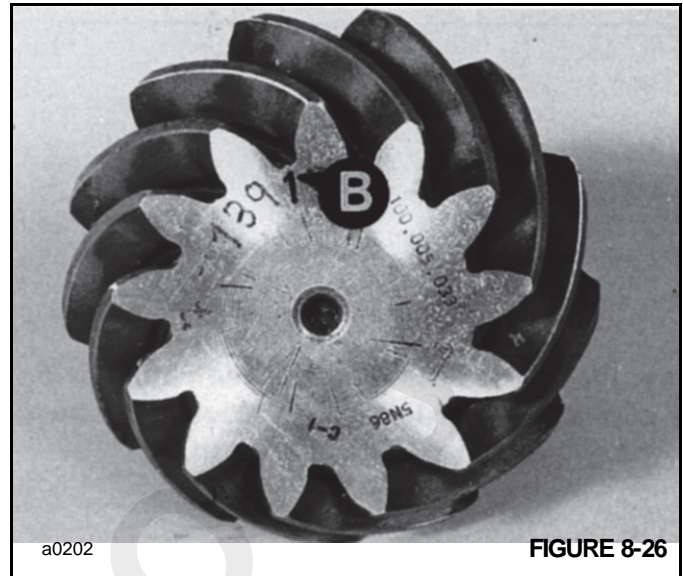
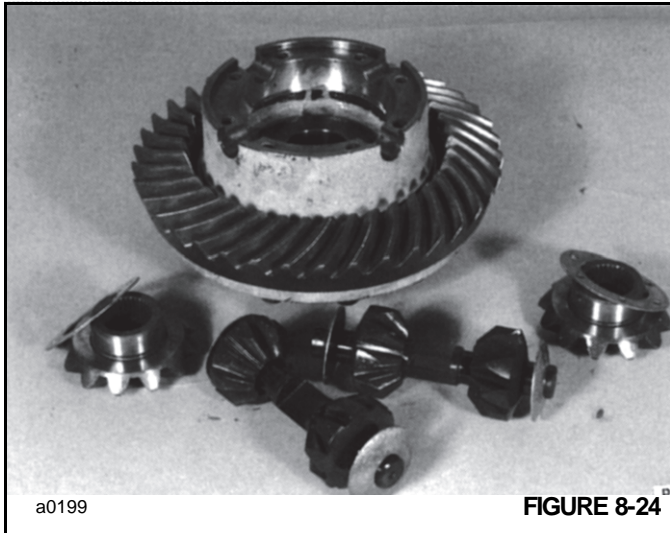


b. Lift off the top half housing Figure 8-23.



- c. Remove the differential gears and spherical washers Figure 8-24. Pull off both differential bearing cones.

If required, remove the crownwheel to differential case half retaining bolts and remove the crownwheel.



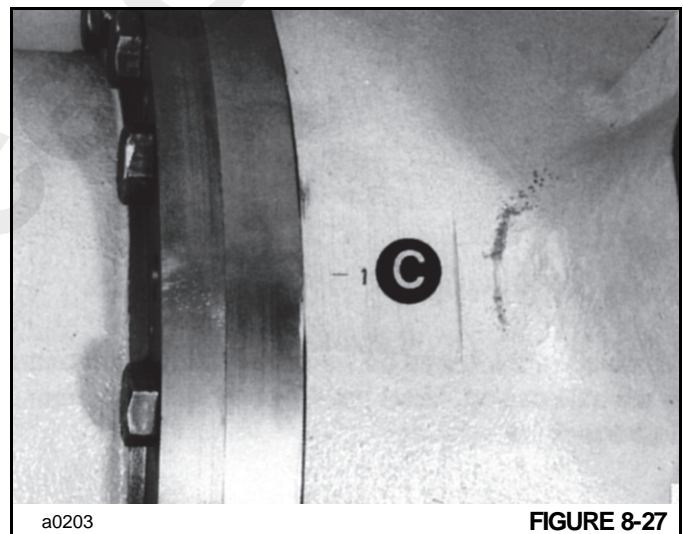
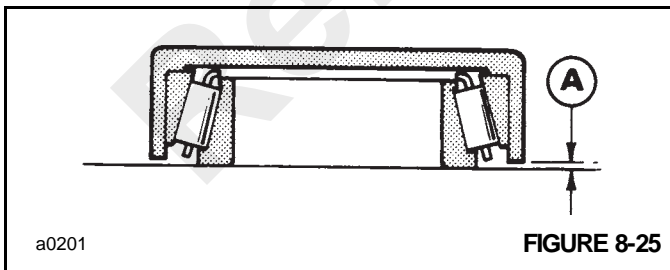
**Assembly**

**Pinion Depth Setting Procedure**

Determine the pinion depth setting as follows:

**NOTE:** See page 8-15 for general guidance on crownwheel and pinion adjustment.

1. Assemble the pinion inner bearing and its cup on a flat surface.
2. Place the pinion bearing measuring cup over the bearing assembly Figure 8-25. Measure gap A. Add tool depth of 30.1 mm. (1.18 in) to gap A to give bearing depth.



3. Find the mounting distance value **B** Figure 8-26 on the pinion and deviation **C** Figure 8-27 on the drive head housing. Both units are in millimeters. To convert millimeters to inches, multiply millimeters by 0.03937.

4. If dimension **B** is positive, add it to the bearing depth. If dimension **B** is negative, subtract it from the bearing depth. See example Crownwheel and Pinion Adjustment on page 8-15.
5. If dimension **C** is positive, subtract it from the total. If dimension **C** is negative, add it to the total. See example Crownwheel and Pinion Adjustment on page 8-15.
6. Subtract the result from the standard value of 31.19 mm (1.23 inches) to give the required shim thickness. See example Crownwheel and Pinion Adjustment on page 8-15.

**Example:**

*Dimensions in Millimeters*

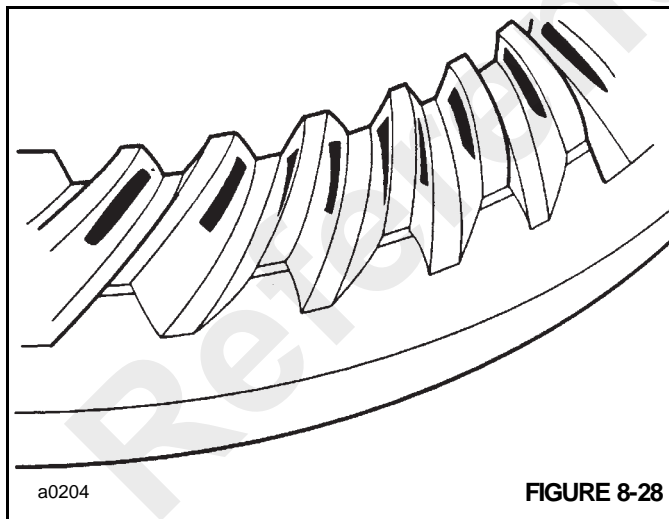
Dimension A	0.25
Add to depth	<u>+30.01</u>
<b>Total</b>	<b>30.26</b>
Add dimension B, if positive. (Subtract if negative)	<u>+0.01</u>
<b>Total</b>	<b>30.27</b>
Add dimension C if negative. Subtract if positive	<u>(+) -0.01</u>
<b>Total</b>	<b>30.28</b>
Standard Value	31.19
Less Calculated total from above	<u>-30.28</u>
<b>Shim Thickness</b>	<b>0.91</b>

**Crownwheel and Pinion Adjustment**

Meshing of the gears should be checked by marking three of the pinion teeth with engineers marking compound and rotating the pinion.

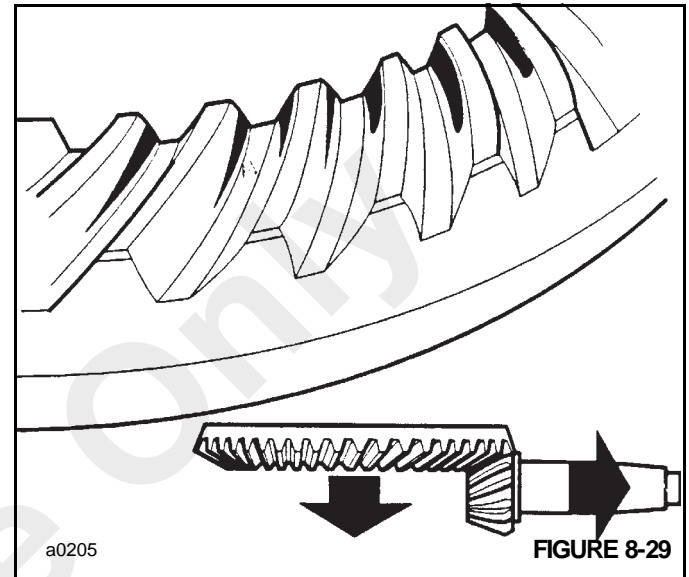
The marking will then be transferred to the crown wheel teeth.

**Correct teeth marking Figure 8-28**



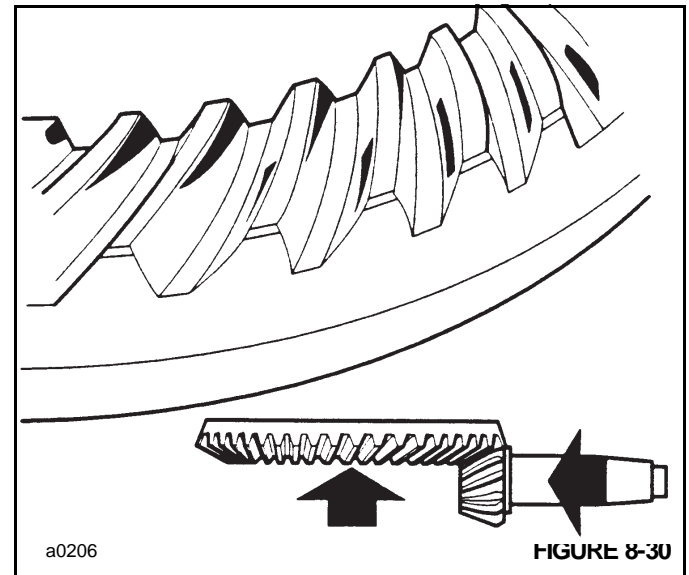
**Pinion too deeply in mesh Figure 8-29**

Decrease the shim thickness between the pinion inner bearing cup and the axle casing. Move the crown wheel towards the pinion to correct the backlash.



**Pinion too far out of mesh Figure 8-30.**

Increase the shim thickness between the pinion inner bearing and the axle casing. Move the crownwheel away from the pinion to correct the backlash.



**Assembly Procedures**

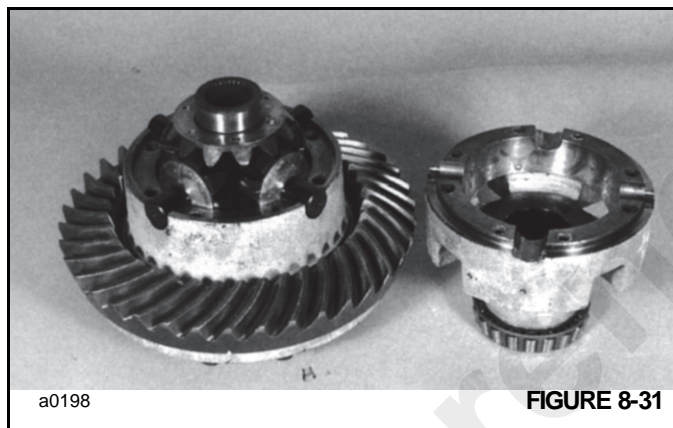
**NOTE:** The crownwheel and pinion are matched and should be replaced as a set, if either one is damaged or excessively worn.

The two differential case halves are also matched, as are the differential side gears and planet gears. Do not use unmatched case halves or gears.

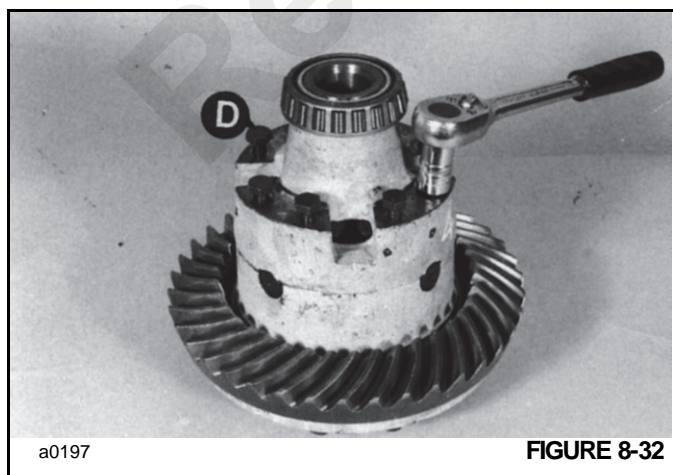
**NOTE:** Make sure all bearings are lightly oiled before installing and setting. Make sure to rotate bearings while setting.

1. If required, install the crownwheel to the differential case half. Tighten the crownwheel retaining bolts to a torque of 166 Nm (122 lb-ft).

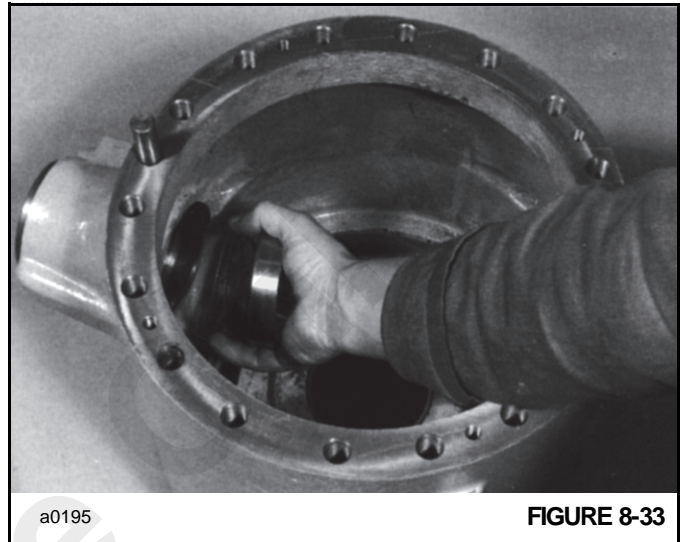
Assemble the differential gears and their spherical washers into the bottom half housing Figure 8-31. Install the differential bearing cones.



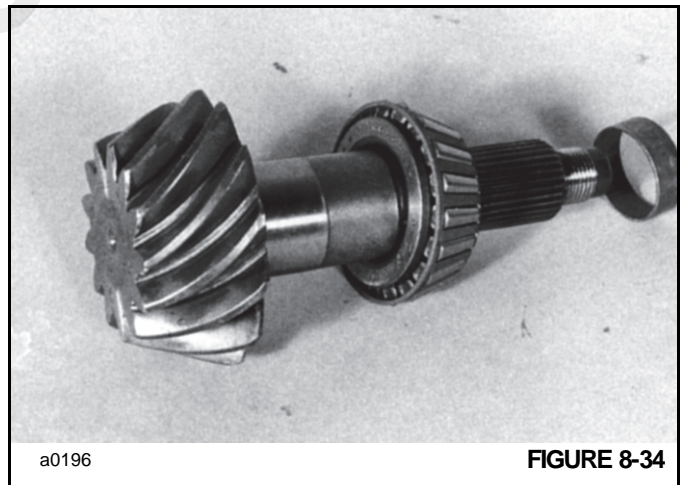
2. Position the top half housing onto the differential, aligning the match mark letters. Apply Loctite® 243 to the threads of bolts **D** Figure 8-32. Install the bolts and tighten to a torque of 56 Nm (42 lb-ft). Check the gears for free rotation.



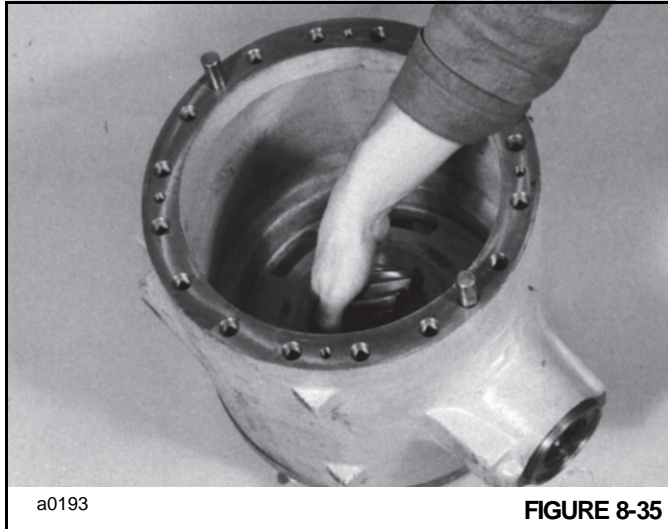
3. Install the pinion bearing cup Figure 8-33, together with the required thickness of shims to give correct pinion depth (see Pinion Depth on page 8-14). To ensure that cup is installed square, use a suitable puller assembly. Do not use a hammer. Install the outer bearing cup.



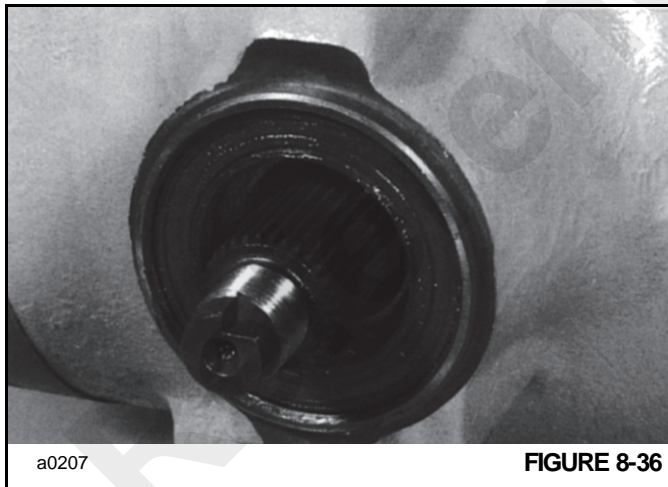
4. Install the pinion inner bearing cone Figure 8-34 and a new collapsible spacer.



5. Insert the pinion into its bore Figure 8-35. Before inserting, ensure that the pinion matches the crownwheel. The code numbers etched on the pinion end face and the crownwheel perimeter should be the same.



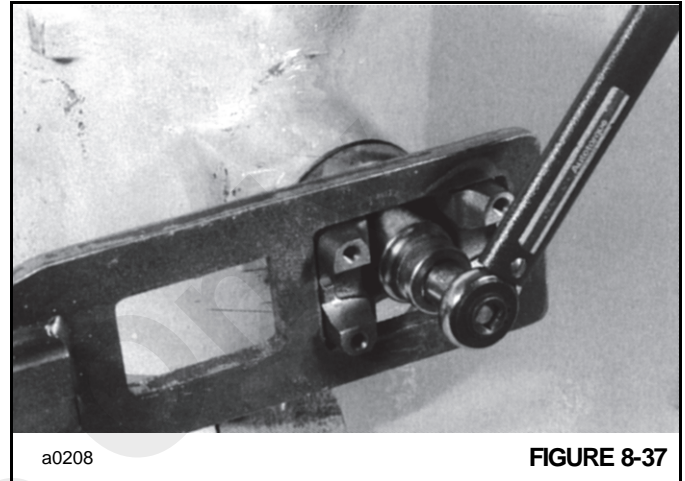
6. Install the outer bearing cone Figure 8-36 and the seal. Pack grease between the lips of the seal before installing.



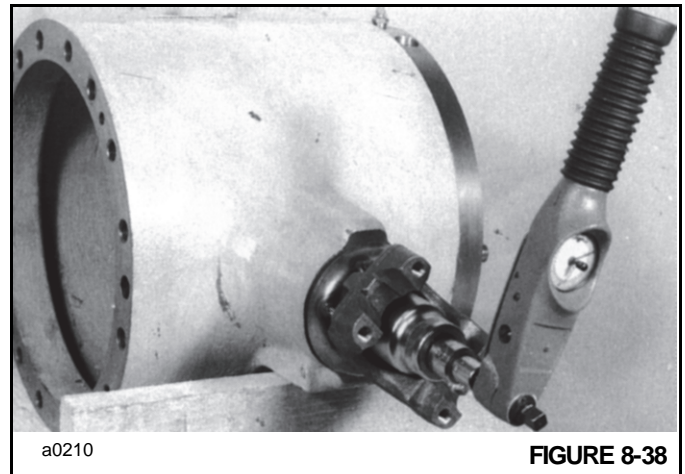
7. Install the drive coupling yoke and secure it with a new stake nut and washer.  
Hold the yoke Figure 8-37 with the drive coupling spanner. Tighten the stake nut until end float is almost

zero, then check the seal drag torque. It should be between 0,40 to 1,0 Nm (3.5 to 8.9 lb-in).

Continue to tighten the stake nut to achieve the correct rolling torque as described in Step 8. If the nut is overtightened, the collapsible spacer must be replaced.

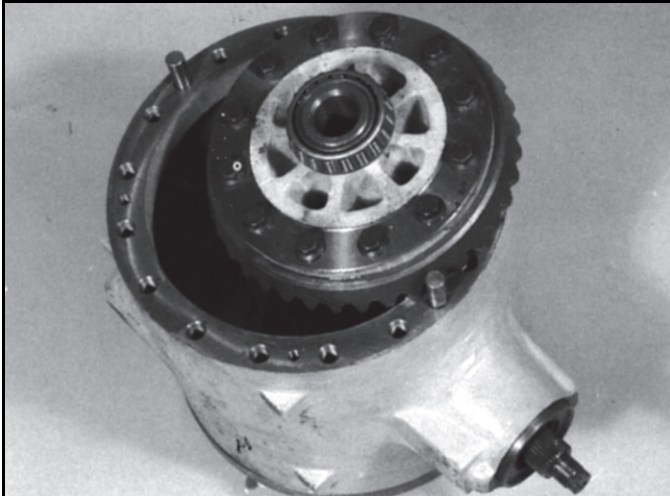


8. Measure the rolling torque Figure 8-38, which should be 1.7 to 2.8 Nm (1.3 to 2.1 lb-ft) excluding seal drag. When the torque is correct, stake the nut to the pinion shaft using a square-ended staking tool.



9. If both brake piston housings were removed, install one at the opposite end of the crownwheel Figure 8-39, using the procedure in Step 10. Then install the crownwheel/ differential assembly into the drive head.





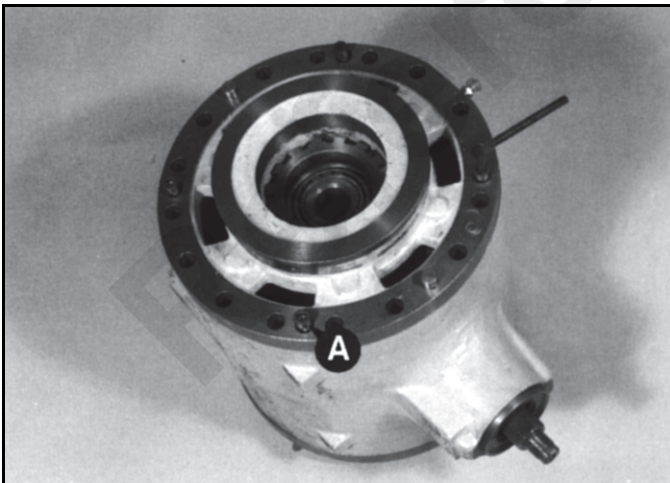
a0192

FIGURE 8-39

10. Apply Loctite® 275 to the drive head mating face. Install the brake piston housing. Ensure that the match marks made during disassembly are aligned. Install capscrews **A** Figure 8-40 (see Note) and tighten to a torque of 56 Nm (42 lb-ft). Torque applies to both piston housings.

**NOTE:** If the old capscrews are to be used, clean the threads with a wire brush and then coat the threads with Loctite® 243. Install and tighten to a torque of 56 Nm (42 lb-ft).

New capscrews are encapsulated and do not require cleaning or manually coating with sealant.

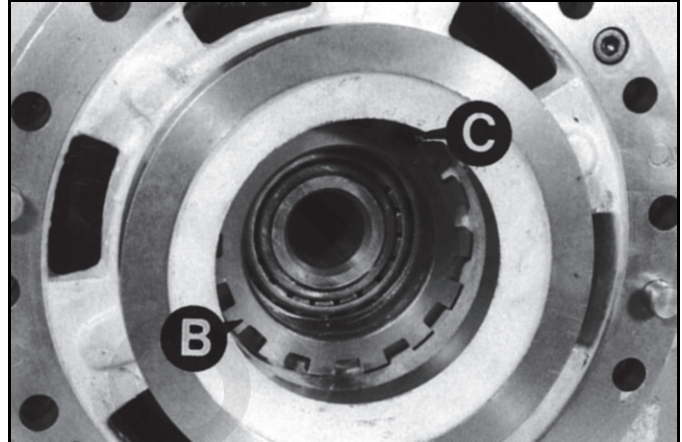


a0189

FIGURE 8-40

11. Adjust differential side nuts **B** Figure 8-42 to give a bearing pre-load of 1,36 to 2,5 Nm (1.0 to 1.84 lb-ft).

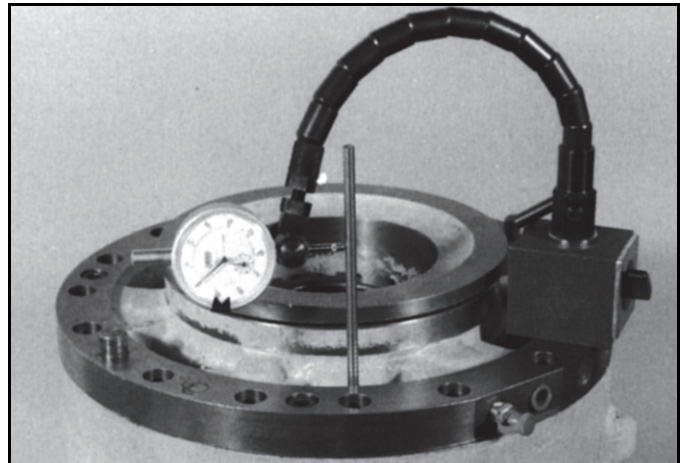
Measure the pre-load by taking another rolling torque reading and subtracting the torque value measured at Step 8. The difference is the bearing pre-load.



a0211

FIGURE 8-41

12. Measure the crownwheel backlash, which should be 0,13 to 0,2 mm (0.005 to 0.008 in) Figure 8-42. Adjust the differential side nuts by equal amounts when altering backlash. When backlash and pre-load are both correct, install the side nut locking pins **C** Figure 8-41. Verify crownwheel, pinion and pre-load are set properly. See Crownwheel and Pinion Adjustment on page 8-15.



a0209

FIGURE 8-42

## REAR AXLES REPAIR

### Removal

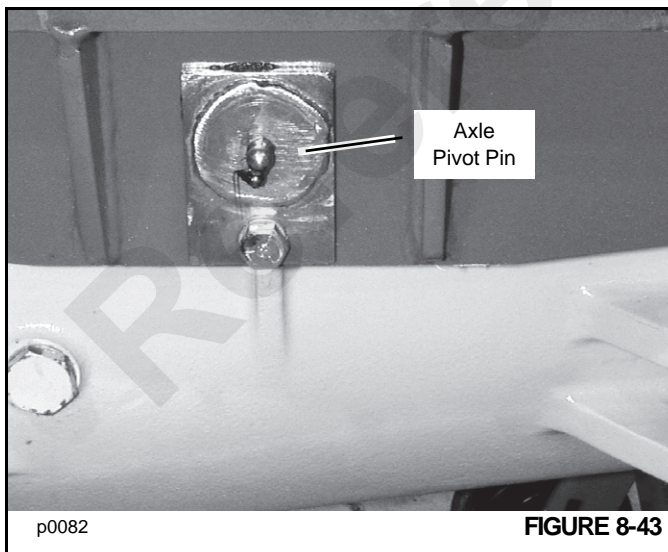


#### WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Loosen the wheel lug nuts and raise and support the crane on axle stands or blocks positioned under the chassis frame. Remove the wheels.
2. Disconnect the drive shaft from the axle by removing four bolts and lockwashers.
3. Disconnect and plug the hydraulic hoses to the steering cylinder.
4. Disconnect, cap and plug the brake hoses from the axle.
5. Support the axle on a trolley jack.
6. Remove the bolt and lockwasher Figure 8-43 securing the axle pivot pin. Remove the axle pivot pin.



7. Lower the axle clear of the mounting bracket and remove it from the crane.

### Installation

1. Place the axle on a trolley jack and position it under the crane frame.
2. Raise axle and position it in the mounting frame.
3. Install the axle pivot pin.
4. Coat the threads of the pin retaining bolt with Loctite® 243 and then secure the axle pivot pin with the bolt and lockwasher.
5. Grease the axle pivot pin through two grease fittings.
6. Connect the brake lines and the steering lines to the axle.
7. Bleed the air from the brake system. See Section 9.
8. Bleed the air from the steering circuit. See Section 10.

### Service Tools

To completely disassemble and assemble the rear axle, special tools are required. Unless you have the tools illustrated Figure 8-3, DO NOT service the axle.

### Replacing the Pinion Oil Seal

The procedure for replacing the pinion or seal on the rear drive axle is the same as the front drive axle. Refer to page 8-6 for replacement procedures.

### Axle Hub Repair

#### Disassembly Figure 8-45



#### WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Disconnect the track rod and steering cylinders.

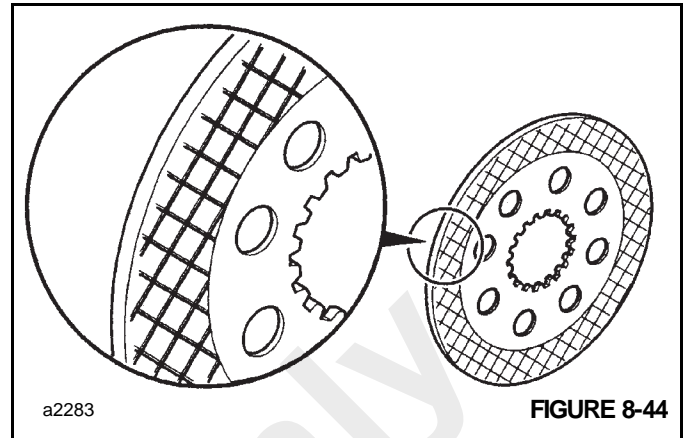
**NOTE:** If the track rod is removed completely, identify R.H. and L.H. ends to ensure correct assembly.

2. Drain all oil from the hub.
3. Remove screws **33** Figure 8-45.
4. Pry off planet gear carrier **27** at the pry points. Remove and discard O-ring **32**.

5. Remove planet gears **28** only if defective. Note that gears can only be removed as assemblies, which consist of the gear, the bearing and two "L" shaped retaining rings. To remove the planet gear, remove the external retaining ring **29**.
6. Pull off the planet gear **28**.
7. The drive shaft thrust pad **26** is drilled and tapped M6 for removal purpose. Remove the thrust pad from gear carrier **27**.
8. Remove retaining ring **31** to allow sun gear assembly **30** to be slid off the drive shaft **42**.
9. Remove retaining ring **25** to allow the brake pack assembly to be slid off the drive shaft **42**.
10. Remove brake pressure plate **24**, counter plates **23** and friction plates **22**.

**NOTE:** If the brake pack is to be reused, note the position of the plates before removing.

11. Examine the friction plates. Wear limit of the friction plates is to the depth of the crosshatching Figure 8-44. Check all plates for flatness and damage. (Some scoring of the counter plates is normal.) Completely replace the brake pack if it is worn or damaged. Do not replace individual plates.



**NOTE:** Excessive wear of the brake and counterplates can indicate sticking brakes or possible residual pressure in the braking system. See Section 9, Brakes.

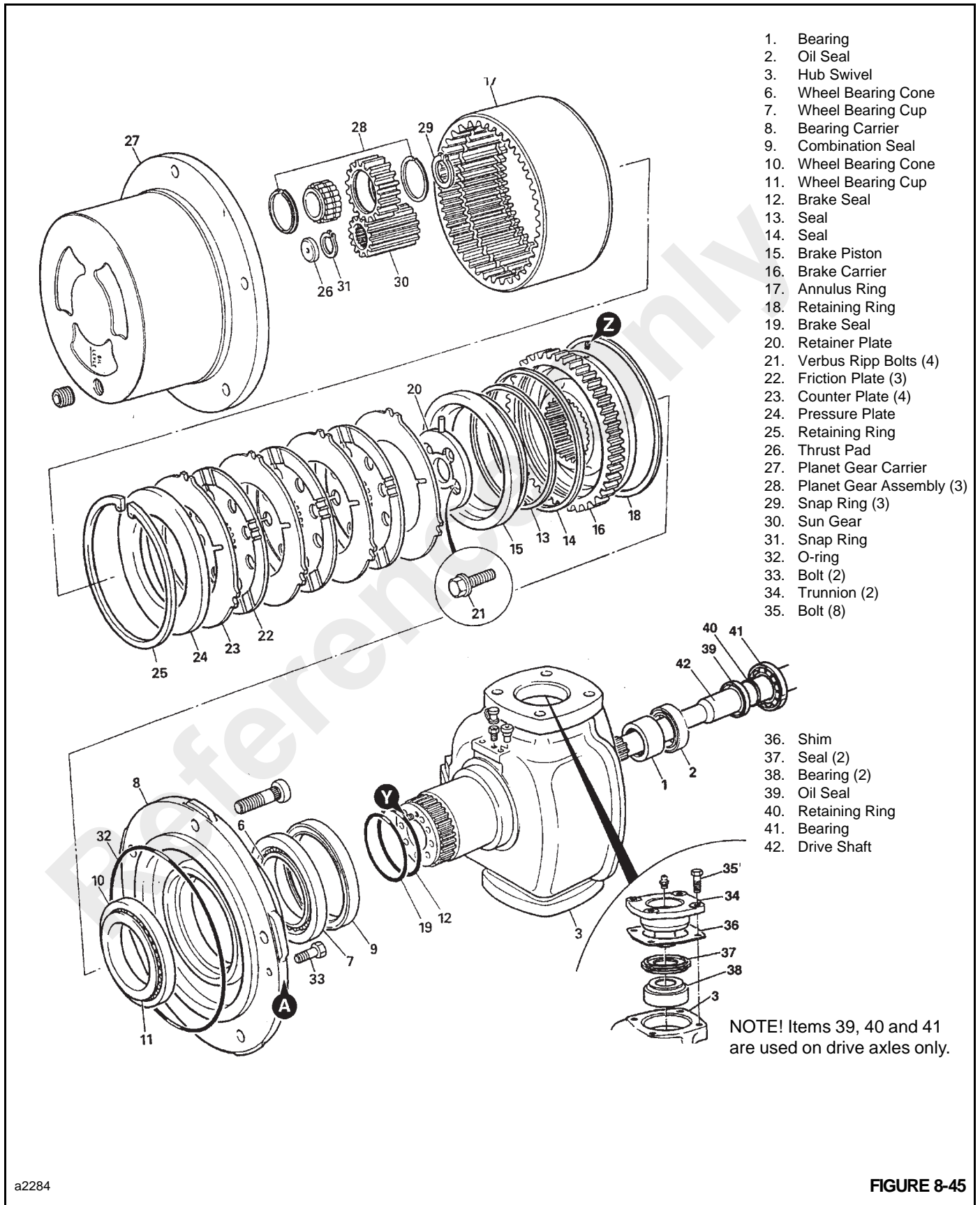
12. Remove Verbus Ripp bolts **21** Figure 8-45 and retaining plate **20**. These bolts are very tight and care must be taken not to distort the bolt heads. Use as short of extension as possible with a six sided socket. Discard the Verbus Rip bolts after removal.



### CAUTION

Do **NOT** reuse Verbus Ripp bolts. They must be replaced throughout the assembly.

13. Remove brake seal **19**, then mark the relationship between the annulus carrier **16**, annulus ring **17** and the hub swivel. Remove the annulus carrier with the annulus ring from the hub swivel.
14. Remove retaining ring **18** to separate the annulus ring from the annulus carrier. Remove brake seal **12** from the hub swivel.



1. Bearing
2. Oil Seal
3. Hub Swivel
6. Wheel Bearing Cone
7. Wheel Bearing Cup
8. Bearing Carrier
9. Combination Seal
10. Wheel Bearing Cone
11. Wheel Bearing Cup
12. Brake Seal
13. Seal
14. Seal
15. Brake Piston
16. Brake Carrier
17. Annulus Ring
18. Retaining Ring
19. Brake Seal
20. Retainer Plate
21. Verbus Ripp Bolts (4)
22. Friction Plate (3)
23. Counter Plate (4)
24. Pressure Plate
25. Retaining Ring
26. Thrust Pad
27. Planet Gear Carrier
28. Planet Gear Assembly (3)
29. Snap Ring (3)
30. Sun Gear
31. Snap Ring
32. O-ring
33. Bolt (2)
34. Trunnion (2)
35. Bolt (8)
36. Shim
37. Seal (2)
38. Bearing (2)
39. Oil Seal
40. Retaining Ring
41. Bearing
42. Drive Shaft

NOTE! Items 39, 40 and 41 are used on drive axles only.

a2284

FIGURE 8-45

15. If removal is necessary, carefully remove the brake piston **15** from its housing. A hydraulic hand pump can be used to force the piston out of the housing.
16. Remove and discard seals **13** and **14**. Inspect the housing bore for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.
17. Pull off bearing carrier **8** together with outer bearing **11**.
18. Pull off inner bearing **6**.
19. Remove and discard combination seal **9**.

**NOTE:** Earlier axles may have an O-ring and wear ring installed. These parts should be discarded.

**NOTE:** The top and bottom trunnions are very similar (bottom trunnion is not illustrated in Figure 8-45) the only difference being that shims **36** are installed to the top trunnion.

20. Mark the position of the top and bottom trunnions **34**, remove bolts **35** and remove the trunnions. Keep shims **36** with the top trunnion. Remove hub swivel **3**.

**NOTE:** Trunnions may be removed easily and without damage to the shims by pumping grease through the grease fitting.

On non-drive axles the short drive shaft will be removed with the hub swivel.

21. Remove top and bottom trunnion seals **37** and bearings **38**.
22. Remove drive shaft **42** from the hub swivel on non-drive axles and from the axle casing on drive axles.
23. Pry out the drive shaft outer oil seal **2**.
24. Remove bearing **1** using an impulse extractor adapter.

**NOTE:** Steps 25 through 27 are for drive axles only.

25. Pry out drive shaft inner seal **39**.
26. Remove retaining ring **40**.
27. Using an impulse extractor remove bearing **41**.
28. If there has been a component failure, remove all traces of debris and clean the magnetic drain plug.

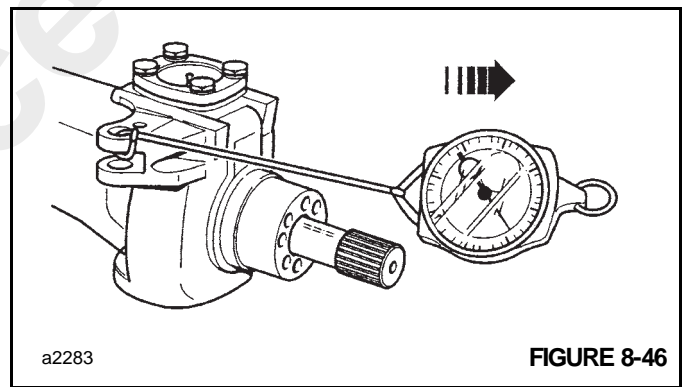
**Assembly**

**NOTE:** The top and bottom trunnions are very similar (bottom trunnion is not illustrated in Figure 8-45, the only difference being that shims **36** are installed to the top trunnion.

**NOTE:** Steps 1 through 3 are for drive axles only.

1. Tap the drive shaft inner bearing **41** into position in the axle casing.
2. Install retaining ring **40**.

3. Install new oil seal **39**. Pack grease between the lips of the seal.
4. Tap drive shaft inner bearing **1** into position in hub swivel **3** drive shaft bore.
5. Install new oil seal **2**. Pack grease between the lips of the seal.
6. Install drive shaft **42**. Take care to locate inner end into splines of differential gears on the drive axle.
7. Press new top and bottom trunnion seals **37** into position, followed by bearings **38**.
8. Locate hub swivel **3** and install the bottom trunnion **34**. Apply Loctite® 243 to threads of bottom trunnion bolts **35** and then tighten to a torque 56 Nm (42 lb-ft). Install top trunnion **34** with normal 0.25 mm (0.010 inch) shim **36** and leave top trunnion bolts **35** finger tight.
9. Attach a spring balance Figure 8-46 to track rod swivel and turn the swivel. Tighten the top trunnion bolts **35** to eliminate end play, but without bearing pre-load, i.e. no increase in spring balance reading.



10. Measure the gap at the top trunnion and subtract 1 mm (0.040 inches) to give shim thickness (bearing pre-load). For example:

$$\begin{aligned} \text{Gap} &= 1.55 \text{ mm (0.061 inches)} \\ \text{less } &= \underline{1.00 \text{ mm (0.040 inches)}} \\ \text{Shim} &= 0.55 \text{ mm (0.021 inches)} \end{aligned}$$

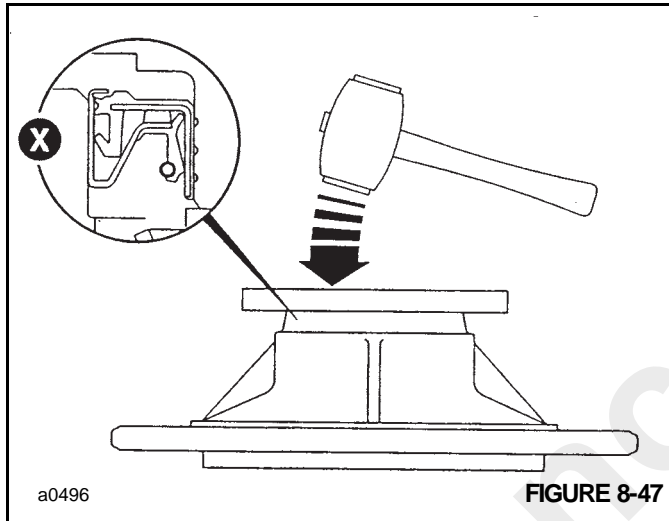
**NOTE:** If the gap measures 1.00 mm (0.040 inches), then no shim is required.

If, after installing the shims, the bearing pre-load is not attainable, install new bearings.

11. Reinstall the top trunnion. Apply Loctite® 243 to the top trunnion bolt threads, install and tighten to a torque of 56 Nm (42 lb-ft).
12. Check the spring balance reading which should be 4.5 kg (10 lb) more than the reading recorded in step 9.

13. Connect the track rod and steering cylinder to the axle steering knuckle. Tighten the track rod nut to a torque of 135 Nm (100 lb-ft), then continue to tighten to next castellation and insert the pin.
14. Lightly oil the inner wheel bearing **6** and its cup **7**. Then install them into bearing carrier **8**.
15. Install a new combination seal **9** into the bearing carrier. Figure 8-47.

Do not lubricate before installing. Drive the seal squarely into carrier until locating lip is flush as shown at **X**.



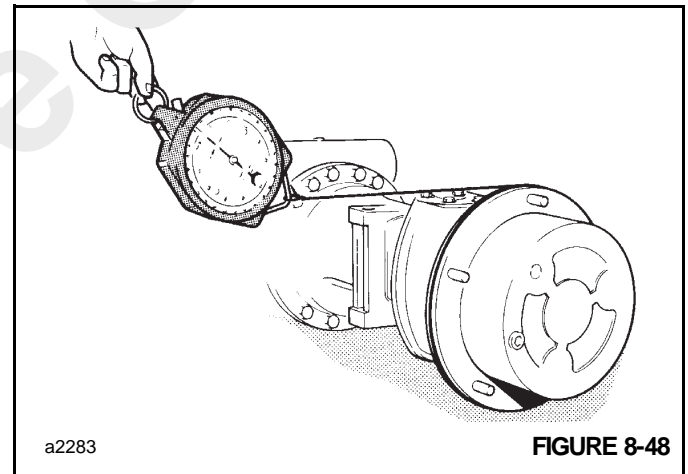
**NOTE:** After assembling the bearing carrier to the swivel hub, make sure that there is sufficient clearance between the hub and seal.

16. Install the cup **10** of outer wheel bearing **11** into the bearing carrier **8**. Grease the bore of the seal and the surface of the hub.
17. Install the bearing carrier **8** onto hub swivel **3**.
18. Install new brake seal **12** to the hub swivel.
19. Install new seals **13** and **14** into the grooves in the brake piston **15** and annulus carrier **16**.
20. Carefully press piston **15** all the way into the annulus carrier housing.
21. Align relationship marks made on disassembly. Assemble annulus ring **17** to annulus carrier **16** and secure with retaining ring **18**. Make sure the two blanking plugs **Z** Figure 8-45 are installed to the annulus carrier. Apply Loctite® 243 to threads.

**NOTE:** Inspect the inside of the annulus carrier and piston for marks. Any sign of scoring on a seal contact surface can cause leaks.

Make sure blanking screw **Y** are installed. Apply Loctite 243 to threads.

22. Install the annulus assembly onto the splined hub. Check that the relationship marks align. Push the annulus assembly into the splined hub until the splines of the annulus assembly are flush with the end of the splined hub. Fit brake seal **19** onto the hub swivel.
23. Install retainer plate **20**, making sure the breather hole and brake galleries align. Secure using Verbus Ripp bolts **21** and tighten until the annulus assembly just rocks.
24. Check the seal drag rolling force:
  - a. Use a spring balance and cord wrapped around the planet carrier flange Figure 8-48. Pull the spring balance so that the hub rotates. Do this several times to set the seal and then record the reading.
  - b. Remove the planet gear carrier and tighten the new Verbus Ripp bolts **21** to 166 Nm (122 lb-ft).
  - c. Repeat steps 24 and 24A and record the reading.



- d. To get the rolling force, subtract the seal drag rolling force (Step 24 A) from reading obtained at step 24C. The result should be 1.4 to 15.3 kg (3 to 34 lb).

If the resulting force is outside these limits check that seal **9** is installed correctly and or replace bearings **6** and **11**.

**NOTE:** A high rolling force reading may indicate the oil seal was damaged during installation.

25. Assemble friction plates **22** and counter plates **23** onto the carrier **16**. If the original brake pack is being used, return the plates to their original positions (see Disassembly, step 10). Soak new friction plates in gear oil before assembly.
26. Assemble the brake friction plate **24**. Install retaining ring **25**.
27. If axle is attached to the machine, bleed the brake system. With the engine running, gently apply the brakes and then release them. Check that the piston

activates and retracts correctly and does not stick in the applied position before installing planet gear carrier **27**.

If the brake piston has not retracted, the brake seal or piston assembly may have been assembled incorrectly. Alternatively, there may be residual pressure holding the piston. Unscrew the brake bleed nipple with the engine running and check that the piston retracts when the pressure is released. Investigate the cause if the piston remains in the applied position. See Residual Brake System Pressure in Section 9.

**28.** Press drive shaft thrust pad **26** (chamfered side down) into the recess in planet carrier **27**.

**29.** Install new planet gears **28** in place of any that were removed. Secure with retaining ring **29**.

**NOTE:** The large radius at the end of the bearing bore installs on the pin first.

**30.** Install sun gear **30** onto the drive shaft and secure with external retaining ring **31**. Install new O-ring **32**.

**31.** Install planet gear carrier **27** onto bearing carrier **8**, turning it slightly to engage the gear teeth and align the two tapped holes **A** Figure 8-45 in the bearing carrier. (The tapped holes are diametrically opposite each other.) Ensure that the planet gear carrier butts fully against the bearing carrier.

**NOTE:** Do not strike the center of the planet gear carrier **27** when installed, as this may dislodge drive shaft thrust pad **26**.

**32.** Install screws **33** and tighten to a torque of 56 Nm (41.3 lb-ft).

**33.** Fill the axle hub with oil. See *Preventative Maintenance on page 5-1*.

## Drive Head Repair (Drive Axles Only)

### Disassembly Figure 8-49

**NOTE:** The axle need not be removed to disassemble the drive head.

1. Drain the oil from the axle center casing. Remove the rear drive shaft from the axle.
2. Remove both hub assemblies with drive shafts (see page 8-7).
3. Mark the installation position of the drive head carrier **2** Figure 8-49.

**4.** Remove bolts **1** and remove drive head carrier **2** from the axle casing.

**5.** Clean the drive head carrier and axle casing mating surfaces.

**6.** Pull out tension pins **3** and **4** and remove castellated nuts **5** and **6**.

**7.** Remove bearing outer races **7** and **8**.

**8.** Drive off the taper roller bearing cone **9** from the crownwheel differential case half.

**9.** Remove differential assembly **10** from the carrier.

**10.** Remove retaining bolts **11** and separate case halves **12** and **13**.

**11.** Remove the two differential side gears **14** and thrust washers **15**.

**12.** Remove the four planet gears **16** and thrust washers **17** from trunnion pins (**B**).

**13.** Pull off taper roller bearing cone **18** from differential case half **12**.

**14.** Remove Verbus Ripp bolts **19** and separate the crownwheel **20** from differential case half **13**.



### CAUTION

Do NOT reuse Verbus Ripp bolts. They must be replaced throughout the assembly.

**15.** Use a drive coupling spanner to prevent drive yoke **23** from rotating. Remove pinion nut **21** and washer **22**. Remove the drive yoke.

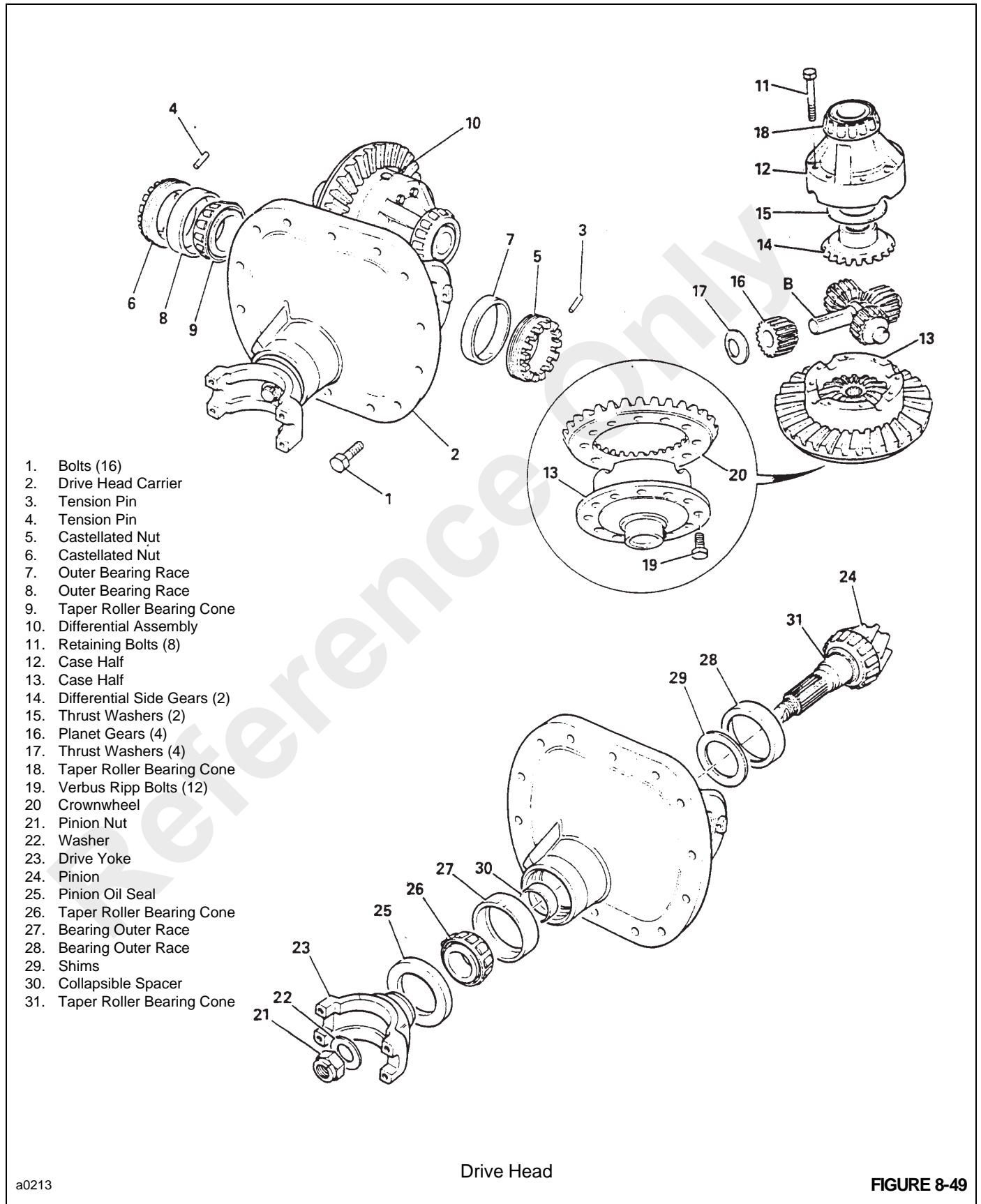
**NOTE:** On later axles, pinion nut **21** and washer **22** are combined. The separate nut and washer should be discarded and replaced with the new combined nut and washer.

**16.** Press pinion **24** from drive head carrier **2**.

**17.** Pull out pinion oil seal **25** and taper roller bearing cone **26**. If necessary remove bearing outer race **27**.

**18.** If necessary, drive out pinion bearing outer race **28** and shim(s) **29** from inner side of the drive head carrier.

**19.** Remove the collapsible spacer **30** and taper roller bearing cone **31** from pinion **24**.



a0213

FIGURE 8-49



**Assembly**

**NOTE:** The crownwheel **20** Figure 8-49 and pinion **24** are matched and should be replaced as a pair if either one is damaged or excessively worn. The differential case halves **12** and **13** are also matched as are gears **14** and **16**. Do not use unmatched halves or gears.

Make sure all bearings are lightly oiled before installing and setting. Make sure bearings are rotated while being set.

1. Install pinion bearing outer race **28** Figure 8-49 to drive head carrier **2** together with required thickness of shims **29** to give correct pinion depth. (See Pinion Depth Setting Procedure on page 8-14). Install the shims behind the outer race Figure 8-49.
2. Install new taper roller bearing cone **31** and a new collapsible spacer **30** onto pinion **24**.
3. Install outer race **27** to drive head carrier **2**.
4. Insert pinion **24** into its bore. (Before inserting verify that the pinion matches the crownwheel. The code numbers etched on the pinion end face and the crownwheel perimeter must be the same).
5. Install new taper roller bearing cone **26**. Pack the cavity between the lips of new oil seal **25** with grease and install the seal to the drive head carrier **2**.
6. Install the drive coupling yoke **23** and secure it with a new combined stake nut **21** and washer **22**.
  - a. Hold the yoke with a drive coupling spanner.
  - b. Tighten the stake nut until end float is almost zero then check the seal drag torque which should be between 0,40 to 0,75 Nm (3.5 to 6.6 lb-ft).
  - c. Continue to tighten the stake nut to collapsible spacer **30** and give a rolling torque of 1,7 to 2,8 Nm (1.3 to 2.1 lb-ft) excluding seal drag, crownwheel not installed.
 

IF THE STAKE NUT IS OVERTIGHTENED, THE COLLAPSIBLE SPACER MUST BE REPLACED.

Make sure that yoke **23** is rotated in both directions to fully seat the bearings before measuring rolling torque.
  - d. When the torque is correct, stake the nut to the pinion shaft, using a square ended staking tool.
7. Install crownwheel **20** to case half **13**, tighten the Verbus Ripp bolts **19** to a torque of 166 Nm (122 lb-ft).
8. Assemble the four planet gears **16** and thrust washers **17** onto the trunnion pins. Install the planet gear assembly and two differential side gears **14** and thrust washers **15** into case half **13**.
9. Position top case half **12** onto bottom half assembly **13** aligning the match mark letters (see Note on page 8-7). Apply Loctite® 243 to the threads of bolts **11**, then install them and tighten to a torque of 56 Nm (32 lb-ft). Check the gears for free rotation.
10. Press taper roller bearing cone **18** onto the spigot of case half **12**.
11. Install the differential assembly **10** into the drive head carrier **2**.
12. Press taper roller bearing cone **9** onto the spigot of case half **13**.
13. Install bearing outer races **7** and **8**, castellated nuts **5** and **6** to drive head carrier **2**.
14. Adjust castellated nuts **5** and **6** to give bearing pre-load (see Note) of 1.36 to 2.5 Nm (1.0 to 1.84 lb-ft).
 

**NOTE:** Measure the pre-load by taking another rolling torque reading and subtract the torque figure measured at step 6C. The difference is the bearing pre-load.
15. Measure the crown wheel backlash, which should be 0.13 to 0.20 mm (0.005 to 0.008 in). Adjust castellated nuts **5** and **6** by equal amounts when altering backlash. When backlash and pre-load are both correct, install tension pins **3** and **4**.
16. Verify that the crownwheel and pinion are set correctly: use an engineers marker on three of the pinion teeth and check markings on the crownwheel are as indicated on page 8-15. Adjust if necessary.
17. Apply Loctite® 275 to the drive head carrier mating face and then install the axle casing (the carrier assembly locates on two dowels). Make sure the assembly is installed in the same match-mark position (see step 3, Disassembly of page 8-11).
18. Apply Loctite® 243 to bolts **1** and install. Tighten the bolts to a torque indicated in Chapter 1, Fasteners and Torque Values.
19. Assemble both hubs and drive shafts and install the rear drive shaft.
20. Fill the axle with recommended oil. See *Preventative Maintenance* on page 5-1.
 

**NOTE:** Tightening torque depends on bolt type. The grade is stamped on the bolt head. If standard grade 8 bolt, tighten to a torque of 72 lb-ft. (98 Nm).

If Verbus Ripp 12.9 grade bolt is used, tighten to a torque of 122 lb-ft. (166 Nm).

Use heavy duty socket.

**CAUTION**

Verbus Ripp bolts must **NOT** be reused.

**DRIVE SHAFTS****Removal**

**NOTE:** Before removing drive shafts always mark both companion flanges and also mark the sliding joints prior to removal.

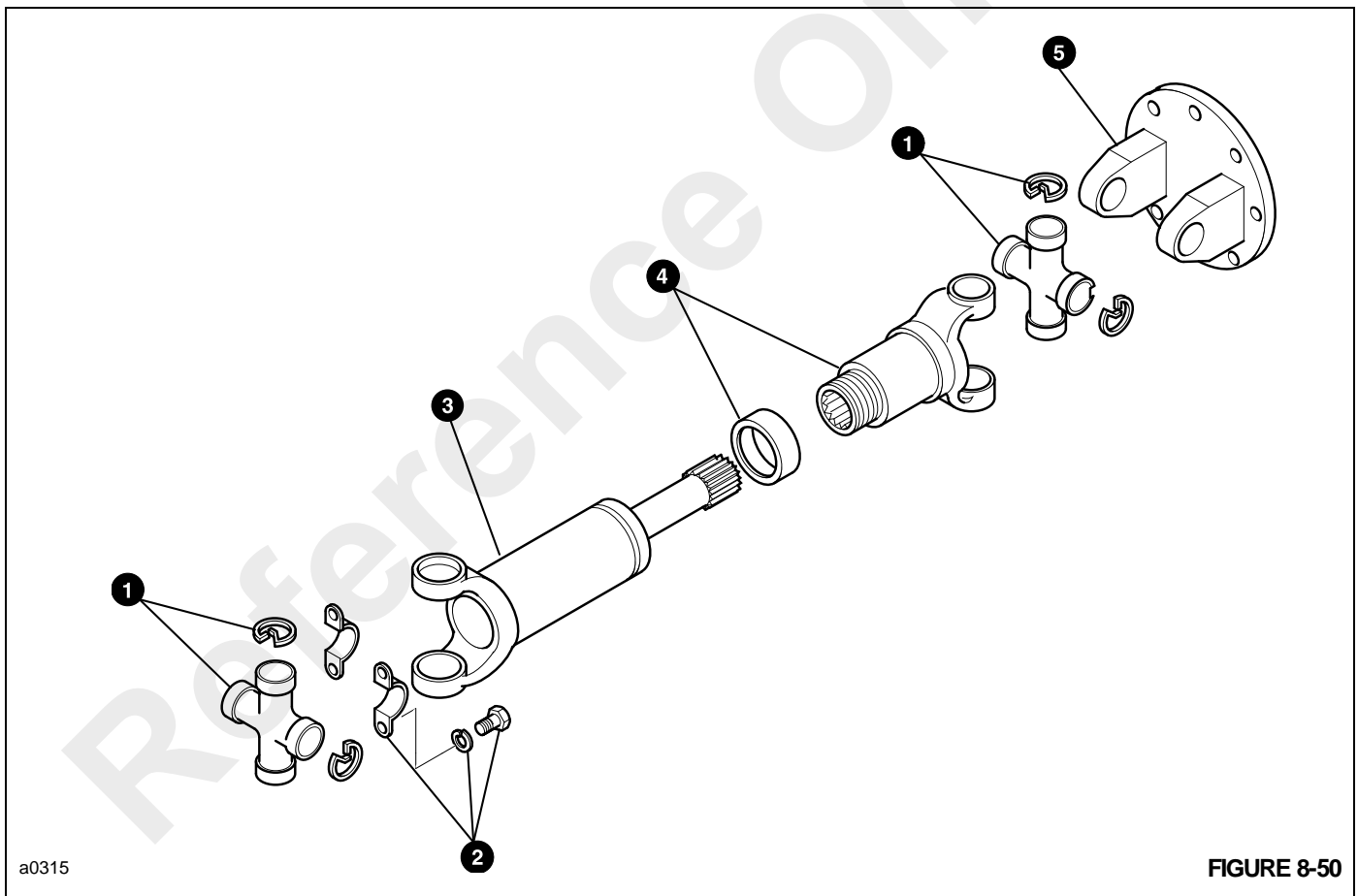
The retaining straps **2** Figure 8-50 and Figure 8-51 stretch with use, therefore these straps must always be replaced with new ones.

**Front Axle Drive Shaft**

1. Remove bolts, lockwashers and mounting straps **2** Figure 8-50 from transmission.
2. Remove flange **5** from the parking brake disc.

**Rear Axle Drive Shaft**

1. Remove bolts, lockwashers and mounting straps **2**, Figure 8-50 from transmission.
2. Remove bolts, lockwashers and mounting straps **2** from rear axle.



a0315

**FIGURE 8-50****Disassembly****Front Axle Drive Shaft**

1. Put the flange yoke **5** Figure 8-50 in a vice. Using pliers, remove two snap rings from the bearing caps in the flange yoke.
2. Apply force on the drive shaft in the direction of the bearings to push the bearings out of the flange yoke.

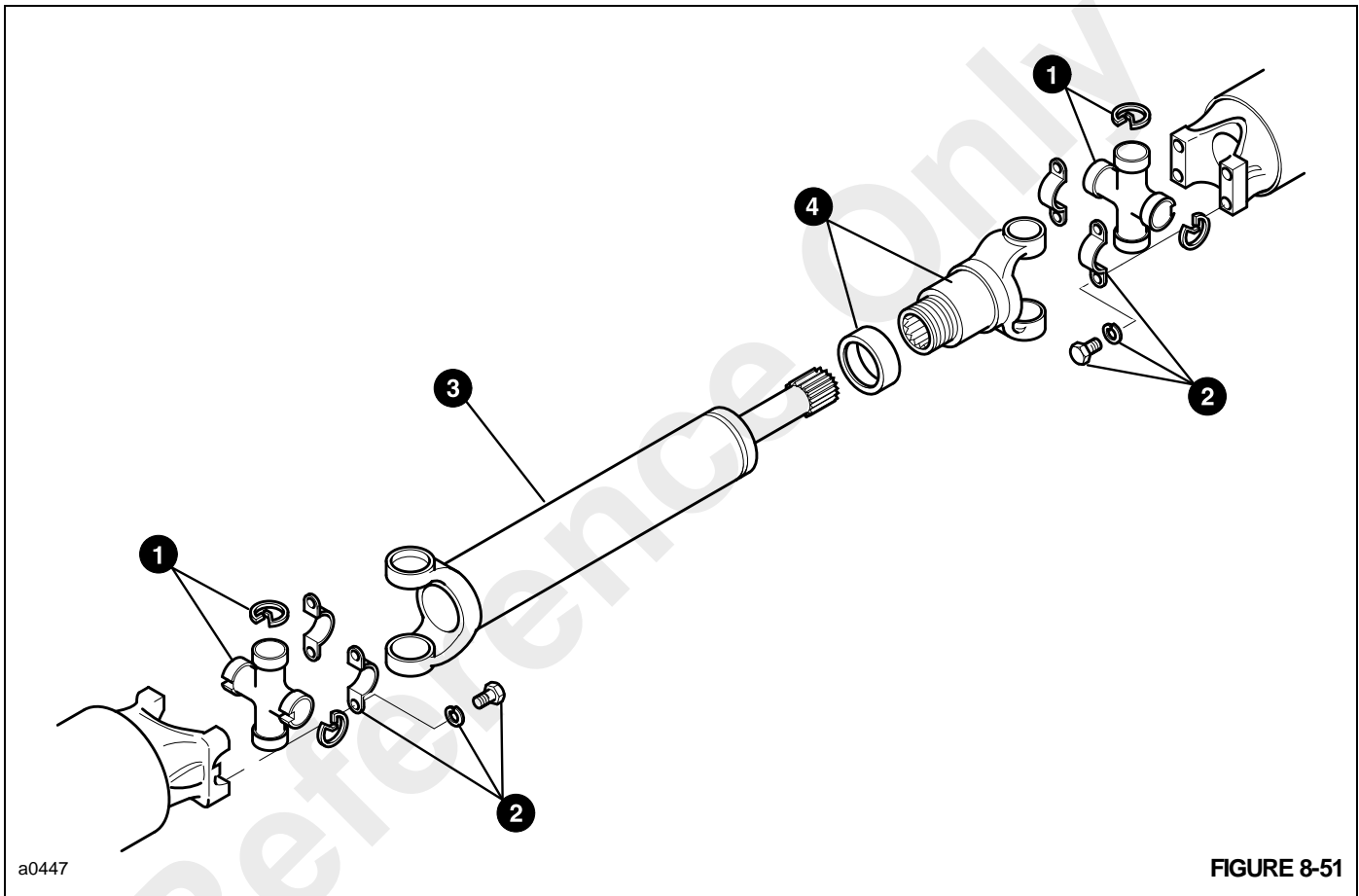
When the bearings are removed, tilt the journal cross to permit removal of the universal joint.

3. Disassemble the journal crosses **1** from the drive shaft using the procedure in step 2. After the snap rings are removed, use a soft drift with a flat face slightly smaller than the diameter of the bearing to remove the bearings.
4. To disassemble the sleeve yoke (**3**) from the slip yoke (**4**), turn the dust cap counterclockwise. When the dust

cap is free, pull the sleeve yoke and dust cap free of the slip yoke.

### Rear Drive Shaft

1. Remove two snap rings from the bearing caps in the slip yoke 4 Figure 8-51.
2. After the snap rings are removed, use a soft drift with a flat face slightly smaller than the diameter of the bearing to remove the bearings.
3. Repeat steps 1 and 2 to the sleeve yoke end.
4. To disassemble the sleeve yoke 3 from the slip yoke 4, turn the dust cap assembly counterclockwise. When the dust cap assembly is free, pull the sleeve yoke and dust cap free of the slip yoke.



### Inspection

Clean all parts with a suitable solvent. Remove all rough areas from any finished surfaces. Make sure the bearing surfaces on the journal crosses are smooth. Do not disassemble the needle bearings. Clean with a brush and compressed air. Apply a small amount of SAE 140 oil into each bearing cap and rotate the bearing on the trunnion to check for wear. If there is any indication of wear or damage to the needle bearings, bearing cap or journal crosses, replace the journal and bearings as an assembly.

Check for damage to the splines of the sleeve yoke. Make sure the splines are clean and smooth. Look for damage or distortion of the drive shaft tube. Damage can cause failure of the drive shaft under high torque loads. The drive shaft

must be straight to inhibit vibration during operation. Replace the drive shaft if there is damage.

### Assembly

#### Front Axle Drive Shaft.

1. If new journal and bearings are not being installed, inspect the seals in the bearing retainers. If they are damaged in any way, replace the complete journal and bearing assembly.
2. Install the journal cross into the yoke of the sleeve yoke. The relief must be towards the sleeve yoke.
3. Apply a small amount of SAE 140 oil to the trunnions on the journal cross. Press the bearings and cap

assemblies into place. Use care not to cause damage to the bearings or caps. Install the snap rings. Make sure the snap rings are engaged fully in the groove.

4. Repeat steps 1 through 3 on opposite end of drive shaft.
5. Repeat steps 1 through 3 to install the flange yoke to the drive shaft.
6. Apply SAE 140 oil to splines on the sleeve yoke 3 Figure 8-50 and Figure 8-51. Assemble the dust cap assembly to the sleeve yoke. Slide the sleeve yoke into the slip yoke (4). Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.

### Rear Axle Drive Shaft

1. If new journal and bearings are not being installed, inspect the seals in the bearing retainers. If they are damaged in any way, replace the complete journal and bearing assembly.
2. Install the journal cross into the yoke of the sleeve yoke. The relief must be towards the sleeve yoke.
3. Apply a small amount of SAE 140 oil to the trunnions on the journal cross. Press the bearings and cap assemblies into place. Use care not to cause damage to the bearings or caps. Install the snap rings. Make sure the snap rings are engaged fully in the groove.
4. Repeat steps 1 through 3 on opposite end of drive shaft.
5. Apply SAE 140 oil to splines on the sleeve yoke 3 Figure 8-50 and Figure 8-51. Assemble the dust cap assembly to the sleeve yoke. Slide the sleeve yoke into the slip yoke 4. Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.

## Installation

### Front Axle Drive Shaft

1. Fasten the flange yoke 5 Figure 8-50 to the parking brake disc on the front axle with eight bolts, lockwashers and nuts.

**NOTE:** The drive shaft must have both ends exactly on the same plane as shown in X Figure 8-52. The yokes must not be at right angles as at Y or at an intermediate angle as at Z.

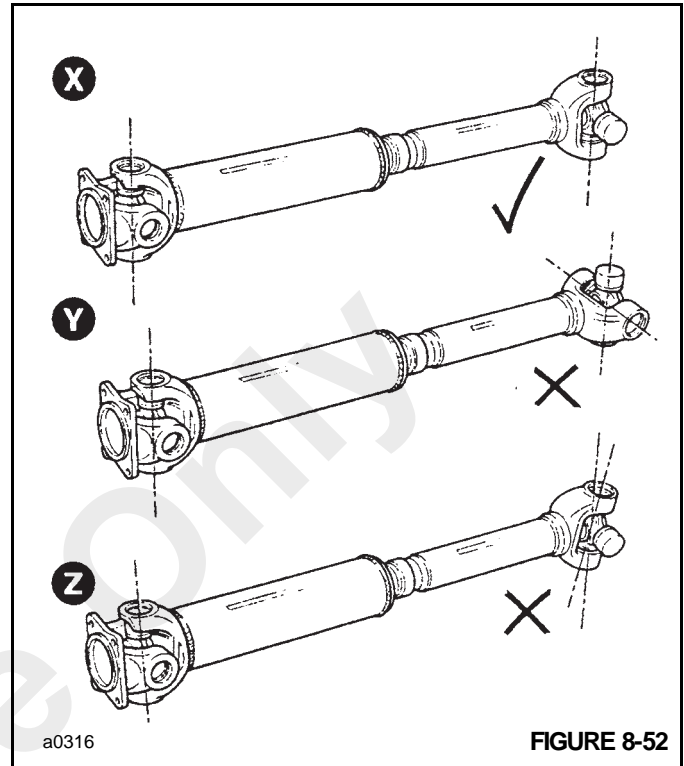


FIGURE 8-52

2. Fasten the other end to the transmission using a new strap kit.

**NOTE:** The retaining straps (2) stretch with use, therefore these straps must always be replaced with new ones.

3. Apply grease with a grease gun to the fittings on the journal crosses and on the slip joint. Apply grease until it exists through the seals. See *Lubrication Procedure on page 8-30*.
4. Check the drive shaft for correct balance before the crane is put into operation. Lower the outriggers to lift the wheels off the ground. Operate the drive train and check for vibration. If vibration is found, stop the engine and check the drive shaft. Make sure the drive shaft yokes are in the same plane.

### Rear Axle Drive Shaft

1. Fasten cross 1 Figure 8-51 to the front axle yoke using a new strap kit 2.

**NOTE:** The retaining straps 2 stretch with use, therefore these straps must always be replaced with new ones.

2. Fasten the other end cross 1 to the transmission yoke with a new strap kit 2.

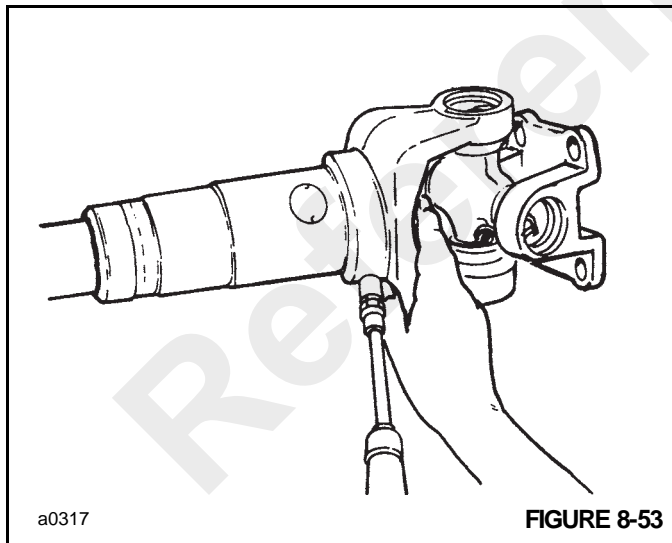
**NOTE:** The drive shaft must have both ends exactly on the same plane as shown in X Figure 8-52. The yokes must not be at right angles as at Y or at an intermediate angle as at Z.

3. Apply grease with a grease gun to the fittings on the journal crosses and on the slip joint. Apply grease until it exists through the seals. See Lubrication Procedure on this page.
4. Check the drive shaft for correct balance before the machine is put into operation. Lower the outriggers to lift the wheels off the ground. Operate the drive train and check for vibration. If vibration is found, stop the machine and check the drive shaft. Make sure the drive shaft yokes are in the same plane.

**Lubrication Procedure**

The drive shaft is an important part of the drive train and needs regular maintenance. There is a grease fitting on the slip joint and on each journal cross. Apply grease to these fittings every week or 50 hours of operation, whichever occurs first. Use Lithium based, E.P. No. 2 bearing grease. Always apply enough grease to the fitting to remove old grease. On the slip joint, apply grease to the fitting until the grease comes through the hole in the end off the shaft. Put your finger over the hole Figure 8-53 and continue to apply grease until the grease shows at the seal on slip joint.

At each lubrication, check the drive shaft for side movement. As wear in the bearings increases, the side movement will increase. Movement must be to minimum to prevent vibration during operation.



**WHEEL & TIRES**



**WARNING**

Never try to disassemble the wheel until all air is released from the tire. The retaining ring and rim of the wheel and tire can come off with explosive force and can cause serious injury or death. Be extremely careful when working with them. Always use a tire and rim cage guard when inflating tires.

**Tire Inflation**

Check the tire pressure daily before operation. Also look for cuts and damage.

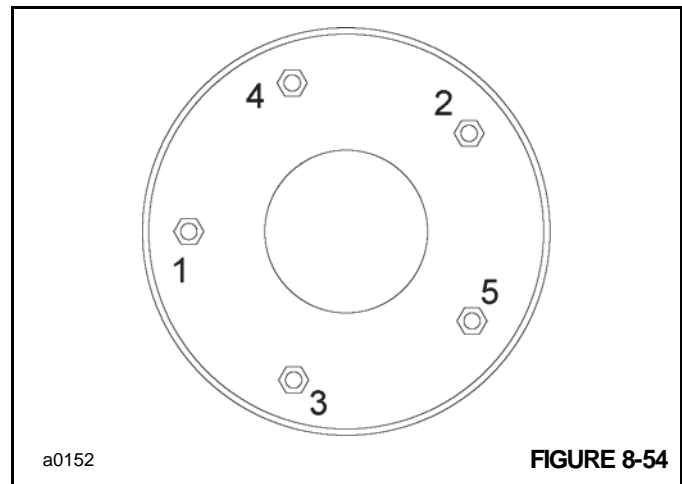
**Tire Pressures**

Tire Size	Pressure
12:R20 Radial	9.31 bar (135 psi)

**Wheel Stud Nuts**

The tightening order of the stud nuts is shown in Figure 8-54. Check the tightness of the lug nuts weekly or after every 50 hours of operation, whichever occurs first.

Wheel stud torque is 680 Nm (500 lb-ft).



## SECTION 9 BRAKE SYSTEM

### SECTION CONTENTS

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### TECHNICAL DATA

#### Front Axle Brakes

Type .....	Oil-immersed multi-plate disc
Actuation .....	Hydraulic
Location .....	Inboard - Axle center casing (2 brake sets)
Friction Plates .....	5 per set
Outside Diameter .....	220 mm (8.66 in)
Inside Diameter .....	180 mm (7.09 in)
Nominal facing area/plate .....	12,616 mm <sup>2</sup> (19.5 in <sup>2</sup> )
Hydraulic Piston Diameter .....	216 mm (8.5 in)
Piston Operation .....	Standard retraction

#### Rear Axle Brakes

Type .....	Oil-immersed multi-plate disc
Actuation .....	Hydraulic
Location .....	Outboard - Axle hubs
Friction Plates .....	3 per set
Outside Diameter .....	220 mm (8.66 in)
Inside Diameter .....	180 mm (7.09 in)
Nominal facing area/plate .....	12,616 mm <sup>2</sup> (19.5 in <sup>2</sup> )

Hydraulic Piston Diameter . . . . .	216 mm (8.5 in)
Piston Operation . . . . .	Standard retraction

**Accumulator**

Type . . . . .	Piston, Hydro-pneumatic
Volume . . . . .	2632 cu. cm (120.63 cu. in)
Nitrogen Recharge Pressure . . . . .	51.71 ± 2.75 bar (750 ± 40 psi)

**Accumulator Charging Valve**

Nominal Accumulator Charge Rate . . . . .	10.2 ± 1.9 L/min (2.7 ± 0.5 gpm)
Nominal High Limit . . . . .	137.90 ± 3.45 bar (2000 ± 50 psi)
Nominal Low Limit . . . . .	113.76 ± 3.45 bar (1650 ± 50 psi)

**Priority Flow Control Valve**

Priority Flow Set At . . . . .	12.3 L/min (3.25 gpm)
Control Pressure . . . . .	7.58 bar (110 psi)
Relief Valve Setting . . . . .	172.37 bar (2500 psi)

Reference

## DESCRIPTION

There are two brake systems used on the crane; the service brake system and the parking brake system.

### Service Brake System

The service brake system Figure 9-1 consists of the hydraulic pump, a relief valve included in the priority flow control valve, an accumulator charging valve, a low pressure warning switch, an accumulator, a needle valve, a brake modulating valve, a brake light switch and the front and rear axle service brakes.

#### *Description Of Operation*

##### Hydraulic Pump

The secondary hydraulic pump (Section No. 2) supplies hydraulic oil flow to the priority flow control valve Figure 9-1.

##### Priority Flow Control Valve

The priority flow control valve in normal operation supplies oil to the accumulator charging valve. If oil is required for the

steering operation the priority flow control valve shifts to furnish flow to the steering system. (See Steering System, Section 10) The priority flow control valve also includes the relief valve used to protect the steering and brake systems.

##### Accumulator Charging Valve

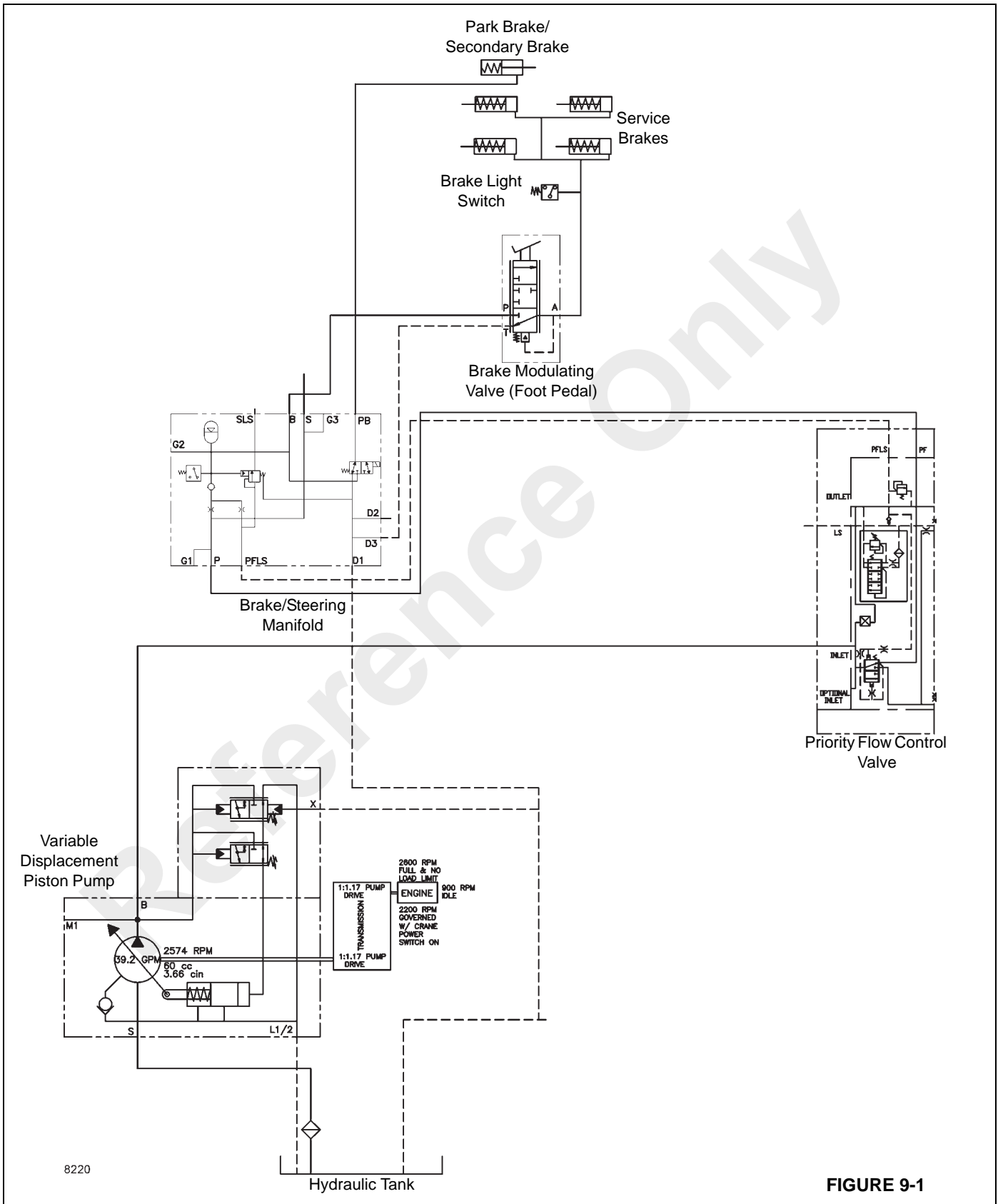
The accumulator charging valve supplies oil to the accumulator on demand. This is accomplished at a preset rate at a selected pressure; neither of which is adjustable.

The flow to the downstream brake modulating valve will be reduced fractionally for a short time when the accumulator is charging. This does not noticeably affect the operation of these components. Full system pressure is available to the downstream components at all times, providing oil delivery and pressure from the pump and relief valve are not impeded.

The accumulator charging flow rates and upper and lower pressure limits are set at the time of manufacture and are not adjustable.

Reference





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FIGURE 9-1

**Low Pressure Warning Switch**

The low pressure warning switch illuminates a red light on the dash when the brake pressure goes below 58.61 bar (850 psi). When the red light illuminates, there still is enough pressure for brake application to stop the crane. After which, the brake system must be checked and repaired.

**Accumulator**

The accumulator is a hydro-pneumatic, piston-type accumulator. This means that the accumulator is charged with nitrogen and stores hydraulic fluid to a pressure of 137.90 bar (2000 psi) for brake system usage.

**Needle Valve**

The needle valve is used during service of the brake system. When closed, it shuts off the hydraulic supply from the accumulator, holding a pressure in the accumulator. This eliminates the need to charge the accumulator after brake system service.

**NOTE:** The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

**Brake Modulating Valve**

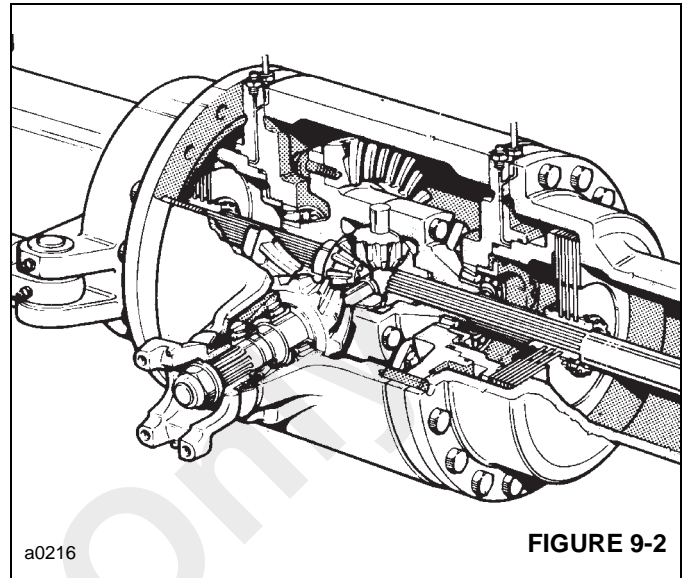
The brake modulating valve is a closed-center spool design. When the valve is in no-applied position, brake port, **A** Figure 9-1 is open to tank port **T**. As the valve is initially actuated, tank port **T** is closed off from brake port **A**. Additional actuation opens pressure port **P** to brake port **A**. More input force will increase the pressure to brake port **A** until actuation effort and hydraulic reaction forces are balanced. When actuation is released, the valve returns to its non-applied position.

**Brake Light Switch**

The brake light switch illuminates the brake lights when the brake modulating valve builds system pressure to 4.14 bar (60 psi).

**Front Axle Brakes**

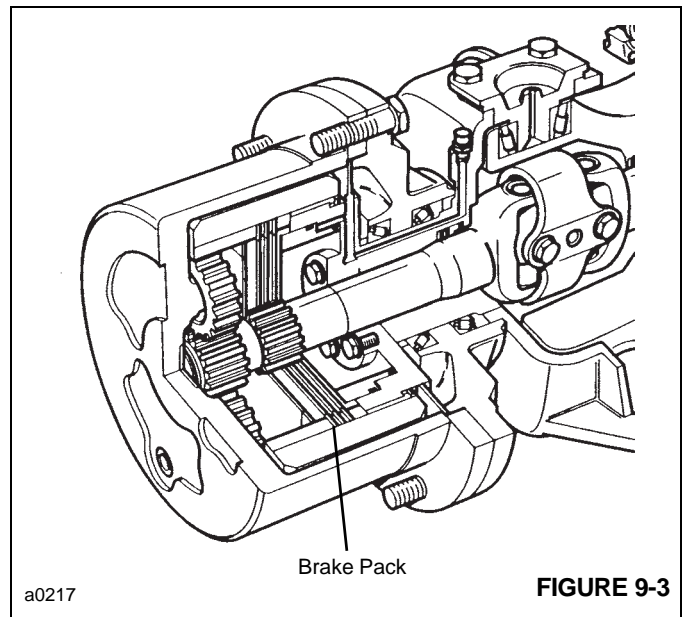
The front brakes are self-adjusting oil immersed and are located on both sides of the axle center housing Figure 9-2. Each brake assembly consists of five friction plates and six counter plates. The brakes are applied when the brake pedal in the operator's compartment is actuated. Brake fluid is forced from the master cylinder through the brake lines to both of the axle brakes. The brake fluid under pressure reacts against the brake pistons, forcing the friction plates against the counter plates, slowing and/or stopping the crane.



**FIGURE 9-2**

**Rear Axle Brakes**

The rear brakes are self-adjusting, oil immersed and are located in each axle hub Figure 9-3. Each brake assembly consists of three friction plates and four counter plates. The brakes are applied when the brake pedal in the operator's compartment is actuated. Brake fluid is forced from the master cylinder through the brake lines to both of the axle brakes. The brake fluid under pressure reacts against the brake pistons, forcing the friction plates against the counter plates, slowing and/or stopping the crane.



**FIGURE 9-3**

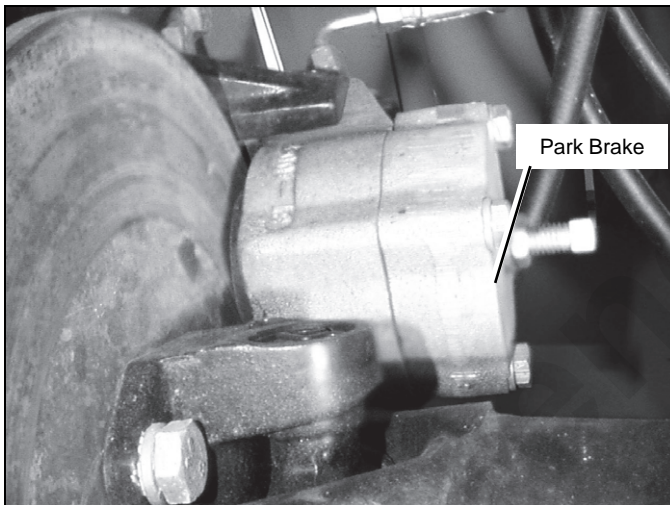
## Parking Brake System

### Description Of Operation

The parking brake system consists of a two-way switch in the instrument panel, a solenoid valve and a parking brake. The system connects into the service brake system and uses the accumulator for system pressure.

### Parking Brake

The parking brake is a disc-type brake Figure 9-4. The brake disc is attached to the input shaft of the front axle. The brake is attached to the frame behind the front axle. When the parking brake switch is placed in the engage position, hydraulic supply is shut off to the parking brake and the springs in the parking brake apply the brake pads against the brake disc, holding the crane from moving.



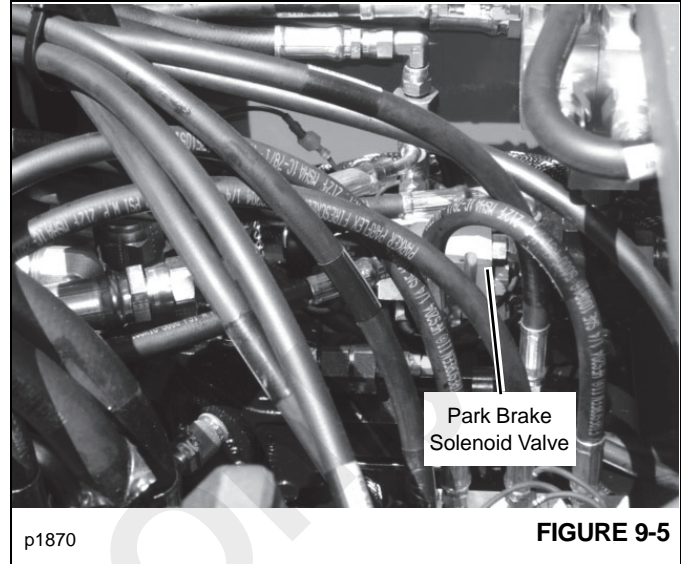
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FIGURE 9-4

### Parking Brake Solenoid Valve

The parking brake solenoid valve Figure 9-5 is activated by the parking brake switch in the operator's instrument panel. It is a normally-closed solenoid valve. When the switch is placed in the ENGAGE position, no current is sent to the solenoid valve, thus the solenoid valve remains closed and the parking brake is engaged.

When the parking brake switch is placed in the DISENGAGE position, electrical current is sent to the solenoid valve. The solenoid shifts the spool in the valve to open the circuit to the parking brake. The hydraulic fluid, under pressure, disengages the brake pads from the brake disc. Even though the parking brake switch may be in the DISENGAGE position, in the event of a loss of pressure in the accumulator below what it takes to apply the service brakes, the parking brake will engage.



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FIGURE 9-5

## MAINTENANCE AND ADJUSTMENTS

### Service Brake Bleeding

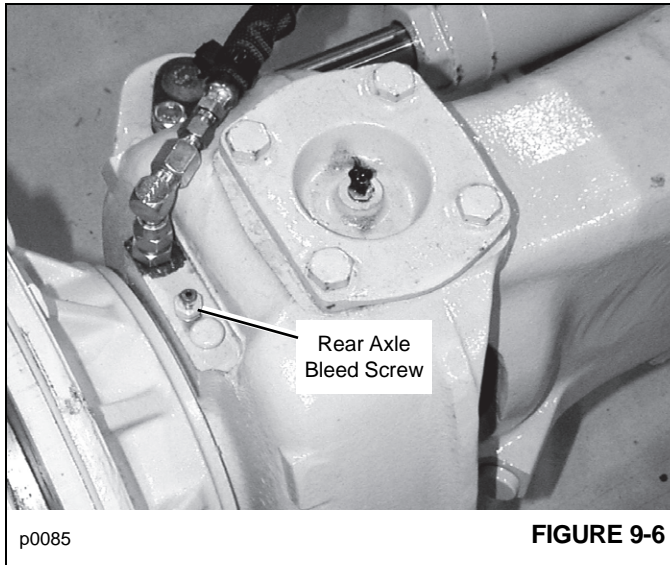
When ever a brake line is disconnected, the brake system must be bled to remove any trapped air. Air in the brake lines will cause the brakes to be spongy.

**NOTE:** Before working on the brake system, make sure the crane is on level ground and that all four wheels are chocked.

The accumulator must be charged before this operation can be performed. If you are not sure the accumulator is charged, engage the parking brake, start the engine and let it run for several minutes.

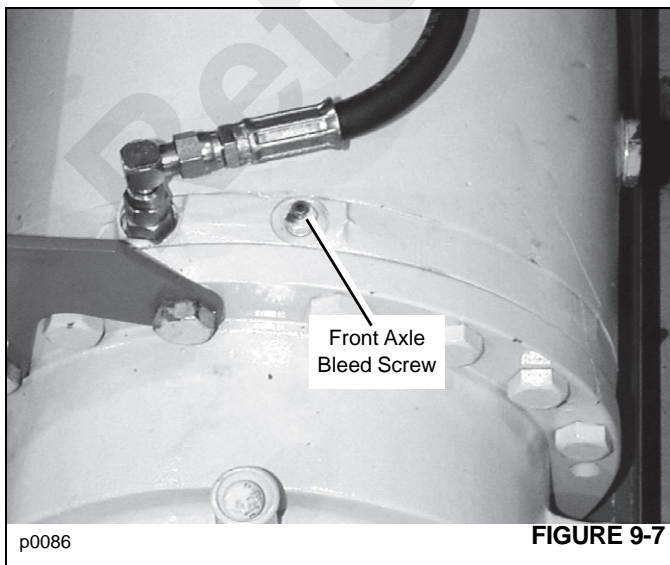
### Rear Axle

1. Engage the parking brake and shut off the engine. Block the rear wheels on both sides.
2. Attach a tube to the right hand bleed screw **A** Figure 9-6 ensuring that the free end of the tube is immersed in fluid contained in a suitable container.
3. Open the brake bleeder screw and apply full pedal strokes of the brake pedal until all air is expelled.
4. Close the brake bleed screw with the pedal fully depressed.
5. Repeat steps 2 through 4 using the left hand bleed screw.



**Front Axle**

1. Engage the parking brake and shut off the engine. Block the rear wheels on both sides.
2. Attach a tube to one of the wheel bleed screws Figure 9-7 ensuring that the free end of the tube is immersed in fluid contained in a suitable container.
3. Open the brake bleeder screw and apply one rapid stroke of the pedal followed by three rapid short strokes from the pedal half way down. After the third short stroke allow the pedal to return quickly to its stop.
4. Continue bleeding normally until all air is expelled. Close the brake bleed screw with the pedal fully depressed.
5. Repeat steps 2 through 4 for the other side.

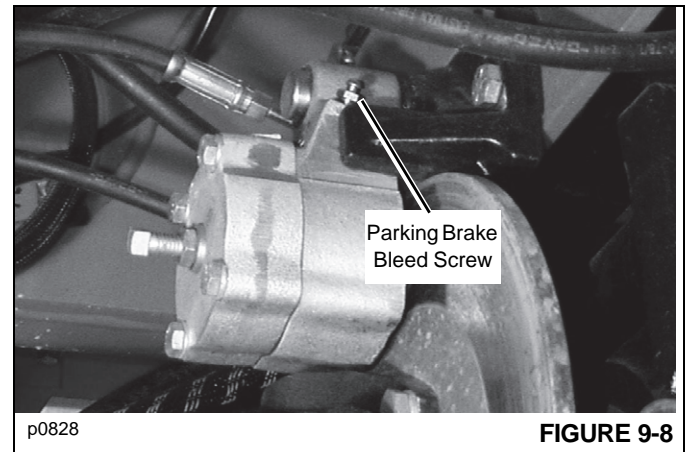


**Parking Brake Bleeding**

**NOTE:** Before working on the brake system, make sure the crane is on level ground and that all four wheels are chocked.

The accumulator must be charged before this operation can be performed. If you are not sure the accumulator is charged, engage the parking brake, start the engine and let it run for several minutes.

1. Engage the parking brake and shut off the engine. Block all wheels on both sides.
2. Attach a tube to the bleed screw on the parking brake Figure 9-8 and place the other end in a suitable container.
3. Open the bleed screw, then disengage the parking brake.
4. Observe the fluid exiting the hose. When there is no air or fluid being released, close the bleed screw with the parking brake still disengaged.
5. Engage the parking brake.
6. Repeat steps 3-5 as needed until no air is release from the fluid.



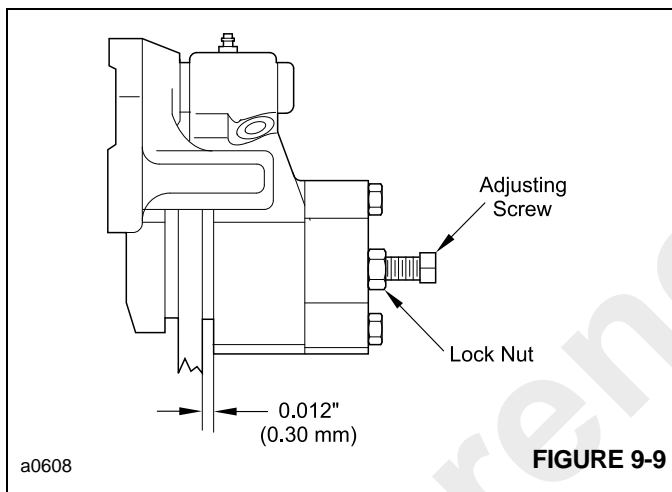
**Parking Brake Adjustment**

**! WARNING**

Before adjusting the parking brake discs, make sure that the machine is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the adjustment.

When the parking brake is engaged and it will not hold the crane in position it may be necessary to adjust the parking brake disc pads.

1. Shut off the engine and place chock blocks in front and behind all four wheels. Release the parking brake. Check that the brake moves freely on the guide/slide pin.
2. Loosen the lock nut and adjusting screw Figure 9-9.
3. Place a 0.030 mm (0.012 in) feeler gauge between the disc and one of the linings.
4. Tighten the adjusting screw until it is just possible to remove the feeler gauge.
5. Tighten the jam nut while holding the adjusting screw with a wrench. Remove the feeler gauge.
6. Engage the parking brake. Then, release the parking brake and recheck that the brake moves freely on the guide/slide pin.



## Accumulator Charging

The accumulator must be charged with NITROGEN. Do not use compressed air. Remove the rubber cap over the charging valve on top of the accumulator and install nitrogen charging apparatus. Charge the accumulator to  $51.71 \pm 2.75$  bar ( $750 \pm 40$  psi).

## Residual Brake System Pressure

If residual pressure is greater than the pressure required to overcome the brake retraction springs in the axle, brake piston retraction will not occur resulting in excessive heat and wear on the brake components,

If the residual pressure in the braking system is above 0.35 bar (5 psi) in the hot condition, the system should be checked to identify the cause of the problem.

**NOTE:** Pressure cannot build up in the hydraulic tank until the oil is hot, or if the pressure is vented by removing the tank cap/breather.

## Checking For Residual Pressure

The following should be done with the engine running and the hydraulic oil at working temperature.

1. Apply and release the brakes. Check that the brakes release immediately.
2. If the brakes do not release immediately, place a container under the axle hub to collect any spilled oil. Unscrew the bleed nipple on the axle to release any residual pressure.

**NOTE:** The same effort should be needed to rotate the hub with bleed nipple either open or closed. If the problem affects only one hub, disassemble and inspect the affected hub.

3. If the brakes release immediately, residual pressure should be suspected.
4. If the brakes do not release immediately, tighten the bleed nipple and check the following:
  - a. Operation of the hydraulic tank breather.
  - b. Foot brake valve operation.
  - c. Hydraulic tank is overfilled.

## TESTS

### Brake Piston Seal Leakage Test (Front Axle Only)

The following test procedure explains how to check if a brake piston is severely damaged/destroyed or if the seals have a small cut or nick. The test procedure must only be done when the axle is COLD.

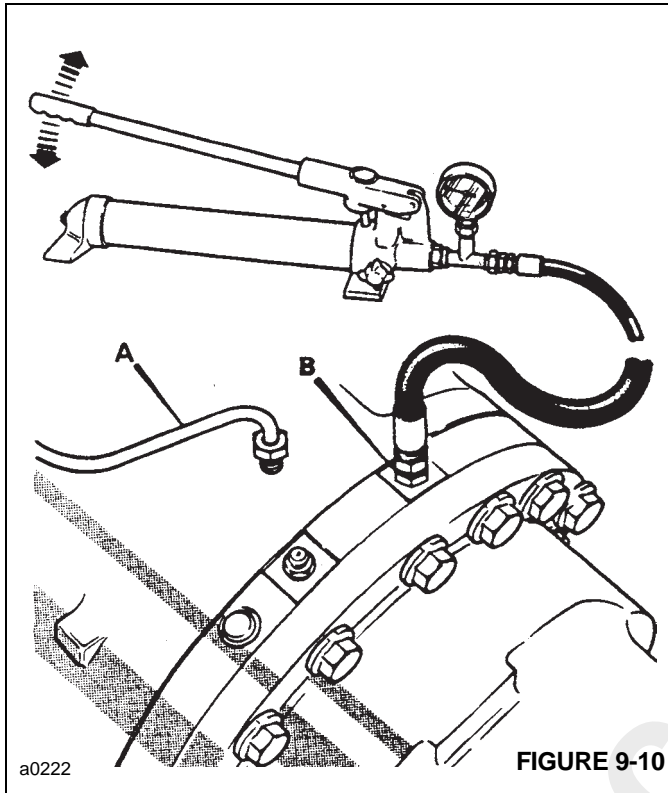
**NOTE:** Before working on the brake system make sure the crane is on level ground and chock all four wheels.

Do not drive the crane with any part of the brake system disconnected. When the test has been completed, reconnect all brake lines and bleed the brake system using recommended procedures, page 9-6.

1. With the engine shut off and the parking brake engaged, actuate the brake foot pedal until no resistance is felt and the system pressure has been released.

**NOTE:** Do not disconnect any lines until the brake circuit pressure has been released.

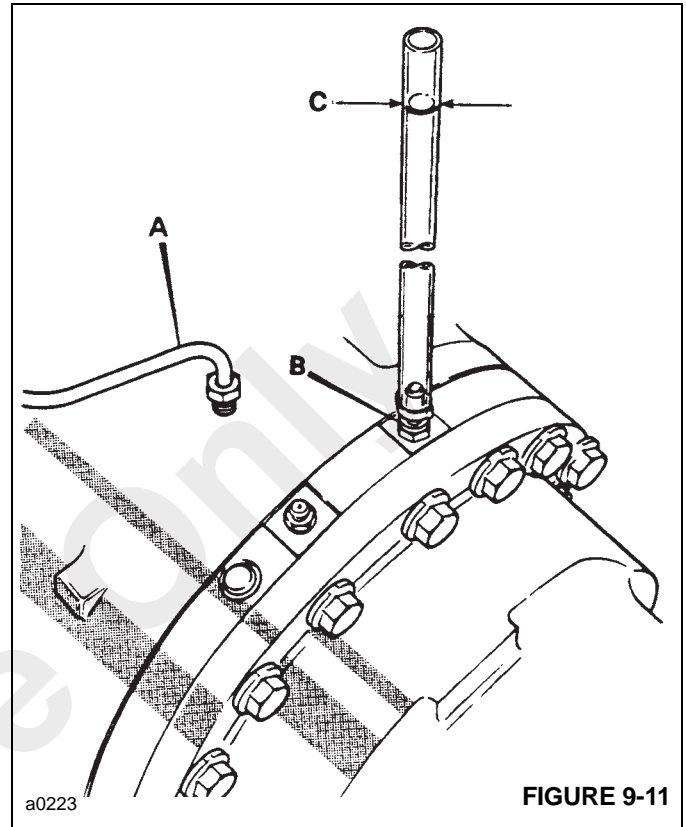
2. Remove and cap the brake piston feed line **A** Figure 9-10.



3. To check for severe piston seal damage:
  - a. Fill the housing of hand pump with Mobil fluid 424, or equivalent hydraulic oil.
  - b. Install the hand pump fitted with a 0 to 68.90 bar (0 to 1000 psi) pressure gauge to port B Figure 9-10.

**NOTE:** The hand pump MUST be filled with Mobil fluid 424 or equivalent hydraulic oil. System pressure is 37.90 bar (550 psi) DO NOT exceed 41.34 bar (600 psi).

- c. Use the hand pump to generate a pressure in the brake piston housing.
  - d. If the pressure falls off rapidly, or if no pressure reading can be obtained, the seals are severely damaged and must be replaced.
4. If pressure falls off slowly, the piston seals may have small cuts or nicks. To verify for small cuts or nicks in the piston seals perform the following test:
  - a. Install an adapter fitted with a piece of clear tube (approximately 120 mm (4.75 in) long) to the brake piston port B Figure 9-11.



**NOTE:** The tube must be kept vertical during the test. Use tape to attach the tube to the side of machine.

- b. Fill the tube until it is approximately three quarters full with Mobil fluid 424 or equivalent hydraulic oil.
  - c. Using a suitable pen, mark the level line (C) of the fluid in the tube.
  - d. After approximately 1/2 hour, check if the level has dropped below the original marked line. If it has then check the brake piston seals for slight nicks, cuts or general wear.
5. Repeat steps 3 through 5 for the opposite brake piston seals.
6. Reconnect all brake lines and bleed the brake system as recommended on page 9-6.

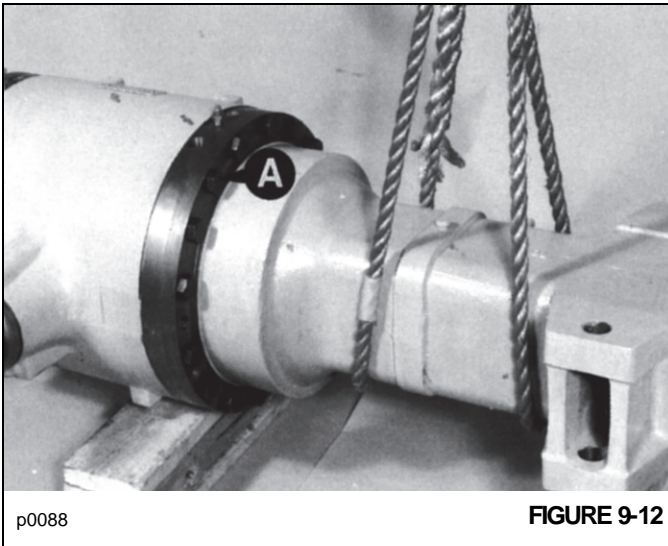
## SERVICE BRAKE REPAIR

### Front Axle Brakes

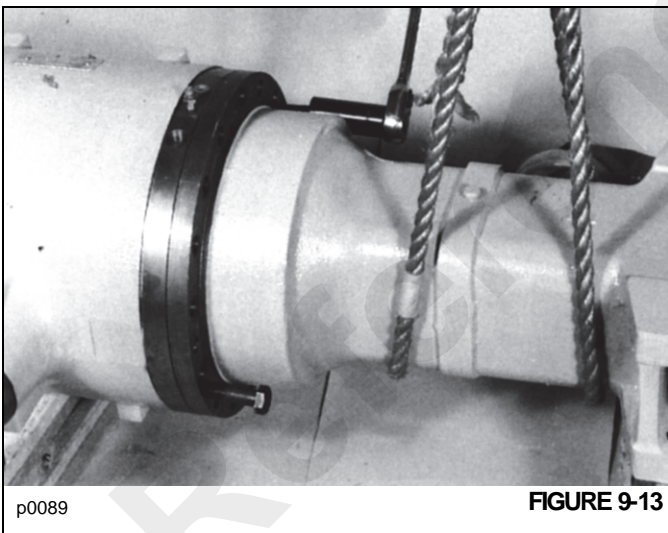
**NOTE:** It is recommended that the axle be removed from the machine when disassembling the front axle brakes. See Servicing the Front Axle in Section 8.

**Disassembly**

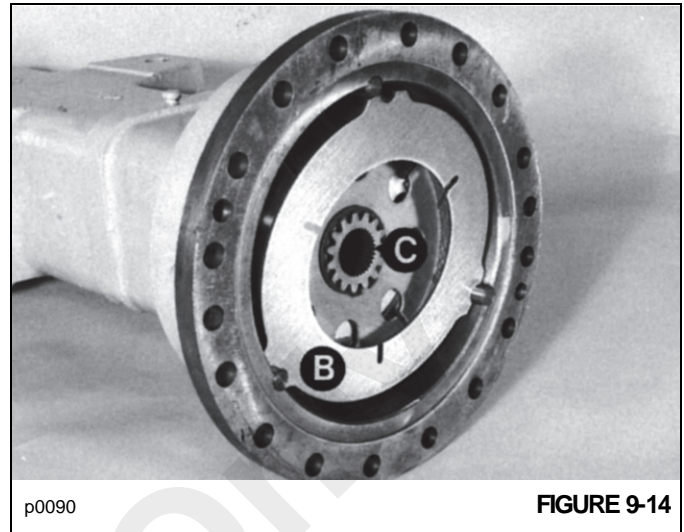
1. Support the axle arm Figure 9-12 and remove bolts A.



2. Jack the axle arm off the drive head, using drive head securing bolts Figure 9-13. Remove all traces of gasket from the mating surfaces.

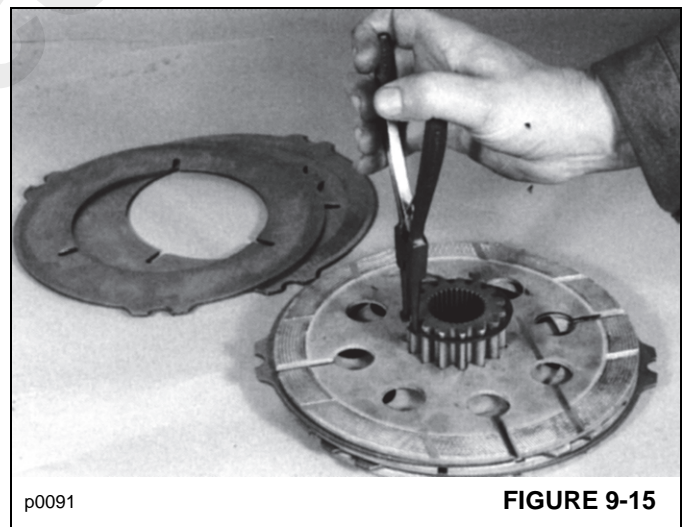


3. There are two counterplates **B** Figure 9-14 one at each end of the brake pack, which are secured to the plate carrier **C**. If the plates are to be reused, note their position and which way round they are then remove the brake pack.

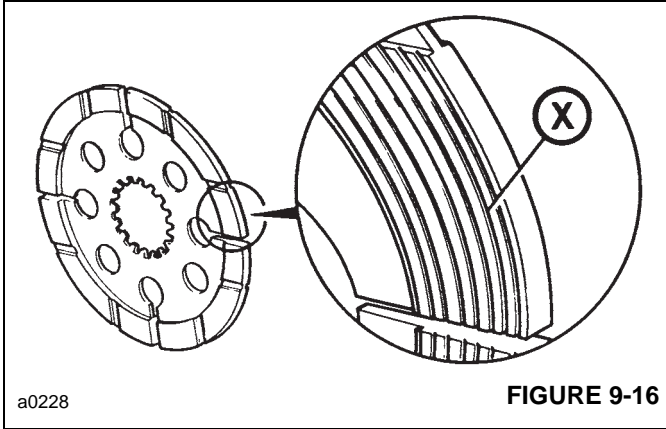


4. Remove the retaining ring Figure 9-15. If the brake pack is to be reused, note the position of the plates before removing them.

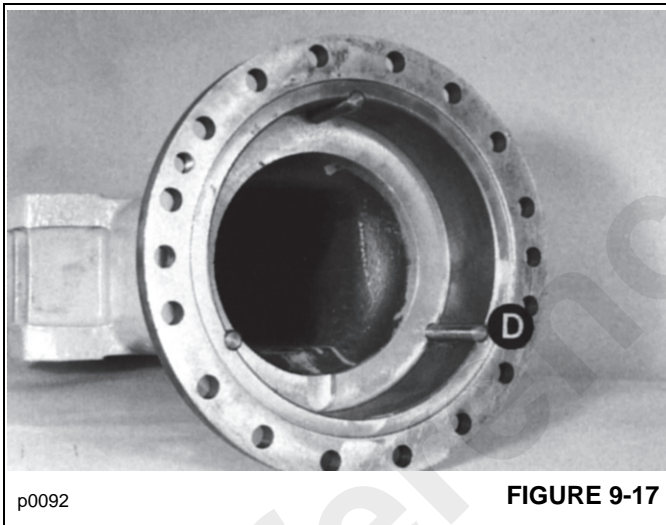
**NOTE:** The planet carrier has an internal chamber at the end which faces away from the drive head.



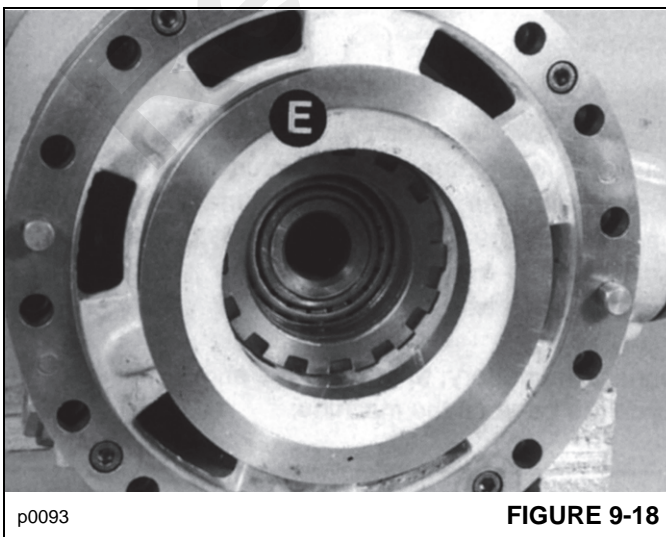
5. Wear limit of friction plates is to the depth of the circumferential grooves **X** Figure 9-16. Check all plates for flatness and damage. (Some scoring of the counterplates is normal.) Completely replace the brake pack if worn or damaged. Do not replace individual plates.



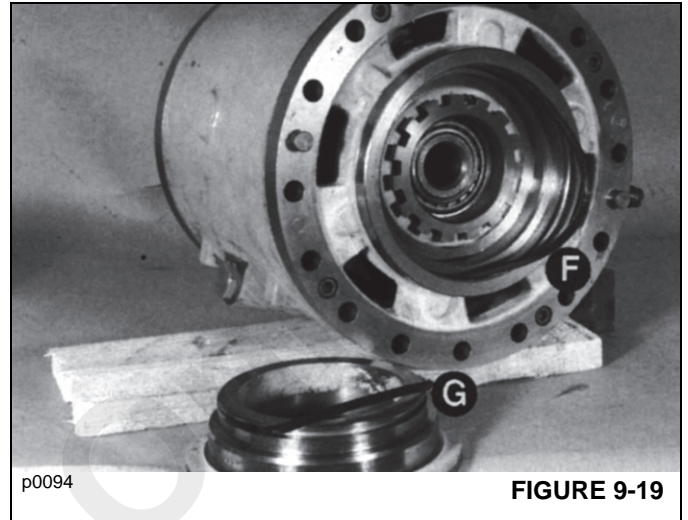
6. Remove the three reaction pins **D** Figure 9-17. Inspect for damage.



7. Carefully remove brake piston **E** Figure 9-18 from its housing, if removal is necessary. A hydraulic hand pump can be used to force the piston out of the housing.

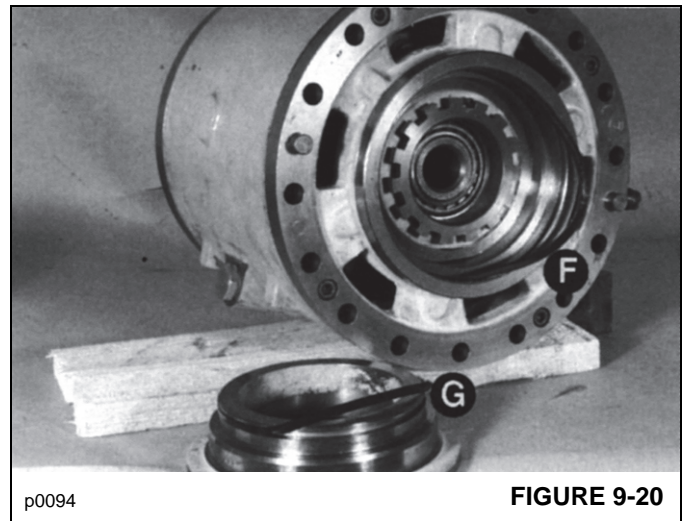


8. Remove and discard seals **F** and **G** Figure 9-19. Inspect the housing for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.



### Assembly

1. Install new seals **F** and **G** Figure 9-20. Make sure they seat squarely in their grooves.



2. Carefully press piston **E** Figure 9-21 all the way into its housing.



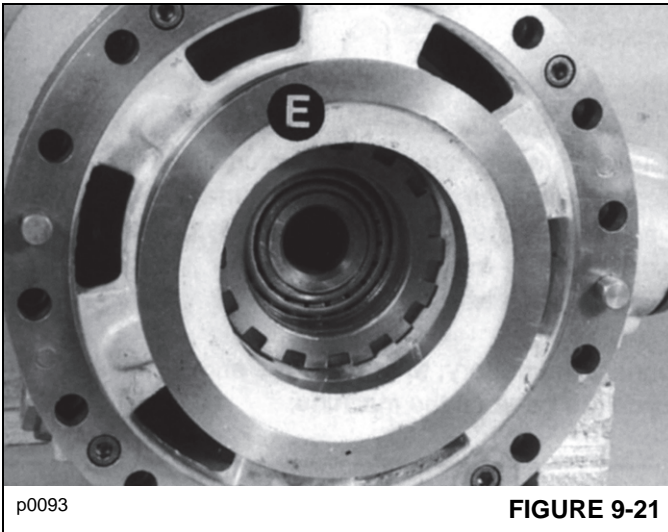


FIGURE 9-21

3. Assemble the friction plates and counterplates onto the carrier. If the original brake pack is being reused, return the plates to their original positions (see Disassembly step 3). Soak new friction plates in gear oil before assembly. Install retaining ring Figure 9-22.

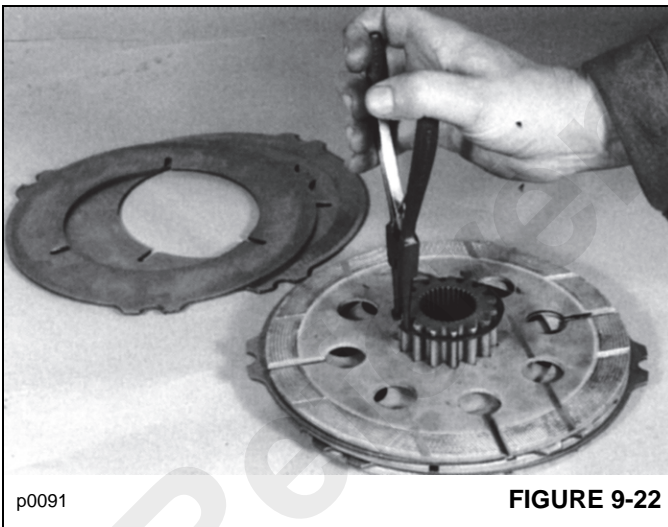


FIGURE 9-22

4. Locate the three reaction pins **D** Figure 9-23 into their grooves, securing them with grease. Push the pins fully into their location holes in the housing.

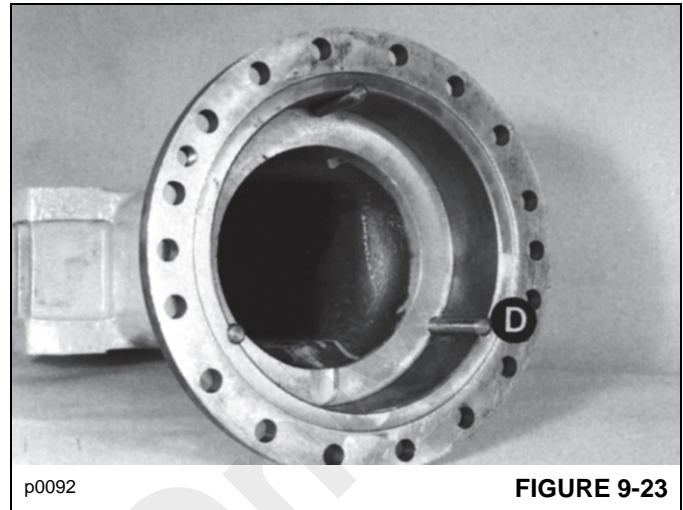


FIGURE 9-23

5. Install one counterplate **B** Figure 9-24 into the housing, then the brake pack, then the other counterplate. Ensure that the chamfered end of the brake carrier **C** faces away from the drive head. Return reused counterplates to their original positions. Push the brake pack fully home.

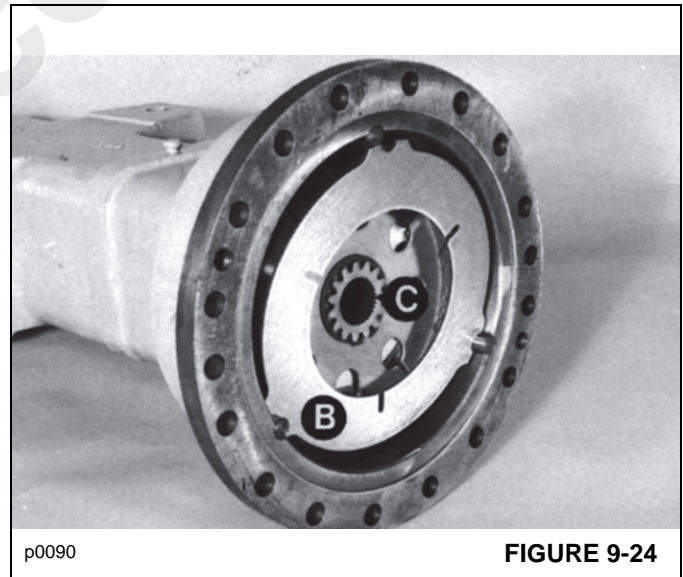
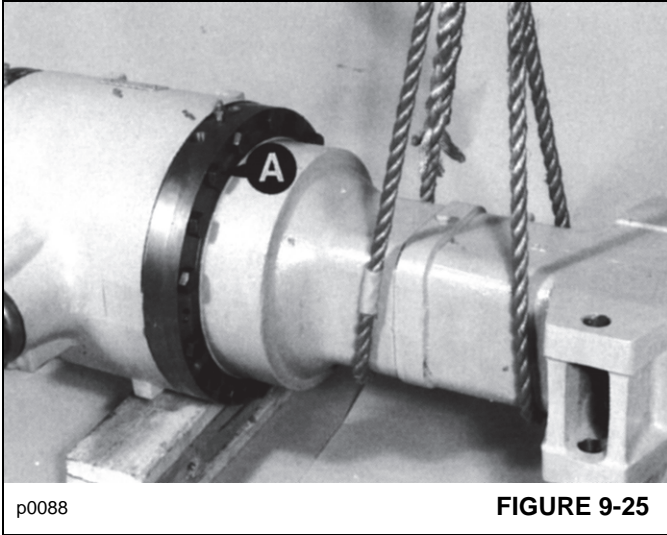


FIGURE 9-24

6. Apply Loctite® 275 to the mating face of the drive head. Locate the axle arm onto the drivehead, with the embossed word "TOP" on the axle arm up most.



7. Install bolts **A** Figure 9-25 and tighten to a torque of 244 Nm (178 lb-ft).

**NOTE:** Check the grade of bolts installed. Grade 8.8 should be tightened to a torque of 244 Nm (178 lb-ft). Grade 12.9 bolts should be tightened to a torque of 400 Nm (295 lb-ft).

8. Fill the axle with recommended lubricant. See *Preventative Maintenance on page 5-1*.
9. Install the axle to the crane's frame. Refer to *Axles/Drive Shafts/Wheels and Tires on page 8-1*.

### Rear Axle Brakes

Refer to *Axles/Drive Shafts/Wheels and Tires on page 8-1* for Axle Hub Assembly Service. The service instructions include disassembly, replacement and assembly of the rear axle brakes.

Reference

## PARKING BRAKE REPAIR


### Lining Kit Replacement



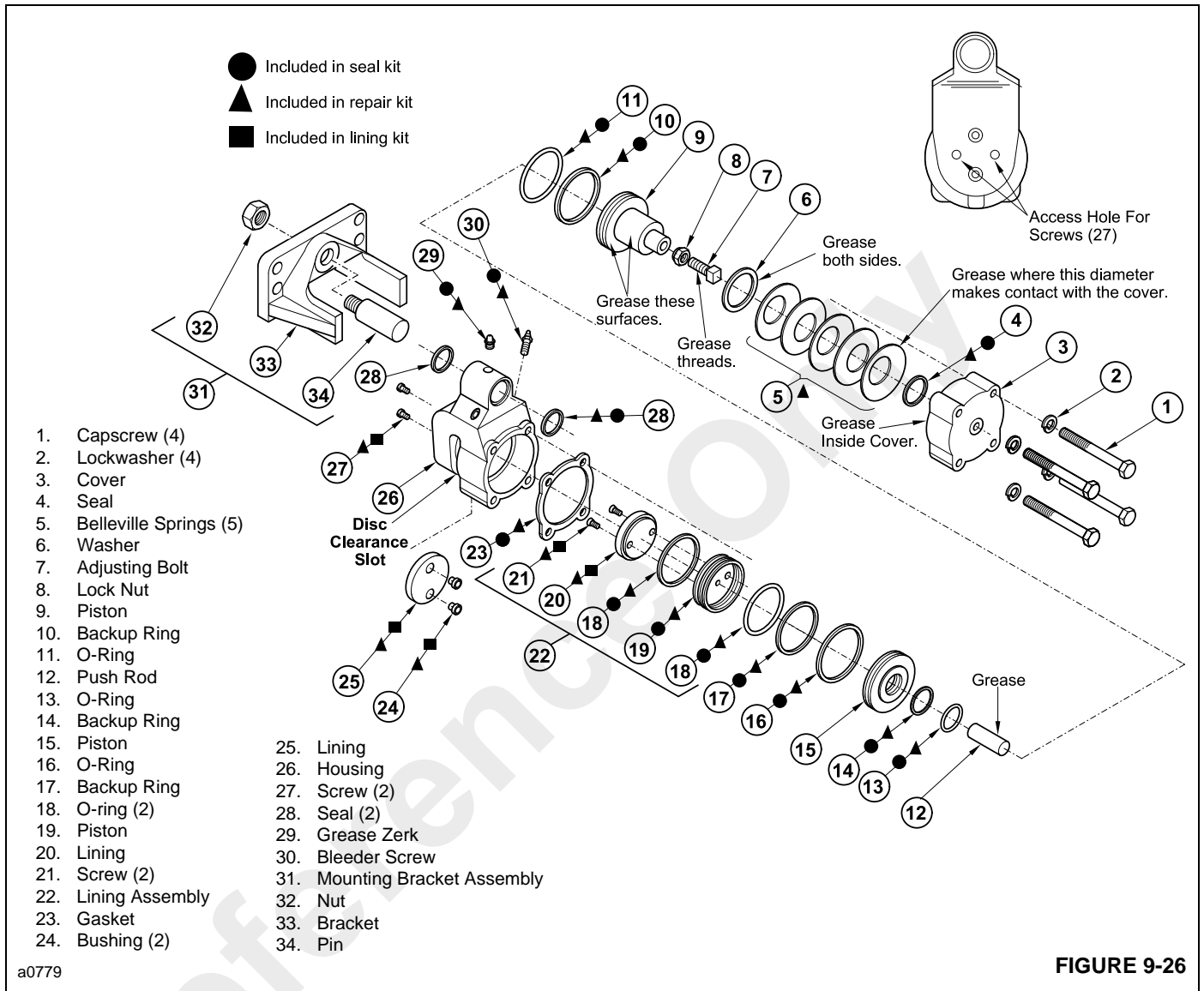
#### WARNING

Before replacing the parking brake linings, make sure that the crane is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the repair.

**NOTE:** The new linings must be kept free of grease, oil, etc.

The lining kit is indicated in Figure 9-26 with a  symbol.

1. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
  2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
  3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
  4. Loosen lock nut **8** Figure 9-26 and back off adjusting bolt **7**.
  5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake.
  6. Separate the mounting bracket assembly **31** from the brake assembly.
  7. Clamp the brake in a vice with soft jaws with the clearance slot facing straight up.
- NOTE:** Clamping should be done on sides of the brake, not on machined surfaces.
8. Remove two screws **27** through access holes in housing **26**. Using a thin blade tool, pry lining **25** from housing **26** and remove the lining and two bushings **24** through the disc clearance slot.
  9. Rotate lining assembly **22** until screws **21** are aligned with the access holes in housing **26**. Remove the two flat head screws **21**. Pry lining **20** from piston **19** and remove the lining through the disc clearance slot.
  10. Install new lining **20** into piston **19** through the disc clearance slot. Install new flat head screws **21** and tighten to a torque of 3,4 - 4,5 Nm (30-40 lb-in).
  11. Insert new bushings **24** into new lining **25**. Install the new lining into housing **26** through the disc clearance slot. Line up the holes with the housing and fasten with two new screws **27**. Tighten to a torque of 2,5 - 3,2 Nm (22-28 lb-in).
  12. Assemble the brake assembly onto mounting bracket **31**. Install the parking brake assembly onto the frame of the crane. Attach the hydraulic hose.
  13. Adjust the lining clearance as described on page 9-7.
  14. Open the accumulator needle valve and then bleed air from the system as described on page 9-6.
- NOTE:** The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.



### Repair Kit Installation

The parking brake has a repair kit available. It includes all the parts necessary to rebuild the brake. These parts are indicated in Figure 9-26 with a ▲ symbol.

### WARNING

Before repairing the parking brake, make sure that the crane is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the repair.

**NOTE:** When removing seals and backup rings be careful not to scratch or mar the pistons.

The new linings must be kept free of grease, oil, etc.

1. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
4. Loosen lock nut 8 Figure 9-26 and back off adjusting bolt 7.

5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake assembly.
6. Separate the mounting bracket assembly **31** from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the cover **3** in a vertical position.

**NOTE:** Clamping should be done on sides of the brake, not on machined surfaces.

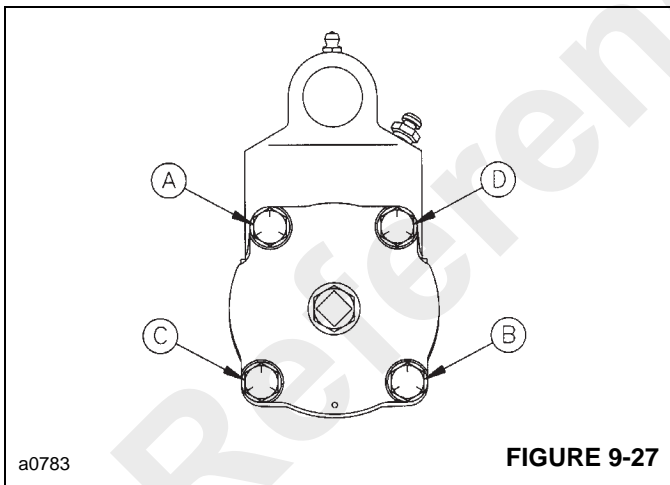
8. Remove bleeder screw **30**.
9. Using a sharp bladed tool, carefully remove two seals **28** from housing **26**. Note the direction the seals were installed.



### WARNING

Cap (3) is under spring pressure. Use care when removing the cap to prevent personal injury.

10. Loosen but do not remove four capscrews **1**. Loosen screws evenly in the order of **A, B, C** and **D** Figure 9-27 until spring pre-load is released.



11. Remove capscrews **1** Figure 9-26, lockwashers **2**, cover **3** and gasket **23**. Using a thin blade screw driver, remove seal **4** from cover **3**.
12. Remove belleville springs **5** and if present, washer **6**. When removing the belleville springs take note of the stacking sequence.
13. Remove piston **9** from housing **26** bore. Remove O-ring **11** and backup ring **10** from the piston. Push rod **12** should also come out with piston **9**.

14. Remove piston **15** from housing **26** bore. Remove O-rings **13** and **16** and backup rings **14** and **17** from piston **15**.

15. Remove lining and piston assembly **22** from housing **26** bore. Holding assembly on a flat surface, separate lining **20** and piston **19** by removing two flat head screws **21**. Remove O-rings **18** from piston **19**.

16. Loosen vice jaws and rotate the brake so that the disc clearance slot is facing upward. Remove pan head screws **27**, lining **25** and bushings **24** from housing **26**.

17. Lubricate all rubber components (NOT THE BRAKE LININGS) in clean hydraulic oil. Use the same type as used in the hydraulic system.

18. Clean all parts (EXCEPT LININGS) and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the hydraulic system. Keep all parts free of contaminants, dirt and debris.

**NOTE:** Coat the surfaces indicated Figure 9-26 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

19. Install new lining **25** Figure 9-26 in housing **26** using new bushings **24** and pan head screws **27**. Tighten the screws to 2.5 - 3.3 Nm (22-28 lb-in).

20. Install new lining **20** on piston **19** using new flat head screws **21**. Tighten screws to a torque of 3.4 - 4.5 Nm (30-40 lb-in). Install new O-rings **18** on piston **19** and insert lining and piston assembly **22** into housing **26** bore.

21. Carefully install two new seals **28** in housing **26**. Be sure to install the seals the same direction as they were removed.

22. Install bleed screw **30**. Tighten to a torque of 12.2 - 20.3 Nm (9-15 lb-ft).

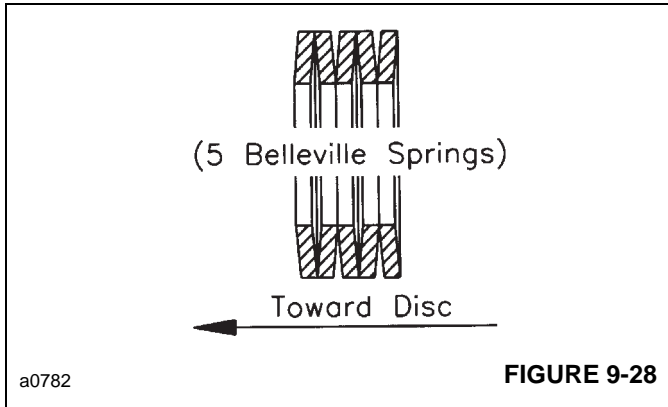
23. Install new O-rings **13** and **16** and new backup rings **14** and **17** on piston **15**. Be sure they are installed in the correct order.

24. Install piston **15** into housing **26** bore. Be sure piston is installed in the correct direction. Be careful not to pinch the O-rings on the inlet ports.

25. Install new backup ring **10** and new O-ring **11** on piston **9**. Be sure they are installed in the proper order. Install push rod **12** in bore of piston **9**. Install piston into housing **26** bore.

26. Fully lubricate the threads of adjusting screw **7** and lock nut **9** and install into cover **3**.

27. Install washer **6**, if used, and new belleville springs **5** over end of piston **9**. Follow the stacking sequence Figure 9-28.



28. Install new seal **4** in cover **3**. Be sure inside of cover is coated with grease.
29. Install new gasket **23**, cover **3**, lockwashers **2** and capscrews **1**. Tighten the screws evenly in the order of **A, B, C** and **D** Figure 9-27. When installed, tighten each screw to a torque of 29.8 - 36.6 Nm (22-27 lb-ft).
30. Assemble the brake assembly onto the mounting bracket **31**.
31. Install the parking brake assembly onto the frame of the crane.
32. Attach the hydraulic hose.
33. Adjust the lining clearance as described on page 9-7.
34. Open the accumulator needle valve and then bleed air from the system as described on page 9-6.

### Seal Kit Installation

The parking brake has a seal kit available. It includes all the parts necessary to replace all the seals in the brake. These parts are indicated in Figure 9-26 with a ● symbol.

**NOTE:** The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

### WARNING

Before replacing the parking brake seals, make sure that the crane is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the repair.

**NOTE:** When removing seals and backup rings be careful not to scratch or mar the pistons.

The linings must be kept free of grease, oil, etc.

1. This will shut off hydraulic pressure to the parking brake. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
  2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
  3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
  4. Loosen lock nut **8** Figure 9-26 and back off adjusting bolt **7**.
  5. Remove the bolts and nuts used to fasten the brake mounting bracket to the crane. Remove the parking brake assembly.
  6. Separate the mounting bracket **31** from the brake assembly.
  7. Clamp the brake in a vice with soft jaws with the cover **3** in a vertical position.
- NOTE:** Clamping should be done on sides of the brake, not on machined surfaces.
8. Using a sharp bladed tool, carefully remove two seals **28** from housing **26**. Note the direction the seals were installed.

### WARNING

Cover **3** is under spring pressure. Use care when removing the cap to prevent personal injury.

9. Loosen but do not remove four capscrews **1**. Loosen screws evenly in the order of **A, B, C** and **D** Figure 9-27 until spring pre-load is released.
10. Remove capscrews **1** Figure 9-26, lockwashers **2**, cover **3** and gasket **23**. Using a thin blade, remove seal **4** from cover **3**.
11. Remove belleville springs **5** and if present, washer **6**. When removing the belleville springs take note of the stacking sequence.
12. Remove piston **9** from housing **26** bore. Remove O-ring **11** and backup ring **10** from piston. Push rod **12** should also come out with piston **9**.
13. Remove piston **15** from housing **26** bore. Remove O-rings **13** and **16** and backup rings **14** and **17** from piston **15**.

14. Remove lining and piston assembly **22** from housing **26** bore. Remove O-rings **18** from the lining and piston assembly.
15. Lubricate all rubber components in clean hydraulic oil. Use the same type as used in the hydraulic system. Keep the linings free of oil, grease and solvents.
16. Clean all parts and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the hydraulic system. Keep all parts free of contaminants, dirt and debris.

**NOTE:** Coat the surfaces Figure 9-26 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

17. Install new O-rings **18** on lining and piston assembly **22** and insert the assembly into housing **26** bore.
  18. Carefully install two new seals **28** in housing **26**. Be sure to install the seals the same direction as they were removed.
  19. Install new O-rings **13** and **16** and new backup rings **14** and **17** on piston **15**. Be sure they are installed in the correct order.
  20. Install piston **15** into housing **26** bore. Be sure piston is installed in the correct direction. Be careful not to pinch the O-ring on the inlet ports.
  21. Install new backup ring **10** and new O-ring **11** on piston **9**. Be sure they are installed in the proper order. Install push rod **12** in bore of piston **9**. Install piston into housing **26** bore.
  22. Fully lubricate the threads of adjusting screw **7** and lock nut **8** and install into cover **3**.
- NOTE:** Completely lubricate Belleville springs with a light coat of Lithium Base, E.P. No. 2 bearing grease.
23. Install washer **6**, if used, and Belleville springs **5** over end of piston **9**. Follow the stacking sequence Figure 9-28.
  24. Install new seal **4** in cover of **3**. Be sure inside of cover is coated with grease.
  25. Install new gasket **23**, cover **3**, lockwashers **2** and capscrews **1**. Tighten the screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-27. When installed, tighten each screw to a torque of 29,8 - 36,6 Nm (22-27 lb-ft).
  26. Assemble the brake assembly onto the mounting bracket **31**.
  27. Install the parking brake assembly onto the frame of the crane.
  28. Attach the hydraulic hose.
  29. Adjust the lining clearance as described on page 9-7.

30. Open the accumulator needle valve and then bleed air from the system as described on page 9-6.

**NOTE:** The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

## BRAKE MODULATING VALVE REPAIR

### Removal



### WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane's hydraulics or jacks to support the crane when working under it.

Disconnect the battery cables while you're under the crane to prevent the engine from being started.

1. Raise the crane by lowering the outriggers.
2. Install jack stands under the frame of the crane.
3. Shut off the engine and set the parking brake.
4. Press the foot brake pedal (brake modulating valve) as many times as it takes to release any pressure remaining in the brake system.
5. From underneath the operator's cab, disconnect the hydraulic hoses from the fittings. Plug the hoses to prevent contaminating the hydraulic system.
6. Remove the three capscrews and self-locking nuts securing pedal mounting plate to the cab floor. Remove the brake modulating valve and pedal assembly.

### Disassembly

1. Remove the brake modulating valve from the pedal assembly, by removing two capscrews **13** Figure 9-29.
  2. Remove boot **1** from piston **2** and housing **12**.
  3. Remove piston **2**, springs **3**, **4** and **5**, shims **6** and retainer assembly **7** from housing **12**.
- NOTE:** Observe and take note of the number of shims **6** being removed from the housing.
4. Carefully remove cup **14** and seal **15** from housing **12** bore. Be careful not to scratch or mar the bore.

5. Remove end plug **8** and spring **10** from housing **12**. Remove O-ring **9** from plug **8**.
6. Carefully remove spool **11** from end plug **8** end of housing **12**.

**NOTE:** Be careful not to damage the spool or housing bore as they are a matched set and not sold separately.

**Assembly**

A seal kit is available for repair of the valve. It consists of the items indicated with a ● in Figure 9-29.

**NOTE:** Lubricate all rubber components in repair kit with clean hydraulic oil of the same type used in the hydraulic system.

1. Clean all parts before assembling. Use a suitable solvent.
2. Lubricate spool **11** Figure 9-29 with clean hydraulic oil and carefully slide into plug end of housing **12**.

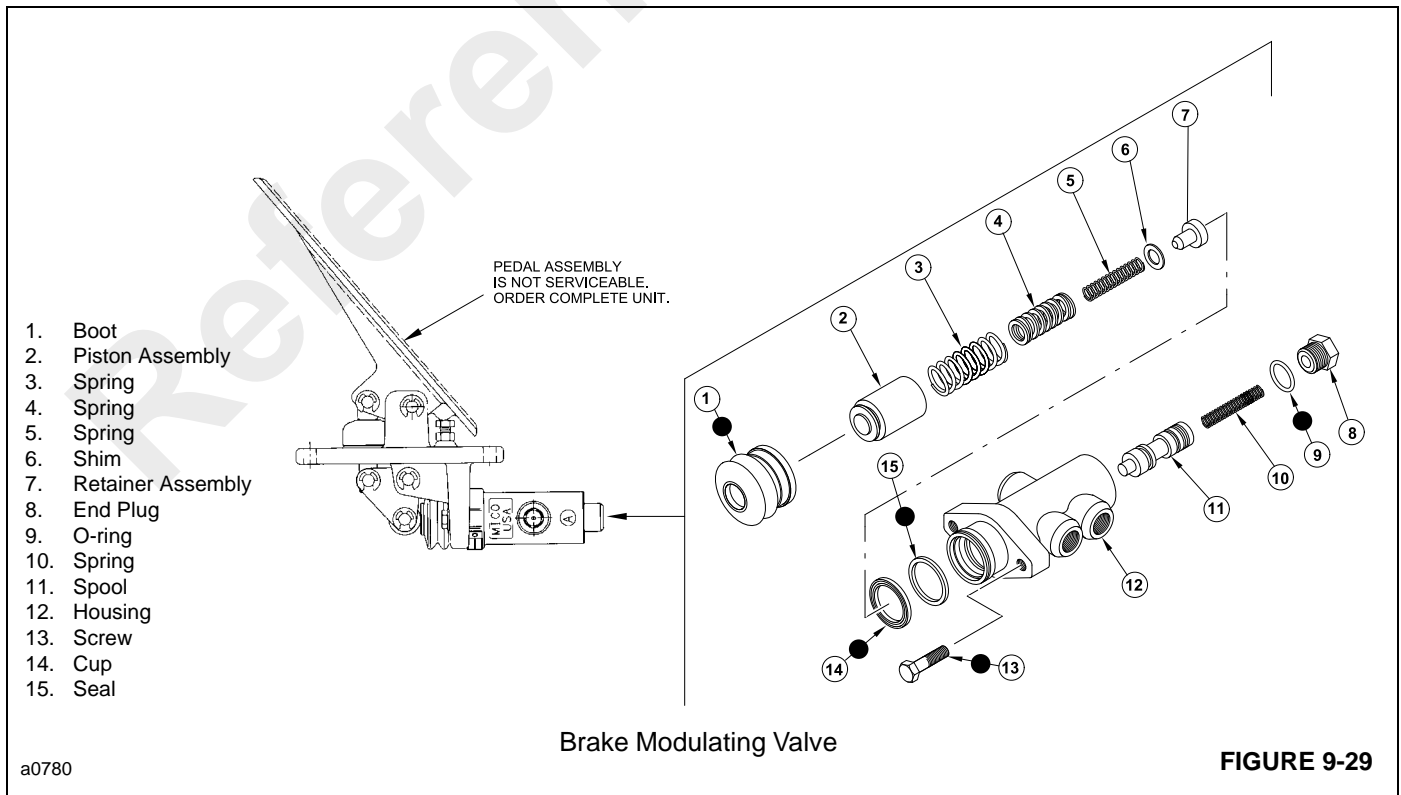
**NOTE:** The spool must slide freely into the bore. If either part is damaged, a new valve assembly may be required.

3. Install new O-ring **9** on end plug **8**.
4. Install spring **10** and end plug **8** into housing **12**. Tighten to a torque of 54.2 - 67.8 Nm (40 - 50 lb-ft).

5. Carefully install new cup **14** and new seal **15** into bore of housing **12**. Make sure they are installed in the proper order and direction. Take care when installing not to scratch or mar the housing bore.
6. Assemble springs **3**, **4** and **5**, shims **6** and retainer assembly **7** into piston **2**.
7. Carefully install piston **2** assembly into bore of housing **12**.
8. Install new boot **1** on housing **12** and piston **2**.
9. Install the valve assembly onto the pedal assembly with new capscrews (13). Tighten to a torque of 24.4 - 29.8 Nm (18 - 22 lb-ft).
10. After final assembly, the valve must develop a pressure of 37.92 ± 3.45 bar (550 ± 50 psi).

**Installation**

1. Place the brake modulating valve and pedal assembly in location in the operator's cab. Secure to the cab floor with three capscrews and self-locking nuts.
2. Connect the three hydraulic hoses to the valve.
3. Open the accumulator needle valve and then start the engine. Allow pressure to build in the brake system.
4. Bleed air from the brake system. See page 9-6.





## TROUBLESHOOTING

## Service Brakes

PROBLEM	POSSIBLE CAUSE	REMEDY
Warning light on instrument panel illuminates.	1. Loss of brake pressure.	1. Any cause under NO BRAKES.
No brakes.	1. Faulty brake modulating valve. 2. Faulty priority flow control valve. 3. Loss of fluid from broken line, loose fitting of hose. 4. Leakage past both brake pistons. 5. Faulty pump section. 6. Faulty accumulator charging valve.	1. Repair or replace. 2. Replace. 3. Check all circuit lines, hoses and fittings. Tighten or replace. 4. Perform leakage test. 5. Replace pump. 6. Replace valve.
Bad brakes (pedal fully applied, crane gradually stops).	1. Severe wear in service brake discs. 2. Leakage past one brake piston.	1. Replace brake discs. See Section 8. 2. Perform leakage test. Repair or replace. See Section 7.
Soft brake pedal.	1. Air in system. 2. High pressure leaks - external.	1. Bleed brake system. 2. Apply full brake pressure, inspect for leakage in lines, hoses and fittings.
Charging valve actuates every time foot pedal is pressed.	1. Accumulator needle valve closed. 2. Loss of nitrogen in accumulator. 3. Insufficient hydraulic pressure in accumulator.	1. Open needle valve. 2. Charge accumulator. 3. Faulty accumulator charging valve. Replace.
Parking brake will not release.	1. Faulty solenoid valve. 2. Loss of fluid from broken line, loose fitting or hose. 3. Faulty priority flow control valve. 4. Faulty parking brake switch. 5. Loose electrical connections. 6. Faulty pump section.	1. Replace solenoid valve. 2. Check all circuit lines, hoses and fittings. Tighten or replace. 3. Replace. 4. Replace switch. 5. Check and tighten. 6. Replace pump.
Parking brake will not hold.	1. Improperly adjusted parking brake. 2. Severely worn brake linings. 3. Faulty parking brake assembly.	1. Adjust brake lining clearance. 2. Replace brake linings. 3. Repair or replace.

## SECTION 10 STEERING SYSTEM

<b>Description</b> . . . . .	<b>10-1</b>	Sensor Operation and Spacing Checks. . . . .	10-9
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### DESCRIPTION

#### General

The main components of the steering system are the hydraulic pump Figure 10-1, the priority flow control valve, the load sensing steering orbitrol, hydraulic tank, one front steering cylinder, two rear steering cylinders and the steering select valve.

When the steering wheel is turned, a pressure demand is sensed by the priority flow control valve through load sensing line between the priority flow control valve and the flow sensing steering orbitrol.

Oil from the hydraulic pump is then distributed through the priority flow control valve and a check valve to the steering orbitrol.

When a turn is made, oil is distributed from the steering orbitrol directly through the steering select valve and/or to the steering cylinders.

When the steering orbitrol is neutral, the load sense signal is ceased, full pump flow is then distributed to the outrigger and brake circuits through the priority flow control valve.

Maximum steering system pressure is controlled by a relief valve in the priority flow control valve.

#### Steering Modes

The crane can be operated in three steering modes. These modes are selected using the steering selector switch

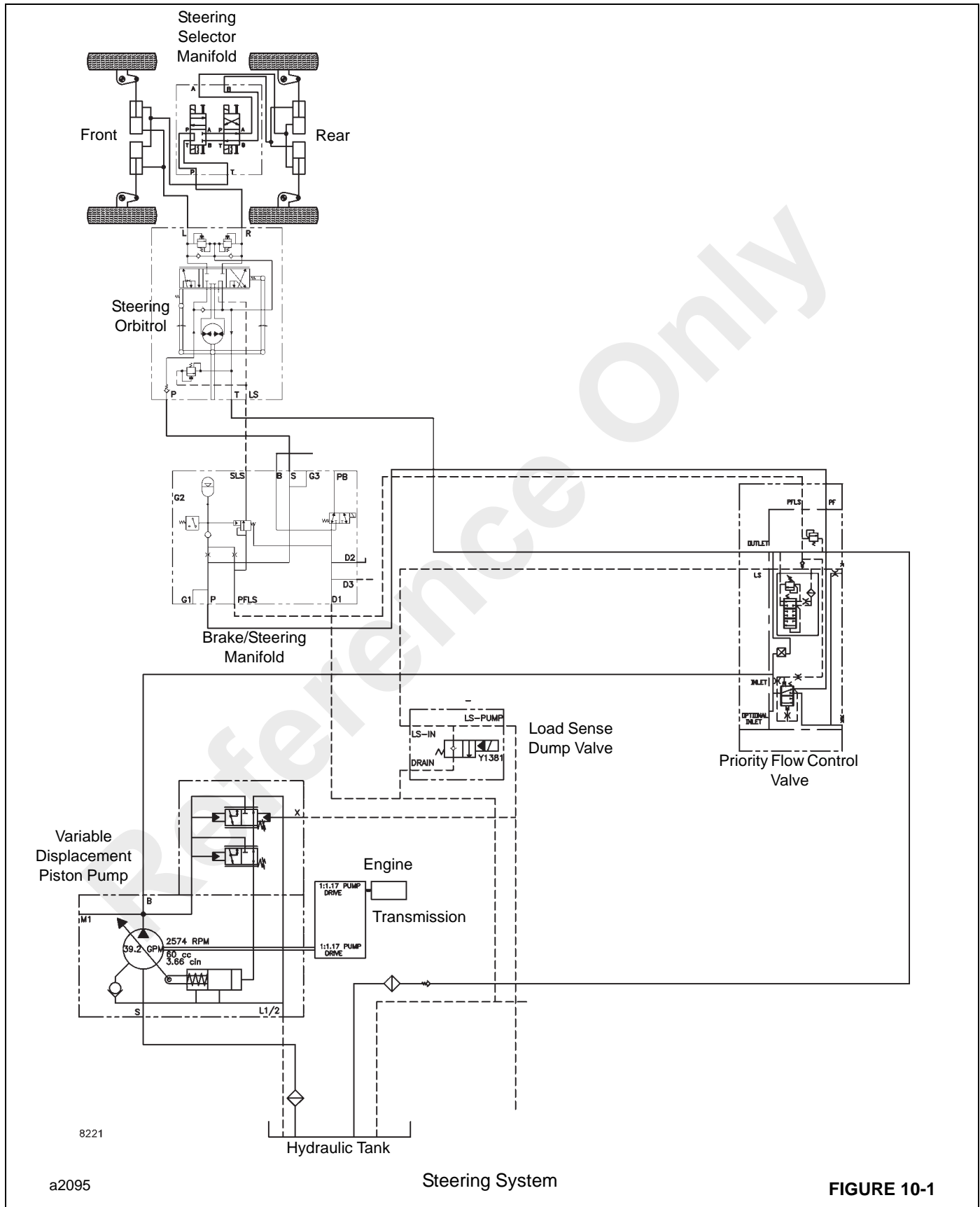
located to the left of the operator on the instrument panel. The three modes are:

- Two-wheel steering
- Four-wheel steering
- Crab steering

#### Two-Wheel Steering

During two-wheel steering, the front wheels steer in the same direction that the steering wheel turns. The rear wheels remain in a fixed forward position.

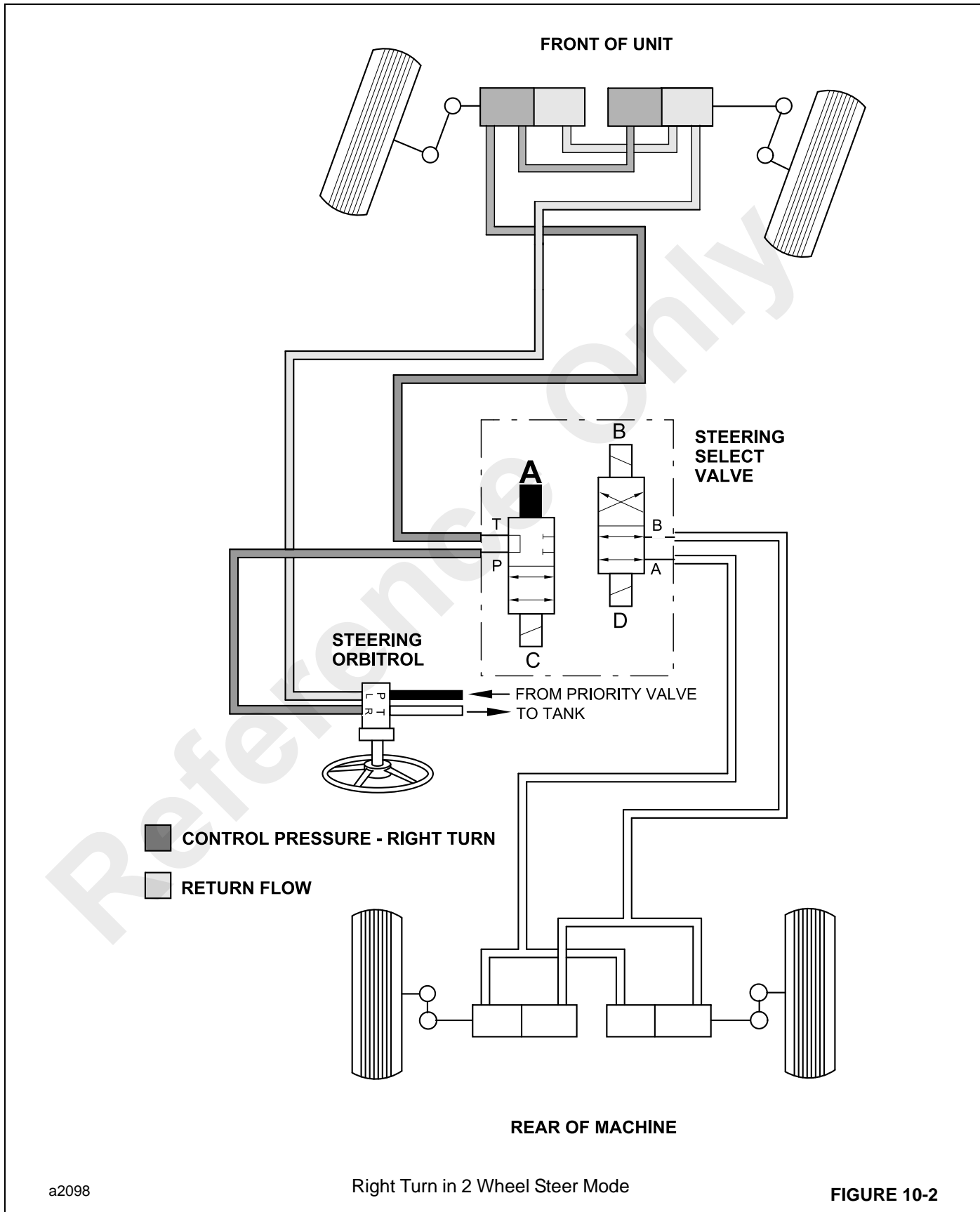
When turning to the right Figure 10-2, hydraulic oil under pressure from the pump flows through the priority flow control valve to the P port of the brake/steering manifold on to the steering orbitrol in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbitrol to port P of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operators compartment. When the steering select switch is placed in the two-wheel steering mode solenoid A is actuated. Oil passes through the porting of the valve block to the base end of the front axle steering cylinders. The pistons move to the left, extending the left cylinder rods and retracting the right cylinder rods, creating a right turn. Return oil from the steering cylinders flows into port L, out of port T of the steering orbitrol and back to tank.



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Steering System

FIGURE 10-1



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Right Turn in 2 Wheel Steer Mode

FIGURE 10-2

## Four-Wheel Steering

During four-wheel steering, the front wheels steer in the direction that the steering wheel is turned, while the rear wheels turn in the opposite direction. This mode provides an extremely short turning radius. It allows the rear wheels to follow the track of the front wheels, which is an advantage in muddy or sandy conditions.

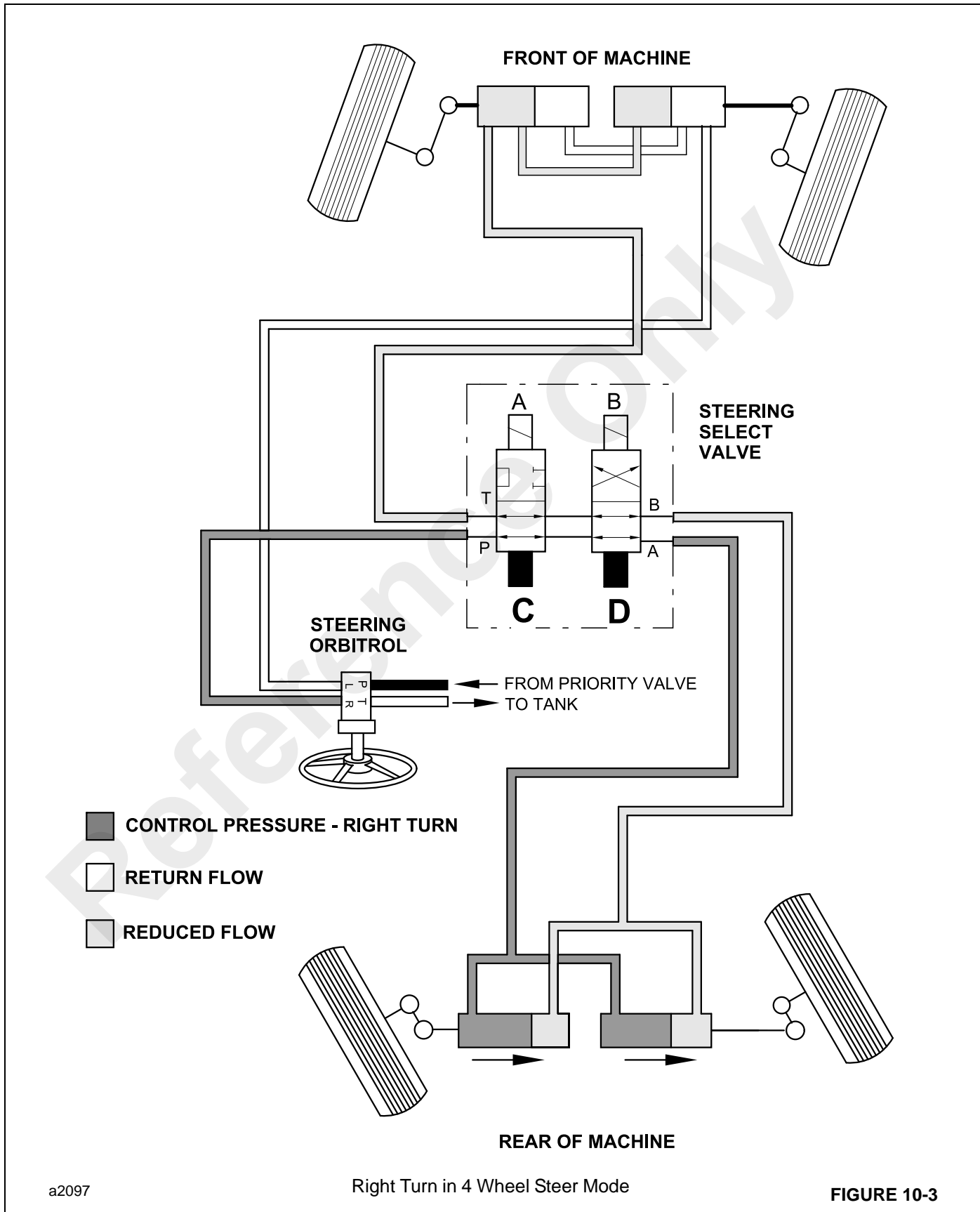
When turning to the right Figure 10-3, hydraulic oil under pressure from the pump flows through the priority flow control valve to the P port of the steering orbitrol in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbitrol to port P of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operator's compartment. When the steering select switch is placed in the four-wheel steering mode solenoids C and D are actuated. Oil passes through the porting of the valve block and out port A to the rear axle steering cylinder. Oil is directed to the rod end of the left steering cylinder and base end of the right cylinder, causing the rear wheels to turn to the left. Return oil under pressure from the rear steering cylinders flows into Port B of the steering select valve block and out Port T to the front steering cylinders. The left rod of the steering cylinder extends and the right rod retracts, turning the front wheels to the right. Return oil from the front

steering cylinders flows into port L and out of port T of the steering orbitrol and back to tank.

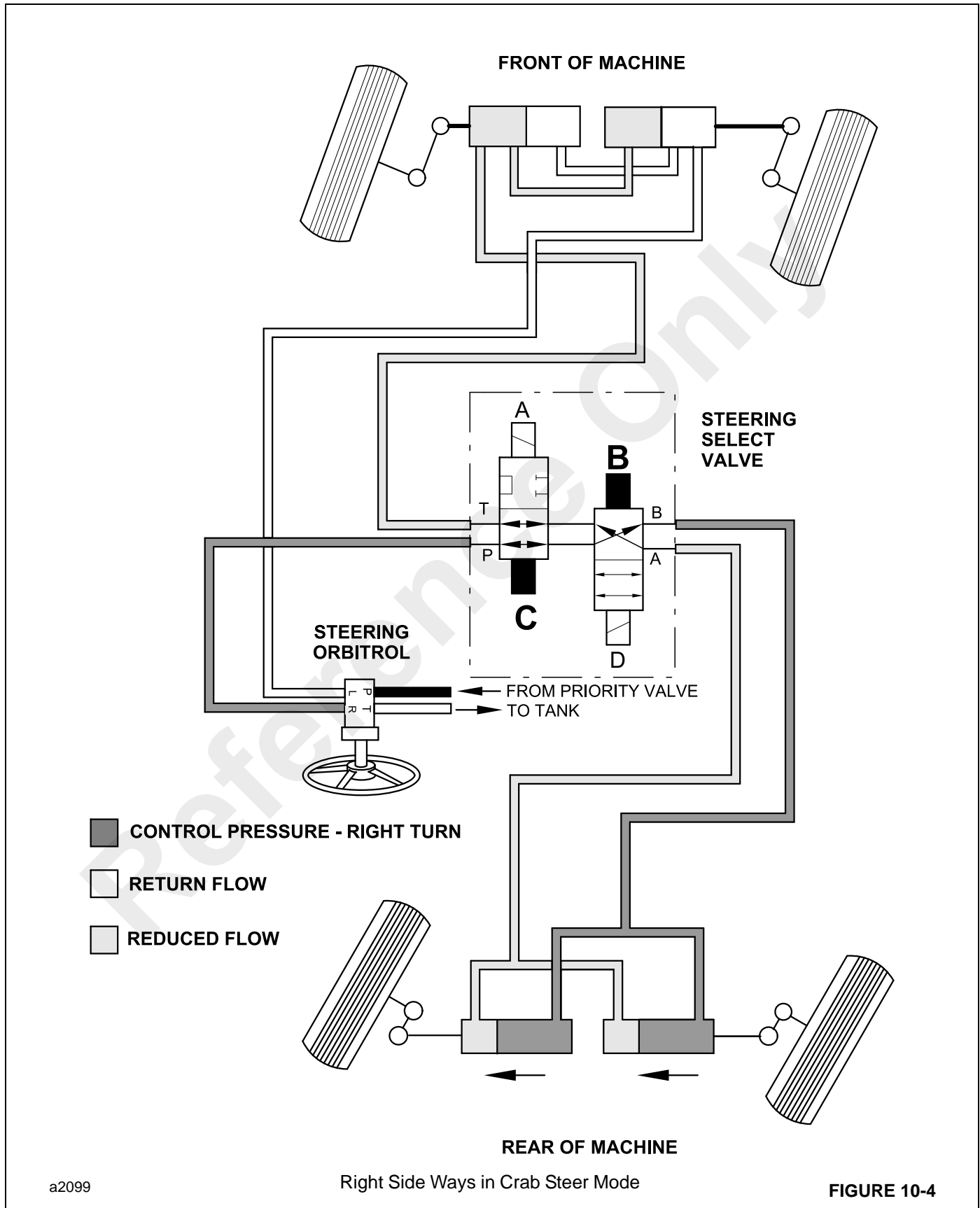
## Crab Steering

During crab steering all the wheels steer in the same direction. This mode allows the operator to move the crane sideways for short distances. This is especially helpful in tight areas on the job.

When turning sideways to the right Figure 10-4, hydraulic oil under pressure from the pump flows through the priority flow control valve to the P port of the steering orbitrol in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbitrol into port P of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operator's compartment. When the steering select switch is placed in the crab-steering mode solenoids B and C are actuated. Oil passes through the porting of the valve block and out port B to the rear axle steering cylinders. Oil is directed to the base end of the left steering cylinder and rod end of the right cylinder, causing the rear wheels to turn to the right. Return oil under pressure from the rear steering cylinders flows to Port A of the steering select valve block and out port T to the front steering cylinders. The left rod of the steering cylinder extends and the right rod retracts, turning the front wheels to the right. Return oil from the front steering cylinder into port L and out of port T of the steering orbitrol and back to tank.



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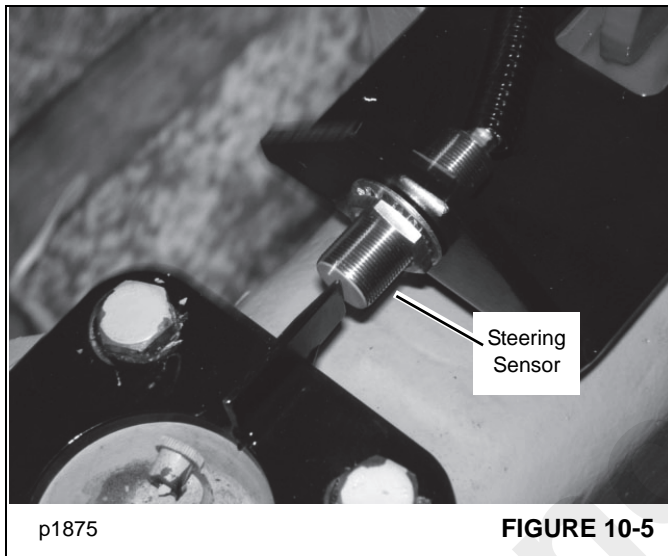
Right Side Ways in Crab Steer Mode

FIGURE 10-4

## STEERING PROXIMITY SWITCHES

### General

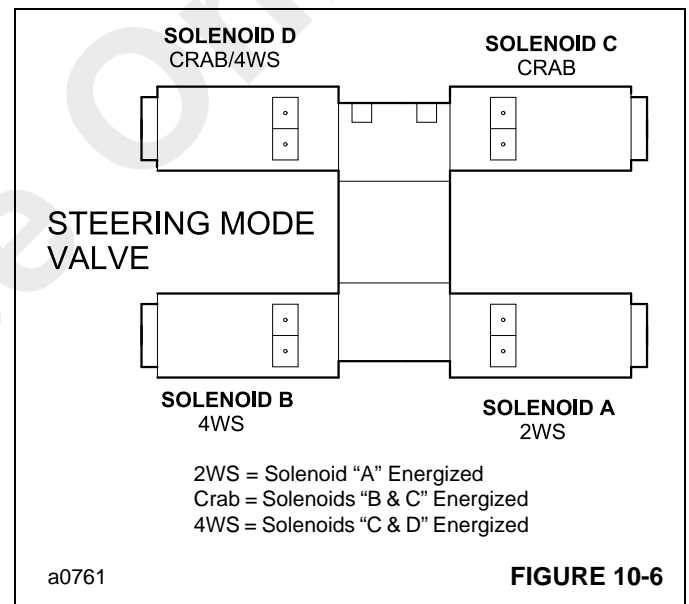
The purpose of the steering proximity switches in the steering system is to prevent the changing of steering modes until all wheels are aligned forward. The sensors are positioned on the front and rear axles Figure 10-5 and are activated when a bracket attached to the steering yoke of the axle, is aligned with the sensor.



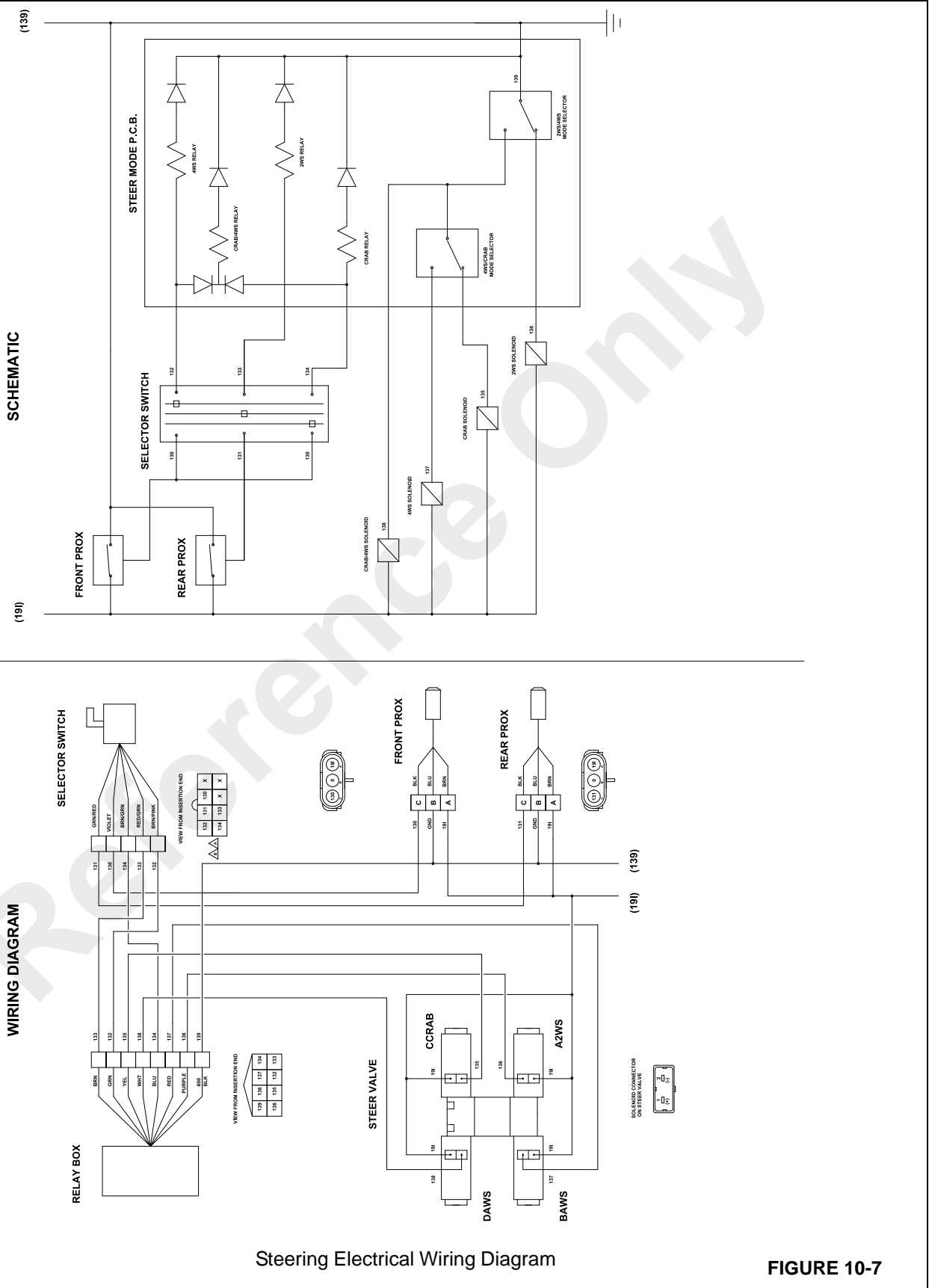
### Principle Of Operation

The steering system electrical circuit includes two sensors Figure 10-7 one selector switch, one relay box and two solenoid valves. The selector switch is controlled by the operator in the cab to select the steering modes. The relay box, located under the instrument panel, contains relays that control the steering mode solenoid valves.

The system is used to select one of the three steering modes. When the selector switch in the cab is placed in either two-wheel steer, four-wheel steer or crab steer, that particular mode of steering is used to steer the crane. The system, however, will not activate unless the front and rear wheels are in or pass over the forward position. For example, when the front wheels are not aligned forward in two wheel steer mode and the crane must be placed in four wheel steer, placing the steering selector switch, located in the cab, to four wheel steer will not place the steering system in four wheel steer mode. Turning the front wheels to forward position or past, activates the proximity switches and energizes the relays in the relay box, which in turn energize the correct solenoid arrangement Figure 10-6 to put the steering system in four wheel steer.







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Steering Electrical Wiring Diagram

FIGURE 10-7

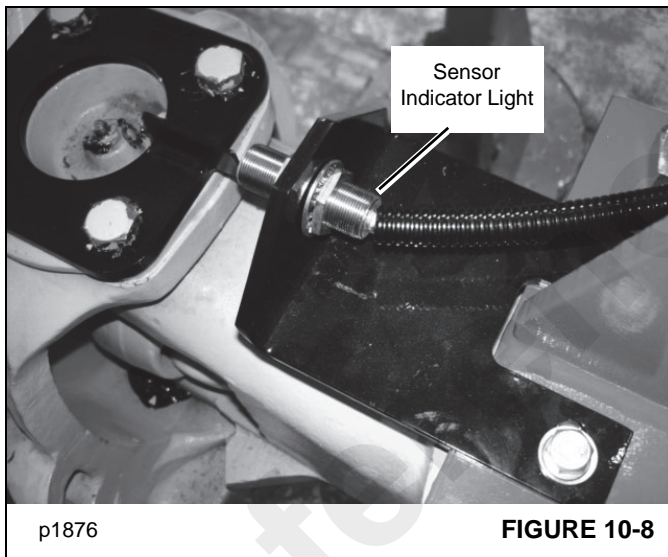
## Sensor Operation and Spacing Checks

### Checking Alignment and Operation

Both sensors must be working and spaced properly for the steering mode selection to function properly.

### Proper Operation Check

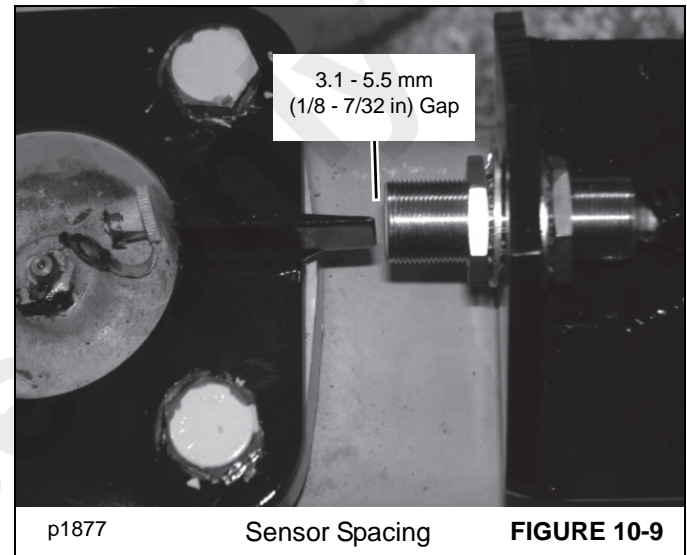
1. Using the outriggers, raise the crane. Shut off the engine but leave the ignition key switch in the ON position to energize the steering sensor circuit.
2. Remove the two tires (front and rear) on left side (cab side) of the crane to obtain access to the steering sensors.
3. Using a piece of metal, pass it within 3,2 mm (1/8 inch) to 5,2 mm (7/32 inch) in front of the sensor. A yellow light Figure 10-8 will illuminate, indicating that the sensor is functioning.



4. If the sensor is working properly, check the spacing between the sensor and sensor bracket. Adjust if necessary.
5. If the sensor is malfunctioning, replace it and adjust the sensor spacing.

### Sensor Spacing Check

1. Align the sensor bracket on the axle steering knuckle with the sensor on the axle Figure 10-9.



2. Measure the distance between the end of the sensor and edge of the sensor bracket. The sensor spacing must be between 3,3 mm (1/8 inch) to 5,6 mm (7/32 inch). If the spacing is incorrect, adjust the spacing with the jam nuts on the sensor. Be sure they are tightened after proper gap is obtained.

Symptom	Probable Cause	Action
Slow steering, hard steering, or loss of power assist.	<ol style="list-style-type: none"> <li>1. Worn or malfunctioning pump.</li> <li>2. Priority valve not operating correctly.</li> <li>3. Malfunctioning relief valve.</li> <li>4. Overloaded steering axle.</li> <li>5. Air in hydraulic system.</li> <li>6. Malfunctioning steering orbitrol.</li> <li>7. Malfunctioning steering mode valve.</li> <li>8. Mechanical failure.</li> </ol>	<ol style="list-style-type: none"> <li>1. Repair or replace the pump.</li> <li>2. Check for stuck spool. Repair or replace. Check load sense line for leaks or poor connection.</li> <li>3. Replace the priority valve.</li> <li>4. Reduce the load.</li> <li>5. Bleed system - bleed the load sense line.</li> <li>6. Remove and inspect.</li> <li>7. Check if spools are sticking. Repair or replace. Check if solenoids are operating. Replace if needed.</li> <li>8. Check for damaged axle components, such as cylinders, tie rods, linkages, etc.</li> </ol>
Steering wheel turns on its own.	<ol style="list-style-type: none"> <li>1. Dirt in steering orbitrol (causing sleeves to stick open).</li> <li>2. Steering actuator centering springs damaged or broken.</li> <li>3. Steering actuator - position of rotor to shaft slot incorrect.</li> </ol>	<ol style="list-style-type: none"> <li>1. Clean and inspect unit.</li> <li>2. Check orbitrol. Repair or replace.</li> <li>3. See page 10-13. Correct if required.</li> </ol>
Crane will not turn when the steering wheel is turned.	<ol style="list-style-type: none"> <li>1. Insufficient oil level.</li> <li>2. Leaks in relevant hoses or component connections.</li> <li>3. Air in the hydraulic system.</li> <li>4. Low pump flow.</li> <li>5. Malfunctioning relief valve.</li> <li>6. Worn or damaged parts in the steering orbitrol.</li> <li>7. Priority valve not operating correctly.</li> <li>8. Steering mode valve not operating correctly.</li> <li>9. Mechanical failure.</li> <li>10. Steering column splined shaft not fully engaged in orbitrol.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check for leaks and fill tank.</li> <li>2. Check hoses and connections for leaks.</li> <li>3. Bleed system -bleed the load sense line.</li> <li>4. Check pump flow. If required, repair or replace the pump.</li> <li>5. Replace priority valve.</li> <li>6. Remove, inspect and repair.</li> <li>7. Check if the priority valve is sticking and repair if necessary. Check the load sense line for leaks or loose connections.</li> <li>8. Check for sticking spools. Clean or replace. Check for faulty solenoids. Replace if necessary.</li> <li>9. Check for damaged axle components, such as cylinders, tie rods, linkages, etc.</li> <li>10. Check shaft engagement.</li> </ol>

Symptom	Probable Cause	Action
Steering fails to respond to selected mode. IMPORTANT: The wheels must pass the proximity sensor to actuate relays to change steering mode.	<ol style="list-style-type: none"> <li>1. Selector switch faulty.</li> <li>2. Proximity switches not operating correctly.</li> <li>3. Steering mode valve not operating.</li> <li>4. Leaks in relevant hoses or component connections.</li> <li>5. Electrical failure.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace switch.</li> <li>2. Check setting of proximity switch. Reset or replace switches.</li> <li>3. Check if spools are sticking. Repair or replace.</li> <li>4. Check hoses and connections for leaks. Tighten or replace.</li> <li>5. Check relevant electrical connectors if problem still persists, do a wiring continuity check of relevant circuits.</li> </ol>
Wander - Tendency of vehicle to deviate from course.	<ol style="list-style-type: none"> <li>1. Air in system.</li> <li>2. Worn steering linkage.</li> <li>3. Loose steering cylinder piston.</li> <li>4. Severe wear in steering orbitrol.</li> </ol>	<ol style="list-style-type: none"> <li>1. Correct condition and add fluid. Bleed system and load sense line.</li> <li>2. Repair or replace linkage.</li> <li>3. Repair or replace cylinder.</li> <li>4. Repair or replace the orbitrol.</li> </ol>
Slip - A slow movement of steering wheel fails to cause any movement in steering wheels.	<ol style="list-style-type: none"> <li>1. Leakage of cylinder piston seals.</li> <li>2. Worn steering orbitrol.</li> </ol>	<ol style="list-style-type: none"> <li>1. Repair or replace cylinder.</li> <li>2. Repair or replace orbitrol.</li> </ol>
Erratic steering.	<ol style="list-style-type: none"> <li>1. Air in system due to low level of hydraulic oil, cavitating pump, leaky fitting, pinched hose, etc.</li> <li>2. Loose steering cylinder piston.</li> <li>3. Sticking check valve.</li> <li>4. Turning steering wheel too rapidly.</li> </ol>	<ol style="list-style-type: none"> <li>1. Correct condition and add fluid. Bleed system and load sense line.</li> <li>2. Repair or replace cylinder.</li> <li>3. Clean or replace.</li> <li>4. Slow movement.</li> </ol>
Spongy or soft steering.	<ol style="list-style-type: none"> <li>1. Air in hydraulic system. Most likely air trapped in cylinders or lines.</li> <li>2. Low fluid level.</li> </ol>	<ol style="list-style-type: none"> <li>1. Correct conditions. Bleed air out of system and load sense line.</li> <li>2. Add fluid and check for leaks.</li> </ol>
Free wheeling - Steering. Wheel turns freely with no feel of pressure and no action on steering wheels.	<ol style="list-style-type: none"> <li>1. Steering column shaft is loose or damaged.</li> <li>2. Lower splines of column may be disengaged or broken.</li> <li>3. Steering orbitrol meter has a lack of oil. This can happen on start up, after repair, or long down time intervals.</li> <li>4. Steering cylinder piston seal blown out.</li> </ol>	<ol style="list-style-type: none"> <li>1. Tighten the steering wheel nut.</li> <li>2. Repair or replace the column.</li> <li>3. Usually starting engine will cure the problem. Bleed system if necessary.</li> <li>4. Determine cause. Correct and replace the seal.</li> </ol>
Excessive free play at steering wheel.	<ol style="list-style-type: none"> <li>1. Loose steering wheel nut.</li> <li>2. Steering column shaft worn or damaged.</li> </ol>	<ol style="list-style-type: none"> <li>1. Tighten the nut.</li> <li>2. Repair or replace the steering wheel connection or column.</li> </ol>
Excessive free play at steered wheels.	<ol style="list-style-type: none"> <li>1. Leaky steering cylinder seals.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace cylinder seals.</li> </ol>

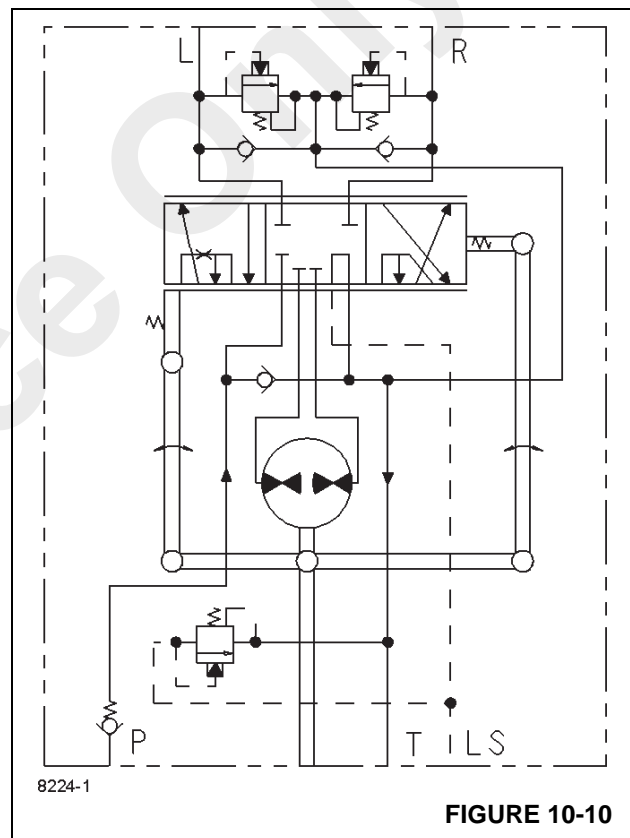
Symptom	Probable Cause	Action
Binding or poor centering of steering wheel.	1. Large dirt particles can cause binding between orbitrol spool and sleeve.	1. Clean the orbitrol. Repair or replace if necessary. If another component has failed, generating contaminants, flush the hydraulic system while bypassing the orbitrol.
Steering orbitrol locks up.	1. Large particles of contamination in metering section. 2. Severe wear and/or broken pin.	1. Clean the orbitrol. Repair or replace if necessary. 2. Repair or replace the orbitrol.

## STEERING ORBITROL

### Description

#### General

The steering orbitrol Figure 10-10 provides directional control and metering of oil for precise steering control. In the neutral or balance position, when the steering wheel is not turned, the IN port (P) is connected to the OUT port (T) and oil from the pump returns to tank Figure 10-10. Oil is locked in the lines by the interacting spool and sleeve. Centering springs keep the spool and sleeve in relative position. The spool is coupled to the steering wheel and rotates inside the sleeve when the steering wheel is turned. Corresponding ports in the spool and sleeve align to meter oil from the pump into the steering circuit and also allow return to tank. When the sleeve catches up with the spool, oil flow is blocked to the steering cylinder lines, and the available supply from the pump is returned to tank.



#### Steering Left

When making a left turn, flow from the pump enters port P Figure 10-10. The gerotor takes this flow and meters it to port L (left turn). Return flow from the steering cylinders, enters port R and is returned to tank through port T.

#### Steering Right

When making a right turn, flow from the pump enters port P Figure 10-10. The gerotor takes this flow and meters to port R (right turn). Return flow from the steering cylinders, enters port L and is returned to tank through port T.

**Emergency Manual Steering**

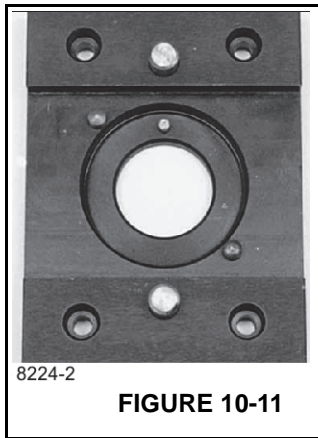
The gerotor Figure 10-10 in the orbitrol permits steering, with difficulty, when power is lost. A check valve between the IN and OUT ports allows for recirculation of the oil to prevent cavitation when steering without power.

**Orbitrol Repair**

**Special Tools**

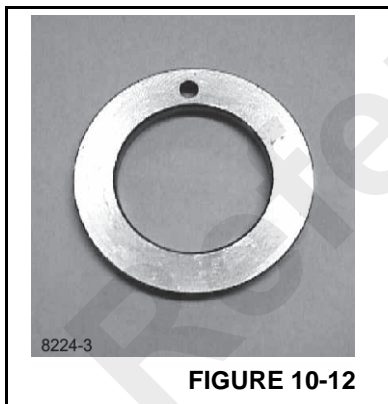
The following special tools are required to assemble the orbitrol:

Holding tool



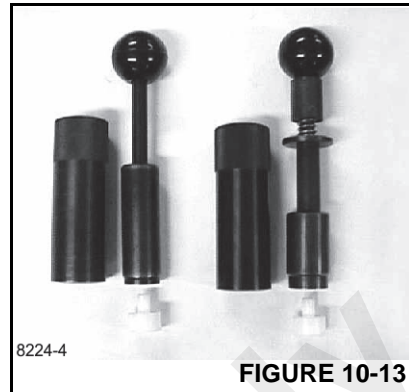
**FIGURE 10-11**

Guide Ring



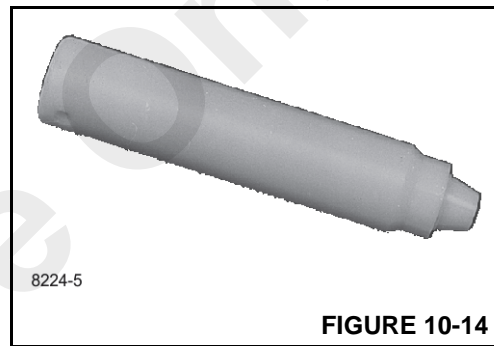
**FIGURE 10-12**

Assembly tool for O-ring and Kin-ring/Roto Glyd



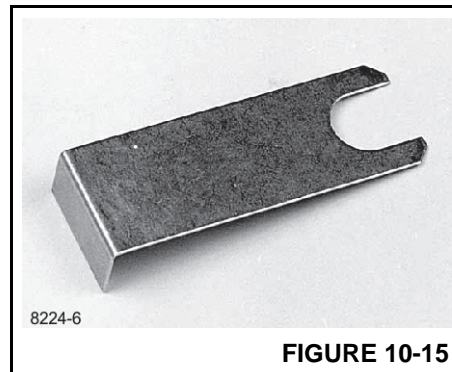
**FIGURE 10-13**

Assembly tool for lip seal



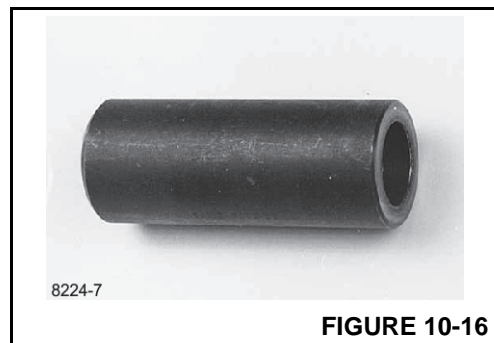
**FIGURE 10-14**

Assembly tool for cardan shaft



**FIGURE 10-15**

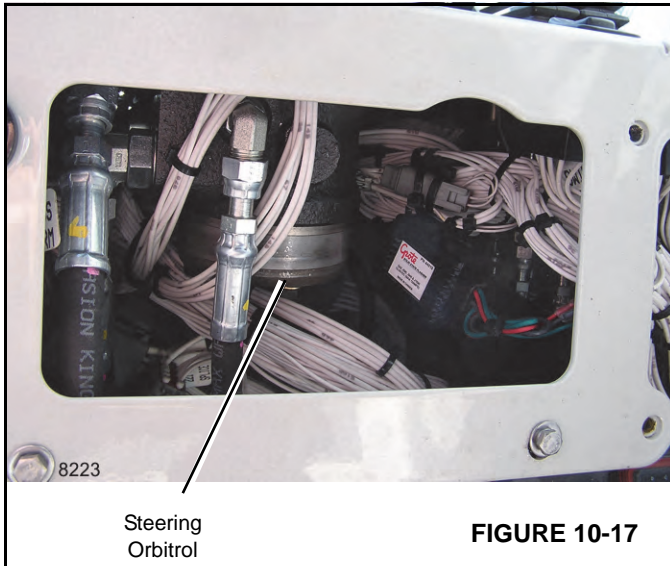
Assembly tool for dust seal



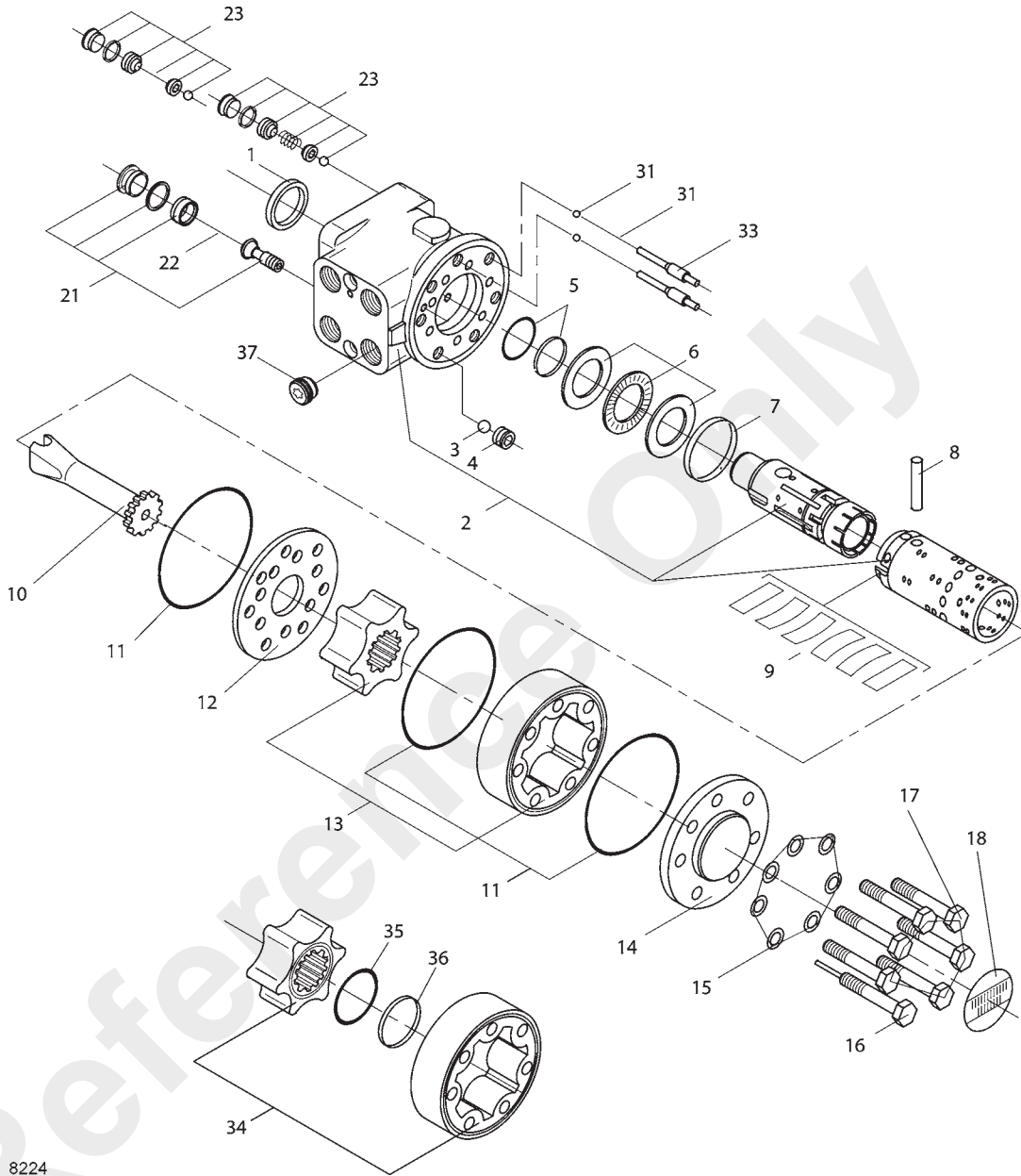
**FIGURE 10-16**

**Removal**

1. Remove the outside cover plate Figure 10-17 in front of the operator's compartment.



2. Completely clean around the area of the steering orbitrol.
3. Put tags on the lines to the steering orbitrol for identification at installation.
4. Rotate the steering wheel a small amount in each direction several times, then release to get a balance of pressure in the steering circuit. Slowly loosen the hydraulics lines at ports L and R to release any remaining pressure. Disconnect the hydraulic lines from IN and OUT ports. Put plugs and caps in the ports and hydraulic lines.
5. Remove the four bolts which fasten the steering column and orbitrol to the mounting bracket. Be sure to hold the steering orbitrol in position while the last bolt is being removed. Remove the steering orbitrol.



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- |                              |                        |
|------------------------------|------------------------|
| 1. Dust Seal Ring            | 15. Washer             |
| 2. Housing, Spool and Sleeve | 16. Special Screw      |
| 3. Ball                      | 17. Screw              |
| 4. Threaded Bushing          | 18. Name Plate         |
| 5. O-Ring & Kin-ring         | 21. Relief Valve       |
| 6. Bearing Assembly          | 22. Spring             |
| 7. Kin-ring                  | 23. Shock Valve        |
| 8. Cross Pin                 | 31. Ball & Spring      |
| 9. Neutral Position Springs  | 33. Suction Valve Pins |
| 10. Cardan Shaft             | 34. Gearwheel Set      |
| 11. O-ring                   | 35. O-ring             |
| 12. Distributor Plate        | 36. Kin-ring           |
| 13. Gearwheel Set            | 37. Bushing            |
| 14. End Cover                |                        |

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Steering Orbitrol

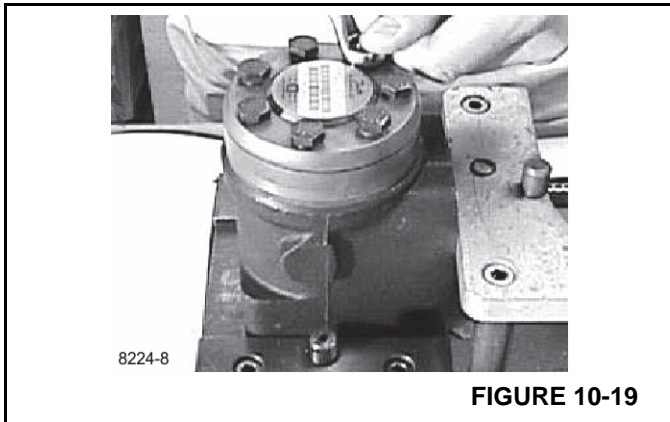
FIGURE 10-18



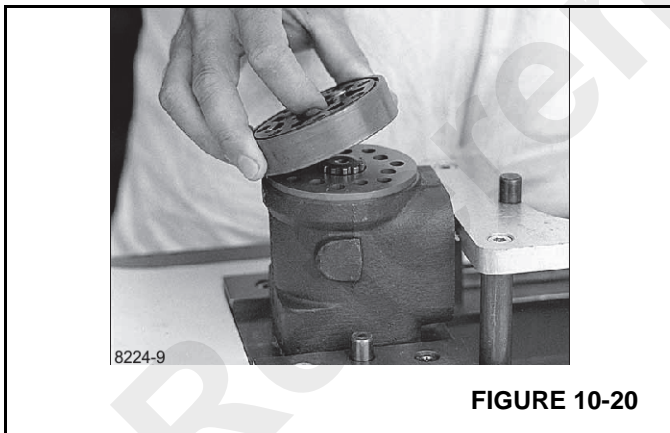
**Disassembly**

Cleanliness is extremely important when repairing a steering orbitrol. Work in a clean area. Use a wire brush to remove foreign materials and debris from around exterior joints of the unit.

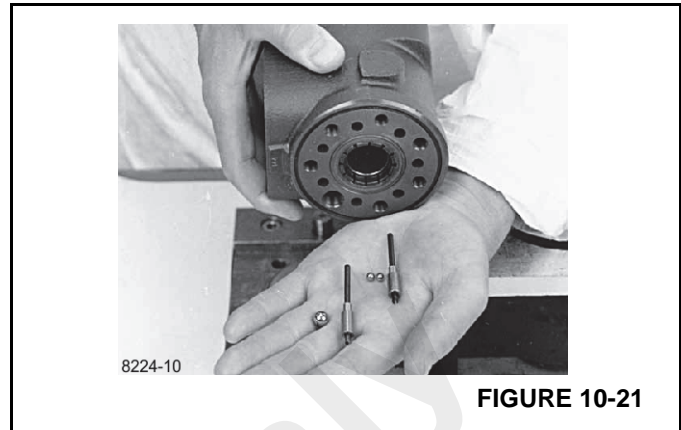
1. Place the steering unit in the holding tool. Screw out the screws in the end cover (6 standard plus one special screw).

**FIGURE 10-19**

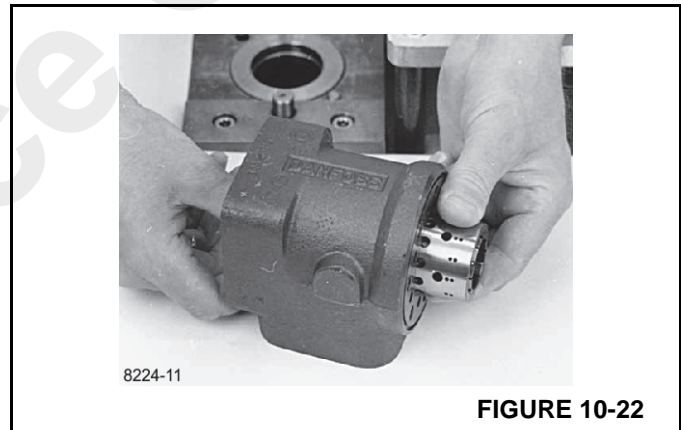
2. Remove the end cover.
3. Lift the gearwheel set (with spacer if fitted) off the unit. Take out the two O-rings.

**FIGURE 10-20**

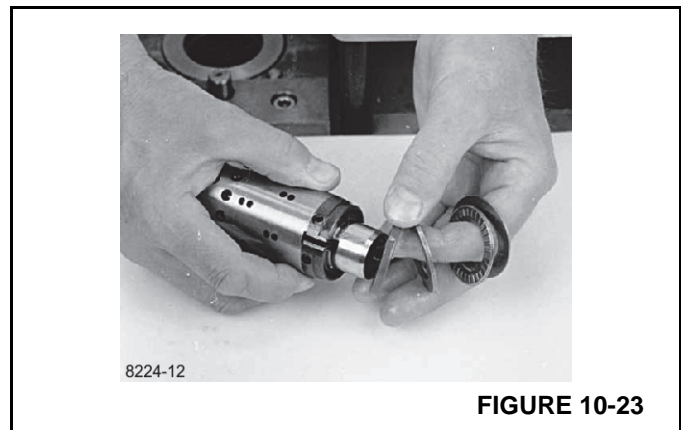
4. Remove cardan shaft (10, Figure 10-18).
5. Remove distributor plate (12).
6. Remove the threaded bushing (4) over the check valve.
7. Remove the O-ring (11).
8. Shake out the check valve ball and suction valve pins and balls (Figure 10-21).

**FIGURE 10-21**

9. Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and needle bearing will be pushed out of the housing together (Figure 10-22).

**FIGURE 10-22**

10. Take ring, bearing races and needle bearing from sleeve and spool. The outer (thin) bearing race can sometimes "stick" in the housing, therefore check that it has come out (Figure 10-23).

**FIGURE 10-23**

11. Press out the cross pin. Use the special screw from the end cover (Figure 10-24).

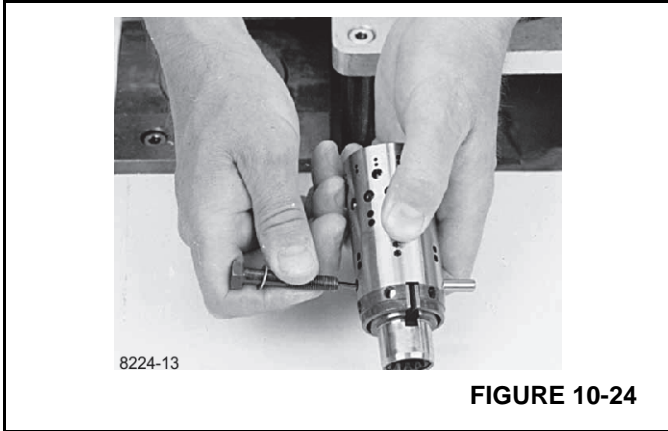


FIGURE 10-24

12. A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs (Figure 10-25). If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are dismantled.

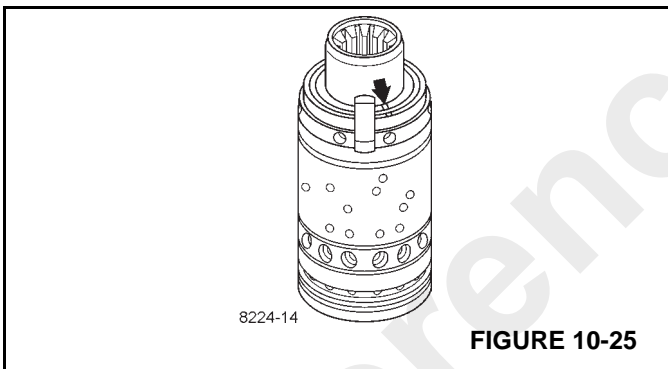


FIGURE 10-25

13. Carefully remove the spool out of the sleeve (2, Figure 10-18).

14. Press the neutral position springs (9) out of their slots in the spool.

15. Remove dust seal and O-ring / Kin-ring / Roto Glyd (Figure 10-27).

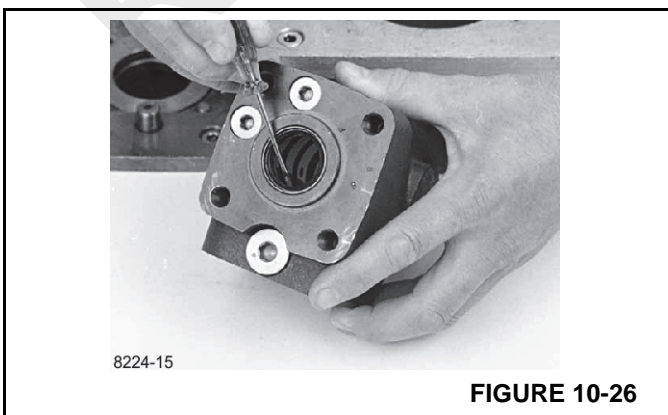


FIGURE 10-26

16. Remove plugs from shock valves using a 6 mm Allen wrench (Figure 10-27).

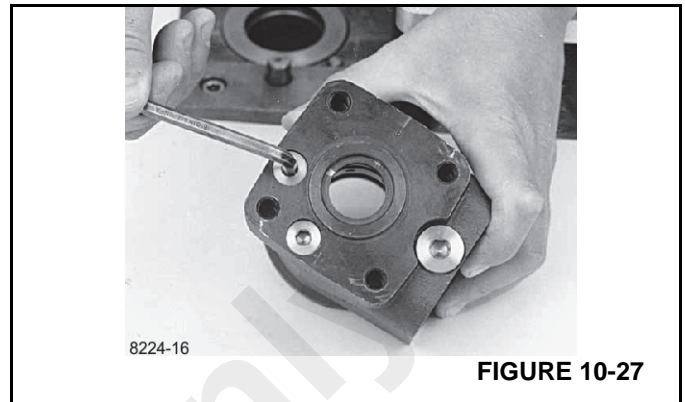


FIGURE 10-27

17. Remove seal washers (Figure 10-28).

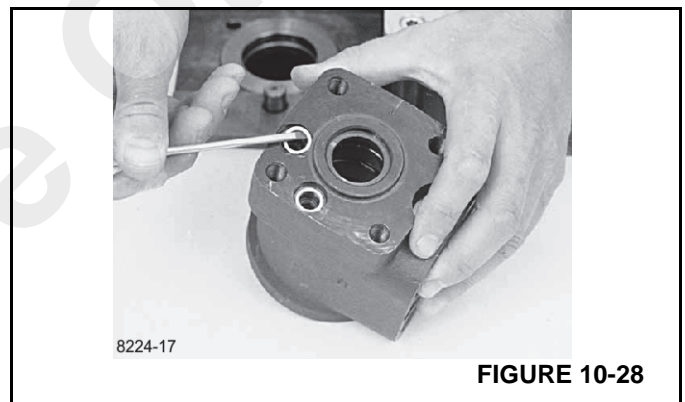


FIGURE 10-28

18. Unscrew the setting screws using a 6 mm Allen wrench (Figure 10-29).

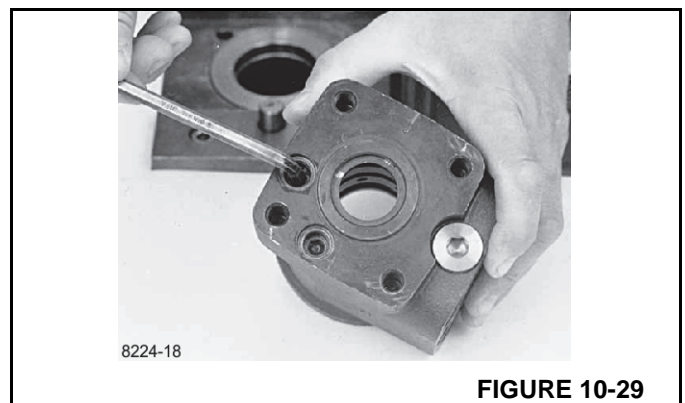


FIGURE 10-29

19. Shake out the two springs and two valve balls into your hand (Figure 10-30). The valve seats are bonded into the housing and cannot be removed.

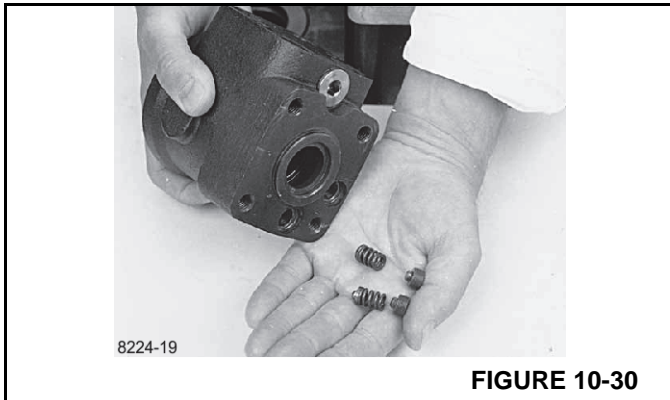


FIGURE 10-31

20. Remove the plug using an 8 mm Allen wrench. Remove seal washers (Figure 10-31).

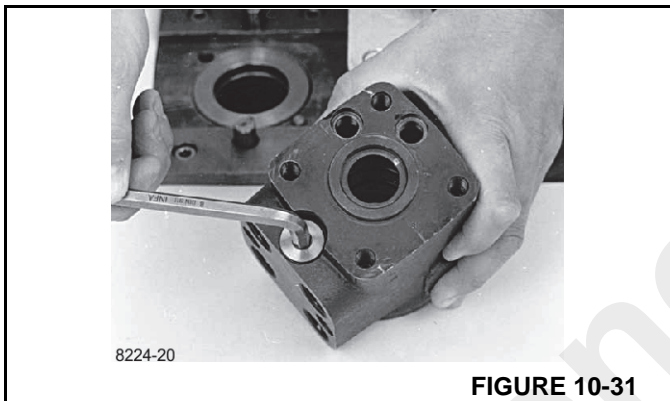


FIGURE 10-32

21. Unscrew the setting screw using an 8 mm Allen wrench (Figure 10-32).

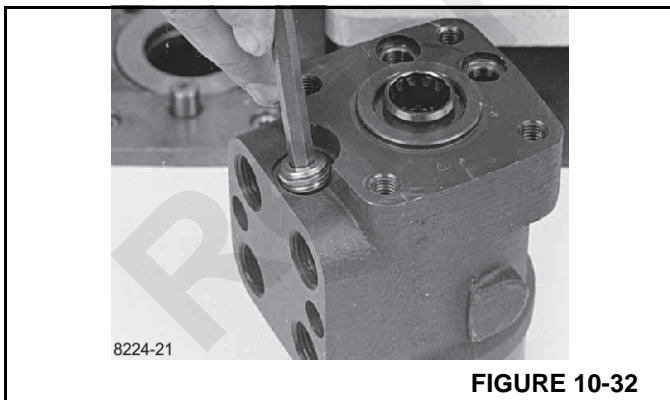


FIGURE 10-32

22. Shake out spring and piston (Figure 10-33). The valve seat is bonded into the housing and cannot be removed.

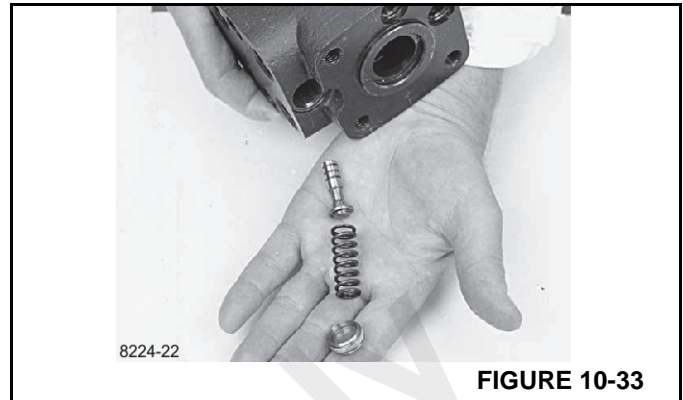


FIGURE 10-33

### Inspection

Check all mating surfaces. Replace any parts that have scratches or burrs that could cause leakage or binding. Clean all metal parts in a clean solvent. Blow dry with air. Do not wipe dry with a cloth or paper towel, because lint or other matter can get into the hydraulic system and cause damage. Do not use a coarse grit emery cloth or try to file or grind any parts.

Replace all seals when assembling the unit. Lubricate all seals with clean petroleum jelly before assembling. DO NOT use excessive lubricant on seals for the meter section.

### Assembly

1. Place the two flat neutral position springs in the slot. Place the curved springs between the flat ones and press them into place. Center the springs in the spool (Figure 10-34).

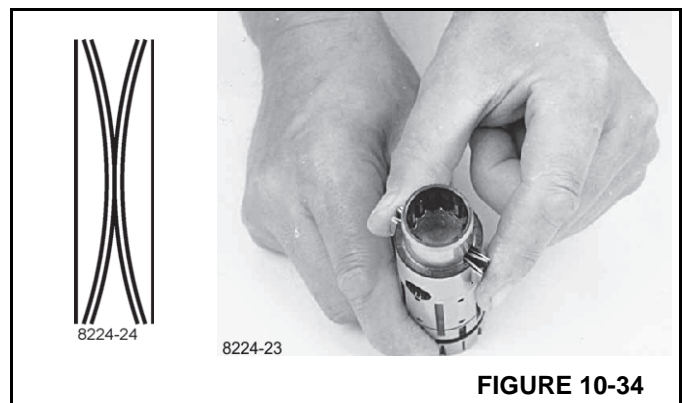


FIGURE 10-34

2. Assemble the spool/sleeve and make sure the marks on spool and sleeve are opposite each other (see Figure 10-25).
3. Press the springs together and push the neutral position springs into place in the sleeve. Line up the springs and center them.
4. Guide the ring down over the sleeve (Figure 10-35).

**NOTE:** The ring should be able to move free of springs.

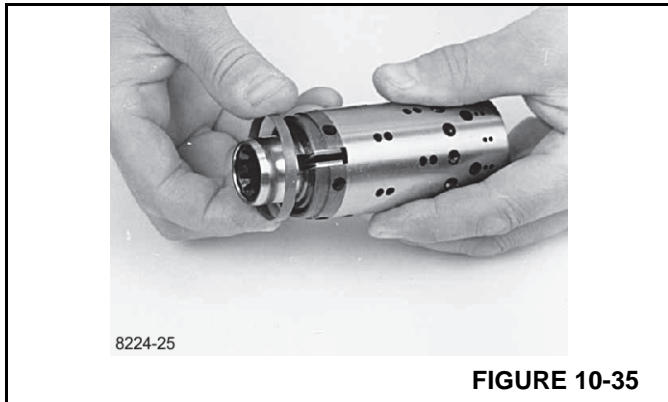


FIGURE 10-35

5. Fit the cross pin into the spool/sleeve (Figure 10-36).

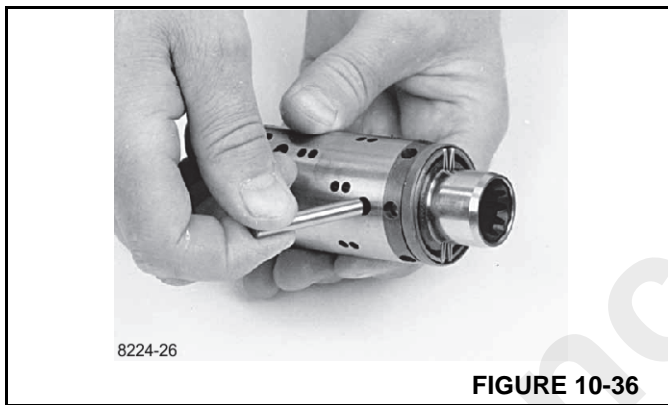


FIGURE 10-36

6. Fit bearing races and needle bearings as shown in Figure 10-37 or Figure 10-38.

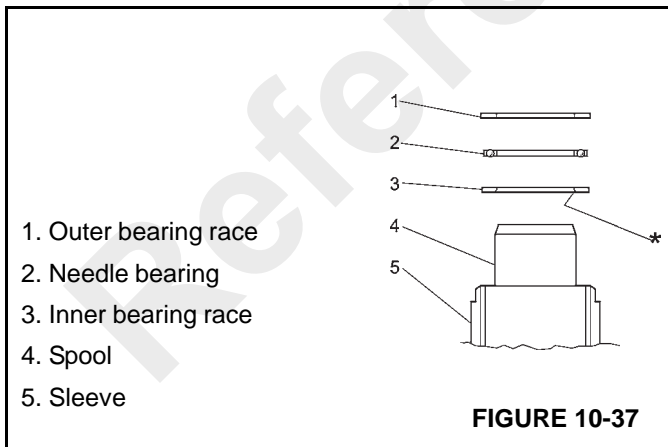


FIGURE 10-37

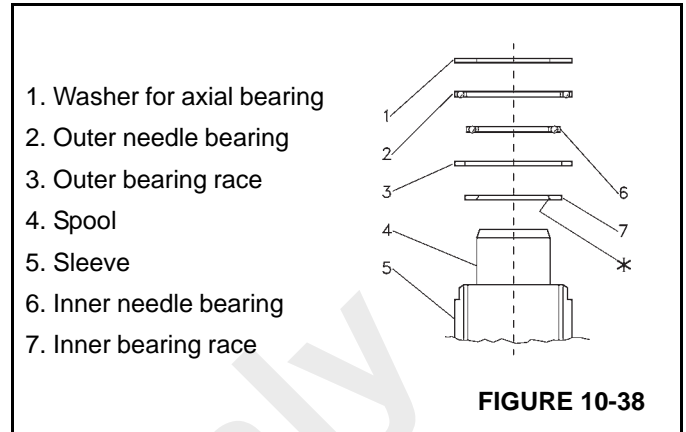


FIGURE 10-38

7. Turn the steering unit until the bore is horizontal. Guide the outer part of the assembly tool into the bore for the spool/sleeve (Figure 10-39).

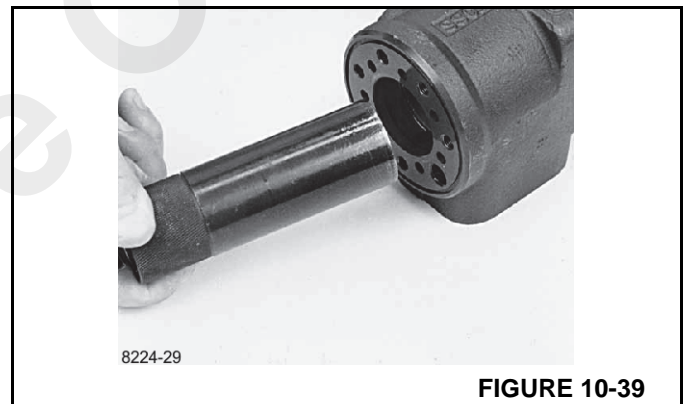


FIGURE 10-39

8. Grease O-ring and kin-ring/roto Glyd with hydraulic oil and place them on the tool (Figure 10-40).

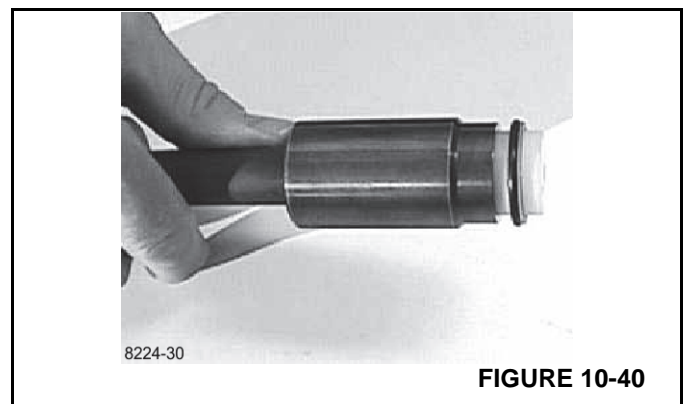


FIGURE 10-40

9. Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom (Figure 10-41).

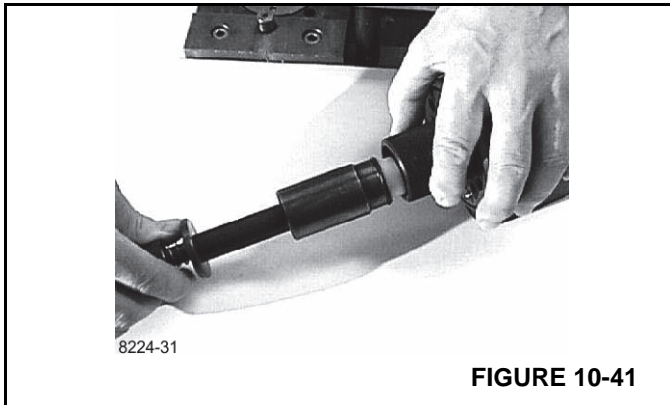


FIGURE 10-41

- 10. Press and turn the O-ring/kin-ring into position in the housing.
- 11. Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore (Figure 10-42).

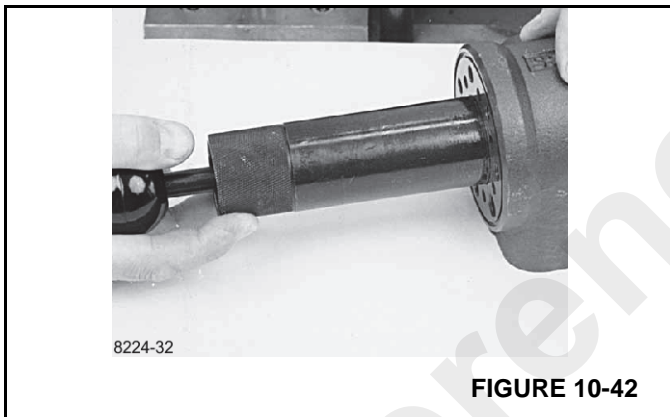


FIGURE 10-42

- 12. Lubricate the lip seal with hydraulic oil and place it on the assembly tool (Figure 10-43).

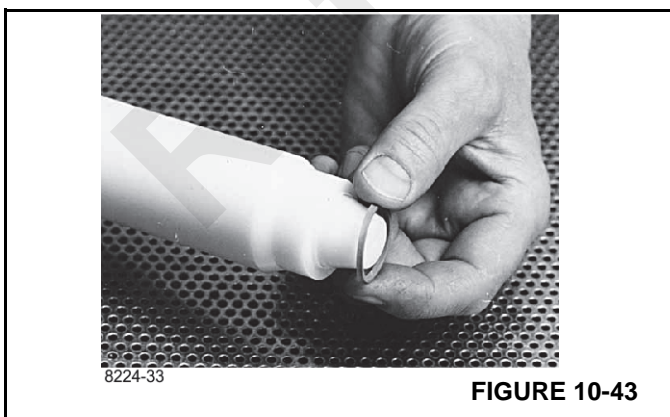


FIGURE 10-43

- 13. Insert the assembly tool fully to the bottom. Press and turn the lip seal into place in the housing (Figure 10-44).



FIGURE 10-44

- 14. With a light turning movement, guide the spool and sleeve into the bore. Fit the spool assembly holding the cross pin horizontal (Figure 10-45).

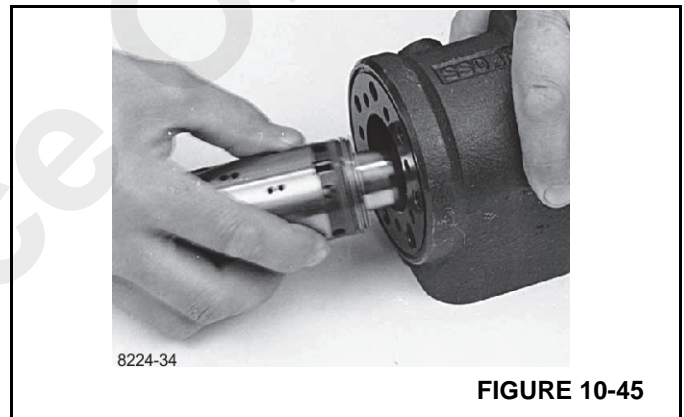


FIGURE 10-45

- 15. The spool assembly will push out the assembly tool guide. The O-ring and kin-ring/roto Glyd are now in position (Figure 10-46).

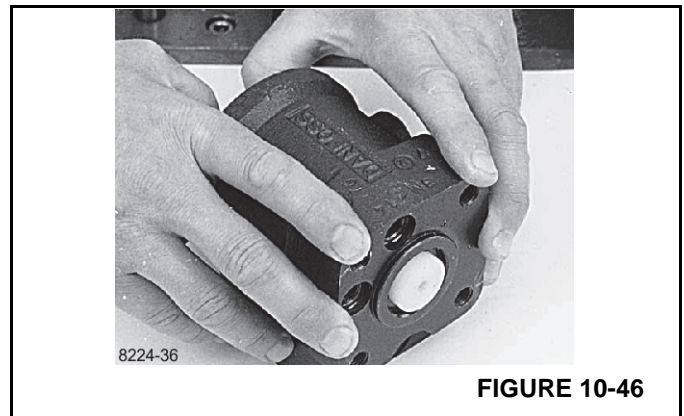


FIGURE 10-46

- 16. Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole shown (Figure 10-47).

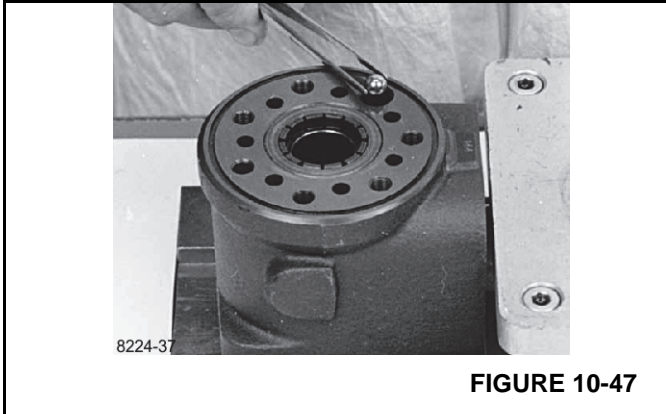


FIGURE 10-47

17. Screw the threaded bushing lightly into the check valve bore. The top of the bushing must lie just below the surface of the housing.

18. Place a ball in the two holes indicated (Figure 10-48).

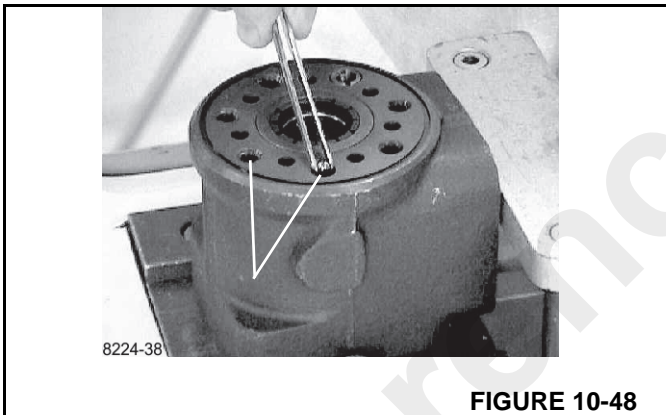


FIGURE 10-48

19. Place a new pin in the same two holes. In some cases a spring has to be fitted on the pin before it is placed in the housing.

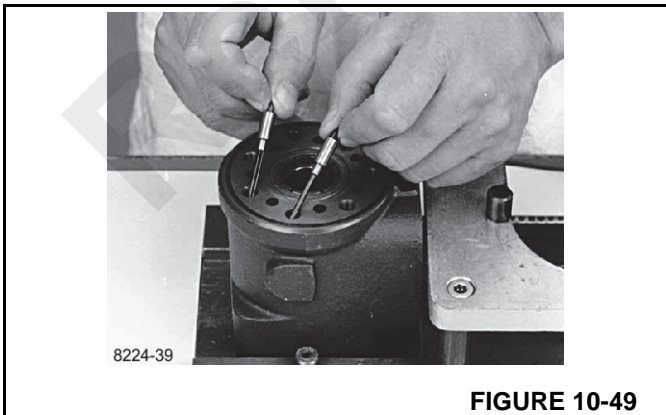


FIGURE 10-49

20. Lubricate an O-ring (11, Figure 10-18) with petroleum jelly and install in groove.

21. Place the distributor plate so that the channel holes match the holes in the housing.

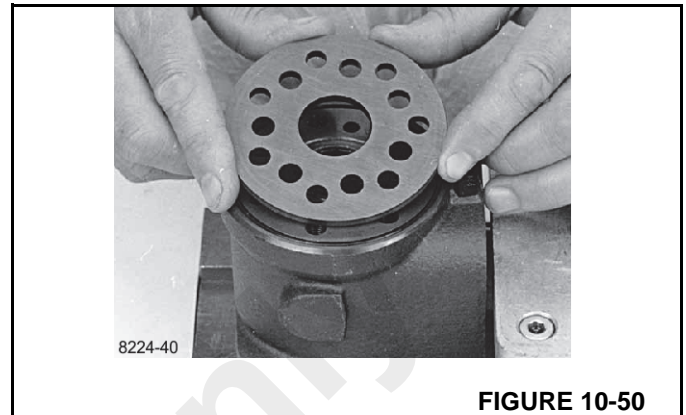


FIGURE 10-50

22. Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.

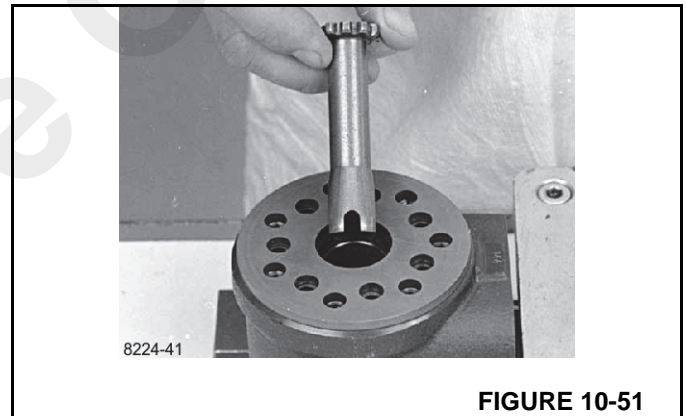


FIGURE 10-51

23. Place the cardan shaft as shown - so that it is held in position by the mounting fork.

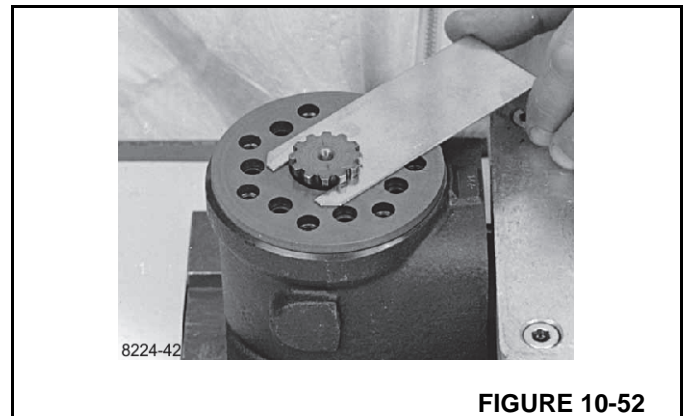


FIGURE 10-52

24. Grease the two O-rings with petroleum jelly and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft (Figure 10-53).

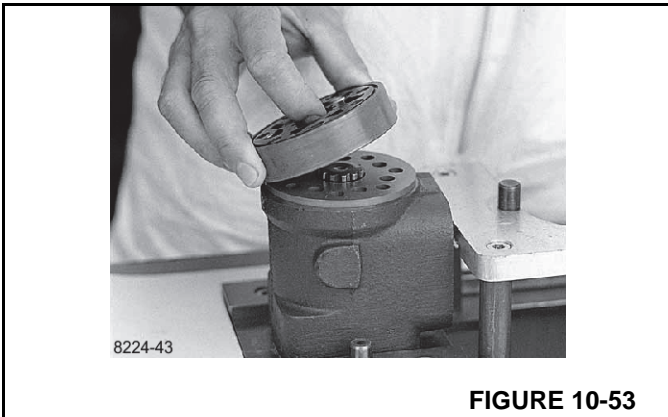


FIGURE 10-53

25. Fit the gearwheel (rotor) and cardan shaft so that a tooth base in the rotor is positioned in relation to the shaft slot as shown. Turn the gear rim so that the seven through holes match the holes in the housing.

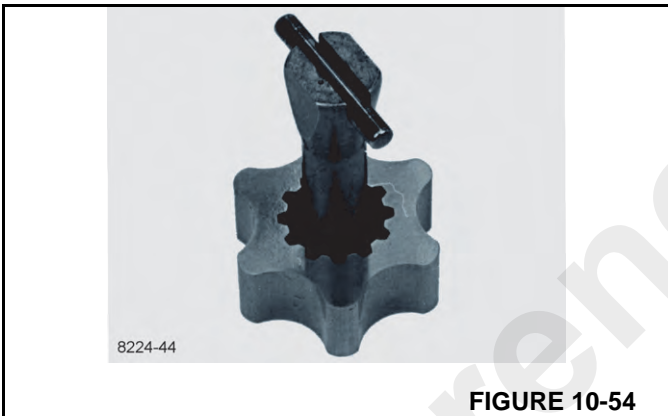


FIGURE 10-54

26. Fit the spacer, if any.

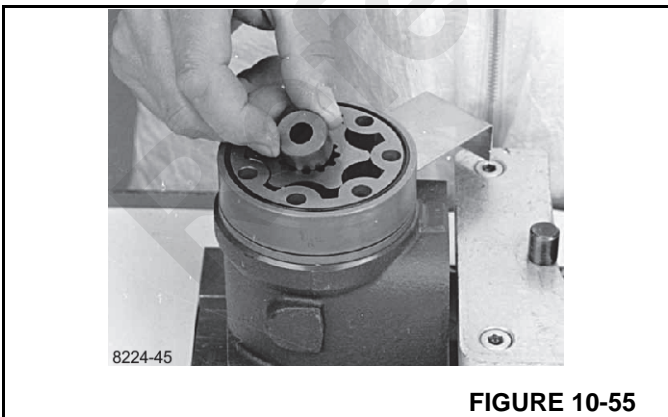


FIGURE 10-55

27. Place the end cover in position.

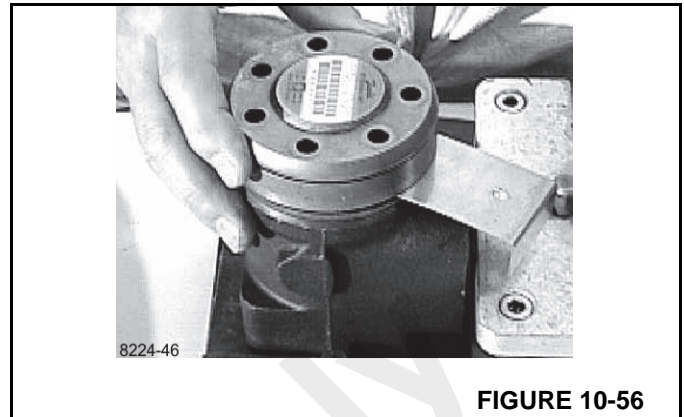


FIGURE 10-56

28. Fit the special screw with washer and place it in the hole shown.

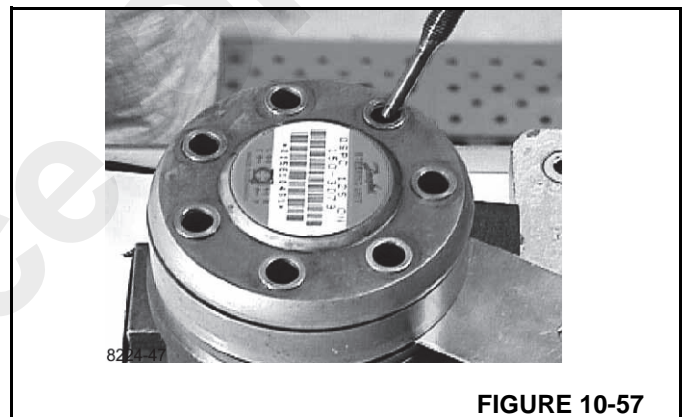


FIGURE 10-57

29. Fit the six screws with washers and insert them. Cross-tighten all the screws with a torque of  $30 \pm 6$  Nm (265.5  $\pm$  53 lb in).

30. Install the piston and spring (Figure 10-58).

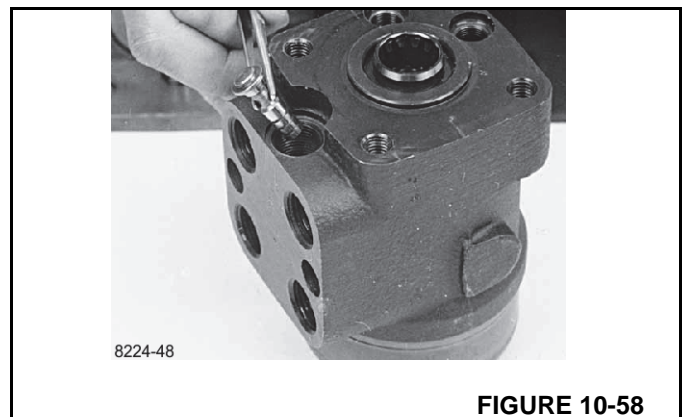


FIGURE 10-58

31. Screw in the setting screw with an 8 mm Allen wrench. Make the pressure setting on a panel or the vehicle.

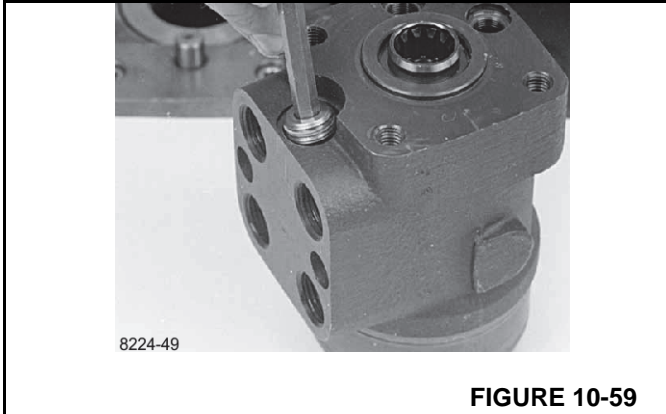


FIGURE 10-59

32. Screw plug with dust seal into the housing using an 8 mm Allen wrench. Tightening torque:  $65 \pm 5$  Nm ( $575.3 \pm 44.2$  lb in).

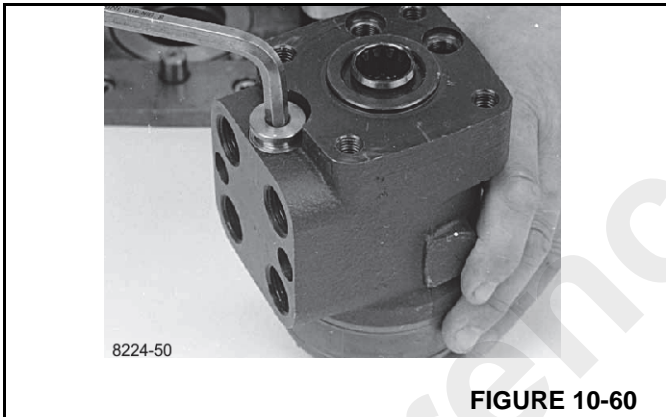


FIGURE 10-60

33. Put a ball in the two holes indicated.

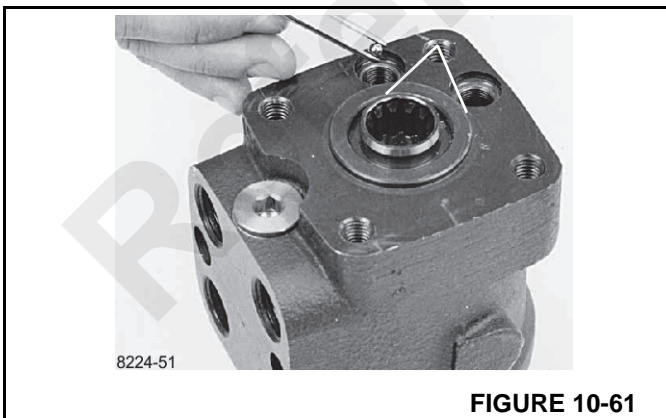


FIGURE 10-61

34. Place springs and valve cones over the two balls.

**NOTE:** The blue spring applies to setting range 90-180 bar (1305-2610 psi). The untreated spring applies to setting range 170-260 bar (2465-3770 psi).

35. Screw in the two setting screws using a 6 mm Allen wrench. Make the pressure setting on a panel or the vehicle.

36. Screw plugs with seal rings into the two shock valves and tighten them with a torque of  $30 + 10$  Nm ( $265.5 + 88.5$  lb in) using a 6 mm Allen wrench.

37. Fit the dust seal ring in the housing using special tool and a plastic hammer.

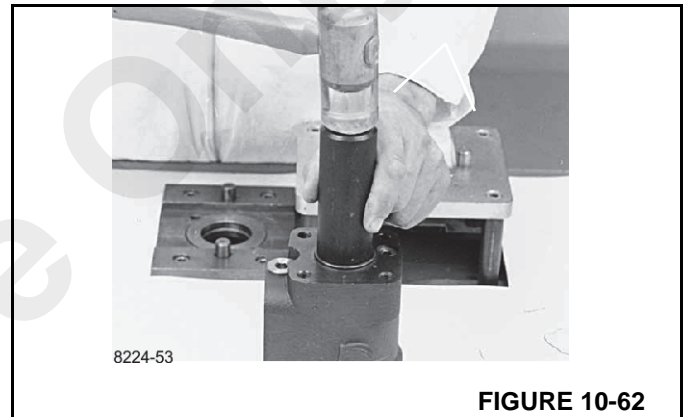


FIGURE 10-62

### Installation

1. Locate the steering orbitrol and steering column in position on the mounting bracket under the instrument panel. Secure in place with four bolts and numerous flat washers.
2. Connect the hydraulic lines to the steering orbitrol.
3. Check the hydraulic oil level in the reservoir. Fill if necessary.
4. Start the engine and turn the steering wheel in both directions to fill the lines with hydraulic fluid and bleed air from the system. Check for leaks and repair if necessary.
5. Check the hydraulic oil level in the reservoir. Fill if necessary.
6. Install the outside cover to the operator's compartment.

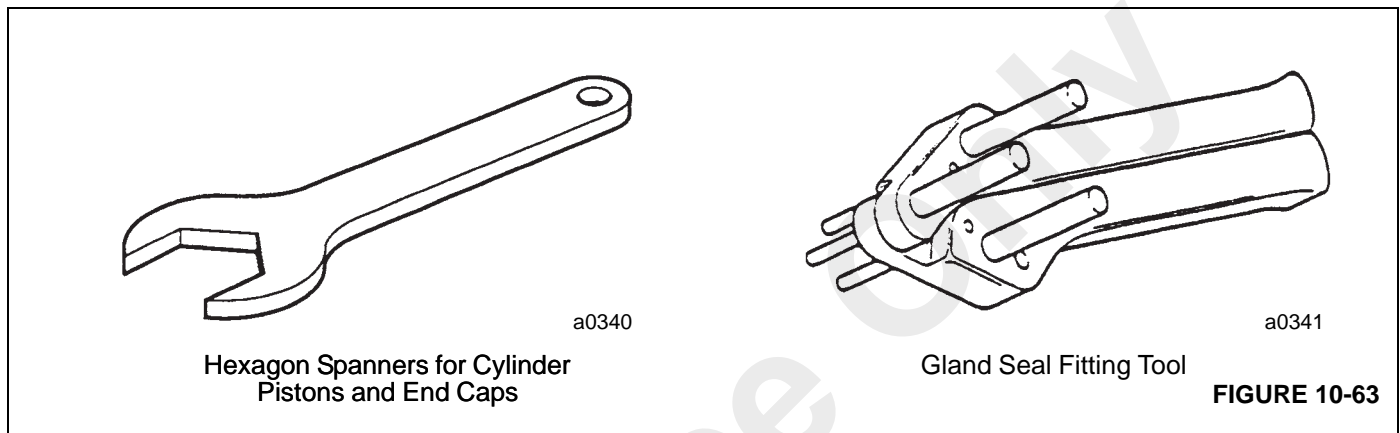


**STEERING CYLINDER**

**Technical Data**

Cylinder Bore . . . . .	.60 mm (2.36 inches)
Stroke . . . . .	.211 mm (8.30 inches)
Rod Diameter. . . . .	.30 mm (1.18 inches)

**Special Tools**



**Cylinder Repair**

**Removal**



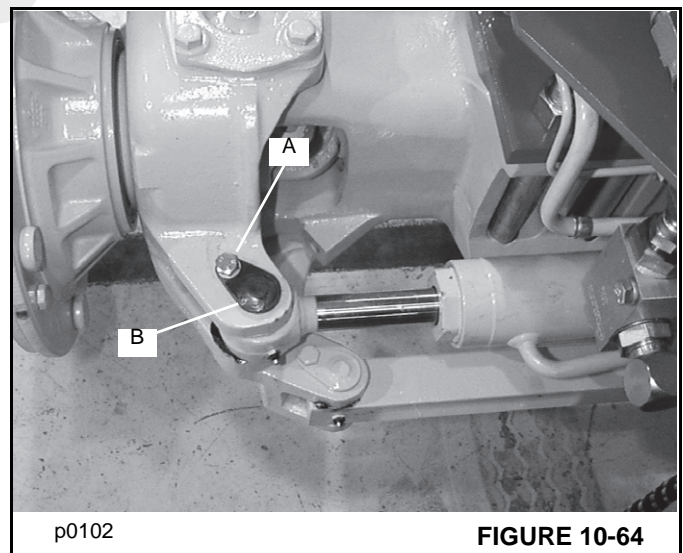
**WARNING**

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

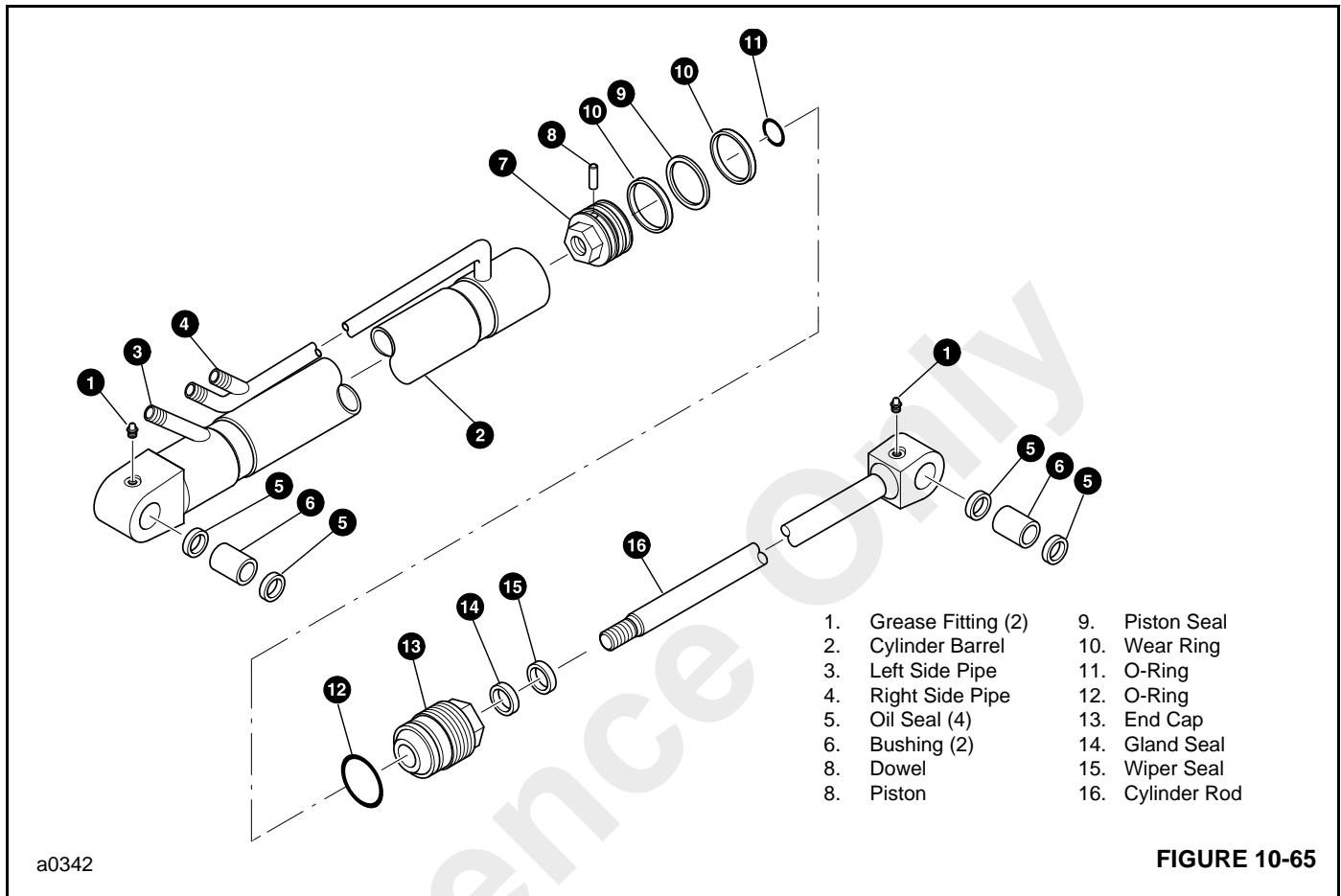
1. Raise and support the crane to gain access to the steering cylinder.
2. With the engine not running, turn the steering wheel in both directions to release any pressure in the hydraulic lines to the steering cylinder.
3. Be prepared to collect the oil as you remove the steering lines. Slowly loosen the hydraulic hoses to release any remaining pressure. Install a plug in the hose end and a cap on the cylinder port. Place a tag on the hoses for identification and correct assembly.
4. Remove locking bolts (A) Figure 10-64 and pivot pins (B) from both ends of the steering cylinder.

5. Remove the steering cylinder from the axle.



**Disassembly**

1. Remove the caps from the cylinder ports and drain remaining oil from the cylinder.
2. Secure the cylinder. If a vice is used, clamp only on the base end of the cylinder, DO NOT clamp across the cylinder tube.
3. Loosen end cap 13 Figure 10-65 using a special spanner wrench (See Special Tools, above) and remove the piston rod assembly 16 from the cylinder barrel.

**CAUTION**

If air or hydraulic pressure is used to force out the piston assembly, ensure that the end cap is securely installed. Severe injury can be caused by a sudden release of the piston rod.

4. Fasten the bushing end of the cylinder rod in a vice. Do not clamp a vise on the cylinder rod.
5. Remove and discard piston seal 9 and wear rings 10 from piston 7.
6. Remove dowel 8 from piston head 7 using a metric screw threaded into the extraction hole in the dowel.
7. Using a special spanner wrench (See *Special Tools on page 10-24*) remove the piston 7 from rod 16.
8. Remove and discard O-ring 11.
9. Remove cap end 13 from cylinder rod 16.

10. Remove and discard O-ring 12, seal gland 14 and wiper seal 15 from cap end 13.

11. Remove and discard the oil seals 5 from both the rod end and base ends of the cylinder.

**Inspection**

1. Clean all parts in a suitable solvent. Dry with compressed air. Make sure threads of piston rod, piston, end cap and cylinder are thoroughly cleaned using a wire brush to remove grease, hydraulic oil and Loctite.
2. Inspect cylinder rod for rust, distortion, pitting or damage to the chrome. If there is damage to the cylinder rod, replace it. Do not try to straighten a bent cylinder rod.
3. Inspect inside of the cylinder barrel for grooves, distortion or other damage. Use a light to illuminate the cylinder bore for careful inspection. Replace any cylinder barrel if there is distortion or damage.
4. Inspect the piston for damage to the lands.
5. Inspect rod and barrel bushings for wear or damage.
6. Replace all seals and rings.

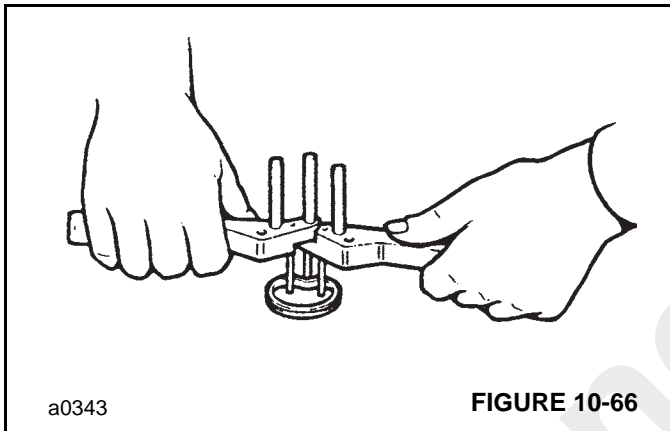
**Assembly**

1. Install new gland seal **14** Figure 10-65 using the special installation tool as follows:

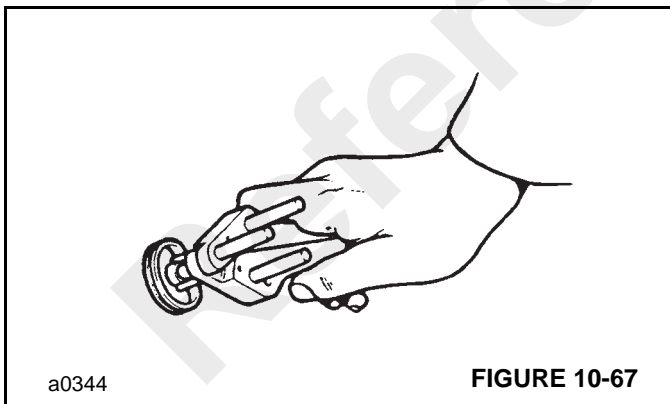
**NOTE:** The size (diameter) and position of pins is determined by the diameter and radial width of the gland seal being installed.

The pins are screwed into threaded holes in the tool body, the spacing of the holes is designed to fit small and large diameter gland seals.

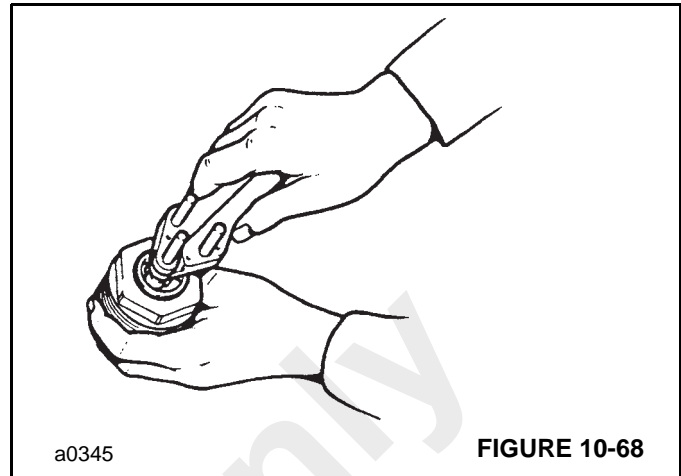
- a. Open the tool Figure 10-66 and insert the new gland seal. The seal must be installed behind the two front pins but in front of the rear pin as shown.



- b. Close the tool Figure 10-67. The seal must form a kidney shape.



- c. Locate the seal in the end cap groove Figure 10-68. When the seal is in position, open the tool to release the seal. Make sure the seal is correctly installed in its groove then remove the tool.



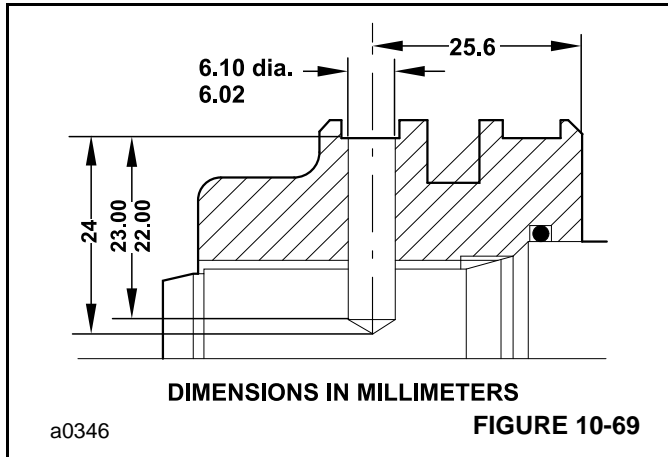
2. Install a new wiper seal **15** Figure 10-65 and new O-ring **12** to end cap **13**. The lip of the wiper seal must be facing out.
3. Apply Loctite Activator T to threads of the end cap and cylinder barrel. Allow the activator to dry for 15 minutes before bringing in contact with Loctite.

**NOTE:** Be sure that lubricants used during assembly do not come in contact with Loctite.

4. Cover the threads on the cylinder rod to prevent lubricant from contacting the Loctite.
5. Apply petroleum jelly to the inside bore of the end cap. Carefully slide the end cap assembly over the end of the piston rod.
6. Install O-ring **11** into piston **7**.
7. Install piston **7** onto cylinder rod **16**. Tighten to a torque of 405 Nm (300 lb-ft).
8. New cylinder rod and piston installed.

If both are required, the following procedure should be followed:

- a. Drill through the piston into the cylinder rod at the dimension Figure 10-69. Use an undersize drill first as a guide, drill to a depth of 24 mm (0.94 in). Then using a 6 mm drill bit, drill the hole for the dowel.
- b. Remove all debris and contamination. Insert dowel **8** Figure 10-65 into drilled hole. Make sure threaded extractor hole is to the outside.



9. New piston on a predrill cylinder rod.
  - a. Re-drill and dowel BOTH the piston and cylinder rod at 90° from the existing drilled dowel hole in the cylinder rod. Follow procedures in step 8.
10. New cylinder rod installed to a predrilled piston.
 

Use the predrilled hole in the piston. Care must be taken not to elongate the existing hole in the piston.

  - a. Using a 6 mm drill make a center mark in the cylinder rod. DO NOT drill the cylinder rod at this time.
  - b. Use an undersized diameter drill bit to drill a guide hole to the depth of 24 mm (0.94 in) Figure 10-69. Make sure the drill bit is centered correctly on the center mark made in Step a.
  - c. Use a 6 mm drill bit and drill a hole to the depth of the guide hole.
  - d. Remove all debris and contamination. Install dowel 8 Figure 10-65.
11. Install wear ring 10 and piston seal 9 onto piston 7.

12. Carefully insert the assembled cylinder rod into the cylinder barrel. Use care to prevent damage to the piston seal and wear ring during installation. Work the piston rod straight into the cylinder barrel.
13. Apply Loctite 932 to the first three threads of the end cap. Slide the end cap into the cylinder barrel and engage the threads. Tighten the end cap with the spanner wrench to a torque of 678 Nm (500 lb-ft).

**NOTE:** If hydraulic oil contacts uncured Loctite a weakening of the bond will result. Cure times vary according to the ambient temperature and the type of activator used. The curing time for Loctite 932 and Activator T at an ambient temperature of 20°C (68°F) is two hours. Do not apply oil to the cylinder before this time.

14. Fill and test the cylinder.

#### Installation

1. Locate the steering cylinder on the axle.
2. Apply anti-seize compound to pivot pins and install in both the rod end and base end of the cylinder.
3. Install locking bolts to hold pins in place.
4. Connect the hydraulic hoses to the cylinder.
5. Lubricate the grease fitting with Lithium based, E.P. No. 2 bearing grease.
6. Check the hydraulic oil level and add oil if necessary.
7. Start the engine and operate the cylinder(s) through several complete cycles to remove air from the system. Operate the cylinders slowly and do not let them hit bottom until movement is positive in both directions. After the circuit is filled with oil, the cylinders can be operated normally.
8. Check for leaks and repair if necessary.
9. Check the hydraulic oil level and fill if necessary.

Reference Only

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**SECTION 11  
STRUCTURALS**

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**BOOMS**

**General**

The three section boom as well as the four section boom is hydraulically extended and retracted by a telescope cylinder inside the boom.

**Removal of Boom Assembly**

1. Remove the hook block and wire rope.
2. Retract the boom
3. Remove the boom extension, if installed.
4. Raise the boom until the pin in the rod end of the lift cylinder can be seen.

**NOTE:** Use at least a 1.8 Metric Ton (2 ton) overhead crane when lifting the boom assembly. Be sure slings and/or chains are capable of handling a 1.8 Metric Ton (2 ton) load.

5. Connect a hoist to the boom that will lift more than 1812 kg (4000 lb).
6. Release the hydraulic pressure in the hoist and telescope circuits. Disconnect the hydraulic tubes on the

mast from the hydraulic hoses coming from the boom. Put caps and plugs on the hydraulic tubes and hoses.

7. Disconnect any electrical wires. See Electric System, page 3-1.
8. Place a support under the cylinder to prevent damage to the cylinder. Remove the pin from the rod of the lift cylinder. Retract the lift cylinder rod.
9. Remove the boom pivot pin and remove the boom. Place the boom on blocks or steel horses.

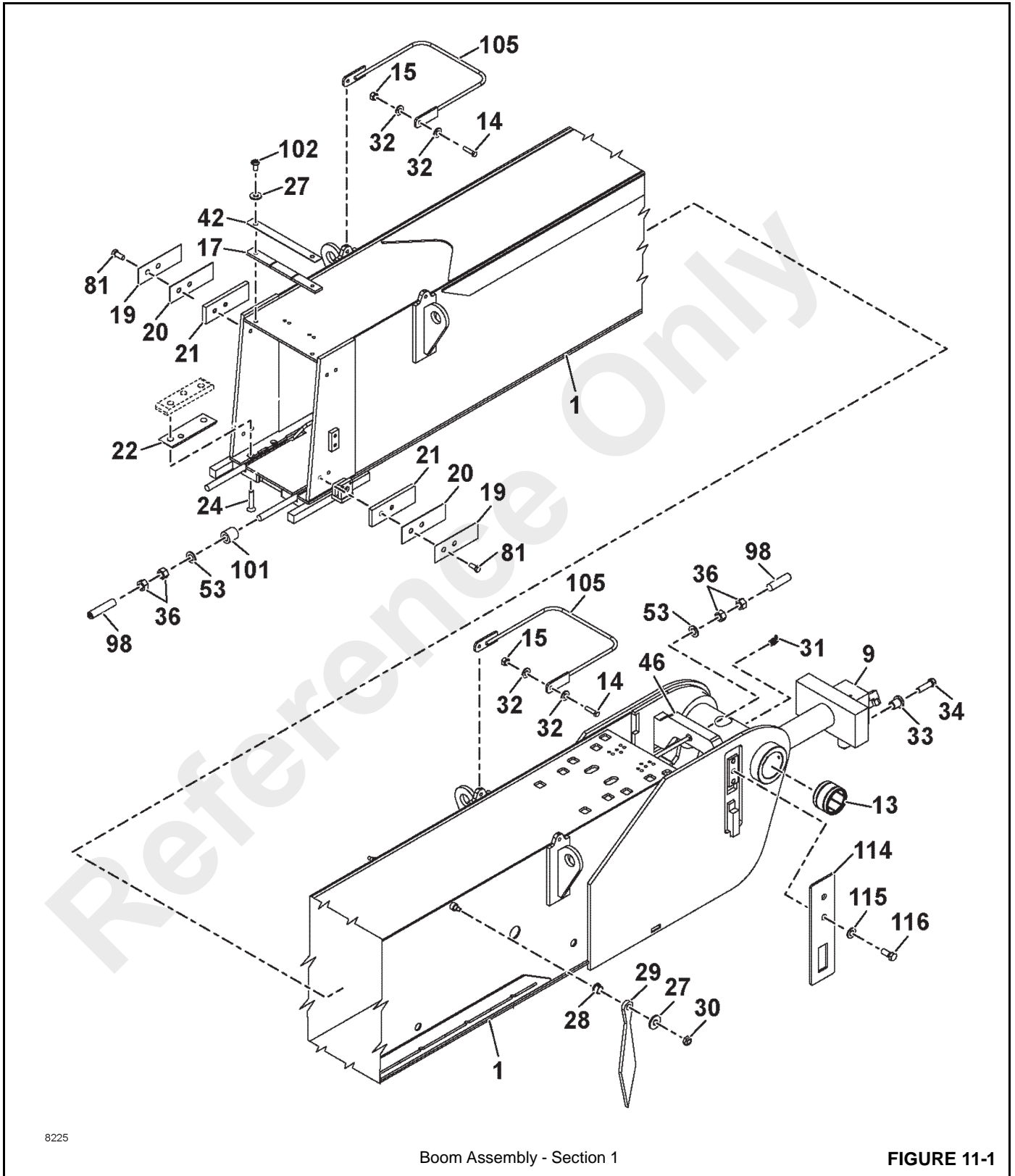
**Installation of the Boom Assembly**

**NOTE:** Use at least a 1.8 Metric Ton (2 ton) overhead crane when lifting the boom assembly. Be sure slings and/or chains are capable of handling a 1.8 Metric Ton (2 ton) load.

1. Using an overhead crane, position the boom between the ears of the mast. Install the mounting pin and fasten with keeper pins and bolts.
2. Lower the boom or extend the lift cylinder as necessary to install the lift cylinder pin and keeper pin and bolt.
3. Connect hoses from the hydraulic swivel to the telescope cylinder.

4. Connect electrical wiring as necessary. Refer to Electric System, page 3-1.
5. Install the wire rope and hook block.
6. Start the engine and operate all boom functions in both directions to remove air from the hydraulic system. Check for leaks.

Reference Only

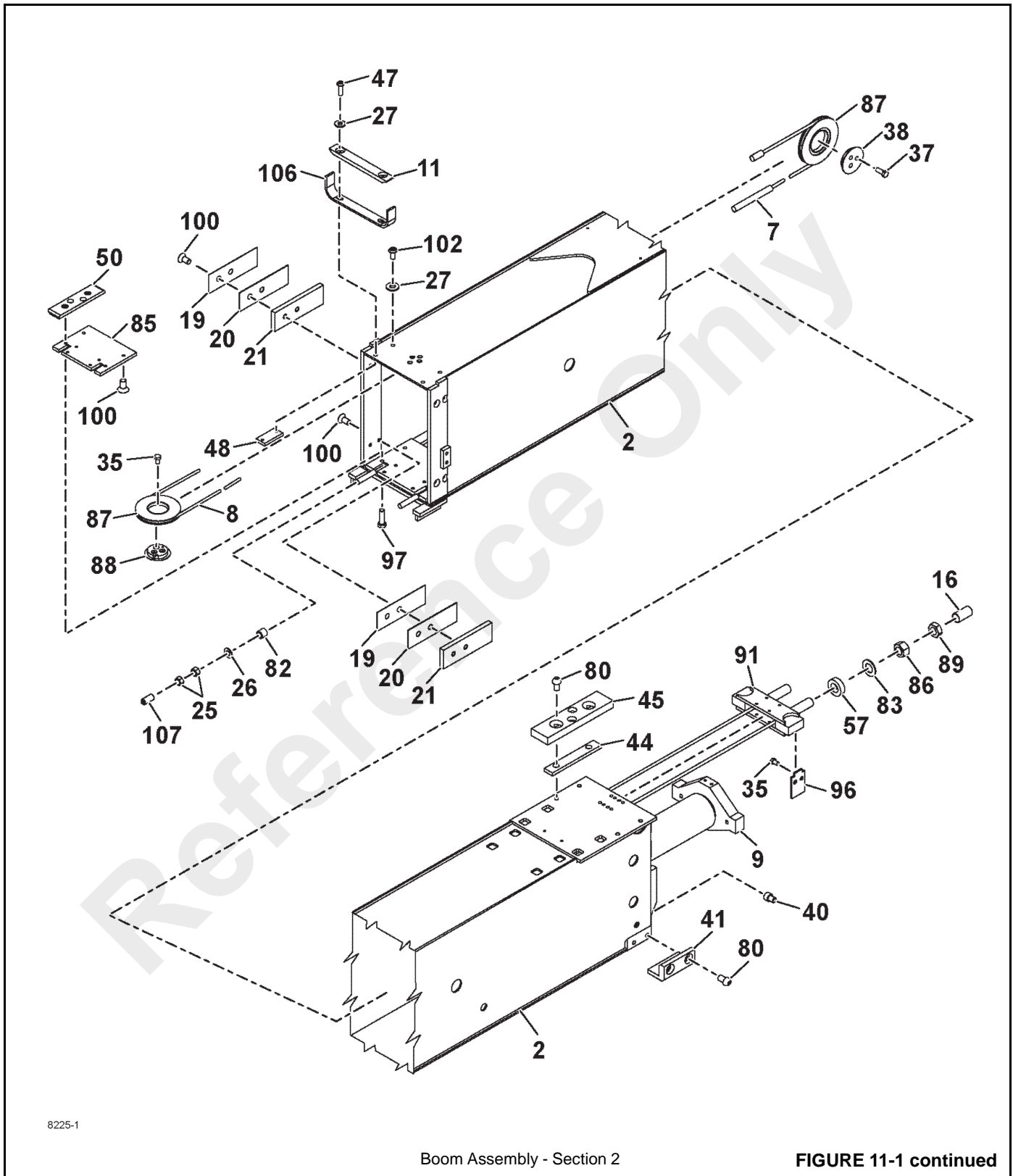


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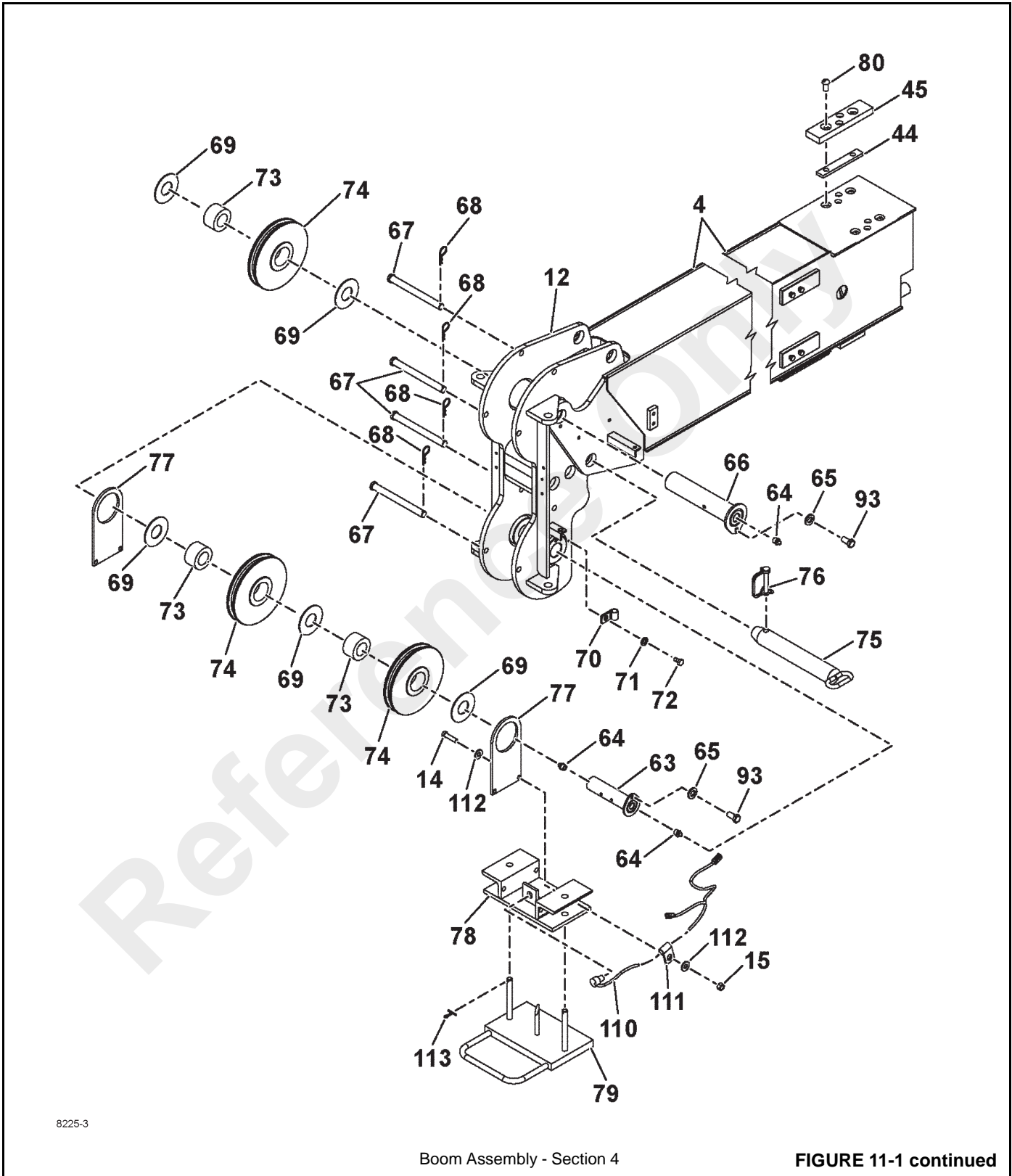
Boom Assembly - Section 1

FIGURE 11-1









8225-3

Boom Assembly - Section 4

FIGURE 11-1 continued

Item	Description
1	1st Boom Section
2	2nd Boom Section
3	3rd Boom Section
4	4th Boom Section
5	Retract Cable
6	Extend Cable
7	Retract Cable
8	Extend Cable
9	Telescope Cylinder
10	Tall Cable Guide
11	Wear Pad
12	Pivoting Boom Head
13	Bronze Bushing
14	Capscrew
15	Hex Nut
16	Cable Protector
17	Wear Pad
18	Capscrew
19	Shim
20	Shim
21	Wear Pad
22	Backing Plate
23	Not used
24	Capscrew
25	Hex Nut
26	Hardened Washer
27	Flat Washer
28	Bearing
29	Pendulum
30	Locknut
31	Grease Fitting
32	Washer
33	Spacer
34	Capscrew
35	Capscrew
36	Hex Nut
37	Capscrew

Item	Description
38	Pin
39	Sheave Wheel
40	Capscrew
41	Wear Pad
42	Shim
43	Capscrew
44	Plate
45	Wear Pad
46	Anchor Plate
47	Capscrew
48	Cable Keeper
49	Not used
50	Wear Pad
51	Plate
52	Capscrew
53	Hardened Washer
54	Anchor Plate
55	Anchor Plate
56	Wear Pad
57	Spacer
58	Wear Pad
59	Flat Washer
60	Sheave Wheel
61	Bearing
62	Pin
63	Lower Sheave Pin
64	Grease Fitting
65	Lock Washer
66	Upper Sheave Pin
67	Clevis Pin
68	Pin
69	Nylatron Spacer
70	Clamp
71	Lock Washer
72	Cap Screw
73	Bearing Assembly
74	Sheave
75	Pivot Lock Pin

Item	Description
76	Pin
77	Pivot Boom Head Hanger
78	Anti-Two Block Assembly Upper Pivot
79	Lower Anti-Two Block Assembly
80	Capscrew
81	Capscrew
82	Spacer
83	Hardened Washer
84	Clamp
85	Plate
86	Hex Nut
87	Sheave Wheel
88	Sheave Pin
89	Jam Nut
90	Capscrew
91	Anchor
92	Anchor Plate
93	Capscrew
94	Capscrew
95	Lock Bar
96	Plate
97	Capscrew

Item	Description
98	Cable Protector
99	Plate
100	Capscrew
101	Spacer
102	Capscrew
103	Snap Ring
104	Shim
105	Guide
106	Short Cable Guide
107	Cable Protector
108	Shim
109	Not used
110	Anti-Two Block Switch Assembly
111	Clamp
112	Washer
113	Cotter Pin
114	Retainer Plate
115	Flat Washer
116	Capscrew

## Disassembly

1. At the rear of the assembly, remove the hoses and fittings from the telescope cylinder. Cap or plug all openings.
  2. Loosen the front top and bottom side wear pads on boom section 1.
  3. Remove the capscrews securing the telescope cylinder to section 1.
  4. Remove the hardware attaching the cable to the anchor platte.
  5. Remove the hardware securing the retainer plate to the anchor plate.
  6. Remove the bolts and lock washers securing the wear pad retainer plates to the front of boom section 1, remove the retainer plates.
  7. Raise up on the boom section 2 assembly and remove the wear pads from the boom section 1.
  8. Slide the assembly out of the boom section 1.
  9. As necessary, remove the following items from the boom section 1:
    - a. Wire rope guide.
    - b. Boom angle indicator.
    - c. Anti-two-block and RCL components.
    - d. Jib attachment brackets.
    - e. Upper rear cable wear pad.
    - f. Grease fittings and boom pivot pin bushings.
    - g. Remove the front top and bottom side wear pads, plugs and set screws.
  10. Remove the hardware securing the cable anchor to boom section 2.
  11. Remove the hardware securing the sheave wheels to the side and top of boom section 2.
  12. Remove the top rear wear pads from boom section 2.
  13. Remove the hardware securing the telescope cylinder bracket to the rear of boom section 2.
  14. Loosen the front top and bottom side wear pads on boom section 2.
  15. Remove the bolts and lock washers securing the wear pad retainer plates to the front of boom section 2, remove the retainer plates.
  16. Lift up on boom section 3 assembly and remove the wear pads from boom section 2.
  17. Slide the assembly out of boom section 2.
  18. As necessary, remove the following items from boom section 2:
    - a. Remove the bolts and lockwashers securing the lower rear wear pads, remove the wear pads.
    - b. Remove the front top and bottom side wear pads, plugs and set screws.
  19. Remove the top rear wear pads from boom section 3.
  20. Remove hardware securing sheave wheels to side of boom section 3.
  21. Raise up on boom section 4 assembly and remove the bolts and lockwashers securing the front bottom wear pads and remove the wear pads from boom section 3.
  22. Slide boom section 4 assembly out of boom section 3.
  23. As necessary, remove the following items from boom section 3:
    - a. Remove the bolts and lockwashers securing the lower rear wear pad, remove the wear pad.
    - b. Remove the wire rope guide.
    - c. Remove the bolts and lockwashers securing the two long wear bars in the bottom of the section and remove the wear bars.
    - d. Remove the bolts and lockwashers securing the bumper to the bracket in the front of the section and remove the bumper and shim(s).
    - e. Remove the bolt, lockwasher and washer securing the holding bracket to the side of the boom section and remove the bracket.
    - f. Remove hardware securing the cable anchor plate to the bottom of boom section 3.
    - g. Slide the telescope cylinder assembly out of the boom section.
- NOTE:** The following steps pertain to the disassembly of boom section 4 of the four section boom and section 3 of the three section boom.
24. Remove the top rear wear pads from boom section 4.
  25. As necessary, remove the following items from the boom section:
    - a. On the three section boom only, remove the bolts and lockwashers securing the rear bottom wear pad and remove the wear pad.
    - b. On the boom nose, remove the four pins and clevis pins.
    - c. On the four section boom, remove the retract adjuster.
    - d. Remove the bolt securing the upper sheave pin and remove the pin, sheave and two nylatron washers.
    - e. Remove the bolt securing the lower sheave pin, and remove the pin, two sheaves and three nylatron washers.

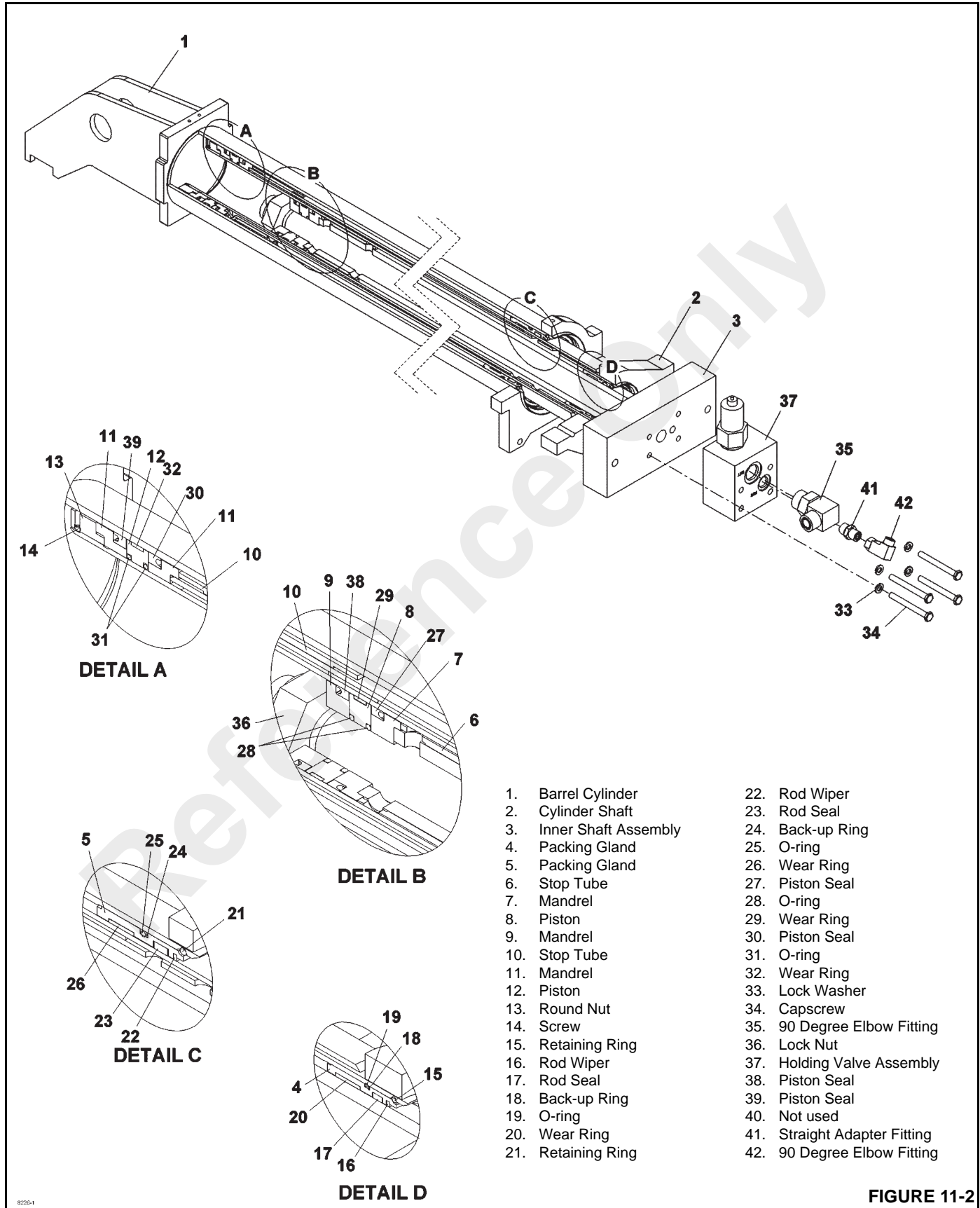


FIGURE 11-2

## Assembly

**NOTE:** During assembly, use Loctite® 243 (blue) on all fastener threads. Apply lubricant (bronze anti-seize) to all wear pads. Apply grease to the inside bottom, top, and sides of all boom sections.

Steps 12 thru 15 pertain to the assembly of boom section 4 of the four section boom and section 3 of the three section boom.

1. As necessary, install the following items on the boom section:
    - a. On the three section boom only, install the rear bottom wear pad and secure with the bolts and lockwashers.
    - b. On the boom nose, install the four clevis pins and pins.
    - c. On the four section boom, install the retract adjuster using two nuts.
    - d. Replace the bearings in the sheaves as necessary.
    - e. Install the upper sheave and two nylatron washers. Install the upper sheave pin and secure with a bolt.
    - f. Install the lower sheave and three nylatron washers. Install the lower sheave pin and secure with a bolt.
  2. Install the top rear wear pads on the boom section.
- NOTE:** Steps 3 thru 6 pertain only to the assembly of boom section 3 of the four section boom.
3. Slide the telescope cylinder assembly into boom section 3.
  4. As necessary, install the following items on boom section 3:
    - a. Install the lower rear wear pad and secure with the bolts and lockwashers.
    - b. Install the wire rope guide, two bolts, washers (4), lockwashers, and nuts.
    - c. Install the sheave wheel and cable and secure with hardware.
    - d. Install the anchor plates and cables and secure with hardware.
    - e. Install the front wear pads and secure with hardware.
  5. Slide the assembly into boom section 3.
  6. Raise up on boom section 4 assembly and install the front bottom wear pads in boom section 3. Install the bolts and lockwashers securing the wear pads.
  7. Install the top rear wear pads on boom section 3.
  8. As necessary, install the following items on boom section 2:
    - a. Install the lower rear wear pads and secure with the bolts and lockwashers.
    - b. Install the front top and bottom side wear pads, plugs and set screws. Do not tighten the set screw at this time.
  9. Slide the assembly into boom section 2.
  10. Install the sheave wheels and secure with hardware.
  11. Install the anchor and cables and secure with hardware.
  12. Raise up on boom section 3 assembly and install the front lower wear pads in boom section 2.
  13. Install the wear pad retainer plates to the front of boom section 2 and secure with the bolts and lock washers.
  14. Install the top rear wear pads on boom section 2.
  15. Tighten the front top and bottom side wear pad set screws on boom section 2 to center the assembly in boom section 2.
  16. As necessary, install the following items on the boom section 1:
    - a. Wire rope guide.
    - b. Boom angle indicator.
    - c. Anti-two-block and RCL components.
    - d. Jib attachment brackets.
    - e. Upper rear cable wear pad.
    - f. Grease fittings and boom pivot pin bushings.
    - g. Install the front top and bottom side wear pads, plugs and set screws. Do not tighten set screws at this time.
  17. Slide the assembly into the boom section 1.
  18. Raise up on the boom section 2 assembly and install the front lower wear pads in the boom section 1.
  19. Install the wear pad retainer plates to the front of boom section 1 and secure with the bolts and lock washers.
  20. Install the anchor plate and secure with hardware.
  21. Secure the telescope cylinder with hardware.
  22. At the rear of the assembly, install the hoses and fittings to the telescope cylinder.
  23. Tighten the front top and bottom side wear pad set screws on boom section 1 to center the assembly in boom section 1.



## WIRE ROPE, SHEAVES AND HOIST BLOCKS

### Wire Rope Description

A wire rope is a machine, by definition: "An assemblage of parts that transmit forces, motion and energy from one to another in some predetermined manner and to some desired end."

A typical wire rope may contain dozens, even hundreds, of individual wires which are formed and fabricated to operate at close bearing tolerances one to another. When a wire rope bends, each of its many wires slide and adjust in the bend to accommodate the differences in length between the inside and the outside of the bend. The sharper the bend, the greater the movement.

Every wire rope has three basic components (Figure 11-3): (1) The wires which form the strands and collectively provide rope strength; (2) the strands, which are laid helical around the core, and (3) the core, which forms a foundation for the strands. The core used in the crane wire rope is an Independent Wire Rope Core (IWRC), which is actually a smaller rope, or a strand similar to the outer strands of the rope. The IWRC core adds about 7.5% to the nominal strength of the wire rope.

The greatest differences in wire ropes are found in the strands, which may vary widely in the pattern and number of wires which are laid together.

The wires of the rope may be made of various metals, including steel, iron, stainless steel, monel, and bronze. The materials of which wires are made is the primary determination of rope strength. High-carbon steel is used in the crane wire rope.

Carbon steel wire ropes come in various grades. The term "Grade" is used to designate the nominal strength of the wire rope. The most common grades are Traction Steel (TS), Plow Steel (PS), Improved Plow Steel (IPS), Extra Improved Plow Steel (EIPS) and Extra Extra Improved Plow Steel (EEIPS). The wire rope used on this crane is an EIPS Grade.

One cannot determine the grade of wire rope by its feel or appearance. To be sure you are using the proper rope, always obtain the wire rope from your distributor.

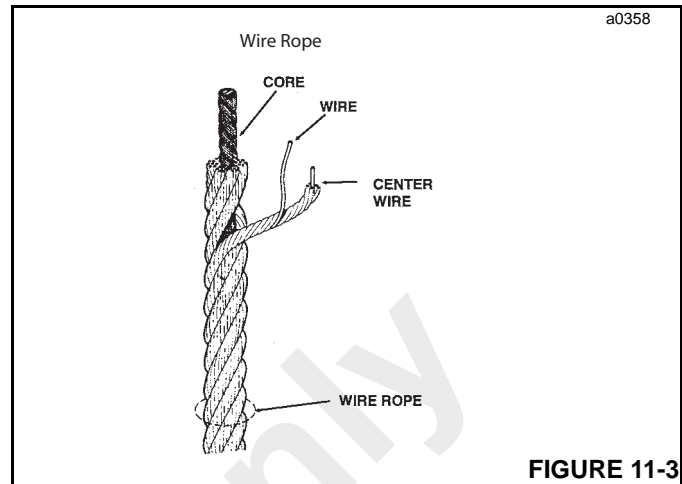


FIGURE 11-3

### Wire Rope Safety

The following information is not a complete discussion of wire rope. What follows is a brief outline of the basic information required to safely use wire rope.

1. Wire rope WILL FAIL IF WORN-OUT, OVERLOADED, MISUSED, DAMAGED or IMPROPERLY MAINTAINED.
2. In service, wire rope loses strength and work capability. Abuse and misuse increases the rate of loss.
3. The NOMINAL STRENGTH, sometimes called CATALOG strength, of a wire rope applies ONLY to a NEW, UNUSED rope.
4. The Nominal Strength of a wire rope SHOULD BE CONSIDERED the straight line pull which will ACTUALLY BREAK a NEW UNUSED rope. The Nominal Strength of a wire rope SHOULD NEVER BE USED AS ITS WORKING LOAD.
5. WIRE ROPES WEAR OUT. The strength of a wire rope begins to decrease when the rope is put to use and continues to decrease with each use.
6. NEVER OVERLOAD A WIRE ROPE. This means NEVER use the wire rope where the load applied to it is greater than the working load determined by the rope manufacturer.
7. NEVER "SHOCK LOAD" a wire rope. A sudden application of force or load can cause both visible external and internal damage. There is no practical way to estimate the force applied by shock loading a rope. The sudden release of a load can also damage a wire rope.
8. Lubricant is applied to the wires and strands of a wire rope when it is manufactured. The lubricant is depleted when the rope is in service and should be replaced periodically. See Preventative Maintenance, for lubrication intervals and procedures.

9. In the U.S.A., regular INSPECTIONS of the wire rope and keeping of PERMANENT RECORDS SIGNED BY A QUALIFIED PERSON ARE REQUIRED BY OSHA FOR ALMOST EVERY WIRE ROPE APPLICATION. The purpose of the inspection is to determine whether or not a wire rope may continue to be safely used on the application. Inspection criteria, including number and location of broken wires, wear and elongation, have been established by OSHA, ANSI, ASME and similar organizations.

IF IN DOUBT, REPLACE THE ROPE. An inspection should include verification that none of the specified removal criteria for this usage are met by checking for such things as:

- Surface wear; nominal and unusual.
- Broken wires; number and location.
- Reduction in diameter.
- Rope stretch (elongation).
- Integrity of end attachments.
- Evidence of abuse or contact with another object.
- Heat damage.
- Corrosion.

In addition, an inspection should include condition of sheaves, drums and other apparatus with which the wire rope makes contact.

10. When a wire rope has been removed from service because it is no longer suitable for use, it must not be reused on another application.
11. Every wire rope user should be aware of the fact that each type of fitting attached to a wire rope has a specific efficiency rating which can reduce the working load of the wire rope assembly or rope system, and this must be given due consideration.
12. Some conditions that lead to problems in wire rope systems include:
- Sheaves that are too small, worn or corrugated can cause damage to a wire rope.
  - Broken wires mean a loss in strength.
  - Kinks permanently damage a wire rope and must be avoided.

- Wire ropes are damaged by knots. Wire rope with knots must never be used.
- Environmental factors such as corrosive conditions and heat can damage a wire rope.
- Lack of lubrication can significantly shorten the useful life of a wire rope.
- Contact with electrical wires and resulting arcing will damage a wire rope.

### Inspecting Wire Rope

Inspect entire length of wire rope for any conditions listed in Figure 11-4. If any of the conditions exist, replace the wire rope.

If the wire rope shows severe wear, make a full inspection of sheaves and drums for grooves, correct alignment, etc.

### Inspection of Sheaves

Inspect all sheaves for wear and proper alignment.

For maximum life of the wire rope, the sheave grooves must be smooth and must be a little larger than the diameter of the wire rope.

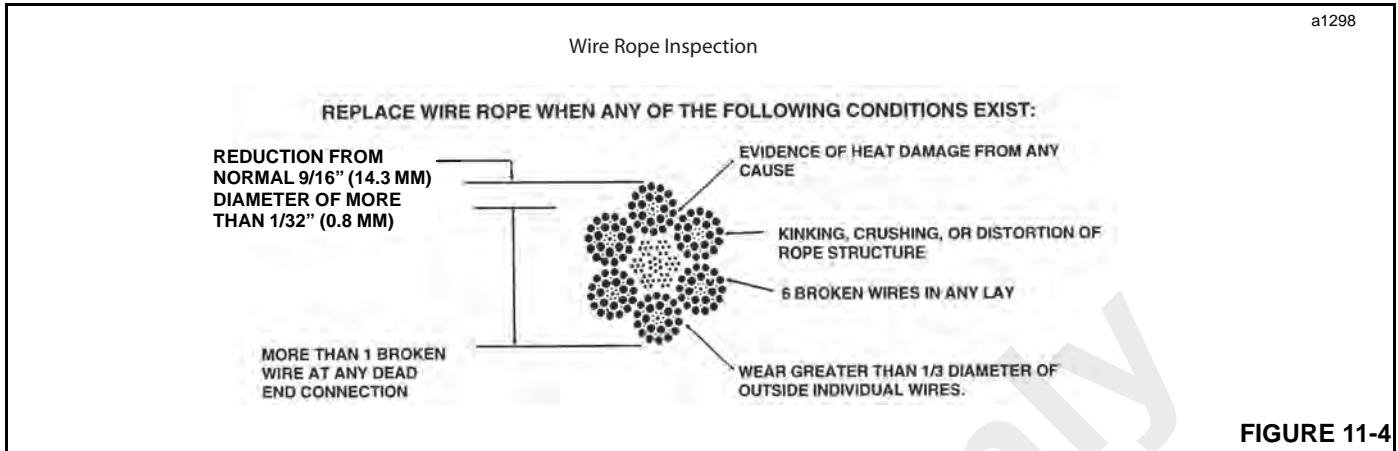
As wear in the sheaves increases, the groove for the wire rope gets smaller, NOT larger. Tracks in the sheaves are caused by the wire rope, and the wire rope will continue to engage the tracks (for example; like a chain engaging a sprocket). A twist in the wire rope or a small change of lay will prevent the wire rope from engaging the track in the sheave. The result will be a rapid wear on the wire rope and on the sheave.

### Wire Rope Lubrication

Lubricate the wire rope with a good grade of spray wire rope lubricant or a light weight oil. A more frequent lubrication (more than monthly) may be required due to operating conditions and usage.

Proper lubrication of the wire rope is just as important as lubrication of other components. The wire rope has many moving parts. Initial lubrication will not last throughout the life of the wire rope. Lubrication is essential to reduce wear and inhibit corrosion of the wires.

After cleaning, apply a light weight oil that will penetrate into the wire rope, or a light weight oil that has been preheated to a temperature between 18° and 36°C (60° and 100°F). Use a brush or cloth to apply the oil.



## Wire Rope Installation

### Installation of Socket and Wedge

Always connect the socket so that the load is pulled on the same line as the socket (See Figure 11-5).

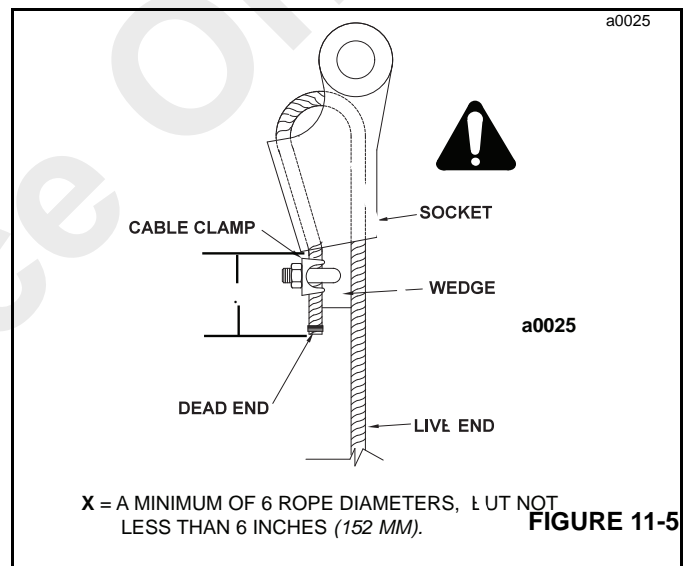


### CAUTION

To prevent personal injury from compressed air, always wear safety glasses when using compressed air for cleaning.

When installing the wedge, hit the wedge several times with a hammer and wood block to make sure the wedge is fully engaged with the socket. Install cable clamp on the loose end of the wire rope as shown in Figure 11-5.

To properly seat the wedge, lift a load equal to the rated capacity of the crane.



**Installation of a New Wire Rope**

The wire rope is given a natural bend or winding from the coil. If the wire rope is on a reel, unwind the wire rope from the reel or coil as shown in Figure 11-6. Use care to prevent reverse bend in the wire rope.

1. Make sure that the equipment (drum, sheaves, etc.) are in good condition.
2. Unwind enough rope from the reel to connect the wire rope to the hoist drum. Use care to prevent twists or sharp bends.

4. After installation, operate the hoist with a minimum load until you see the wire rope is moving easily over the sheaves and is winding correctly on the hoist drum.
5. Gradually increase the speed and load until the wire rope is moving at normal load and speed. This run-in period adjusts the moving parts to each other.

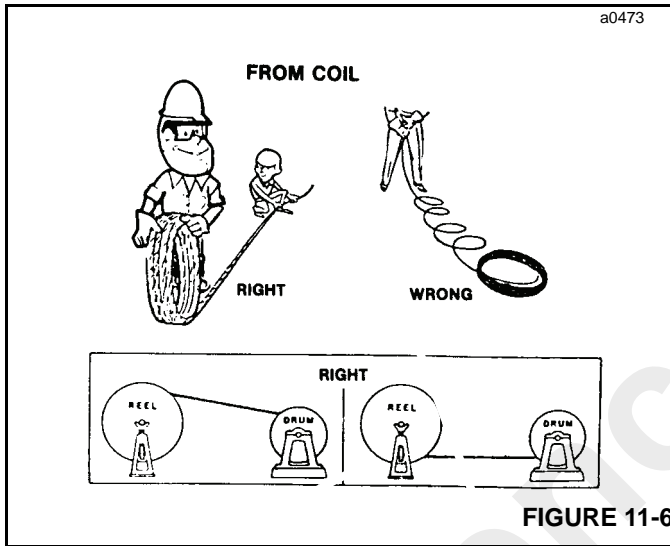


FIGURE 11-6

3. Operate the hoist slowly to move the wire rope directly from the reel to the hoist drum. Keep the wire rope under tension and make sure the wire rope winds correctly on the drum. Loose windings will increase wear on the wire rope and cause bad performance.

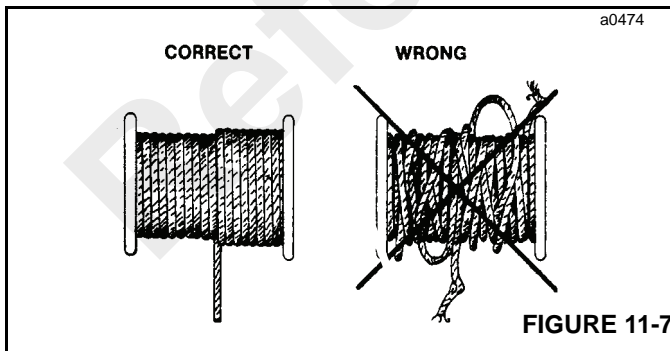


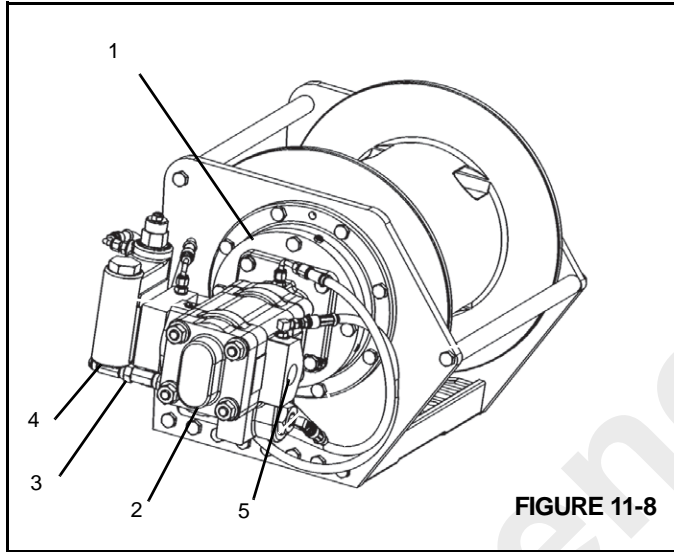
FIGURE 11-7

**MAIN HOIST**

**Description**

The hoist is composed of motor control valve, a fixed displacement hydraulic motor, a multiple disc brake, and a pair of planetary gear sets.

The multiple disc brake is spring applied and hydraulically released through a port in the brake housing. An overrunning clutch allows the hoist to raise the load without releasing the brake while at the same time holding the load until there is sufficient pressure to release the brake when hoisting down.



**FIGURE 11-8**

Item	Component
1	Brake
2	Motor
3	Case Drain
4	Pressure Port to Raise
5	Pressure Port to Lower

**Maintenance**

Inspect the hoist daily for oil leaks, loose bolts, and worn hoist cable. Check the gearbox and brake oil every 500 hours. Do an oil change every 1000 hours. Refer to *Preventative Maintenance*, page 5-1. Inspect the hoist from the deck of the crane. Do not stand on the turret.

**WARNING**  
**Fall Hazard!**

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state, or federal regulations. Death or serious injury may result.

**Warm-up Procedure**

A warm-up procedure is recommended at each start-up and is essential if ambient temperature is below +40°F (4°C). Run the crane at idle with the hoist control lever in neutral and allow sufficient time for the hydraulic system to warm up. Operate the hoist at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil and circulate lubricant through the planetary gear sets.

**Removal**

**WARNING**  
**Crushing Hazard!**

The combined weight of the hoist and 390 ft of wire rope is 730 lbs (331 kg). Death or serious injury may result.

**NOTE:** See Figure 11-8 for item identification.

6. Remove the cable from the hoist drum.
7. Tag and disconnect the hoist hydraulic lines. Cap and plug all hydraulic openings.
8. Attach a lifting device to the hoist and take up the slack.
9. Remove the mounting bolts from the hoist.
10. Remove the hoist from the crane with the lifting device.

**Hydraulic Hoses**

Inspect the hydraulic hoses and replace as required.

**Hoist Installation**

1. Attach a lifting device to the hoist.
2. Lift the hoist with a lifting device onto the turret.
3. Install mounting bolts and washers.
4. Remove the lifting device.
5. Reinstall the hydraulic hoses as per removal tags.

**Drum Rotation Indicator**

The drum rotation indicator (DRI) is located on the left side of the hoist and transmits a rotation signal to a solenoid (thumb thumper) located in the hoist control lever on the operator's control panel.

The DRI transducer may have an optional integral Last Layer Indicator (LLI) which is programmed to notify the operator when there are three wraps of cable left on the drum.

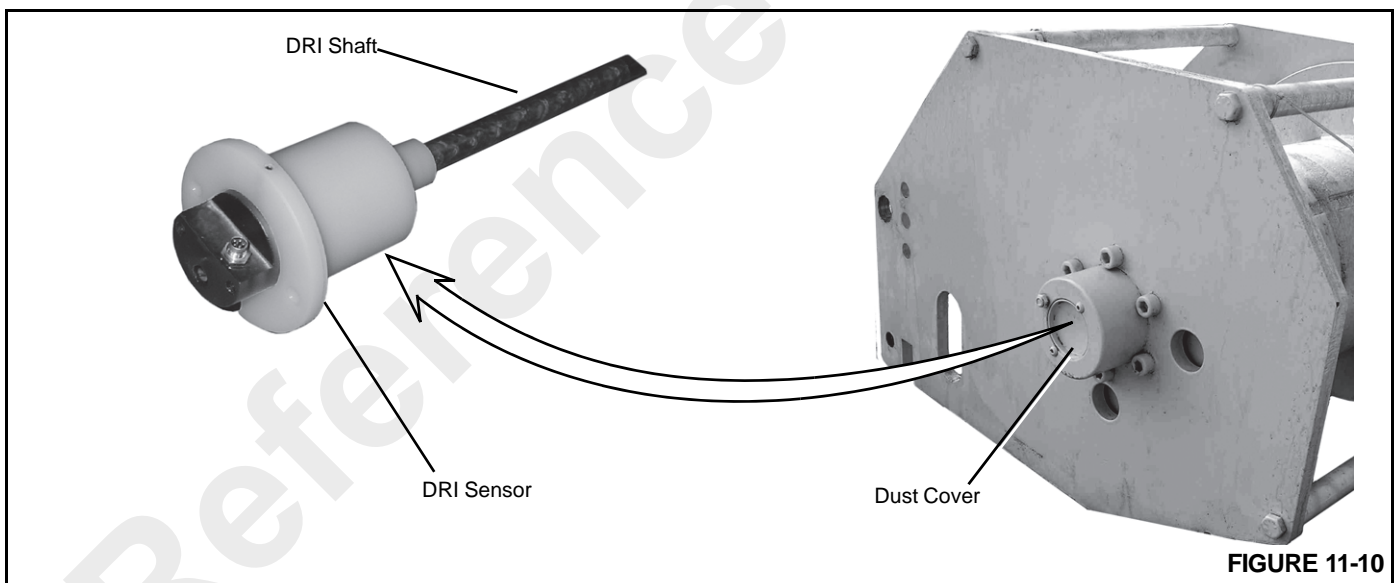
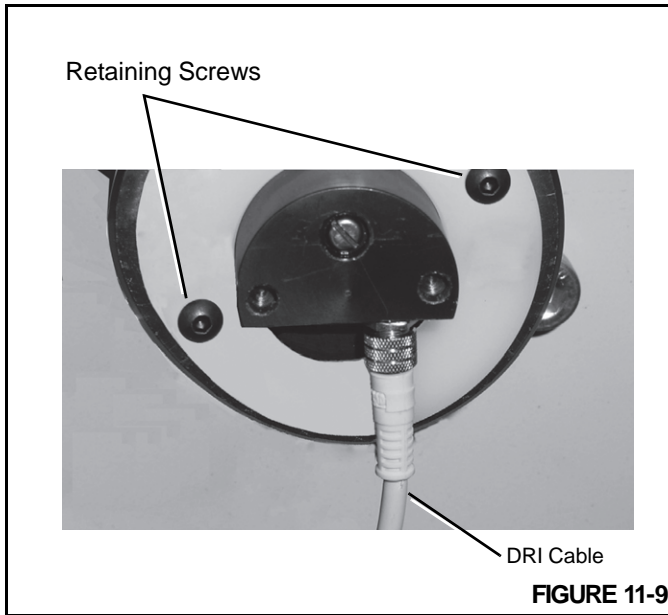
**Removal**

- Loosen the collar on the connector and unplug the DRI cable.
- Remove the two retaining screws.

- Remove the DRI unit from the hoist.

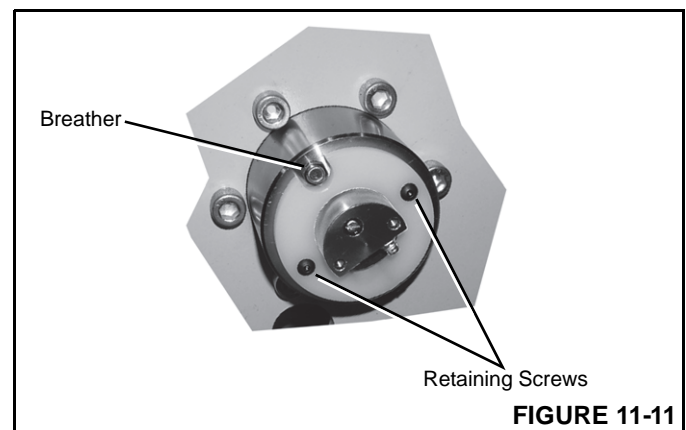
**Installation**

The DRI is installed on the left side of the drum. For initial installations, remove the dust cover from the center of the drum.



To install the DRI, use the following procedure:

1. Insert the DRI into the drum. Rotate the DRI so that the DRI shaft engages the drive inside the drum.
2. Push the DRI into the drum so that the notch is lined up with the breather, refer to Figure 11-11.



3. Secure the DRI with the retaining screws.
4. Loosen the set screw on the bottom of the DRI flange (Figure 11-12).
5. Use a spanner wrench and rotate the DRI so that the connector is pointed down.
6. Tighten the set screw after the DRI is positioned.
7. Plug in the DRI cable and tighten the collar to secure the connector.

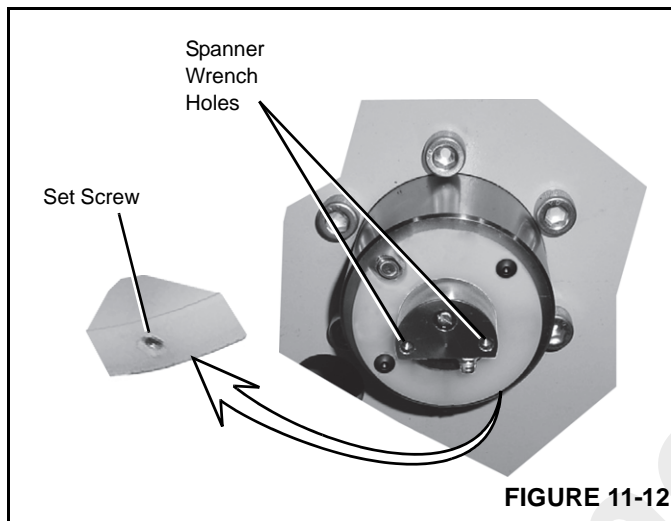


FIGURE 11-12

### Programming the Last Layer Indicator (Optional)

The last layer indicator (LLI) needs to be programmed to alert the operator when the cable is down to the third wrap. To program the LLI:

1. Run the hoist to the third wrap.
2. Remove the programming screw on the DRI as shown in Figure 11-13.
3. Remove power from the LLI by disconnecting the DRI cable.
4. With a ballpoint pen or small punch, push and hold the learn button (Figure 11-13) and return power to the LLI by reconnecting the DRI cable.
5. Release the DRI learn button.
6. Run the hoist to the start of the second layer.
7. Press and hold the learn button for a few seconds.
8. Replace the LLI programming screw.

**NOTE:** Failure to replace the programming screw could effect the operation of the LLI.

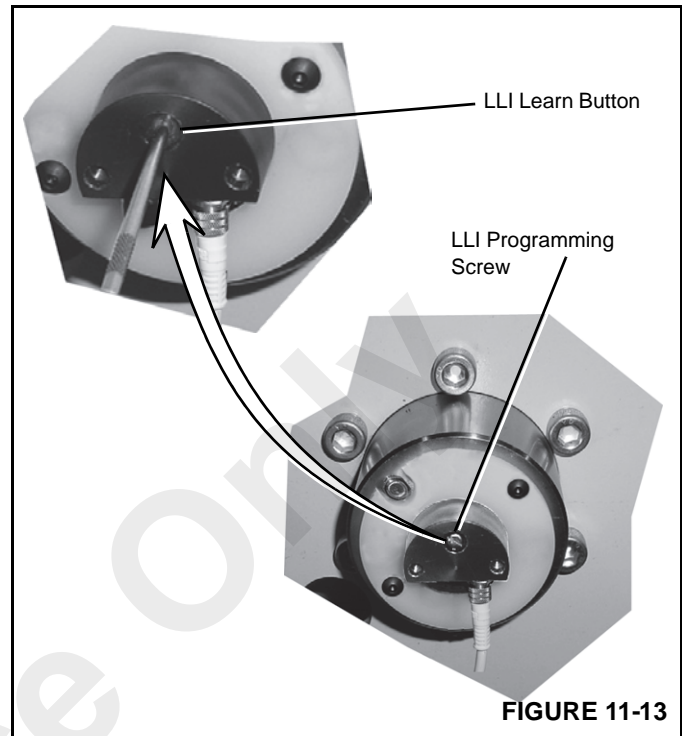


FIGURE 11-13

## Hoist Repair

### Disassembly

The following steps describe how to disassemble the hoist. Inspect and replace all worn parts.

1. Stand the hoist on its end with the motor pointing up. Place blocking under the side plate so the hoist is not sitting on the shaft (Figure 11-14).

**NOTE:** See Figure 11-16 for item number identification.

2. Remove the brake hose (46) from the straight adapter (45).
3. Remove the motor and counterbalance assembly from the hoist by removing two capscrews (47) and two lockwashers holding the motor (44) to the brake cover (20). See *Motor*, page 11-23 for motor and counterbalance valve disassembly.
4. Remove the brake sub-assembly from the hoist by removing the eight capscrews (9) holding the brake housing to the side plate (41). Re-install two of these capscrews into the two extra tapped holes and tighten them evenly until the brake housing is loose from the side plate. Take note of the vent (30) location for reassembly. See *Brake*, page 11-19 for brake repair.

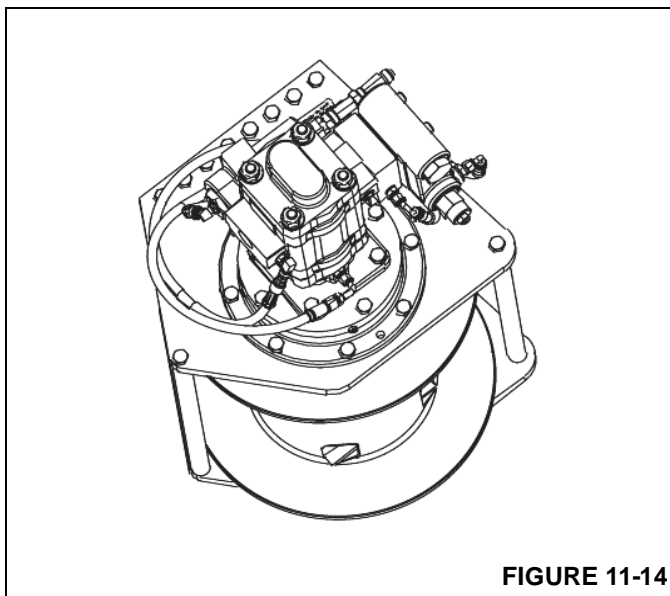


FIGURE 11-14

5. Remove the side plate (41) by removing the three capscrews (1).
6. Lift the bearing carrier (26) from the drum. If necessary remove and replace the bearing (28) and seal (306).
7. Remove the input sun gear (8) and thrust washer (6) from the input planet assembly (36).
8. Remove the input planet set (36) from the drum. Inspect the planet set for wear. See *Planetary Set*, page 11-23 for disassembly and repair.
9. Remove the output sun gear (16) and thrust washer (6) from the output planet assembly (4).
10. Remove the output planet set (4) from the cable drum. Inspect the planet set for wear. See *Planetary Set*, page 11-23 for disassembly and repair.
11. Remove the cable drum (5) and inspect the gear teeth for excessive wear. Remove and replace the bearing (28) and seal (306) located in the drum.
12. Inspect retaining ring (48) to insure it is still in groove and is not bent over.
13. If necessary remove output shaft (32) from side plate (29) by removing six capscrews (3) holding side plate (29) to shaft (32). Take note of vent (30) location for reassembly.
3. Attach the shaft (32) to the side plate (29) using the six capscrews (3). Make sure the vent (30) is oriented properly. Torque the capscrews to recommended values, refer to *Fasteners and Torque Values*, page 1-12.
4. Install retaining ring (48) onto the shaft (32)
5. Lay the unit down with the rods (2) pointing up. Support the side plate (29) with blocking (Figure 11-14) so that the hoist is not setting on shaft (32).
6. Set cable drum (5) onto shaft (32) and seat drum on bearing (28). Be careful not to damage seal (306).
7. Install the output planet set (4).
8. Install the output sun gear (16) into the output planet set.
9. Install the thrust washer (6) into the output planet set.
10. Install the input planet set (36) into the drum. Make sure that it fits over the output sun gear (16).
11. Install the input sun gear (8) and thrust washer (6) into the input planet set.
12. Install the thrust washer (6) into the input planet set.
13. Install a new O-ring (304) and if necessary bearing (28) & seal (306) into the bearing carrier (26). Grease the O-ring and seal then install the bearing carrier into the drum.
14. Position the side plate (1) over cable drum on rods (43). Secure the side plate with the three capscrews (2). Tighten capscrews to 109 to 122 Nm (80 to 90 lb-ft).
15. Install the brake sub-assembly into the side plate (1). Make sure that the pilot of the brake housing aligns with the bore in the bearing and that the bolt holes for the motor and vent are oriented properly. Install the eight capscrews (2). Tighten the capscrews evenly to 109 to 122 Nm (80 to 90 lb-ft).
16. Install a new O-ring (305) onto the face of the motor and reinstall the motor/counterbalance valve assembly. Reconnect the hose (70).
17. Fill both the gearbox and the brake section with the proper amount and type of lubricants. See *Preventative Maintenance*, page 5-1.

### Reassembly

**NOTE:** See Figure 11-16 for item number identification.

1. Thoroughly clean all parts. Replace those that show wear or damage.
2. Inspect the cable drum (5) for structural integrity and replace if necessary.

### Hoist Service

#### Brake

**NOTE:** See Figure 11-16 for item number identification.

1. Evenly remove the four capscrews (11) holding the brake cover (20) in place. Spring pressure will raise the



cover up as the capscrews are loosened. Remove the cover from the brake housing.

2. Remove the springs (24) from the piston and check the springs for free height. Each spring should measure at least 30.5 mm (1.20 in) with no force.
3. To remove the brake piston (10), install two pieces of all-thread (3/8-16NC) in the bottom of two spring pockets.
4. Using jam nuts, screw the all-thread pieces in evenly until the piston is clear of the housing. An alternate way of removing the piston is to use shop air to slowly pressurize the brake cavity until the piston is out of the bore.
5. Grasp the brake driver/clutch assembly (Items 38, 13, 23, 14, 15 & 17) and remove it from the brake housing.
6. Remove the stator plates (19) and friction discs (18) from the brake housing and check for excessive wear. Be sure to check the top stator plate for scoring caused by the removal tools and polish if necessary. Friction discs should measure no less than 1.397 mm (0.055 in) thickness and stator plates should measure no less than 1.727 mm (0.068 in) thickness.
7. With a hook wire or pry bar, remove the seal.
8. Examine the bushing (39) in the brake housing for wear and replace if necessary.
9. If brake housing (21) is removed from the hoist, examine the journal on the brake housing, where the seal (304) fits, for wear. If severely worn, replace the brake housing.
10. Carefully disassemble the brake driver/clutch assembly noting the direction of lockup for the clutch (34). The clutch assembly must be re-assembled with the arrow pointing in the proper direction for the hoist to function properly. Inspect the outside diameter on the input driver (38) and inside diameter of the brake driver (13) where the clutch (34) runs. If there is any pitting or spalling (flakes of a material that are broken off) on the driver then it and the clutch must be replaced.
11. Re-assemble the driver/clutch assembly, making sure that the clutch is installed properly.
12. Install a new seal into the brake housing. If the brake housing is removed from the hoist temporarily install the input sun gear into the brake housing, and slide the driver/clutch assembly onto the sun gear spline.
13. Install the stator plates (19) and friction discs (18) into the brake housing starting with a stator and alternating friction discs and stator plates. There is one more stator

plate than friction disc so the last item installed is a stator plate.

14. After installation, check the brake stack up to make sure that the dimensions are within the tolerance shown in Figure 11-15. If your measurement is greater than shown, either some friction discs and stator plates have been left out, or the friction discs are worn beyond acceptable tolerances. If your measurement is less than shown, too many plates or discs have been inserted or they are not seated properly.
15. Coat the new backup rings and O-rings with light oil and install onto the piston (10) with the backup rings toward the outside of the piston. See Figure 11-15 for proper O-ring and backup ring installation.

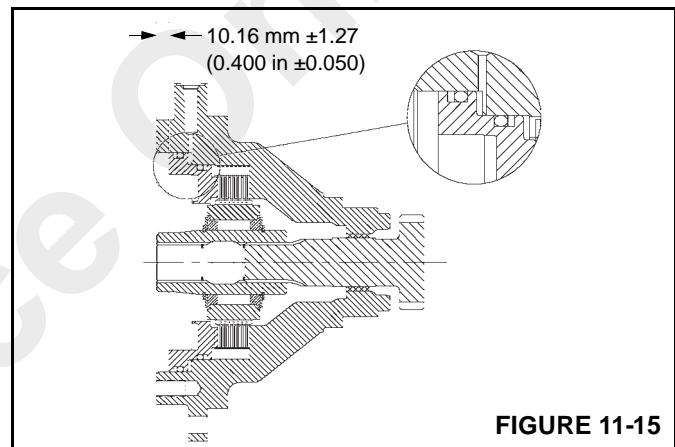
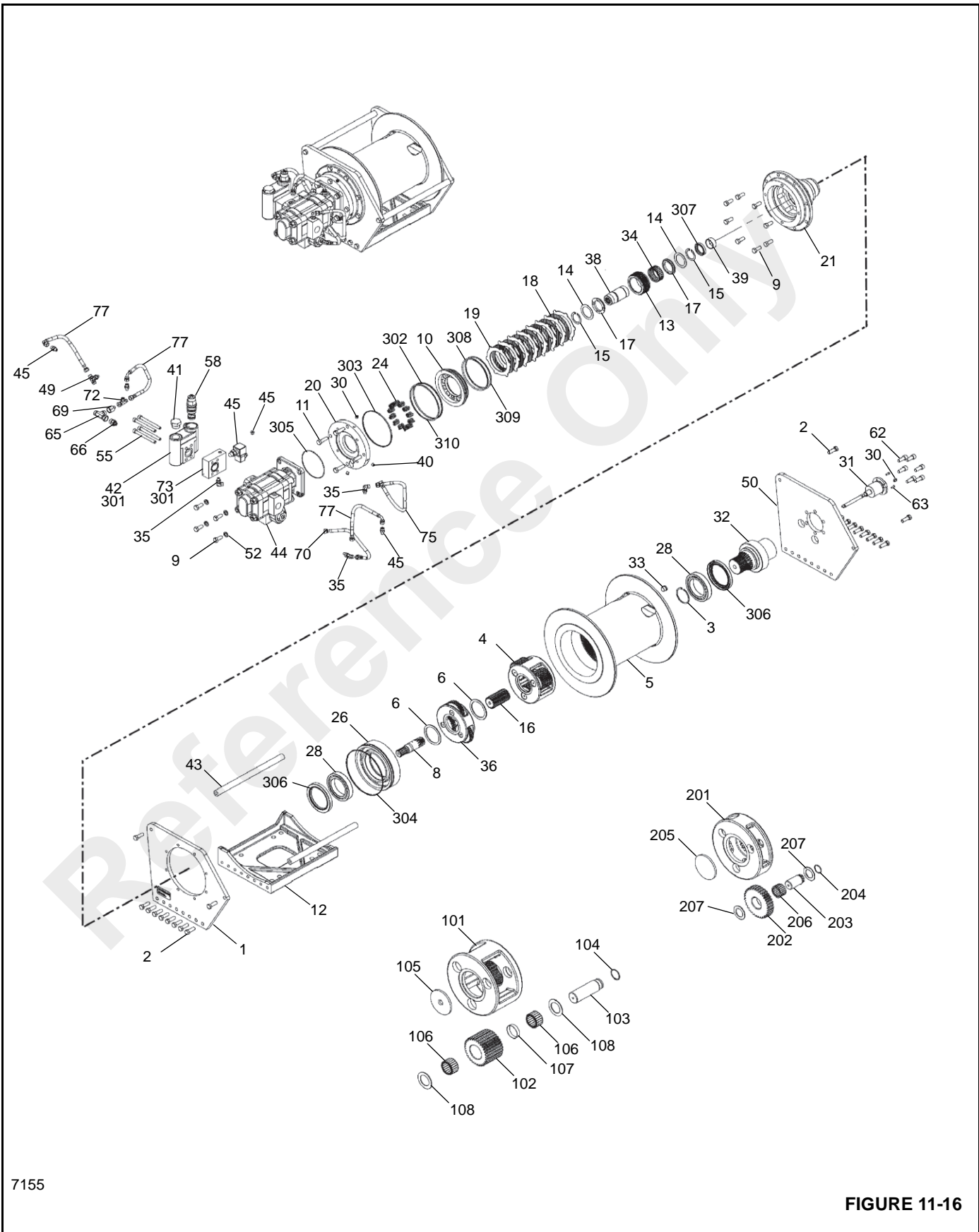


FIGURE 11-15

16. Carefully install the piston into the brake housing and gently tap it down until it is seated.
17. Install the springs (24) into the spring pockets of the piston. If working in a horizontal position, coat the bottom of each spring with chassis lube to keep it in position.
18. Coat the new O-ring with light oil and install into the groove on the brake cover (20).
19. Install the cover (20) onto the brake housing (21) and tighten it evenly, alternating between opposite capscrews. Make sure that the cover is aligned properly with the brake housing to orient the motor and vent as they should be.
20. Check the brake release with a portable hydraulic pump. Full release should be obtained at 17.24 bar  $\pm$  1.38 bar (250 psi  $\pm$  20 psi). Also, check the brake for proper operation by applying 10.69 bar (155 psi) to the brake port and adapting a torque wrench to the input shaft. The torque in the hoist-down, or payout, direction should be 120 to 156 Nm (95 to 115 lb-ft).



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FIGURE 11-16

Item	Quantity	Description
1	1	Plate, Side
2	20	Capscrew
3	1	Snap Ring
4	1	Gear Set
5	1	Drum Housing
6	2	Race, Bearing
8	1	Gear, Input Sun
9	12	Capscrew
10	1	Brake Piston
11	4	Screw
12	1	Base Plate
13	1	Brake Driver
14	2	Race
15	2	Snap Ring
16	1	Gear, Sun Output
17	2	Bushing
18	7	Friction Disc
19	8	Plate, Stator
20	1	Cover, Brake
21	1	Brake Housing
24	12	Brake Spring
26	1	Carrier, Bearing
28	2	Bearing
30	2	Breather
31	1	Sender, DRI/LLI
32	1	Shaft, Output
33	1	Plug, O-ring
34	1	Clutch
35	3	Fitting, 90 deg
36	1	Input Gear Set - 201 thru 207
38	1	Driver, Input
39	1	Bushing
40	2	Plug
41	1	Plug, Flush
42	1	Counterbalance Block
43	2	Support Rod
44	1	Motor Assy
45	4	Fitting, Adapter
49	1	Fitting, Tee
50	1	Plate, Side
52	4	Lockwasher, 1/2 ID
55	4	Capscrew
58	4	Counterbalance Valve

Item	Quantity	Description
61	4	NCC Label
62	6	Capscrew
63	2	Screw, Buttonhead
64	1	Cord Set
65	1	Fitting, Tee
66	1	Fitting, Straight Adapter
69	1	Fitting, Reducer
70	1	Hose Assy
72	1	Fitting, Tee Adapter
73	1	Manifold Block
74	1	Valve, Cart. Solenoid
75	1	Hose Assy
77	3	Hose Assy
80	1	O-ring
81	1	Cord Set Rotation
82	1	Shaft DRI
101	1	Housing, Carrier
102	3	Gear, Planet
103	3	Pin
104	3	Retainer
105	1	Plate
106	6	Bearing
107	3	Spacer
108	6	Race, Bearing
201	1	Housing, Carrier
202	3	Gear, Planet
203	3	Pin
204	3	Retainer
205	1	Plate
206	3	Bearing
207	6	Race, Bearing
301	2	O-ring
302	1	O-ring
303	1	O-ring
304	1	O-ring
305	1	O-ring
306	2	Seal, Oil
307	1	Seal, Oil
308	1	O-ring
309	1	Ring, Back-up
310	1	Ring, Back-up
315	1	Kit, Seal

**Planetary Set**

**NOTE:** See Figure 11-16 for item number identification.

1. Remove the spiral retaining rings from the planet pins.
2. Remove the pins from the carrier by carefully tapping them out.
3. Remove the planet gears, thrust washers and bearings from the carriers.
4. Inspect the pins, bearings, and gear bores for evidence of wear and replace if necessary.
5. On output planet sets, note that two bearings with a spacer between them are used.
6. Before reassembly, be sure to insert the round plates into the carriers.
7. To re-assemble, be careful to line up the planet pins with the thrust washers and bearings and then press the knurled part of the pin into the carrier.

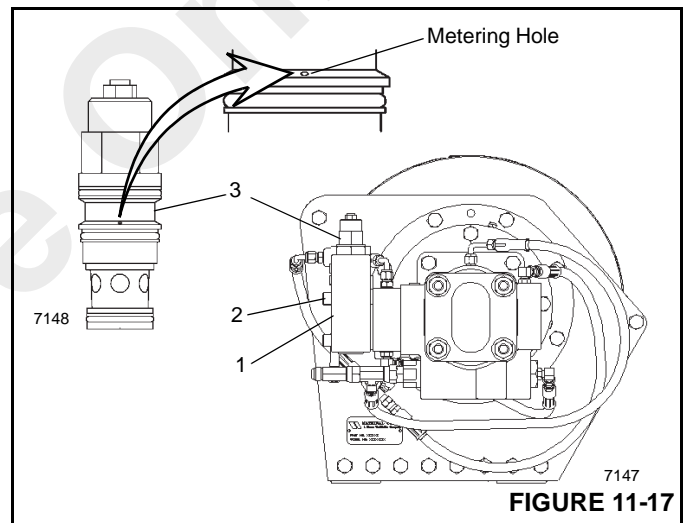
**CAUTION**

**Possible Equipment Damage!**

If the pins are not lined up properly, the thrust washers can be shattered during the pressing operation.

**Motor**

1. Remove the hose and the counterbalance block (42) from the motor assembly.
2. To remove the counterbalance block (42), loosen and remove the 4 capscrews (55).
3. Remove the counterbalance valve (58) from the counterbalance block and inspect the small metering hole located on the side of the cartridge valve to make sure it is not obstructed (Figure 11-17). Also inspect the O-rings to insure that they are not cut or flattened.
4. Motors and cartridge valves are not serviceable in the field. Return them to an authorized distributor for service.



**FIGURE 11-17**

**TROUBLESHOOTING**

Problem	Cause	Solution
Hoist does not hold load	Excessive back pressure in the system. Brake discs are worn out. Hoist clutch is slipping.	Check the system for restrictions and reduce the back pressure. Replace brake discs. Inspect the clutch and driver for wear and replace worn parts.
The hoist does not raise the load it should.	Relief valve setting may be too low to allow proper lifting. Load being lifted may be more than the hoist's rating.	Increase relief valve pressure setting. Reduce the load or re-rig to increase mechanical advantage.
The hoist does not lower the load.	The brake valve was connected improperly after being disconnected. The cartridge in the brake valve may have a plugged metering hole.	Check plumbing and connect lines properly. Remove the cartridge and clean it if necessary.
Oil leaks from the vent on the motor side of the hoist.	The motor shaft seal may have failed. Brake piston seals may have failed.	Replace this seal and reduce back pressure if high pressure caused the shaft seal to fail. Service the brake section and replace worn parts.

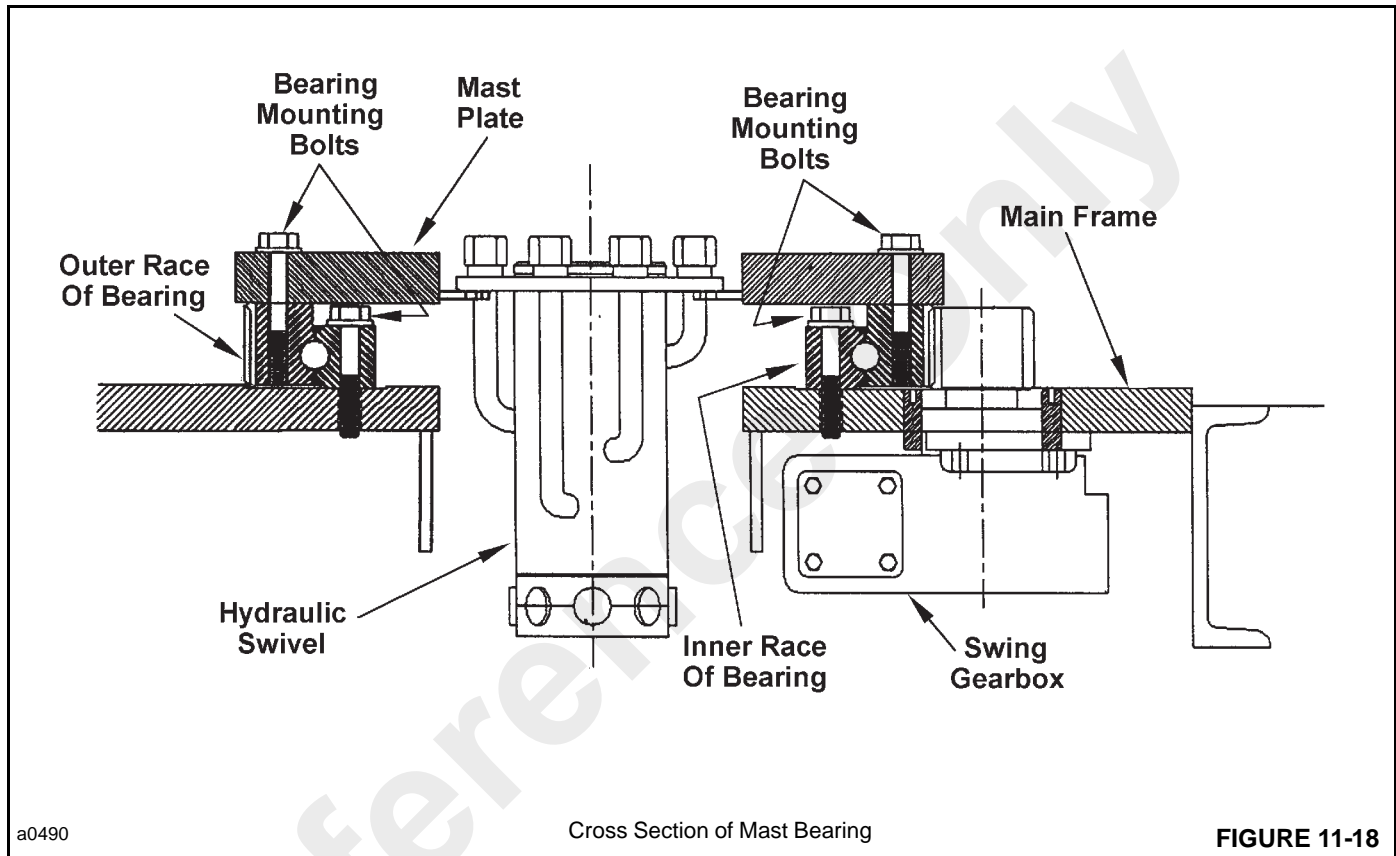
## BEARING, MAST AND RELATED PARTS

### General

The mast is fastened to the main frame of the crane through a bearing. The inner race of the bearing is fastened to the frame and the outer race of the bearing is fastened to the mast. See Figure 11-18.

The rotation of the mast is done by a gearbox which is mounted below the frame deck. A hydraulic motor connected to the gearbox provides power for rotation of the mast.

The bearing is filled with grease through two grease fittings on the inner race of the bearing. A slotted hole in the mast plate allows access to the inner race and the grease fittings.

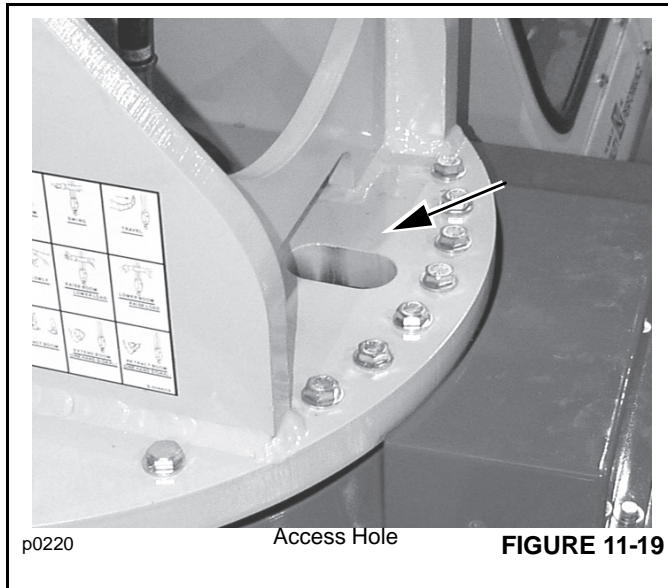


### Mast Bearing

The bearing is a ball thrust bearing. The outer race rotates outside of the inner race on a row of steel balls.

Apply grease weekly or every 50 hours of operation, whichever occurs first. Use a Lithium based, E.P. No. 2 bearing grease, or equivalent.

There are two grease fittings to grease the bearing and they are directly across from each other. Rotate the mast until the access hole (Figure 11-19) aligns with the grease fitting. Apply grease to the bearing. Rotate the mast through several rotations and then repeat the procedure with the other grease fitting. The excess grease will extrude out of the bearing seal.



## Mast Bearing Bolts

Very high stress is put on the mast bolts during crane operation. It is important that these bolts be checked at regular intervals.

Check the torque on the bolts after the first week or 50 hours of operation, whichever occurs first, and then every month or 250 hours of operation, whichever occurs first. Make a record of any loose bolt. If any bolt does not hold to correct torque after the second check, remove and replace the bolt. A loose bolt indicates possible failure of the bolt.

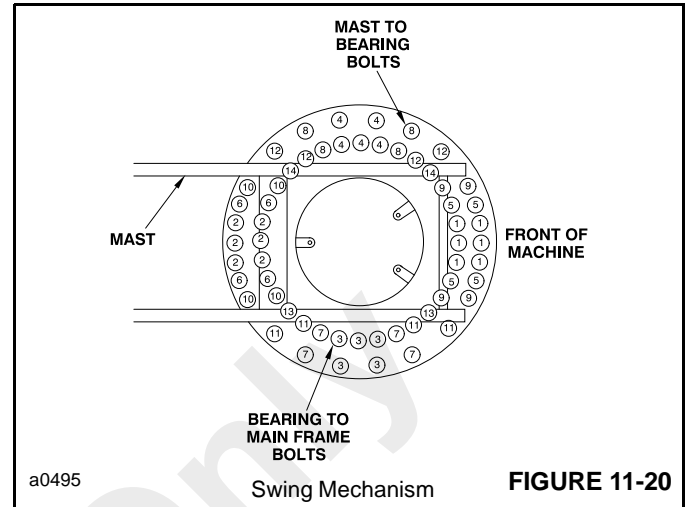
The correct torque on each unplated bolt should be 754 to 816 Nm (556 to 602 lb-ft).

Use the torque sequence shown in Figure 11-20 when checking the torque on the bolts.

**NOTE:** Use only special Class 12.9 unplated bolts for replacement of the mast bolts. Order the bolts from your Grove distributor, see your parts manual.

If a broken bolt is found, replace the bolt and also replace the bolt on each side of the broken bolt.

The proper torque will not be obtained without the hardened steel washers under the bolt heads on the outer (mast) bolt circle.



## Inspection for Bearing Wear

Because of conservative design parameters, static loading and slow intermittent rotation, there are very few mast bearings that ever see their full design use.

However, the mast bearing does have moving internal parts that are prone to wear if not maintained properly. As the bearing wears, there will be free-play or movement in the bearing. Some of the symptoms of mast bearing wear are:

- Metal particles in the grease around the seal.
- Increased drive power required.
- Noisy rotation.
- Rough rotation.

If one or more of the above symptoms are present, the following procedure should be used to test the bearing for excessive wear.

- On a level, hard packed surface, set the machine up on its outriggers.
- With the boom forward, fully extended and in a horizontal position, place a dial indicator on the swing gearbox cover and mast as shown in Figure 11-21.
- Set the dial indicator to zero.

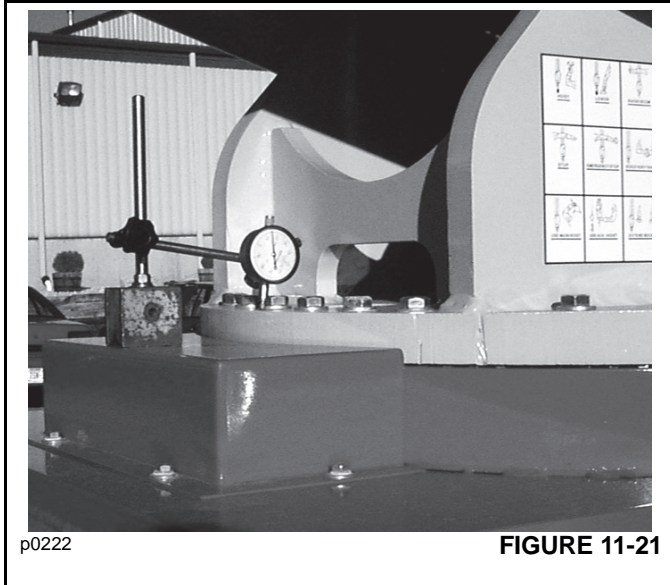


FIGURE 11-21

4. Raise the boom to its full raised position and record the amount of movement on the dial indicator.
5. Lower the boom and then rotate it 180°. Repeat steps 2 through 4.
6. Average the two readings. The maximum allowable movement is 1.52 mm (0.060 in). The mast bearing must be replaced if the movement is greater than the stated measurement.

## Replacing the Mast Bearing

### Removal

1. Refer to boom removal in this section and remove the boom from the mast.
2. Remove swivel stop (36, Figure 11-23) from the bottom of the hydraulic swivel (15).
3. Attach tags to the hydraulic hoses and lines with the swivel port number to which they connect.
4. Disconnect the hydraulic lines from the lower swivel ports. Put caps or plugs on the fittings and hydraulic lines.
5. Using an overhead crane, remove the counterweight (2) from the mast.
6. Refer to hoist removal in this section and remove the hoist assembly.
7. Connect a hoist to the mast capable of handling the weight of the mast. Remove the 26 bolts (16) and flat washers (17), which fasten the mast to the mast bearing.
8. Remove the mast and place it on blocks.
9. Remove the 26 bolts (18) and flat washers (17) and remove the mast bearing (19) from the frame.

### Installation

1. Using a suitable solvent, clean the holes in the bearing plate on the main frame. Remove the residue with compressed air. Clean all dirt from the bearing plate.
2. Locate the mast bearing (19, Figure 11-23) in place on the bearing plate.
3. Install the bolts (18) and flat washers (17) to fasten the mast bearing to the bearing plate.
4. Figure 11-20 shows order of tightening the bolts. Each bolt must first be tightened to a torque of 754 to 816 Nm (556 to 602 lb-ft) and then loosened slightly. After which, each bolt must again be torqued to 754 to 816 Nm (556 to 602 lb-ft).

**NOTE:** For ease of lubrication when turntable mast is removed, apply grease to grease fittings located on the bearing before mounting the turntable mast to the bearing. Reference *Mast Bearing*, page 11-24 for lubrication procedure.

5. Make sure the top surface of the mast bearing and the bottom surface of the mast base are clean.
6. With a hoist, raise and then lower the mast into position over the mast bearing. Install bolts (16, Figure 11-23) and washers (17).
7. Figure 11-20 shows the order for tightening the bolts. Each bolt must first be tightened to a torque of 754 to 816 Nm (556 to 602 lb-ft), and then loosened slightly. After which, each bolt must again be tightened to a torque of 754 to 816 Nm (556 to 602 lb-ft).
8. Install swivel stop (36, Figure 11-23) to hydraulic swivel (15).
9. Connect the hydraulic lines to the hydraulic swivel.
10. Install counterweight (2) onto the mast.
11. Install the hoist assembly to the mast.
12. Install the boom assembly.

## Swing Gearbox and Pinion

### Maintenance

#### Gearbox

The swing gearbox has a worm gear set which rotates on taper roller bearings. The gears and bearings are given lubrication by the grease in the gearbox. Gaskets inhibit external leakage from the gearbox. Keep the gear case filled with grease.

#### Swing Gear/Pinion

The swing pinion and gear must be lubricated at regular intervals.

**Adjustment****Checking Backlash**

Check the backlash between the swing gear and the swing gearbox pinion every six months or after 1500 hours of operation, whichever occurs first.

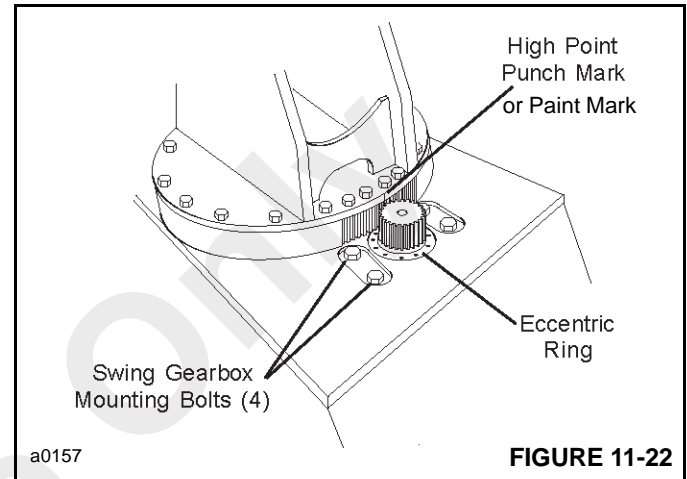
1. Remove the swing gear pinion cover.
2. Start the engine and rotate the mast until the high point on the swing gear is engaged with the pinion (Figure 11-22). The high point is punch-marked on the edge of the gear or is a painted mark on the gear.
3. Using a 0.013 mm (0.005 in) feeler gauge, check the backlash between the gear and pinion. There should be 0.013 mm (0.005 in) clearance between the swing gear tooth and the pinion tooth. If there is any other clearance, adjust the backlash.

**Backlash Adjustment**

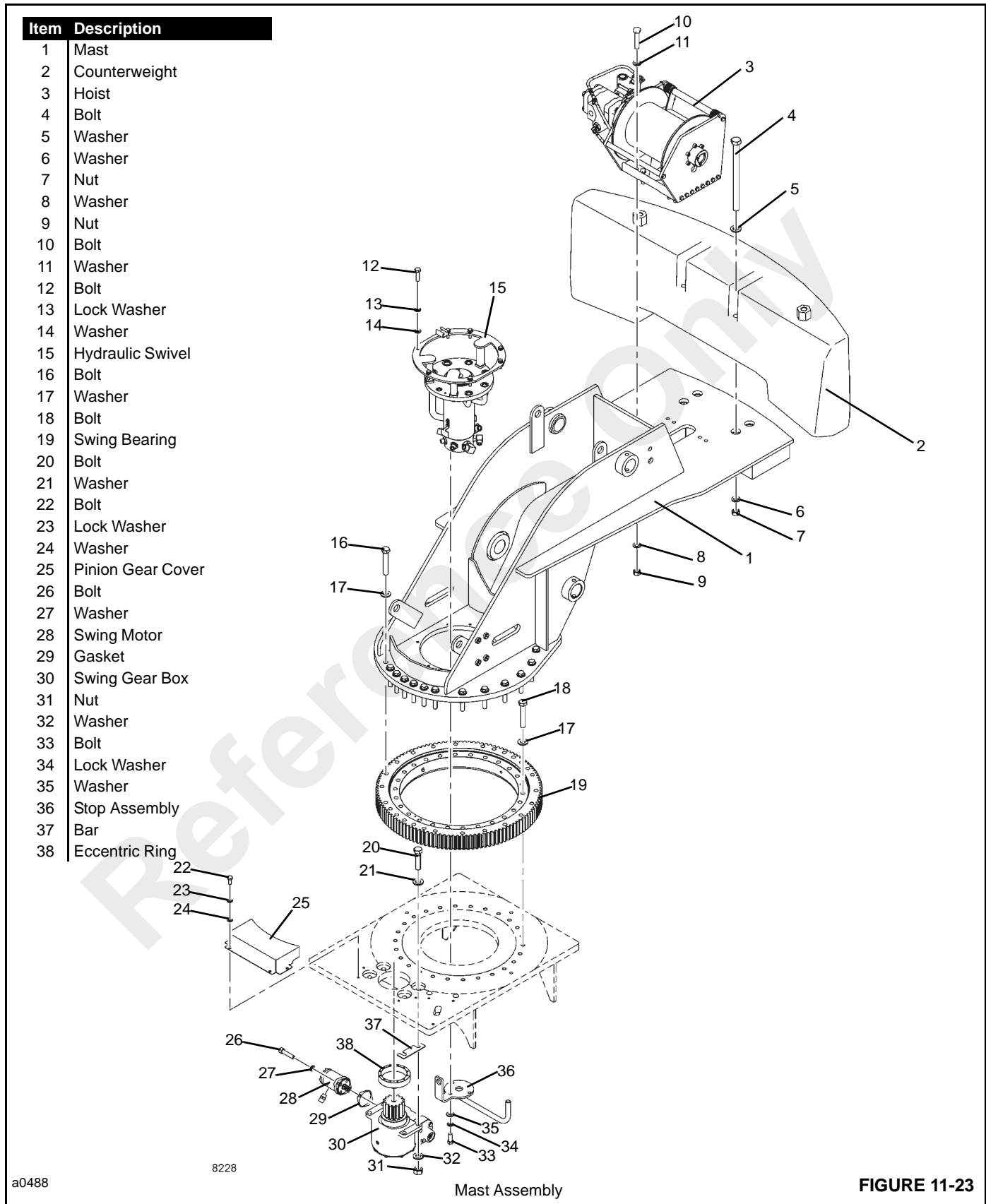
**NOTE:** Be sure the swing gear and pinion are aligned at the high spot of the swing gear.

1. Slightly loosen the four bolts securing the gearbox (Figure 11-22).
2. Use a 0.013 mm (0.005 in) feeler gauge between the pinion and swing gear.

3. With a spanner wrench, turn the eccentric ring to move the pinion until it contacts the feeler gauge (0.013 mm (0.005 in) backlash).
4. Tighten the four bolts to appropriate torque.
5. Install the swing pinion cover.







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FIGURE 11-23

## Swing Gearbox Repair

### Removal

1. Use a hoist and blocks to hold the boom in position and prevent the mast from rotating
2. Remove the swing motor from the gearbox.

**NOTE:** Do not rotate the mast after the hydraulic motor has been removed from the gearbox. Internal bearings will become dislodged. Make note of the position of the swing motor for installation.

3. Provide support for the gearbox and remove the four bolts which fasten the gearbox to the frame. Remove the gear box and eccentric ring from beneath the crane.

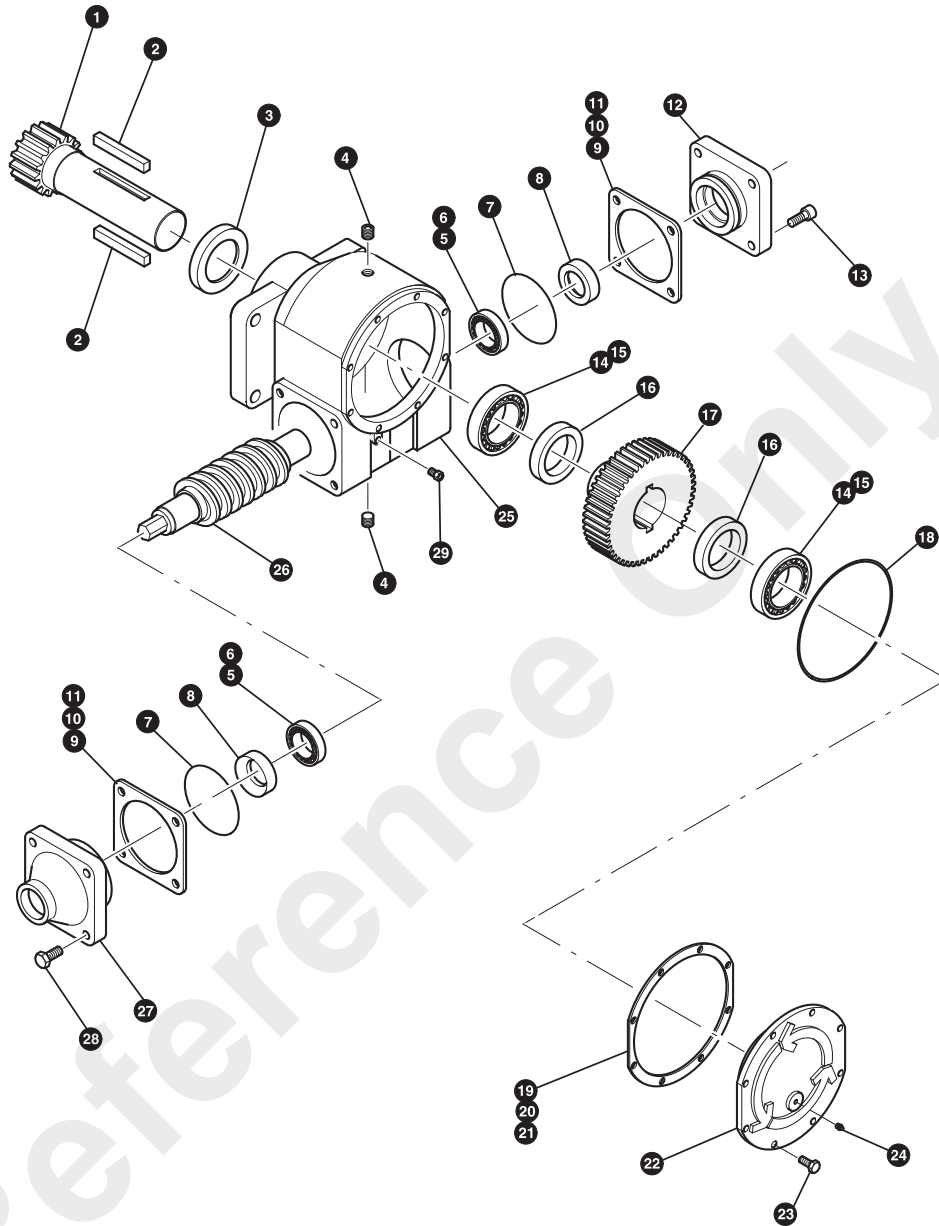
### Disassembly

1. Clean the outside of the gearbox before disassembly.
2. Loosen bolts (23, Figure 11-24) from cover (22). Remove the cover from the gear housing (25).
3. Clean as much grease out of the housing as possible. Properly dispose of the grease.

**NOTE:** Tie the shim sets together to prevent any shim from being lost.

4. Remove shims (19) through (21) from the gear case. Be careful not to damage or lose any of the shims.
5. Remove O-ring (18) and cover (22).

6. Remove socket head capscrews (13). Remove end motor cap (12).
7. If shims (9) through (11) are located between cover (12) and housing (25) remove the shims. Be sure not to damage or lose any of the shims.
8. Remove and discard O-ring (7) and seal (8).
9. Remove capscrews (28) and remove end cap (27).
10. If shims (9) through (11) are located between cover (27) and housing (25) remove the shims. Be sure not to damage or lose any of the shims.
11. Remove and discard O-ring (7) from end cap (27).
12. Using a suitable puller, remove bearing cup (5) from end cap (27). Remove and discard seal (8).
13. Using a suitable puller, remove bearing cone (15) from pinion shaft (1). Remove spacer (16).
14. Using a suitable puller, remove worm gear (17) from pinion shaft (1). Remove spacer (16).
15. Using a suitable puller, remove bearing cone (15) from pinion shaft (1).
16. Remove pinion shaft (1) and worm (26) from housing (25).
17. Remove wiper seal (3) from housing (25).



Item	Description
1	Pinion Shaft
2	Key (2)
3	Oil Seal
4	Pipe Plug (2)
5	Bearing Cup (2)
6	Bearing Cone (2)
7	O-Ring (2)
8	Seal (2)
9	Shim (2)
10	Shim (2)

Item	Description
11	Shim (2)
12	End Motor Cap
13	Socket Head Capscrew
14	Bearing Cup (2)
15	Bearing Cone (2)
16	Spacer (2)
17	Worm Gear
18	O-Ring
19	Shim
20	Shim

Item	Description
21	Shim
22	Cover
23	Capscrew (8)
24	Grease Fitting
25	Housing
26	Worm
27	End Cap
28	Capscrew (4)
29	Breather

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Tulsa Swing Gearbox Exploded View

FIGURE 11-24

18. Using a suitable puller, remove bearing cup (14) from housing (25).
19. Using a suitable puller, remove bearing cup (14) from cover (22).

### Inspection

Clean all parts. See Section 1. Make sure the breather (29, Figure 11-24) is clean. Make a careful inspection of all parts, including gears, shafts and bearings.

Replace all seals and gaskets.

### Assembly

1. If removed, install a new bearing cup (14) into housing (25).
2. Install new wiper (3) into housing (25).
3. Install pinion shaft (1) into housing (25) through seal (3). Be careful not to damage the seal.

**NOTE:** Before installing any bearing cone, pack the bearing with a Lithium base, E.P. No. 2 bearing grease.

4. Pack both bearing cones (6) with grease and install onto worm (26).
5. Insert worm (26) into housing (25).
6. Pack first bearing cone (15) with grease and install onto pinion shaft (1). Install first spacer (16).
7. Using two keys (2), install worm gear (17) onto pinion shaft (1).
8. Install second spacer (16) and second bearing cone (15) onto pinion shaft (1). Be sure bearing cones are packed with grease before assembly.
9. Install seal (8) into end cap (12). Install bearing cup (5). Install O-ring (7). Lubricate the seal and O-ring with grease before assembly.
10. Install seal (8) into motor cap (27). Install O-ring (7). Lubricate seal and O-ring with grease before assembly.
11. Insert the end of worm (25) into end motor cap (12). Fasten end motor cap (12) to housing (25) with socket head capscrews (13).
12. Align the gear teeth of worm (25) with the teeth of worm gear (17).
13. If the original bearing cups and cones were installed in the end caps and onto the worm, the existing shims (9) through (11) may be installed between housing (25) and end cap (27). Install the shims and end cap (27). Attach end cap (27) with capscrews (28).  
If new bearings were installed, proper bearing pre-load must be determined before final installation of the end cap (27).

- a. Install end cap (27) without shims installed.
- b. Using a dial indicator, measure the amount of axial movement of the worm. Proper axial movement must be between -0.025 to +0.05 mm (-0.001 to +0.002 in). Determine the amount of shims required to acquire the proper axial movement. Then, install the shims between housing (25) and end cap (27). Fasten with capscrews (28).

14. If the original bearings were installed on pinion shaft (1), then the existing shims (19) through (21) may be installed between cover (22) and housing (25). Install shims and fasten cover (22) with capscrews (23).

If new bearings were installed, proper bearing pre-load must be determined before final installation of the cover.

- a. Install the cover without shims.
- b. Using a dial indicator, measure the amount of axial movement of the pinion shaft. Proper axial movement must be between -0.076 to -0.127 mm (-0.003 to -0.005 in). Determine the amount of shims required to acquire the proper axial movement. Then, install the shims between housing (25) and cover (22). Fasten with capscrews (23).

15. Fill the housing with a Lithium base E.P. No. 2 bearing grease through the grease fitting on the cover. See Preventative Maintenance, page 5-1.

### Installation

1. Install the gearbox in reverse order of removal.
2. When installing the swing motor, use a new gasket.
3. Align the pinion gear with the swing gear following the instructions in Swing Gearbox and Pinion, page 11-26.

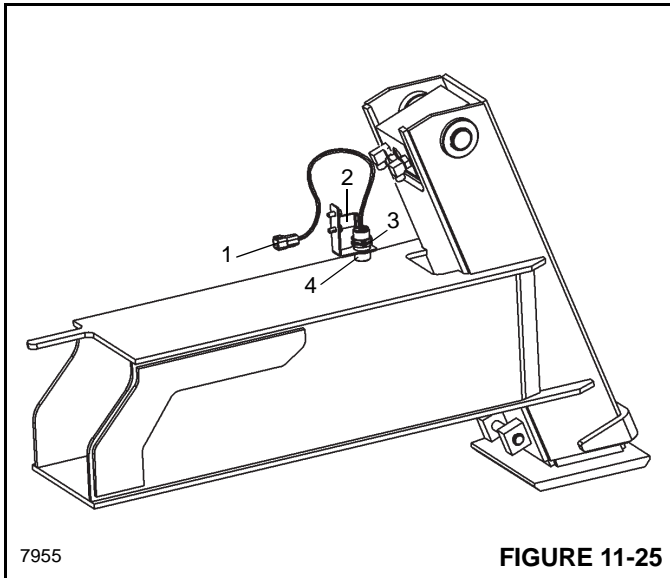
## OUTRIGGERS

### Outrigger Monitoring System (OMS) (Optional—Standard in North America)

The Outrigger Monitoring System (OMS) proximity switches (if equipped) are mounted outside the outrigger housing tubes. The proximity switches identify whether an outrigger beam is at the fully extended position or at any position less than fully extended.

### Removal

1. Disconnect switch cable (1) from harness.
2. Remove switch mounting bracket (2).
3. Remove jam nuts (3) and thread switch (4) out of the mounting bracket.



### Installation

1. Feed cable through the mounting bracket and jam nuts.
2. Thread switch through mounting bracket.
3. Thread nuts on switch.
4. Thread switch up until it touches tab of mounting bracket and LED is pointed away from the bracket.
5. Tighten jam nuts against mounting bracket.
6. Adjust bracket and/or switch to have 3 to 10 mm (0.12 to 0.38 in) gap between end of switch and outrigger beam.
7. Connect switch cable to wire harness.

### Removal

1. Engage the parking brake and put blocks under the wheels to prevent crane movement.

**NOTE:** If outrigger proximity switches are installed, disconnect them before removing the outriggers.

2. Extend the outrigger. Disconnect rod of the horizontal outrigger cylinder (12, Figure 11-26) from the outrigger beam (7). Retract the horizontal cylinder.
3. Lower the jack outrigger (6) just far enough to remove the load on the outrigger beam (7).
4. Stop the engine. With the ignition switch in the ON position, actuate the outrigger switches in both directions to release pressure in the hydraulic circuits. Turn the ignition switch to the OFF position.
5. Disconnect the two hydraulic lines for the vertical cylinder (13) from the bulkhead elbow attached to the frame.

6. Use a hoist to remove the outrigger assembly from the frame.

### Disassembly

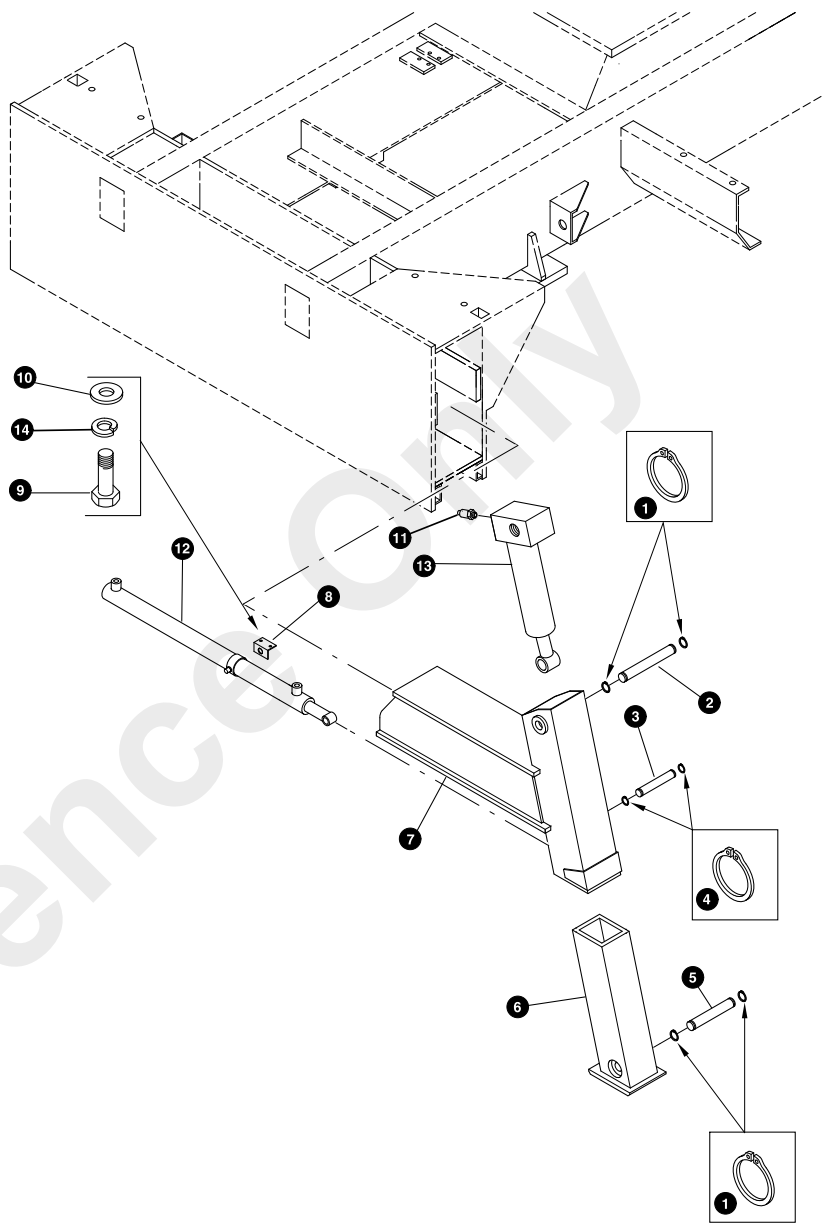
1. Remove retaining ring (1, Figure 11-26) from either side of mounting pin (5). Drive the pin out.
2. Pull outrigger jack (6) from outrigger beam (7).
3. Disconnect the hydraulic hoses from the vertical cylinder (13). Remove the hoses.
4. Remove retaining ring (1) from either side of mounting pin (2). Hold the cylinder in position and drive out the mounting pin.

### Assembly

1. Completely clean the outrigger beam and outrigger jack. Use steam or a suitable solvent. Also, clean the slide contact surfaces of the main frame.
2. Install outrigger jack (6, Figure 11-26) over the vertical cylinder (13). Align the cylinder rod with the mounting holes in the jack outrigger. Install pin (5) and retaining ring(s) (1).
3. Lubricate the inside of outrigger beam box and the outside of the jack outrigger with STP Oil Treatment, "LUBAID NF", or bronze anti-seize compound.
4. Align and install the jack outrigger and cylinder into the outrigger beam. Install pin (2) and retaining ring(s) (1).
5. Install the hydraulic hoses to the vertical cylinder ports.
6. Connect the outrigger proximity switches, if equipped.

### Installation

1. Lubricate the slide blocks inside the mainframe with STP Oil Treatment, "LUBAID NF" or bronze anti-seize compound. Use a hoist and install the outrigger assembly into the main frame.
2. Connect the hoses to the bulkhead elbows on the main frame. Make sure the hoses are routed in the top center of the outrigger beam and will not be damaged when the outriggers are retracted.
3. Connect the horizontal outrigger cylinder (12, Figure 11-26) to the outrigger beam (7). Install pin (3) and retaining ring(s) (4).
4. Apply a thin layer of STP Oil Treatment, "LUBAID NF", or bronze anti-seize compound to the slide block contact surfaces on the outrigger beam.
5. Operate outrigger and check for correct installation. Stop the engine. Check for leakage at the hose connections.



Item	Description
1	Retaining Ring (4)
2	Mounting Pin
3	Mounting Pin
4	Retaining Ring (2)
5	Mounting Pin
6	Jack Outrigger
7	Outrigger Beam
8	Cylinder Mounting Bracket (2)
9	Hex Bolt (4)
10	Flat Washer (4)
11	Counterbalance Valve
12	Horizontal Cylinder
13	Vertical Cylinder
14	Lockwasher (8)

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Outrigger Assembly

FIGURE 11-26

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**SECTION 12**  
**SCHEMATICS/WIRING DIAGRAMS**

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