

CD09

Service/Maintenance Manual



8688



WARNING

California Proposition 65

Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well-ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system.
- Do not idle the engine except as necessary.

For more information, go to www.P65warnings.ca.gov/diesel

Batteries, battery posts, terminals, and related accessories can expose you to chemicals, including lead and lead compounds, which are known to the State of California to cause cancer and birth defects or other reproductive harm. Wash hands after handling. For more information, go to www.P65warnings.ca.gov

California Spark Arrestor

Operation of this equipment may create sparks that can start fires around dry vegetation. A spark arrestor may be required. The owner/operator should contact local fire agencies for laws or regulations relating to fire prevention requirements.

The original language of this publication is English.

SERVICE MANUAL

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

CD09

Crane Model Number

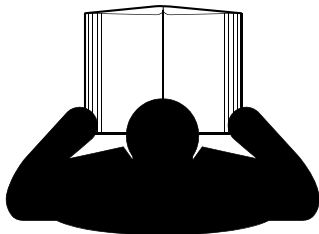

This Manual is Divided into the following Sections:

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
SECTION 8	AXLES/DRIVE SHAFTS/WHEELS AND TIRES
SECTION 9	BRAKE SYSTEM
SECTION 10	STEERING SYSTEM
SECTION 11	STRUCTURALS
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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.

	<div data-bbox="730 1407 1282 1491">  <h2>DANGER</h2> </div> <p data-bbox="587 1512 1372 1575">An untrained operator subjects himself and others to death or serious injury. Do not operate this crane unless:</p> <ul data-bbox="587 1585 1412 1942" style="list-style-type: none"> • 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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SECTION 1

INTRODUCTION

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This manual contains information on maintenance, service and repair of the Model CD09 crane. 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.

SERIAL NUMBER DECAL

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 decal is shown below



FIGURE 1-1

GENERAL SPECIFICATIONS

Engine

Tier 4 Final Diesel

Make and model	Cummins QSF2.8 -4 Cyl. Diesel Tier 4 Final
Type of Aspiration	Turbocharged
Horsepower	74 hp @ 2500 rpm
Low idle speed	900 rpm
Maximum engine speed	2500 rpm

Tier 3 Diesel

Make and model	Cummins QSF2.8 -4 Cyl. Diesel Tier 3
Type of Aspiration	Turbocharged
Horsepower	72 hp @ 2400 rpm
Low idle speed	900 rpm
Maximum engine speed	2400 rpm

Dual Fuel

Make and model	KEM GM 4.3L
Type of Aspiration	Naturally
Horsepower	78 hp @ 2500 rpm (Gasoline)
.....	63 hp @ 2500 rpm (LPG)
Low idle speed	900 rpm
Maximum engine speed	2500 rpm

Tires

Size	10.00-15
Type	Bias Ply
Air pressure.....	8.62 bar (125 psi)

Wheel nut torque 475 Nm \pm 14 (350 lb-ft \pm 10)

Electrical System

Rating 12 VDC negative ground

Number and type of batteries:

Standard Battery One-maintenance free

Battery 150 amp/hr

Battery rating 150 amp/hr

Alternator 120 amps-Diesel

..... 105 amps-Duel Fuel

Fuel Tank

Capacity 66.9 L (17.7 gal)

Hydraulic System

Primary Pump Piston, 65 cc - CW

Swing Motor Single section, gerotor-type

Hoist Motor Gerotor

Hydraulic Filter Return line filter with full flow by-pass protection and service indicator. Replaceable cartridge with filtration rating of 16/14/12 (5 micron).

Hydraulic Cylinders Double-acting cylinders for lift, telescope, steering and outriggers

Hydraulic Tank 84.8 L (22.4 gal.) capacity, steel construction with internal baffles

Boom

Reach (from center line of rotation)

3 Section Boom 10.42 m (34.2 ft)

Boom Extension - Fixed (optional) 3.66 m (12 ft)

Boom Elevation 0° to 70°

Mast Rotation - 360°

Mast Bearing (Diameter) 581.66 mm (22.9 in)

Swing Drive Mechanism Hydraulic motor driven worm drive gearbox

Swing Speed 2.1 rpm

Wire Rope

Wire Rope (Main Hoist):

Diameter 14 mm (9/16 in)

Type Std & CE: 6 X 19 EEIPS IWRC, Bright 44.5 kN (10,000 lb) line pull

..... AUS: 35 X 7 EEIPS+ WSC Rotation Resistant 41.6 kN (9,350 lb) line pull

Wire Rope (Optional Below Deck Winch):

Diameter 9.5 mm (.38 in)

Length 30.5 m (100 ft)

Weight

Crane Gross Vehicle Weight 8,065 kg (17,780 lb)

Torque Converter

Model Borg and Beck

Type Hydraulic

Transmission

Type Dana

Model T12000

Type 2WD Powershift

Travel Speeds

Two-Wheel Steer

Tier 4/Dual Fuel

1st gear 4 km/hr (2.5 mph)

2nd gear 8.7 km/hr (5.4 mph)

3rd gear 22 km/hr (13.7 mph)

4th gear 32.2 km/hr (20 mph)

Tier 3

1st gear 3.5 km/hr (2.2 mph)

2nd gear 7.7 km/hr (4.8 mph)

3rd gear 19.3 km/hr (12 mph)

4th gear 28 km/hr (17.4 mph)

Front Axle Drive

Type International Transmissions Limited

Model SD55

Ratio 18:1

Rear Axle Non-Drive

Type International Transmissions Limited

Model S55

Operating Dimensions

Two-Wheel Steer

- Outside turning radius
(center line outside tires) 5.05 m (16' 7")
- Outside turning radius
(end of boom extension, 33.2' boom) 6.50 m (21' 4")

Four-Wheel Steer

- Outside turning radius
(center line outside tires) 3.18 m (10' 5")

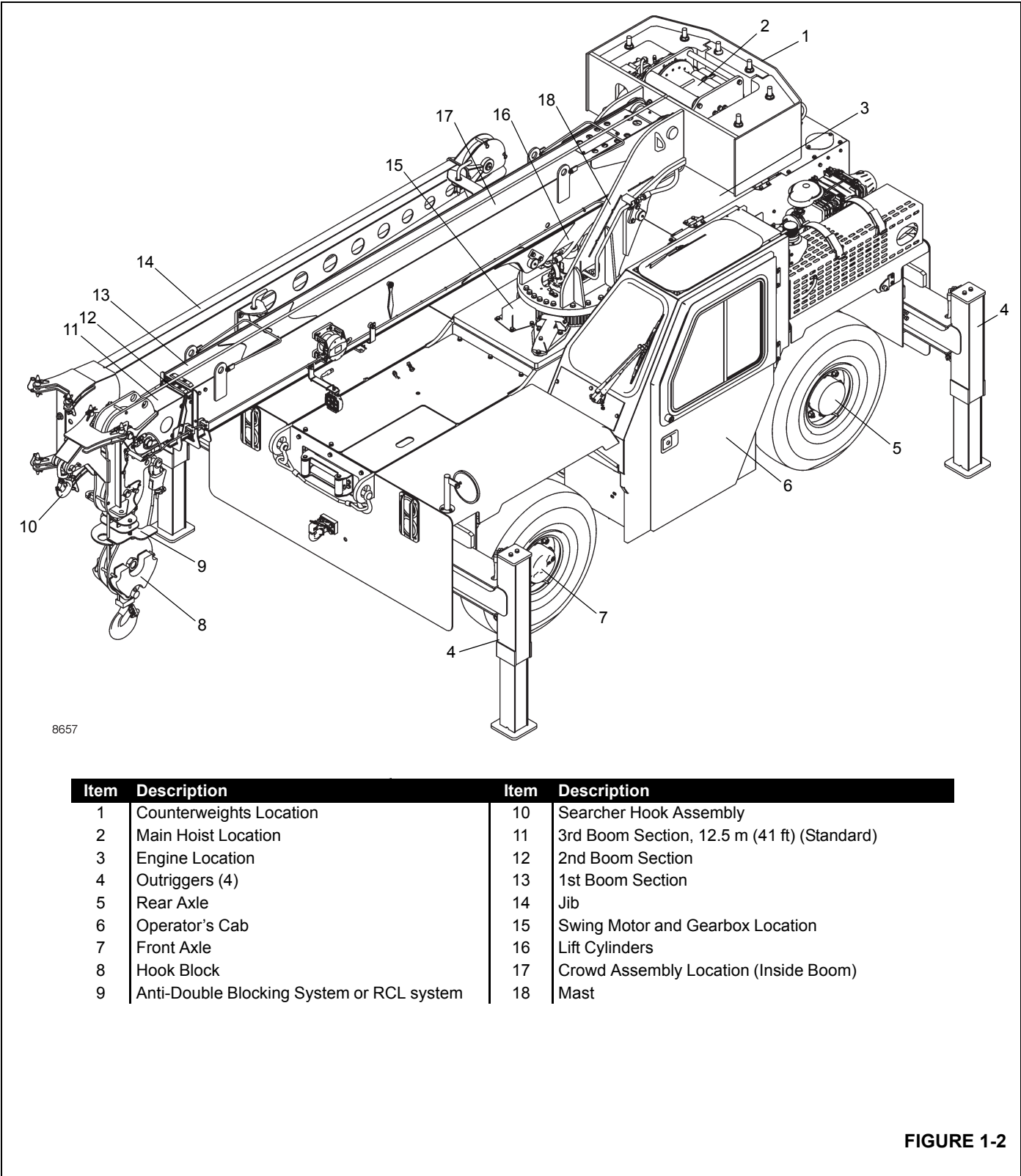
- Outside turning radius
(end of boom extension, 33.2' boom)4.65 m (15' 3")

Boom Angle

Maximum.....70°
Minimum.....0°

Outriggers

Type Hydraulic
Construction Welded box



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 1-3:

- Evidence of kinking or crushing (1)
- Chaffing or cuts; wire is exposed (2)
- Damaged or leaking fittings (3)
- Localized ballooning (4)

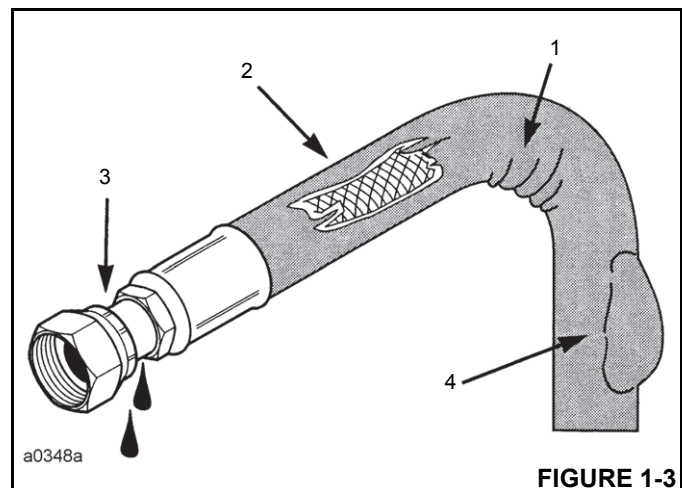


FIGURE 1-3

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 of 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.
- Outtrigger 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.

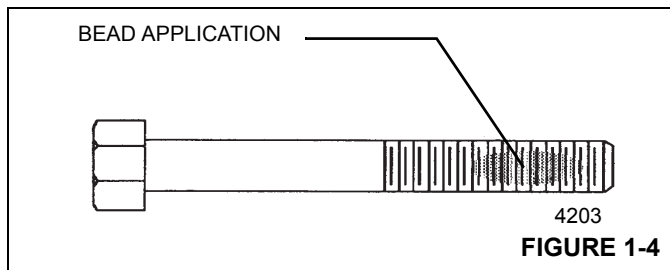
The following procedure covers the proper application and curing method for medium strength Loctite adhesive/sealant (Loctite #243) and primer (Locquic® Primer T7471).

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 1-4).
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.

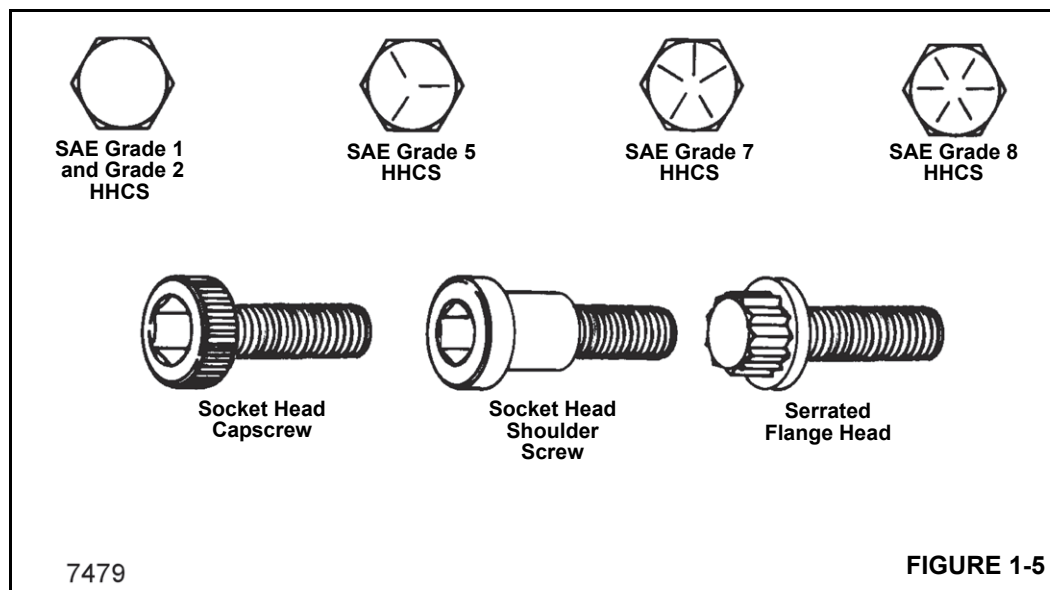


FIGURE 1-5

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)																
Class	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)																
Class	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)														
Class	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)														
Class	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

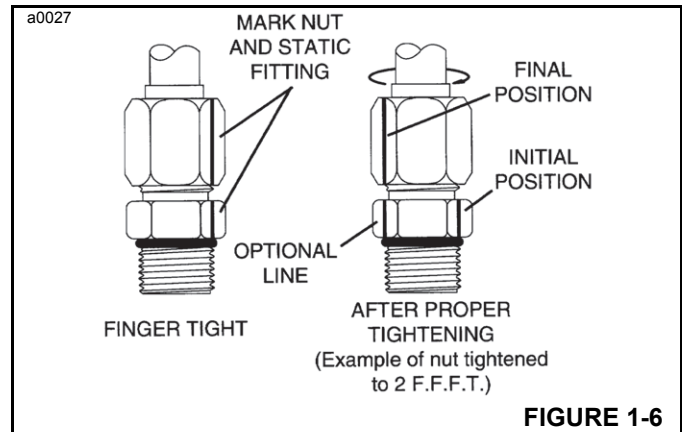
F.F.F.T. METHOD (Flats from Finger Tight)

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 1-6).

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

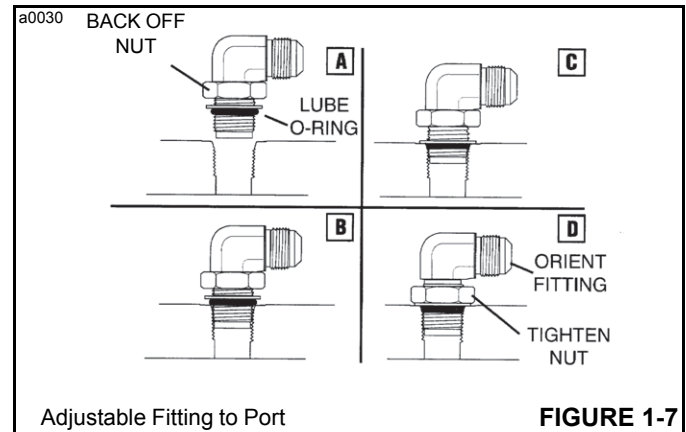
ADJUSTABLE STEEL STR. THREAD O-RING FITTINGS	
SAE SIZE	(F.F.F.T.)
2	1.0 ± 0.25
3	1.0 ± 0.25
4	1.5 ± 0.25
5	1.0 ± 0.25
6	1.5 ± 0.25
8	1.5 ± 0.25
10	1.5 ± 0.25
12	1.5 ± 0.25
14	1.5 ± 0.25
16	1.5 ± 0.25
20	2.0 ± 0.25
24	2.0 ± 0.25
32	2.0 ± 0.25

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 1-7A).
3. Back off locknut as far as possible (Figure 1-7A).
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 1-7B).
5. To orientate the fitting, unscrew the fitting the required amount, but not more than one full turn (Figure 1-7C).
6. Hold the fitting in the desired position and tighten the nut (Figure 1-7D) following the F.F.F.T. method, See F.F.F.T. METHOD (Flats from Finger Tight) starting with step 4.

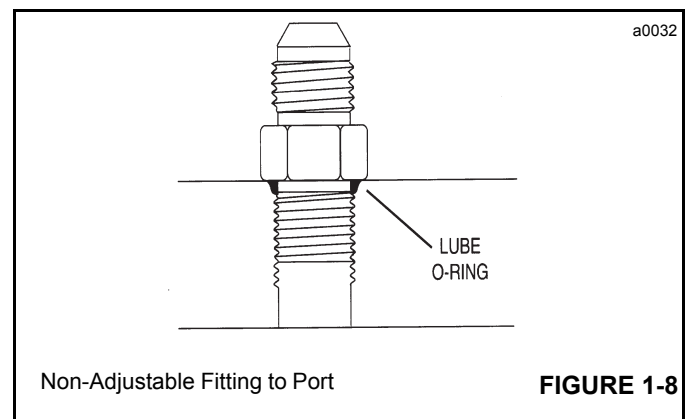
Nonadjustable Straight Thread O-ring Fitting - Fitting to Port (Table 1-13)

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 1-8).
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

NON--ADJUSTABLE STEEL STR. THREAD O-RING FITTINGS		
SAE SIZE	TORQUE	
	(lb in)	(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 1-9).

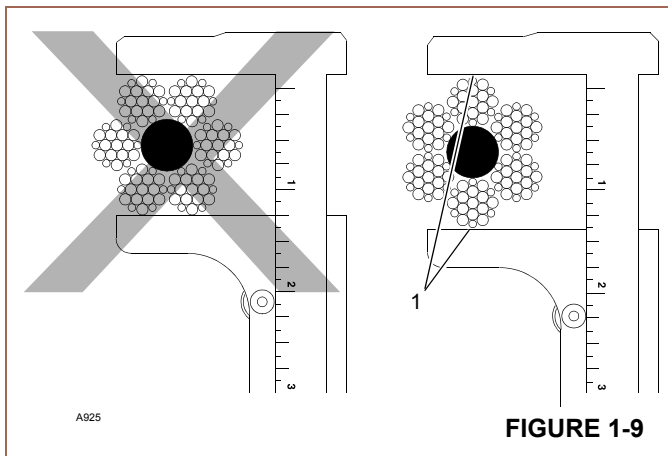


FIGURE 1-9

13. When checking for broken wires (5) Figure 1-10 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).

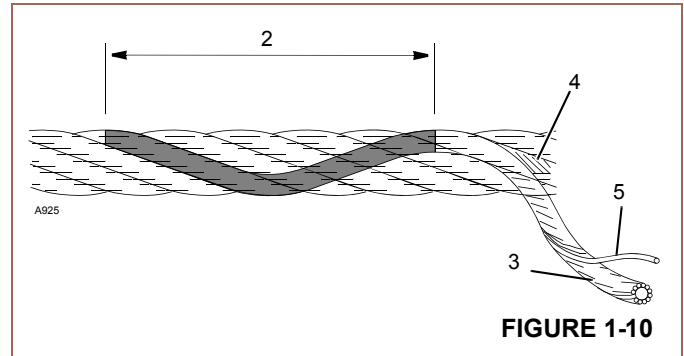


FIGURE 1-10

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 1-11, 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.

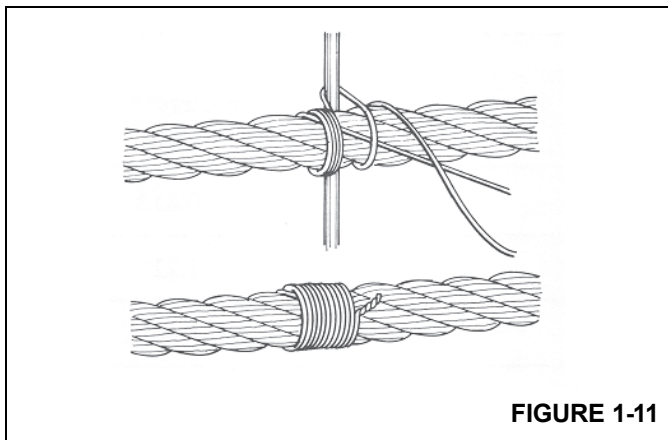


FIGURE 1-11

Method 2

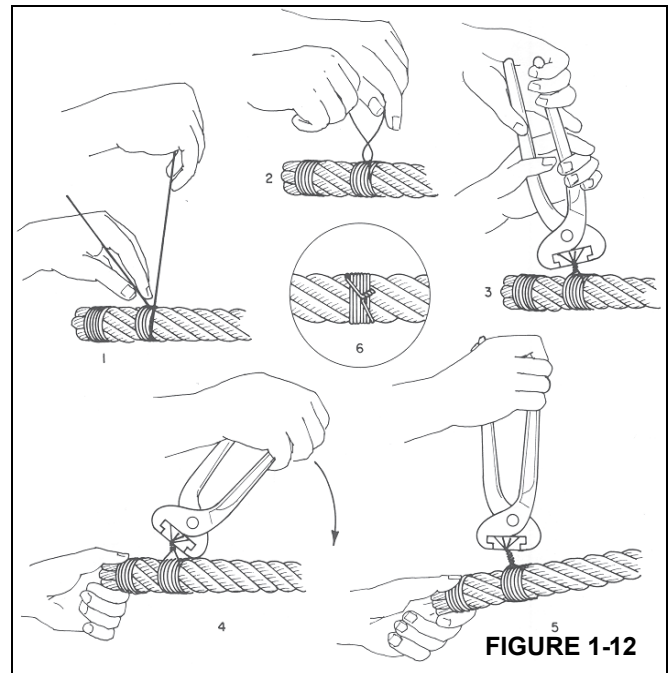


FIGURE 1-12

Wind a length of soft annealed wire Figure 1-12 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 1-13 should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).

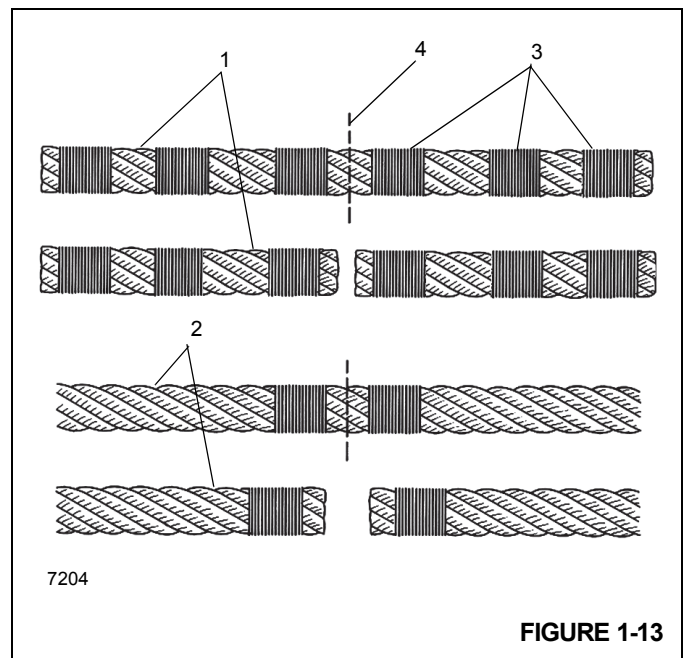


FIGURE 1-13

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.

SECTION 2
SAFETY PRACTICES

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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.	Prevents serious injury or death.
	Never use compressed air to blow dust, filings, dirt, etc., from work area unless the correct type of nozzle is used.	Prevents serious injury to operator and/or bystanders.
	Look around before using an air hose. Warn others.	Yourself and bystanders may get grit into their eyes, ears or skin.
Hand Tools	Never use the wrong tool for the job.	Many cuts, abrasions and injuries are caused by defective or wrong tools.
	Always use the recommended tool.	These tools will reduce work, labor and cost.
	Always keep tools clean and in good working condition.	

General Considerations

	What to Do	Why
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

	What to do	Why
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	Make sure all test equipment is in good condition. Use only specified gauges. Comply with test procedures specified.	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 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:

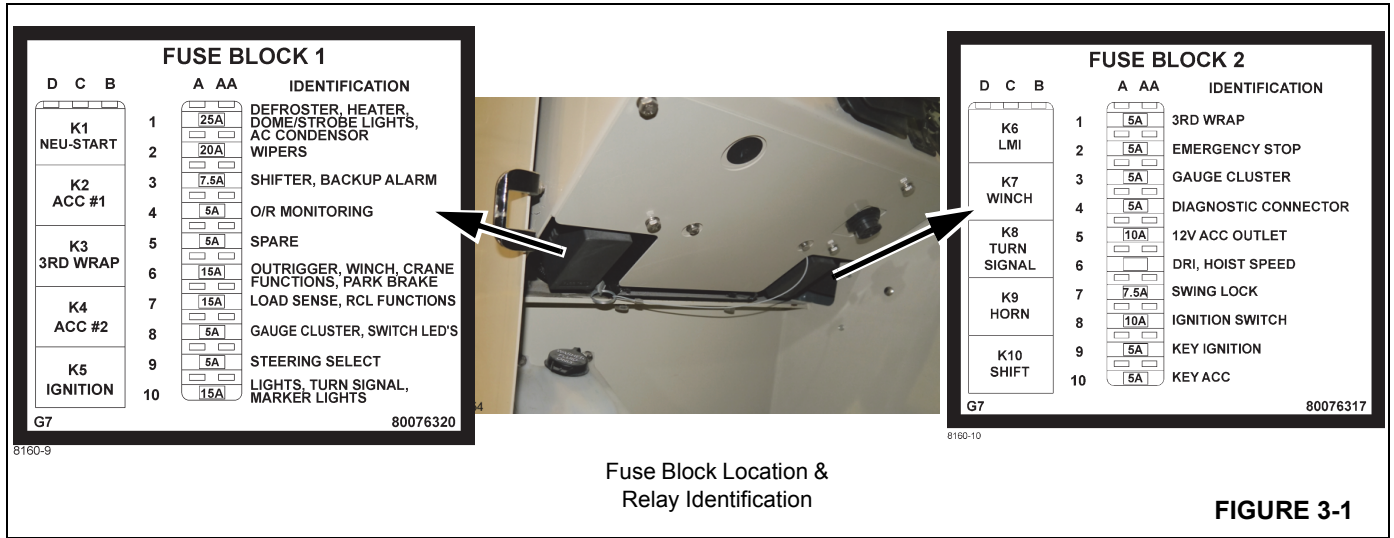
- Dash Wire Harness
- Main Frame Wire Harness
- Engine Wire Harness
- Boom Wire Harness
- Cab Wire Harness

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.



Fuse Box #1 Circuit Identification

Fuse	Amps	Circuit
FU1	25	Defroster, Heater, Dome/Strobe Lts., AC Condenser
FU2	20	Wipers
FU3	7.5	Shifter, Back Up Alarm
FU4	5	Outrigger Monitoring
FU5	5	Spare
FU6	15	Outriggers, Winch, Crane Functions, Park Brake
FU7	15	Load Sense, RCL Functions
FU8	5	Gauge Cluster, Switch LEDs
FU9	5	Steering Select
FU10	15	Lights, Turn Signal, Marker Lights

Fuse Box #2 Circuit Identification

Fuse	Amps	Circuit
FU1	5	3rd Wrap
FU2	5	Emergency Stop
FU3	5	Gauge Cluster
FU4	5	Diagnostic Connector
FU5	10	12V ACC Outlet
FU6	-	DRI, Hoist Speed
FU7	7.5	Swing Lock
FU8	10	Ignition Switch
FU9	5	Key Ignition
FU10	5	Key ACC

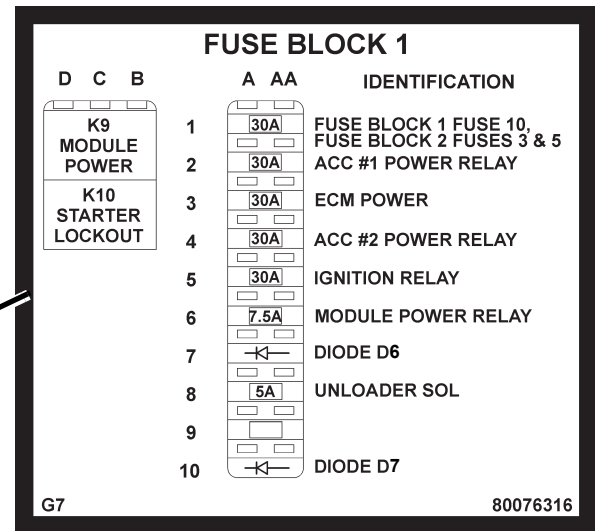


FIGURE 3-2

Fuse	Amps	Circuit
6	7.5	Module Power Relay
7	-	Diode D6
8	5	Unloader Solenoid
9		Not Used
10	-	Diode D7

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 battery. 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 battery is 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 on the right side of the crane in front of the rear tire. 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.

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 disconnect switch. 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, transmission shifter, starter lockout relay 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 and transmission shifter is in neutral position.
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 Explained

In order for the crane to start when the ignition switch is held in the START position, the transmission must be in neutral position. This allows voltage to go to the park brake switch. The park brake switch must be in the ON position to allow voltage to go to the coil of the neutral start relay in fuse box #1. The neutral start relay will close allowing voltage to go to the common post of the starter lockout relay located in fuse box #3. In order for the starter lockout relay to close it must receive power and ground to its coil from the engine ECM. When power and ground are present from the engine ECM to the coil of the starter lockout relay it will close. When it closes voltage passes through the common post to the normally open post to the auxiliary start relay coil. This will

close that relay allowing voltage to go to the starter motor relay "S" post. This will close that relay allowing battery power to the starter motor.

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 lights. 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	Sealed
Turn Signal	Sealed
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

Hour meter is controlled by the engine ECM and only operates 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 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 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 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 supplies electrical current to the components in the cab not connected to the dash wire harness.

Boom Wire Harness

The boom wire harness 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.

ACCESSORY CIRCUITS

Anti-Double Blocking System

General

This mechanism (Figure 3-4) 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.

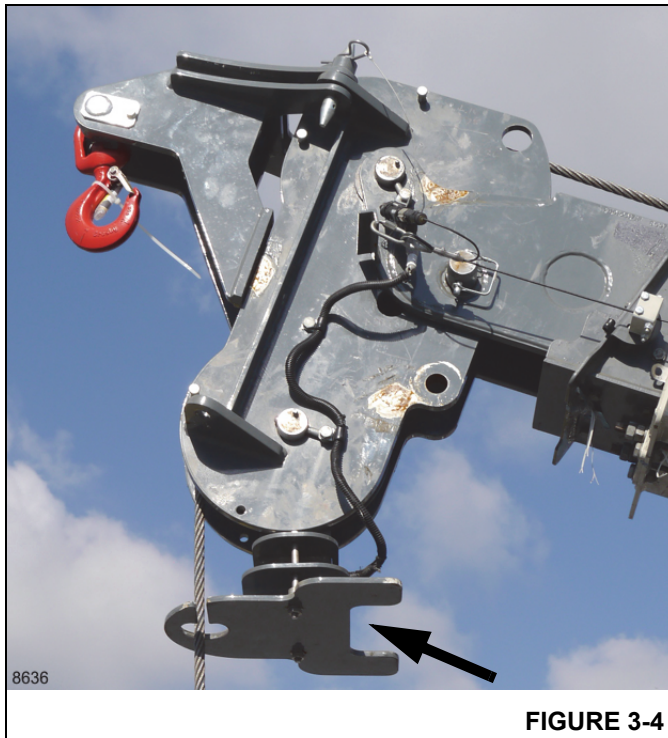


FIGURE 3-4

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"> 1. Alternator belt loose or broken. 2. Worn brushes or open brush leads or connections. 3. Open circuit, short circuit or ground stator winding. 4. Fault in voltage regulator. 5. Short circuit or open circuit in rectifier diodes. 6. Open circuit or short circuit in rotor (field) winding. 7. Wires connected wrong, loose, or broken. 8. Dirty slip rings or bad slip ring connections. 	<ol style="list-style-type: none"> 1. Replace and/or tighten to specification. 2. Replace or repair alternator. 3. Replace alternator. 4. Replace voltage regulator. 5. Replace or repair alternator. 6. Replace alternator. 7. See wiring diagram. Repair or replace wires. 8. Inspect slip rings. Clean or repair as required.
High charging rate (battery at full charge).	<ol style="list-style-type: none"> 1. Low electrolyte level in battery. 2. Fault in wiring system. 3. Loose or dirty connections. 4. Malfunction in voltage regulator. 	<ol style="list-style-type: none"> 1. Add distilled water. 2. Repair or replace faulty wiring. 3. Clean and tighten connections. 4. Replace voltage regulator.
Low charging rate.	<ol style="list-style-type: none"> 1. Loose or worn alternator belt. 2. Bad alternator. 3. Bad battery. 4. Low electrolyte level. 5. Short circuit in system. 6. Worn alternator. 7. Malfunctioning voltage regulator. 8. Low engine speed. 	<ol style="list-style-type: none"> 1. Adjust or replace belt. 2. Replace or repair. 3. Replace battery. 4. Add distilled water. 5. Check and repair. 6. Test, replace or repair alternator. 7. Replace the voltage regulator. 8. Run engine at higher speed.

Problem	Possible Cause	Solution
Alternator Noise.	<ol style="list-style-type: none"> 1. Badly worn belt. 2. Pulleys out of alignment. 3. Loose pulley. 4. Worn bearings. 5. Short in rectifier diodes. 	<ol style="list-style-type: none"> 1. Replace belt and adjust. 2. Align fan and alternator pulleys. 3. Check for broken key or worn keyway, if used. Tighten pulley nut. 4. Replace or repair alternator. 5. Replace or repair alternator.
Starter motor does not turn.	<ol style="list-style-type: none"> 1. Open circuit, dirty or loose connections. 2. Bad starter relay. 3. Bad ignition switch. 4. Worn starter motor, bad starter solenoid, or internal problem in engine. 5. Dead battery. 6. Parking brake not engaged. 7. Bad neutral start relay. 8. Bad starter lockout relay. 9. Bad transmission shifter neutral switch. 10. Bad park brake switch. 	<ol style="list-style-type: none"> 1. Clean and tighten connections at battery and starter. Check wiring and connections between ignition switch and starter solenoid. 2. Replace starter relay. 3. Replace switch. 4. Repair or replace starter, replace solenoid, or see engine manual. 5. Recharge or replace battery. 6. Engage parking brake. 7. Replace relay. 8. Replace relay. 9. Replace switch. 10. Replace switch.

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 4-16.
No movement when system is first started.	Faulty pump.	Overhaul or replace pump.
	Low oil level.	Check and add oil.
	Air or restriction in inlet line to pump pressure.	Check and tighten inlet line. Clear restriction.
Loss of movement during operation.	Cold oil or wrong weight of oil.	Use correct oil, follow normal warming procedure.
	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.
Overheating of hydraulic oil.	Broken gear or shaft in pump.	Overhaul or replace.
	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.
Foam in hydraulic oil tank.	Dirty oil.	Change oil and filters. See Preventative Maintenance, Chapter 5.
	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.
Short life of pump bearings, shafts, etc.	Bad seal in pump, motor or cylinder.	Overhaul or replace.
	Dirt in oil.	Change oil and filter more frequently.
Pump leakage (external).	Wrong type of oil.	Use correct oil.
	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.	See Difficult to Engage Valve Spools.
	Not enough oil from pump to operate the cylinder.	See Loss of Movement During Operation.
	Bad leak in hydraulic swivel.	Replace seals.
	Load sense relief valve held open by dirt on valve seat.	Disassemble and clean or replace the load sense relief valve.
Cylinder extends, but does not retract.	Malfunction in holding valve.	Replace the holding valve. DO NOT ADJUST.
	Restriction in hose to control valve.	Check and correct.
Cylinder retracts but does not extend.	Malfunction in anti-double blocking electrical system.	See Electric System.
	Bad cartridge in anti-double blocking solenoid valve.	Replace cartridge.
	Restriction in pilot control line to control valve.	Locate and repair.
	Faulty controller.	Repair or replace.
Boom moves slowly downward when control valve is in NEUTRAL position.	Internal leakage in cylinder.	Replace piston seals.
	Leakage in holding valve.	Replace holding valve. DO NOT ADJUST.
	Faulty controller.	Repair or replace.
	Broken centering spring in control valve section.	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.	Clean and apply lubricant to boom slides. See Preventative Maintenance, Chapter 5.
	Load too heavy.	Reduce load.
	Faulty pump.	Overhaul or replace.
	Leakage in hydraulic swivel.	Replace seals in the swivel.
	Load sense relief valve malfunction.	Check load sense relief pressure.
	Dirt or restriction in main relief.	Disassemble the relief valve and clean.
Boom extends, but will not retract.	Restriction in hose to the control valve.	Check and correct.
	Malfunction in the holding valve.	Replace the holding valve. DO NOT ADJUST

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

Table 4-4
Outrigger Circuit Troubleshooting

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

Problem	Possible Cause	Remedy
Difficult or slow swing.	Friction or restriction in mast bearing. Faulty swing motor or gearbox.	See <i>Structurals</i> , page 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), end plate (4), drive shaft (5), swash plate (6), shaft seal (7), regulator (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.

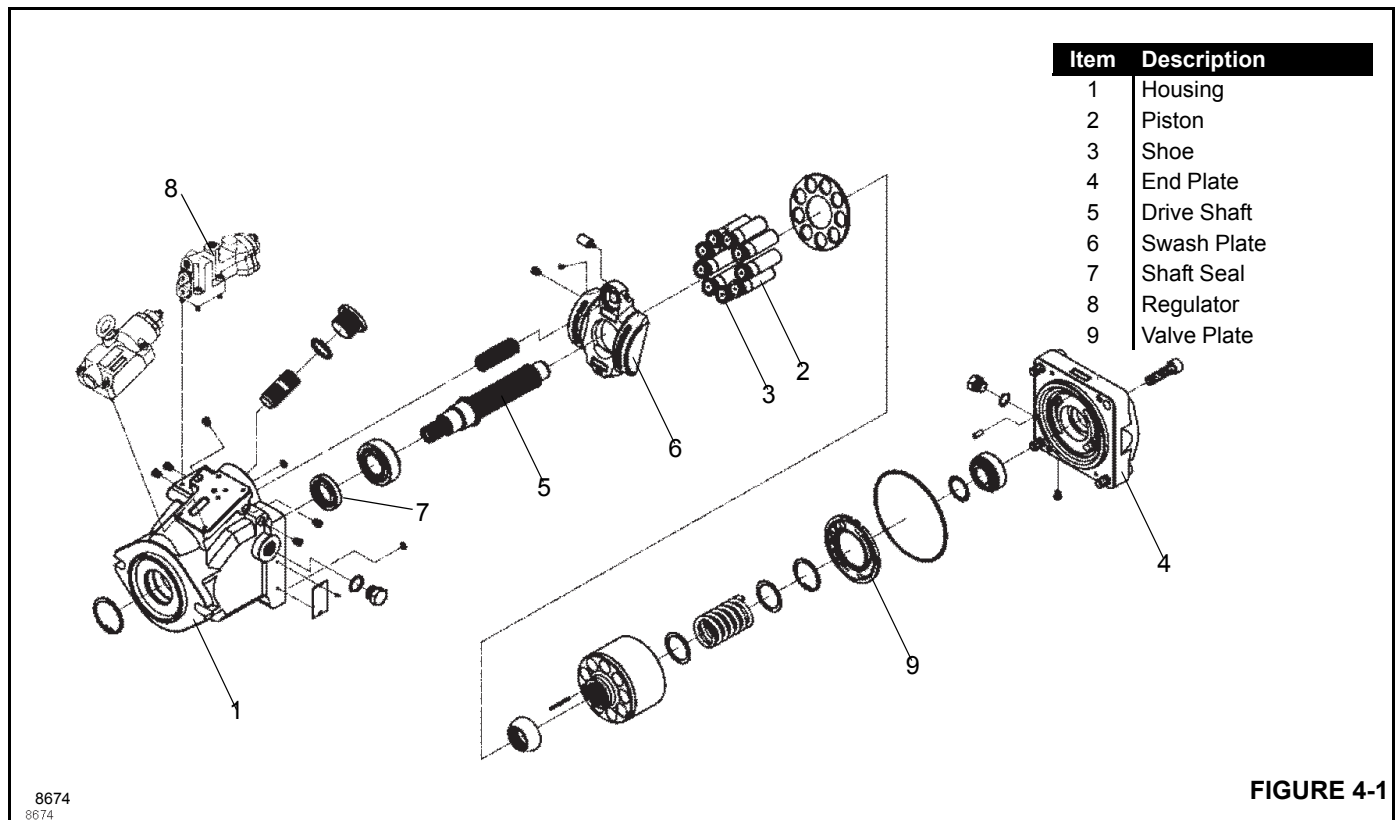


FIGURE 4-1

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

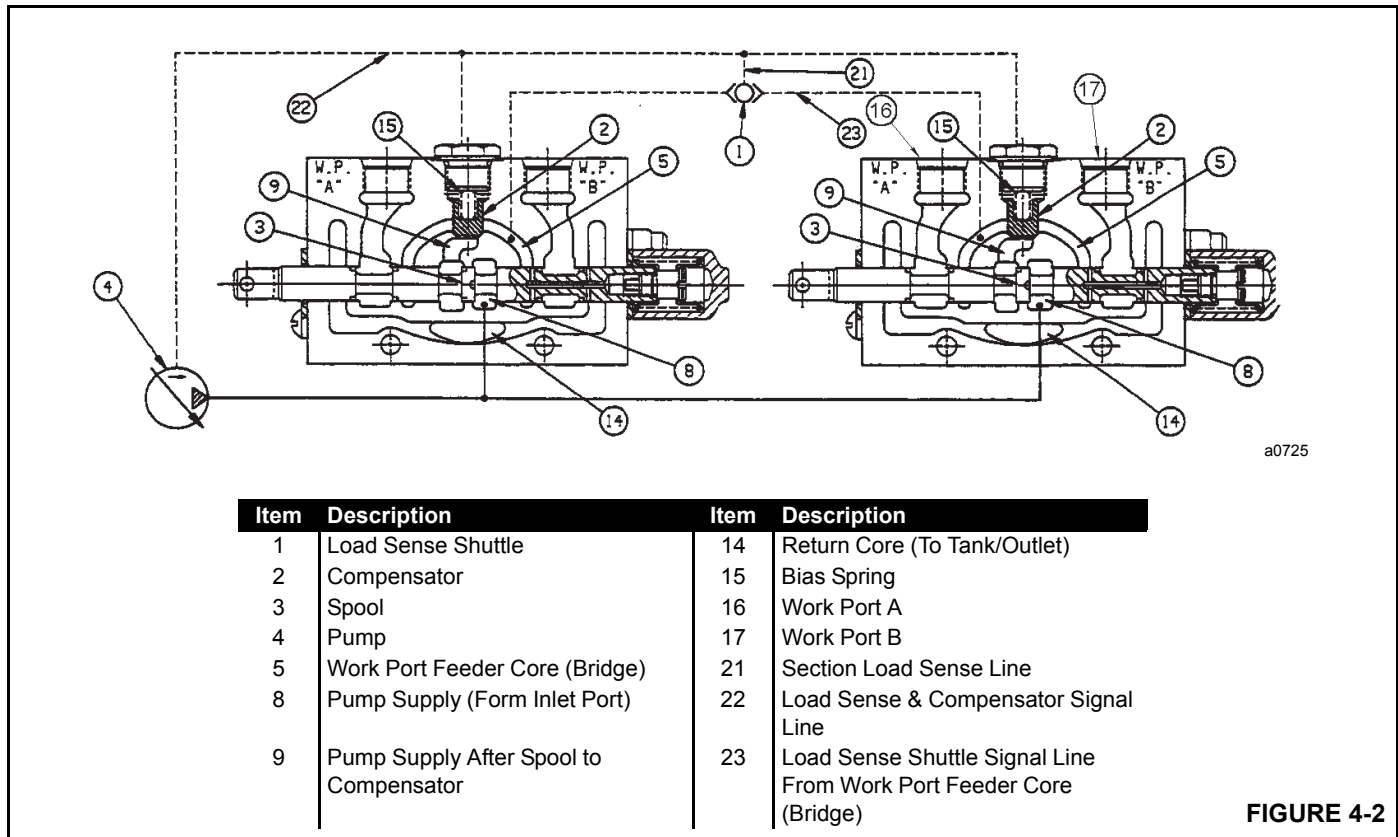
signal with load sense pressure plus pump margin or differential pressure. It is this margin or differential pressure that overcomes the compensators (2) and permits flow to bridge (5) and work port A (16) or B (17). This system establishes a constant pressure differential across a variable orifice spool (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. 0

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

Port No. 1

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

Port No. 5

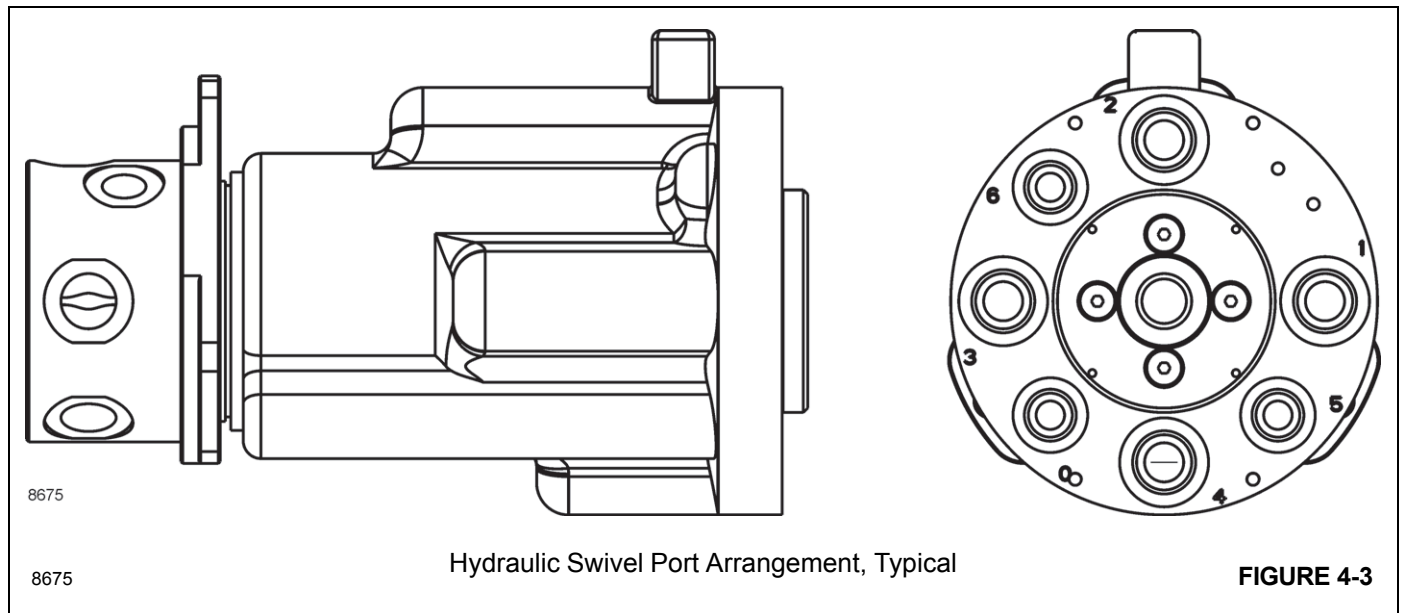
Hydraulic oil under pressure flows through this port when the boom is being raised. When lowering the boom the hydraulic oil under low pressure flows through this port.

Port No. 6

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

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 one lift cylinder, a holding valve, Ports 5 and 6 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 cylinder.

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 5 of the

hydraulic swivel and enters the base end of the lift cylinder through the holding valve. In this direction, the oil flows freely through the holding valve 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 6 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 cylinder 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 the cylinder is suspected, check for leakage as follows:

1. Remove the cylinder from the machine. See page 4-34.
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 4-34.

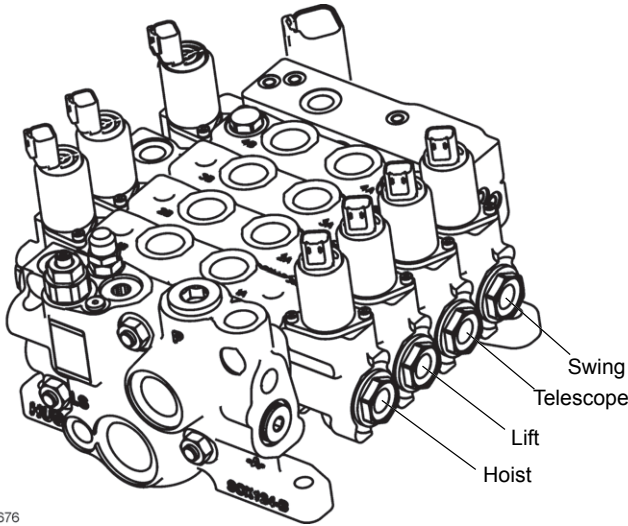
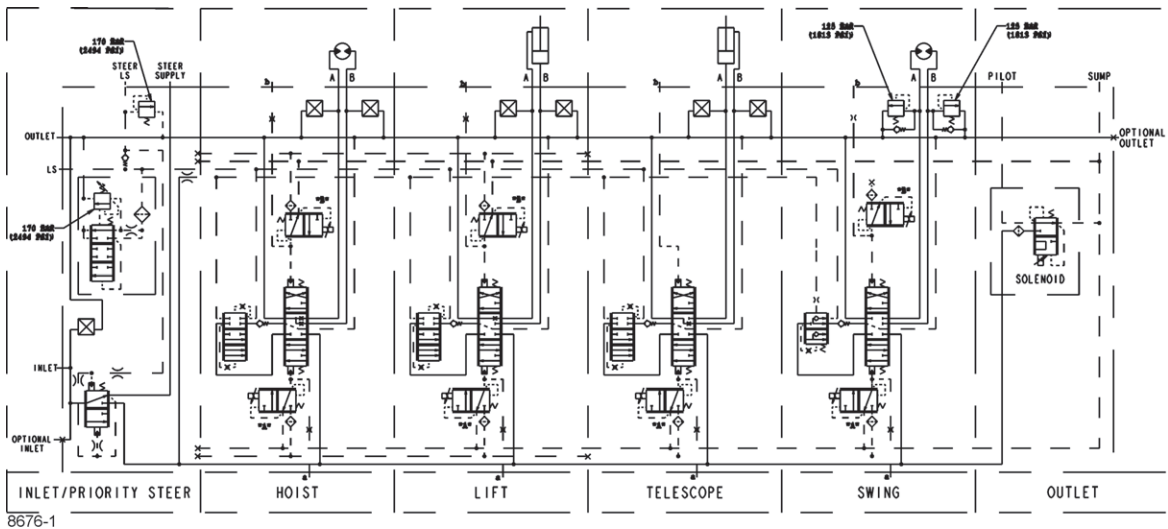


FIGURE 4-4

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 1 and 3 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 1 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 3 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 3 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 1 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 ± 3.45 bar (1950 ± 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 ± 3.45 bar (1800 ± 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 4-10 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 motor control valve, ports 2 and 4 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 4 to the motor control valve. In this direction, the oil flows freely through the motor control 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 2 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 2 to the hoist motor. The motor starts to turn, and the increase in pressure on the up stream side of the motor causes the motor control valve to open and also the hoist brake to disengage. The oil then returns through swivel port 4 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 0 back to the hydraulic tank.

Motor Control Valve

The motor control 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.

During hoist lowering pilot pressure from the up stream side of the motor opens the motor control 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 motor control 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 motor control 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 motor control valve setting. The valve is adjusted by the manufacturer.

Hydraulic Swivel

See page 4-10 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.

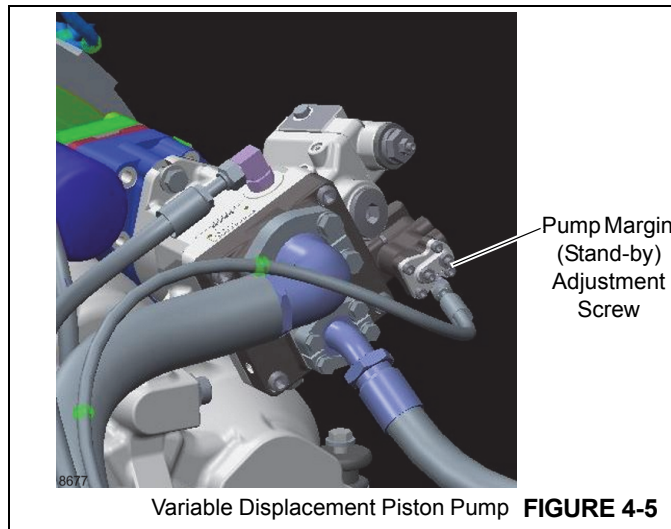
PRESSURE SETTING PROCEDURES

Checking and Adjusting Hydraulic Pressure Settings

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.

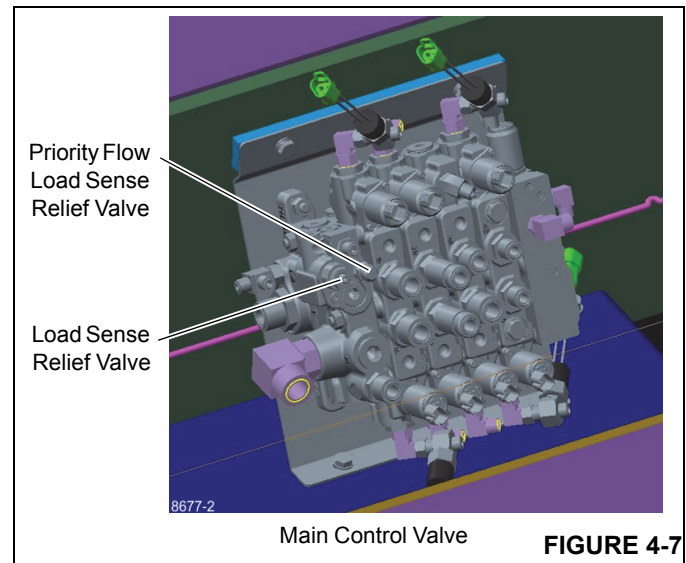
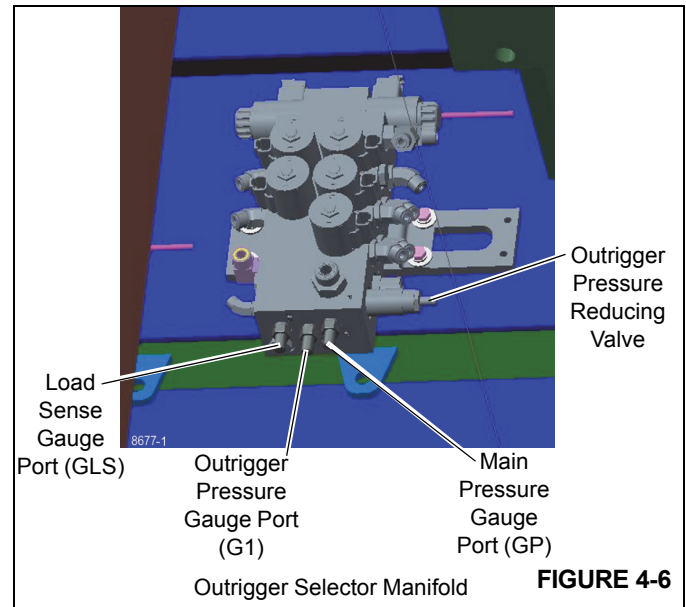
NOTE: When checking the directional control valve relief settings, unless otherwise specified, start with the engine at idle RPM and move the controller to its fully stroked position. Then slowly accelerate the engine to the specified RPM. Read gauge and make adjustment to specified setting.

When checking the outrigger relief valve setting, start with the engine at idle RPM and activate and hold the extend or retract switch as specified. Then slowly accelerate the engine to the specified RPM. Read gauge and make adjustment as required.



Procedure for checking/setting Pump Margin (Stand-by) Pressure

1. With the engine shut off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at the GP port of the Outrigger Selector Manifold (see Figure 4-6).
2. Start engine and read the pressure gauge while at engine idle. A reading of 425 ± 25 psi (29 ± 1.7 bar) 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 pump margin (stand-by) set screw from the pump compensator valve (see Figure 4-5).
5. Adjust the margin pressure setting by turning the pump margin adjusting screw (see Figure 4-5) until 425 ± 25 psi (29 ± 1.7 bar) pressure is obtained on the gauge; clockwise increases pressure, counterclockwise reduces the pressure.
6. Tighten the margin set screw.
7. Shut off the engine and disconnect the pressure gauge.



Procedure for checking/setting Load Sense Relief Valve Pressure

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple @ the load sense test port GLS (see Figure 4-6) located on front outrigger manifold.
2. Start Engine; ensure the boom is all the way down. Activate the boom down function at full engine RPM, gauge should read 2500 ± 50 psi (172 ± 3.5 bar), if the pressure needs to be adjusted, turn the load sense relief valve adjusting screw (see Figure 4-7) until 2500 ± 50 psi (172 ± 3.5 bar) pressure is obtained on the pressure gauge; clockwise increases pressure, counterclockwise decreases pressure.

3. Tighten the jam nut on the load sense relief valve.
4. Shut the engine off and disconnect the pressure gauge.

Procedure for Checking/Setting Outrigger Circuit Pressure

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto front outrigger pressure gauge @ the G1 port (see Figure 4-6).
2. Start and accelerate the engine to maximum RPM and actuate the outrigger enable switch to the extend position while another person observes the pressure gauge. The pressure should be 2000 psi \pm 50 psi (138 \pm 3.5 bar).
3. If the pressure reading is incorrect. Loosen the jam nut on the outrigger pressure reducing valve (see Figure 4-6) at the front of the machine on the front outrigger box weldment.
4. Adjust the outrigger circuit pressure by turning the adjustment screw until 2000 psi \pm 50 psi (138 \pm 3.5 bar) is obtained on the pressure gauge; clockwise increases pressure, counterclockwise decreases pressure.
5. Tighten the jam nut.
6. Shut down the engine and remove the pressure gauge.

Procedure for Checking/Setting Priority Flow Load Sense Relief and Accumulator Relief

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple @ the G1 test port (see Figure 4-8) located on the brake/steering manifold.
2. With the parking brake on, start the engine. Set crane up on a level surface with outrigger jacks fully extended.
3. With the engine at full RPM 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 Priority Flow Load Sense relief valve adjusting screw (see Figure 4-7) until 2400 \pm 50 psi (165 \pm 3.5 bar) is obtained on the pressure gauge; clockwise increases pressure, counterclockwise decreases pressure.
4. Shut down the engine and remove the pressure gauge.
5. Depress brake pedal repeatedly to relieve pressure and install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple @ the G2 port (see Figure 4-8) located on brake/steering manifold.
6. With the engine at idle, repeatedly depress the service brake pedal on the cab floor until the gauge pressure reads approximately 1700 psi (117 bar). Once you have found the pressure, push the brake pedal again to

recharge. Watch the gauge and verify the low charging limit to be 1600 \pm 100 psi (110 \pm 7 bar) (when it starts to recharge). Then watch gauge as valve is charging it should cut out at 2000 \pm 100/-0 psi (138 \pm 7/-0 bar) if not adjust at UP10 piloted unloading valve (see Figure 4-8); clockwise increases pressure, counterclockwise decreases pressure.

NOTE: If charge valve does not cut out check load sense relief valve pressure per Procedure for checking/setting Load Sense Relief Valve Pressure.

7. Shut down the engine, depress brake pedal repeatedly to relieve pressure and remove the pressure gauge.

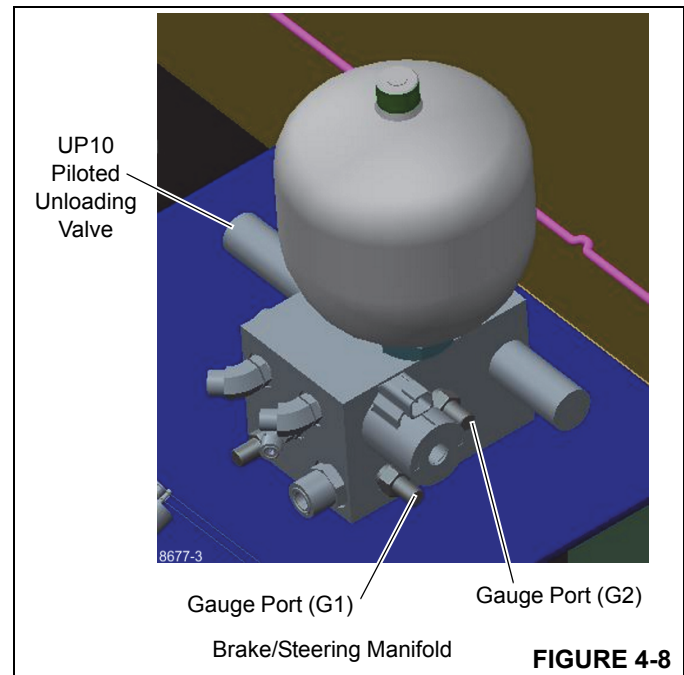


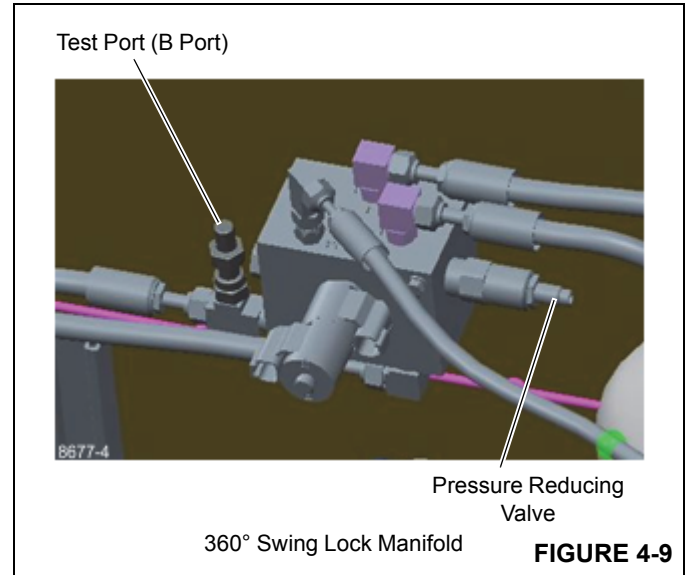
FIGURE 4-8

Procedure for checking Swing Pressure

1. With the engine shut off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at the GLS port (see Figure 4-6), disconnect both the hydraulic hoses from either the swing motor or the main control valve. Cap the adapters and plug the hoses.
2. Start engine and accelerate the engine to full RPM.
3. Watching the pressure gauge, actuate the Swing actuator until the Swing relief valve opens. The valve should open at 2000 psi \pm 100 psi (135 \pm 7 bar).
4. This pressure is not adjustable.
5. Shut down the engine and remove pressure gauge, reconnect the swing motor hoses.

Procedure for checking 360° Swing Lock Pressure (Optional)

1. With the engine shut off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple @ the test port (see Figure 4-9).
2. Start engine and accelerate the engine to full RPM.
3. Watching the pressure gauge, actuate the “lock” function and hold. The gauge should read 2500 psi \pm 50 psi (172 \pm 3.5 bar).
4. Adjust the circuit pressure by turning the pressure reducing valve adjustment screw (see Figure 4-9) until 2500 psi \pm 50psi (172 \pm 3.5 bar) is obtained on the pressure gauge: clockwise increases pressure, counterclockwise decreases pressure.
5. Shut down the engine and remove pressure gauge.



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. 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 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 piston pump flows to the O/R manifold inlet. The pressure reducing relieving valve regulates the O/R circuit pressure to 2,000 psi. Depending upon the selection of the O/R extend/retract switch (left side of the dash) the solenoid valve will be actuated and the oil will be sent to the rod side or piston side of the cylinders. While holding the extend/retract switch down the jack cylinders or the extend cylinders can be actuated by the corresponding selector switch (right side of dash). The cylinder extends or retracts and oil pushes ahead of the piston through one of the ports of the cylinder. The oil returns through the O/R manifold and back to tank through the return filter.

Outrigger Valves

NOTE: Outriggers will not function until park brake switch is in the ON position.

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 ± 3.45 bar (2100 ± 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	Right Front Jack Cylinder
3	Right Front Beam Cylinder
4	Left Front Beam Cylinder
5	Left Front Jack Cylinder
A1	Left Front Jack Return
A2	Left Front Beam Return
A3	Right Front Beam Return
A4	Right Front Jack Return
P	From Pump
T	To Tank

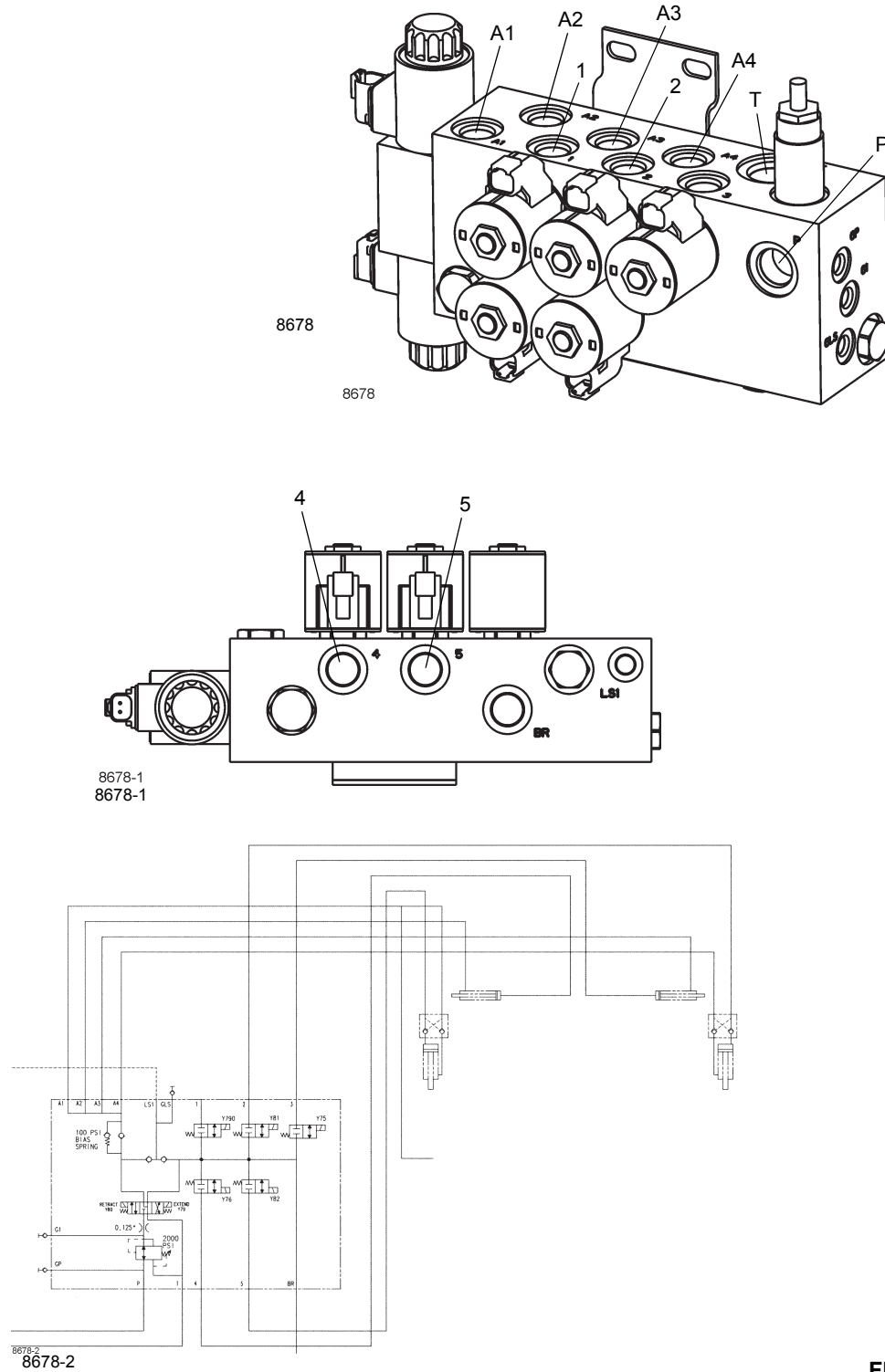


FIGURE 4-11

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 4-16.
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, set the parking brake and place chock blocks at each wheel. Before disconnecting any lines or hoses from the swing motor, actuate the swing control lever in both directions, several times, to release any pressure in the circuit.

CAUTION

The swing motor can only be reached from under the machine. Shut off the engine, set the parking brake and remove the ignition key. 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 hoses and ports to keep dirt out.
3. Remove the two mounting socket head cap screws and lock washers from the swing motor. Remove the swing motor and gasket. Discard the gasket.

Table 4-8
Relief Valve Troubleshooting

Problem	Probable Cause	Remedy
Can't get pressure.	Poppet D, E, or K stuck open or contamination under seat.	Check for foreign matter between poppets D, E or K and their mating parts. Parts must slide freely.
Erratic Pressure.	Pilot poppet seat damaged. Poppet C sticking in D.	Replace the relief valve. Clean and remove surface marks for free movement.
Pressure setting not correct.	Normal wear. Lock nut & adjusting screw loose.	Adjust pressure.
Leaks.	Damaged seats. Worn O-ring. Parts sticking due to contamination.	Replace the relief valve. Replace the relief valve. Disassemble and clean.

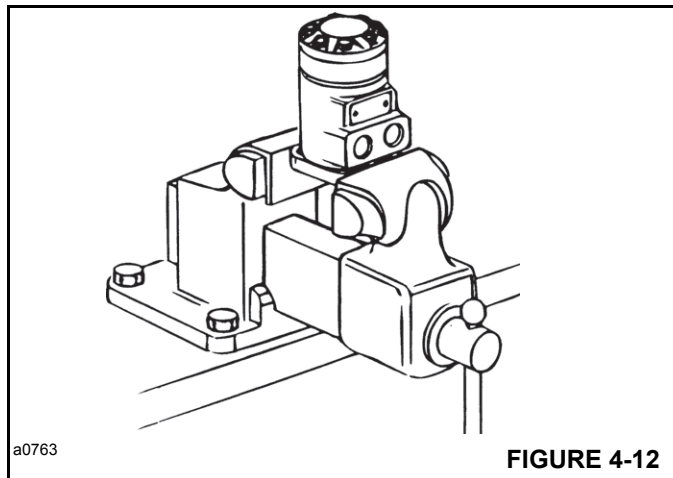
Disassembly

NOTE: 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.

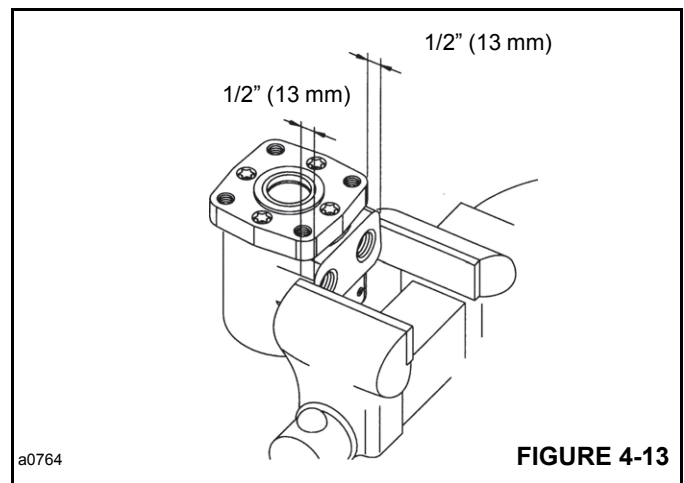
1. Place the motor in a vice and clamp across the edges of the flange (Figure 4-12) with the output shaft facing down. When clamping use protective devices on the jaws, such as soft jaws, pieces of rubber or wood.

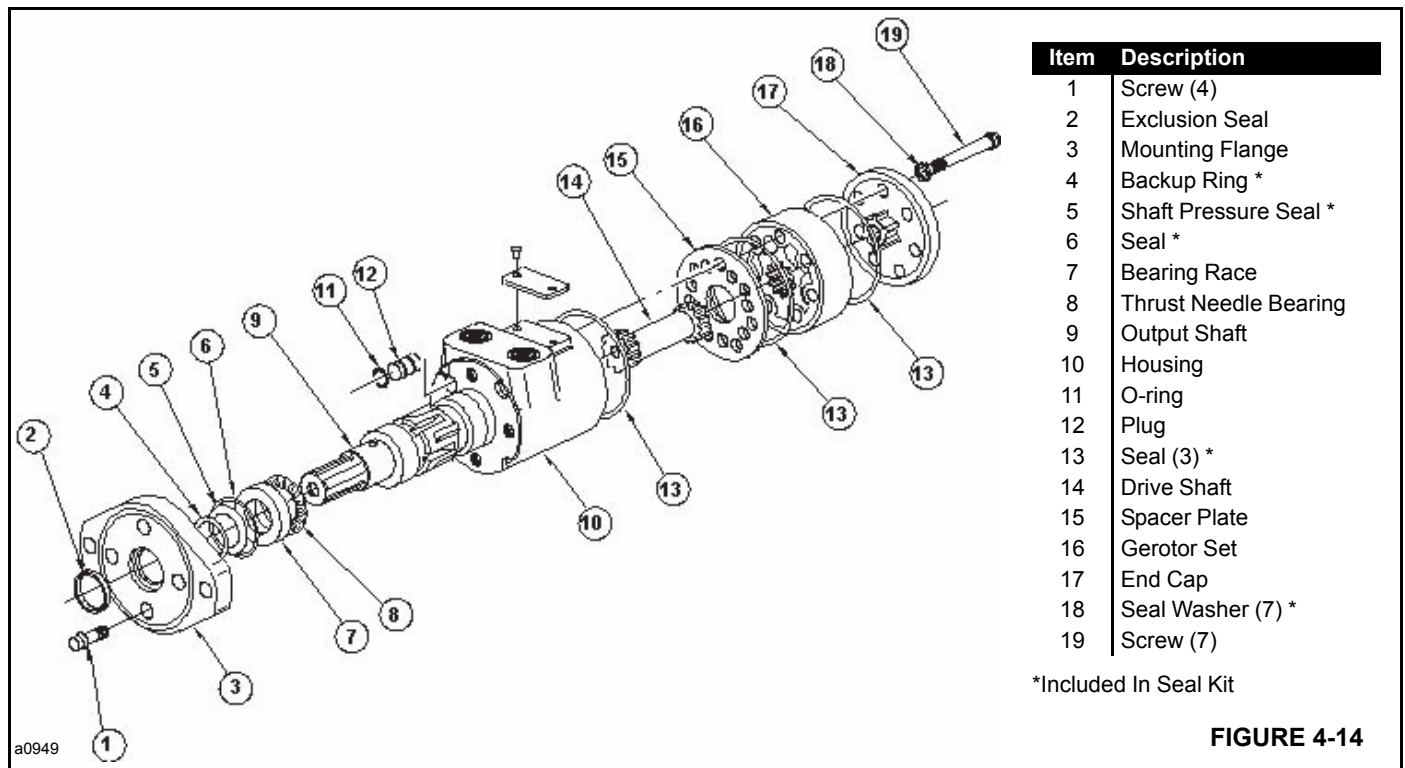
CAUTION

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 cap screws (19, Figure 4-14) 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 shaft (14).
6. Remove spacer plate (15).
7. Remove seal (13) from housing (10).
8. Remove output shaft (9) from housing (10).
9. Remove needle thrust bearing (8) from shaft or housing.
10. Reposition the motor in the vice. Clamp across ports as shown in Figure 4-13. **DO NOT** clamp on housing. Excessive clamping pressure on side of housing causes distortion.





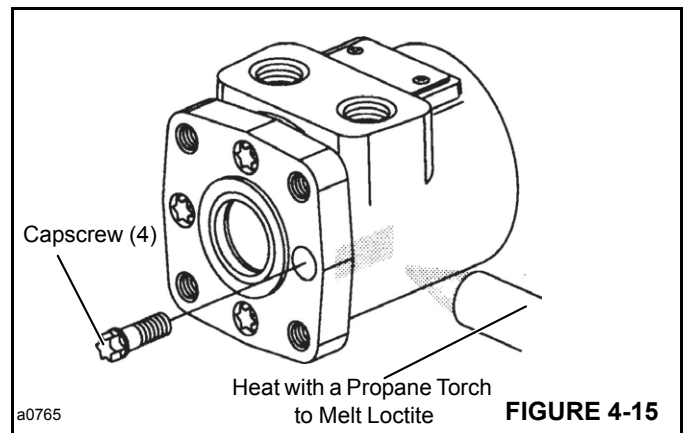
11. Remove four cap screws (1) from mounting flange (3). These screws were installed with Loctite to hold them in place.

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

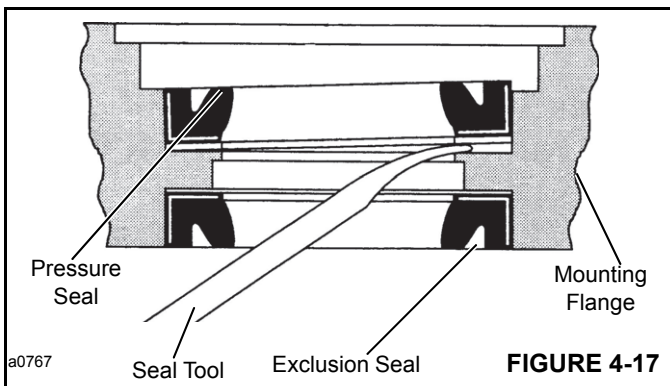
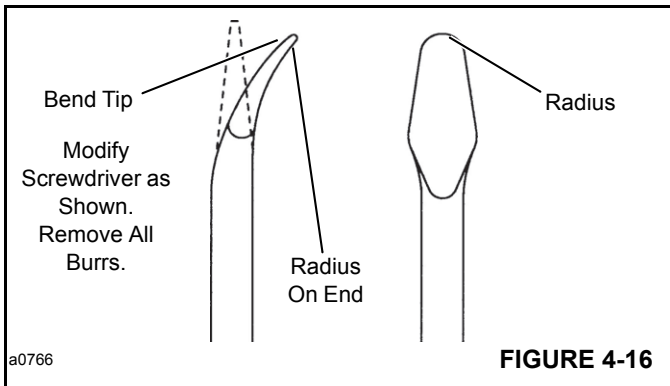
NOTE: If a torque higher than given above is required to break the cap screws loose, apply heat according to the following:

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. See Figure 4-15.

Be careful not to overheat the housing and damage the motor. Gradually apply torque to the cap screw 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 cap screws.



12. Carefully remove flange (3, Figure 4-14) from housing (10).
13. Exclusion seal (2), backup ring (4), pressure seal (5) and seal (6) will come off with flange (3). Use the seal removal tool shown in Figure 4-16 and 4-17 to remove the exclusion and pressure seals.



14. A metal plug (12, Figure 4-14), 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.

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.

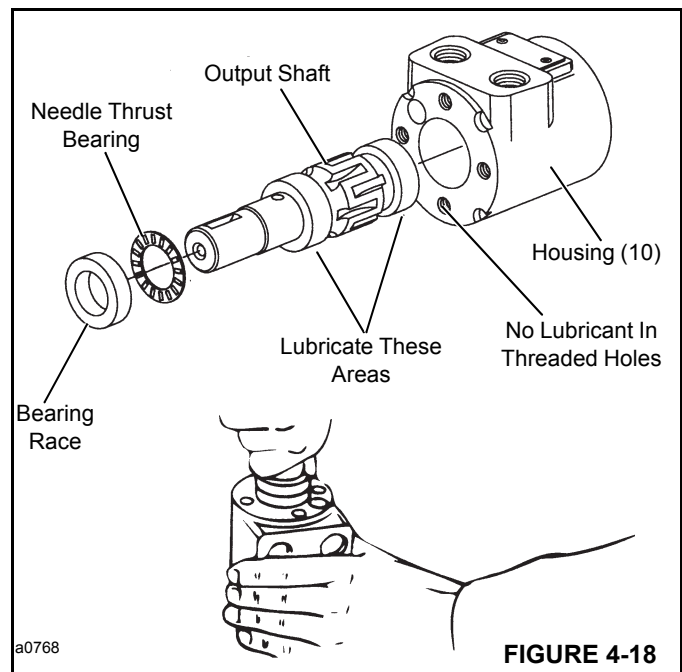
1. Wash the housing with a suitable solvent to remove oil, grease and debris. Pay particular attention to the four tapped holes on the flange end.
2. Blow dry with compressed air. Clean and dry the tapped holes.
3. Wire brush the screw threads to remove cured Loctite and other debris. Discard any screws 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

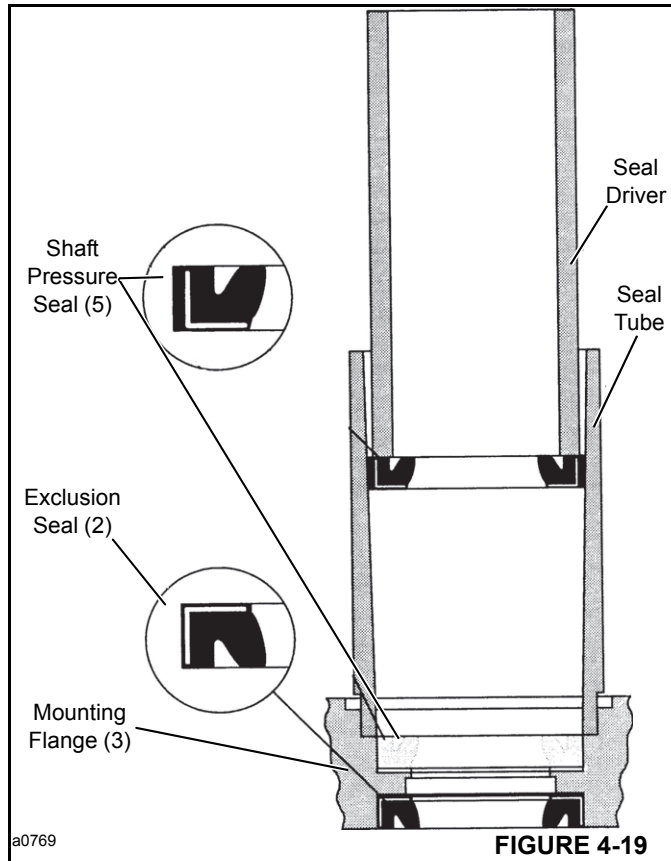
1. If plug (12, Figure 4-14) was removed, lubricate the new O-ring (11) and install on the plug. The plug has two O-ring grooves, but requires only one O-ring in the groove closest to the end of the plug. Push the plug into the housing (10) until it is flush with the housing. Be careful not to damage the O-ring.
2. Lubricate output shaft (9, Figure 4-14) with hydraulic oil (See Figure 4-18) and install the shaft into housing (10).

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



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 (See Figure 4-18). The bearing race must rotate freely when in position.

4. Visually check seal seats in the mounting flange (3) for scratches or other marks that might damage the seals (5). Check for cracks in flange (3) that could cause leakage.
5. Install exclusion seal (2, Figure 4-14) in flange (3) with the lips of the seal facing out. See Figure 4-19. Carefully press the exclusion seal in place.



6. Install shaft pressure seal (5) in flange (3) with lips of seal face up using a suitable driver. See Figure 4-19. Carefully press the pressure seal in place.

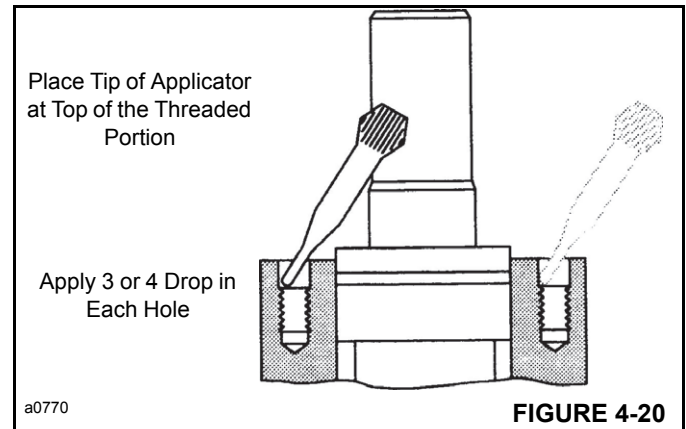
NOTE: After installing the seal in the flange, examine the seal condition. If damaged or improperly installed, replace the seal before continuing with assembly.

7. Install O-ring (6, Figure 4-14) 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.

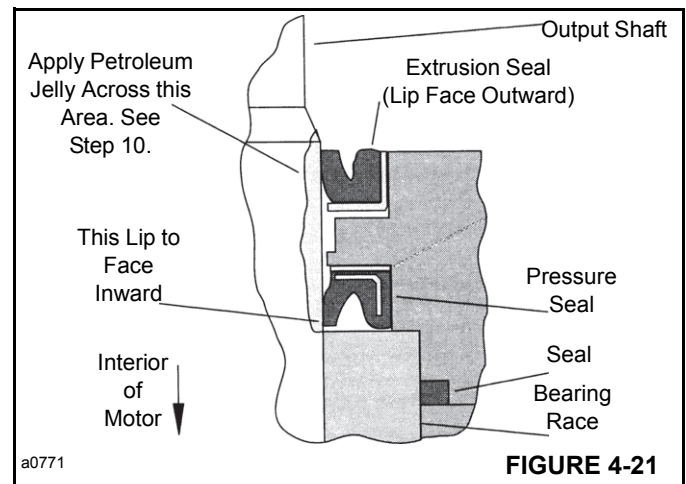
Use of primer is optional. With primer, Loctite curing time is approximately 15 minutes. Without the primer the curing time is approximately 6 hours.
9. Apply 3 or 4 drops of Loctite sealant at the top of the threads for each of the four holes in the housing (see Figure 4-20). Do not allow parts with 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.



10. Before installing the flange and seal assembly over shaft (9, Figure 4-14), 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 (see Figure 4-21).



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

11. 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.

Gerotor End

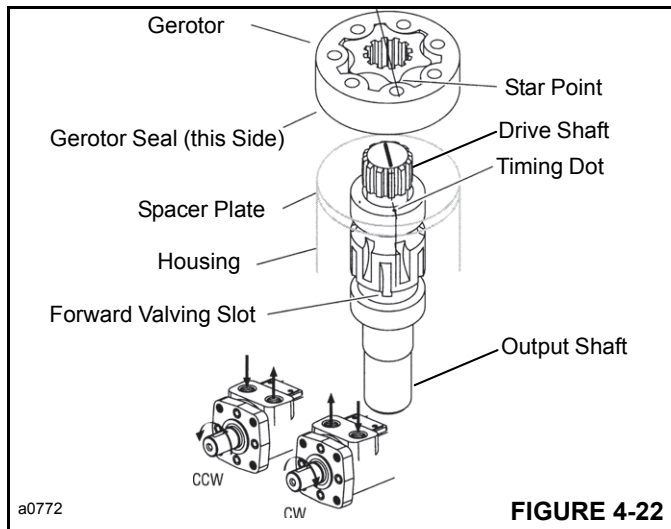
12. Reposition the motor in the vise with gerotor end up. Clamp across the ports. Do not clamp on side of housing.

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.

13. Pour approximately 30 ml (1 oz) of clean hydraulic oil in the output shaft cavity.
14. Install O-ring (13, Figure 4-14) in the housing groove. Avoid twisting the seal.

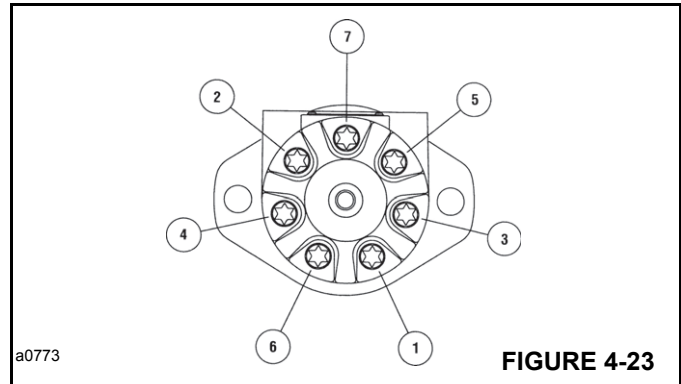
Timing Procedure

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

**FIGURE 4-22**

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

16. Install spacer plate (15).
17. 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).
18. Rotate gerotor (16, Figure 4-14) to line up with bolt holes. Be careful not to disengage star from drive or disturb the gerotor seal.
19. Install seal (13) in end cap (17). Carefully place the end cap on gerotor (16).
20. Install cap screws (19) and seal washers (18) in end cap (17). Tighten the cap screws to 7.4 Nm (40 lb-in). Make sure the seal washers are properly seated. Then, tighten the cap screws to a torque of 27-29 Nm (235-250 lb-in) in the sequence shown in 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 cap screws and lock washers.
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 from the motor. Discard all O-rings.

Disassembly

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

Installation

1. Install the line mount body, 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.

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.

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**

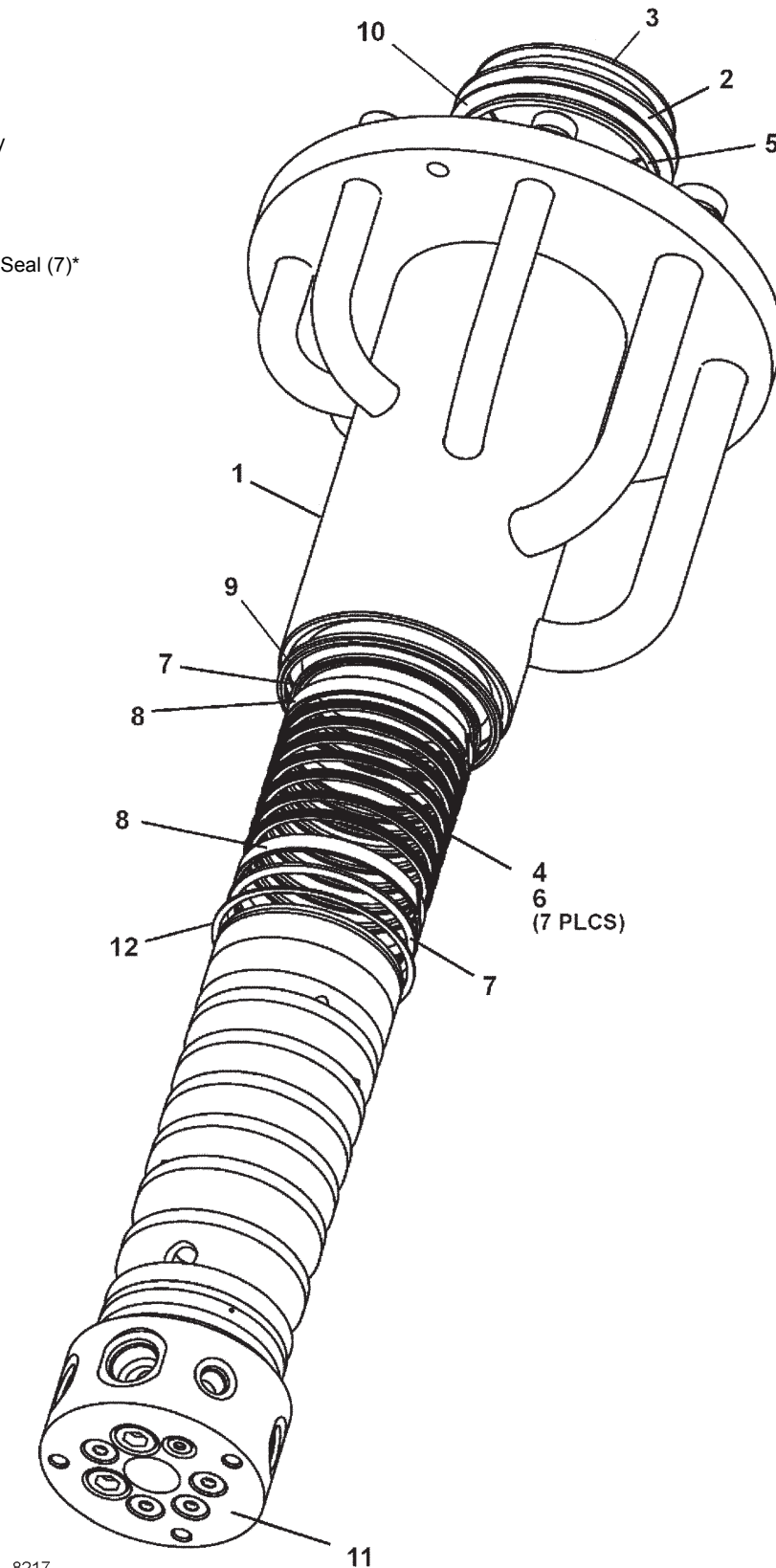
CAUTION

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

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 4-24

Disassembly

1. Remove retaining ring (3) (Figure 4-24) 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 4-24) 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 4-9 in both directions as directed in steps 2 through 5.

Table 4-9: 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 4-9 to the rod port. Hold this

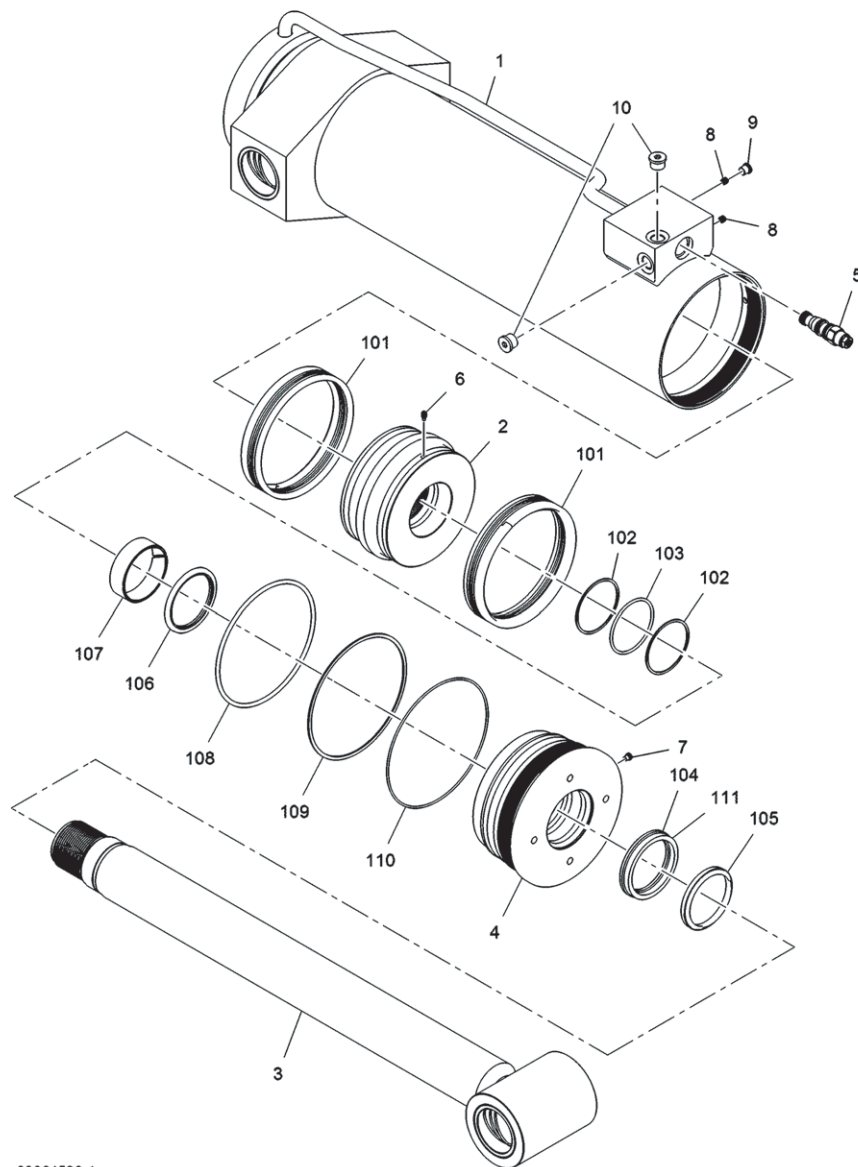
pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No internal or external leakage is permitted.

5. Fully extend the cylinder rod. Keep the rod port open. Apply test pressure in Table 4-9 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.

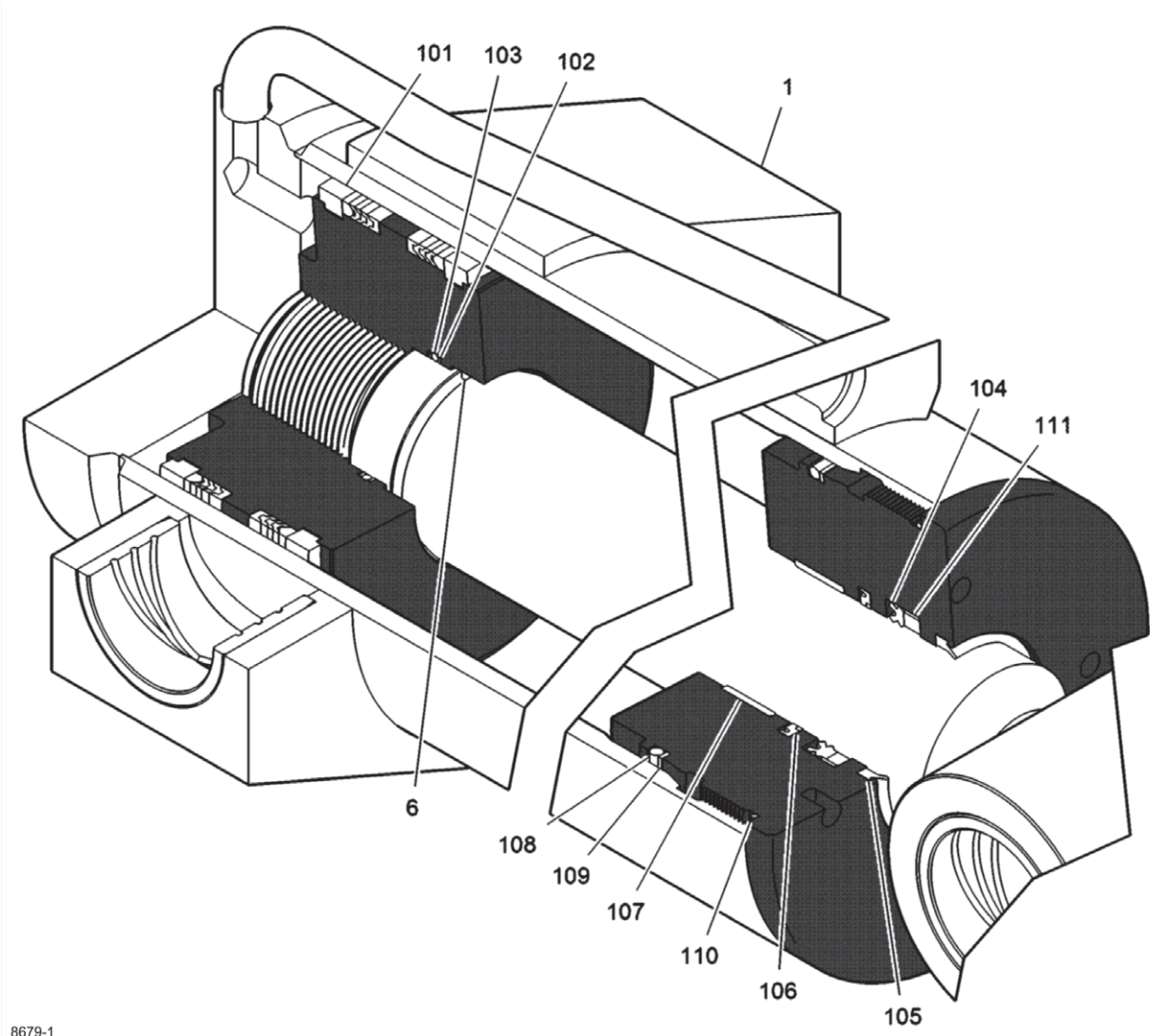
1. Cylinder Barrel
2. Cylinder Piston
3. Cylinder Rod
4. Cylinder Head
5. Counterbalance Valve
6. Sockethead Set Screw
7. Sockethead Set Screw
8. Orifice Fitting
9. Plug, #4 SAE
10. Plug, #8 SAE
101. Seal Assy.
102. Backup Ring
103. O-Ring
104. Seal
105. Wiper Seal
106. Buffer Seal
107. Wear Ring
108. O-Ring
109. Backup Ring
110. O-Ring
111. Backup Bearing



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Lift Cylinder Sheet 1

FIGURE 4-25



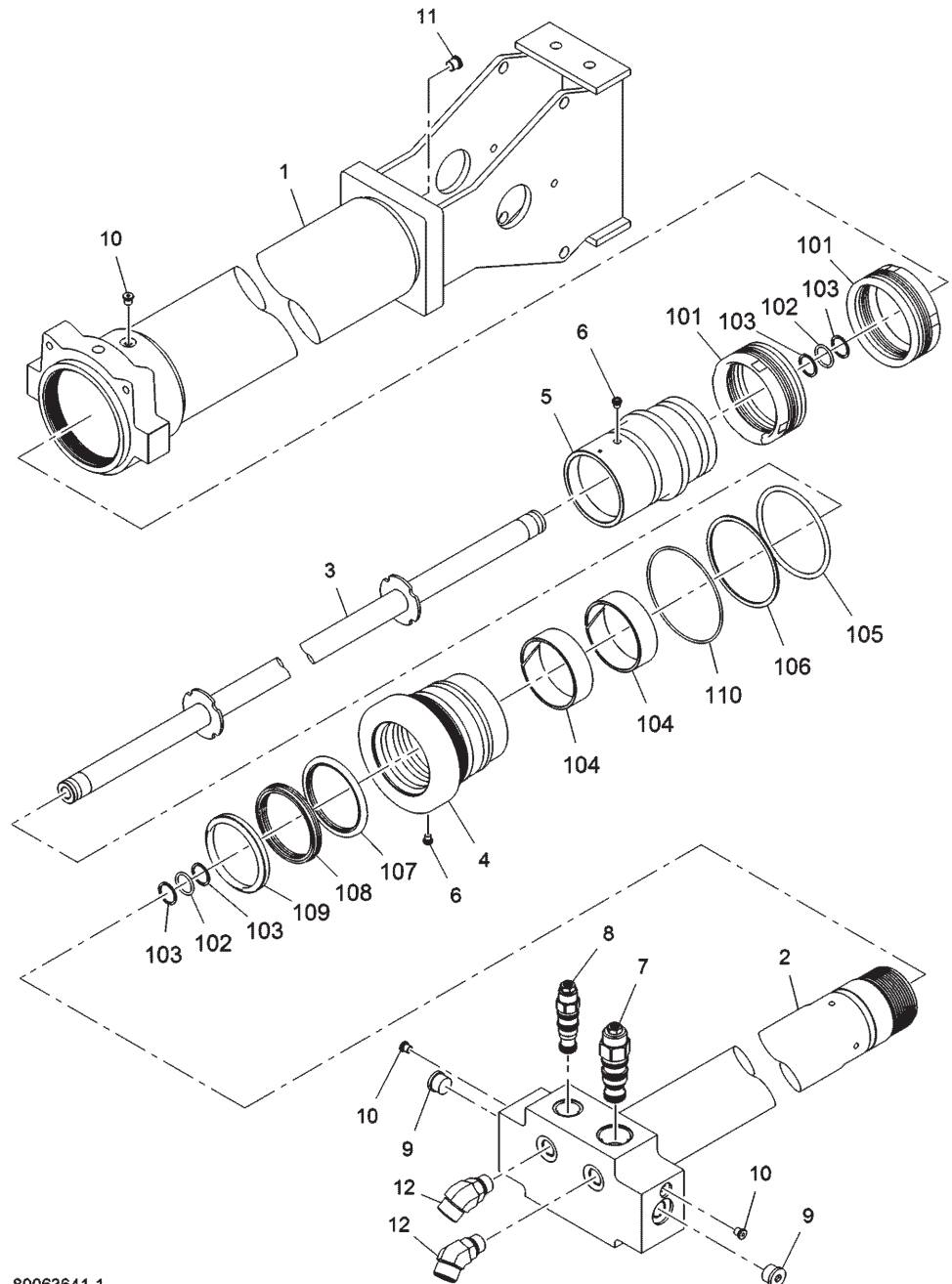
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Lift Cylinder Sheet 2

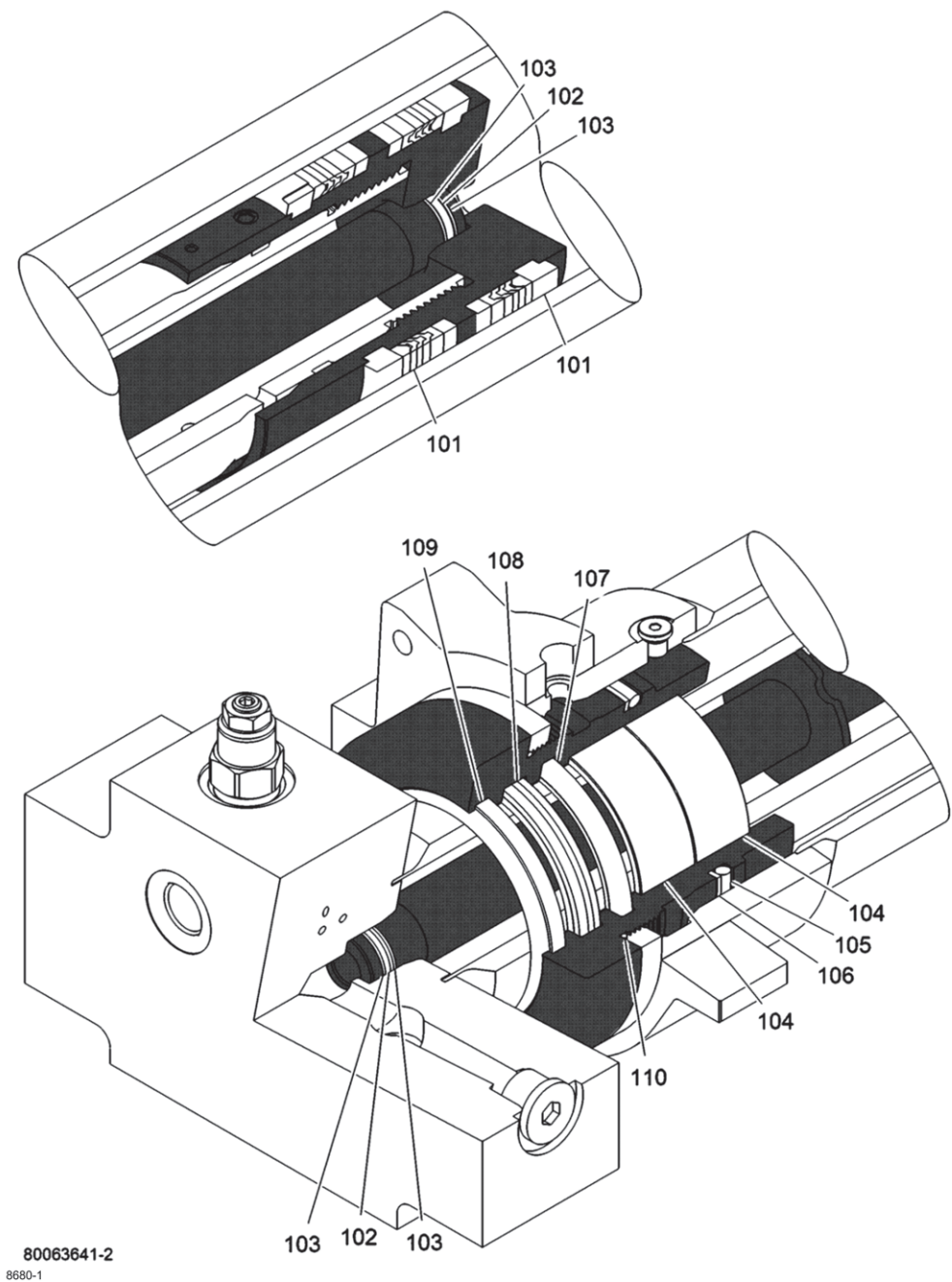
FIGURE 4-25 continued

1. Barrel
2. Rod
3. Tube
4. Head
5. Piston
6. Sockethead Set Screw
7. Counterbalance Valve
8. Counterbalance Valve
9. Plug, #8 SAE
10. Plug, #2 SAE
11. Plug, #4 SAE
12. Elbow
101. Seal
102. O-Ring
103. Backup Ring
104. Wear Ring
105. O-Ring
106. Backup Ring
107. Buffer Seal
108. Deep Z Seal
109. Wiper Seal
110. O-Ring



Telescope Cylinder Sheet 1

FIGURE 4-26

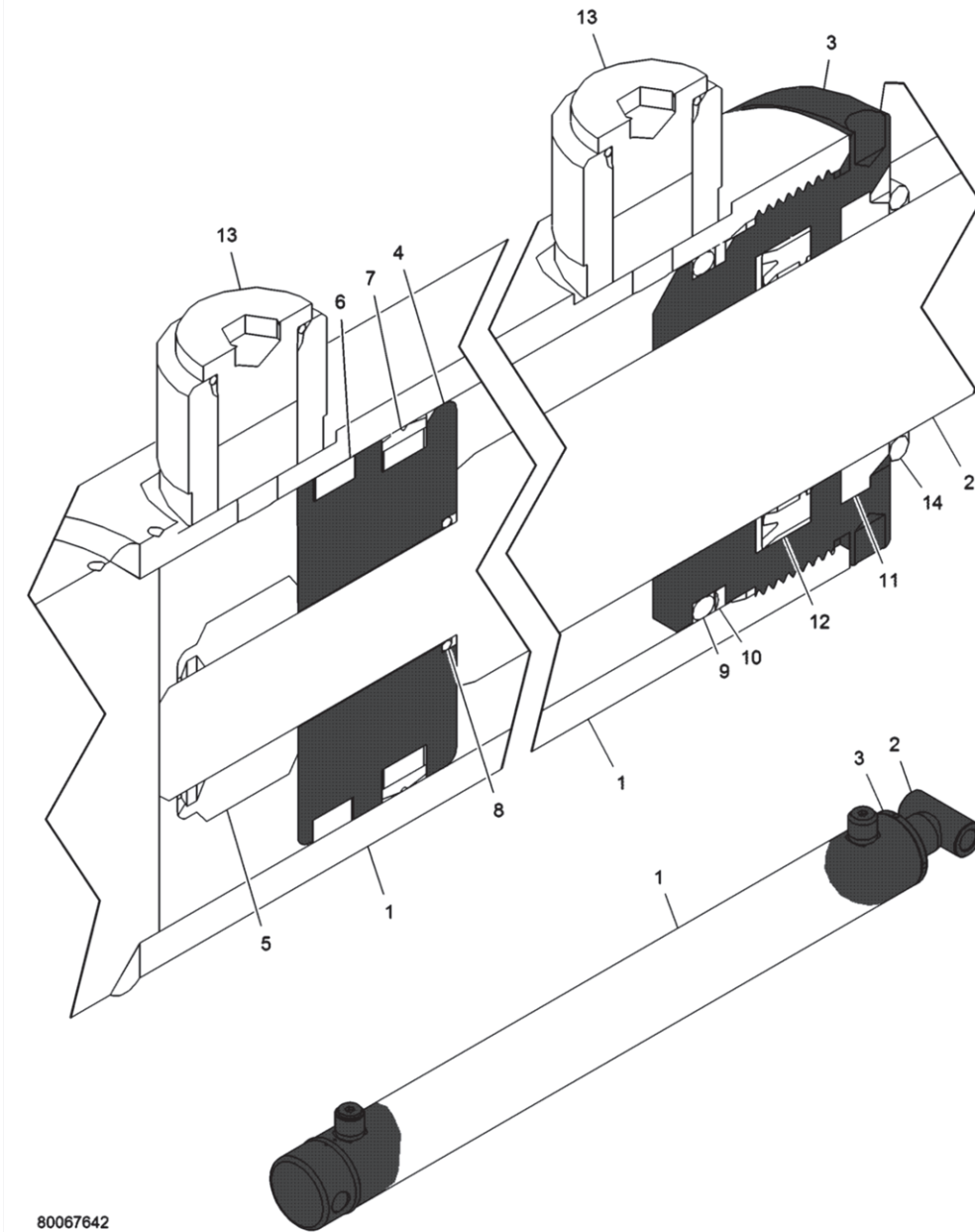


Telescope Cylinder Sheet 2

FIGURE 4-27

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1. Body Assembly
2. Rod Assembly
3. Rod Gland
4. Piston
5. Hex Nut
6. Wear Ring
7. Piston Seal
8. O-Ring
9. O-Ring
10. Backup Ring
11. Wiper
12. Rod Seal
13. Plug
14. O-Ring



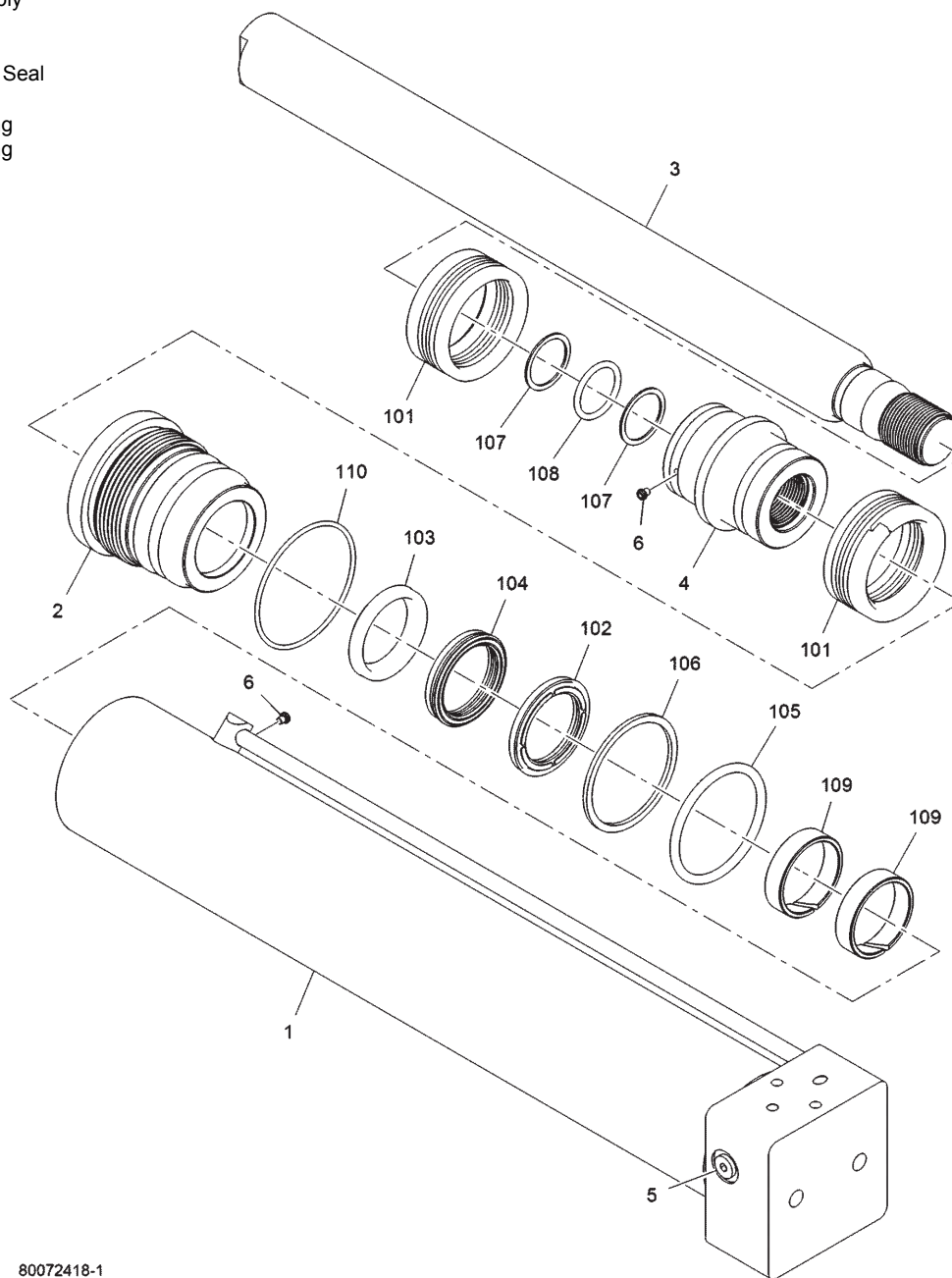
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Horizontal Outrigger Cylinder

FIGURE 4-28

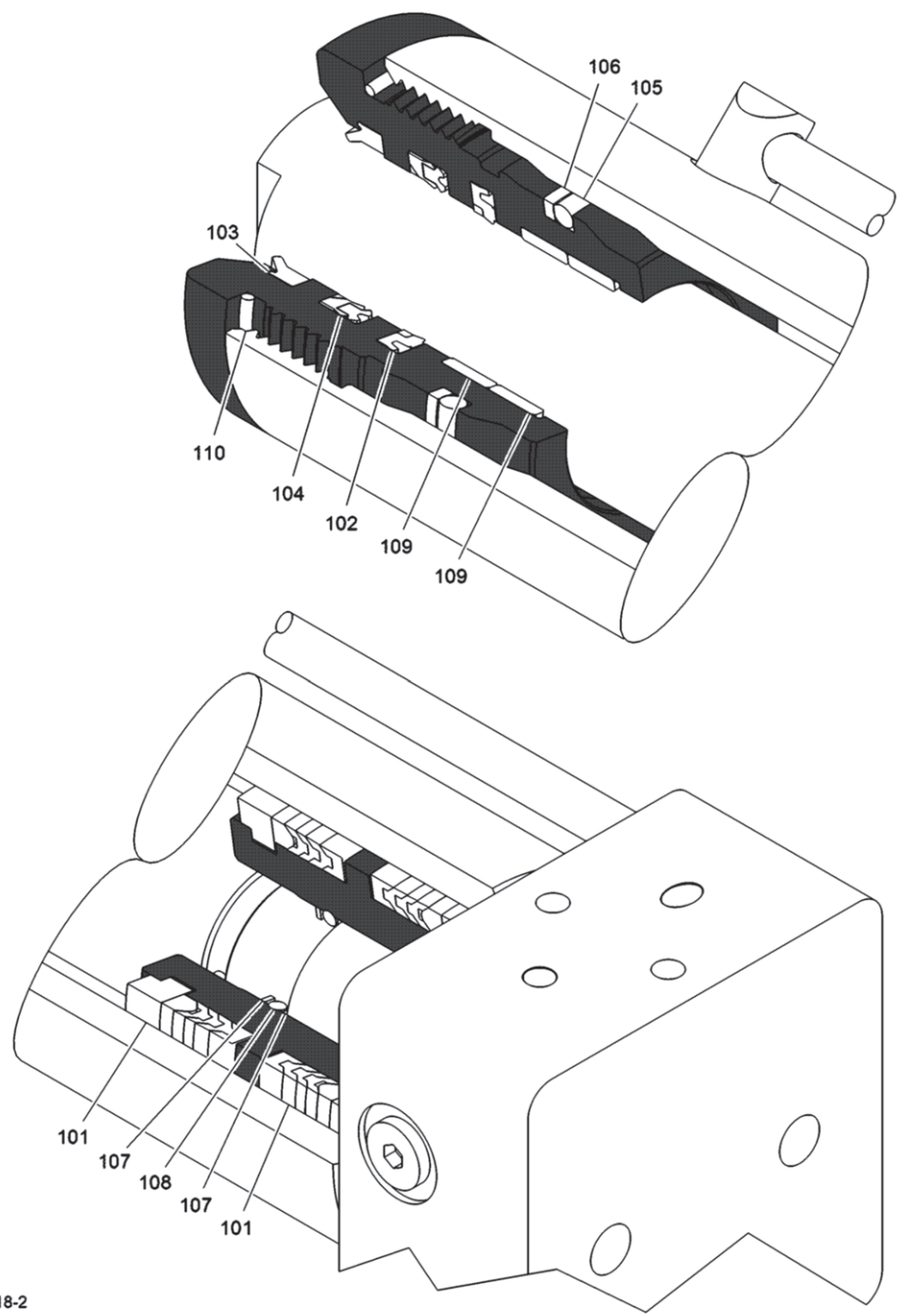
1. Cylinder Barrel
2. Head
3. Cylinder Rod
4. Piston
5. Plug
6. Sockethead Set Screw
101. Seal Assembly
102. Buffer Seal
103. Wiper Seal
104. Deep Z Rod Seal
105. O-Ring
106. Back-Up Ring
107. Back-Up Ring
108. O-Ring
109. Wear Ring
110. O-Ring



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Vertical Outrigger Cylinder Sheet 1

FIGURE 4-29



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8682-1

8682-1

Vertical Outrigger Cylinder Sheet 2

FIGURE 4-30

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.

SECTION 5
PREVENTATIVE MAINTENANCE

SECTION CONTENTS

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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.
 - COVERS** - Keep all protective covers in place.
 - PARKING BRAKE** - Check operation. Have crane repaired if required.
 - ENGINE** - Check operation. Remove all dirt or debris, and all flammable materials before running engine.

LUBRICANTS

It is not the policy of The Manitowoc Company, Inc. to publish lists of approved lubricants or guarantee lubricant performance. The responsibility for the quality of the lubricants 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.

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.

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.

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.

Lubrication Symbol Chart

LUBE SYMBOL	DESCRIPTION
EP-MPG	Multipurpose Grease
AFC	Anti-Freeze/Coolant
HYDO	Hydraulic Oil
EO-10W-30	Engine Oil for Dual Fuel
EO-5W-30	Engine Oil for Dual Fuel (Below -18 °C (0 °F))
EO-15W-40	Engine Oil for Tier 4 Diesel
ASC	Anti-Seize Compound
EP-OGL	Open Gear Lube Spray
AGMA EP-4	Gear Lubricant
LCC/SCA	Liquid Coolant Conditioner/ Supplemental Coolant Additive

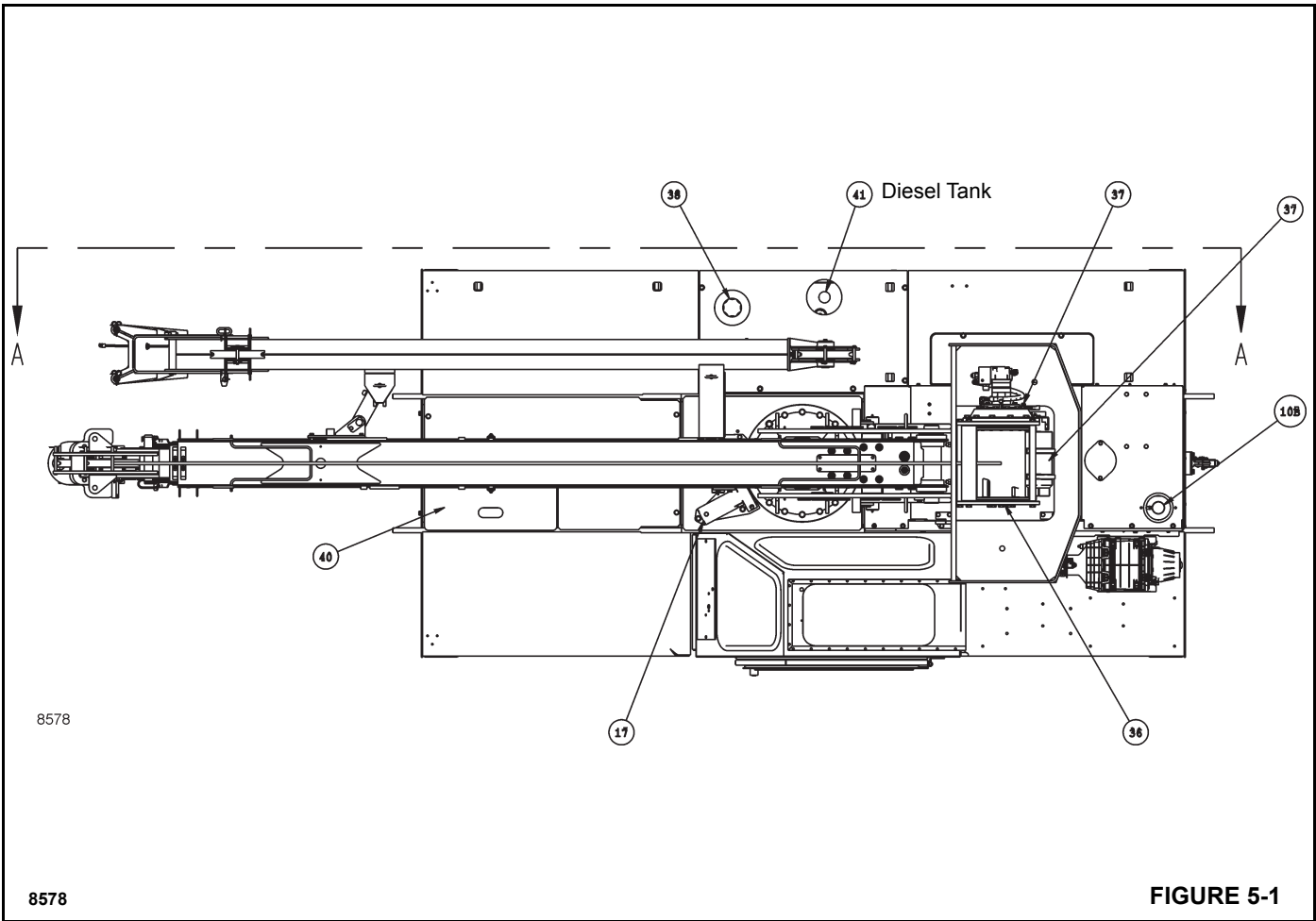
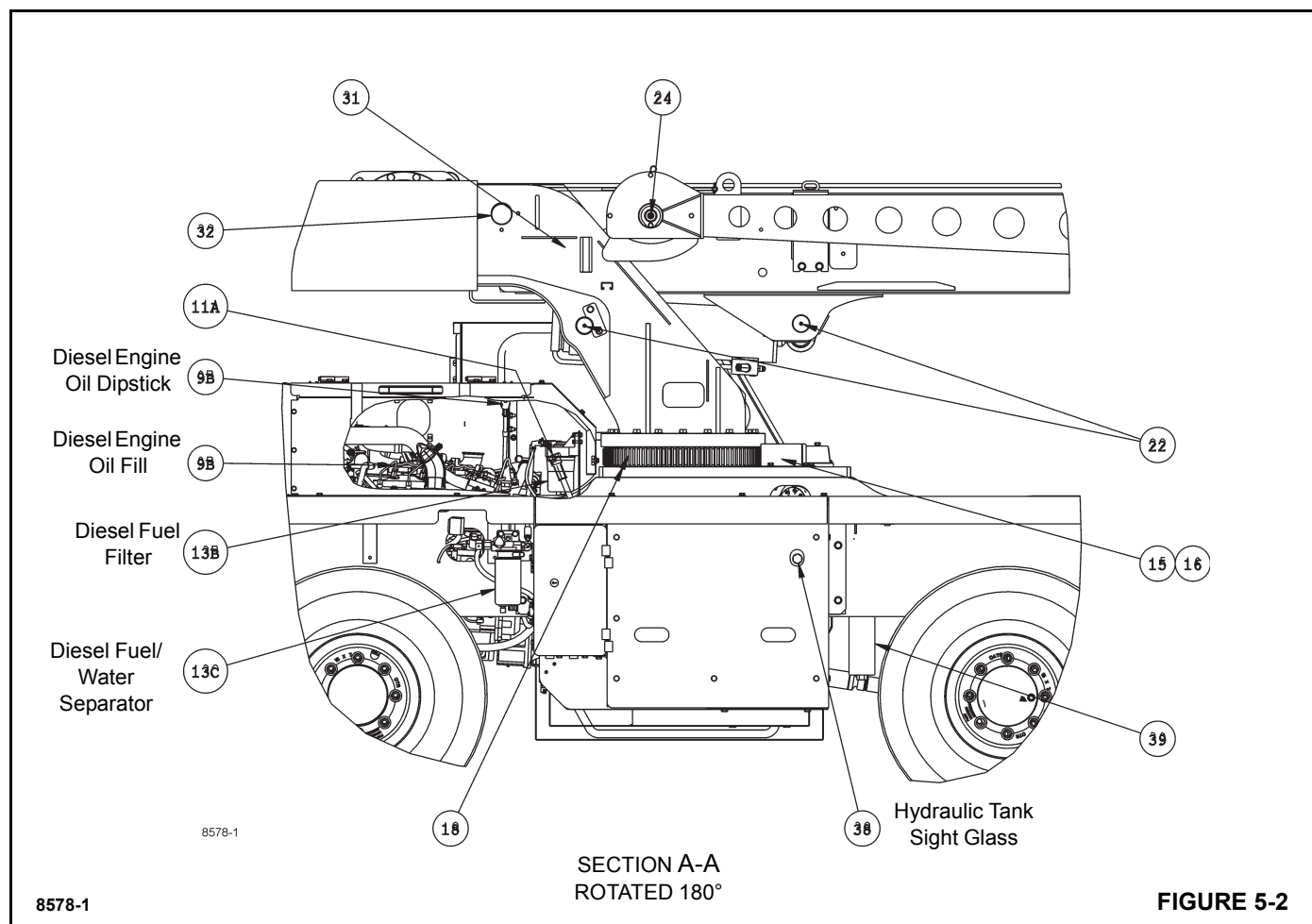
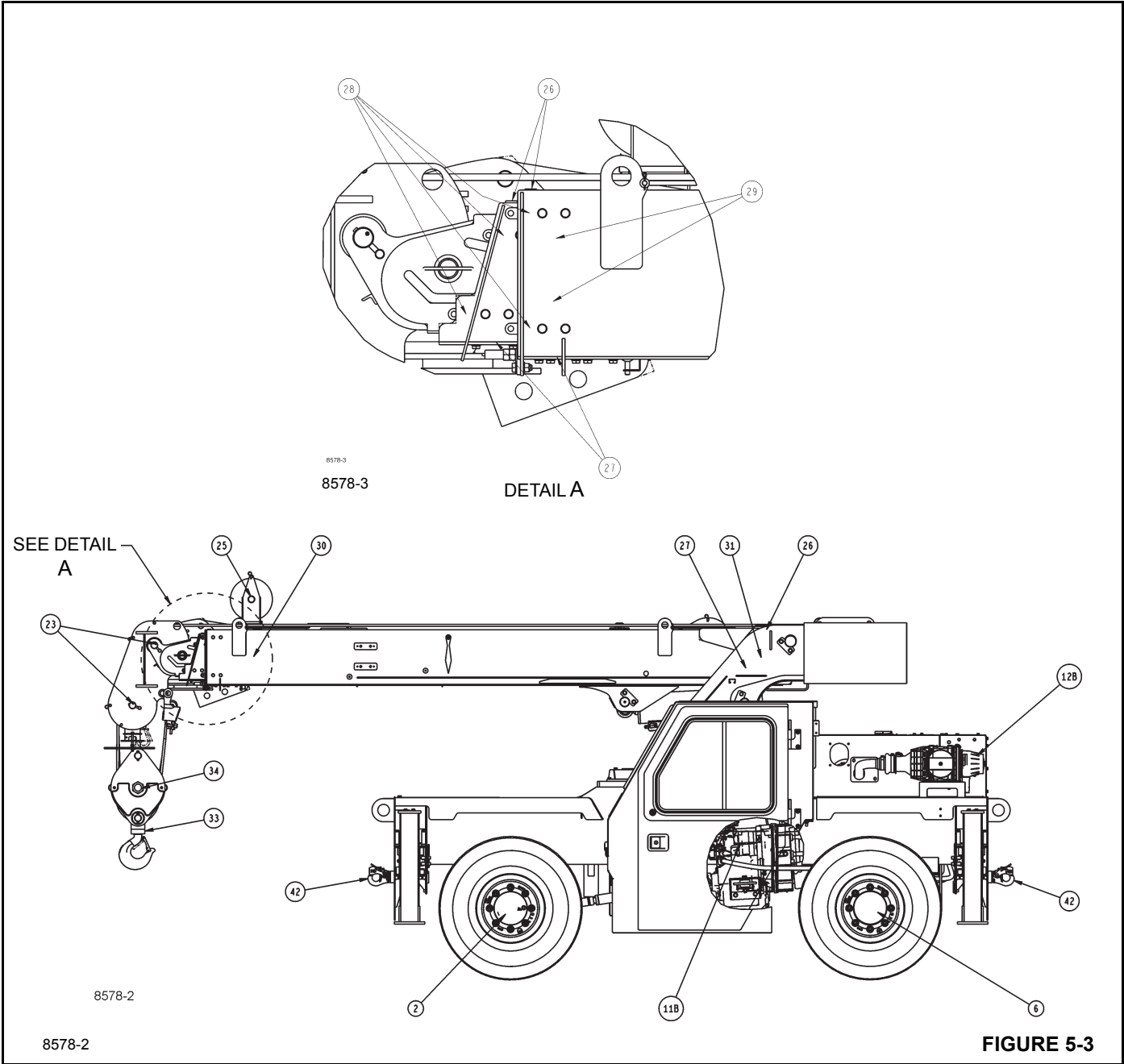
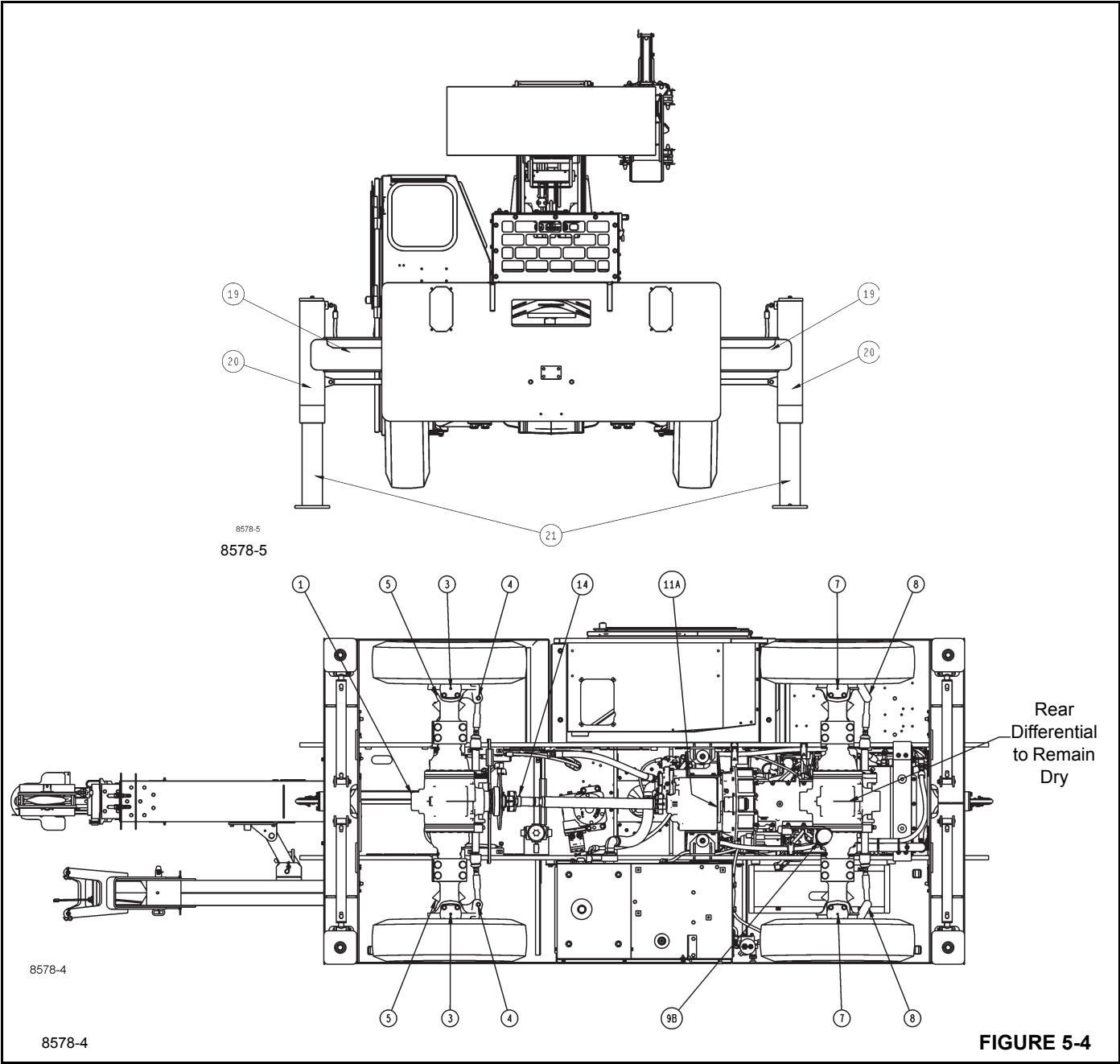
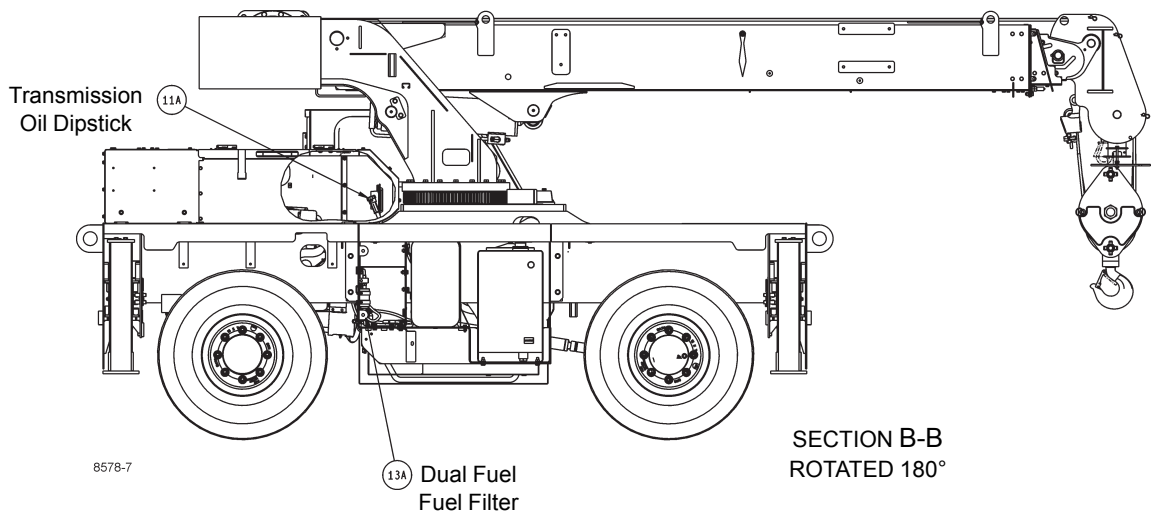
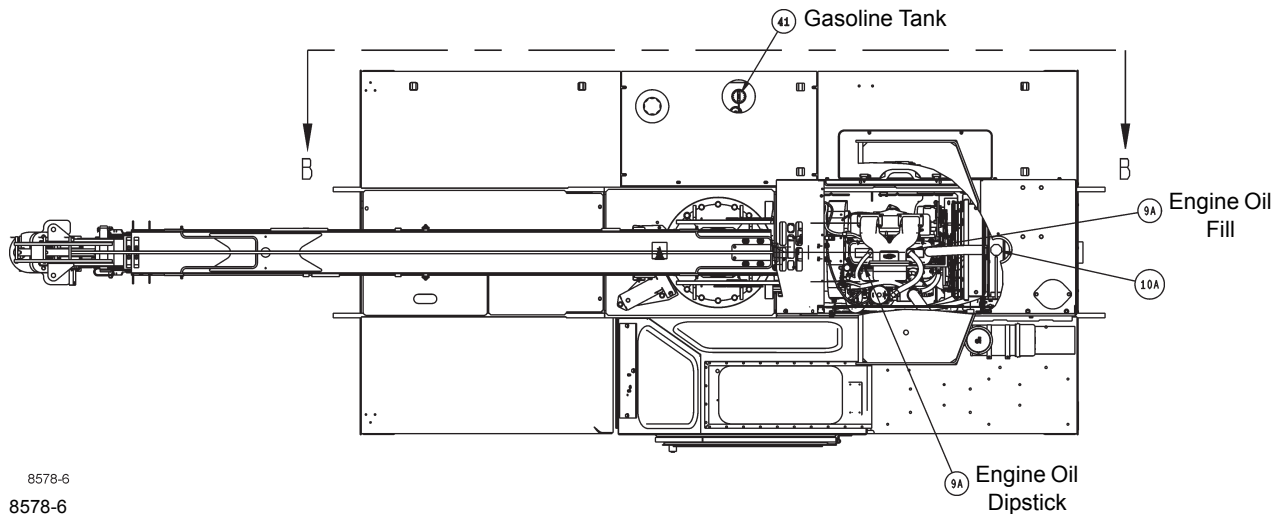


FIGURE 5-1



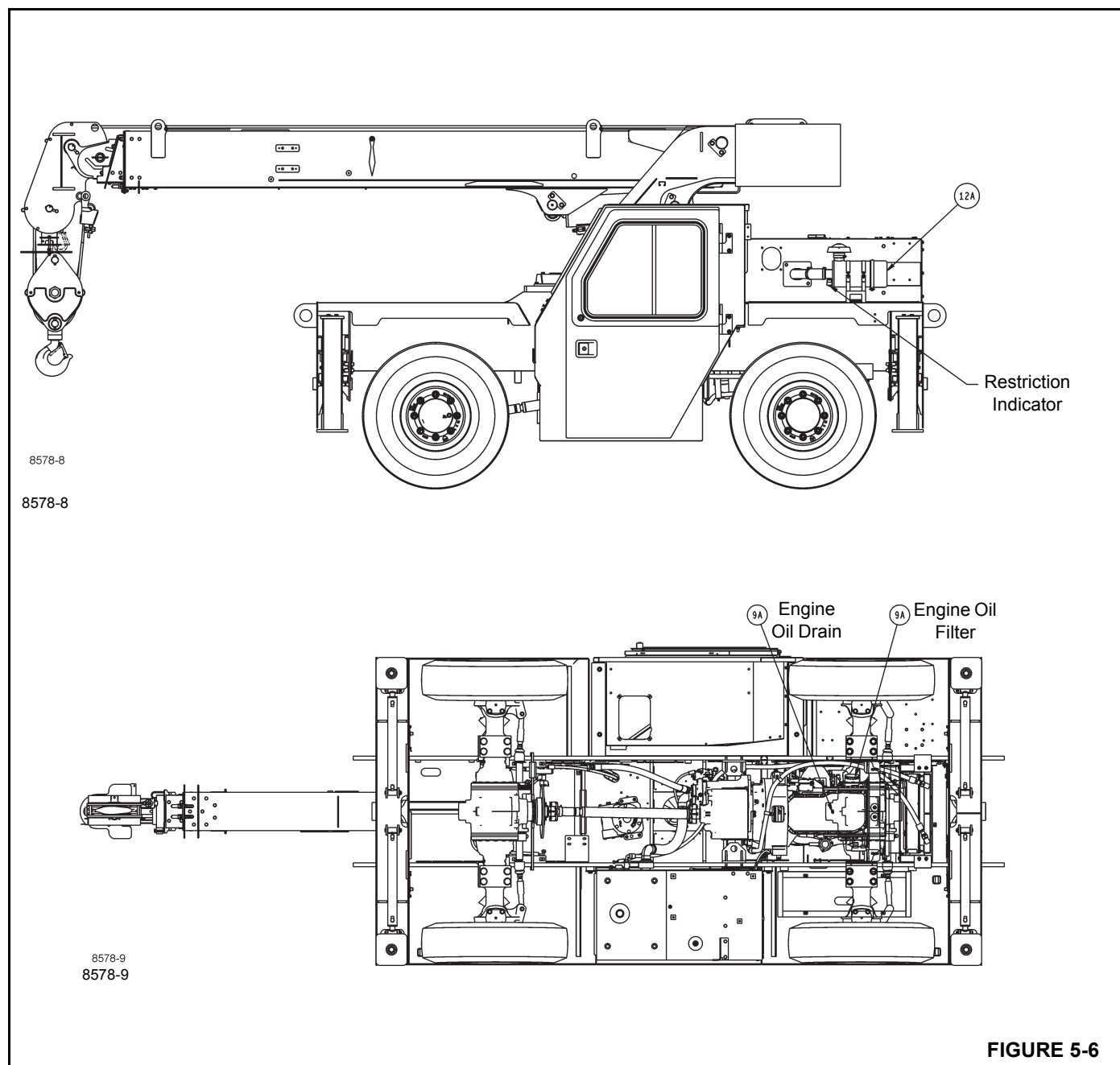






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FIGURE 5-5



Item Number	Location Name	Approximate Capacity	Lube Symbol	Instructions (See Notes)	Service Points	Service	Service Hours
FRONT DRIVE/STEER AXLE							
1	Differential	9.0 L [2.4 Gal]	HYDO	1, 2, 3	2	Drain & Fill	4000/2 Years
			HYDO	1, 2, 3	2	Check & Fill	500/3 Months
2	Planetary Hub Gears	0.8 L [0.8 Qts]	HYDO	1, 2, 3	2	Drain & Fill	4000/2 Years
			HYDO	1, 2, 3	2	Check & Fill	500/3 Months
3	Kingpin Bearings		EP-MPG	1, 4	4	Lube	500/3 Months
4	Steer Cylinder Bearings		EP-MPG	1, 4	4	Lube	500/3 Months
5	Universal Joints		EP-MPG	1, 4	2	Lube	500/3 Months
REAR STEER AXLE							
6	Hubs	0.8 L [0.8 Qts]	HYDO	1, 2, 3	2	Drain & Fill	4000/2 Years
			HYDO	1, 2, 3	2	Check & Fill	500/3 Months
7	Kingpin Bearings		EP-MPG	1, 4	4	Lube	500/3 Months
8	Steer Cylinder Bearings		EP-MPG	1, 4	4	Lube	500/3 Months
DRIVETRAIN							
9A	Dual Fuel Engine Crankcase	4.7 L [5.0 Qts]	See Below	1, 2	1	Drain & Fill	175/1 Month
	3.0L Dual Fuel		EO-10W-30	1, 2	1	Check & Fill	10/Daily
	3.0L Dual Fuel - Below 18°C		EO-5W-30	1, 2	1	Check & Fill	10/Daily
	Filter (Engine)		N/A	1	1	Change Filter	175/1 Month
9B	Diesel Engine	8.2 L [8.7 Qts]	EO-15W-40	1, 2	1	Drain & Fill	500/6 Months
	2.8L Diesel		EO-15W-40	1, 2	1	Check & Fill	10/Daily
	Filter (Engine)		N/A	1, 2	1	Change Filter	500/6 Months
	Engine Cooling System	See Values Below	AFC	5	1	Drain & Fill	See Service Manual
10A	Dual Fuel	4.7 L [5.0 Qts]	AFC	1,2,5, 6,7	1	Check & Fill	10/Daily
10B	Diesel	8.2 L [8.7 Qts]	AFC	1,2,5, 6,7	1	Check & Fill	10/Daily
	Engine Coolant System LCC/SCA	As Required	LCC/SCA		1	Test & Add	See Service Manual

Item Number	Location Name	Approximate Capacity	Lube Symbol	Instructions (See Notes)	Service Points	Service	Service Hours
11A	Transmission & Torque Converter	16.7 L [4.4 Gal]	HYDO	1,2,8, 9	1	Drain & Fill	1000/6 Months
			HYDO	1,2,8	1	Check & Fill	10/Daily
11B	Filter (Transmission)		N/A	1,2,9	1	Change Filter	175/1 Month
12A	Air Cleaner Filter, Dual Fuel		N/A	10	1	Change Filter	See Note 11
12B	Air Cleaner Filter, Diesel		N/A	20	1	Change Filter	See Note 21
13A	Fuel Filter, Dual Fuel		N/A		1	Change Filter	500/3 Months
13B	Fuel Filter, Diesel		N/A		1	Change Filter	500/6 Months
13C	Fuel/Water Separator		N/A			Drain	10/Daily
	Filter (Fuel/Water Separator)		N/A		1	Change Filter	500/6 Months
14	Driveline Slip Joint		EP-MPG	1, 4	1	Lube	500/3 Months

TURNTABLE

15	Turntable Gear Box		EP-MPG	1, 4	1	Lube	500/6 Months
16	Turntable Gear & Drive Pinion		EP-OGL	1, 11	1	Spray On	500/6 Months
17	Turntable Swing Lock		EP-OGL	1, 11	1	Spray On	500/6 Months
18	Turntable Bearing		EP-MPG	1, 4, 11	2	Lube	500/6 Months

OUTRIGGERS

19	Outrigger Slide Box		EP-MPG	1, 12	8	Brush On	50/Weekly
20	Outrigger Jack Tube		EP-MPG	1, 13	4	Brush On	50/Weekly
21	Outrigger Cylinder		EP-MPG	1	4	Brush On	50/Weekly

LIFT CYLINDER

22	Lift Cylinder Pivot Pins		EP-MPG	1, 4, 11	2	Lube	500/3 Months
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BOOM

23	Boom Nose Sheaves		EP-MPG	1, 4, 11, 14	2	Lube	250/3 Months
24	Jib Boom Sheaves		EP-MPG	1, 4, 11	1	Lube	250/3 Months
25	Not Used						
26	Boom Section Upper Wear Pads		EP-MPG	1, 15, 16, 17	6	Brush On	50/Weekly
27	Boom Section Lower Wear Pads		EP-MPG	1, 15, 16, 17	6	Brush On	50/Weekly

Item Number	Location Name	Approximate Capacity	Lube Symbol	Instructions (See Notes)	Service Points	Service	Service Hours
28	Boom Section Side Wear Pads		EP-MPG	1, 15, 16, 17	8	Brush On	50/Weekly
29	Tele Cylinder Wear Pads		EP-MPG	1, 16, 17	8	Brush On	125/3 Months
30	Boom Extend Sheave		EP-MPG	1	1	Lube	250/3 Months
31	Boom Retract Sheave		EP-MPG	1	1	Lube	250/3 Months
32	Boom Pivot Shaft		EP-MPG	1	2	Lube	250/3 Months
33	Hook Block Swivel Bearing		EP-MPG	1	1	Lube	250/3 Months
34	Hook Block Sheaves		EP-MPG	1	1	Lube	250/3 Months
HOIST							
35	Hoist Winch			1, 18		Check & Fill	50/Weekly
		1.5 L [1.6 Qts]	AGMA EP-4	1,2,9,18	1	Drain & Fill	2500/12 Months
36	Hoist Drum Bearing		EP-MPG	1, 17	1	Lube	50/Weekly
37	Cable Follower		EP-MPG	1, 17	2	Spray On	250/3 Months
HYDRAULIC							
38	Hydraulic Tank	84.8 L [22.4 Gal]	HYDO	1, 2, 18	1	Check & Fill	10/Daily
39	Hydraulic Filter		N/A	19	1	Change Filter	See Note 20
MISCELLANEOUS							
40	Underdeck Winch		N/A		N/A	N/A	Not Required
41	Fuel Tank						
	Gasoline Tank	67 L [17.7 Gal]	N/A			N/A	N/A
	Diesel Tank	67 L [17.7 Gal]	N/A			N/A	N/A
42	Pintle Hooks		EP-MPG	1, 17	2	Lube	1000/6 Months

NOTES:

- Service by whichever interval occurs first.
- Final fluid levels shall be adjusted by indicating arrows, dipstick markings or to filler plugs.
- Caution: use of semi-synthetic lubricant is required to avoid damage to components during published service intervals.
- Use grease fittings provided.
- Capacities indicated are for a fully formulated mixture of 50% AFC and 50% water.
- Engine coolant capacity listed is the combined capacity for the entire cooling system.
- Verify heater core valves and petcock in top radiator tube, if equipped, are open then fill surge tank to bottom of filler neck. Run engine through two (2) thermal cycles. check level and refill as required.
- Check with engine running at idle, transmission in neutral and oil at 82-93 °C [180-200 °F].
- Change filter at first 50 to 100 hours, thereafter, at normal intervals. drain with oil temperature at 65-93 °C [150-200 °F].
- Replace air cleaner element when indicator shows red (20" H₂O).
- All points requiring periodic lubrication shall be lubricated as required at assembly.

- 12.** Brush lubricant on bottom of outrigger beams and on the inside, bottom of outrigger beams where the extension cylinder guide support travels.
- 13.** Brush lubricant on I.D. of jack cylinder support tubes.
- 14.** One fitting per sheave.
- 15.** Spread grease on bottom plates, top plates and side plates of boom in area that the wear pads move on.
- 16.** Extend boom for access through holes.
- 17.** Lubricate more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.
- 18.** The hydraulic oil shall meet or exceed Manitowoc cleanliness specification 6829014631.
- 19.** Replace hydraulic filter element when restriction indicator gauge on the filter head is red.
- 20.** Replace air filter when amber engine warning flashes for first 30 seconds after key is turned to on position. ECM will also give fault code 5576. If filter is not replaced ECM will give a solid amber engine warning lamp, when restriction is greater than 25" H₂O, after key is turned to on position. ECM will give fault code 3341 for this case, filter must be changed if this fault code is given. Engine performance will be reduced if filter is not replaced at proper service intervals.

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						
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 cable 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 chains				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 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 hydraulic oil						X	
Replace the hydraulic oil filter						X	
Check coolant for contamination						X	
Replace the hoist gearbox lubricant							X
Replace the engine coolant							X
Inspect the crane structure and booms for damage							X
Test the Rated Capacity Limiter (RCL)							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.

SCHEDULED MAINTENANCE

Daily (Walk-around) Inspection

NOTE: You must read and understand the warnings and basic safety rules, found in *Safety Practices*, page 2-1 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 5-19, 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 beyond the bottom of the fill neck. Allow room for fuel expansion.

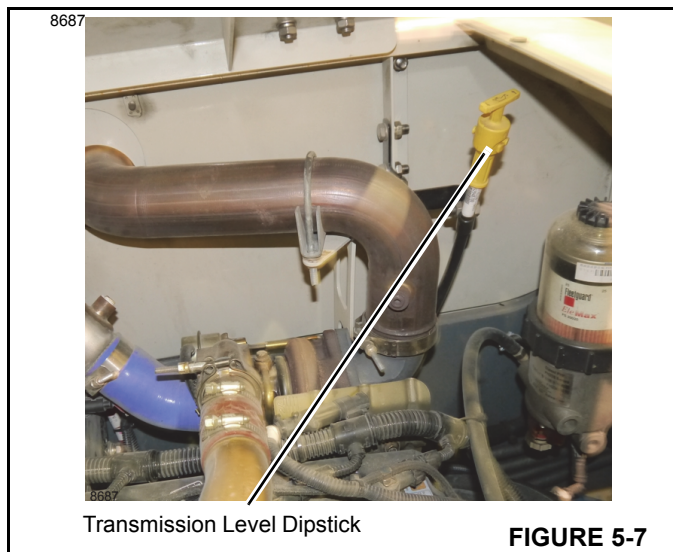
Tighten the fuel cap securely. If the cap is lost, replace only with original equipment.

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 82° to 93°C (180° to 200°F). Level the crane, engage the parking brake and let the engine idle.
2. Lift the engine compartment cover and support in place using the furnished prop rod. Remove the dipstick (Figure 5-7) 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.



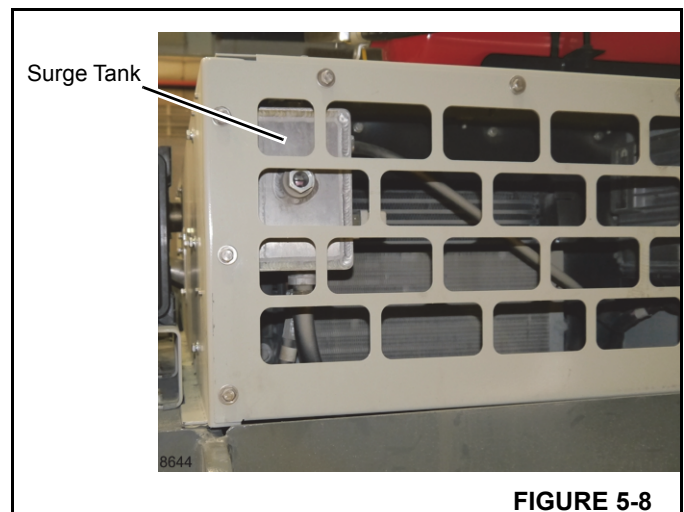
Check Engine Coolant Level



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 surge tank (Figure 5-8) is at least half full—coolant visible in the sight glass. If coolant is low, fill the surge tank 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.

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



Drain Water from Engine Fuel Filter

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 5-9). The hydraulic oil should be 3 mm (0.125 in) from the top of the sight gauge. If low, fill tank with clean recommended hydraulic oil.

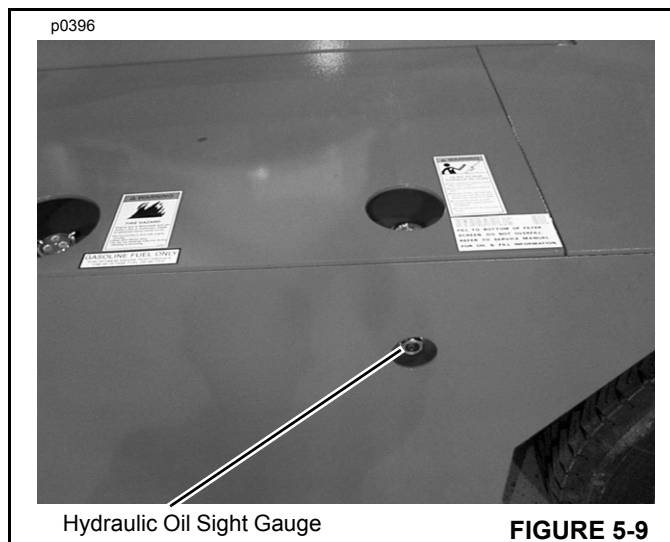


FIGURE 5-9

Check the Air Cleaner Restriction Indicator

On tier 3 and dual fuel machines the air cleaner is equipped with a filter restriction indicator (Figure 5-10). 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.

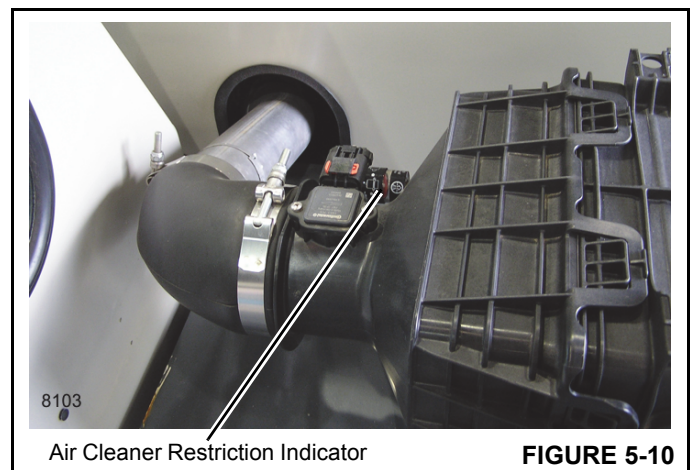


FIGURE 5-10

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 filter element has a chance to do its job.
3. Remove the wing nut securing the safety element to the air housing. 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 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.

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 or 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.

Install the Element

1. Install the safety element over the stud in the housing and slide it all the way in.
2. Install and tighten the wing nut. Hand tighten it only. 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. Install and tighten the wing nut. Hand tighten only.
4. Install the air cleaner housing cover and fasten the latches.
5. Reset the air cleaner restriction indicator by pushing in the reset button (Figure 5-21).
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 8.62 bar (125 psi). This pressure will differ from the recommended tire pressure from the tire manufacture.

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

50 Hours of Operation (Weekly)

NOTE: You must read and understand the warnings and basic safety rules, found in *Safety Practices*, page 2-1 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 (Figure 5-11) to remove any accumulation of dust or debris.

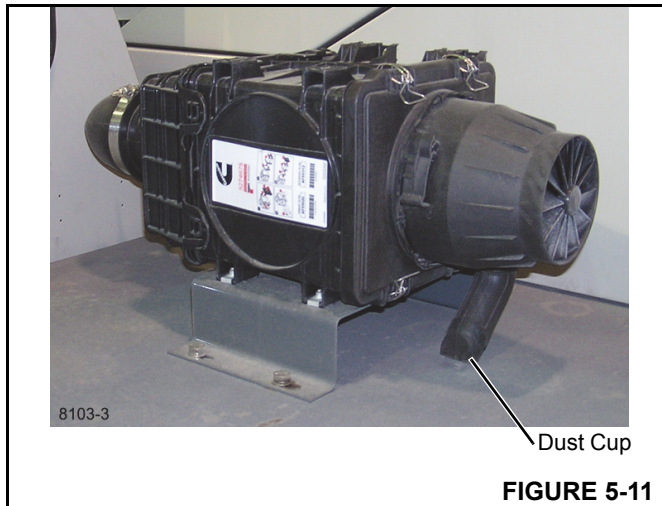


FIGURE 5-11

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.

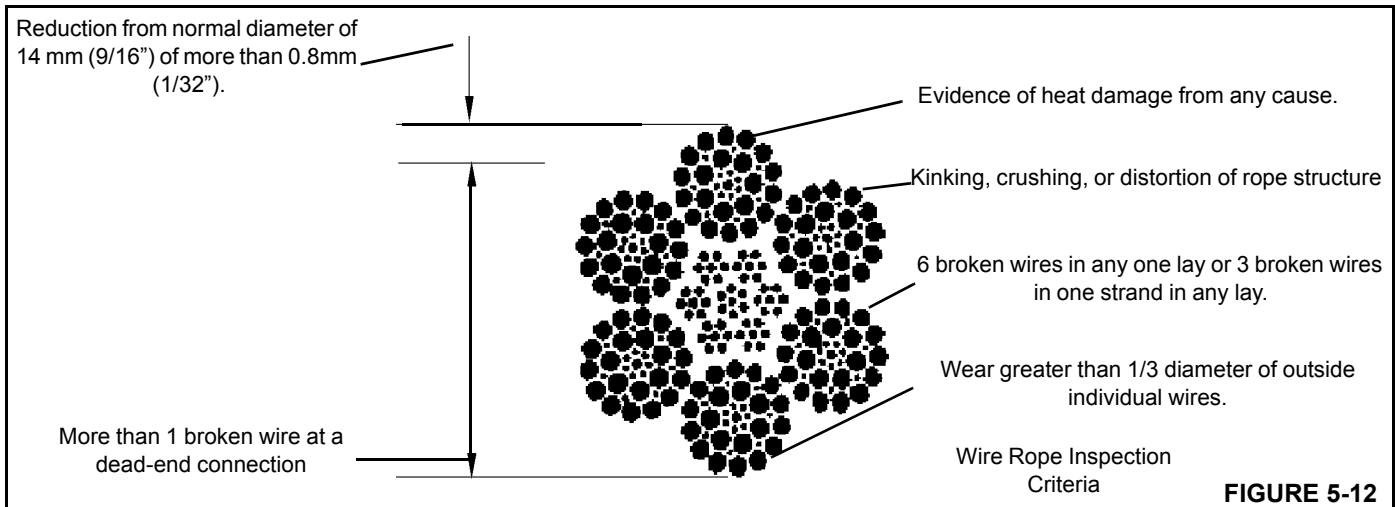
If you are not familiar with wire rope inspection, information on how to inspect wire rope, sheaves and drums is available from your distributor. Order Wireco Report No. 107.

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 5-12 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.

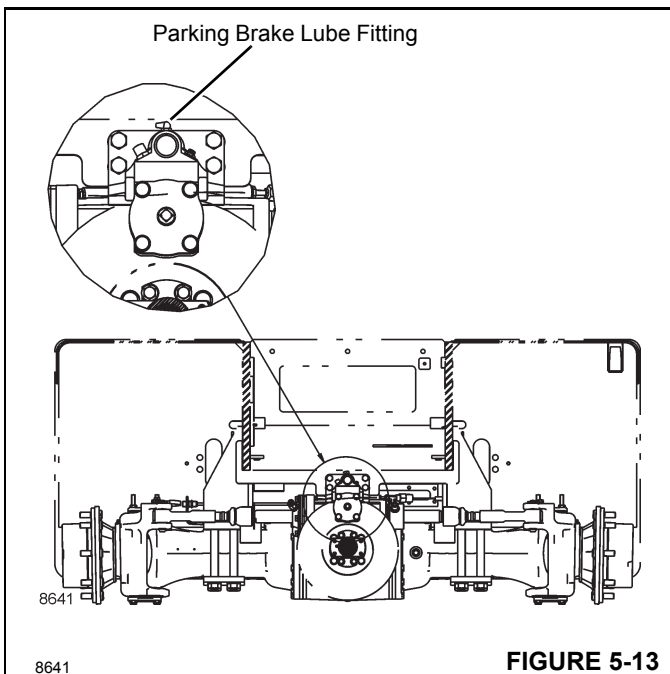


Grease Fittings

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

Lubricate Parking Brake

Apply grease to the fitting on the parking brake (Figure 5-13).

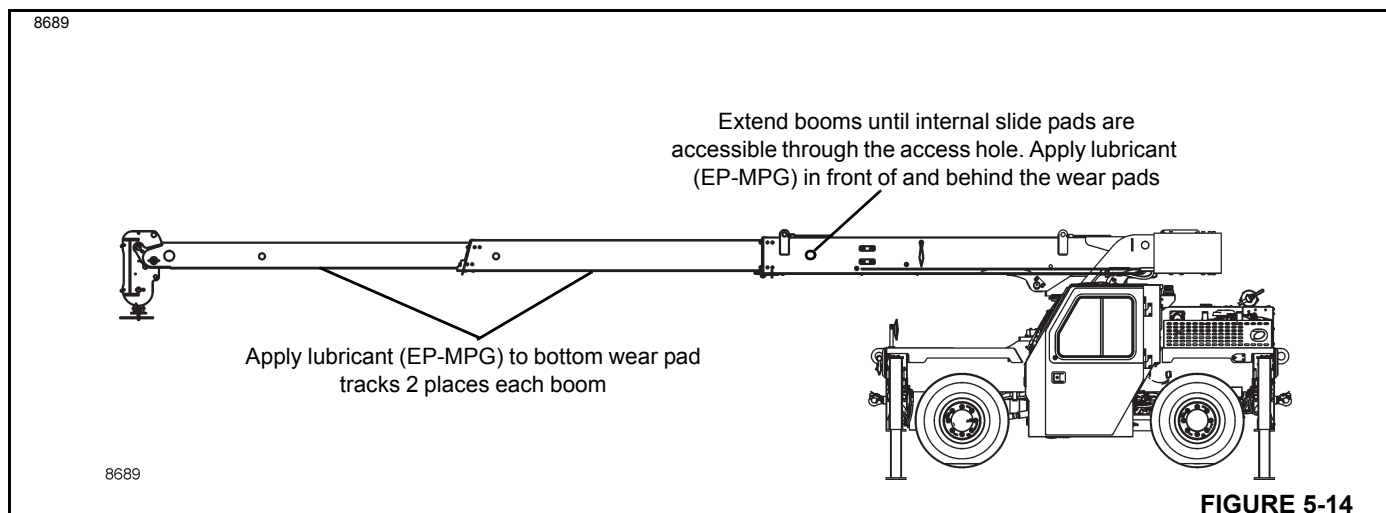


Lubricate Hoist Drum Bearing

Clean the drum bearing grease fitting and re-lube with an NLGI #2 EP grease with no more than 1% molybdenum. The grease fitting is located on the left side of the hoist.

Lubricate the Boom Slides

1. Extend the outriggers. Lower the boom and extend the boom to approximately 16.8' boom length for grease point access 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 bronze anti-seize, or equivalent, to the boom sliding surfaces (Figure 5-14) on the boom sections. Only use a small amount of lubricant for best results.
5. Apply bronze anti-seize, 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 *Safety Practices*, page 2-1 of this manual, before performing any operation or maintenance procedures.

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

Change Hoist Gearbox Oil (First Interval Only)

Drain and fill the hoist gearbox with gear lubricant (AGMA).

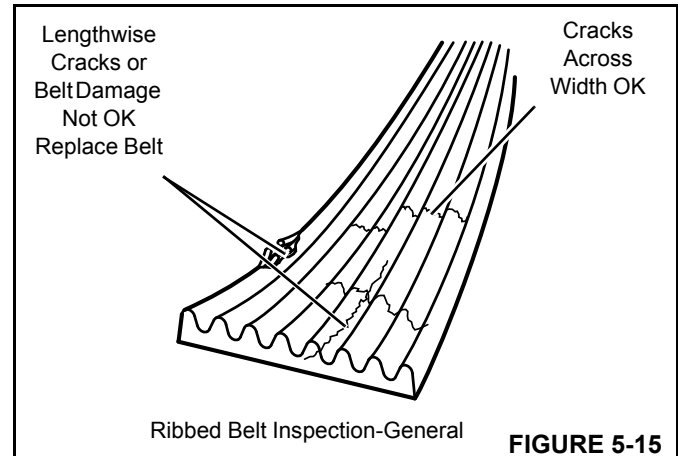
Inspect the Fan Belts

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 5-15.



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 475 ± 14 Nm (350 ± 10 lb-ft).

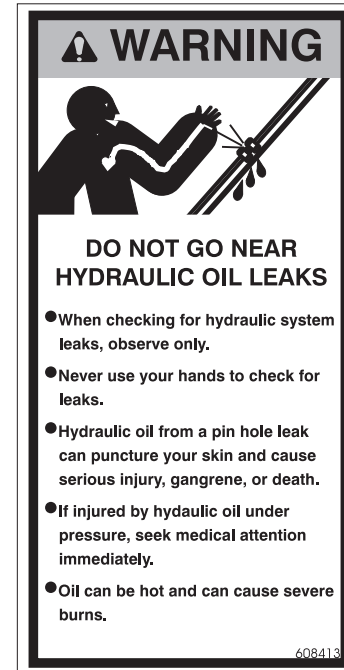
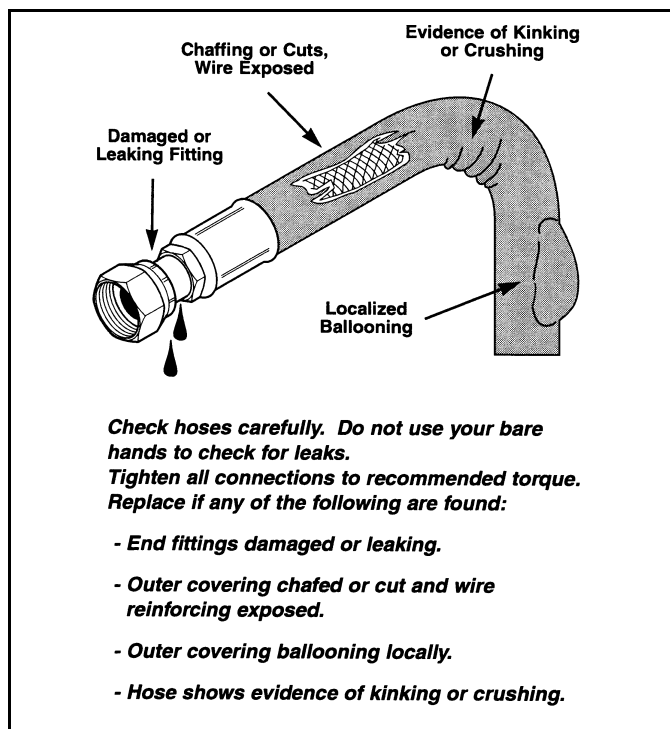
250 Hours of Operation (Monthly)

NOTE: You must read and understand the warnings and basic safety rules, found in *Safety Practices*, page 2-1 of this manual, before performing any operation or maintenance procedures.

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

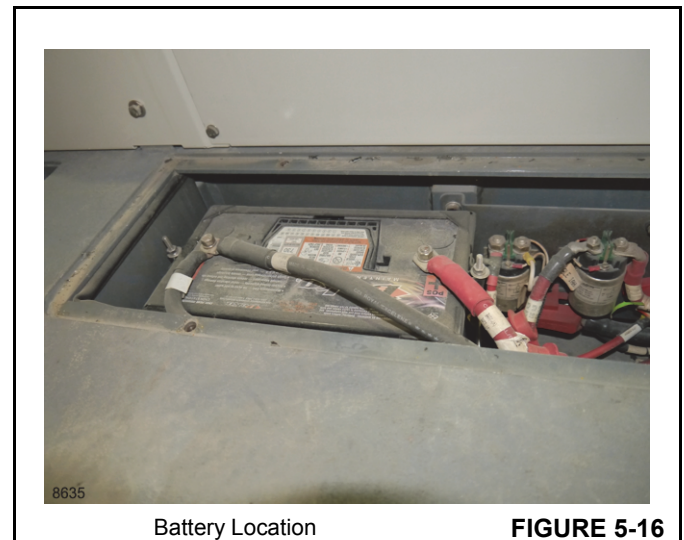
Inspect the Hydraulic Hoses

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.



Clean Battery and Cables

1. Remove the battery compartment cover.



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 prevent 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.

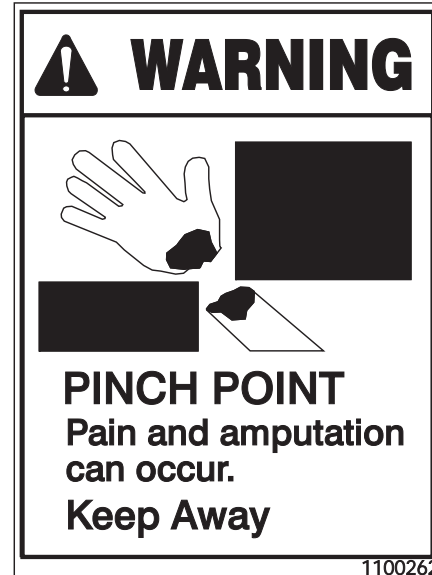
3. After cleaning the wire rope, apply a good grade of wire rope lubricant, to the entire length of the wire rope. Or, apply a light weight oil that has been preheated to a temperature between 18° to 36°C (60° and 100°F). Use a brush or cloth to apply the oil.

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.

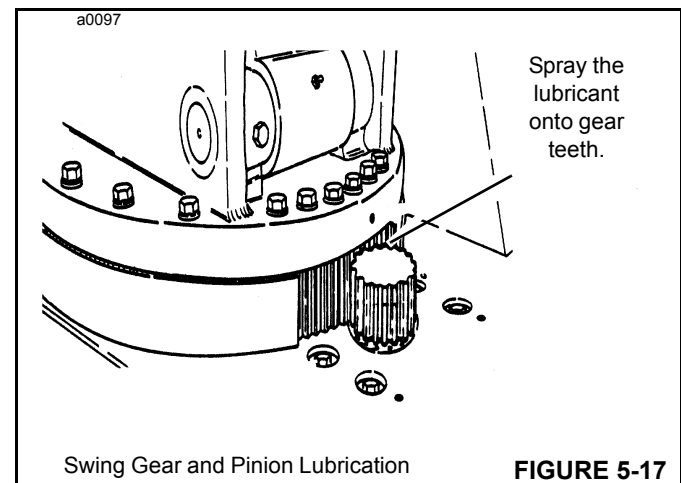
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Rotating gears can cause injury. Keep hands clear of rotating pinion and gear while the mast is rotating.

3. Spray the open gear lube onto the pinion and swing gear teeth (Figure 5-17).



Swing Gear and Pinion Lubrication

FIGURE 5-17

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 open gear 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

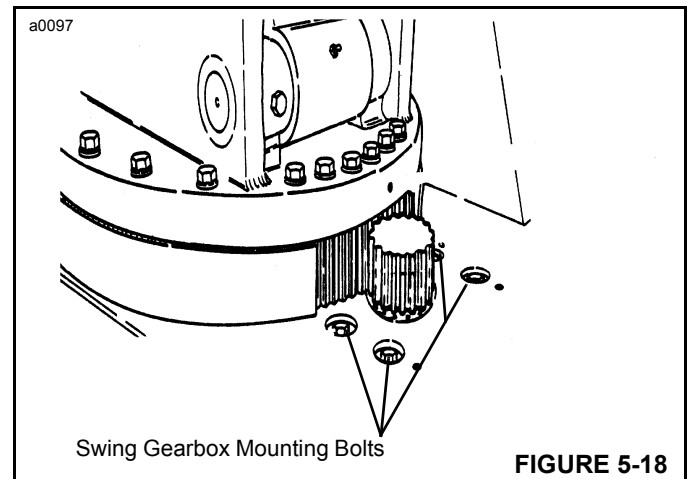
NOTE: Maintain correct torque on all bolts. Failure to do so may result in severe damage to the crane.

Hoist Gearbox Mounting Bolts

Torque the 3/4" mounting bolts (4) to 265 Nm (196 lb-ft).

Swing Gearbox Mounting Bolts

Torque the M12 gearbox mounting bolts (4) to 110 Nm (81 lb-ft). See Figure 5-18. If the bolts are loose, check gear backlash.



Mast Mounting Bolts

Because of the cyclic loading on the mast bolts, it is important that these bolts be checked at regular intervals. Refer to the Service Manual for the proper bolt torque procedure.

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 bolt (mast to swing bearing) should be 312-339 Nm (230-250 lb-ft). The correct torque on each inside bolt (swing bearing to frame) should be 481-522 Nm (355-385 lb-ft).

NOTE: Use only special Grade 8 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 5-19.

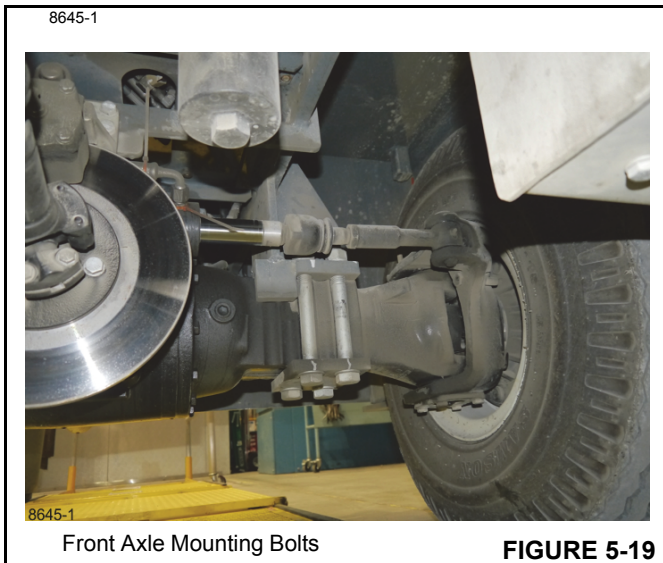


FIGURE 5-19

500 Hours of Operation (3 Months)

NOTE: You must read and understand the warnings and basic safety rules, found in *Safety Practices*, page 2-1 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

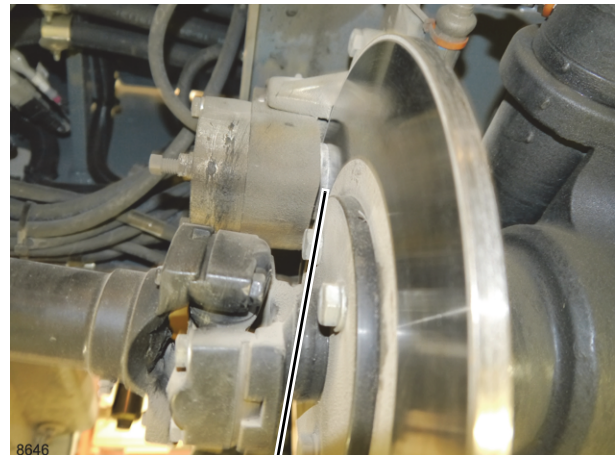
Inspect the tires for any signs of damage, such as cracks, large gouges, deterioration, etc. If damage is found, it must be carefully analyzed to determine if the tire is safe to use. Replace all tires that are unsafe.

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 5-20). 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.



Parking Brake Pads

FIGURE 5-20

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 it visually to make sure it is clean before installing a 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.

7. Install the new element over the stud 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, or if the element is not the right model number. It may be too short for the housing.
9. Install the air cleaner housing cover and secure with the latches.
10. Reset the air cleaner restriction indicator by pushing in the reset button.

Add Rust Inhibitor to Engine Cooling System



For maximum protection of the engine cooling system, add a supplemental coolant additive (SCA) to the radiator when the SCA test levels are low. When the engine is cold, remove the radiator cap and pour the additive in the radiator reservoir, following manufacturer's instructions.

Lubricate the Outrigger Slides

1. Extend the outriggers.
2. Clean the outriggers with a suitable solvent.
3. Apply Mobil EP grease, or equivalent, to the areas shown in Figure 5-21. Do not over lubricate.

Extend, retract, raise and lower the outriggers several times to spread the grease.

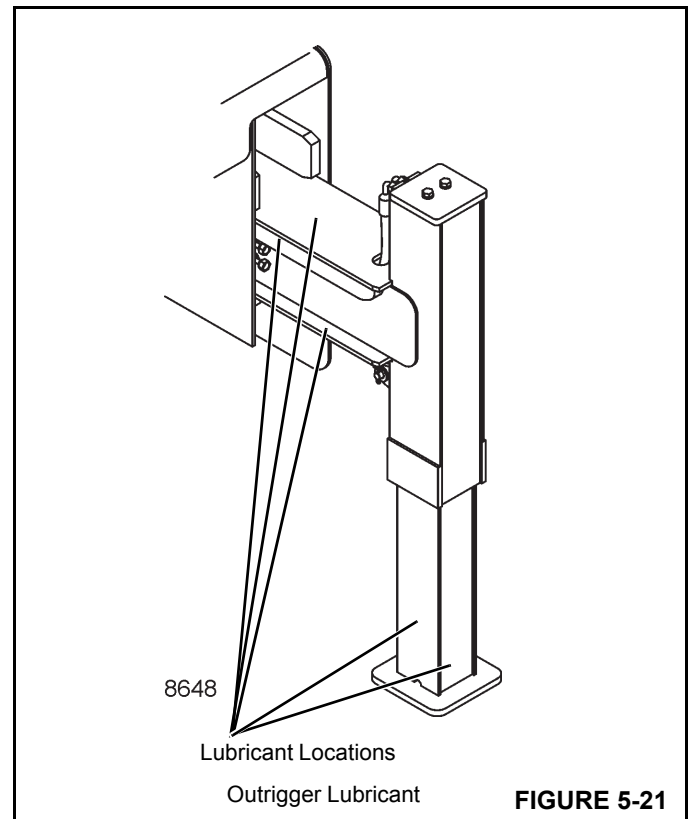
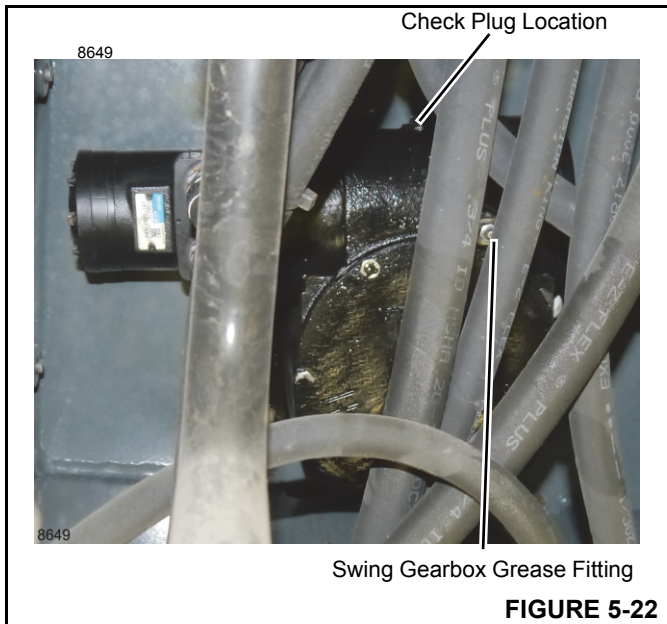


FIGURE 5-21

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.

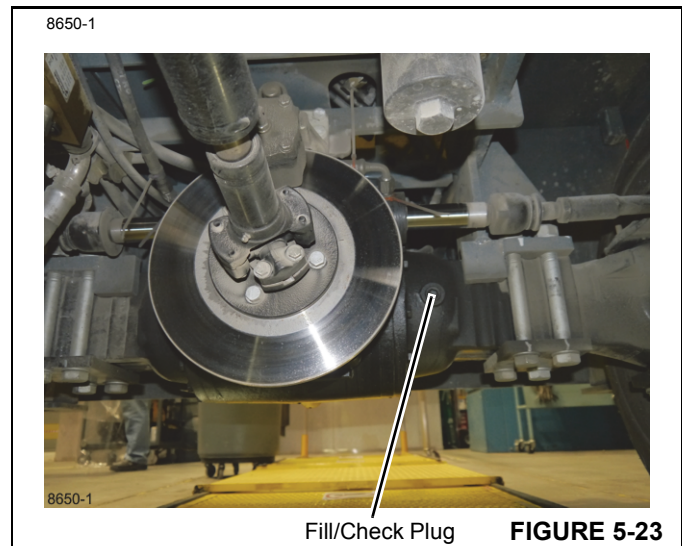


1. Engage the parking brake and shut off the engine. Remove the ignition key.
2. Clean the grease fitting and check plug (Figure 5-22).
3. Remove the check plug.
4. Apply Lithium Base, E.P. No. 2 bearing grease to the fitting. Fill gear box until grease exits the check plug hole. Install the check plug.

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.

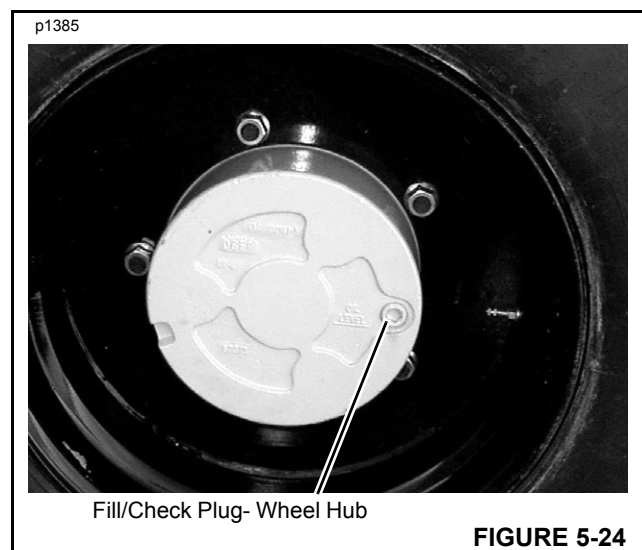
1. Clean around the axle housing fill/check plug (Figure 5-23) and remove the plug.



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 5-24).



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 4 for the other wheel hub.

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 oil level plug (Figure 5-25) and then remove the plug.
4. Check the lubricant level, which should be to the bottom of the oil level hole.
5. If necessary, add AGMA No. 4 EP gear lube to gearbox until it reaches the bottom of the oil level hole.
6. Reinstall the level plug.

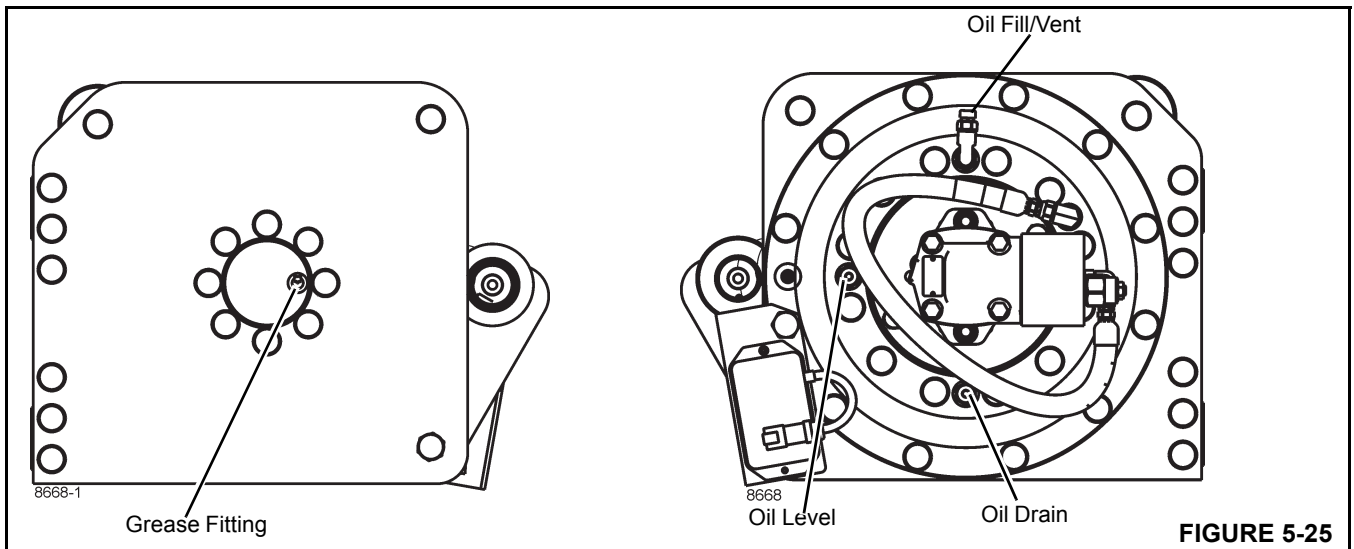


FIGURE 5-25

1000 Hours of Operation (6 Months)

NOTE: You must read and understand the warnings and basic safety rules, found in *Safety Practices*, page 2-1 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.

2. Place the container under the drain plug and remove the drain plug (Figure 5-26). Drain any oil left in the transmission into the container. Install the drain plug.

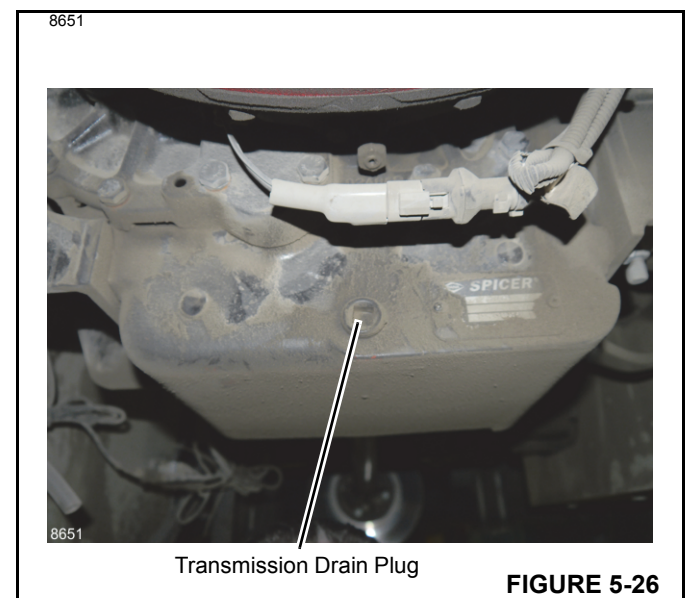
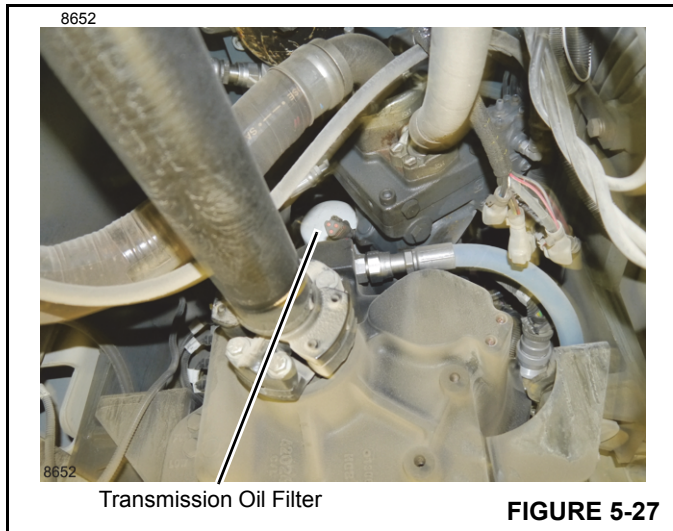


FIGURE 5-26

3. Remove the transmission oil filter by unscrewing it from the transmission housing (Figure 5-27). Properly discard the filter.
4. Coat the seal of the new filter with clean transmission oil.

5. 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.



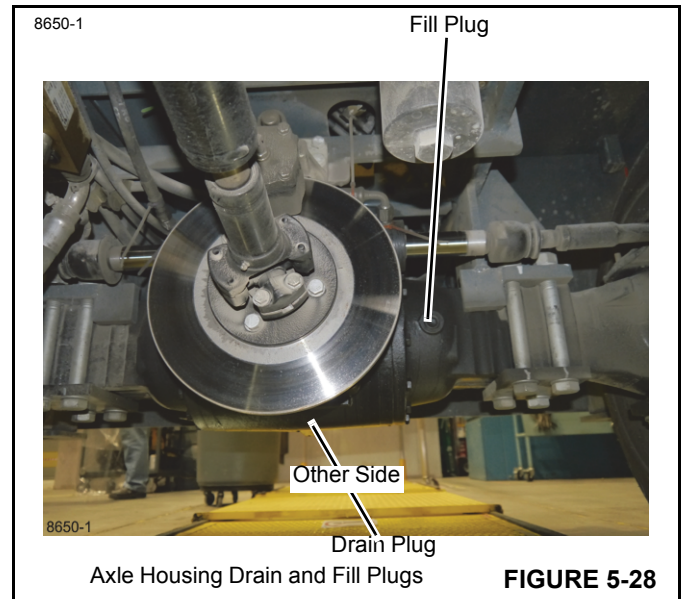
6. Fill the transmission with ISO 46/68 grade hydraulic oil, or equivalent, to the upper mark on the dipstick (approximately 13 liters [3.43 gallons]).
7. Start the engine and let it run at idle speed for a period not exceeding five minutes. This allows the oil to fill the transmission filter, torque converter and hoses.
8. With the engine idling and the transmission in neutral check oil level. If low, add oil to the upper mark on the transmission dipstick. **DO NOT OVERFILL.**

Replace the Front 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.

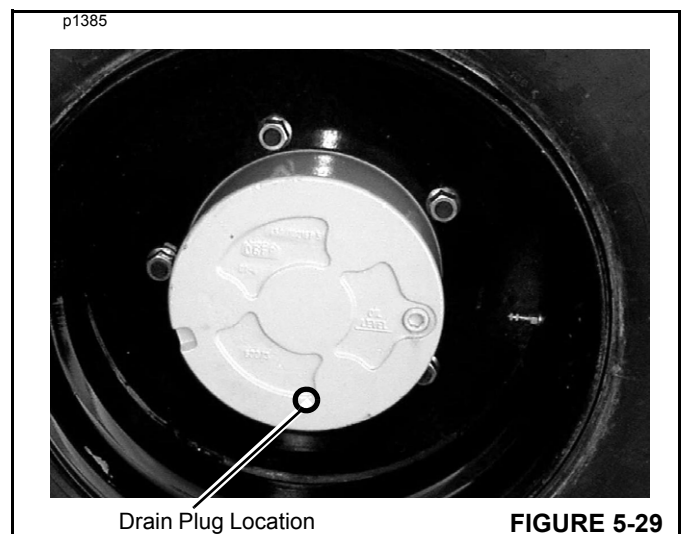
Rear axle center housing to remain dry.

1. Clean around the fill plug in the axle housing (Figure 5-28). Remove the plug.
2. Place a container under the axle housing drain plug. Remove the drain plug and drain the fluid into the container. Install the drain plug.



3. Fill the axle housing with recommended lubricant through the fill plug hole. Fill until the oil reaches the bottom of the fill hole.
4. 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 5-29).
4. Clean around the drain plug and then remove it. Drain the wheel hub oil into a suitable container.

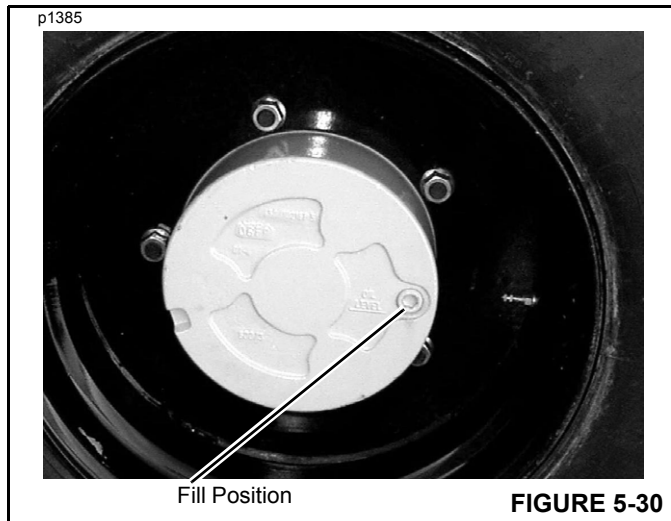


FIGURE 5-30

5. Turn the wheel hub until the drain hole is horizontal (Figure 5-30).
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.
8. Repeat the above procedure for the other wheel hub.

Replace the Hydraulic Oil

NOTE: ISO (International Standards Organization) #46/68 Hydraulic Oil (Mobil Fluid #424) is recommended 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:

1. Fully retract and lower the booms.
2. Retract all outriggers.
3. 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.

4. Level the crane, engage the parking brake, shut off the engine and remove the ignition key.
5. Place a suitable container under the hydraulic tank drain ports (Figure 5-31).

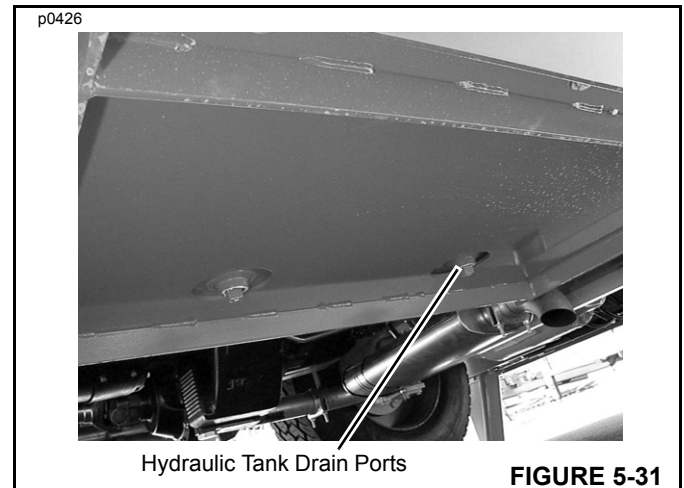


FIGURE 5-31

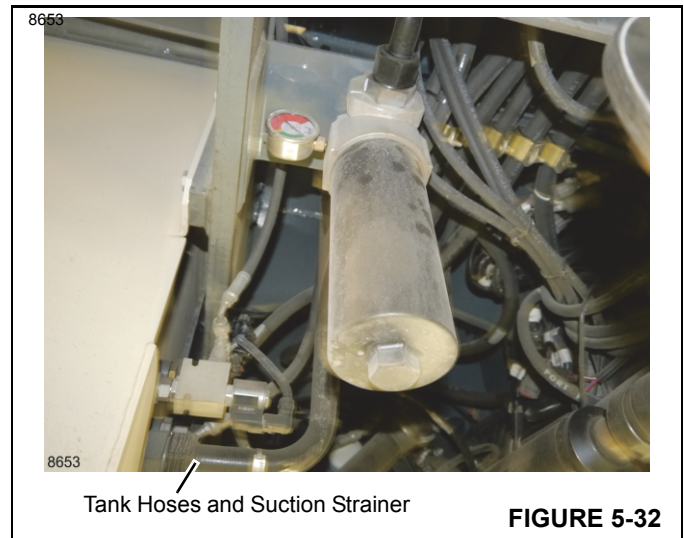
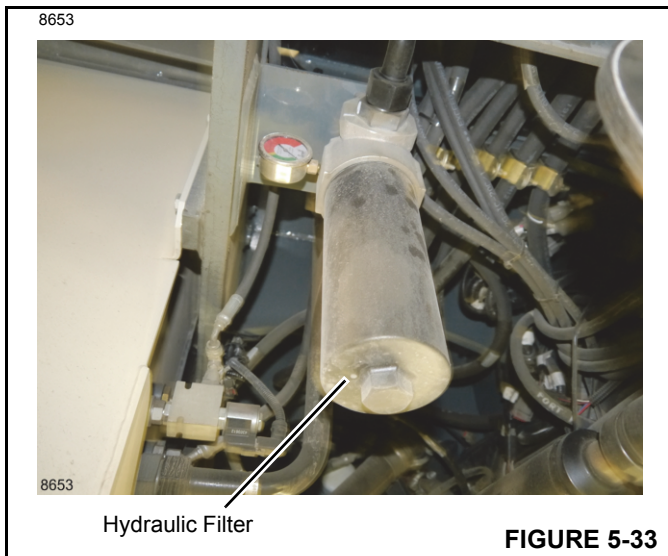


FIGURE 5-32

6. When the tank is empty, disconnect the two hydraulic lines from the rear of the hydraulic oil tank (Figure 5-32). 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*, page 5-32.
10. Fill the hydraulic tank with Mobil Fluid 424 hydraulic oil until level with 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 level with the sight glass. Add hydraulic oil if necessary.
13. Visually check for leaks.

Replace the Hydraulic Oil Filter**FIGURE 5-33**

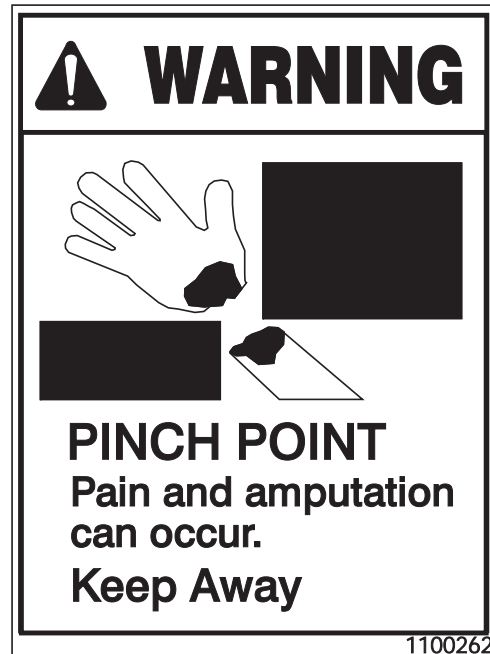
1. Engage the parking brake and shut off the engine.

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 crane (Figure 5-33).
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 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.

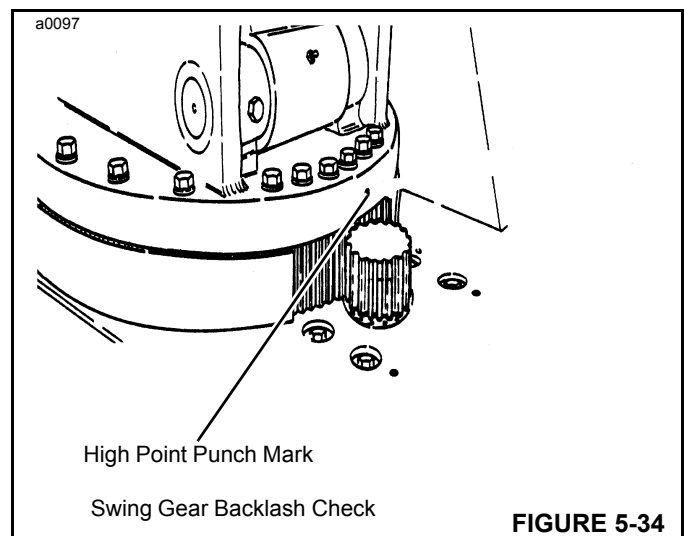
Check Swing Gear/Pinion Backlash

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 punch-marked on the mast plate (Figure 5-34).

2. Using a feeler gauge, check the backlash between the gear and pinion. There should be no clearance between the swing gear tooth and the pinion tooth. If there is any clearance, adjust the backlash. See the *Service Manual* Section 6, *Adjustments*.

**FIGURE 5-34**

2000 Hours of Operation (Yearly)

NOTE: You must read and understand the warnings and basic safety rules, found in *Safety Practices*, page 2-1 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 Hoist Gearbox and Brake Lubricant

1. Lower the boom to lowest position, engage the parking brake. Leave the engine running.

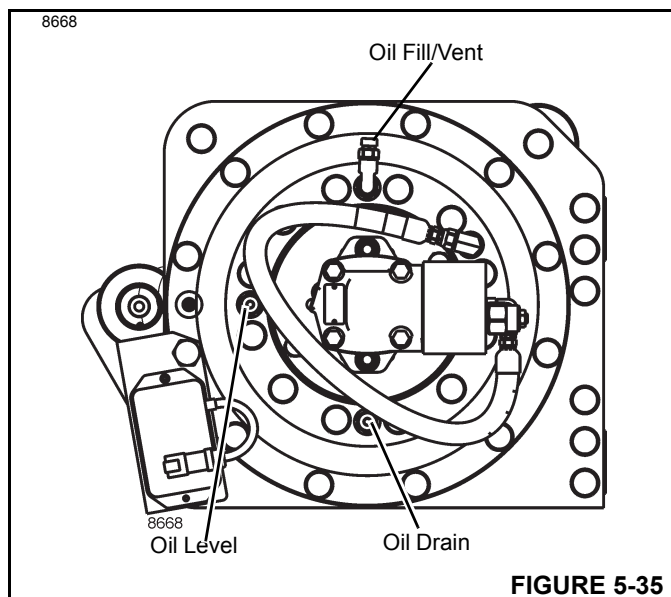


FIGURE 5-35

2. Clean around the oil fill/vent. Remove the oil fill/vent (Figure 5-35) and clean it in a suitable solvent.
3. Clean around the oil level plug (Figure 5-35) and remove the plug.
4. Place a suitable container under the drain plug.
5. Using a 6mm Allen wrench and a 19mm wrench, remove the drain plug and 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.
6. Install the drain plug.
7. Fill the gearbox through the fill hole until the fluid is even with the bottom of the oil level hole. Fill with AGMA No. 4 EP gear lube.
8. Install the oil fill/vent.

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 Manitowoc distributor.
- 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 indicator 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.



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 battery. The only condition in which the battery may cause a problem is when it has been completely discharged for a long period of time. Under this condition the alternator may not be able to recharge the battery and a battery charger will be required for charging the battery.

Before using a battery charger, an attempt can be made to recharge the battery using the engine alternator by first jump starting the crane 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



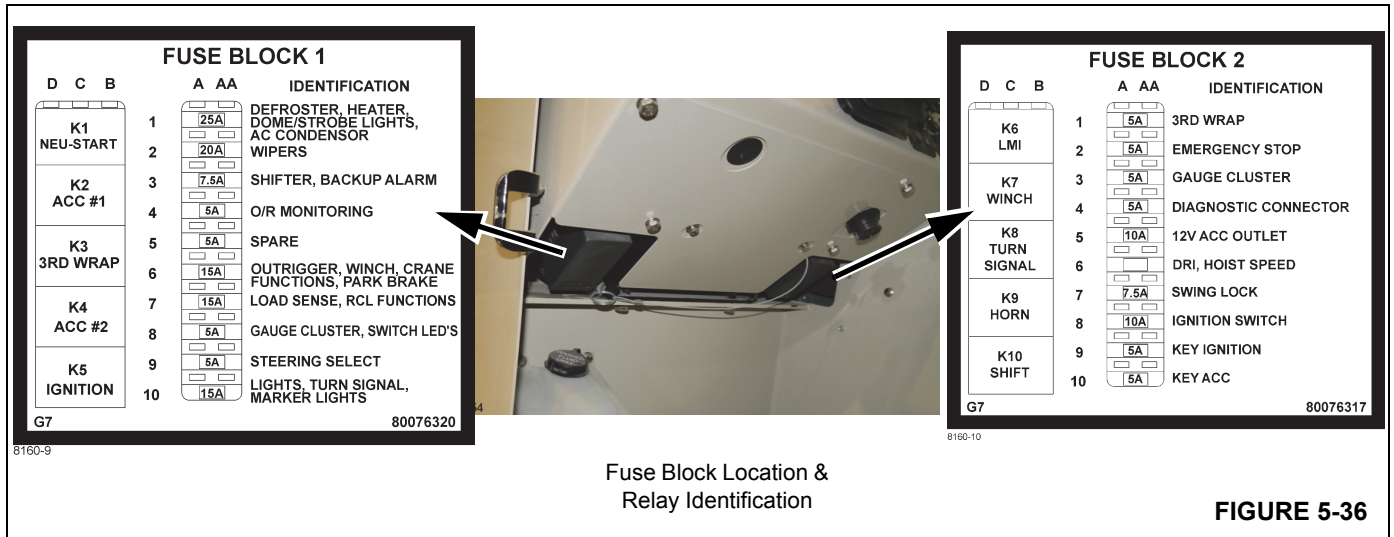
Fuel Storage

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.

Fuse/Relay Replacement

Fuses and relays are located in two fuse blocks below the instrument panel and one in the battery compartment (Figure 5-36 and Figure 5-37).



Fuse Box #1 Circuit Identification

Fuse	Amps	Circuit
FU1	25	Defroster, Heater, Dome/Strobe Lts., AC Condenser
FU2	20	Wipers
FU3	7.5	Shifter, Back Up Alarm
FU4	5	Outrigger Monitoring
FU5	5	Spare
FU6	15	Outriggers, Winch, Crane Functions, Park Brake
FU7	15	Load Sense, RCL Functions
FU8	5	Gauge Cluster, Switch LEDs
FU9	5	Steering Select
FU10	15	Lights, Turn Signal, Marker Lights

Fuse Box #2 Circuit Identification

Fuse	Amps	Circuit
FU1	5	3rd Wrap
FU2	5	Emergency Stop
FU3	5	Gauge Cluster
FU4	5	Diagnostic Connector
FU5	10	12V ACC Outlet
FU6	-	DRI, Hoist Speed
FU7	7.5	Swing Lock
FU8	10	Ignition Switch
FU9	5	Key Ignition
FU10	5	Key ACC

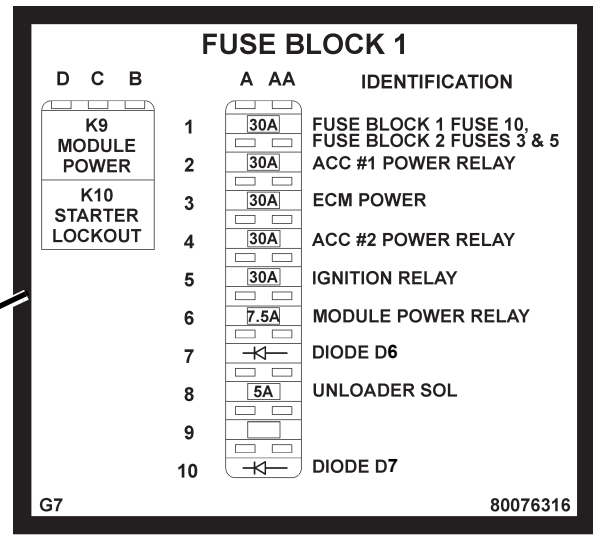


FIGURE 5-37

Fuse	Amps	Circuit
6	7.5	Module Power Relay
7	-	Diode D6
8	5	Unloader Solenoid
9		Not Used
10	-	Diode D7

SECTION 6
ENGINE AND ENGINE SYSTEMS

SECTION CONTENTS

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Engine Crankcase System	6-1	Engine Air Intake System	6-5
Crankcase Oil Data.	6-1	Engine Exhaust System	6-5
Engine Cooling System	6-2	Checks and Adjustments	6-6
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Thermostat	6-2	Installation	6-8
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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

There are three engines available for this crane:

- A dual fuel KEM GM 3.0L
- A Cummins QSF2.8 -4 Cyl. Diesel Tier 3
- A Cummins QSF2.8 -4 Cyl. Diesel Tier 4 Final

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.

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, Section 5.

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.

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 Surge Tank

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 surge tank 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 surge tank 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.

NOTE: On a crane equipped with a dual fuel engine it is necessary to remove the fan and the fan drive bracket in order to remove the thermostat.

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

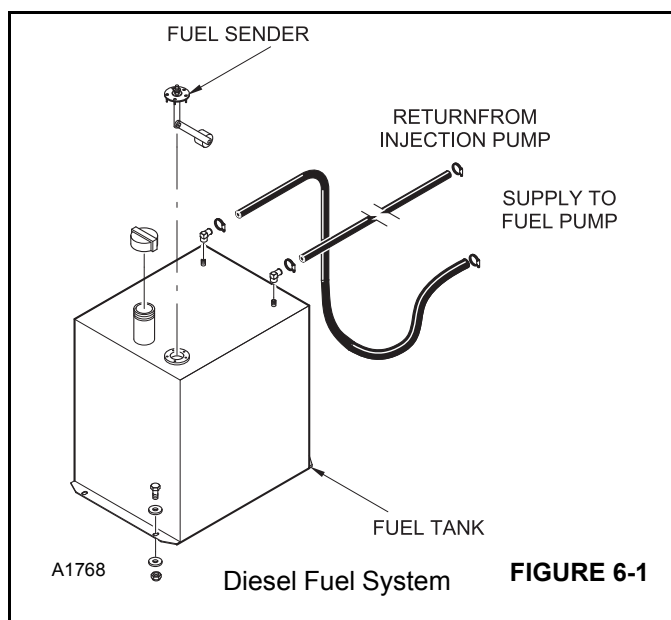
The diesel engine fuel system is a closed-loop fuel system which includes a fuel tank, an engine fuel filter, an engine fuel pump and the fuel lines.

A fuel supply line carries fuel from the bottom of the fuel tank to the engine fuel pump Figure 6-1. 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 Electric System, page 3-1.

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.

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.

The fuel filter 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 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.

Fuel Injectors

Fuel injectors should be taken out and examined at regular intervals. Refer to the engine operator's manual.

QSF 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

Diesel

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.



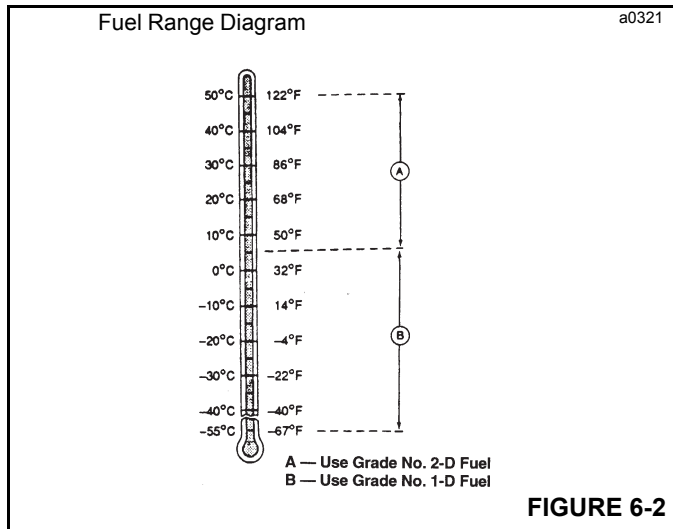
WARNING

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.

NOTE: 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 diesel fuel as defined by ASTM Designation D-975 for diesel engines. In European countries, use ISO 1585 commercial diesel fuel. Find the expected air temperature at time of start up on the thermostatic scale in Figure 6-2. Correct diesel fuel grade (A, B) is shown next to the scale.



NOTE: If engine is operating at temperatures -40° to -57°C (-40° to -70°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°C (10°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.

Gasoline

The gasoline engine operates only on lead-free gasoline with the following minimum or higher octane ratings:

Anti-Knock Index Number (AKI) -- 87 or 89

CAUTION

The use of gasoline with a lower octane than 87 will result in serious damage to the engine. Engine damage resulting from use of low octane gasoline is considered misuse of the engine and will void the engine warranty and the crane warranty.

Gasoline Containing Alcohol

Many types of gasoline being sold today contain alcohol. Two commonly used alcohol additives are Ethanol and Methanol.

The gasoline engine may be operated using gasoline blended with no more than 10% Ethanol meeting the octane specifications of AKI 87 or 89.

NOTE: In some cases, methanol or ethanol (wood alcohol) or other types of alcohol may be added to gasoline. The engine should operate satisfactory on blends containing up to 5% methanol by volume when solvents and other necessary additives are used. DO NOT use blends containing more than 5% methanol by volume or blends that do not contain solvents and corrosion inhibitors.

NOTE: Discontinue use of any gasohol or alcohol/gasoline blend if fuel system problems occur. Do not use such fuels unless they are UNLEADED.

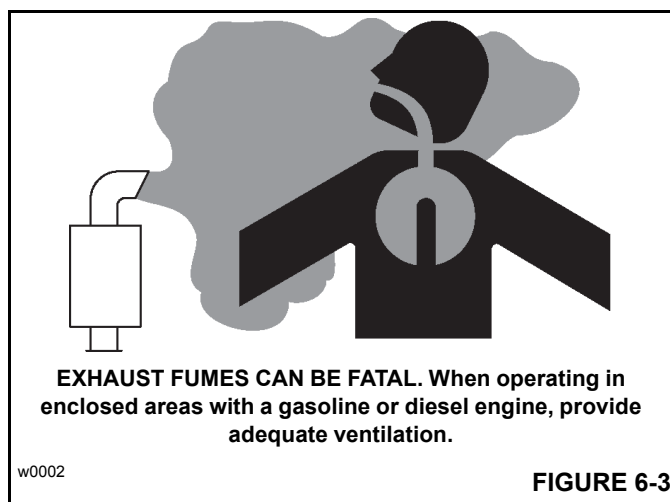
ENGINE AIR INTAKE SYSTEM

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.

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.

Slip Joint Exhaust Connectors

Slip joint exhaust couplers require tightening to avoid exhaust leaks. Perform the following procedures at the appropriate intervals.

After 1000 Hours, or One Year

Visually inspect the exhaust connector. If necessary, tighten the v-clamps by one full turn of the nuts.

2000 Hours or 2 Years

Tighten the v-clamps by 1 ½ turns of the nuts.

4000 Hours or 4 Years

Tighten the v-clamp by 1 ½ turns of the nuts.

5000 Hours or 5 Years

Remove the v-clamps and gaskets, and replace them with new gaskets and clamps. Tighten the v-clamps to 9.6 to 11.3 Nm (85 to 100 lb-in) of torque.

CHECKS AND ADJUSTMENTS

Table 6-1: Engine Troubleshooting Chart

Problem	Probable Cause	Action
Engine hard to start or will not start.	<ol style="list-style-type: none"> 1. Improper starting procedure. 2. No fuel. 3. Air in fuel line. 4. Crankcase oil too heavy. 5. Improper type of fuel. 6. Water, dirt or air in fuel system. 7. Clogged fuel filter. 	<ol style="list-style-type: none"> 1. Review starting procedure in Engine Operator's Manual. 2. Check fuel gauge. 3. Bleed the fuel line. 4. Use oil with proper viscosity. 5. User proper fuel for operating conditions. 6. Drain, flush, fill and bleed system. 7. Replace the filter element.
Engine runs irregularly or stalls frequently.	<ol style="list-style-type: none"> 1. Low coolant temperature. 2. Clogged fuel filter. 3. Water dirt or air in fuel system. 4. Dirty or faulty fuel injection nozzles. 5. Clogged air filter. 	<ol style="list-style-type: none"> 1. Remove and check thermostat. 2. Replace filter element. 3. Drain, flush, fill and bleed. 4. Have authorized distributor or distributor check the nozzles. 5. Replace the filter elements.
Below normal engine temperature.	<ol style="list-style-type: none"> 1. Defective thermostat. 2. Defective temperature gauge. 	<ol style="list-style-type: none"> 1. Remove and check thermostat. 2. Check gauge, sender and all connections.
Lack of power.	<ol style="list-style-type: none"> 1. Engine overload. 2. Intake air restriction. 3. Clogged fuel filters. 4. Overheated engine. 5. Below normal engine temperature. 6. Faulty engine. 	<ol style="list-style-type: none"> 1. Reduce the load. 2. Service air cleaner. 3. Replace fuel filters. 4. Refer to Engine Operator's Manual. Check for plugged radiator/oil cooler fins. 5. Remove and check thermostat. 6. Refer to Engine Operator's Manual.
Low oil pressure.	<ol style="list-style-type: none"> 1. Low oil level. 2. Faulty gauge or sender. 3. Improper type of oil. 	<ol style="list-style-type: none"> 1. Add oil. 2. Check gauge, sender and connections. 3. Drain and fill crankcase with proper viscosity and quality.
Engine overheats	<ol style="list-style-type: none"> 1. Engine overloaded. 2. Low coolant level. 3. Plugged radiator/oil cooler fins. 4. Faulty radiator cap. 5. Cooling system needs flushing. 6. Defective thermostat. 7. Defective temperature gauge or sender. 	<ol style="list-style-type: none"> 1. Reduce the load. 2. Fill radiator to proper level, check radiator and hoses for loose connections or leaks. 3. Clean fins. 4. Replace radiator cap. 5. Flush cooling system. 6. Replace thermostat. 7. Check and replace.

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. Unplug harness connectors from transmission shift solenoids.
 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 CAC tubes attached to the radiator.
 11. Remove the radiator.
 12. 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.
13. Disconnect the fuel lines from the fuel tank. Plug or cap the lines to prevent leakage.
 14. Disconnect the drive shaft(s) from the transmission. See Section 7.
 15. Disconnect the exhaust pipe from the exhaust manifold of the engine.
 16. Drain the hydraulic tank.
 17. Disconnect the hydraulic hoses from the hydraulic pump.
 18. Disconnect the engine ground cable from the engine or the engine flywheel.
 19. Remove the rear axle.
 - a. Attach a chain to the front engine lifting bracket 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 cylinder.
 - 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
 20. Remove the rear engine support mounting bolts, washers, rubber mounts and nuts.
 21. Using a trolley jack, raise the transmission so it can be removed out the rear of the chassis.
 22. 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.
 23. 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.
 24. 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

transmission To Engine Installation Procedure .	7-1	Servicing Machine After Transmission Overhaul.	7-2
Description of Operation	7-1	Cleaning and Inspection	7-3
Torque Converter	7-1	Troubleshooting	7-4
Transmission	7-2		

TRANSMISSION TO ENGINE INSTALLATION
PROCEDURE

1. Remove all burrs from flywheel mounting face and nose pilot bore. Clean drive plate surface with solvent.
2. Check engine flywheel & housing for conformance to standard SAE No.3 per SAE J927 and J1033 tolerance specifications for pilot bore size, pilot bore runout and mounting face flatness. Measure and record engine crankshaft end play.
3. Install two 2.50 in [63.5 mm] long transmission to flywheel housing guide studs in the engine flywheel housing. Rotate the engine flywheel to align a drive plate mounting screw hole with the flywheel housing access hole.
4. Install a 4.00 in (1219 mm) long drive plate locating stud .3750-24 fine thread in a drive plate nut. Align the locating stud in the drive plate with the flywheel drive plate mounting screw hole positioned in step No. 3.
5. Rotate the transmission torque converter to align the locating stud in the drive plate with the flywheel drive plate mounting screw hole positioned in step No.3. Locate transmission on flywheel housing. Aligning drive plate to flywheel and transmission to flywheel housing guide studs, install transmission to flywheel housing screws. Tighten screws to specified torque. Remove transmission to engine guide studs. Install remaining screws and tighten to specified torque.
6. Remove drive plate locating stud.
7. Install drive plate attaching screw and washer. Snug screw but do not tighten. Some engine flywheel housings have a hole located on the flywheel housing circumference in line with the drive plate screw access

hole. A screwdriver or pry bar used to hold the drive plate against the flywheel will facilitate installation of the drive plate screws. Rotate the engine flywheel and install the remaining seven (7) flywheel to drive plate attaching screws. Snug screws but do not tighten. After all eight (8) screws are installed torque each one 26 to 29 lb-ft torque [35-39 Nm]. This will require tightening each screw and rotating the engine flywheel until the full amount of eight (8) screws have been tightened to specified torque.

8. Measure engine crankshaft end play after transmission has been completely installed on engine flywheel. This value must be within 0.001 in [0.025 mm] of the end play recorded in step No 2.

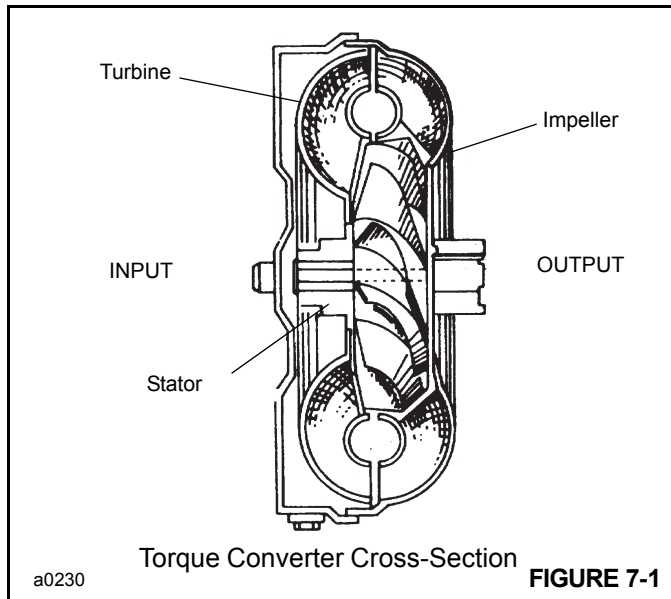
DESCRIPTION OF OPERATION

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 7-1 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

Specifications and Service Data

Transmission Out Pressure

With transmission outlet oil temperature, 180°-200° F. [82.3° -93.3° C] and transmission in **NEUTRAL**. Operating specifications: 25 psi [173 kPa] minimum pressure at 2000 rpm engine speed AND a maximum of 100 psi [690 kPa] outlet pressure with engine operating at no-load governed speed.

Controls

Speed Selection -Electric

Clutch Type

Multiple discs, hydraulically actuated, spring released, automatic wear compensation, and no adjustment. All clutches oil cooled and lubricated.

Clutch Inner Disc

Friction.

Clutch Outer Disc

Steel.

Oil Filtration

Full flow oil filter safety by-pass, also strainer screen in sump at bottom of transmission case.

Clutch Pressure

185 psi [1275.5 kPa] minimum -With parking brake set (see note), oil temperature 180°-200° F [82.2°-93.3° C], engine at idle (400 to 600 R.P.M.), shift through direction and speed clutches. All clutch pressure must be equal within 5 psi, [34.5 kPa]. If clutch pressure varies in any one clutch more than 5 psi, [34.5 kPa] repair clutch.

Normal operating pressure 240-280 psi [1654.8 -1930.5 kPa] at 2000 rpm.

NOTE: Never use service brakes while making clutch pressure checks, Units having brake actuated declutching in forward and/or reverse will not give a true reading.

ALWAYS USE PARKING BRAKE WHEN MAKING CLUTCH PRESSURE CHECKS.

SERVICING MACHINE AFTER TRANSMISSION OVERHAUL

The transmission, torque converter, and its allied hydraulic system are important links in the driveline between the engine and the wheels. The proper operation of either unit depends greatly on the condition and operation of the other; therefore, whenever repair or overhaul of one unit is performed, the balance of the system must be considered before the job can be considered complete.

After the overhauled or repaired transmission has been installed in the machine, the oil cooler, and connecting hydraulic system must be thoroughly cleaned. This can be accomplished in several manners and a degree of judgment must be exercised as to the method employed.

The following are considered the minimum steps to be taken:

1. Drain entire system thoroughly.
2. Disconnect and clean all hydraulic lines, where feasible, hydraulic lines should be removed from machine for cleaning.
3. Replace oil filter elements, cleaning out filter cases thoroughly.
4. The oil cooler must be thoroughly cleaned. The cooler should be "back flushed" with oil and compressed air until all foreign material has been removed. Flushing in direction of normal oil flow will not adequately clean the cooler. If necessary, cooler assembly should be removed from machine for cleaning, using oil, compressed air, and steam cleaner for that purpose. DO NOT use flushing compounds for cleaning purposes.
5. Reassemble all components and use only type oil recommended for lubrication section. Fill transmission through filler opening until fluid comes up to LOW port on transmission.
Remove LOWER check plug, fill until oil runs from LOWER oil hole. Replace filler and level plug.
Run engine two minutes at 500-600 rpm to prime torque converter and hydraulic lines. Recheck level of fluid in transmission with engine running at idle (500-600 rpm). Add quantity necessary to bring fluid level to run freely from LOWER oil level check plug hole. Install oil level plug. Recheck with hot oil (180-200° F) [82.2-93.3° C]. Bring oil level to FULL port to run freely from UPPER oil level plug hole.
6. Recheck all drain plugs, lines, connections, etc., for leaks and tighten where necessary.

Cleaning and Inspection

Cleaning

Clean all parts thoroughly using solvent type cleaning fluid. It is recommended that parts be immersed in cleaning fluid and moved up and down slowly until all old lubricant and foreign material is dissolved and parts are thoroughly cleaned.

CAUTION

Care should be exercised to avoid skin rashes, fire hazards, and inhalation of vapors when using solvent type cleaners.

Bearings

Remove bearings from cleaning fluid and strike flat against a block of wood to dislodge solidified particles of lubricant. Immerse again in cleaning fluid to flush out particles. Repeat above operation until bearings are thoroughly clean. Dry bearings using moisture-free compressed air. Be careful to direct air stream across bearing to avoid spinning. Do not spin bearings when drying. Bearings may be rotated slowly by hand to facilitate drying process.

Housings

Clean interior and exterior of housings, bearing caps, etc., thoroughly. Cast parts may be cleaned in hot solution tanks with mild alkali solutions providing these parts do not have ground or polished surfaces. Parts should remain in solution long enough to be thoroughly cleaned and heated. This will aid the evaporation of the cleaning solution and rinse water. Parts cleaned in solution tanks must be thoroughly rinsed with clean water to remove all traces of alkali. Cast parts may also be cleaned with steam cleaner.

CAUTION

Care should be exercised to avoid inhalation of vapors and skin rashes when using alkali cleaners.

All parts cleaned must be thoroughly dried immediately by using moisture-free compressed air or soft, lintless absorbent wiping rags free of abrasive materials such as metal filings, contaminated oil, or lapping compound.

Inspection

The importance of careful and thorough inspection of all parts cannot be overstressed. Replacement of all parts showing indication of wear or stress will eliminate costly and avoidable failures at a later date.

Bearings

Carefully inspect all rollers: cages and cups for wear, chipping, or nicks to determine fitness of bearings for further use. Do not replace a bearing cone or cup individually without replacing the mating cup or cone at the same time. After inspection, dip bearings in Automatic Transmission Fluid and wrap in clean lintless cloth or paper to protect them until installed.

Oil Seals, Gaskets, Etc.

Replacement of spring load oil seals, O-rings, metal sealing rings, gaskets, and snap rings is more economical when unit is disassembled than premature overhaul to replace these parts at a future time. Further loss of lubricant through a worn seal may result in failure of other more expensive parts of the assembly. Sealing members should be handled carefully, particularly when being installed. Cutting, scratching, or curling under of lip of seal seriously impairs its efficiency.

Apply a thin coat of Permatex No.2 on the outer diameter of the oil seal to assure an oil tight fit into the retainer. When assembling new metal type sealing rings, same should be lubricated with coat of chassis grease to stabilize rings in their grooves for ease of assembly of mating members. Lubricate all O-rings and seals with recommended type Automatic Transmission Fluid before assembly.

Gears and Shafts

If magna-flux process is available, use process to check parts. Examine teeth on all gears carefully for wear, pitting, chipping, nicks, cracks, or scores. If gear teeth show spots where case hardening is worn through or cracked, replace

with new gear. Small nicks may be removed with suitable hone. Inspect shafts and quills to make certain they are not sprung, bent, or splines twisted, and that shafts are true.

Housing, Covers, etc.

Inspect housings, covers, and bearing caps to be certain they are thoroughly clean and that mating surfaces, bearing bores, etc., are free from nicks or burrs. Check all parts carefully for evidence of cracks or condition which would cause subsequent oil leaks or failures.

TROUBLESHOOTING

Problem	Possible Cause	Remedy
Low Clutch Pressure	<ol style="list-style-type: none"> 1. Low oil level. 2. Clutch pressure regulating valve stuck open. 3. Faulty charging pump. 4. Broken or worn clutch shaft or piston sealing rings. 5. Clutch piston bleed valve stuck open. 	<ol style="list-style-type: none"> 1. Fill to proper level. 2. Clean valve spool and housing. 3. Replace pump. 4. Replace sealing rings. 5. Clean bleed valves thoroughly.
Low Charging Pump Output	<ol style="list-style-type: none"> 1. Low oil level. 2. Suction screen plugged. 3. Defective charging pump. 	<ol style="list-style-type: none"> 1. Fill to proper level. 2. Clean suction pump. 3. Replace pump.
Overheating	<ol style="list-style-type: none"> 1. Worn oil sealing rings. 2. Worn charging pump. 3. Low oil level. 4. Dirty oil cooler. 5. Restriction in cooler lines. 	<ol style="list-style-type: none"> 1. Remove, disassemble, and rebuild converter assembly. 2. Replace. 3. Fill to proper level. 4. Clean cooler. 5. Change cooler lines.
Noisy Converter	<ol style="list-style-type: none"> 1. Worn charging pump. 2. Worn or damaged bearings. 	<ol style="list-style-type: none"> 1. Replace. 2. A complete disassembly will be necessary to determine what bearing is faulty.
Lack of Power	<ol style="list-style-type: none"> 1. Low engine RPM at converter stall. 2. See "Overheating" and make same checks. 	<ol style="list-style-type: none"> 1. Tune engine check governor. 2. Make corrections as explained in "Overheating."

SECTION 8

AXLES/DRIVE SHAFTS/WHEELS AND TIRES

SECTION CONTENTS

Description	8-1	Limited Slip Differential	8-16
Front Axle	8-1	Rear Axle Repair	8-19
Rear Axle	8-1	Drive Shaft	8-19
Technical Data	8-2	Removal	8-19
Front Drive Axle	8-2	Disassembly	8-20
Rear Axle	8-2	Inspection	8-20
Front Drive Axle Repair	8-3	Assembly	8-20
Removal	8-3	Installation	8-20
Installation	8-3	Lubrication Procedure	8-21
Special Tools	8-3	Wheel & Tires	8-21
Axle Hub Repair	8-7	Tire Inflation	8-21
Drive Head Repair	8-10	Wheel Stud Nuts	8-21

DESCRIPTION

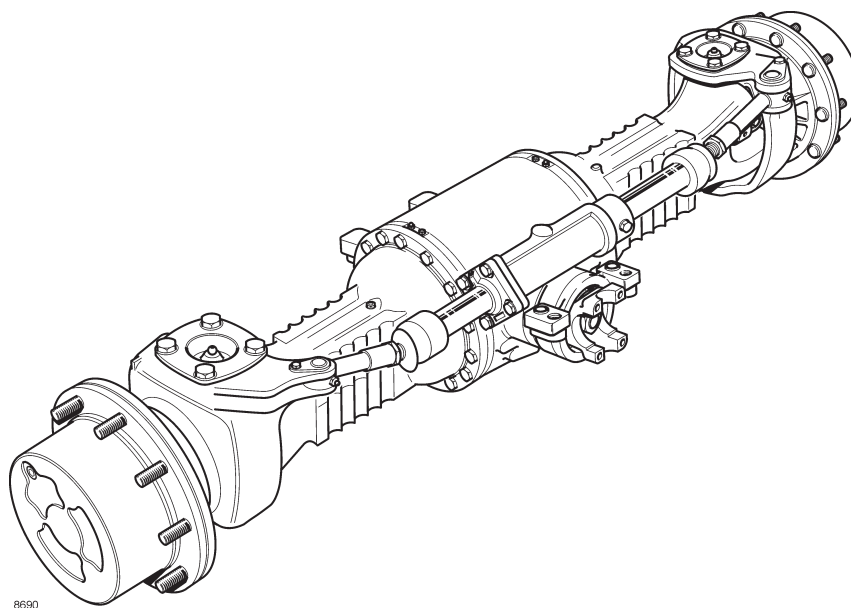
Front Axle

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 is equipped with a rear non-drive axle. The rear axle is the same as the front except that it is missing the internal drive shaft, gears and brakes.



8690

Front Drive Axle

FIGURE 8-1

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 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
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

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.

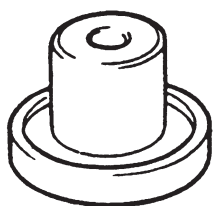
Installation

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 *Brake System* on page 9-1.
9. Bleed the air from the steering circuit. See *Steering System* on page 10-1.
10. Install the wheels to the axle. Lower the crane. Torque the lug nuts to 475 ± 14 Nm (350 ± 10 lb-ft).

Special Tools

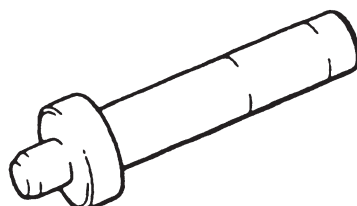
To completely disassemble and assemble the front drive axle, special service tools are required. Unless you have these or similar tools DO NOT service the axle.

The tools illustrated on the next pages are available from your Grove distributor.



a0167

Driver - Crownwheel Bearing
and Differential Bearing Cones
992/07604



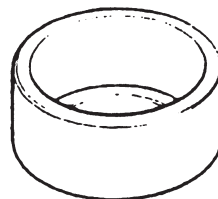
a0174

Bearing Pad Driver
892/00182



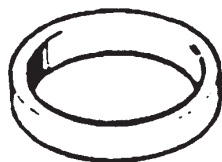
a0168

Adapter - Steer/Drive Axle
Pinion Bearing Cone
992/07609



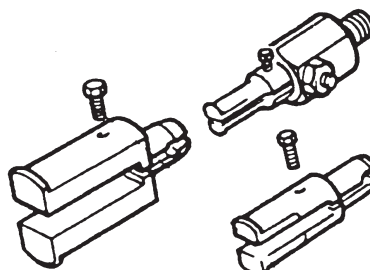
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Measuring Cup - Pinion Head
Bearing
992/07606



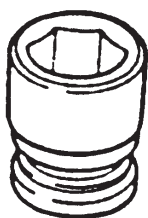
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Spacer - Pinion Bearing Pre-load
992/07607



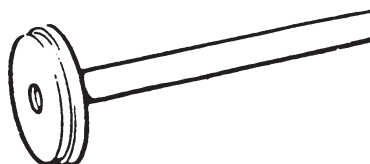
a0172

Adapter - Impulse Extractor
Small - 17 to 25 mm
Medium - 25 to 45 mm
Large 45 to 80 mm
892/00225



a0173

17 mm A/F x 3/4 in. square drive-892/00817
22 mm A/F x 3/4 in square drive-892/00818
15 mm A/F x 1/2 in square drive-892/00819
19 mm A/F x 3/4 in square drive-892/00333



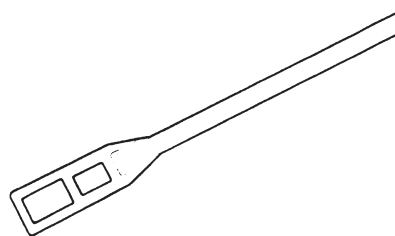
a0175

Driver - Pinion Head Bearing
Cup
992/07603



a0179

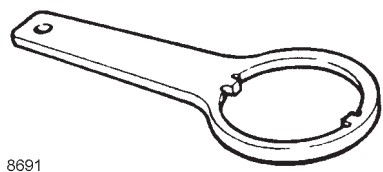
Impulse Extractor Set for Hub
Bearing Seals
892/00224



a0180

Drive Coupling Spanner for
Axle York Couplings
892/00812

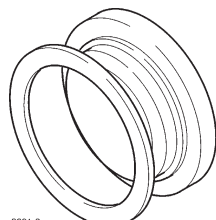
FIGURE 8-2



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8691

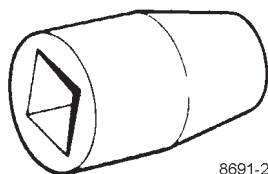
Spanner for Half Shaft Nuts
992/07601



8691-3

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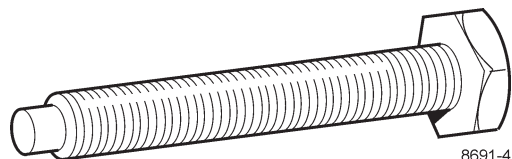
Oil Seal Insertion Tool
892/00891



8691-2

8691-2

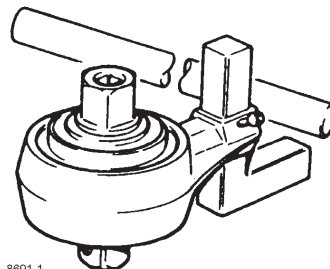
Splined Bolt Socket for driveshafts
892/00822



8691-4

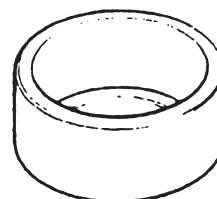
8691-4

Annulus Removal Tool
892/00833



8691-1

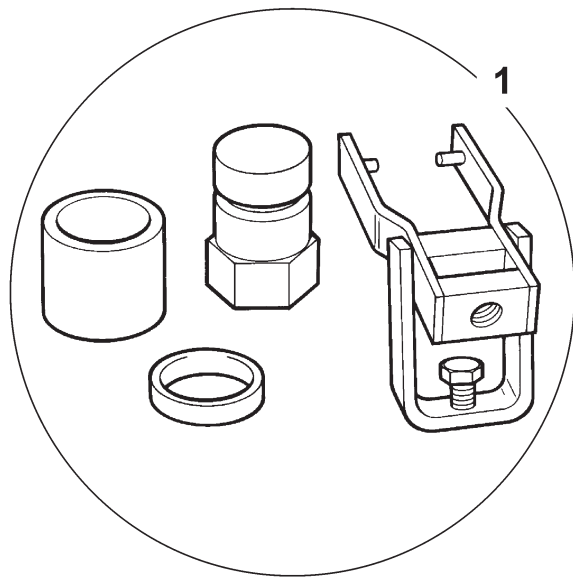
Torque Multiplier (use in conjunction with a torque wrench to give a 5:1 multiplication when tightening pinion nuts)
992/04000



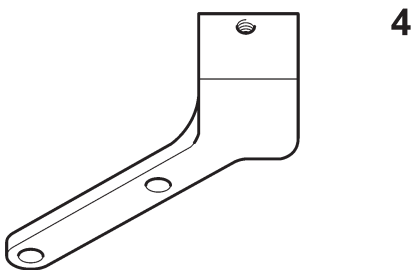
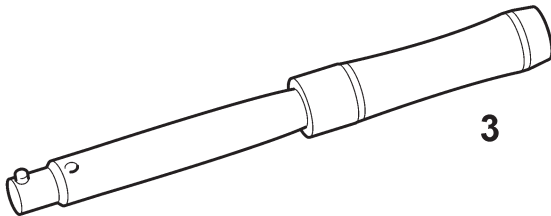
a0171

Measuring Cup - Pinion Head
Bearing
892/00174

FIGURE 8-3

**Solid Spacer Setting Kit**

- 1 892/00918 Setting Tool Kit
- 2 921/52627 Spacer 14.20 Service use
- 3 993/70111 Break back Torque Wrench
- 4 892/01075 Support Bracket
- 5 921/53300 Spacer Kit - SD55 Axles



8691-5

FIGURE 8-4

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 **1** Figure 8-5.
3. Using a soft-faced mallet, tap the planet gear carrier **2** to "crack" the joint between the carrier and the bearing carrier **12**. Then pry the planet gear carrier from the bearing carrier. Remove and discard O-ring **3**.
4. Remove a planet gear **4** 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 **7**, then pull off the planet gear.
5. The drive shaft thrust pad **8** is drilled and tapped M6 for removal purposes. Remove the drive shaft thrust pad from planet gear carrier.
6. Remove the external circlip **9** and spacer **10**.
7. Remove the Verbus Ripp bolts **11**. 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 special tool (part Number 892/00833) as jacking screws, jack the annulus assembly **14**, **15** and **16** off the bearing carrier **12**. Ensure that the ring dowels **13** remain either in the hub swivel **23** or the annulus carrier **14**.

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 circlip **15** to separate the annulus ring **16** from the annulus carrier **14**.
10. Pull off bearing carrier **12** together with the outer wheel bearing cone and cup **17**. Remove combination seal **19**. Remove the inner bearing cup from the inboard side of the carrier.
11. Pull off inner wheel bearing **18**.

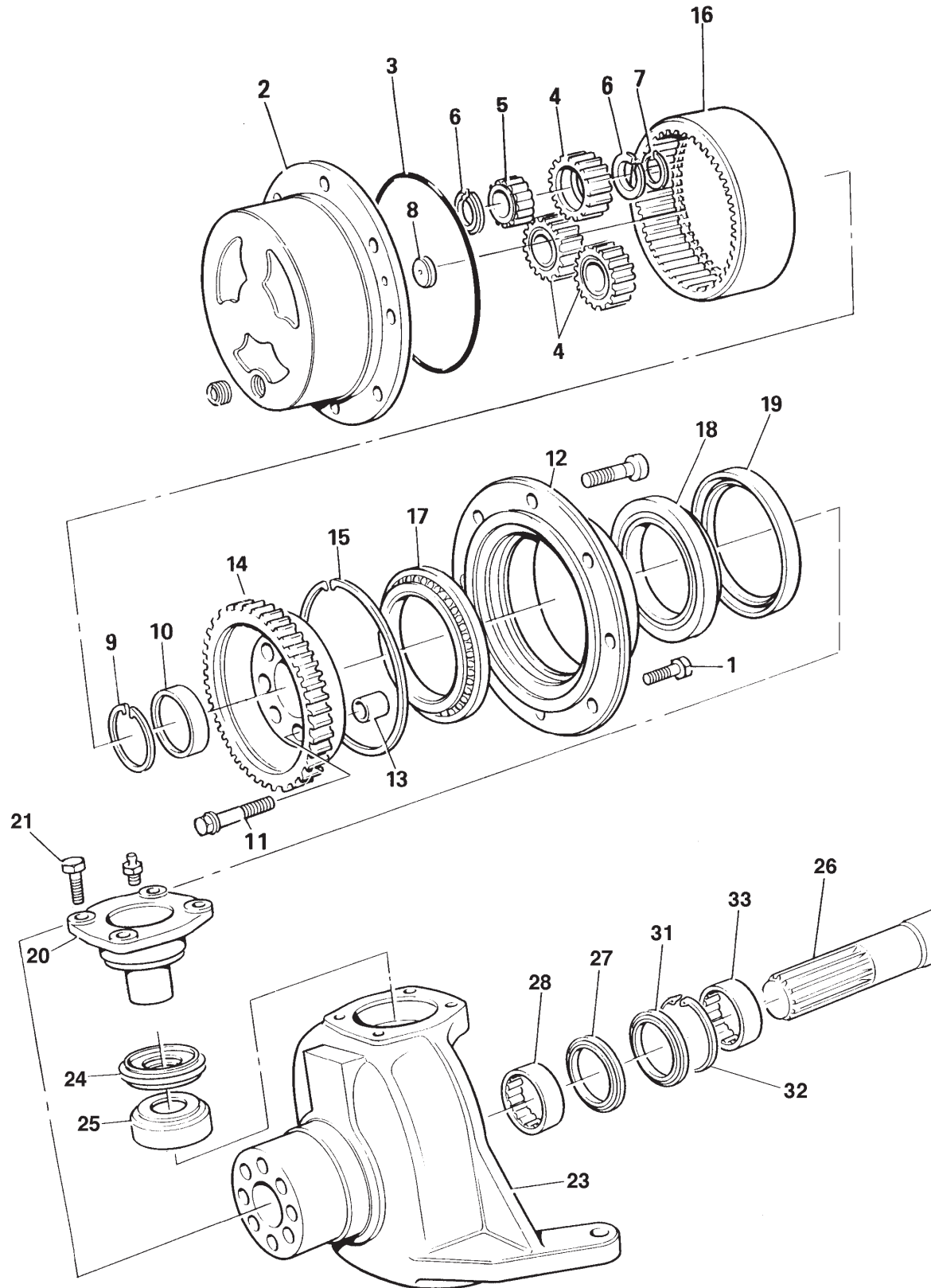
NOTE: Earlier type axles may have an O-ring and wear ring installed in place of combination seal **19**. These parts should be discarded.

12. On later units, remove and discard combination seal **19**.
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).

14. Mark the position of the top and bottom trunnions **20**, remove bolts **21** and remove the trunnions. Withdraw the hub carrier **23**.
15. Remove top and bottom trunnion seals **24** and bearings **25**.



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FIGURE 8-5

16. Remove drive shaft **26** from the axle casing.
17. Pry out drive shaft inner oil seal **27**.
18. Using tool 892/00225, remove bearing **28**.
19. Pry out drive shaft inner seal **31**.
20. Remove circlip **32**.
21. Using tool 892/00225, 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 **22** are installed to the top trunnion only.

1. Tap the drive shaft inner bearing **33** Figure 8-5 into position in the hub swivel drive shaft bore. Secure with circlip **32**.
2. Install a new oil seal **31**. Pack grease between lips of the seal.
3. Tap drive shaft outer bearing **28** into position in the hub swivel.
4. Install new oil seal **27**. Pack grease between the lips of the seal.
5. Install drive shaft **26**, taking care to locate inner end into the splines of the differential gears.
6. Press new top and bottom oil seals **24** into position followed by bearings **25**. Grease bearings and oil seal before installing in axle.
7. Locate hub swivel **23** and install bottom trunnion **20**. Apply Loctite® 243 to the threads of the bottom trunnion bolts **21** and then tighten to a torque of 98 Nm (72 lb-ft). Install top trunnion **20** and leave top trunnion bolts **21** finger tight).
8. Attach a spring balance (Figure 8-6) to track rod swivel and turn the swivel. Tighten the top trunnion bolts **21** to eliminate end float but without bearing pre-load, that is, no increase in spring balance reading.

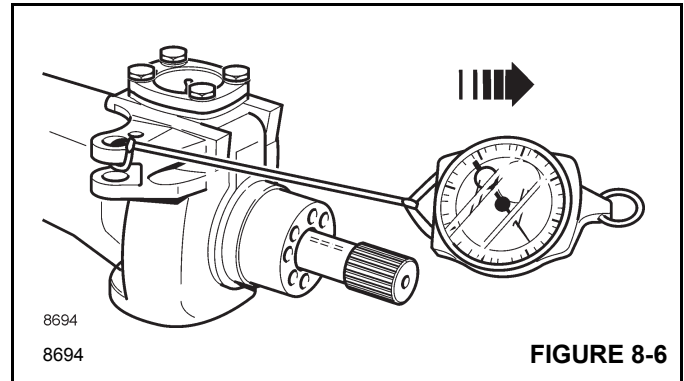


FIGURE 8-6

9. Reinstall the top trunnion. Apply Loctite® 243 to the top trunnion bolt threads, install and tighten to a torque of 98 Nm (72 lb-ft).

Check the spring balance reading which should be 4.5 kg (10 lb) more than the reading recorded in step 8.

10. Connect the track rod and steering cylinder to the axle steering knuckle.
11. Lightly oil the inner wheel bearing **18** and its cup. Then install them into bearing carrier **12**.
12. Install a new combination seal **19** into the bearing carrier.

Do not lubricate before installing. Drive the seal squarely into the carrier **12** until the locating lip is flush, as shown in **X** Figure 8-7.

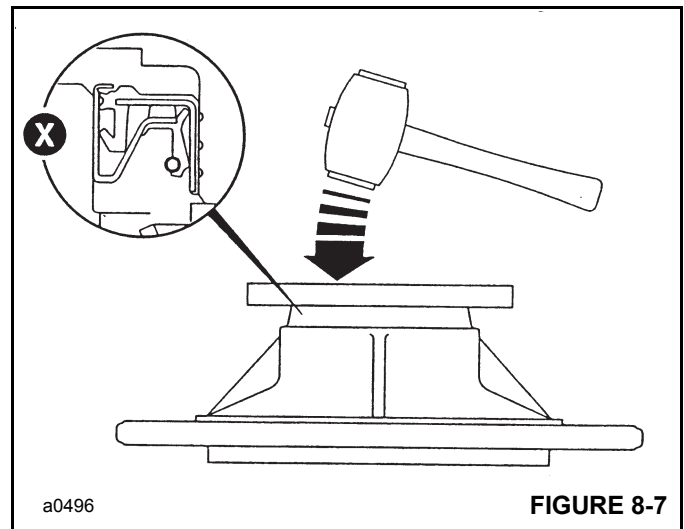


FIGURE 8-7

NOTE: After assembling the bearing carrier to the swivel hub, make sure that there is sufficient clearance between the hub and seal.

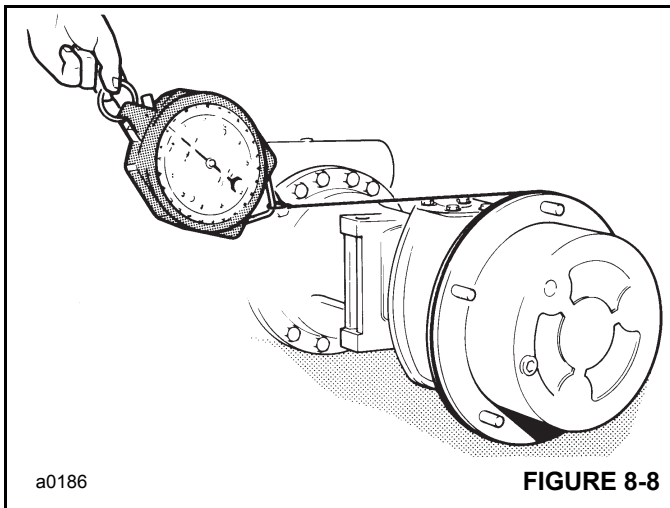
13. Install the cup of outer wheel bearing **17** Figure 8-5 into the bearing carrier **12**. Grease the bore of the combination seal and the surface of the hub.
14. Install the bearing carrier **12** onto hub swivel **23**.

15. Lightly oil the bearing race of outer wheel bearing 17. Install the bearing onto the axle arm. Rotate the carrier 12 (and therefore the bearing) during installation.
16. Assemble annulus ring 16 to annulus carrier 14. Secure with circlip 15.
17. 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 11. Do not fully tighten the bolts but allow the bearing carrier to rock slightly.

CAUTION

Verbus Ripp bolts must **NOT** be reused.

18. Check the seal drag rolling force:
 - a. Use a spring balance and cord wrapped around the planet carrier flange Figure 8-5. Pull the spring balance so that the hub rotates. Do this several times to let the seal bed in and then record the reading.
 - b. Remove the planet gear carrier Figure 8-5 and tighten the new Verbus Ripp bolts 11 to 320 Nm (236 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 2 to 22 Nm (1.5 to 16 lb-ft).
- If the resulting force is outside these limits check that seal 19 is installed correctly and/or replace bearings (17 and 18).
- NOTE:** A high rolling force reading may indicate that the oil seal was damaged during installation.
19. Press the drive shaft thrust pad 8 (chamfered side down) into the recess in planet gear carrier 2.

20. Install new planet gears 4 in place of any that were removed (see Step 4 in Disassembly). Secure with circlip 7.

NOTE: Large radius end of the bearing bore installs onto the pin first.

21. Install a new O-ring 3.
22. Install planet gear carrier 2 onto bearing carrier 19 turning it slightly to engage the gear teeth and aligning the two tapped holes **W** Figure 8-5 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 2 when installed, as this may dislodge drive shaft thrust pad 8.

23. Install screws 1 and tighten to a torque of 56 Nm (41.3 lb-ft).
24. 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 8-3.

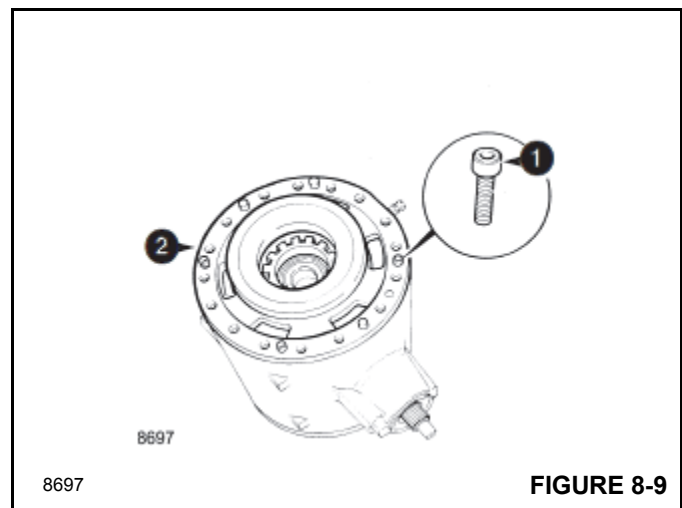
It will be necessary to provide a suitable stand to support the axle after removal.

The crownwheel and pinion are a matched set and should be replaced together if either is damaged or excessively worn.

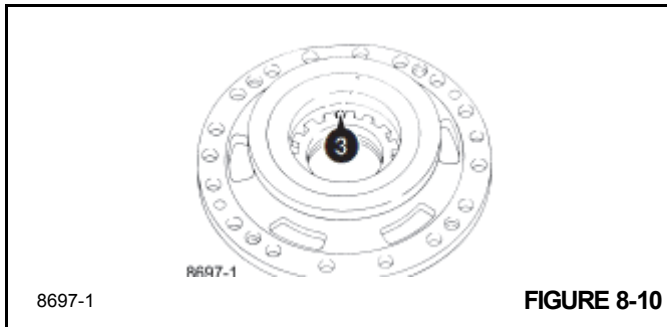
The differential case halves are also a matched set as are the differential side gears and planet gears. Do not use unmatched case halves and gears.

Disassembly

1. Position the drive head as shown in Figure 8-9, with the crownwheel at the top. Remove capscrews.

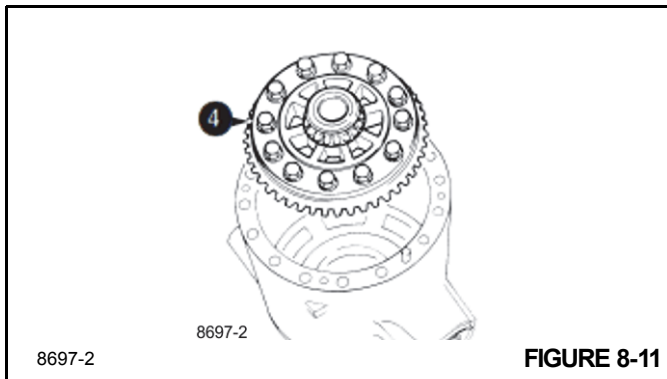


2. Match - mark the brake piston housing and drive head. Pull off the brake piston housing.
3. Drive out the differential side nut locking pin (Figure 8-10), to allow readjustment on assembly. Remove the other brake piston housing only if damaged, but remove its locking pin regardless (to allow side load adjustment on assembly).

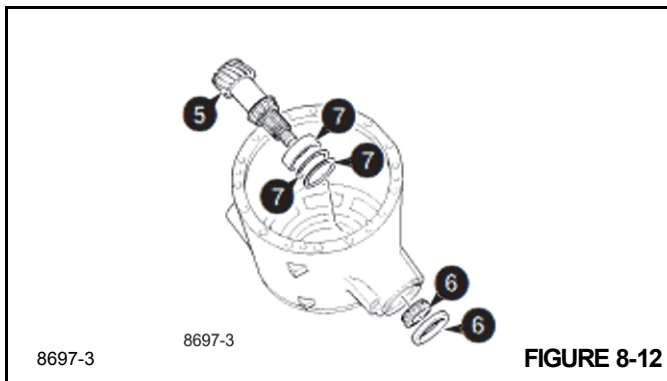


4. Lift out the crownwheel/differential assembly (Figure 8-11).

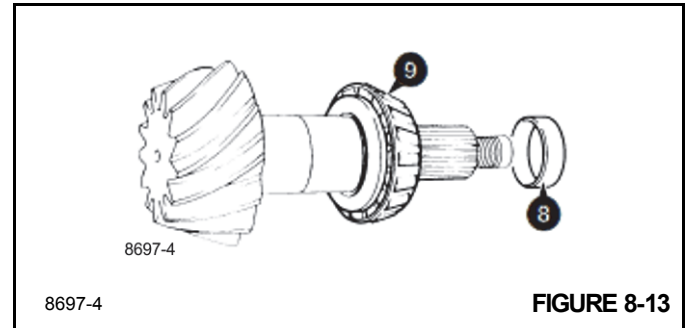
NOTE: If both brake piston housings are to be removed, mark the crownwheel end of the drive head casing to ensure that the assembly is returned to its original position.



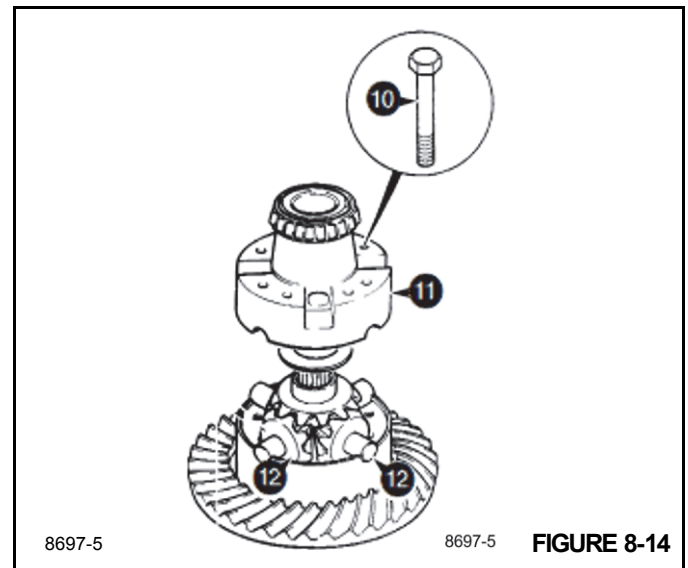
5. Using a soft faced hammer, hit the pinion end shaft until the pinion is free from its front bearing, then withdraw the pinion (Figure 8-12).



6. Withdraw the pinion seal and outer bearing cone.
7. If necessary, drive out the pinion inner bearing cup and shims. Discard the shims. Repeat for the outer bearing cup if required. Note that there are no shims for the outer bearing cup.
8. Remove and discard the pinion spacer (Figure 8-13).



9. Pull off the bearing cone.
10. To dismantle the differential assembly, first remove bolts (Figure 8-14).



11. Lift off the top half housing.
12. Remove the differential gears and spherical washers. Pull off both differential bearing cones.

Assembly

Pinion Depth Setting

1. Place new pinion head bearing assembly on a flat surface and position service tool 892/00174 over the bearing. Measure gap A (Figure 8-15) (e.g. 0.20 mm)

and add this to the cup depth stamped on the tool (e.g. 30.01 mm) to obtain the bearing depth.

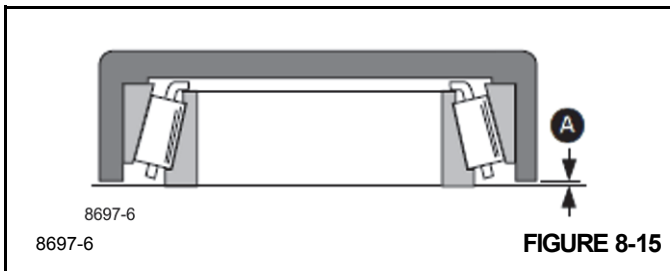


FIGURE 8-15

- From the face of the pinion, obtain the etched deviation figure **B** (Figure 8-16) (e.g. + 2) which is in units of 0.01 mm. If positive, add this to the bearing depth; if negative, subtract from the bearing depth.

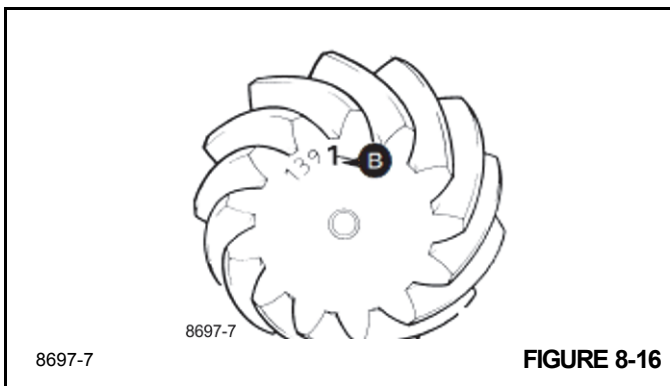


FIGURE 8-16

- Obtain the deviation figure **C** (Figure 8-17) (e.g. - 1) stamped on the differential housing bolt flange. If negative, add to bearing depth; if positive, subtract from bearing depth.

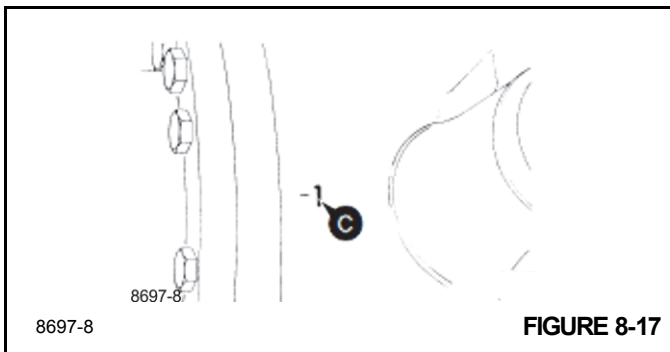


FIGURE 8-17

- Subtract the total of the above figures from the standard value of 31.19 mm. The result will be the thickness of shims required behind the pinion head bearing cup.
- Example (all dimensions in millimeters)

Cup depth	30.01
Gap A	+0.20

Bearing depth	30.21
Pinion deviation B (+ 2)	+0.02
Housing deviation C (- 1)	+0.01
Total	30.24

Standard value	31.19
Less Total above	30.24
Shim Thickness	0.95

NOTE: In the event that the setting data stamp has been omitted from the drive head casing, adopt the following setting procedure:

- Revise the shim pack size by the difference in setting height marked on the old and new crownwheel pinion sets.

NOTE: The crown wheel and pinion are matched and should be renewed as a pair if either one is damaged or excessively worn. The two differential housing halves are also matched. Do not use unmatched halves. If required, fit a new crownwheel to the differential case half, torque tighten crownwheel retaining bolts to 166 Nm (122 lb-ft).

- Assemble the differential gears and their spherical washers into the bottom half housing (Figure 8-18). Fit the differential bearing cones.

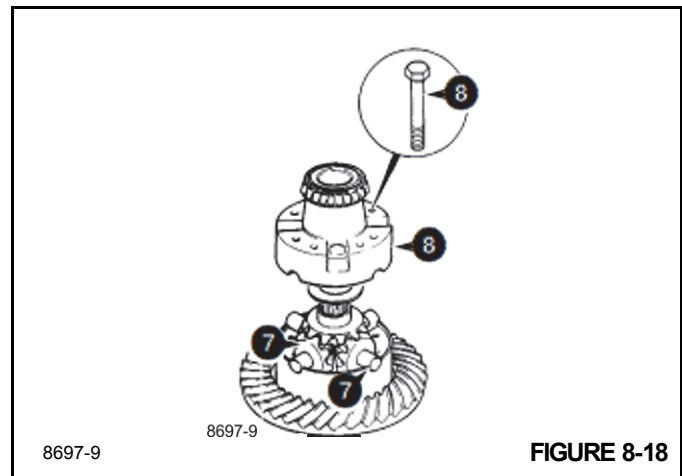


FIGURE 8-18

- Position the top half housing onto the differential, aligning the match mark letters (see Note above). Apply Loctite 243 to the threads of bolts, then fit and torque - tighten to 56 Nm (42 lb-ft). Check the gears for free rotation.
- Fit the new inner bearing cone on to the pinion and the largest available solid spacer eg (14.20 mm) (Figure 8-19) from the solid spacer setting kit, refer to *Special Tools* on page 8-3.

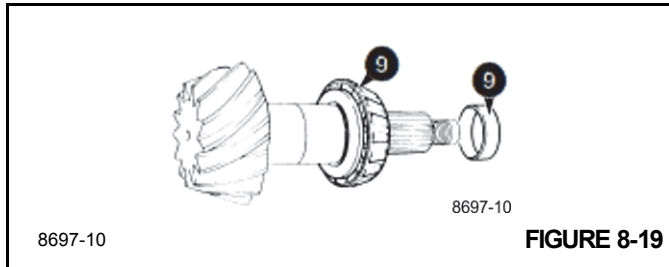


FIGURE 8-19

10. Determine the correct thickness required for the shims **10** (Figure 8-20), refer to *Pinion Depth Setting* on page 8-11.

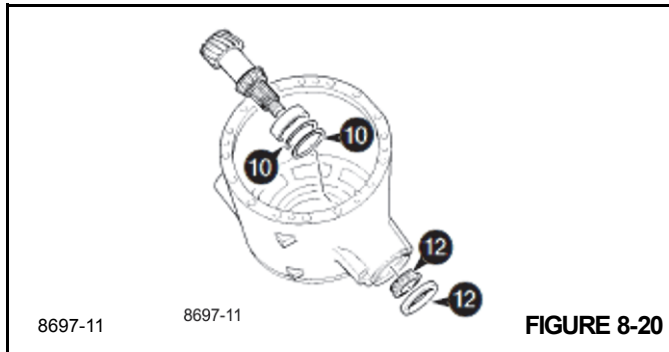


FIGURE 8-20

11. Fit shims **10** behind the pinion inner bearing cup. To ensure the cup is fitted square, use a suitable puller assembly. Do not use a hammer. Fit the outer bearing cup.
12. Insert the pinion into its bore. (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).
13. Fit the pinion outer bearing cone. Do not fit the oil seal at this stage.
14. Fit special tool sleeve **B** (Figure 8-21) and special pinion shaft adapter **C**. Tighten adapter **C** to approximately 50 Nm, making sure the pinion is free to rotate and there is end float, this will prevent any damage to the bearing. If the pinion is not free to rotate or there is no end float at this stage check the bearing is fitted correctly. Also check the correct size spacer has been fitted.

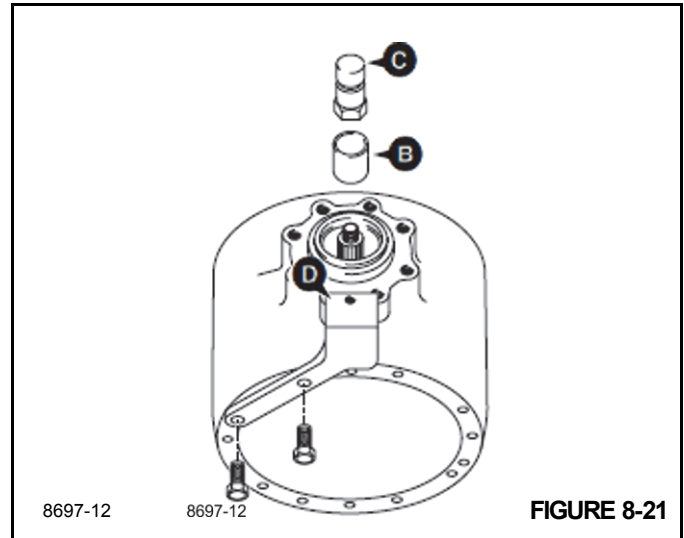


FIGURE 8-21

15. Fit special bracket **D** to the drive-head housing using two M10 x 30 nuts and bolts. Fit special tool support pillar **E** (Figure 8-22) to bracket **D** so that the fork end engages in adapter **C**. Ensure that fork **E** is centrally located on adapter **C**. If necessary, re-align bracket **D** to suit.
16. Fit dial test indicator (DTI) **F**. Ensure that the DTI is mounted on the drive head and not on bracket **D**.
17. Set torque wrench **G** to 35 Nm (25.8 lb-ft) and measure the end float while rotating the shaft.

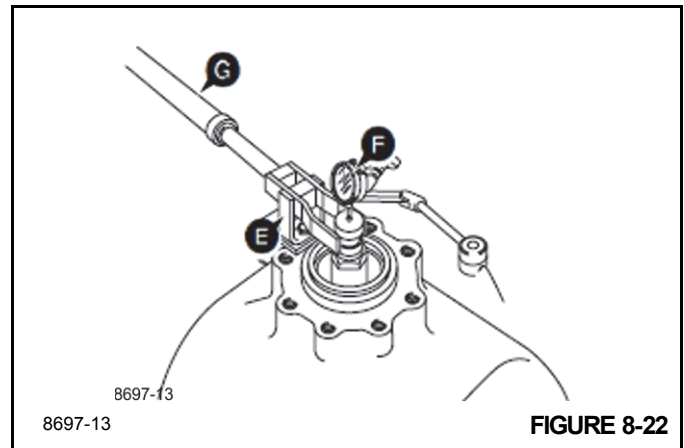


FIGURE 8-22

18. To select the right size solid spacer, subtract the end float obtained at step 17 from the solid spacer size (14.20 mm). Also subtract 0.04 mm to allow for theoretical bearing tolerance and pre load. The result is the size of spacer to be fitted from the solid spacer setting kit. If there is no spacer of this size, fit the next nearest size spacer, refer to *Special Tools* on page 8-3.

Example

Temporary spacer size	14.20
Subtract end-float	0.25

Total	13.95
Subtract tolerance & preload	<u>0.04</u>
Result	13.91

(No spacer available this size, use next nearest size spacer i.e 13.900)

19. Remove sleeve B and temporary spacer. Fit correct size spacer from solid spacer setting kit, refer to *Special Tools* on page 8-3. During removal take care to avoid damaging the outer bearing.

20. Fit sleeve B. Tighten adapter C to no more than 50 Nm to protect against bearing damage while spacer selection is verified making sure the pinion is free to rotate. Check there is no end float and pinion is free to turn smoothly by hand. Remove adapter C and fit stake nut K. Then check that rolling torque is less than 2.0 Nm. If the rolling torque exceeds 2.0 Nm, check that the shaft has been assembled correctly.

NOTE: If the pinion is not free to rotate check the correct size spacer has been fitted.

21. If rolling torque measured at step 20 is too high, fit the next larger size spacer. If rolling torque is too low, fit the next smallest size spacer. If a correct spacer is not available from the range, check that drive head is assembled correctly.

22. Remove adapter C and sleeve B.

23. Fit new oil seal H, grease between seal lips before fitting. Fit coupling yoke J and NEW stake nut K.

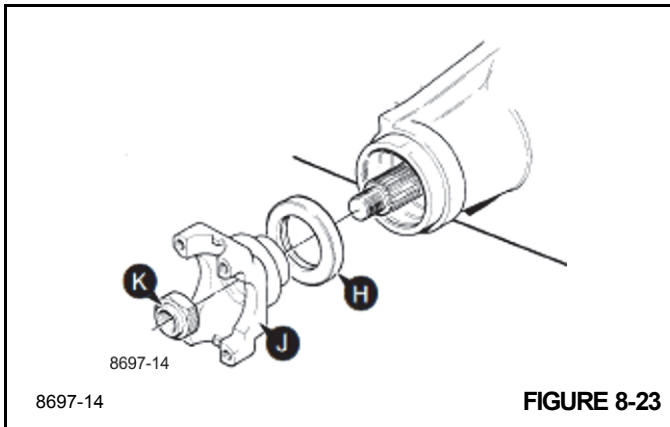


FIGURE 8-23

24. Progressively torque tighten stake nut K, occasionally rotating coupling yoke, up to a minimum of 250 Nm. Providing the correct size spacer has been selected the rolling torque should be between 2.3 and 3.4 Nm

including seal drag. When the torque is correct, stake the nut to the pinion shaft using a square-ended staking tool.

NOTE: The nut tightening torque can be increased to a maximum of 300 Nm provided that the pinion rolling torque does not exceed the maximum of 3.4 Nm.

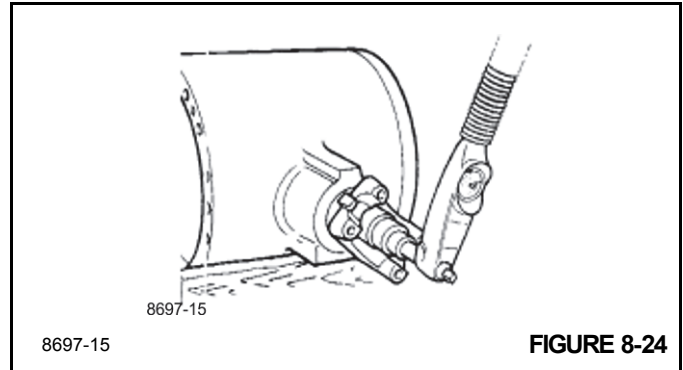


FIGURE 8-24

25. If both brake piston housings were removed, fit the one at the opposite end to the crownwheel, using the procedure in Step 26. Then install the crownwheel/differential assembly into the drive head.

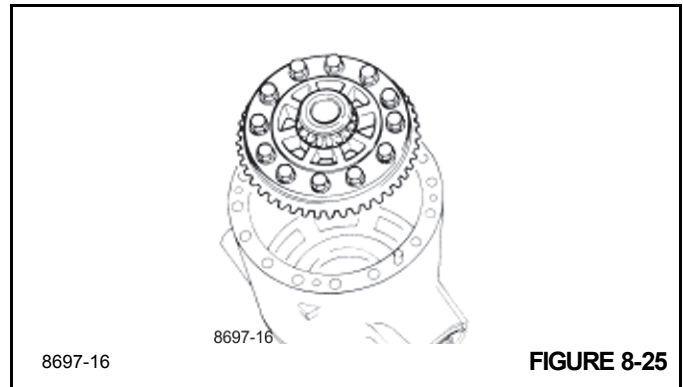
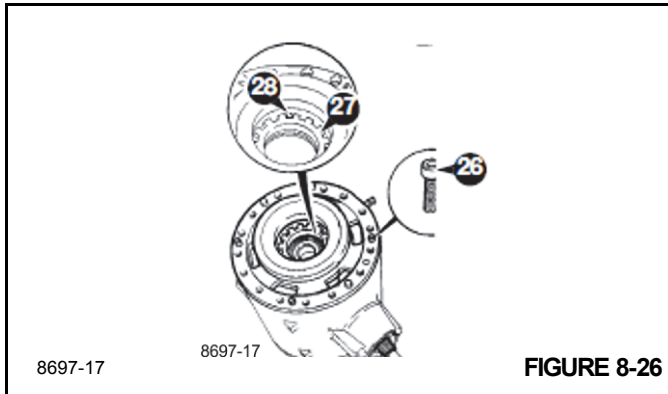


FIGURE 8-25

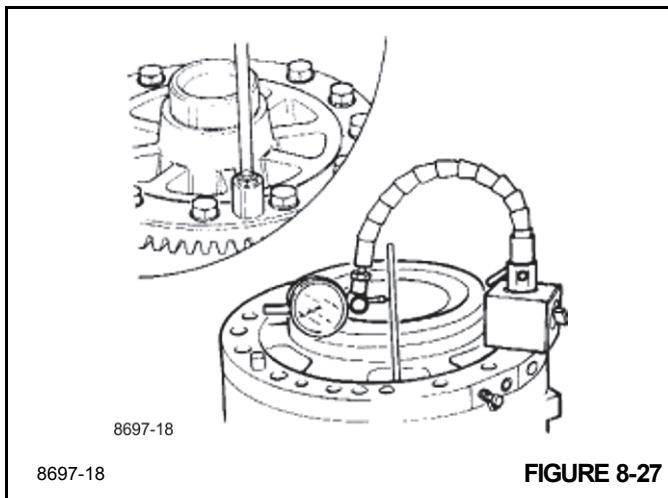
26. Apply Loctite 574 to the drive head mating face, then fit the brake piston housing. Ensure that the match - marks made during dismantling are aligned. Fit capscrews (Figure 8-26). Torque - tighten to 56 Nm (42 lb-ft). (Applies to both piston housings.)

27. Adjust differential side nuts to give a bearing preload of 1.13-2.26 Nm (0.8-1.6 lb-ft). (Measure the preload by taking another rolling torque reading and subtracting the torque figure measured at step 24. The difference is the bearing preload.)



28. Measure the crownwheel backlash, which should be 0.17 - 0.28 mm (0.006 - 0.010 in). Adjust the differential side nuts by equal amounts when altering backlash. When backlash and preload are both correct, fit the side nut locking pins, see step 27.

29. Check tooth marking to verify crownwheel and pinion are set correctly, refer to Crownwheel and Pinion Meshing.

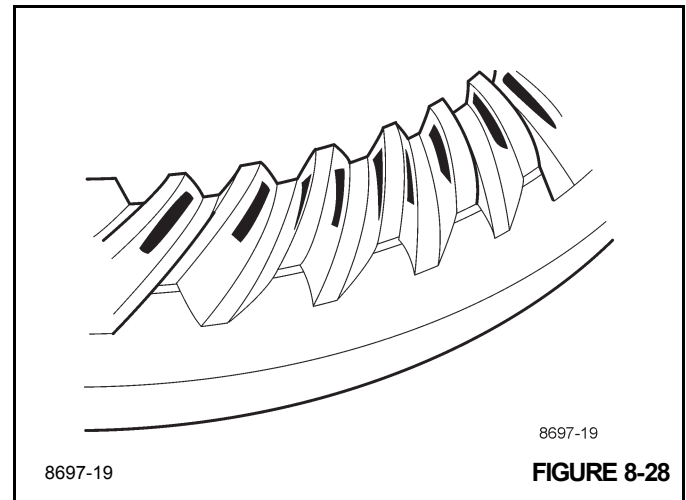


Crownwheel and Pinion Meshing

Meshing of the gears should be checked by marking three of the pinion teeth with engineers marking compound and rotating the pinion.

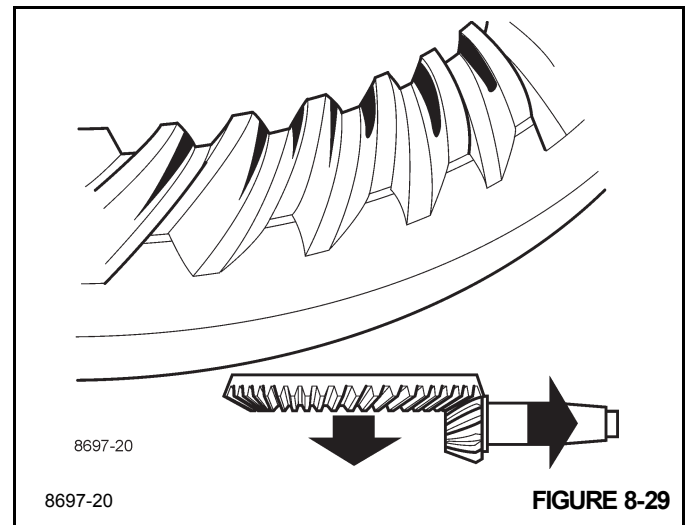
The marking will then be transferred to the crown wheel teeth.

Correct tooth marking (Figure 8-28).



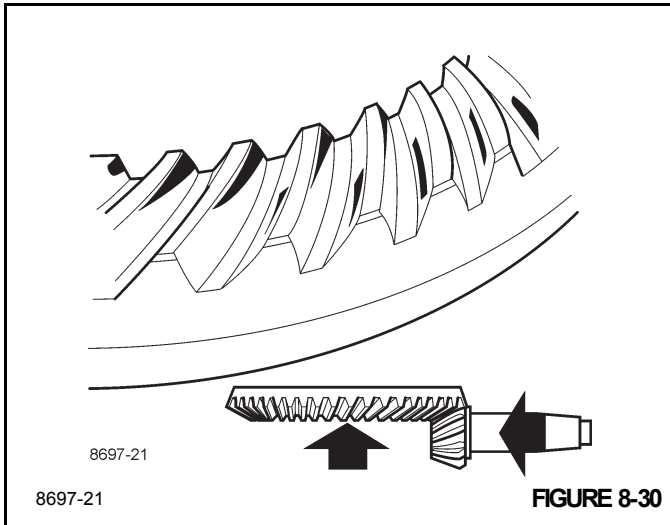
Pinion too deeply in mesh (Figure 8-29).

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 cup and the axle casing. Move the crown wheel away from the pinion to correct the backlash.



The numerical sequence shown on the illustration (Figure 8-31) is intended as a guide to dismantling

The two differential halves are matched, before dismantling mark the two halves for subsequent assembly.

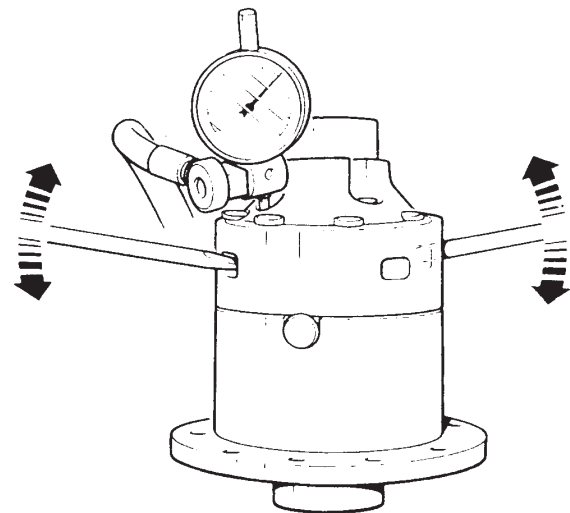
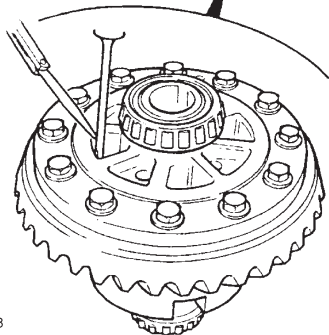
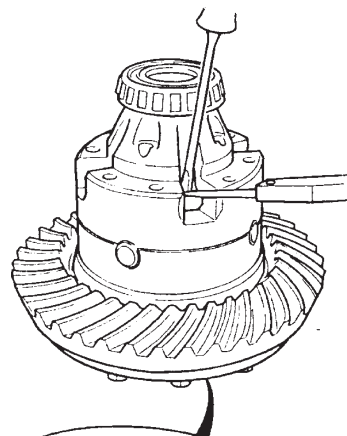
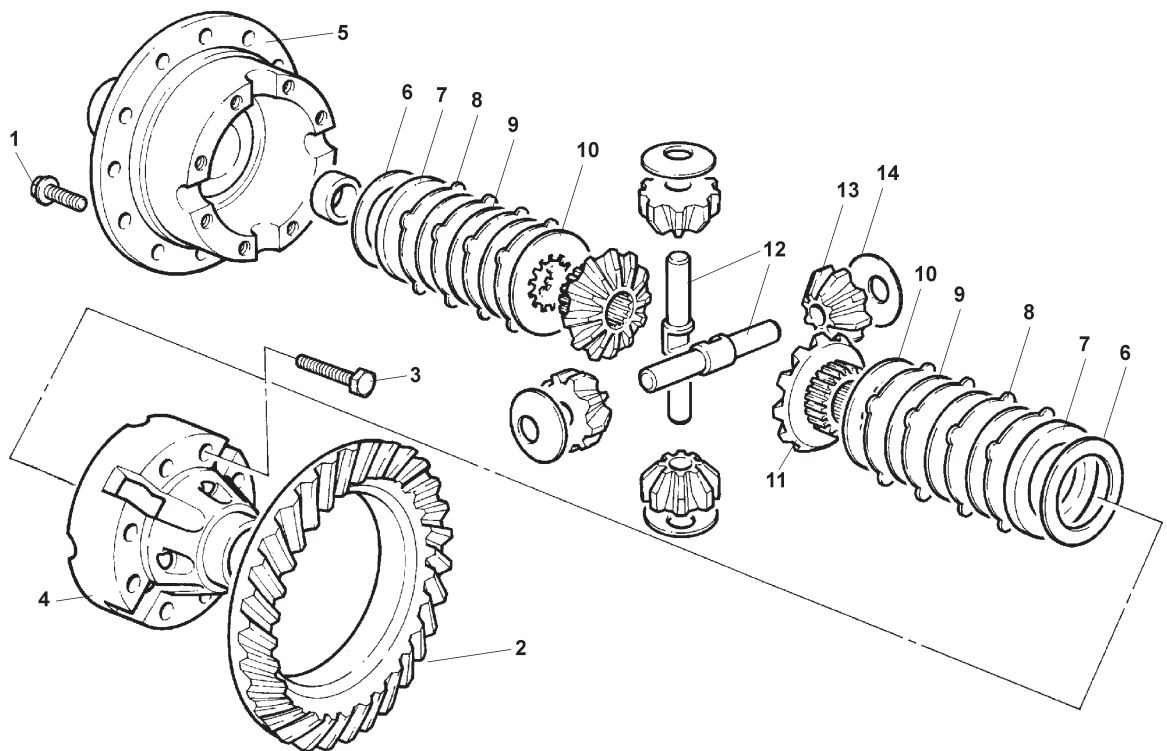
Note the relative positions of the friction and counter plates before dismantling, they must be fitted in the same positions.

If worn, the friction and counter plates must be renewed as a complete set.

Limited Slip Differential

Disassembly

NOTE: For removal of the differential and pinion assembly from the drive head casing refer to *Drive Head Repair* on page 8-10, steps 1 - 9.



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FIGURE 8-31

Assembly

1. Assemble trunnion pins **12**, side gears **11** with pressure plates **10**, counter plates **8**, friction plates **9**, planet gears **13** and thrust washers **14** into the 'crownwheel half of the differential assembly **5**.

NOTE: Do not fit the shims **6** at this point.

2. Align the two halves of the differential assembly with the marks made during dismantling. Assemble using bolts **3**.
3. Using a dial test indicator (or feeler gauges), with two screwdrivers or suitable levers, gently apply pressure to side gear **11** away from the trunnion pins **12** as shown. Measure and note the end-float of the side gear.
4. Turn the differential assembly over and repeat step 3 for the second side gear.
5. Dismantle the differential assembly. Add shims **6** to give end-float between 0.1 and 0.2 mm (0.004 and 0.008 in.).

NOTE: Shimming must be carried out whenever the differential is dismantled, however the end float 0.1 and 0.2 mm (0.004 and 0.008 in.) can be exceeded on previously assembled differential as this is only an initial setting figure which allows for bedding in.

6. Repeat steps 2, 3, and 4. If the end float is correct, tighten bolts **3** to 56 Nm (41 lb-ft).
7. Fit crownwheel **2** using new Verbus Ripp bolts **1**, tighten bolts to 166 Nm (122 lb-ft).

Replacing the Pinion Oil Seal

The pinion oil seal **4** (Figure 8-32) may be renewed without removing the axle from the machine.

**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 road wheels and uncouple the axle propshaft. Measure the axle rolling torque and record the reading.
2. Mark the position of the coupling yoke on the splined shaft. Using Service Tool 892/00812, remove the drive yoke **1** together with its stake nut **2**.
3. Remove the seal **4** and fit a new one. Pack between the lips of the new seal with grease before fitting. Take care not to damage the housing when removing old oil seal.
4. Align the locating marks on the yoke and splined shaft. Fit the coupling yoke and new combined stake nut and washer.

NOTE: Do not excessively hammer the yoke during assembly or damage to the shaft bearings could occur. If necessary, press fit the parts. Fully support the shaft during assembly.

- a. Using Service Tool 892/00812, tighten the nut to 300 Nm (221 lb-ft).
- b. Measure the rolling torque. The reading should be 0.5 to 1 Nm (0.37 to 0.74 lb-ft) more than that recorded in Step 1 (see Note).
- c. If necessary, progressively torque tighten nut to achieve correct rolling torque.
- d. Stake the nut using a square ended staking tool.
- e. Refit the road wheels and couple the propshaft.

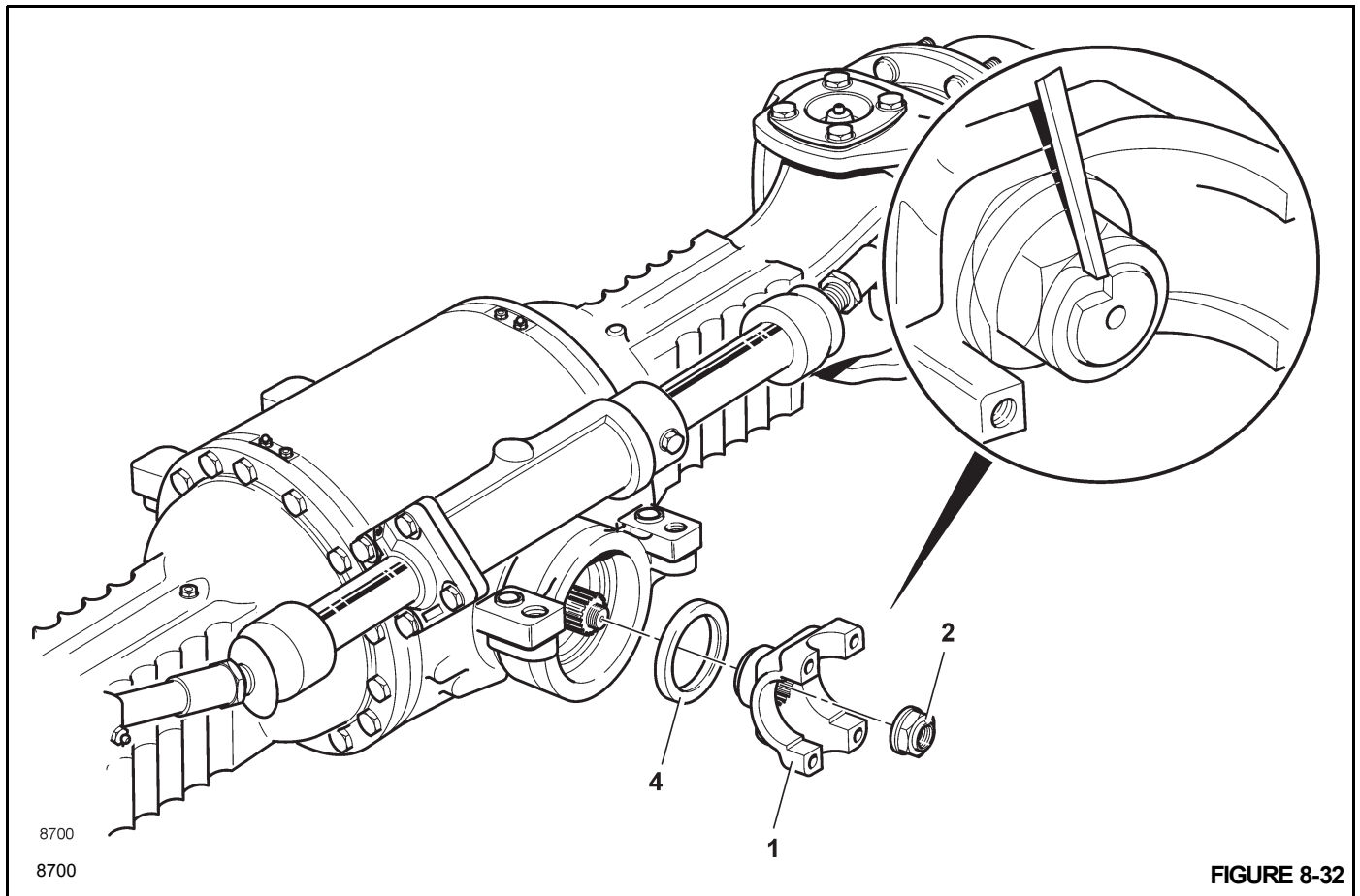


FIGURE 8-32

REAR AXLE REPAIR

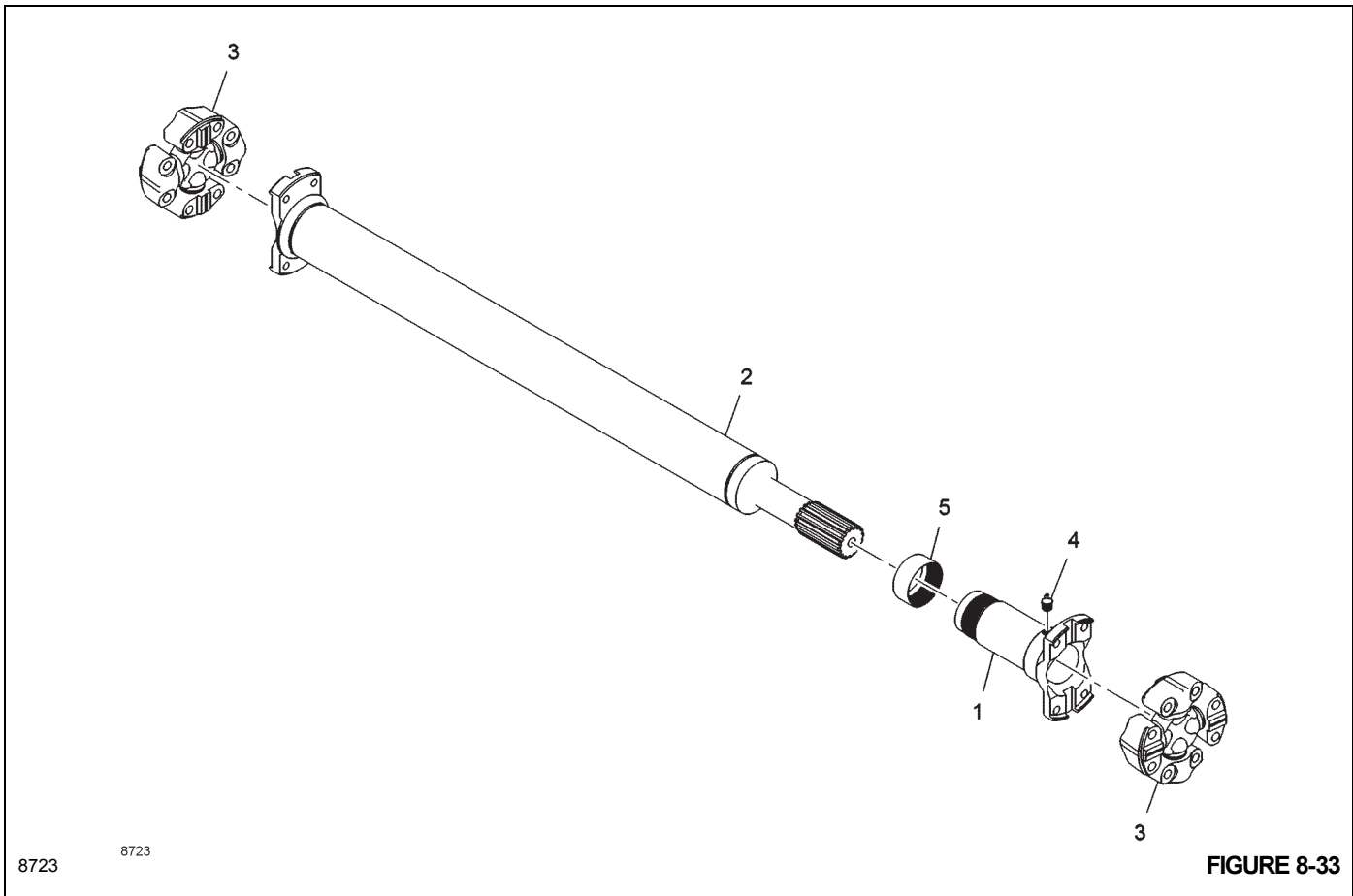
The rear axle is the same as the front axle except it does not have the differential gears, axle shafts and brakes. Use the information from the front axle when servicing the rear axle.

DRIVE SHAFT

Removal

NOTE: Before removing the drive shaft always mark both companion flanges and also mark the sliding joints prior to removal.

1. Remove bolts and lockwashers from the U-joint (Figure 8-33) mounted on the transmission.
2. Remove bolts and lockwashers from the U-joint mounted on the parking brake disc.



Disassembly

1. Remove bolts and lockwashers connecting the slip yoke assembly **1** to the U-joint **3**.
2. Remove bolts and lockwashers connecting the yoke with tube and spline end **2** to the U-joint **3**.
3. To disassemble the yoke with tube and spline end **2** from the slip yoke **1**, turn the dust cap **5** counterclockwise. When the dust cap is free, pull the yoke with tube and spline end and dust cap free of the slip yoke.

Inspection

Clean all parts with a suitable solvent. Remove all rough areas from any finished surfaces. Remove and clean the grease fitting **4**.

Check for damage to the splines of the yoke with tube and spline end. 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.

The U-joints are sealed components and do not disassemble. If a U-joint shows signs of wear replace the U-joint as an assembly.

Assembly

1. Apply SAE 140 oil to splines on the yoke with tube and spline end **2** Figure 8-33. Assemble the dust cap assembly **5** to the yoke with tube and spline end. Slide the yoke with tube and spline end into the slip yoke **1**. Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.
2. Install the grease fitting.
3. Attach the drive shaft to the U-joints with bolts and lockwashers.

Installation

1. Fasten the yoke with tube and spline end **2** U-joint Figure 8-33 to the parking brake disc on the front axle with bolts, lockwashers.

NOTE: The drive shaft must have both ends exactly on the same plane as shown in Figure 8-33.

2. Fasten the other end to the transmission.

3. Apply grease with a grease gun to the slip joint. Apply grease until it exists through the dust cap. See *Lubrication Procedure* on page 8-21.
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.

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. Apply grease to the fitting 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 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.

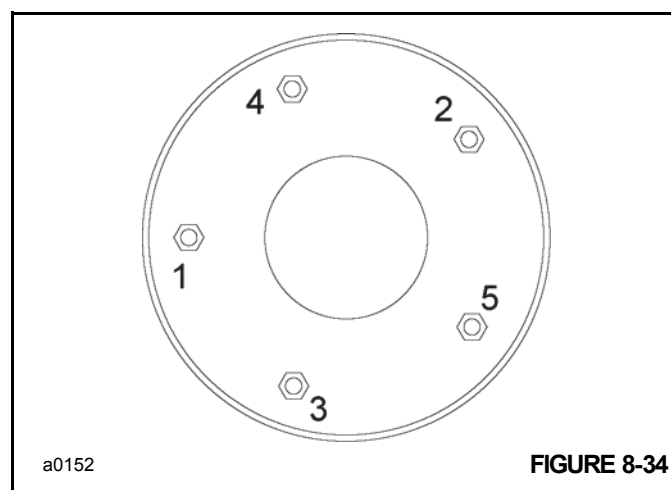
Tire Pressures

Tire Size	Pressure
10-15 Bias Ply	8.62 bar (125 psi)

Wheel Stud Nuts

The tightening order of the stud nuts is shown in Figure 8-34. Check the tightness of the lug nuts weekly or after every 50 hours of operation, whichever occurs first.

Wheel stud torque is 475 Nm (350 lb-ft).



SECTION 9
BRAKE SYSTEM

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TECHNICAL DATA

Front Axle Brakes

Type	Oil-immersed multi-plate disc
Actuation	Hydraulic
Location	Inboard - Axle Arms (2 brake sets)
Friction Plates	4 per set
Outside Diameter	165 mm (6.5 in)
Inside Diameter	103 mm (4.06 in)
Piston Operation	Positive retraction

Accumulator

Type	Bladder, Hydro-pneumatic
Volume	2.0 L (122 cu. in)
Nitrogen Pre-charge Pressure	51.71 ± 0.69 bar (750 ± 10 psi)

Accumulator Charging Valve

Nominal High Limit	137.90 ± 3.45 bar (2000 ± 50 psi)
Nominal Low Limit	110.31 ± 3.45 bar (1600 ± 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)

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 axle service brakes.

Description of Operation

Hydraulic Pump

The hydraulic pump 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

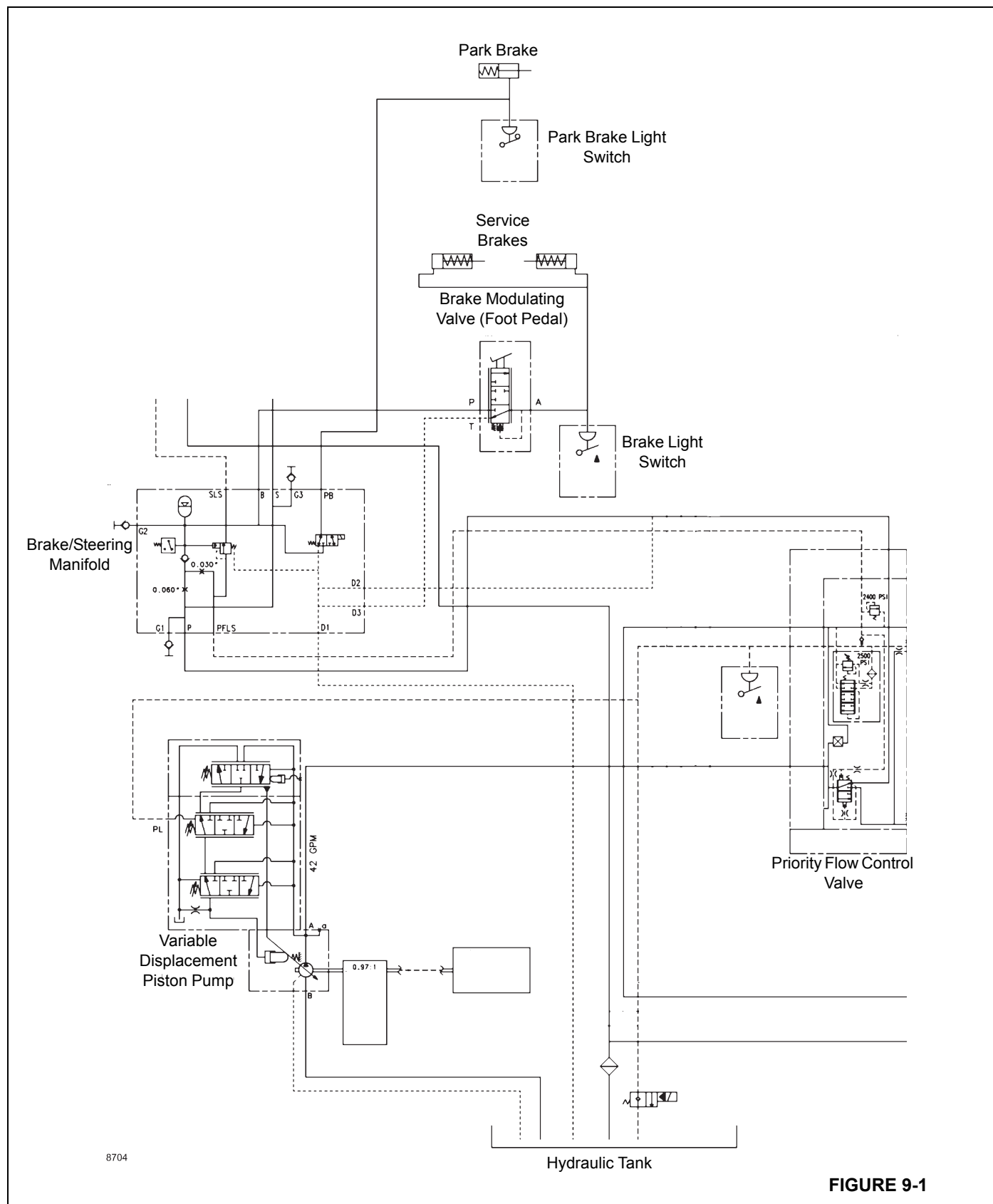
steering operation the priority flow control valve shifts to furnish flow to the steering system. (See Steering System, Section 10) The priority flow control valve also includes the relief valve used to protect the steering and brake systems.

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.



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.

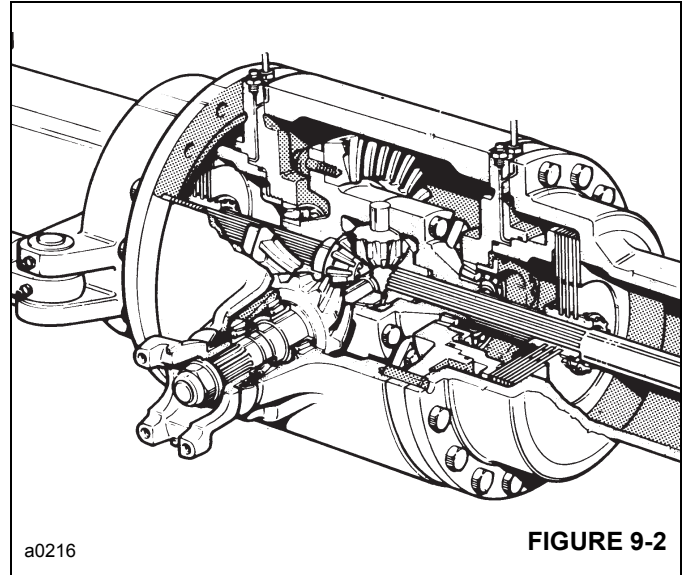


FIGURE 9-2

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 9-3. 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.

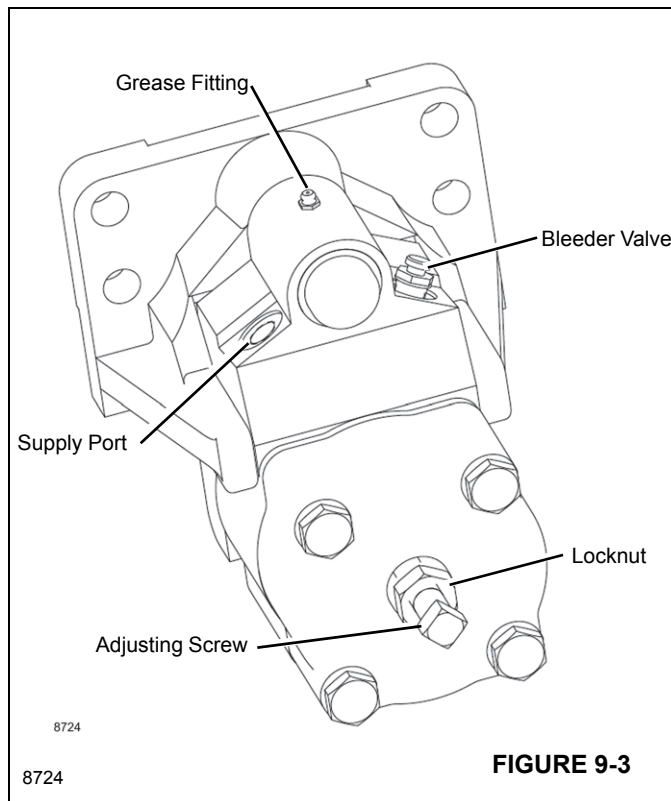


FIGURE 9-3

Parking Brake Solenoid Valve

The parking brake solenoid valve Figure 9-4 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.

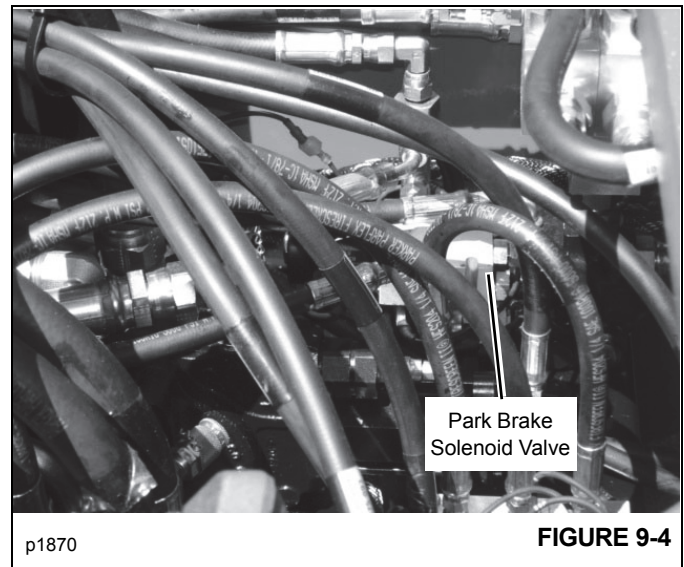


FIGURE 9-4

MAINTENANCE AND ADJUSTMENTS

Service Brake Bleeding

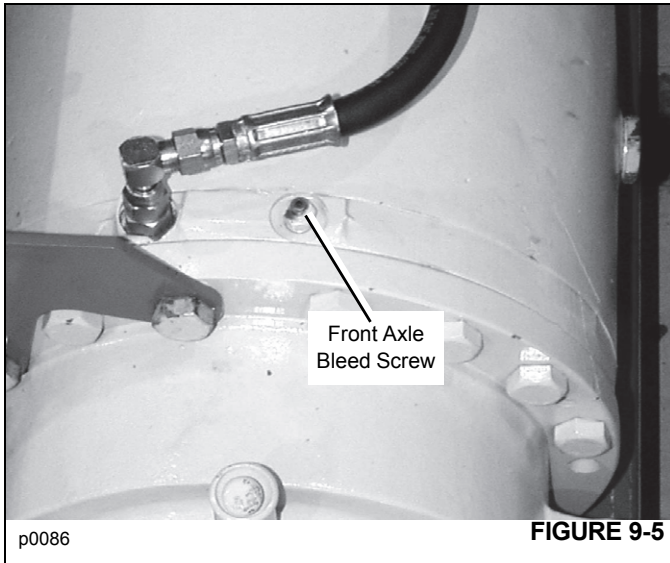
When ever a brake line is disconnected, the brake system must be bled to remove any trapped air. Air in the brake lines will cause the brakes to be spongy.

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.

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 9-5 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.

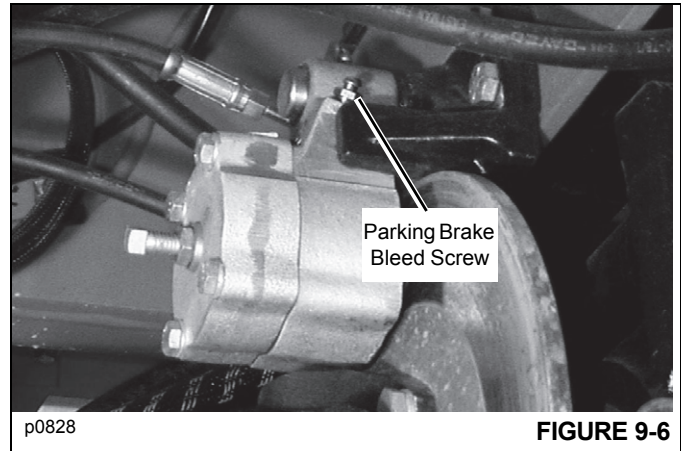


Parking Brake Bleeding

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 9-6 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 9-7.
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.

Lining Replacement



WARNING

Before replacing the lining, 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.

1. Loosen lock nut and back off adjusting screw. See Figure 9-7.
2. Disconnect fluid line from brake. Cap end of fluid line and supply port of brake to prevent debris from entering system.
3. Remove bolts used to fasten the mounting bracket assembly to the machine. Remove brake and mounting bracket assembly from machine and remove mounting bracket assembly from brake.
4. Place brake in a soft jawed vise with disc clearance slot facing up. Clamping should be done on the sides of the brake on machined surfaces.
5. Remove screws and bushings. Using a thin blade tool, pry lining from housing and remove through disc clearance slot.
6. Rotate lining assembly until screws are aligned with access holes in housing. Remove flat head screws. Pry lining from piston and remove through disc clearance slot.
7. Install new lining into piston through disc clearance slot. Install new flat head screws and torque to 2.7-3.4 N-m (24-30 lb-in).
8. Insert new bushings into new lining. Install new lining into housing through disc clearance slot. Line up the holes with the housing and fasten with new screws, torque to 2.5-3.2 N-m (22-28 lb-in).
9. Reinstall brake on machine. See the following procedure and *Parking Brake Adjustment* on page 9-6.

Brake Installation

1. Verify the bleed port is located correctly. The bleeder valve plug should be located on the top side of the brake housing when the brake is installed. See Figure 9-3.
2. Loosen lock nut and back off adjusting screw slightly. Push lining assembly back into brake housing.



CAUTION

Brake linings are susceptible to contamination. When installing or servicing brakes, keep all oil and fluids away from the linings. Poor brake performance may result if the linings are contaminated.

3. Mount brake and bracket assembly on disc and bolt securely to machine. Torque mounting bolts to 127 N-m (94 ft-lb).
4. Connect hydraulic supply line to brake.
5. Apply hydraulic pressure to the brake supply port (maximum of 172.4 bar [2500 psi]). The hydraulic pressure will release the brake, allowing the stator pads to be separated.
6. Bleed the system by opening the bleeder valve. Close bleeder screw and cycle brake 5 times. Repeat opening bleeder screw/cycling brake until all air is out of system. Torque bleeder valve to 12.2-20.3 N-m (9-15 lb-ft). See Figure 9-3.

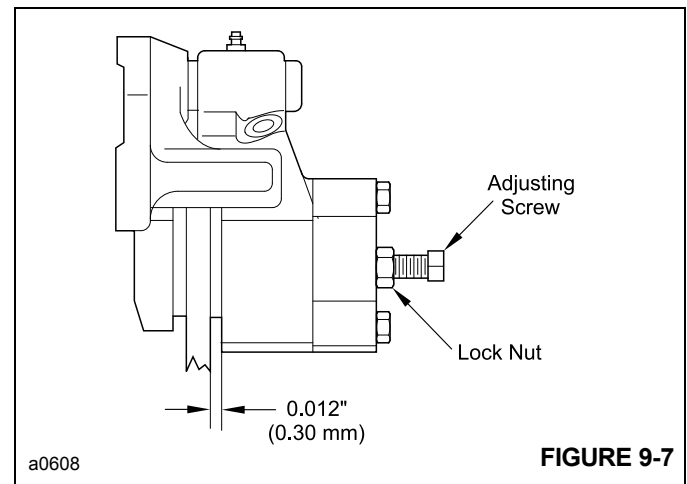


FIGURE 9-7

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 ± 0.69 bar (750 ± 10 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.

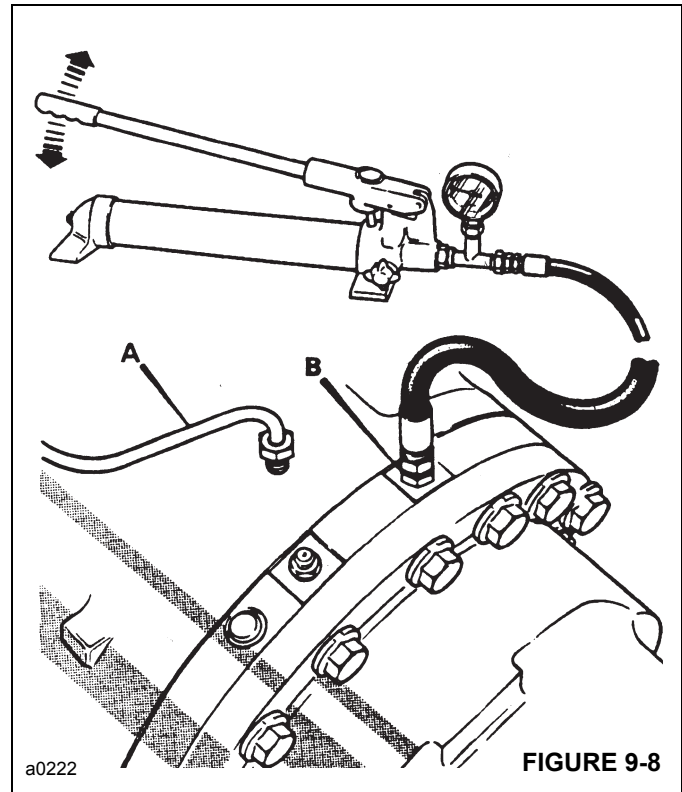
NOTE: Before working on the brake system make sure the crane is on level ground and chock all four wheels.

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 9-4.

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 9-8.



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 9-8.

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 9-9.

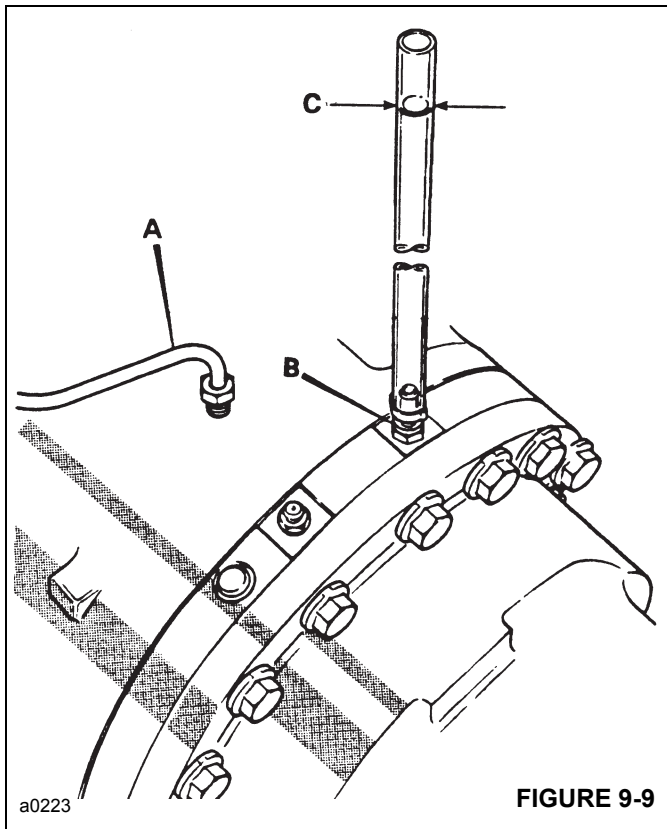


FIGURE 9-9

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 9-5.

SERVICE BRAKE REPAIR

Axle Arm and Brakes

Disassembly

Axles are fitted with brake controlled back off to maintain a constant clearance of 0.6 mm (0.02 in) within the brake pack.

It is important that only one side at a time is dismantled to prevent damage to the bearings and preserve the crownwheel and pinion backlash setting.

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. It is recommended that the axle be removed from the machine when dismantling the axle brakes, refer to Removal and Replacement.

NOTE: Before dismantling it is good practice to mark components for alignment and identify them as right and left hand to ensure correct assembly.

2. Remove bolts 1. Use a heavy duty (6 point) socket to unscrew them.

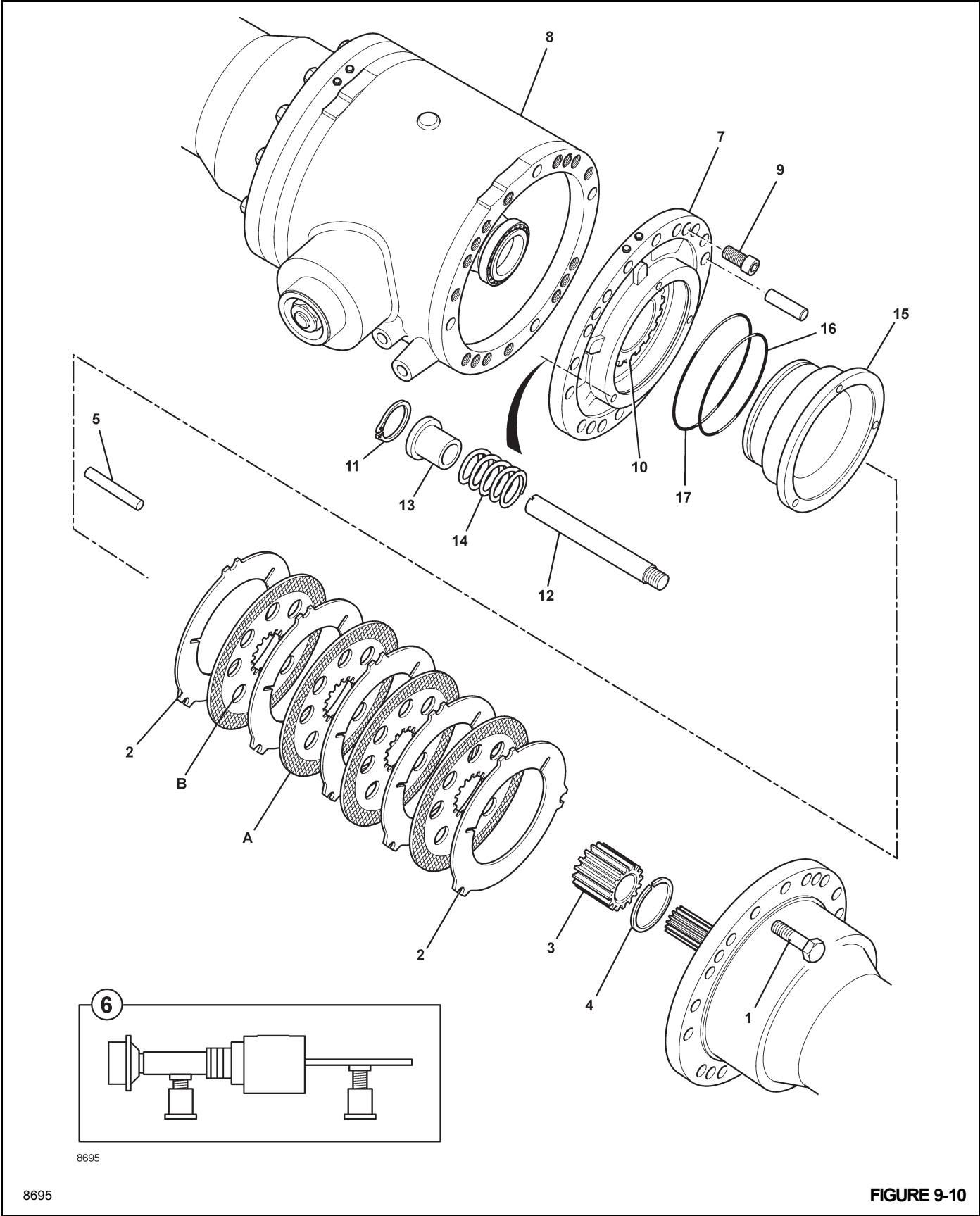


FIGURE 9-10

3. Carefully separate the stub axle arm from the drive head. If necessary tap the casing with a soft faced hammer. Remove all traces of the old sealant from the mating faces.

NOTE: The brake pack comprises 4 friction plates and 5 counter plates. There are two counterplates **2**, one at each end of the brake pack, which are not secured to the plate carrier **3**. If the plates are to be re-used, note their positions and which way round they are then withdraw the brake pack.

4. Remove the circlip **4**. If the brake pack is to be re-used, note the positions of the plates before removing them.
5. The wear limit of friction plates is to the depth of the cross hatching **A**. Check all plates for flatness and damage. (Some scoring of the counterplates is normal.) Renew the brake pack complete if worn or damaged. Do not renew individual plates.
6. Remove the three reaction pins **5**. Inspect for damage.

NOTE: If new brake and friction plates are being fitted new brake back off pins and tension bushes must also be fitted. Failure to do so could result in the brake being permanently on.

7. Before removing the brake housing and piston assembly support the differential with a drive shaft or other suitable support, as shown at **6**.
8. Match mark the brake piston housing **7** and the drive head. Undo four capscrews **9** and remove the brake housing and piston assembly.

NOTE: Do not disturb nut **10** otherwise the bearing pre load will have to be reset.

9. Remove circlips **11**, remove back off pins **12**, tension bushes **13** and springs **14**.
10. Remove brake piston **15** from brake housing **7**.
11. Remove and discard seals **16** and **17**. Inspect the housing bore for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.

Assembly

1. Remove all traces of old sealant from the mating faces of the drive head and the brake piston housing.
2. Fit new seals **17** and **16**. Make sure they seat squarely in their grooves.
3. Apply Loctite 243 to threads of back off pins **12**. Screw the back off pins **12** into the brake piston. Carefully press the piston **15** all the way into its housing **7**.
4. Fit the springs **14** over the back off pins.
5. Place the tension bush **13** over the back off pin **12**. Using a suitable tool (steel tube) drive the tension bush onto the back off pin using a soft face hammer until the circlip **11** can just be fitted.
6. Apply Loctite 574 to the drive head mating face, then fit the brake piston housing assembly. Ensure that the match marks made during dismantling are aligned.
7. Fit capscrews **9** and torque tighten to 56 Nm (42 lb-ft).
8. Remove the differential support.
9. Assemble the five friction plates and six counterplates **2** onto the brake carrier **3**. If the original brake pack is being re-used, return the plates to their original positions, refer to Disassembly. Soak new friction plates in Mobil Fluid 424 before assembly. Fit circlip **4**.

NOTE: On assembly of the brake packs, the oil flow holes **B** must be aligned with each other when being fitted to the brake plate carrier.

10. Locate the three reaction pins **5** into their grooves, securing them with grease. Push the pins fully into their location holes in the housing.
11. Install one counterplate **2** into the housing securing it in place with grease, then the brake pack, then the other counterplate. Return re-used counterplates to their original positions. Push the brake pack fully home.
12. Apply Loctite 574 to the mating face of the drive head, and Loctite 243 to the threads of bolts **1**. Locate the stub axle arm onto the drive head, ensure that the match marks made during dismantling are aligned.
13. Fit bolts **1** and torque tighten to 98 Nm (72 lb-ft).

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 9-11 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 9-11 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 9-6.
 14. Open the accumulator needle valve and then bleed air from the system as described on page 9-5.
- 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.

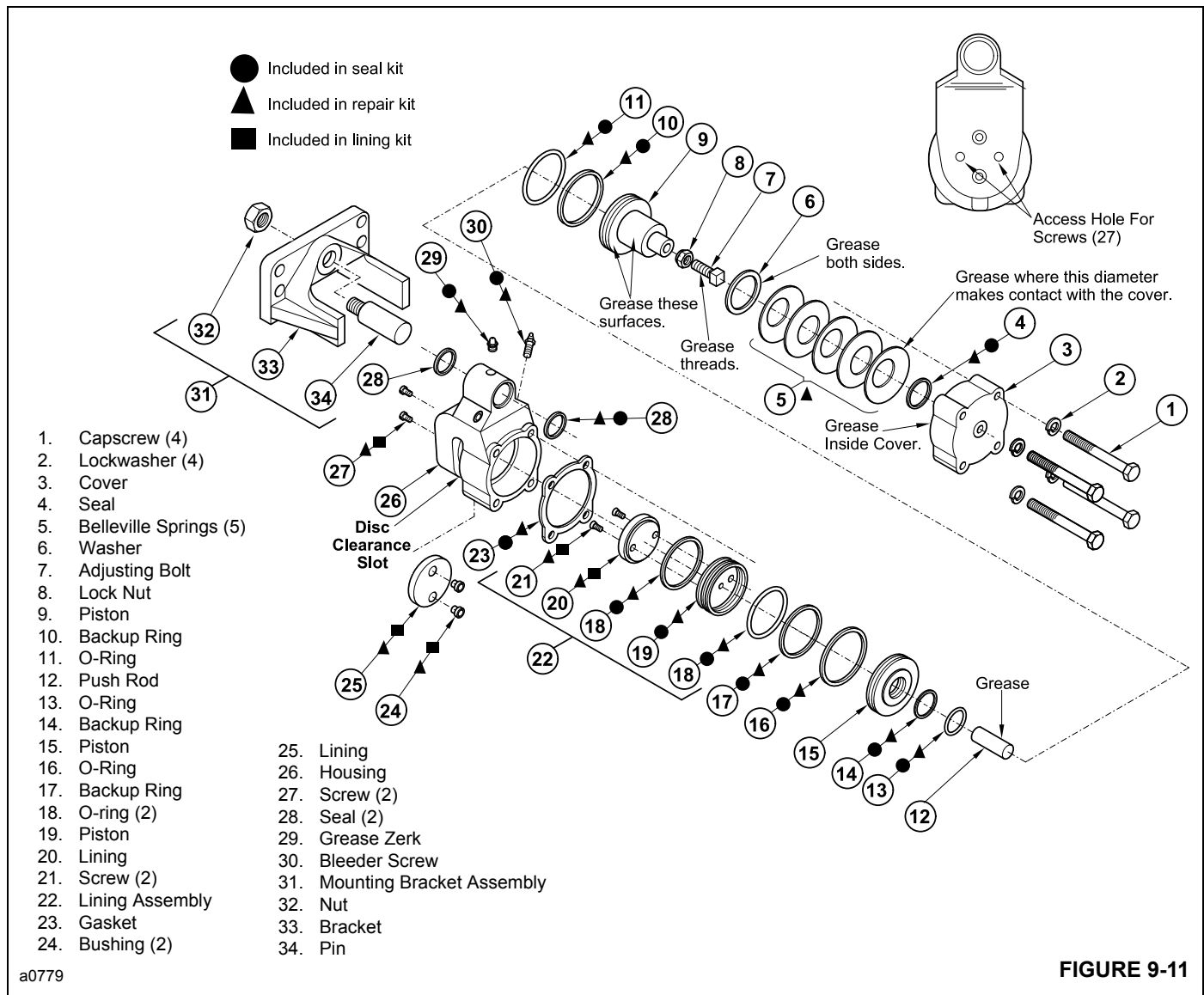


FIGURE 9-11

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 9-11 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 9-11 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.

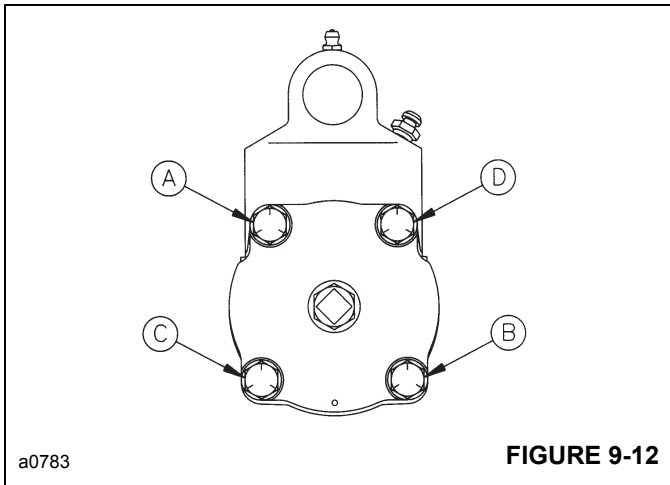
8. Remove bleeder screw **30**.
9. Using a sharp bladed tool, carefully remove two seals **28** from housing **26**. Note the direction the seals were installed.



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 9-12 until spring pre-load is released.



11. Remove capscrews **1** Figure 9-11, 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 9-11 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

19. Install new lining **25** Figure 9-11 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).

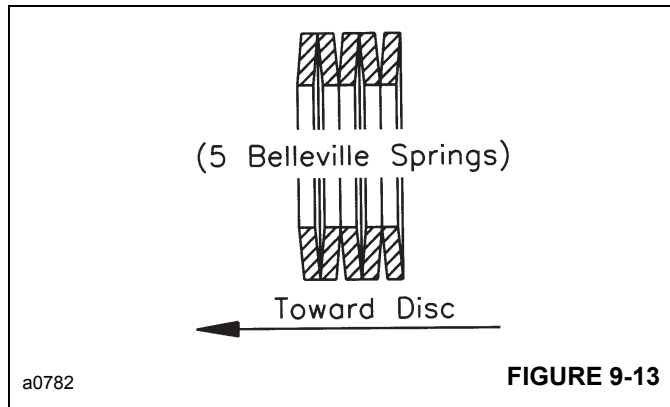
23. Install new O-rings **13** and **16** and new backup rings **14** and **17** on piston **15**. Be sure they are installed in the correct order.

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 9-13.



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 9-12. 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 9-6.
34. Open the accumulator needle valve and then bleed air from the system as described on page 9-5.

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 9-11 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 9-11 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 9-12 until spring pre-load is released.
10. Remove capscrews **1** Figure 9-11, 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 9-11 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 9-13.
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 9-12. 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 9-6.

30. Open the accumulator needle valve and then bleed air from the system as described on page 9-5.

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 9-14.
 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 9-14.

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 9-14 with clean hydraulic oil and carefully slide into plug end of housing **12**.

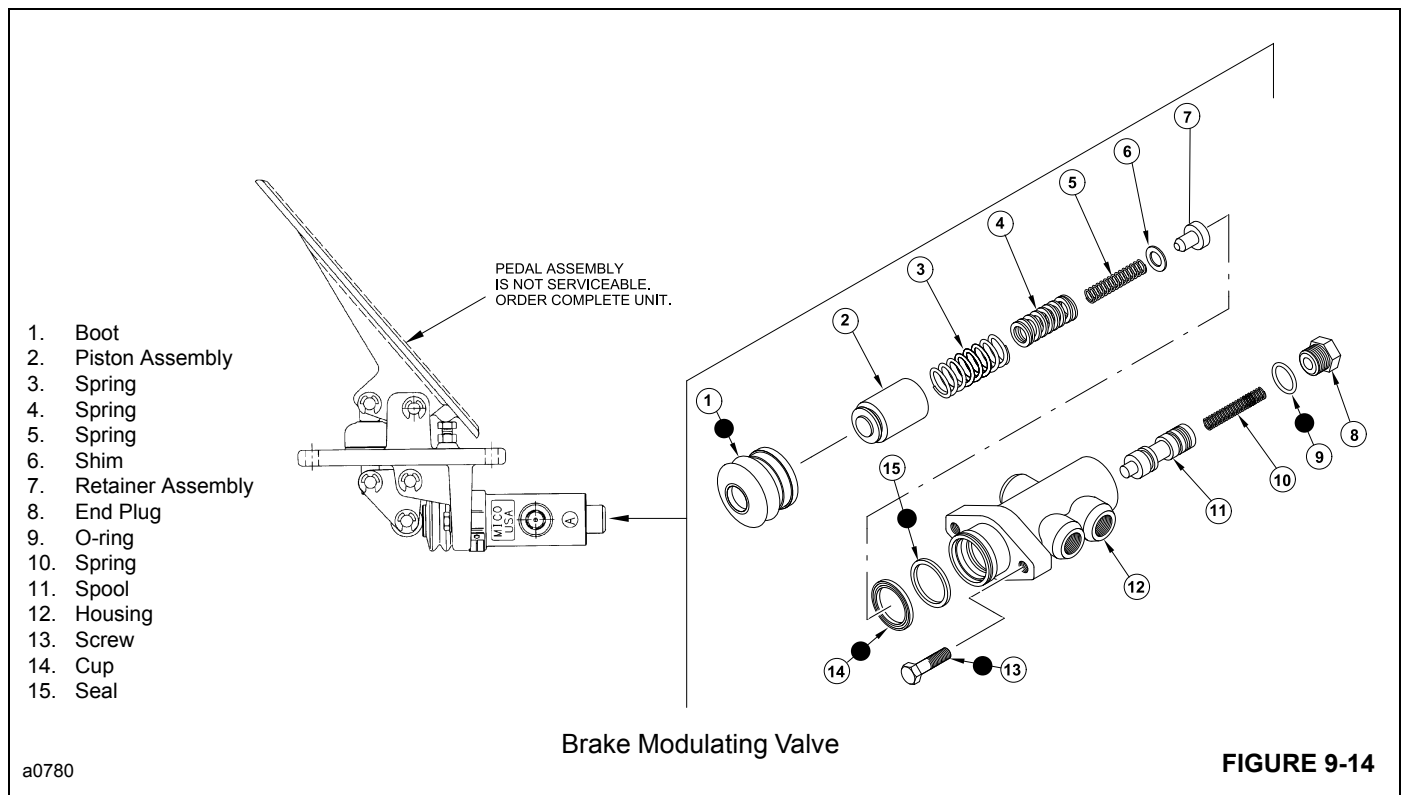
NOTE: The spool must slide freely into the bore. If either part is damaged, a new valve assembly may be required.

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 9-5.



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

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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 power track rod, one rear power track rod 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 power track rods.

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.

Priority flow is handled by the directional control valve. The brake/steering manifold controls the functionality of the brakes and steering.

Steering Modes

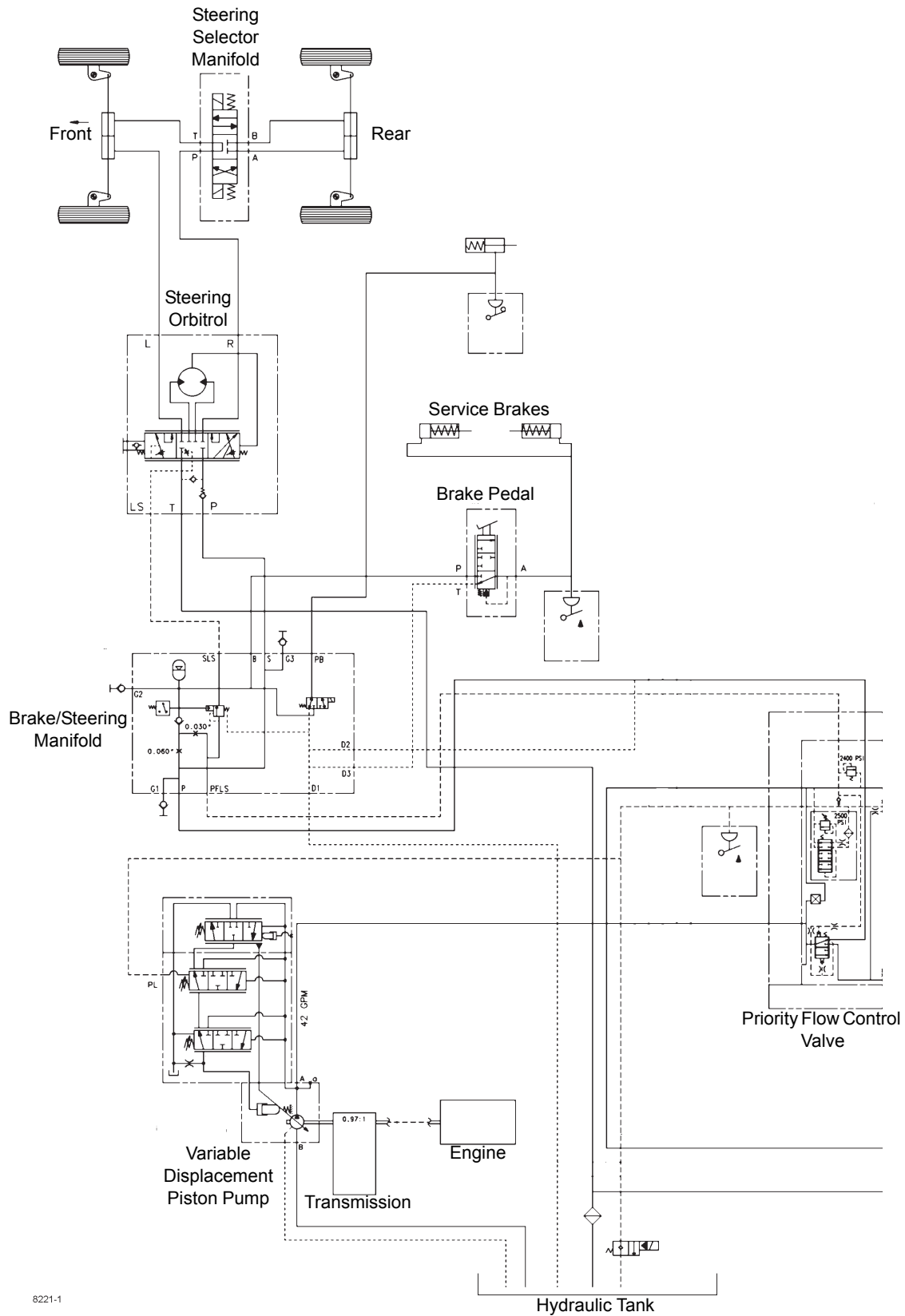
The crane can be operated in three steering modes. These modes are selected using the steering selector switch located to the left of the operator on the instrument panel. The three modes are:

- 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, 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 two 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 no solenoid is actuated. Oil passes through the porting of the valve block to the right end of the front axle power track rod. The pistons move to the left, extending the left rod and retracting the right rod, 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.



8221-1

8221-1

Steering System

FIGURE 10-1

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, 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 two 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 one of the solenoids is actuated. Oil passes through the porting of the valve block and out port A to the rear axle power track rod. Oil is directed to the left rod, 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 power track rod. The left rod 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, 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 two 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 the other solenoid is actuated. Oil passes through the porting of the valve block and out port B to the rear axle power track rod. Oil is directed to the left rod, 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 power track rod. The left rod 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.

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 10-2 and are activated when a bracket attached to the steering yoke of the axle, is aligned with the sensor.

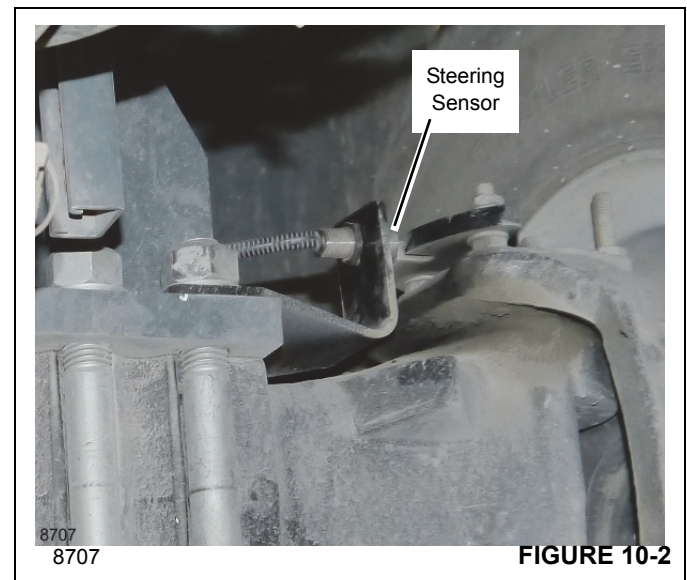
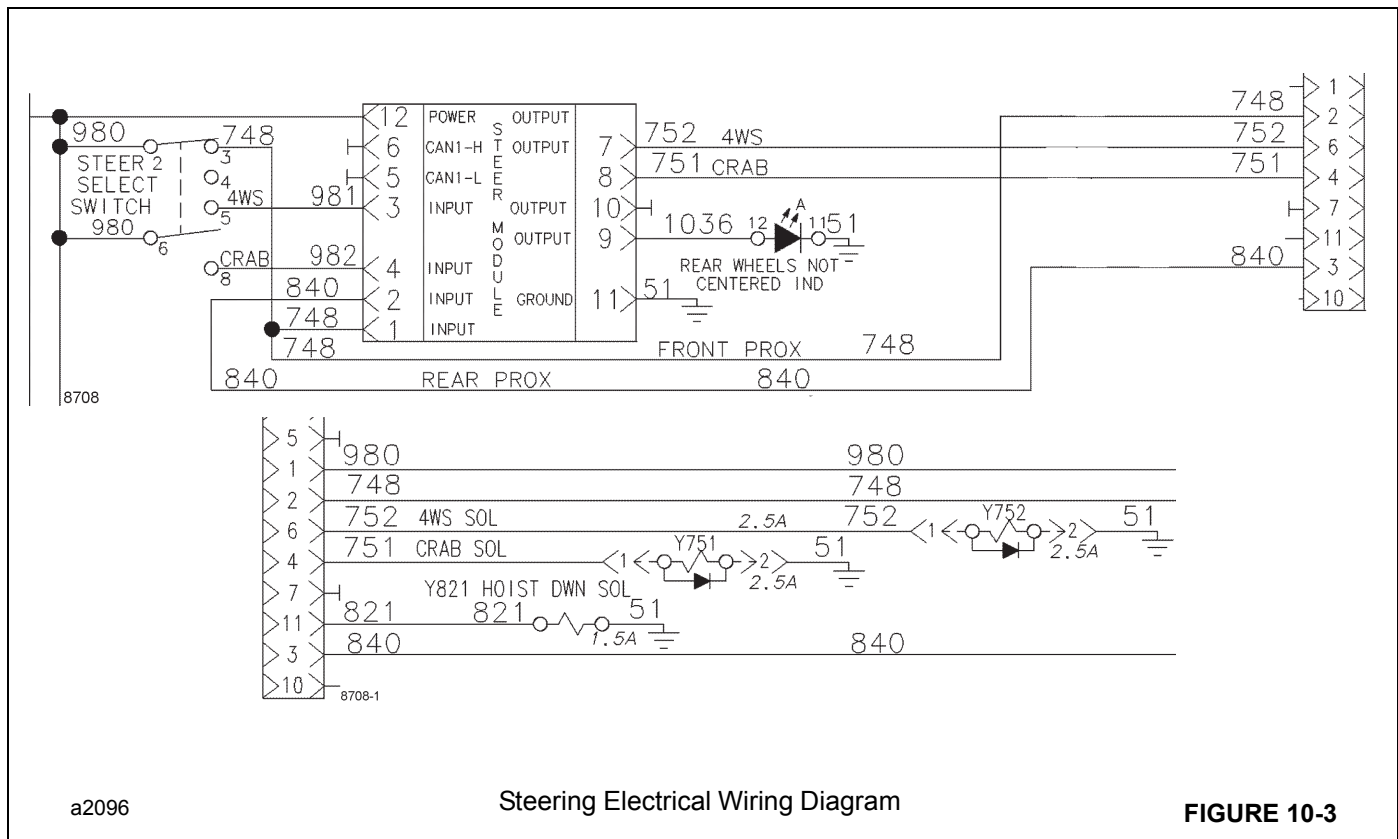


FIGURE 10-2

Principle Of Operation

The steering system electrical circuit includes two sensors Figure 10-3 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 to put the steering system in four wheel steer.



Sensor Operation and Spacing Checks

Checking Alignment and Operation

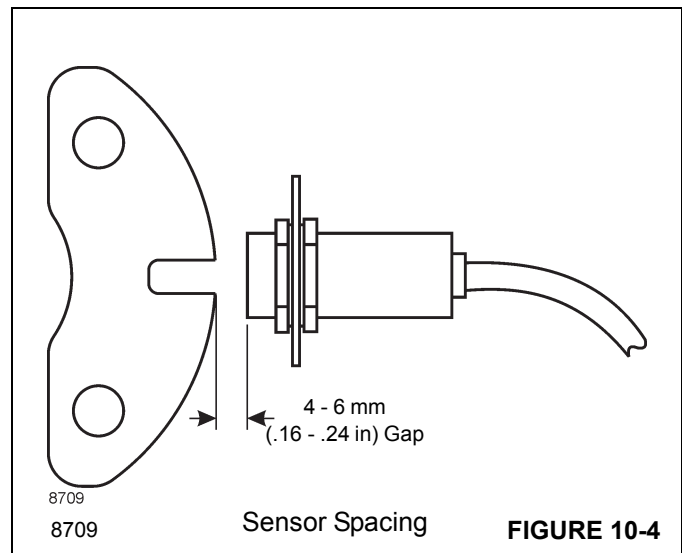
Both sensors must be working and spaced properly for the steering mode selection to function properly.

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 4 mm (0.16 inch) to 6 mm (0.24 inch) in front of the sensor. A yellow light 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 10-4.



2. Measure the distance between the end of the sensor and edge of the sensor bracket. The sensor spacing must be between 4 mm (0.16 inch) to 6 mm (0.24 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"> 1. Worn or malfunctioning pump. 2. Priority valve not operating correctly. 3. Malfunctioning relief valve. 4. Overloaded steering axle. 5. Air in hydraulic system. 6. Malfunctioning steering orbitrol. 7. Malfunctioning steering mode valve. 8. Mechanical failure. 	<ol style="list-style-type: none"> 1. Repair or replace the pump. 2. Check for stuck spool. Repair or replace. Check load sense line for leaks or poor connection. 3. Replace the priority valve. 4. Reduce the load. 5. Bleed system - bleed the load sense line. 6. Remove and inspect. 7. Check if spools are sticking. Repair or replace. Check if solenoids are operating. Replace if needed. 8. Check for damaged axle components, such as cylinders, tie rods, linkages, etc.
Steering wheel turns on its own.	<ol style="list-style-type: none"> 1. Dirt in steering orbitrol (causing sleeves to stick open). 2. Steering actuator centering springs damaged or broken. 3. Steering actuator - position of rotor to shaft slot incorrect. 	<ol style="list-style-type: none"> 1. Clean and inspect unit. 2. Check orbitrol. Repair or replace. 3. Correct if required.

Symptom	Probable Cause	Action
Crane will not turn when the steering wheel is turned.	<ol style="list-style-type: none"> 1. Insufficient oil level. 2. Leaks in relevant hoses or component connections. 3. Air in the hydraulic system. 4. Low pump flow. 5. Malfunctioning relief valve. 6. Worn or damaged parts in the steering orbitrol. 7. Priority valve not operating correctly. 8. Steering mode valve not operating correctly. 9. Mechanical failure. 10. Steering column splined shaft not fully engaged in orbitrol. 	<ol style="list-style-type: none"> 1. Check for leaks and fill tank. 2. Check hoses and connections for leaks. 3. Bleed system -bleed the load sense line. 4. Check pump flow. If required, repair or replace the pump. 5. Replace priority valve. 6. Remove, inspect and repair. 7. Check if the priority valve is sticking and repair if necessary. Check the load sense line for leaks or loose connections. 8. Check for sticking spools. Clean or replace. Check for faulty solenoids. Replace if necessary. 9. Check for damaged axle components, such as cylinders, tie rods, linkages, etc. 10. Check shaft engagement.
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"> 1. Selector switch faulty. 2. Proximity switches not operating correctly. 3. Steering mode valve not operating. 4. Leaks in relevant hoses or component connections. 5. Electrical failure. 	<ol style="list-style-type: none"> 1. Replace switch. 2. Check setting of proximity switch. Reset or replace switches. 3. Check if spools are sticking. Repair or replace. 4. Check hoses and connections for leaks. Tighten or replace. 5. Check relevant electrical connectors if problem still persists, do a wiring continuity check of relevant circuits.
Wander - Tendency of vehicle to deviate from course.	<ol style="list-style-type: none"> 1. Air in system. 2. Worn steering linkage. 3. Loose steering cylinder piston. 4. Severe wear in steering orbitrol. 	<ol style="list-style-type: none"> 1. Correct condition and add fluid. Bleed system and load sense line. 2. Repair or replace linkage. 3. Repair or replace cylinder. 4. Repair or replace the orbitrol.
Slip - A slow movement of steering wheel fails to cause any movement in steering wheels.	<ol style="list-style-type: none"> 1. Leakage of cylinder piston seals. 2. Worn steering orbitrol. 	<ol style="list-style-type: none"> 1. Repair or replace cylinder. 2. Repair or replace orbitrol.

Symptom	Probable Cause	Action
Erratic steering.	<ol style="list-style-type: none"> 1. Air in system due to low level of hydraulic oil, cavitating pump, leaky fitting, pinched hose, etc. 2. Loose steering cylinder piston. 3. Sticking check valve. 4. Turning steering wheel too rapidly. 	<ol style="list-style-type: none"> 1. Correct condition and add fluid. Bleed system and load sense line. 2. Repair or replace cylinder. 3. Clean or replace. 4. Slow movement.
Spongy or soft steering.	<ol style="list-style-type: none"> 1. Air in hydraulic system. Most likely air trapped in cylinders or lines. 2. Low fluid level. 	<ol style="list-style-type: none"> 1. Correct conditions. Bleed air out of system and load sense line. 2. Add fluid and check for leaks.
Free wheeling - Steering. Wheel turns freely with no feel of pressure and no action on steering wheels.	<ol style="list-style-type: none"> 1. Steering column shaft is loose or damaged. 2. Lower splines of column may be disengaged or broken. 3. Steering orbitrol meter has a lack of oil. This can happen on start up, after repair, or long down time intervals. 4. Steering cylinder piston seal blown out. 	<ol style="list-style-type: none"> 1. Tighten the steering wheel nut. 2. Repair or replace the column. 3. Usually starting engine will cure the problem. Bleed system if necessary. 4. Determine cause. Correct and replace the seal.
Excessive free play at steering wheel.	<ol style="list-style-type: none"> 1. Loose steering wheel nut. 2. Steering column shaft worn or damaged. 	<ol style="list-style-type: none"> 1. Tighten the nut. 2. Repair or replace the steering wheel connection or column.
Excessive free play at steered wheels.	<ol style="list-style-type: none"> 1. Leaky steering cylinder seals. 	<ol style="list-style-type: none"> 1. Replace cylinder seals.
Binding or poor centering of steering wheel.	<ol style="list-style-type: none"> 1. Large dirt particles can cause binding between orbitrol spool and sleeve. 	<ol style="list-style-type: none"> 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.	<ol style="list-style-type: none"> 1. Large particles of contamination in metering section. 2. Severe wear and/or broken pin. 	<ol style="list-style-type: none"> 1. Clean the orbitrol. Repair or replace if necessary. 2. Repair or replace the orbitrol.

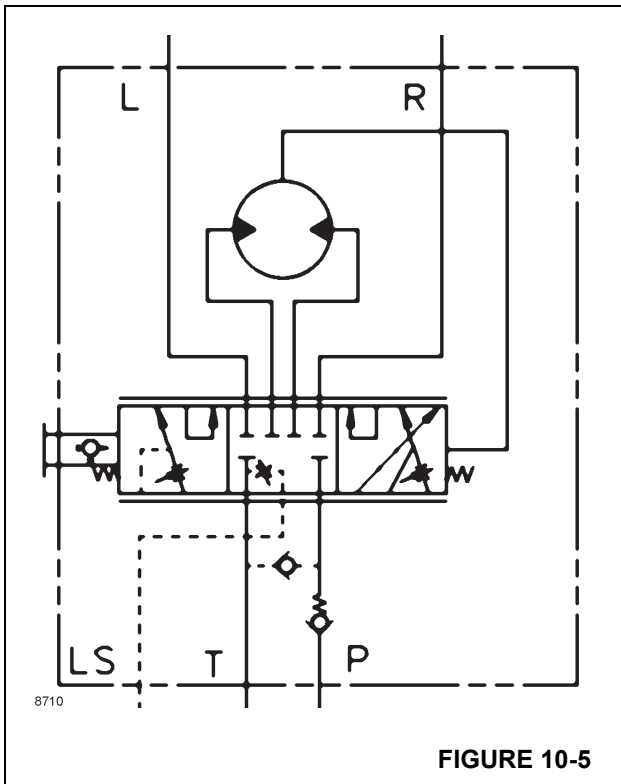
STEERING ORBITROL

Description

General

The steering orbitrol Figure 10-5 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 10-5. 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 10-5. 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

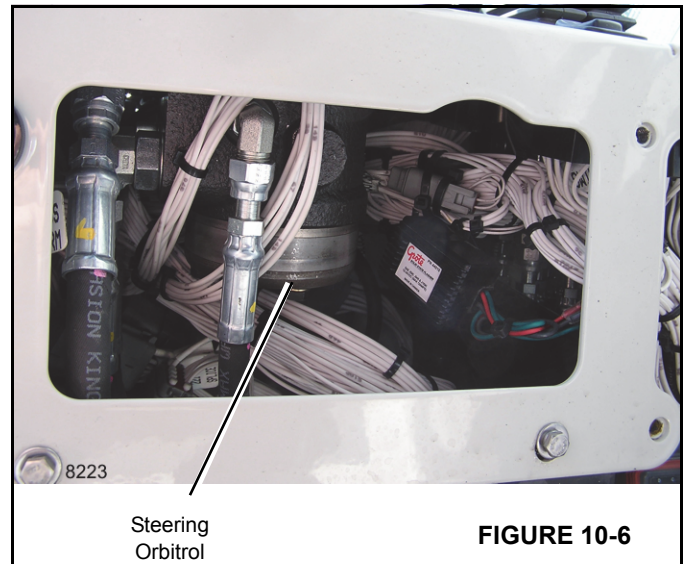
When making a right turn, flow from the pump enters port P Figure 10-5. The gerotor takes this flow and meters it to port R (right turn). Return flow from the steering cylinders, enters port L and is returned to tank through port T.

Emergency Manual Steering

The gerotor Figure 10-5 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.

Removal

1. Remove the outside cover plate Figure 10-6 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.

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

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.

NOTE: Depending on accessibility, the steer cylinder can be removed and replaced with the axle on the machine. Where accessibility is limited, the axle should be removed before removal of the cylinder (see *Removal on page 8-3*).

1. Thoroughly clean external parts.
2. Disconnect and cap hydraulic hoses to prevent loss of fluid and ingress of dirt. Label hoses for identification and correct refitting.
3. Remove locking screws **A** and pivot pins **B**. Swing the track-rod clear of the steering joints.
4. Remove screws **C** and washers **D** (4 off each) from the cylinder mounting flange.
5. Using a soft faced hammer, tap the closed end of the cylinder and carefully withdraw the cylinder and trackrod from the housing.

NOTE: Before removal, mark the cylinder flange and housing for relocation.

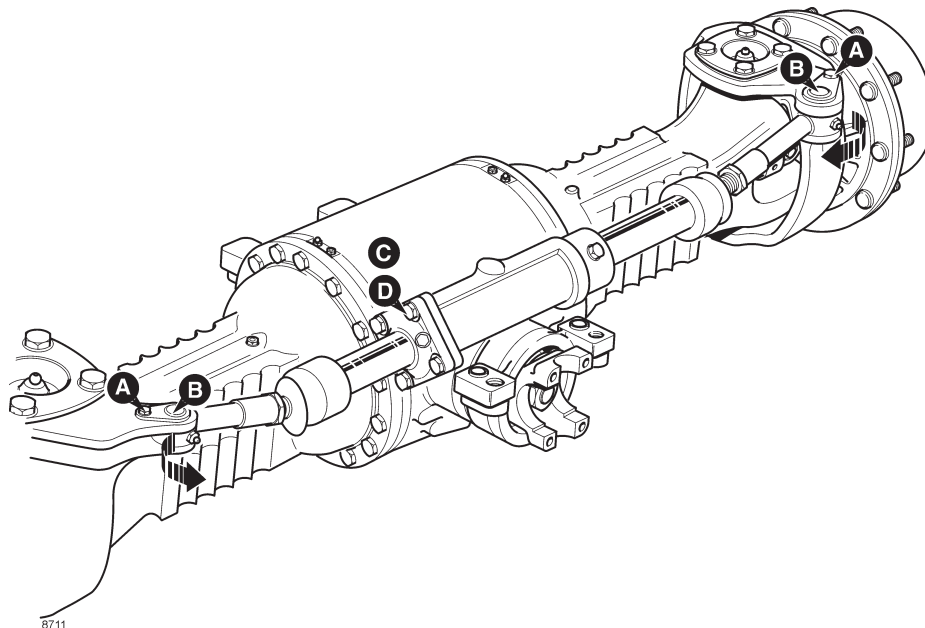
Replacement

Replace the power track rod by reversing the removal procedure.

Apply Anti-Seize Paste to pivot pins **B** to facilitate subsequent removal.

After connecting hoses, check the hydraulic fluid level, and if necessary top-up.

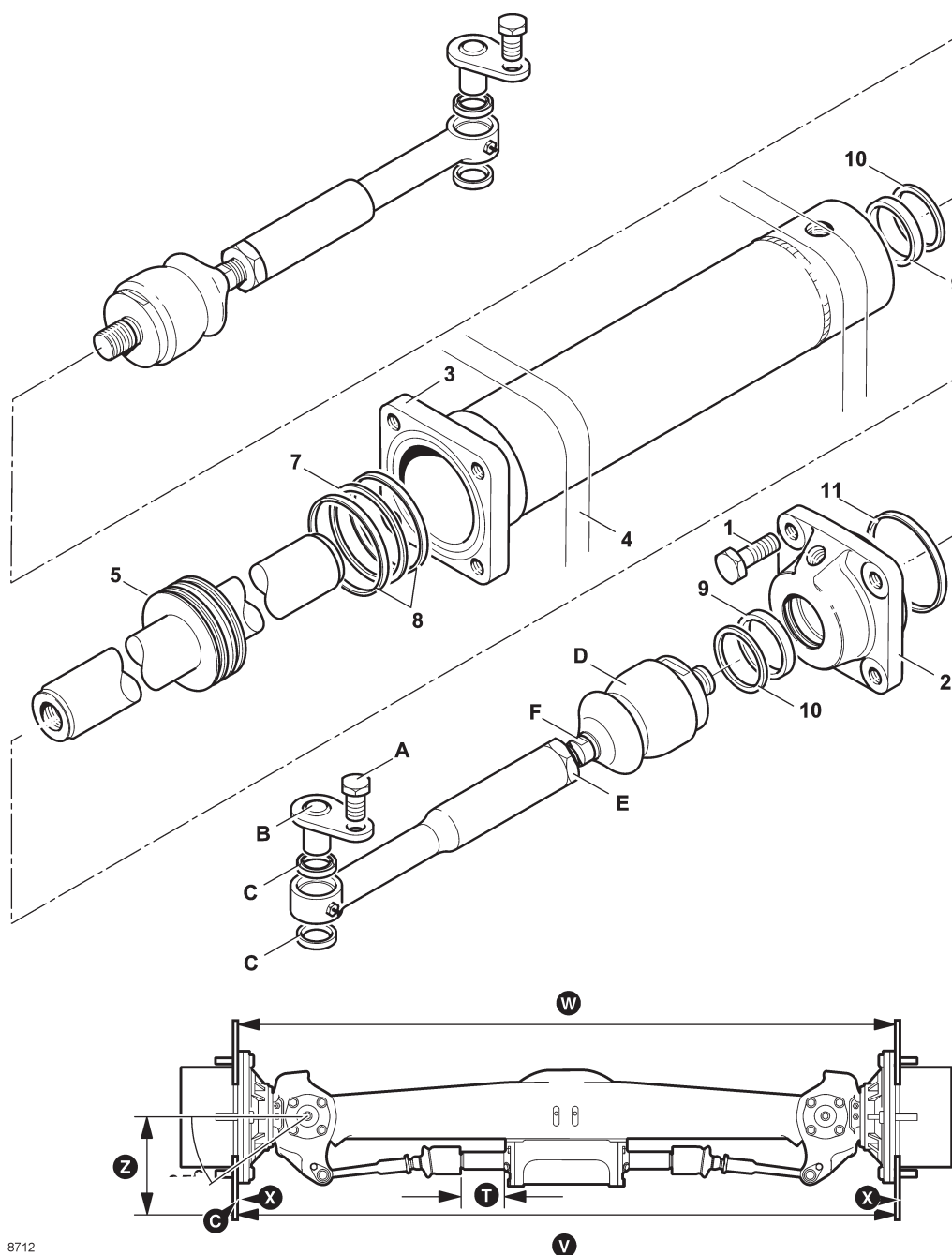
Bleed the Hydraulic System (see Steering System - Bleeding Procedure).



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FIGURE 10-7

Disassembly

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FIGURE 10-8

The following procedures can only be carried out with the axle removed from the machine.

It will be necessary to provide a suitable stand on which to support the axle once it has been removed from the machine.

1. Remove setscrew **A** (Figure 10-8), extract pivot pin **B** and disengage the track rod ends from the steering knuckles.
2. Remove the ball joints **D**.

NOTE: The piston rod operates at full length and damage to the surface will cause fluid leaks. DO NOT attempt to grip the rod with pipe grips etc.

- a. Using two suitable open ended spanners located on the flats at **F** and **G** (Figure 10-9), rotate against each other until one ball joint unscrews.

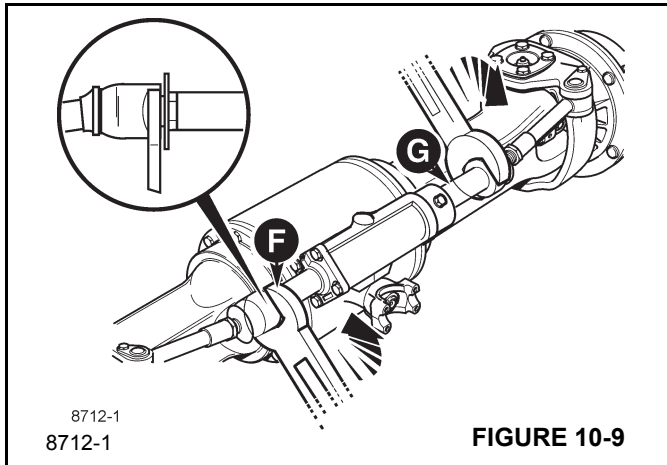


FIGURE 10-9

- b. Unscrew the ball joint until an open ended spanner can be fitted on rod **5** (Figure 10-10). Screw the ball joint against the spanner to secure the spanner and to prevent damage to the rod.

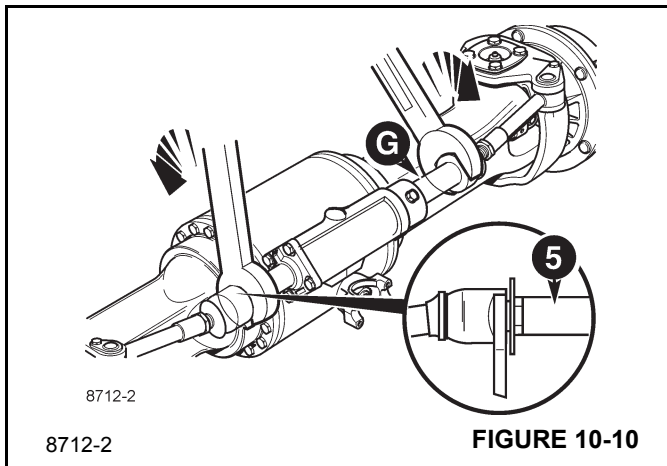


FIGURE 10-10

- c. Using the spanner at **5** to lock the rod, rotate the spanner at **G** to undo the other ball joint.

NOTE: Mark cover **2** (Figure 10-8) and cylinder flange **3** relative to housing flange **4** before removal.

3. Take out screws **1** and remove the cylinder cover/piston guide **2**. Remove and discard seals **9** and **10** with cover seal **11**.

4. Pull piston/rod assembly **5** out of the cylinder. Remove and discard guide rings **8** and seal **7** from the piston.

NOTE: The piston is shrunk onto the piston rod. DO NOT attempt to remove it.

5. Using a soft faced hammer, carefully tap the closed end of cylinder **3** and withdraw the cylinder from its housing.
4. Remove and discard seals **9** and **10**.

Assembly

1. Fit new seal **7** and guide rings **8** to the piston. Ensure they are seated correctly.
2. Grease piston rod seal **9**, wiper ring **10** and fit them into the grooves in the closed end of cylinder **3**. Ensure they are seated correctly.
3. Grease the machined external shoulders on cylinder **3** and insert the closed end into housing **4**. Using a soft faced hammer, carefully tap the flange until the cylinder is fully seated in the housing. Align the flange marking with the housing mark.
4. Apply grease to piston seal **7** and the surfaces of the piston rod. Insert piston/rod assembly **5** into the cylinder, ensuring it is the correct way round, with the piston sleeve towards the closed end of the cylinder, carefully guiding the rod through the seals in the closed end of cylinder **3**.
5. Grease and fit seal **9**, wiper ring **10** and cover seal **11** to the cylinder cover/piston guide. Ensure they are seated correctly.
6. Apply Loctite 574 to cylinder flange face **3**.

Locate cover/piston guide **2** onto the piston rod and slide into position against cylinder flange **3**, aligning the location mark made during dismantling.

7. Insert screws **1** and torque tighten to 166 Nm (122 lb-ft).
8. Coat the first three external threads of track rod end ball joint **D** with Loctite 243 and screw into the end of the steering piston rod. Torque tighten to 400 Nm (295 lb-ft).
9. Grease and fit new web seals **C** to the hub steering knuckle. Ensure the seals are fitted correctly and are fully seated in position.
10. Connect the track rod ends to the hub carrier steering knuckles.

Coat the surface of pivot pin **B** with anti-seize paste and insert the pin into the hub carrier and fit the setscrew **A**. Apply Loctite 243 to the threads and torque tighten to 56 Nm (41 lb-ft).

11. Centralize the steering so that the distance **T** measured from the end of the piston guide to the steering ball joint face is 134 mm (5.27 in).

12. Attach a straight edge **X** to both hubs using a wheel mounting nut.

Make a mark at position **Y** which corresponds to the distance **Z**, wheel center to rim flange on each straight edge.

13. Measure the distance **V** between the two straight edges. Rotate both hubs through 180° and measure the distance **W**. The two measurements should be the same. If not, carry out step 14.

14. Loosen the locknut **E** on each track rod end. To adjust the tracking, use a spanner to rotate the inner ends of the track rods.

Repeat steps 13 and 14 until the two measurements are the same.

Finally check that a steering angle of 40° can be achieved in both directions. If the steering angle is not the same in both directions it is necessary to adjust both track rod ends to compensate while still meeting the requirements of step 13.

Finally torque tighten the locknut **E** on each track rod end to 240/260 Nm (177/192 lb-ft).

Bleeding Procedure

Whenever any hydraulic steering component is disconnected or removed the system must be bled as follows:

With the engine running, this procedure must be carried out in the correct order that is laid down. You must not alter the order of selections and operations.

1. Select 2 Wheel Steer

- a. Turn steering wheel to left, until front wheels are fully locked to the left.

- b. Turn steering wheel to right, until front wheels are fully locked to the right.

2. Select 4 Wheel Steer

- a. Turn steering wheel to left, until front wheels are fully locked to the left.

3. Select 2 Wheel Steer

- a. Turn steering wheel to full right lock.
 - b. Turn steering wheel to full left lock.
 - c. Turn steering wheel to full right lock.

4. Select 4 Wheel Steer

- a. Turn steering wheel to left, until the front wheels are fully locked to the left.

5. Select 2 Wheel Steer

- a. Turn steering wheel to full right lock.
 - b. Turn steering wheel to full left lock.
 - c. Turn steering wheel to full right lock.

6. Select 4 Wheel Steer

- a. Turn steering wheel to left, until front wheels are fully locked to the left.

7. Select 2 Wheel Steer

- a. Turn steering wheel to full right lock.
 - b. Turn steering wheel to full left lock.
 - c. Turn steering wheel to full right lock.

8. Select 4 Wheel Steer

- a. Turn steering wheel to left, until the front and rear wheels are fully locked.

SECTION 11

STRUCTURALS

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BOOMS

General

The 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.

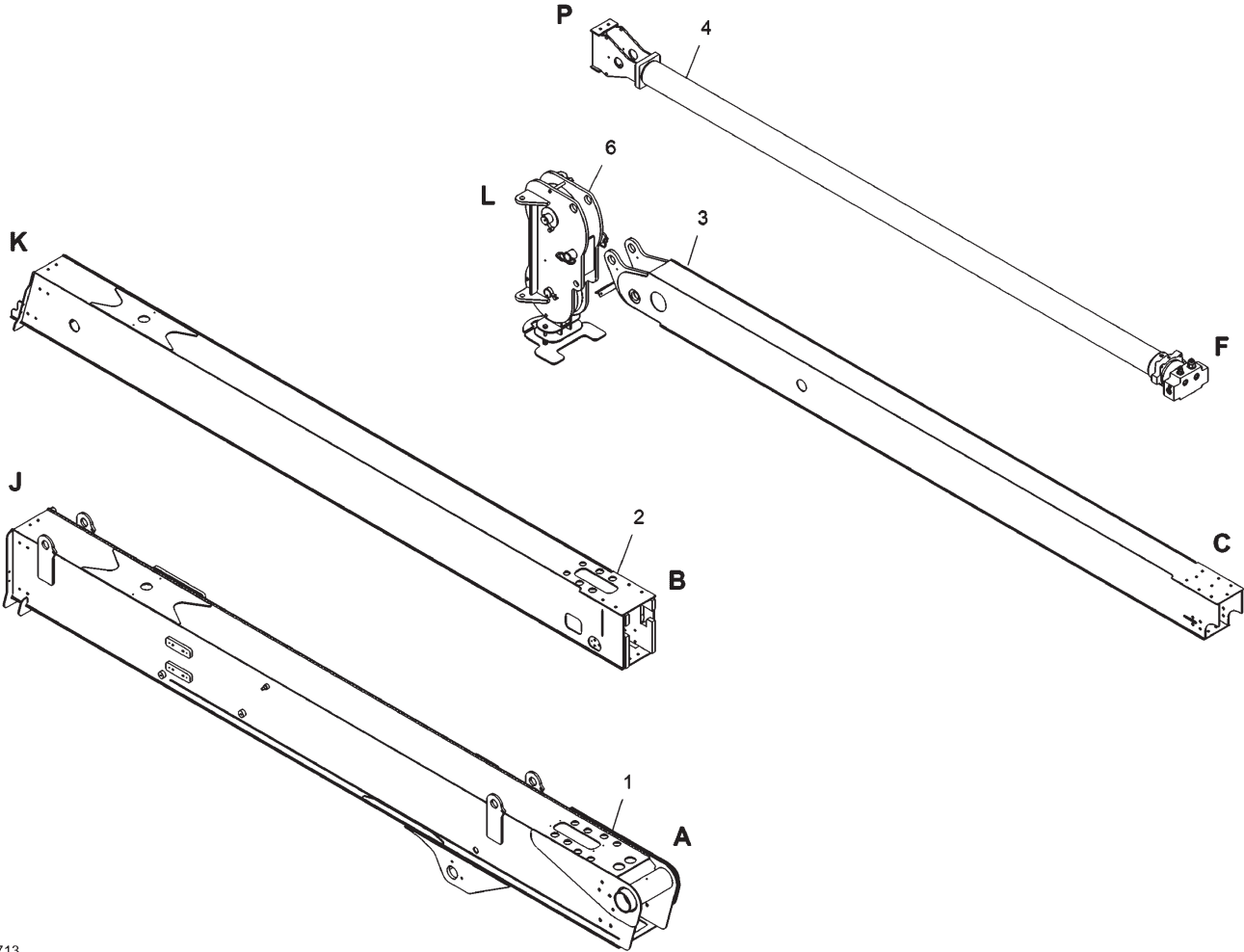
NOTE: Use at least a 1.8 Metric Ton (2 ton) overhead crane when lifting the boom assembly. Be sure slings and/or chains are capable of handling a 1.8 Metric Ton (2 ton) load.

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, Section 3.
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

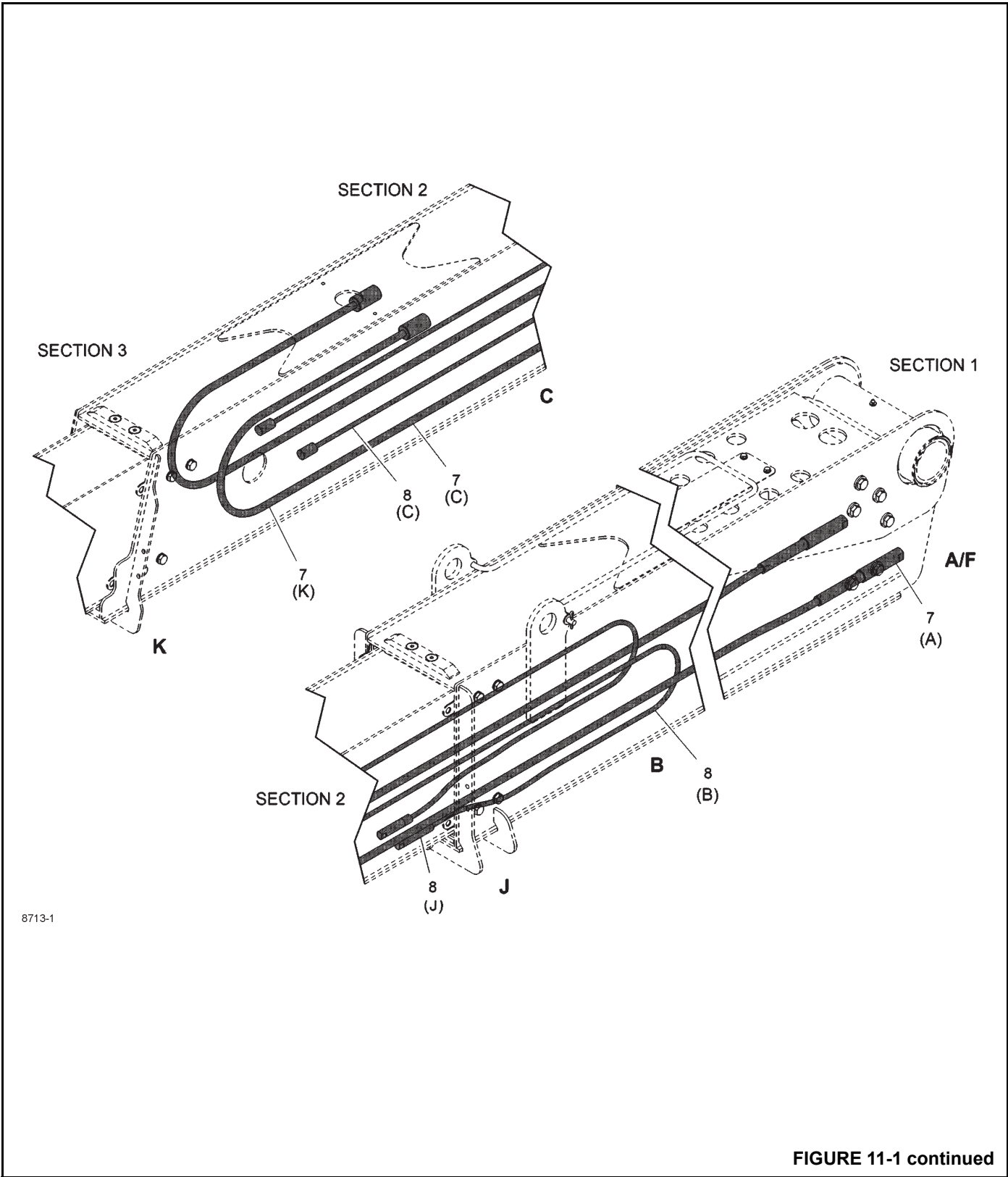
NOTE: Use at least a 1.8 Metric Ton (2 ton) overhead crane when lifting the boom assembly. Be sure slings and/or chains are capable of handling a 1.8 Metric Ton (2 ton) load.

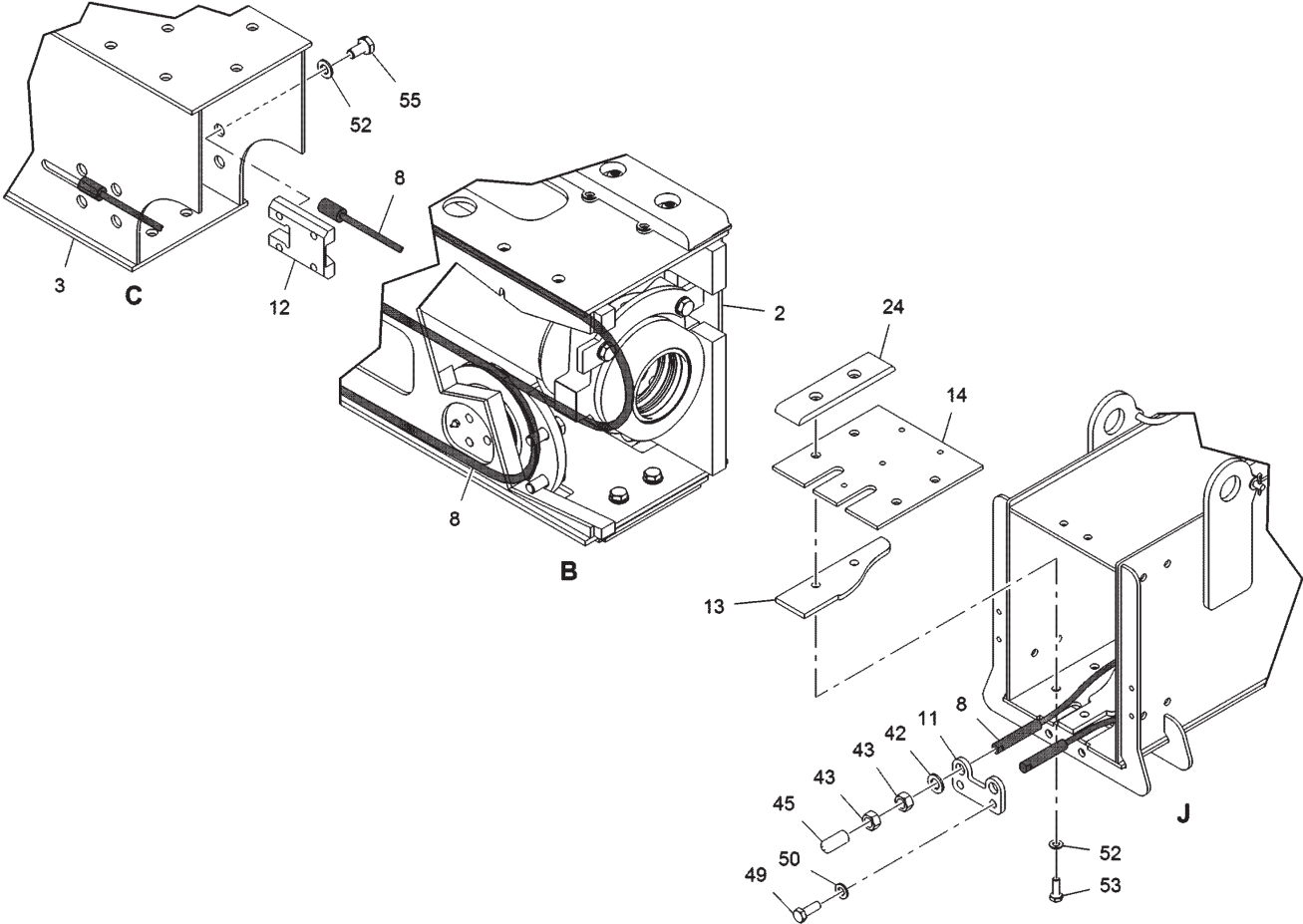
1. Using an overhead crane, position the boom between the ears of the mast. Install the mounting pin and fasten with keeper pins and bolts.
2. Lower the boom or extend the lift cylinder as necessary to install the lift cylinder pin and keeper pin and bolt.
3. Connect hoses from the hydraulic swivel to the telescope cylinder.
4. Connect electrical wiring as necessary. Refer to Electric System, Section 3.
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.



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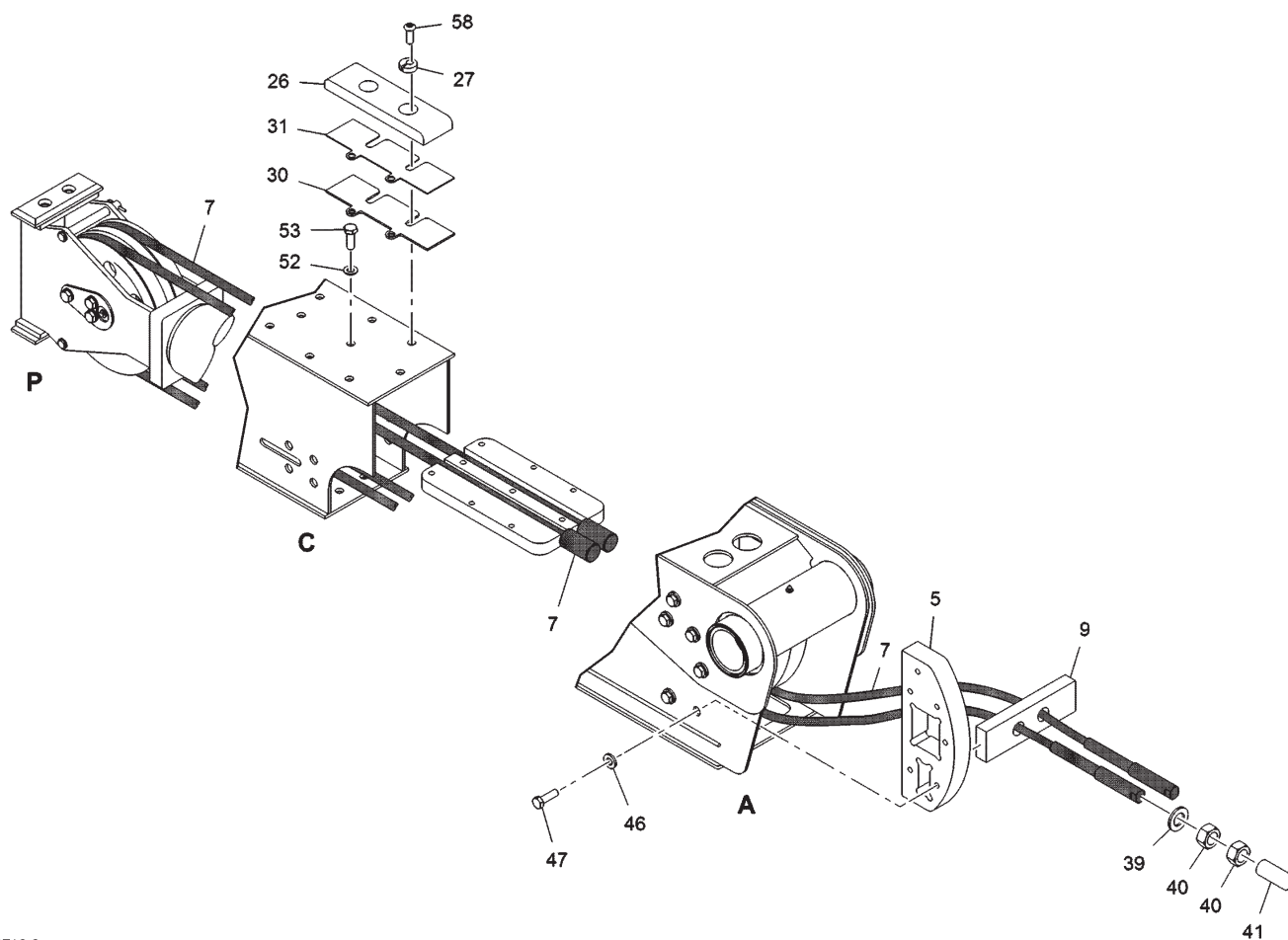
FIGURE 11-1





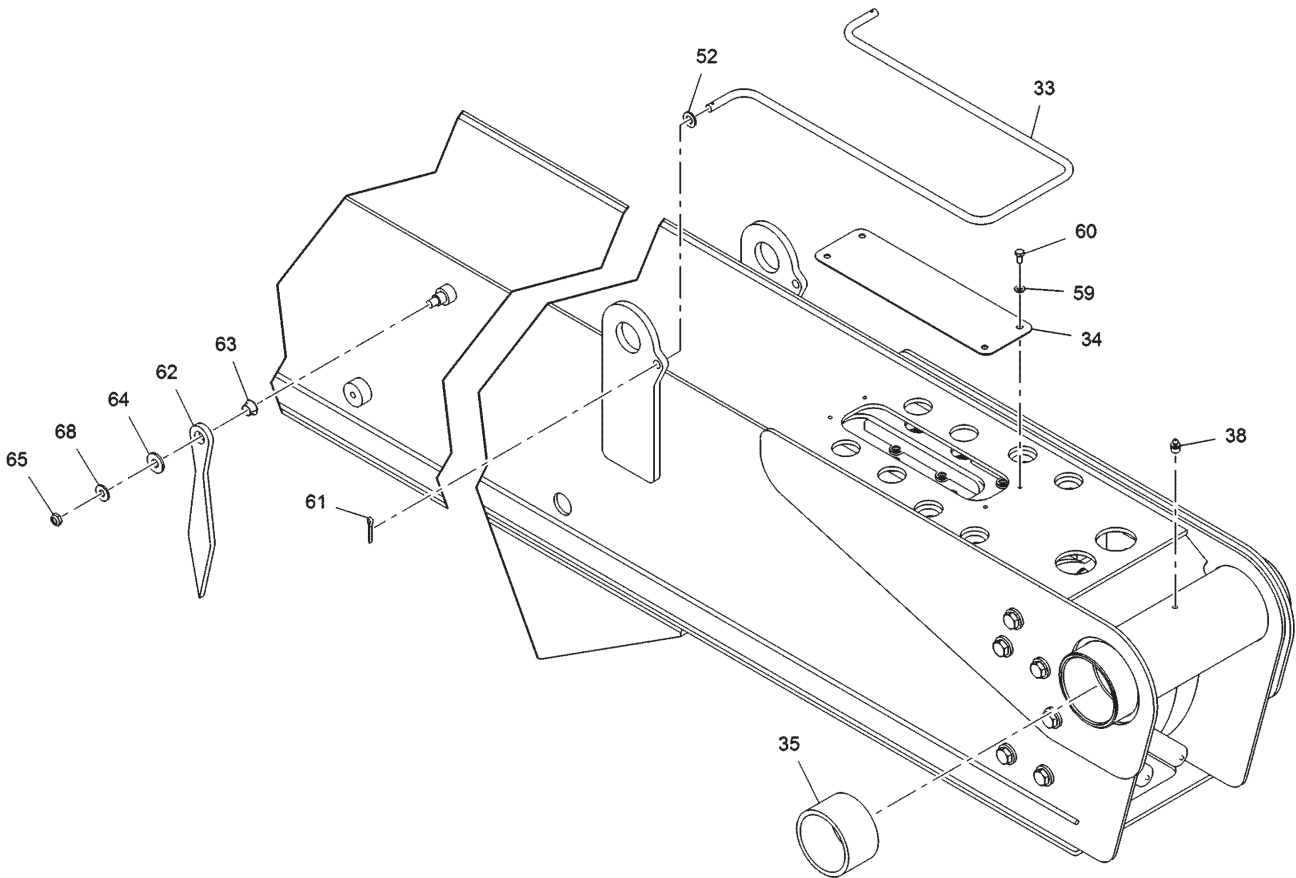
8713-2

FIGURE 11-1 continued



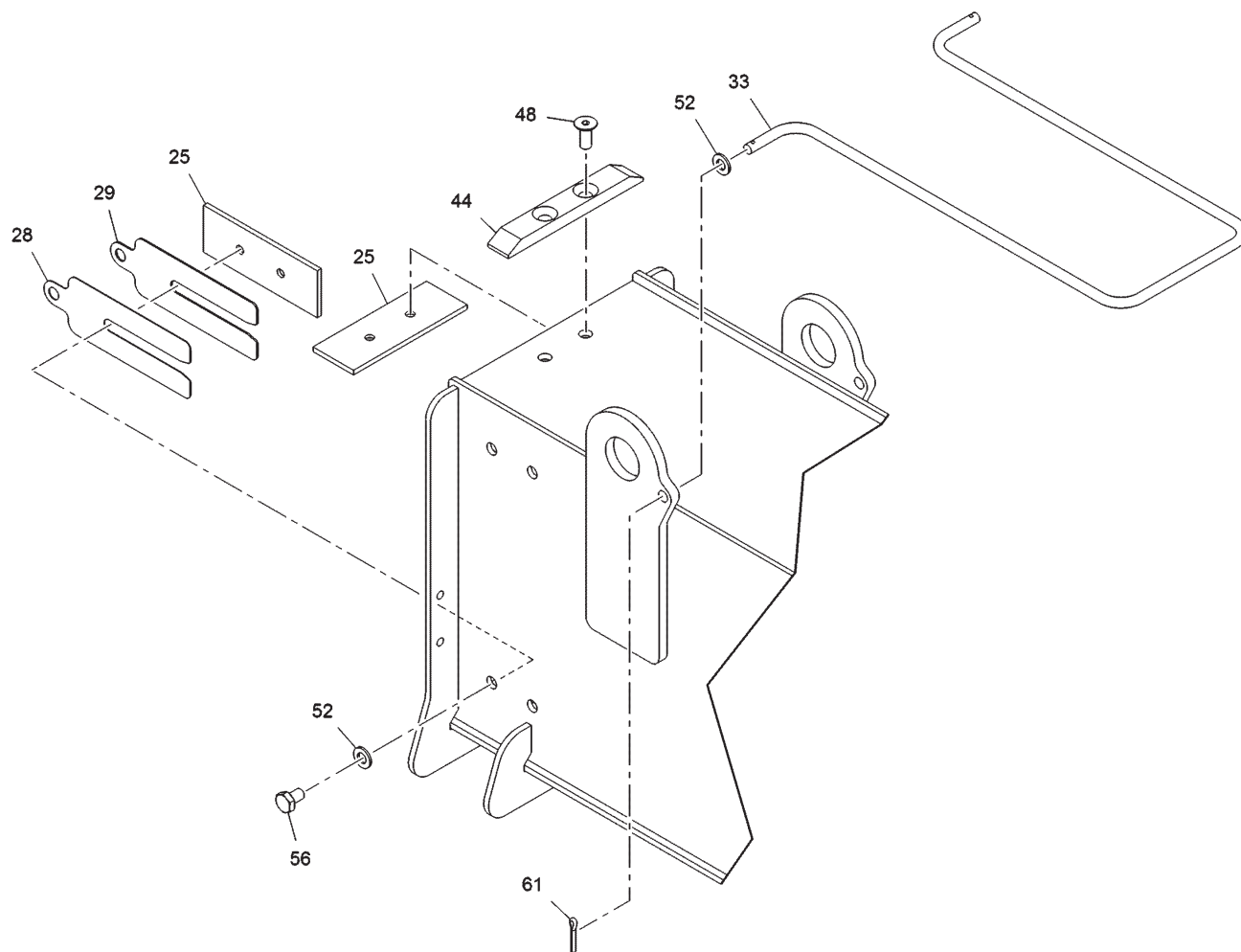
8713-3

FIGURE 11-1 continued



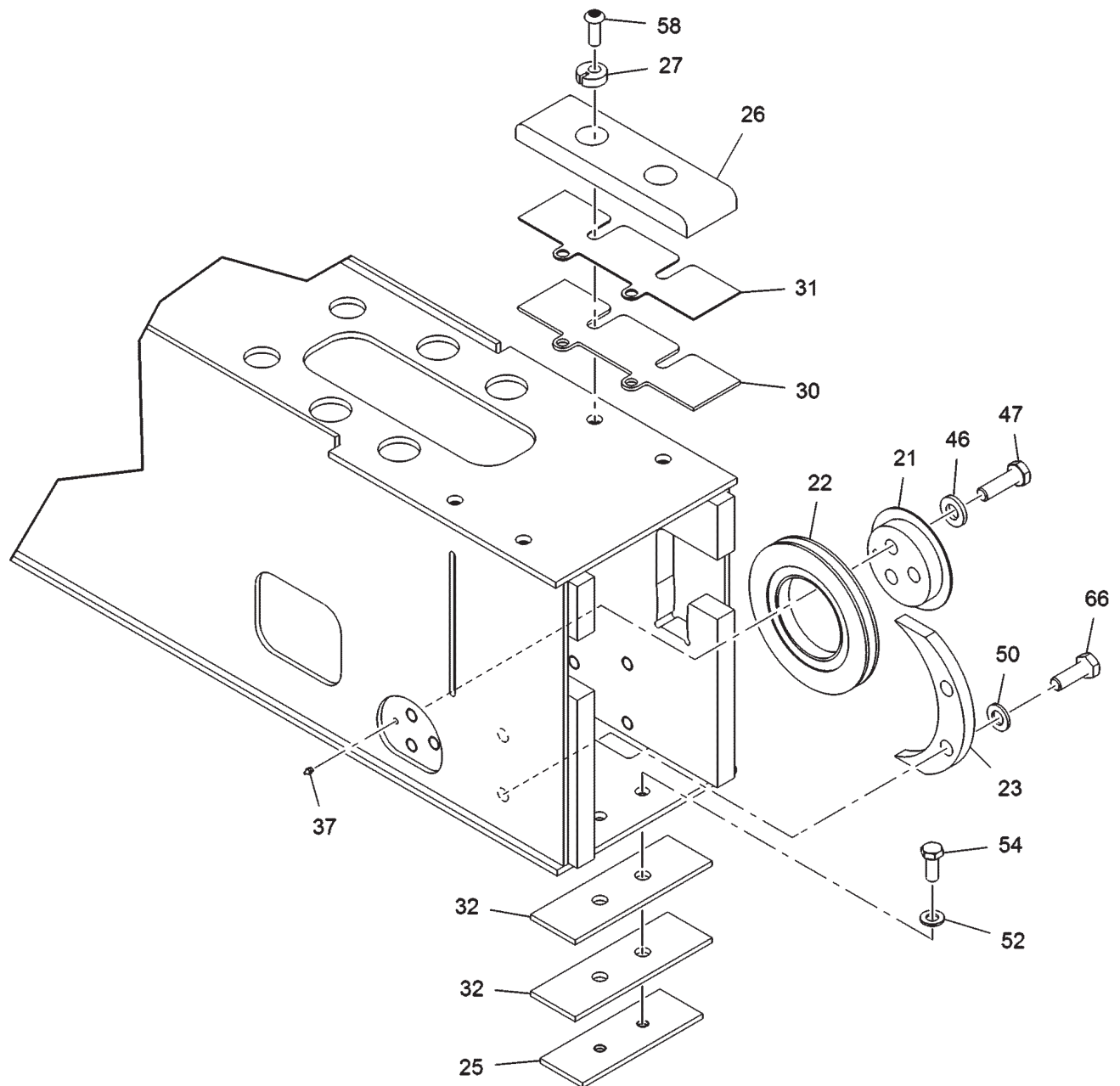
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FIGURE 11-1 continued



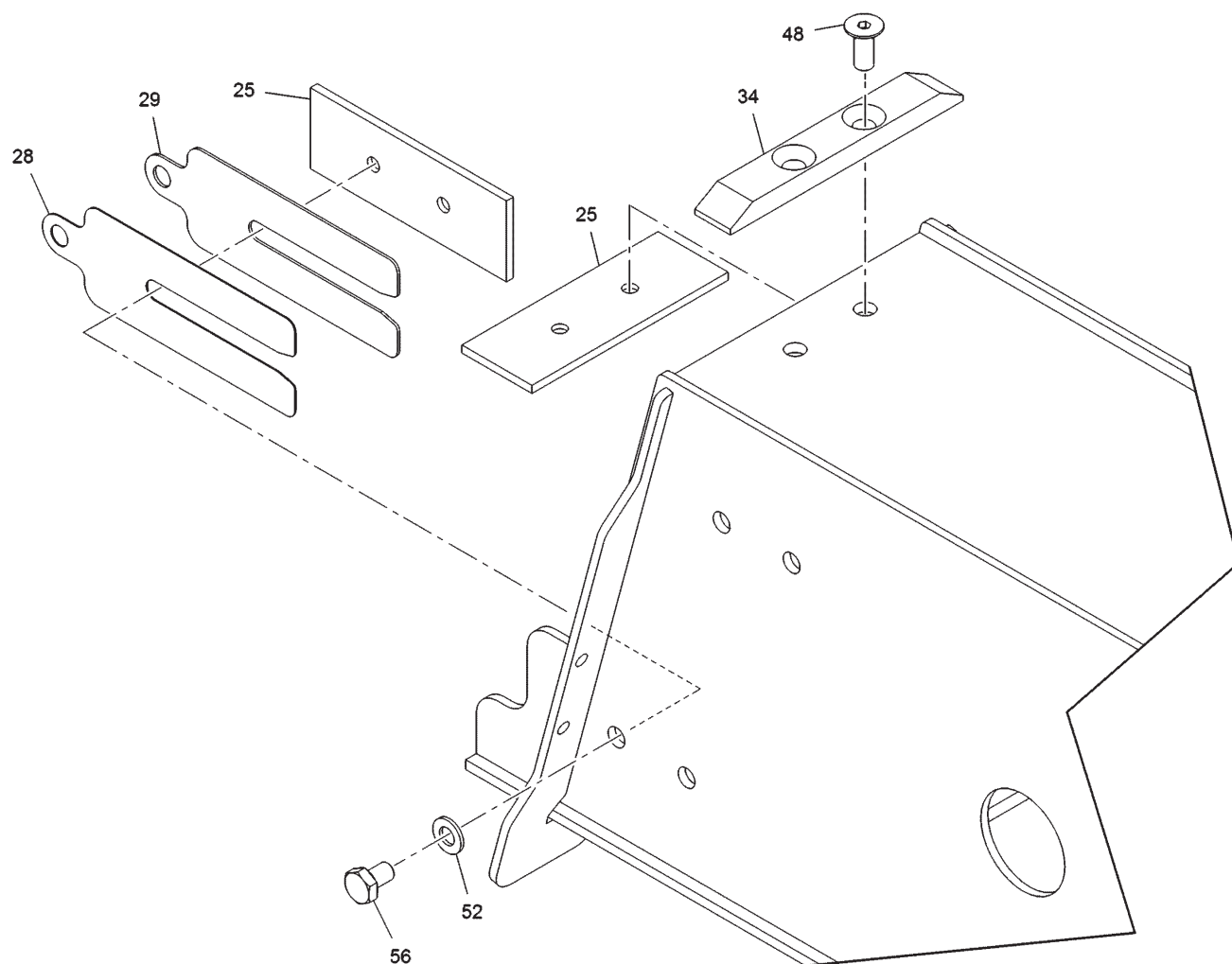
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FIGURE 11-1 continued



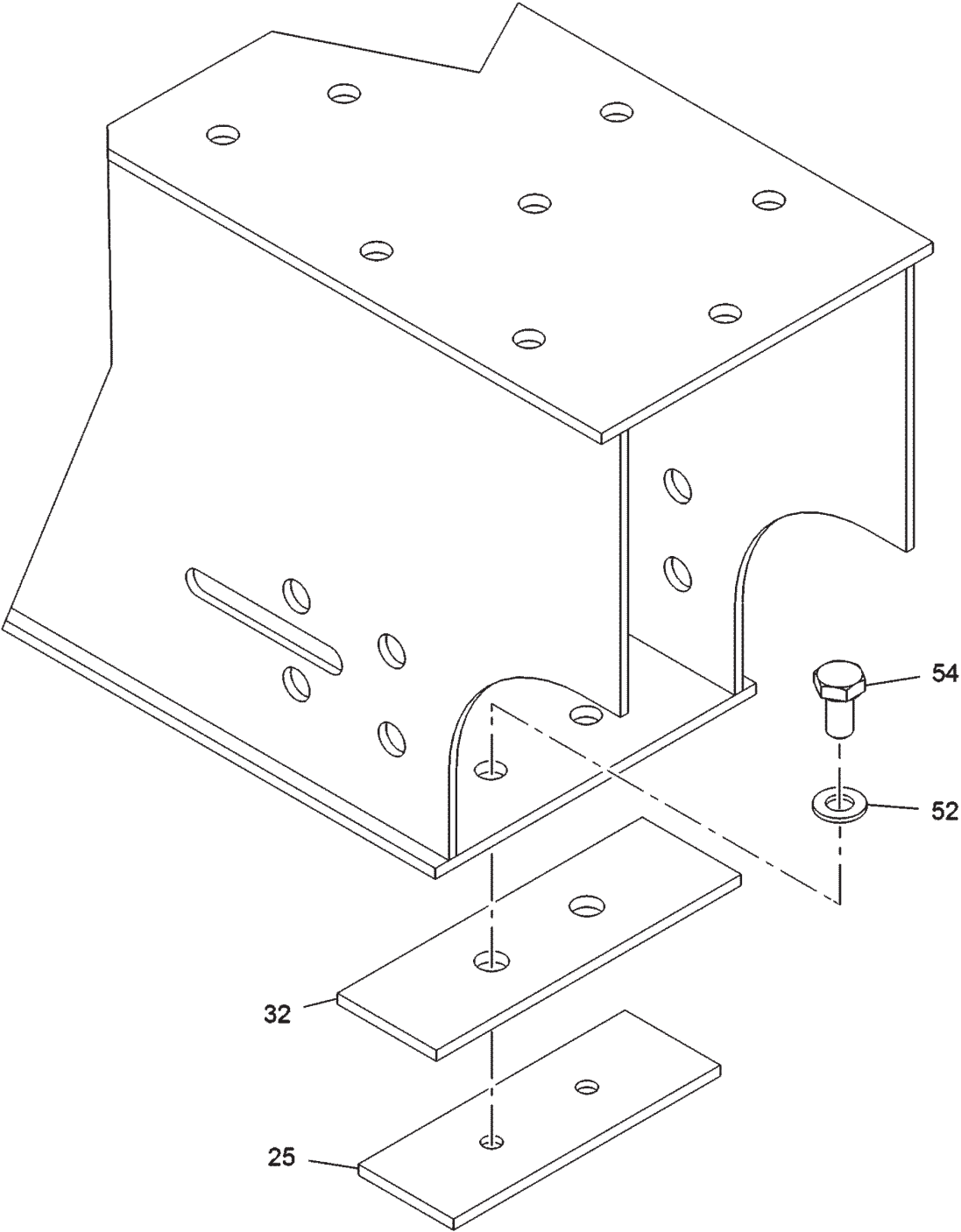
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FIGURE 11-1 continued



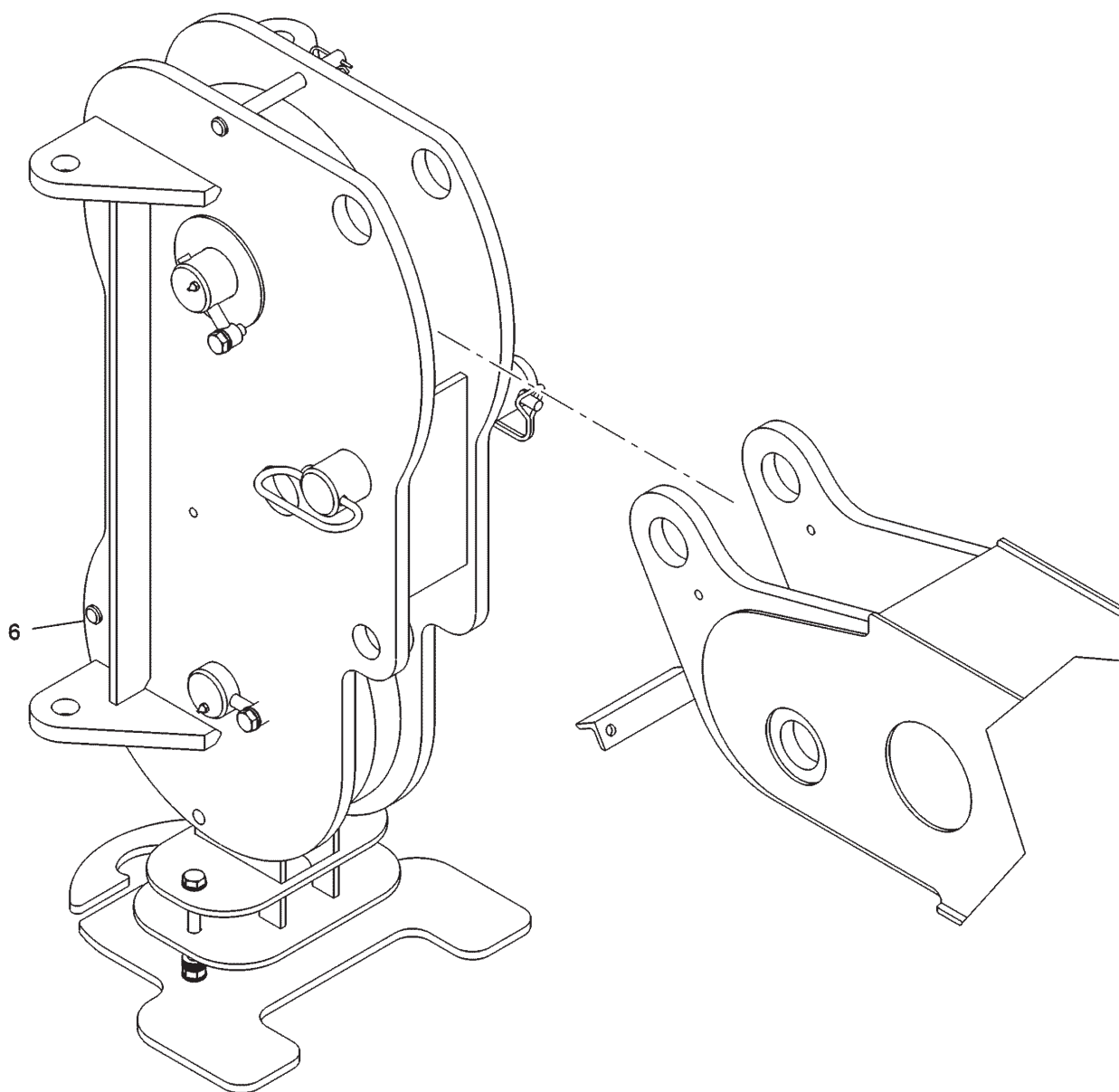
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FIGURE 11-1 continued



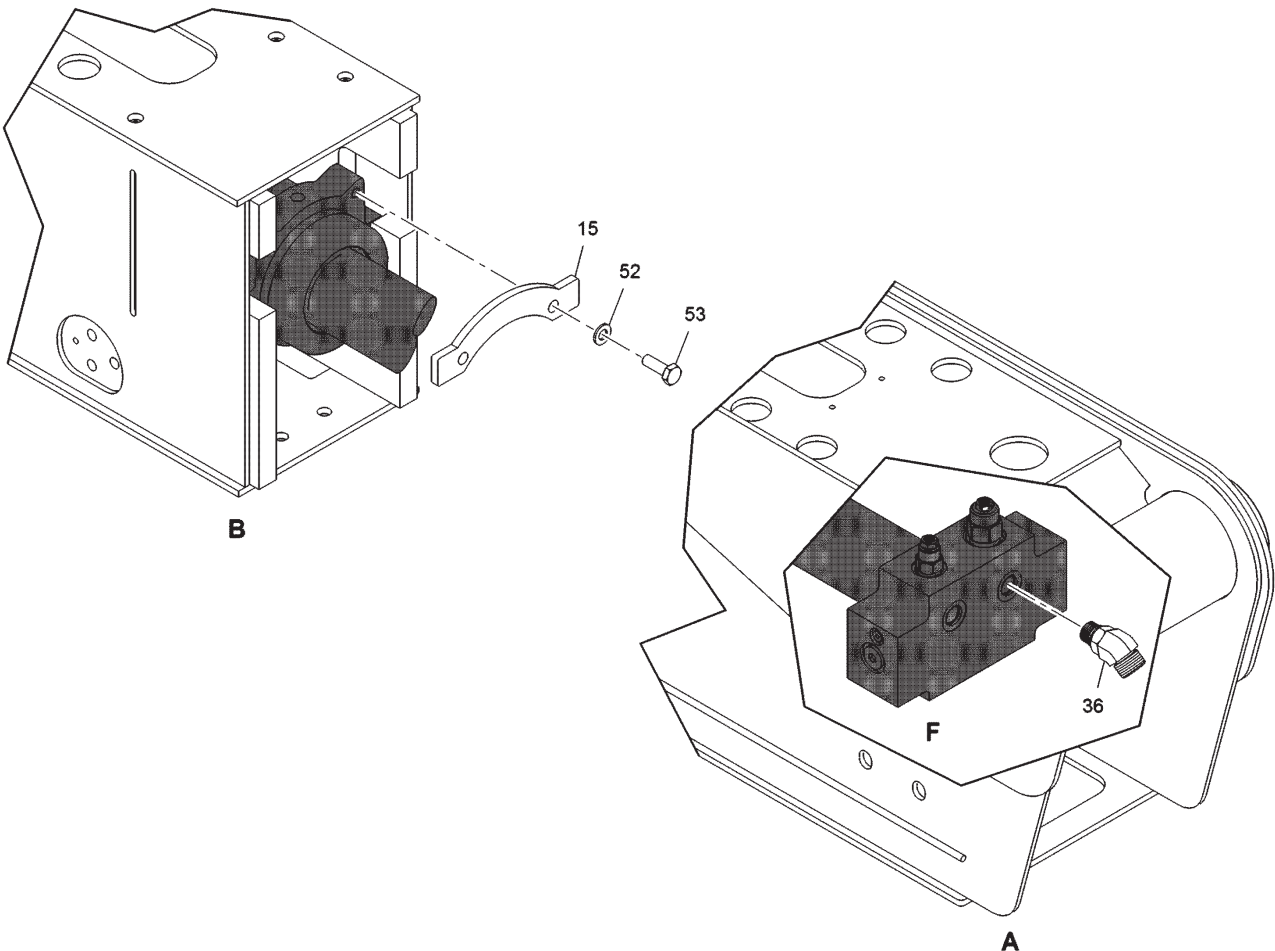
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FIGURE 11-1 continued



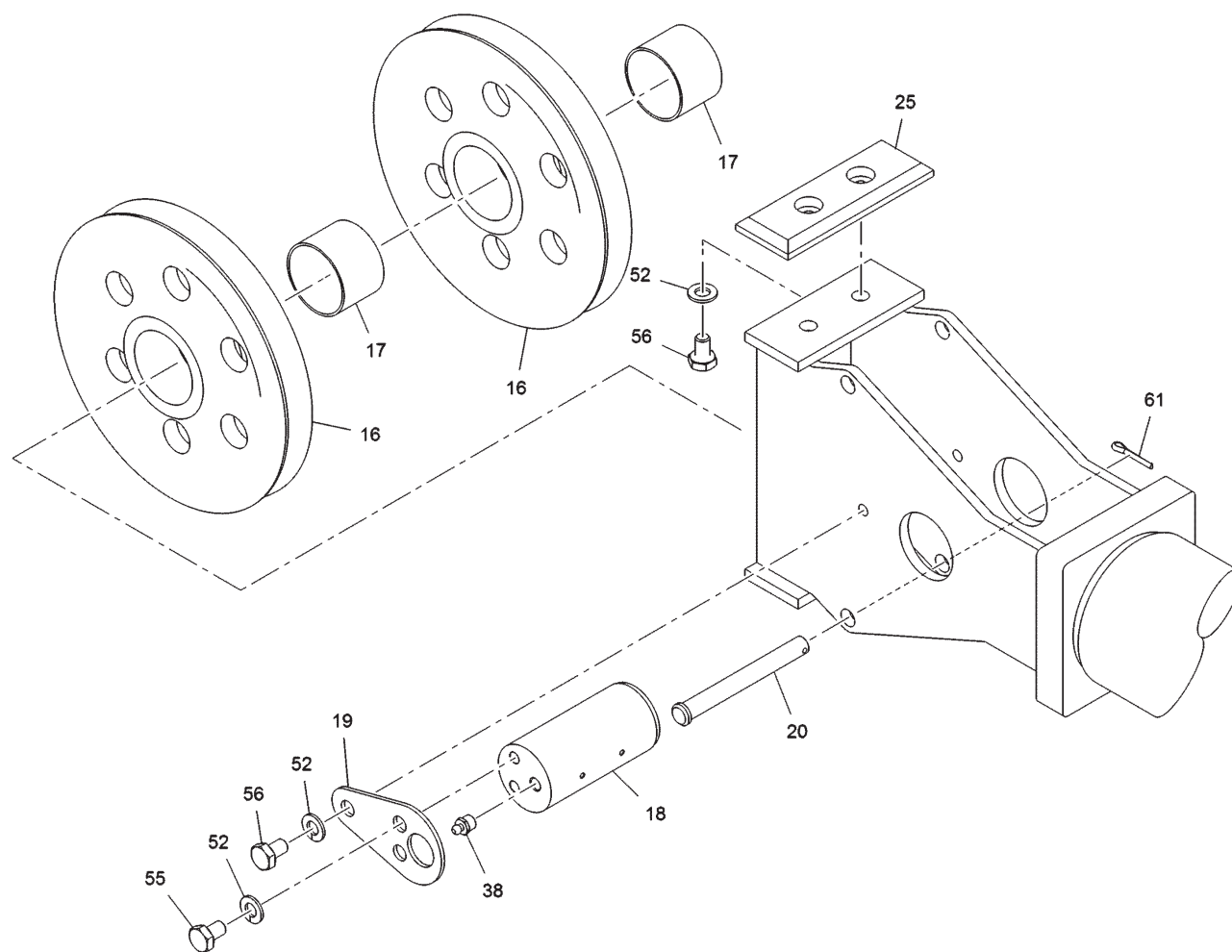
8713-9

FIGURE 11-1 continued



8713-10

FIGURE 11-1 continued



8713-11

FIGURE 11-1 continued

Item	Description
1	Base Section
2	Mid Section
3	Tele 2
4	Hydraulic Cylinder
5	Anchor Plate
6	Boom Nose Installation
7	Extend Cable
8	Retract Cable
9	Cable Anchor Plate
10	Extend Cable Anchor
11	Retainer
12	Retract Cable Anchor
13	Plate
14	Retract Cable Retainer
15	Block
16	Sheave
17	Bearing
18	Sheave Pin
19	Plate
20	Clevis Pin
21	Pin
22	Sheave Wheel
23	Cable Guide Plate
24	Wear Pad
25	Wear Pad
26	Wear Pad
27	Cam Plate
28	Shim
29	Shim
30	Shim
31	Shim
32	Shim
33	Cable Guide
34	Plate
35	Bearing

Item	Description
36	Flat Washer
37	Grease Fitting
38	1/8 Straight Grease Fitting
39	Flat Washer
40	Hex Nut
41	Cable Protector
42	Flat Washer
43	Hex Nut
44	Wear Bar
45	Cable Protector
46	Flat Washer
47	Hex Head Capscrew
48	Socket Head Capscrew
49	Hex Head Capscrew
50	Flat Washer
51	Hex Nut
52	Flat Washer
53	Capscrew
54	Hex Head Capscrew
55	Hex Head Capscrew
56	Hex Head Capscrew
57	Hex Head Capscrew
58	Button Head Capscrew
59	Washer
60	Hex Head Capscrew
61	Cotter Pin
62	Pendulum
63	Bearing
64	Flat Wide Washer
65	Locknut
66	Socket Head Capscrew
67	Capscrew
68	Flat Washer

Disassembly

The boom can be disassembled by using two different methods. Alternative #1 disassembles the boom in the conventional manner. Alternative #2 removes the extend cylinder from the rear of the boom, after removal of the hoist. This feature facilitates cylinder service without complete boom tear down.

For reference, the front of the boom refers to the sheave case end, the rear of the boom is the hoist mount end. Left and right are viewed from front to rear.

If the boom is to be unpinned from the turret of the crane structure, please refer to the Boom Removal Procedure section in this book. If the required service procedure is to be performed on the boom while still pinned to the turret, please follow these directions.



WARNING

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

1. Extend and set the outriggers.
2. Fully retract the boom and place in a horizontal position.
3. Hoist removal optional, please refer to the Hoist Removal Procedure in this book.

Boom Disassembly Alternative #1

1. Gaining access through rear of boom, loosen capscrews retaining the extend cable anchor in the rear of the 3rd section.
2. Extend boom 24 inches (60 cm). Loosen and remove the nuts which secure the extend cables to the cable anchor plate. Tag and disconnect hydraulic lines to the extend cylinder.
3. Drape extend cables inside boom, and slide cable anchor plate out of the side of the hoist mount if hoist has been removed from boom.
4. Loosen and remove two capscrews, lockwashers and spacers which anchor the extend cylinder rod butt plate to the rear of the 1st section.
5. Loosen and remove two capscrews and lockwashers securing spacer bar to the inside top of the front of the 1st section. Remove spacer bar.
6. Loosen and remove four capscrews securing wear pads to the bottom of the 1st section. Removal of side wear pads is optional. Adequate clearance exists between adjoining section side pads for boom disassembly. If side pad removal is required, tag all pads, shims, and corresponding locations for proper reassembly.
7. Support 2nd-3rd assembly at the front with an appropriate lifting method. Raise the 2nd-3rd assembly inside the 1st section to allow for front bottom pad removal. Remove bottom wear pads.
8. With the 2nd-3rd assembly supported, slide assembly out of the 1st. Relocation of the sling point on the 2nd-3rd assembly will be necessary for proper balancing of the assembly as it slides out of the 1st section. Keep tension on retract cables as the assembly is pulled out of the 1st, to minimize the chance of retract cable damage.
9. Place 2nd-3rd assembly on a suitable horizontal surface. Take care not to pinch or crush retract cables while lifting or supporting assembly.
10. Remove top rear wear pads on the 2nd section. They will lift off the cam plates easily. Do not remove or loosen the capscrews holding the cam plates to the section. This will affect side clearance during re-assembly.
11. Loosen and remove four capscrews securing the rear bottom wear pads on the 2nd section. This pad serves as a bottom and side pad as well as the retract cable keeper under the retract sheaves. Removal of this pad will allow the retract cables to uncoil off the retract sheaves. Place retract cable ends in a location to minimize the possibility of damage.
12. Loosen and remove four capscrews securing retract sheave pin and retract sheaves to 2nd section. Remove sheaves and pins.
13. Loosen and remove two capscrews functioning as upper retract cable keepers.
14. Loosen and remove two capscrews securing lock bar to the extend cylinder collar. This bar constrains the vertical movement of the extend cylinder. Remove bar.
15. Loosen capscrews retaining extend cable anchor to back of the 3rd section. Total removal of the capscrews will allow the cable anchor to be completely disassembled, backing capscrews out approximately 0.50 inch (12 mm) will allow the anchor assembly to slide rearward out of the section as the extend cylinder is removed.
16. Support extend cylinder with an appropriate lifting device and pull the extend cylinder out of the boom while keeping the extend cables tensioned slightly by hand to minimize the possibility of damage to the cables. Pull cylinder to within 3 feet (91 cm) of complete removal from the boom sections.
17. Pull the extend cable anchor out from its retaining pocket on the bottom of the 3rd section. A slight angle applied to the anchor as it's being pulled to the rear will permit easier removal through the 2nd section.

18. Remove the extend cylinder from the boom. Remove extend cables. Place cylinder and cables in suitable area to prevent possible damage.
19. Remove retract cables from the back of the 3rd section by removing capscrews and cover plates from ends of cables. Place cables in location to prevent possible damage.
20. Loosen and remove two capscrews, cable guide, wear pad and spacer bar from the front top of the second section.
21. Loosen and remove four capscrews attaching the bottom wear pads to the second section. Slightly lift third section, and remove pads.
22. Slide 3rd section out of 2nd section. Removal of side pads is optional, as the side pads have adequate clearance for boom disassembly. If removal of side pads is required, tag all shims, pads and corresponding locations for proper re-assembly.
23. Loosen and remove all remaining capscrews and wear pads from boom sections.

Boom Disassembly Alternative #2

The boom design allows for removal of the extend cylinder from the rear of the boom without complete disassembly of the boom sections. This procedure allows quick access to the cylinder, retract cables, and various internal boom components for service or replacement.



WARNING

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

1. Remove hoist. Please refer to the hoist removal section in this manual.
2. Gaining access through rear of boom, locate the two capscrews that retain the extend cable anchor at the bottom rear of the 3rd section. Loosen these two capscrews and back them out approximately 1/2". This will free the anchor from the 3rd section but the anchor assembly will stay together. Remove the extend cylinder lock bar by loosening and removing the two screws that secure the bar.
3. From full retraction extend the boom out 12 inches (30 cm) and loosen and remove the nuts which secure the extend cables to the hoist anchor plate. Drape extend cables inside of boom. Then remove hoist anchor plate from boom.
4. Loosen and remove the two capscrews and spacers which anchor the extend cylinder to the rear of the boom section.
5. Retract the extend cylinder 4" which will move the cylinder rod butt plate close to the back of the 2nd section. Then remove hoses from cylinder butt plate and cap the two fittings.
6. Using the appropriate lifting device, lift the extend cylinder up and out of retaining slot on rear of the 2nd section.
7. Pull the extend cylinder out through rear of boom assembly approximately one-half of the total length of cylinder. Keep the extend cables tight while moving the cylinder out of boom to minimize the possibility of damage to the cables. At this point lift extend cylinder up until it contacts the top of the boom sections. Then remove cable anchor located on bottom of 3rd section out of the rear of boom.
8. Adjust lifting device to provide even weight distribution on extend cylinder. Then continue to pull extend cylinder and cables out of rear of boom. Store cylinder and cables in an area to minimize the possibility of damage.

Additional Maintenance, Disassembled Boom

1. Clean all boom sections and inspect for wear, dents, bent or bowed boom sections, gouged metal, broken welds or any abnormal conditions. Repair or replace as required.
2. Inspect all sheaves for excessive groove wear or abnormal rim wear. Replace as required.
3. Inspect all sheave bearings for excessive wear or cut liner material. If installed bearing diameter is 0.015 inch (.38 mm) larger than the pin diameter, bearing must be replaced. Any cut or gouge which causes the bearing liner to be distorted is cause for bearing replacement.
4. Clean and inspect all cable assemblies according to the wire rope inspection procedures in this section. Pay particular attention to any wire breakage within 6 feet (180 cm) of the end connections. Replace cable assemblies as required. Lubricate all cable assemblies before reinstalling them in the boom.
5. Inspect all sheave pins for nicks, gouges or pitting due to rust in the bearing surface area. Replace if any damage is evident.

Assembly

NOTE: Do not use Loctite on any cable threaded ends. Always use the locknut and nut provided.

When initially assembling threaded ends of cables, thread the first on past the flat in the cables so adjustment can be made later.

1. Assemble sheaves into 3rd section sheave case. Top sheave is to be installed to the left hand side of the boom with the spacer to the right hand side.
2. Attach rear wear pads on bottom of 3rd section.
3. Install 3rd section boom into 2nd section. Slide together approximately 5 feet (150 cm).
4. Assemble bottom front wear pads for 2nd section and Teflon plugs.
5. Using appropriate lifting device, lift 3rd section to allow for wear pad installation in front of 2nd. Install wear pads. Slide sections together within 12 inches (30 cm) of full retraction.
6. Install front side wear pads with appropriate shims, between 3rd and 2nd sections. If boom has been disassembled, and no sections have been replaced, use same shim quantity and location as was previously used. If locations are in question, refer to shim calibration section in this book.
7. Uncoil retract cable assemblies, and insert button end into anchors in back of the 3rd section. Secure button with cover plates. Place uncoiled cable in area that will minimize the potential for damage.
8. Assemble retract sheaves and retract sheave pins in rear of 2nd section. Coat surfaces of bearings with grease before assembly.
9. Place retract cables over top of retract sheaves. Install keeper capscrew above sheave to hold retract cables in place.
10. Reeve cables over retract sheave and install keeper/wear pad to bottom rear of 2nd section. This pad acts as a side pad, bottom pad, and a cable retainer.
11. Assemble exterior extend cylinder components. Install and center sheave pin into butt plate of extend cylinder. Install bearings into extend cable sheaves. Coat surface of bearings with grease and assemble extend sheaves on sheave pin.
12. Wrap approximately 10 feet (300 cm) of each 1/2 inch (12.7 mm) diameter extend cable around extend sheaves and install extend cable anchor. Do not tighten capscrews clamping anchor together completely. These capscrews if tightened completely will not allow cable anchor to install into 3rd section.
13. Install wear pad over extend cylinder sheave side plates. This serves as a wear pad to keep the end of the extend cylinder centered in the boom, as well as an extend cable retainer.
14. Slide extend cylinder/extend cables into 2nd/ 3rd boom assembly enough to assemble extend cable anchor into bottom rear of 3rd section. Be aware of extend cable location when inserting cylinder into boom sections, inadvertent crushing or other damage to cables will warrant replacement.
15. Tighten capscrews clamping extend anchor together. These capscrews will protrude through the 3rd section bottom plate, locking the anchor in position.
16. Visually verify that the extend cables are properly routed on their sheaves and continue to slide the extend cylinder and cables into the boom sections. Keep extend cables supported and slightly tensioned during insertion of cylinder, to maintain proper cable placement.
17. As the extend cylinder keeper plate nears the 2nd section, adjust the height of the cylinder to allow the cylinder to access the cylinder keeper cutouts in the doubler plates on the sides of the 2nd section.
18. Drop the cylinder down into the vertical cutouts in the doubler plates on the sides of the 2nd section.
19. Install lock bar and capscrews to the extend cylinder.
20. Position 2nd/3rd/cylinder assembly in position to be inserted into 1st section. Lay retract cables out under 2nd/3rd/cylinder to allow easy installation as the booms are assembled.

21. Slide 2nd/3rd/cylinder assembly into 1st section boom approx. 2 feet (60 cm). Use caution during this step to keep retract cables straight and on the correct side of the boom assembly as the sections are assembled.
22. Continue to slide 2nd/3rd/cylinder assembly into 1st until it is approximately halfway into 1st.
23. Assemble bottom front wear pads in 1st section, trapping ends of retract cables in slots on bottom of 1st section. Lift 2nd/3rd/cylinder assembly up to ease installation.
24. Slide boom together to within 12 inches (30 cm) of complete retraction. Install upper front spacer bar in 1st section and upper front wear bar and cable guide assembly to 2nd.
25. Retract boom completely, using proper hardware and spacers, connect extend cylinder butt plate to the hoist mount. Hydraulic power source can be utilized at this time if slight cylinder length adjustment is necessary.
26. Slide extend cable anchor into position in hoist mount. Push threaded ends of extend cables through holes in anchor and assemble hex nuts onto threaded ends.
27. Assemble top rear wear pads to the top of the 2nd and 3rd boom sections. Wear pads can be inserted from the hoist mount end of the boom, and the cam plates dropped through the holes in the aligned boom top plates. Rotate cam plates with screwdriver to move wear pads against boom side plates. These cam plates function as rear side clearance adjustment.
28. Visually check each end of boom for proper extend, retract cable routing and placement. Inspect from sheave case end.
29. Adjust slack out of extend and retract cables at hex nut adjustment points. Slowly cycle boom in and out several times. Torque cables per procedure located elsewhere in this book.

TOP/BOTTOM PAD REPLACEMENT ASSEMBLED BOOM

Inspect top and bottom wear pads periodically for signs of abrasion or excessive wear. Excessive is defined as 3/16 of an inch (4.76 mm) from the original pad thickness. Top rear pad thickness 0.75 inch (19.05 mm), bottom front 1st section 1 inch (25.4 mm), bottom front 2nd section 0.50 inch (12.7 mm). Uneven pad wear of 3/32 inch (2.38 mm) from side to side on the wear pad would be considered excessive as well. If any of these conditions exist, the top and bottom pads can be replaced without complete disassembly of the boom.

Top Rear Pad Replacement

1. Retract boom completely.
2. Remove capscrews through access holes on top rear of sections.
3. Remove wear pads and cam plates from the rear of the boom through open winch mount end.
4. Note all pad locations and tag accordingly.
5. Inspect pads for wear using previously mentioned inspection criteria.
6. Install new pads through winch mount end of boom, drop cam plates through access holes and install capscrews.
7. Rotate cam plates in the direction that will move the wear pad against the adjoining boom section, hold cam plate in position and torque capscrew to proper specification. This top pad design also sets the rear side clearance for the boom sections, proper torque is critical for proper boom operation.

Front Bottom Pad Replacement

1. Extend boom approximately 4 feet (120 cm) out.
2. Using an appropriate lifting device, sling around the 3rd section boom and lift it up until weight is removed from the bottom pads in the front of the 2nd and 1st boom sections.
3. Loosen and remove the four capscrews holding the pad plate in between the 3rd and 2nd sections, remove pads. Note all pad locations and tag accordingly.
4. Loosen and remove the four capscrews holding the bottom front wear pads to the 1st section, remove pads. Retract cable adjustment ends may have to be loosened during this step. Note all pad locations and tag accordingly.
5. Replace all wear pads, wear pad plate and re-torque retract cables if disassembly of cables was required.

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.

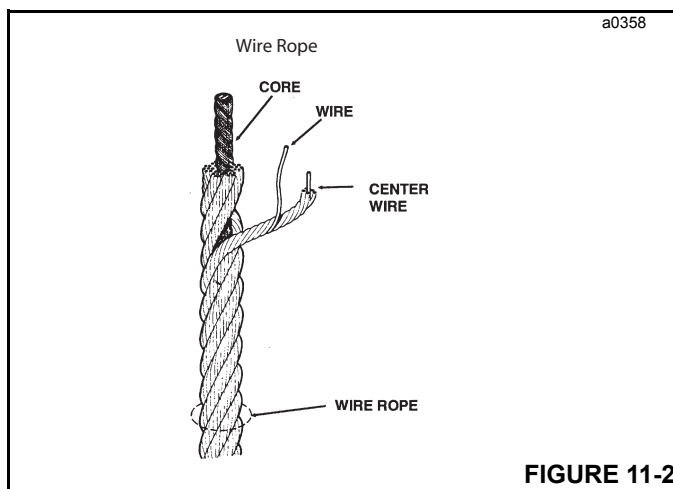
Every wire rope has three basic components (Figure 11-2): (1) The wires which form the strands and collectively provide rope strength; (2) the strands, which are laid helical around the core, and (3) the core, which forms a foundation for the strands. The core used in the crane wire rope is an Independent 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.



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 or MINIMUM BREAKING 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 ALLOWABLE 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.

- 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.
- 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.
- 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.
- Swivels should not be used with ropes that are not rotation resistant. Also, if using rope that is not rotation resistant in single part reeving, the load must be restrained from rotating. Damage to the rope will occur if the above are not followed.

Inspecting Wire Rope

Inspect entire length of wire rope for any conditions listed in Figure 11-3. 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.

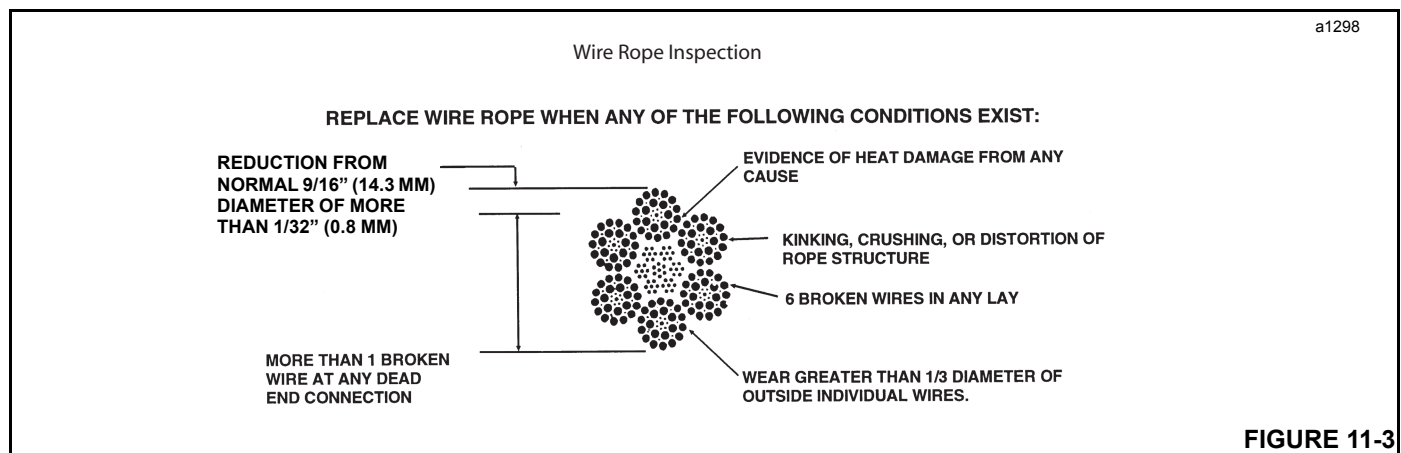
As wear in the sheaves increases, the groove for the wire rope gets smaller, NOT larger. Tracks in the sheaves are caused by the wire rope, and the wire rope will continue to engage the tracks (for example; like a chain engaging a sprocket). A twist in the wire rope or a small change of lay will prevent 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 11-4).



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 11-4.

To properly seat the wedge, lift a load equal to the rated capacity of the crane.

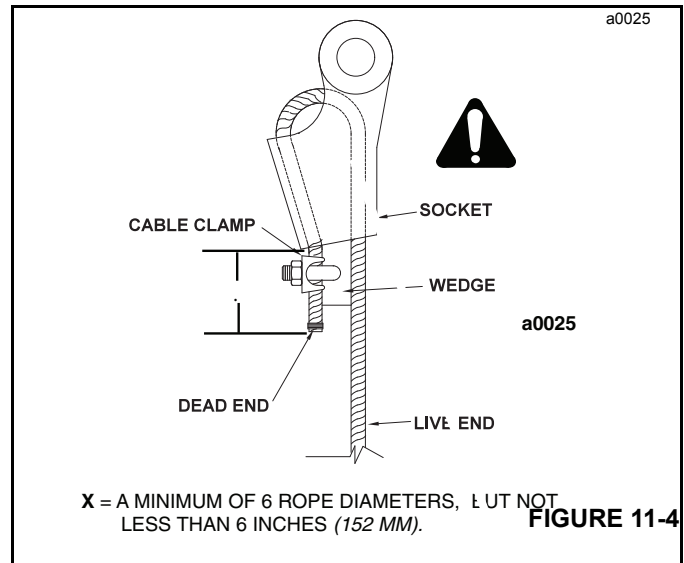
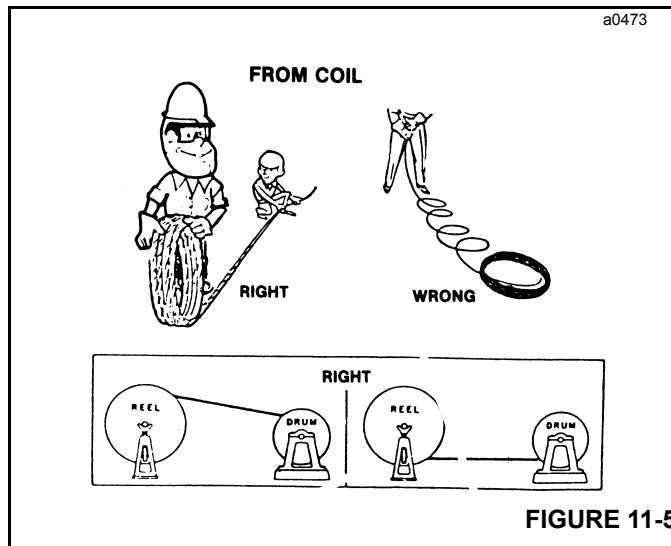


FIGURE 11-4

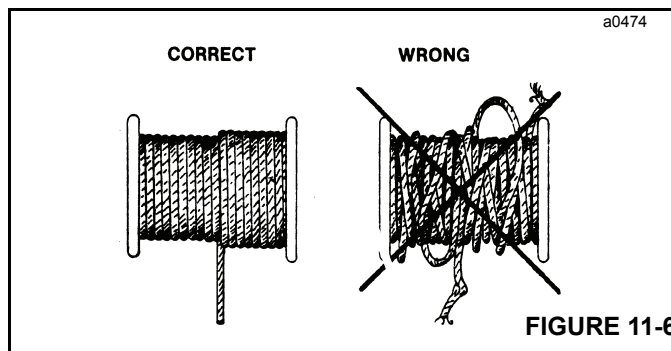
Installation of a New Wire Rope

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 11-5. 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.



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.



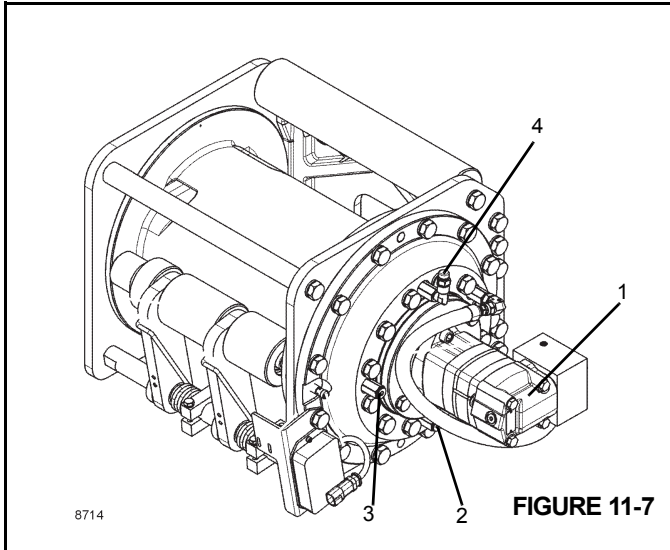
4. After installation, operate the hoist with a minimum load until you see the wire rope is moving easily over the sheaves and is winding correctly on the hoist drum.
5. Gradually increase the speed and load until the wire rope is moving at normal load and speed. This run-in period adjusts the moving parts to each other.
6. Run as much rope off the drum as is possible to the three wrap limit. Pick a load that will generate 20% of the allowable line pull and re-spool the rope onto the drum.
7. Repeat for loads that will generate 50%, then 100% of allowable line pull. Do not ignore load chart limits.
8. This process will tension and align the wires within the rope and cause it to pack more solidly, which will reduce the chance of crushing the rope.
9. Any time the lower layers have been re-spoiled back onto the drum under a light load, steps 6 - 7 should be repeated.

MAIN HOIST

Description

The hoist is composed of a valve for blocking and controlling descent, a hydraulic motor, a fail-safe negative brake, and a epicyclical reduction gear.

The 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.



Item	Component
1	Motor
2	Oil Drain
3	Oil Level
4	Oil Fill/Vent

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 120 ft of wire rope is 639 lbs (290 kg). Death or serious injury may result.

NOTE: See Figure 11-7 for item identification.

1. Remove the cable from the hoist drum.
2. Tag and disconnect the hoist hydraulic lines. Cap and plug all hydraulic openings.
3. Attach a lifting device to the hoist and take up the slack.
4. Remove the mounting bolts from the hoist.
5. Remove the hoist from the crane with the lifting device.

Hydraulic Hoses

Inspect the hydraulic hoses and replace as required.

Hoist Installation

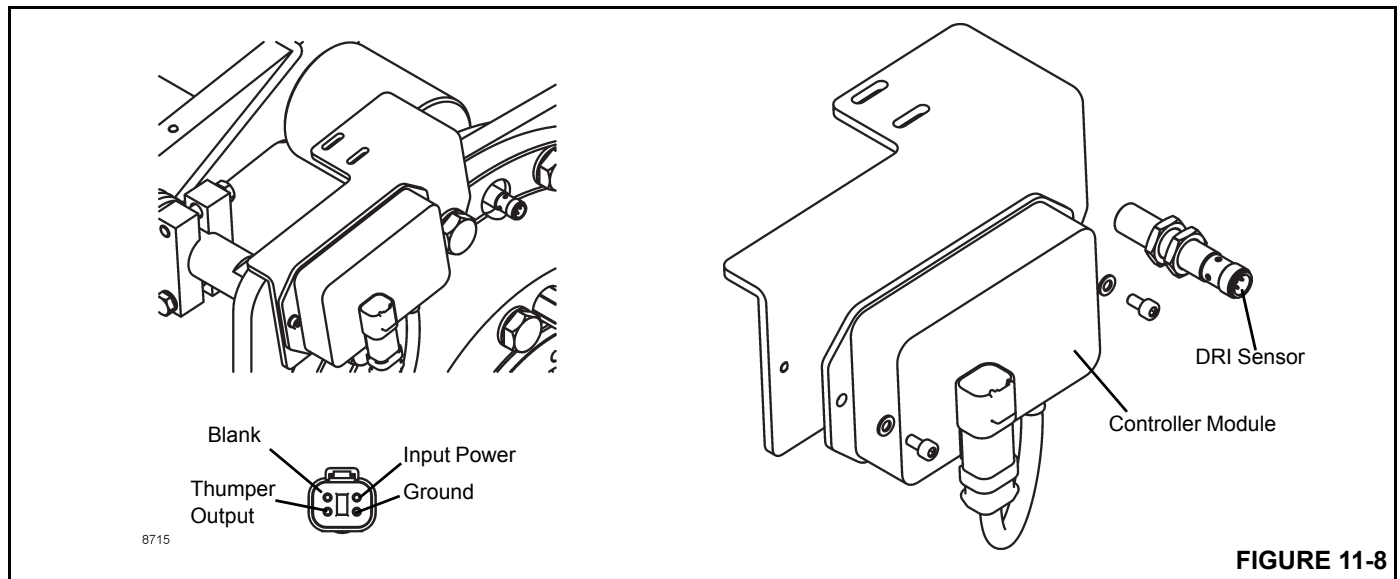
1. Attach a lifting device to the hoist.
2. Lift the hoist with a lifting device onto the turret.
3. Install mounting bolts and washers.
4. Remove the lifting device.
5. Reinstall the hydraulic hoses as per removal tags.

Drum Rotation Indicator

The drum rotation indicator (DRI) (Figure 11-8) 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.

Removal

1. Unplug the DRI cable from the DRI sensor.
2. Unscrew the jam nuts on the sensor and unscrew the sensor.

Installation**FIGURE 11-8**

To install the DRI sensor, use the following procedure:

1. Screw the sensor into the side of the hoist until there is a gap of distance 1.5-2 mm (0.06-0.08 in) between the sensor and sensor plate.
2. Secure the DRI sensor with the jam nuts.
3. Plug the DRI cable to the DRI sensor and the controller module.

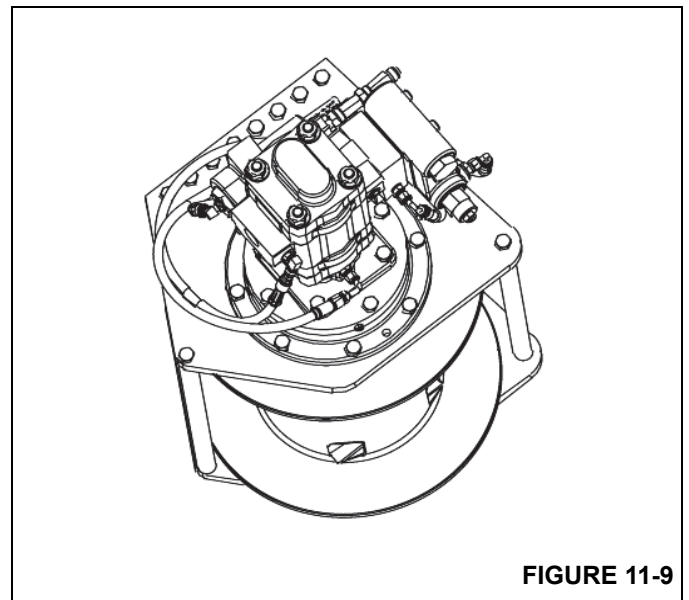
Hoist Repair**Disassembly**

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 11-9).

NOTE: See Figure 11-11 for item number identification.

2. Disconnect the hose assembly (item 41). Remove counterbalance manifold (item 33) by removing cap screws (item 35). Remove the hydraulic motor (item 31) and O-ring (item 39) by removing cap screws (item 32).
3. Remove motor connection (item 21) and O-ring (item 24) by removing cap screws (item 23) and washers (item 22).
4. Remove DRI assembly (item 43) by removing the cap screw (item 13) and washer (item 12). Remove the sensor (item 43) by loosening the locknut and unscrewing the sensor.
5. Remove the 90 degree fitting (item 37).
6. Remove the inner circle of cap screws and washers (items 12 and 13) from the reaction flange (item 5). Remove the cap screws (items 12 and 13) from roller assembly (items 16, 17 and 18), pressure roller (item 30), union bar (item 14) and the base frame (item 3). Using the appropriate lifting aids, lift the support (item 2) and the reaction flange (item 5) off the hoist as a unit.
7. Remove motor input shaft (item 19) and circlip (item 20).
8. Remove winch drive (item 7) and drum (item 6) together by lifting the assembly off of the drum support shaft (item 4).
9. Remove winch drive (item 7) from drum (item 6) after removing the cap screw and washers (items 28 and 29).

**FIGURE 11-9**

10. With the drum resting on the end with the large opening, remove the internal circlip (item 11), oil seal (item 9), bearing (item 8), and seal (item 10).
11. The union bar (item 14), tension roller assembly (item 30), and roller assembly (item 16, 17 and 18) can be removed from support (item 1) by removing the cap screw and washers (items 12 and 13).
12. Remove the drum support shaft (item 4) from the support (item 1) after removing the cap screws and washers (items 12 and 15).

Reassembly

NOTE: See Figure 11-11 for item number identification.

1. Thoroughly clean all parts. Replace those that show wear or damage.
2. Inspect the drum (Item 6) for damage, replace if necessary.
3. Inspect bearing and seal surfaces for damage.
4. Install roller assembly (items 16, 17 and 18), union bar (item 14), and base frame (item 3) onto the support (item 1) with the cap screws and washers (items 12 and 13). Torque the cap screws to 201-214 Nm (148-157 ft-lbs).
5. Press inner seal (item 10), bearing (item 8), outer seal (item 9) and circlip (item 11) into drum (item 6). Make sure to orient the seal lips according to Figure 11-10.
- and 15). Torque the cap screws to 295-314 Nm (218-232 ft-lbs).
9. Install the drum (item 6) onto the drum support shaft (item 4). Carefully align the drum and shaft to prevent damaging the seals.
10. Install the winch drive (item 7) into the drum (item 6) with the cap screws and washers (items 28 and 29). Torque the cap screw to 189-201 Nm (139-148 ft-lbs).
11. Install the circlip (item 20) onto the motor input shaft (item 19) and install into the winch drive (item 7).
12. Install the support (item 2) and input reaction flange (item 5) onto pressure roller assembly (item 30), union bar (item 14), and roller assembly (items 16, 17 and 18) using the cap screws and washers (items 12 and 13). Torque the cap screws to 201-214 Nm (148-157 ft-lbs).
13. Install the inner circle of cap screws and washers (items 12 and 13) through the input reaction flange (Item 5) into the winch drive (item 7). Torque the cap screws to 201-214 Nm (148-157 ft-lbs).
14. Install 90 degree fitting (item 37) onto the winch drive (item 7).
15. Install O-ring (item 24) onto the motor connection (item 21) and install the motor connection (item 21), onto winch drive (item 7) with the cap screws and washers (items 22 and 23). Torque the cap screws to 81-86 Nm (60-63 ft-lbs).
16. Install the O-ring (item 39) onto the hydraulic motor (item 31). Install the hydraulic motor (item 31) onto the motor connection (item 21) with the cap screws (Item 32). Torque the cap screws to 81-86 Nm (60-63 ft-lbs).
17. Install the manifold (item 33) using three socket head cap screws (item 35). The O-rings between the manifold (item 33) and hydraulic motor (item 31) are included with replacement manifolds. If the manifold (item 33) is not replaced, the O-rings may be replaced with a 2-117 O-ring. Torque the socket head cap screws to 47-50 Nm (35-37 ft-lbs).
18. Install the 90 degree fitting (item 38), the valve (item 34) onto the manifold (item 33).
19. Install the hose (item 41) onto the hydraulic fittings (items 32 and 38).
20. Install the DRI assembly (item 43) onto the reaction flange (item 5) and support (item 2) using a cap screw and washer (items 12 and 13). Torque the cap screws to 201-214 Nm (148-157 ft-lbs).
21. Install the DRI sensor (item 43) and set gap distance 1.5-2 mm (0.06-0.08 in) between the sensor and sensor plate (item 25).

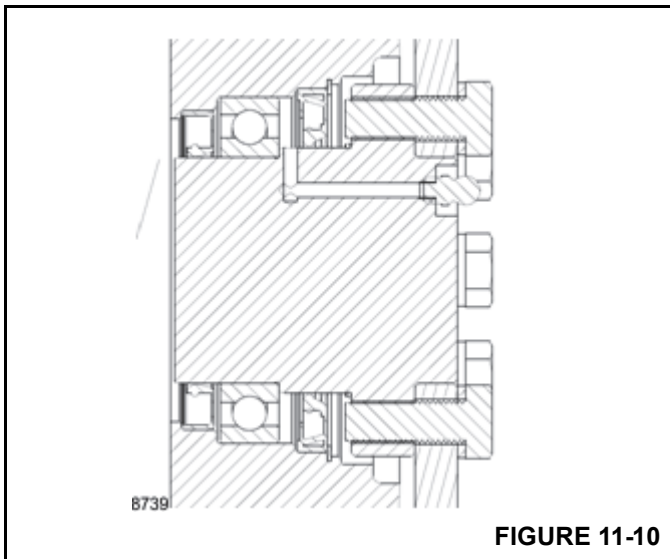
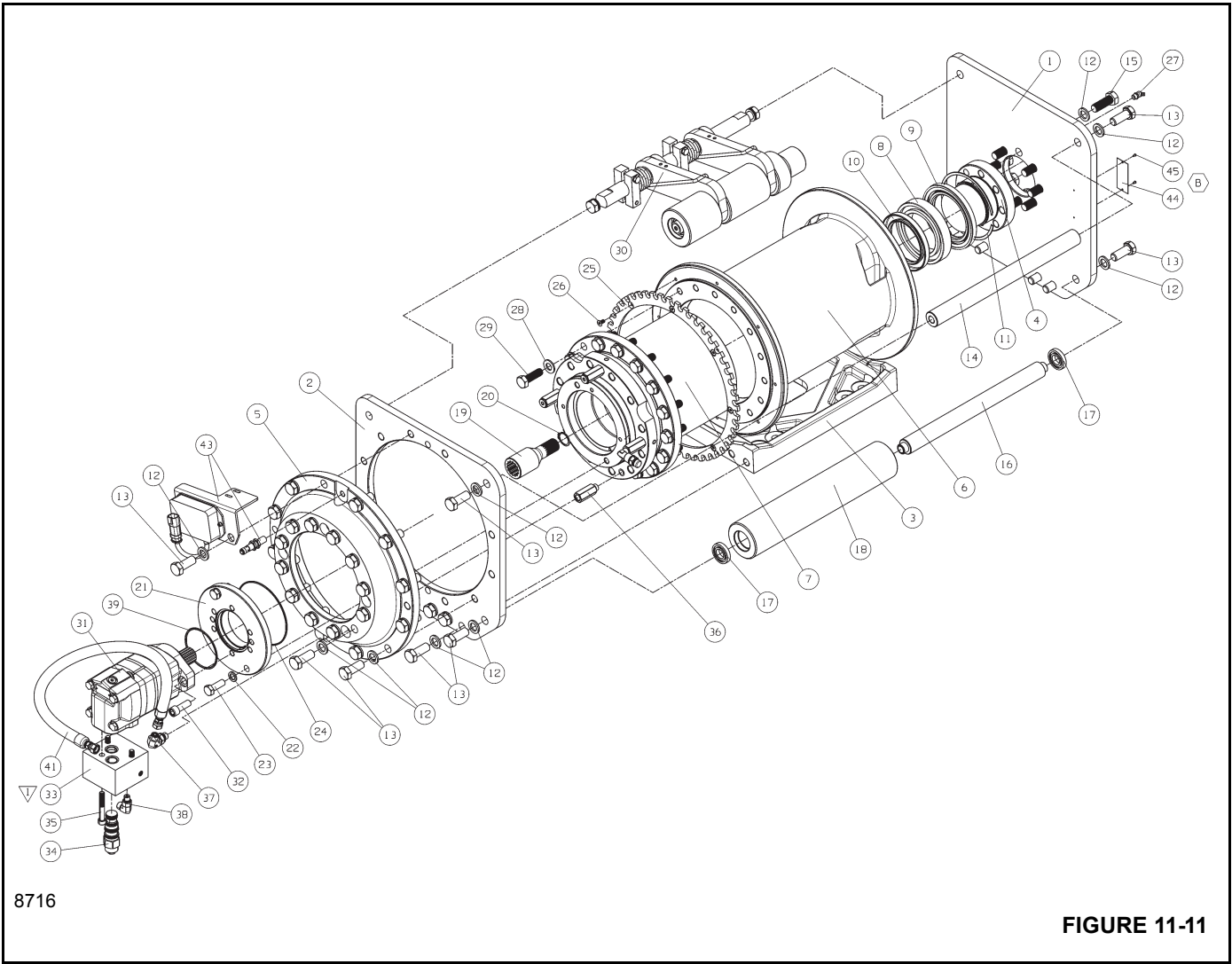


FIGURE 11-10

6. Apply grease to seal lips to prevent seal damage during startup.
7. Install pressure roller (item 30) onto support (Item 1).
8. Install the drum support shaft (item 4) onto the support (item 1) using the cap screws and washers (items 12



Item	Description
1	Support, Contrabearing
2	Support, Gearbox Side
3	Frame, Base
4	Shaft, Drum Support
5	Reaction Flange, Motor End
6	Drum
7*	Winch Drive
8	Bearing
9	Oil Seal
10	Oil Seal
11	Circlip
12	Washer
13	Screw
14	Union Bar
15	Screw
16	Union Bar
17	Bearing
18	Cylinder, Roller
19	Shaft, Motor Input
20	Circlip
21	Motor Connection
22	Washer

Item	Description
23	Screw
24	O-Ring
25	Plate, Sensor
26	Screw
27	Grease Fitting
28	Washer
29	Screw
30*	Pressure Roller
31	Motor, Hydraulic
32	Screw
33	Manifold
34	Valve
35	Screw
36	Fitting
37	Fitting
38	Fitting
39	O-Ring
41	Hose
42	Wedge
43	Switch
44	Name Plate
45	Nail

* See the following sub-assembly

Pressure Roller

Disassembly

NOTE: See Figure 11-12 for item number identification.

1. Remove the screws (item 19) and covers (item 18) from each end of the shaft (item 12).
2. Mark the position of the retainers (item 5) and clamps (item 7).
3. Remove the rollers (items 13 and 15) from the shaft (item 12). The bearings (item 16) can be removed from

the rollers (items 13 and 15) if replacement is needed. Remove the spacers (item 17) from the shaft.

4. Remove the clamps (item 7) by removing the cap screws and washers (items 8 and 9). Remove the retainers (item 5), washers (item 6) and springs (item 3) from the shaft (item 1). Remove the set screws (item 20) and slide the levers (item 2) off of both shafts (items 1 and 12).
5. Remove the roller (item 14) and spacers (item 17) from the shaft (item 12).

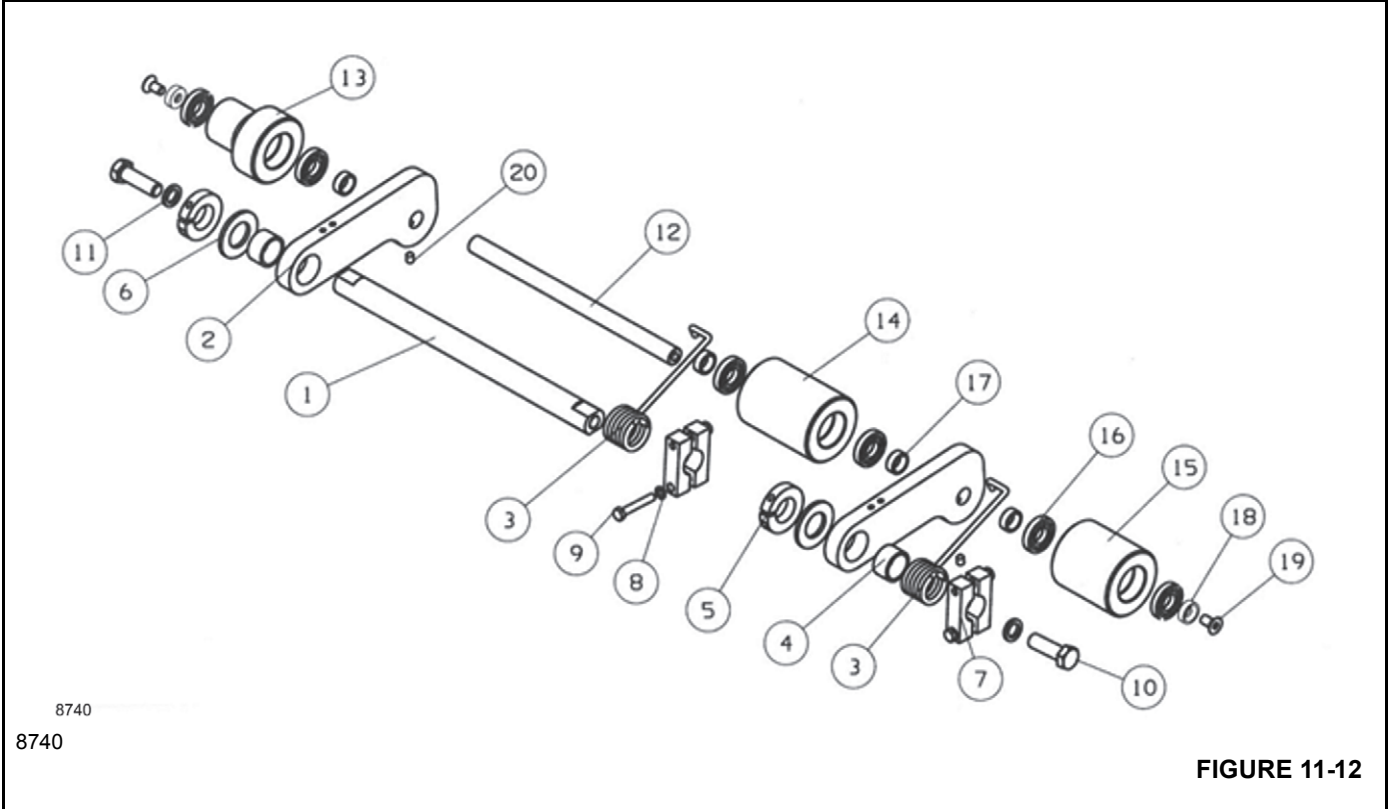


FIGURE 11-12

Item	Description
1	Shaft
2	Lever
3	Spring
4	Bearing
5	Washer
6	Washer
7	Plate
8	Washer
9	Screw
10	Screw

Item	Description
11	Tab Washer
12	Shaft
13	Cylinder
14	Cylinder
15	Cylinder
16	Bearing
17	Spacer
18	Cover
19	Screw
20	Screw

Assembly

NOTE: See Figure 11-12 for item number identification.

1. Inspect the bearings (item 16) and bushings (item 4) for wear. Replace if necessary.
2. Loosely assemble the clamps (item 7) with the cap screws and washers (items 8 and 9). Slide the retainers (item 5), washers (item 6), levers with bushings (item 2), and springs (item 3) onto the shaft (item 1). Place these items in the order shown on the exploded view. Do not tighten the cap screws at this time.
3. Slide the shaft (item 12) through both levers (item 2) placing the roller (item 14) and spacers (item 17) between the two levers (item 2).
4. Place the rollers (items 13 and 15) along with the spacers (item 17) onto the ends of the shaft (item 12). Orient the rollers (items 13 and 15) according to the exploded view. Using the screw and covers (items 18 and 19) retain the rollers (item 15) on the shaft (item 12). Torque the fasteners to 69-73 Nm (51-54 ft-lbs).

Hoist Drive**Disassembly**

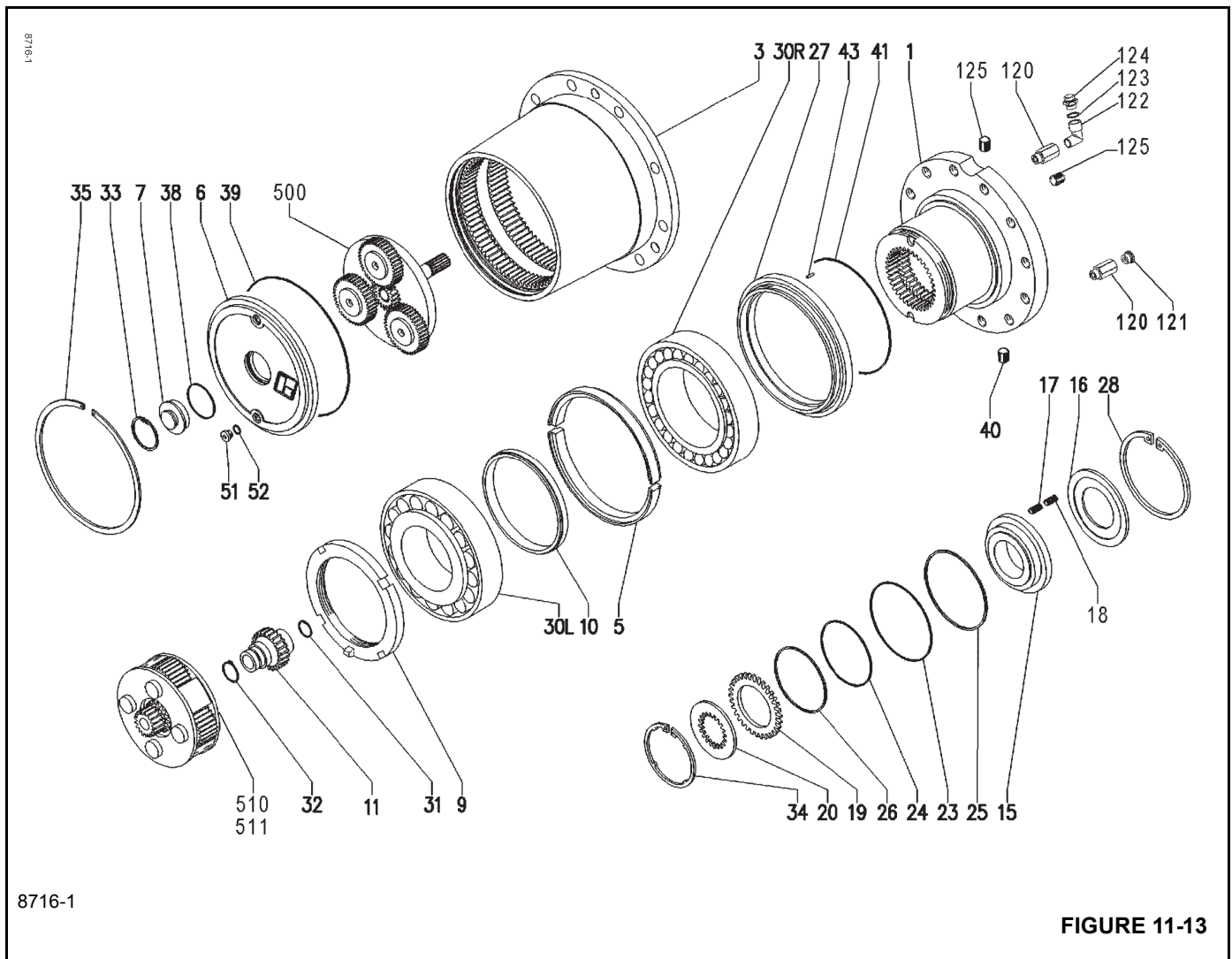
NOTE: See Figure 11-13 for item number identification.

1. Remove the disk (item 35), then the cover (item 6) can be removed. Remove the O-Ring (item 39) from the cover (item 6).
2. Remove the reduction stage (item 500) from hub (item 3), and then remove the reduction stage (item 510).
3. To remove the brake driver (item 11) from the reduction stage (item 510), remove the circlip (item 32) then remove the brake driver (item 11).
4. Remove the lock nut (item 9) from spindle (item 1). Remove the bearing (item 30L), spacer (item 10), circlip (item 5), bearing (item 30R), face seal (item 27) and the locating pin (item 43) from the spindle (item 1).
5. To disassemble the brake, the springs (items 17 and 18) need to be compressed before removing the circlip (item 28).

**CAUTION**

The brake components are loaded with spring tension. Care needs to be taken to avoid personal injury.

6. Remove the circlip (item 28). Carefully release the spring tension. Once the spring tension is released the plate (item 16) can be removed along with the springs (items 17 and 18) as well as the piston (item 15).
7. Remove the blocking rings and O-rings (items 23, 24, 25, and 26).
8. Remove the brake discs and brake plates (items 19 and 20) and the circlip (item 34).



Item	Description
1	Spindle
3	Hub
5	Circlip
6	Cover
7	Thrust Washer
9	Lock Nut
10	Spacer
11	Shaft
15	Piston
16	Circlip
17	Spring
18	Spring
19	Disk
20	Disk
23	O-Ring
24	O-Ring
25	Blocking Ring
26	Blocking Ring
27	Face Seal
28	Circlip
30	Bearing

Item	Description
31	Circlip
32	Circlip
33	Circlip
34	Circlip
35	Disk
38	O-Ring
39	O-Ring
40	Plug
41	O-Ring
43	Pin
51	Plug
52	Washer
120	Extension
121	Plug
122	Nipple
123	Washer
124	Plug
125	Plug
500	1a Reduction Stage
510	2a Reduction Stage
511	2a Reduction Stage

Assembly

NOTE: See Figure 11-13 for item number identification.

1. Thoroughly clean and inspect parts before reassembly. Replace any worn parts.
2. Install the O-ring (item 41) onto the spindle (item 1). Install the alignment pin (item 43) and install half of the face seal (item 27) onto the spindle (item 1).
3. Install the bearing (item 30R) onto the spindle (item 1), and install the spacer (item 10) onto the spindle (item 1).
4. Press in the bearing race (item 30L) into the hub (item 3). Insert the two halves of the circlip (item 5) into the hub (item 3). Press in the second bearing race (item 30R).
5. Install other half of the face seal (item 27) into the hub (item 3).
6. Place the spindle (item 1) along with the previously installed bearing (item 30R) into the hub (item 3).
7. Clamp flanges from both the spindle (item 1) and the hub (item 3) together.
8. Flip the unit over so it is resting on the spindle (item 1). Heat the bearing (item 30L) and install over the spindle

(item 1). Install the locknut (item 9) and torque to 1100-1200 Nm (811-885 ft-lb).

9. Install the brake disks (item 19), brake plates (item 20), and the circlip (item 34) into the spindle (item 1).
10. Install the blocking rings and O-rings (items 23, 24, 25, and 26) into the spindle (item 1). Install the piston (item 15) into the spindle (item 1). Install the springs (items 17 and 18) into the piston.
11. Install the plate (item 16) and compress the springs (items 17 and 18) until the circlip (item 28) can be installed into the spindle.
12. Install brake shaft (item 11) into the reduction stage (item 510) using the circlip (item 32).
13. Install the reduction stage (item 510) into the assembly. Make sure that the alignment pin on the reduction stage (item 510) lines up with the notch on the nut (item 9).
14. Install the second reduction stage (item 500) into the assembly.
15. Install the O-ring (item 39) onto the cover (item 6). Install the cover (item 6) onto the assembly and use the circlip (item 35) to retain it.

Third Wrap Switch

Disassembly

1. Unplug the connector (item 9, Figure 11-14) from crane harness.
2. Remove the socket head cap screws (item 3, Figure 11-14), washers (item 4, Figure 11-14), and nuts (item 5, Figure 11-14).
3. Remove the switch (item 1, Figure 11-14) from the DRI/ third wrap bracket (item 43, Figure 11-11).
4. Remove the wire harness (item 9, Figure 11-14) from the switch (item 2, Figure 11-14) by loosening the nut (item 8, Figure 11-14).
5. Remove the cap screws (item 6, Figure 11-14) and washers (item 7, Figure 11-14) from the levers (item 2, Figure 11-12).
6. Remove the actuator plate (item 2, Figure 11-14) from the levers (item 2, Figure 11-12).

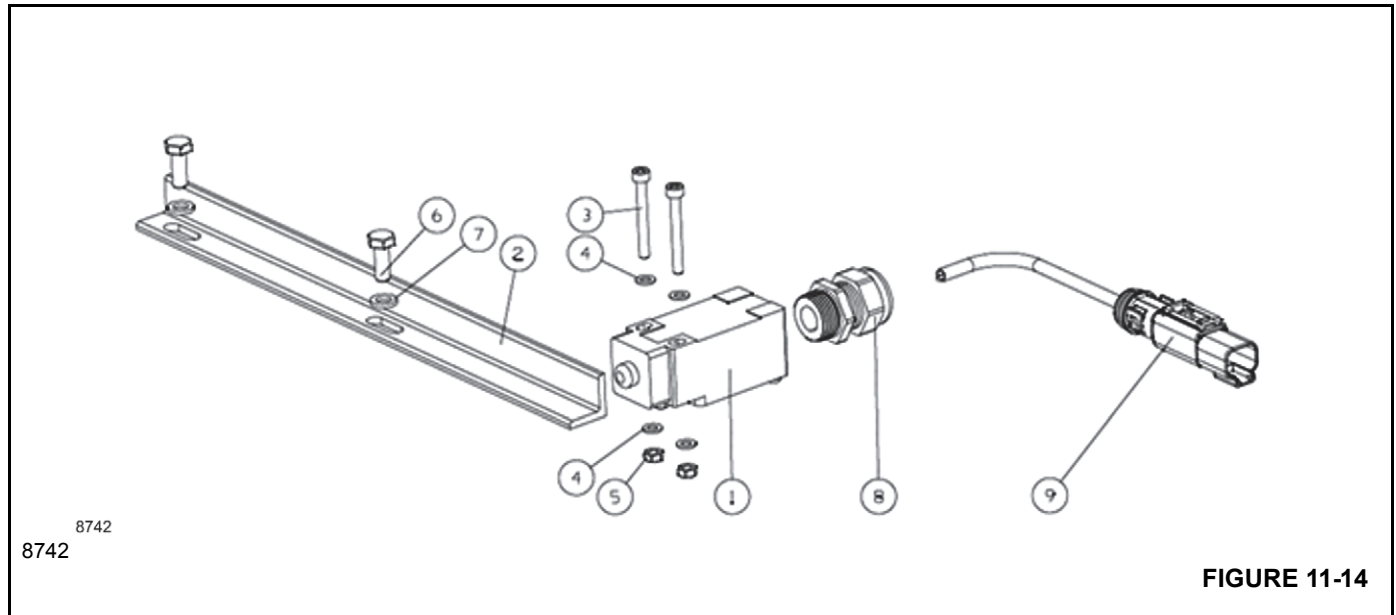


FIGURE 11-14

Assembly

1. Using the cap screws (item 6, Figure 11-14) and washers (item 7, Figure 11-14) fasten the actuator plate (item 2, Figure 11-14) to the levers (item 2, Figure 11-12). Torque the cap screws (item 6, Figure 11-14) to 9.5 Nm (7 lb-ft).
2. Install the wire harness (item 9, Figure 11-14) into the switch (item 1, Figure 11-14) and tighten the nut (item 8, Figure 11-14).
3. Install the switch (item 1, Figure 11-14) onto the DRI/ third wrap bracket (item 43, Figure 11-11) using the socket head cap screws (item 3, Figure 11-14), washers (item 4, Figure 11-14), and nuts (item 5, Figure 11-14). Tighten the socket head cap screws (item 3, Figure 11-14) so that the switch will still move.
4. Adjust the position of the switch (item 1, Figure 11-14) so that the actuator bar (item 2, Figure 11-14) contacts the switch (item 1, Figure 11-14) pin lightly once the roller assembly (item 30, Figure 11-11) is in the lowest position.
5. Attach the connector (item 9, Figure 11-14) to the crane harness.

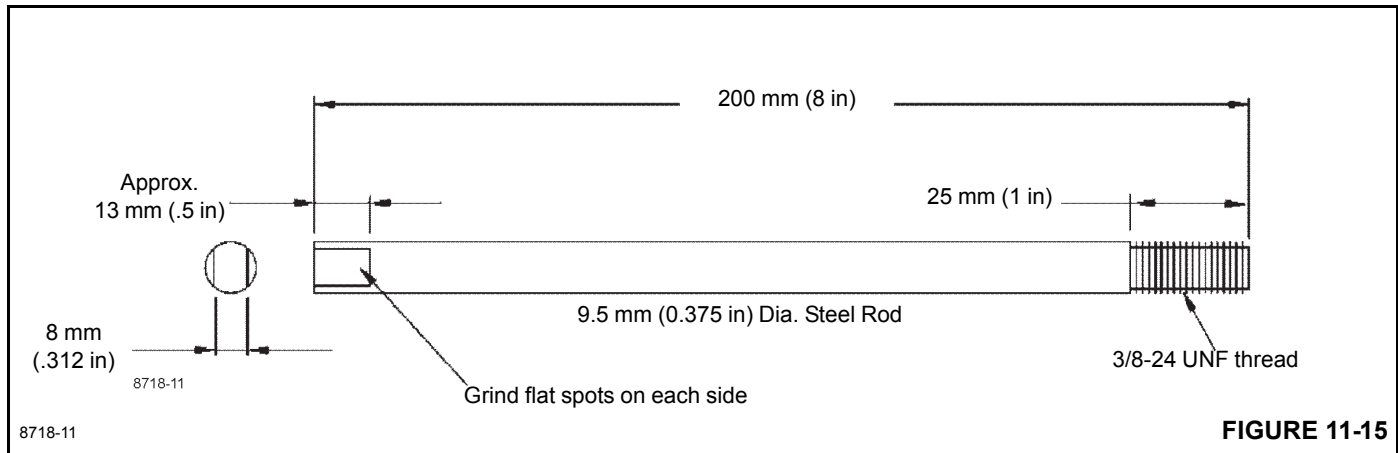
Hoist Motor

Special Tools

- Shaft seal installation tool (600496).
- Bullet (600465) for 1 inch diameter shafts.

The following tools are not necessary for disassembly and reassembly, but are extremely helpful.

- Alignment studs (2)

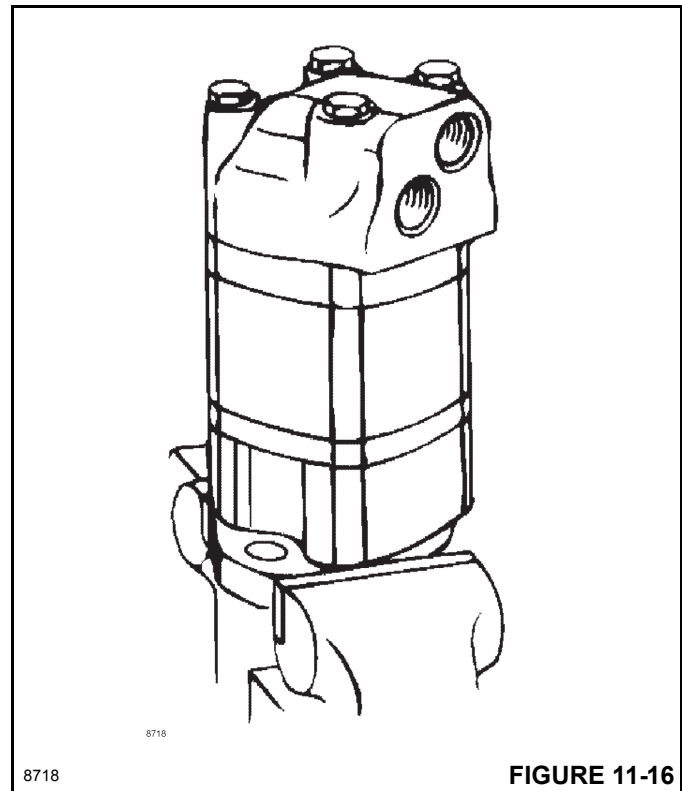


Disassembly

Cleanliness is extremely important when repairing a hydraulic motor. Work in a clean area. Before disconnecting the lines, clean the port area of the motor thoroughly. Use a wire brush to remove foreign material and debris from around the exterior joints of the motor. Check the shaft and key slot, remove all nicks, burrs or sharp edges that might damage the bearing housing seals when installing the shaft and bearing assembly. Before starting the disassembly procedures, drain the oil from inside the motor.

1. Place the motor in a vise with the output shaft down. Clamp across the mounting flange of the motor not the housing. Excessive clamping pressure will cause distortion. When clamping, use some protective device on the vise, such as special soft jaws, pieces of hard rubber or board.

NOTE: Although not all drawings show the motor in a vise, we recommend that you keep the motor in the vise during disassembly and reassembly. Follow the clamping procedures explained throughout the manual.



2. Remove four bolts from motor.

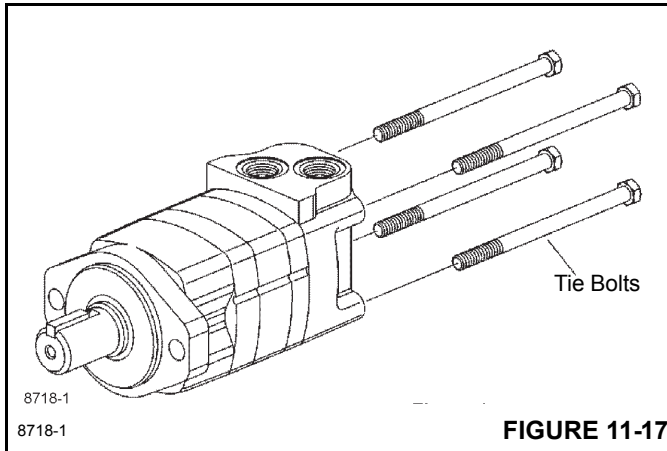


FIGURE 11-17

3. Lift valve housing straight up. If done carefully the pins, springs, balance ring assembly, and valve will remain on the valve plate.

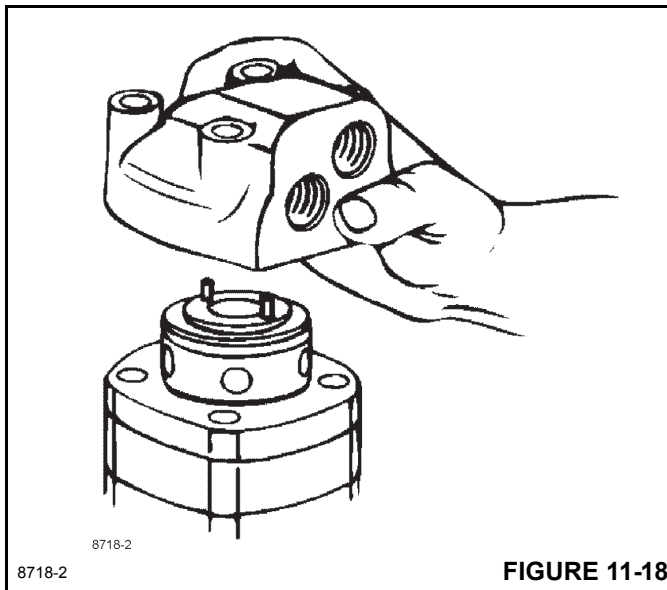


FIGURE 11-18

4. Carefully remove 76 mm (3 in) diameter seal from valve housing.
5. Remove case drain plug with seal, from valve housing.

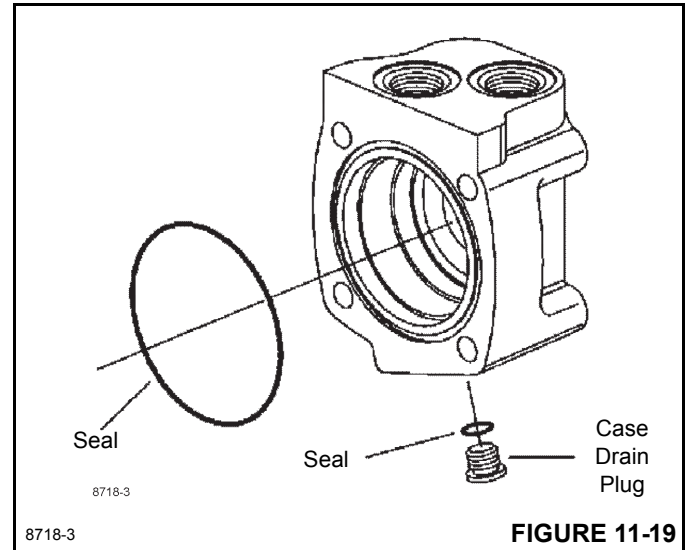


FIGURE 11-19

6. Remove two pins and two springs from balance ring assembly.
7. Remove balance ring assembly.
8. Remove inner and outer face seals from balance ring.
9. Remove the valve.

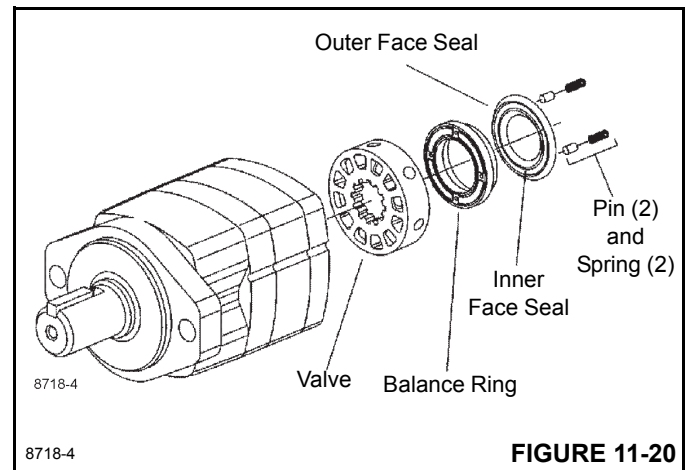


FIGURE 11-20

10. Remove the valve plate.
11. Remove the 76 mm (3 in) diameter seal from valve plate.
12. Remove the valve drive.

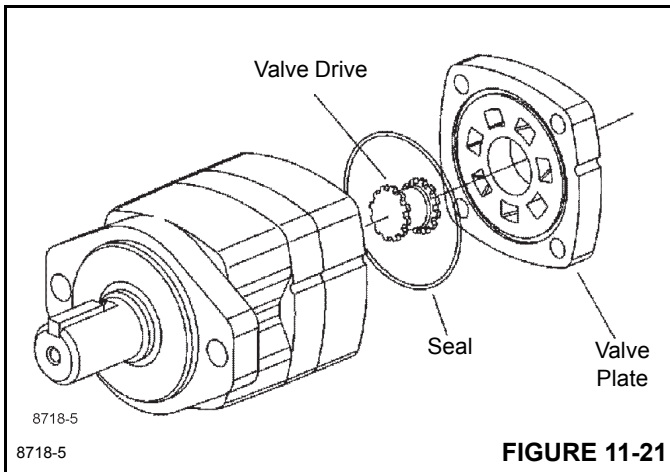


FIGURE 11-21

13. Remove the Geroler. Be sure to retain the rollers in the outer ring if they are loose.
14. Remove the drive.
15. Remove the 76 mm (3 in) diameter seal from wear plate.

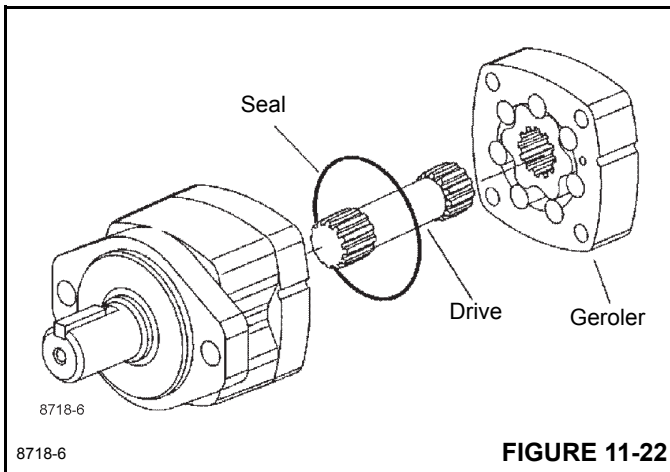


FIGURE 11-22

16. Remove the wear plate.
17. Remove the shaft face seal from the wear plate.
18. Remove the 76 mm (3 in) diameter seal from bearing housing.

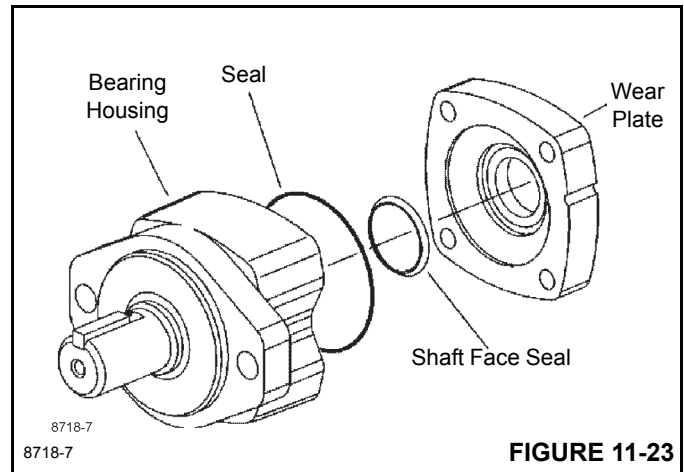


FIGURE 11-23

19. You may need a press to remove shaft and bearing assembly from bearing housing. (Key must be removed before removing shaft.)

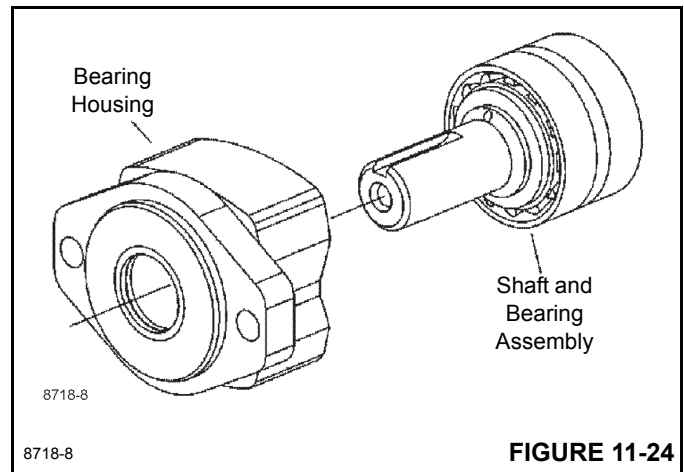


FIGURE 11-24

20. Use a small screwdriver to remove shaft seal, back-up washer and exclusion seal from bearing housing. Do not damage bore of housing.

NOTE: Individual parts of shaft and bearing assembly are not sold separately. Replace as a unit.

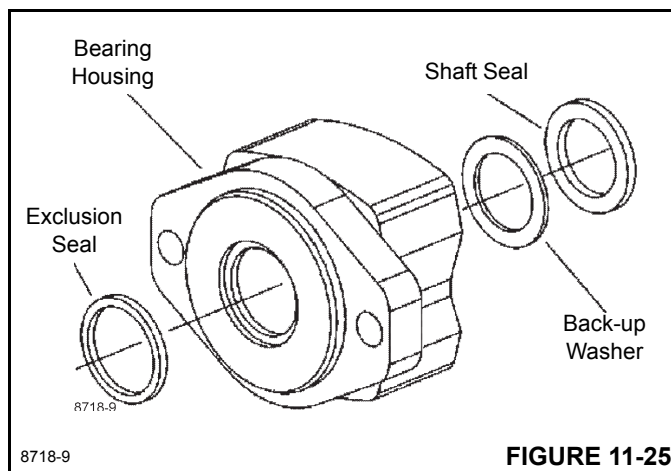


FIGURE 11-25

Reassembly

Check all mating surfaces. Replace any parts that have scratches or burrs that could cause leakage. Clean all metal parts in clean solvent. Blow dry with air. Do not wipe dry with cloth or paper towel because lint or other matter can get in the hydraulic system and cause damage. Do not use a coarse grit or try to file or grind these parts. Check around the keyway and chamfered area of the shaft for burrs, nicks or sharp edges that can damage the seals when reassembling the bearing housing.

NOTE: Lubricate all seals (prior to installation) with petroleum jelly such as Vaseline. Use new seals when reassembling this motor. Refer to parts list (6-129) for proper seal kit number.

1. Use a press to install exclusion seal in outer bore of bearing housing. Lip of seal must face outward. If a press is not available use a plastic or rubber hammer, being careful not to damage or cock seal in the bore.
 2. Place back-up washer into seal bore. Place shaft seal onto installation tool (600496) and press seal into seal bore of the housing.
 3. Clamp housing in vise, see Figure 11-16.
 4. Place protective bullet (see note below) over shaft. Apply petroleum jelly to inside diameter of dust and shaft seal. You may need a press to install shaft and bearing assembly. Do not distort shaft seal. Damage to this seal will cause leakage.
- NOTE:** Bullet (600465), for 1 inch dia. shafts, available—by special order. Use tape over other shafts to prevent cutting the seals.
5. Apply petroleum jelly to the 76 mm (3 in) diameter seal. Install seal into the bearing housing.
 6. Alignment studs can be very helpful in reassembly of the motor. See Figure 11-15. If you use studs, install 2 studs diagonally opposed in the bearing housing.

7. Install the shaft face seal in the wear plate. Do not distort seal.
8. Install the wear plate.
9. Apply a light film of petroleum jelly to the 76 mm (3 in) diameter seal and install seal in the wear plate.

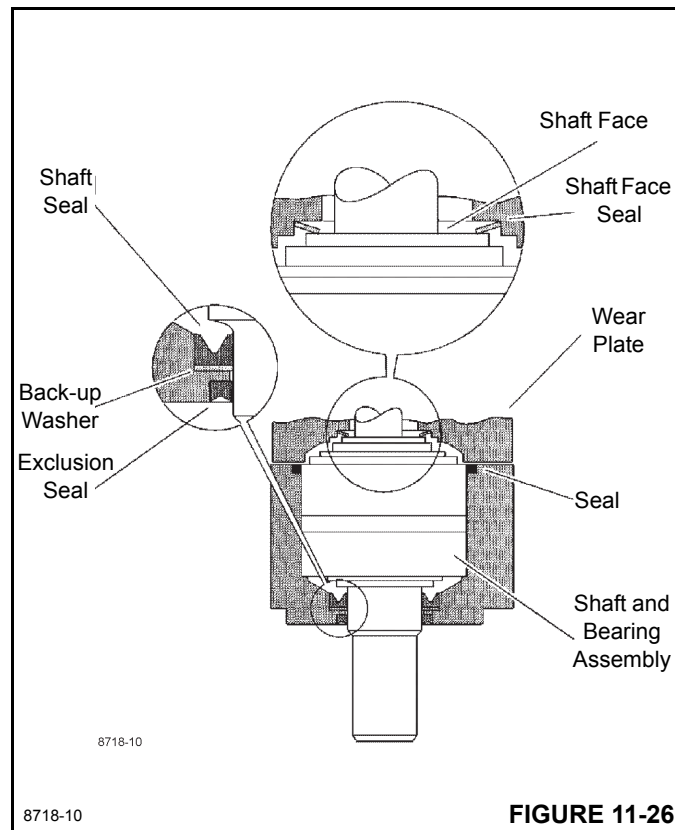


FIGURE 11-26

10. Install the drive into the output shaft.
11. Align the notch on the outside of the Geroler with the notch on the wear plate. Install the Geroler against the wear plate. Be sure to retain the rollers in the outer ring if they are loose.
12. Install the valve drive in the Geroler.

NOTE: Installation at this time involves 3 steps in the timing of the motor. Timing determines the direction of rotation of the output shaft.
Timing parts include:

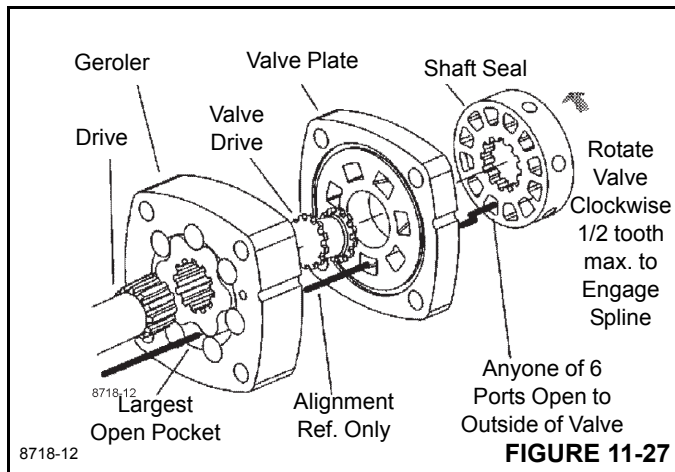
- Geroler
- Valve Drive
- Valve Plate
- Valve

Timing Step # 1 — Locate the largest open pocket in the Geroler and mark it on the outside edge of the Geroler.

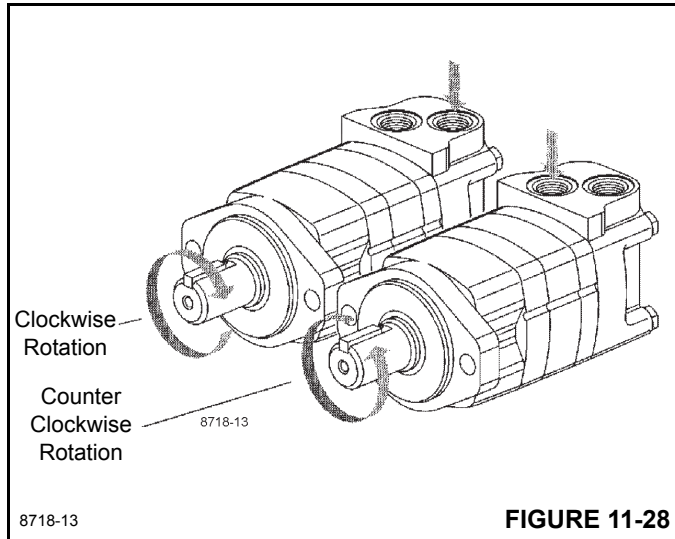
13. Apply a light film of petroleum jelly to the 76 mm (3 in) diameter seal. Install seal in groove of valve plate.

14. Align the notch on the outside of the valve plate with the notch on the Geroler as shown.

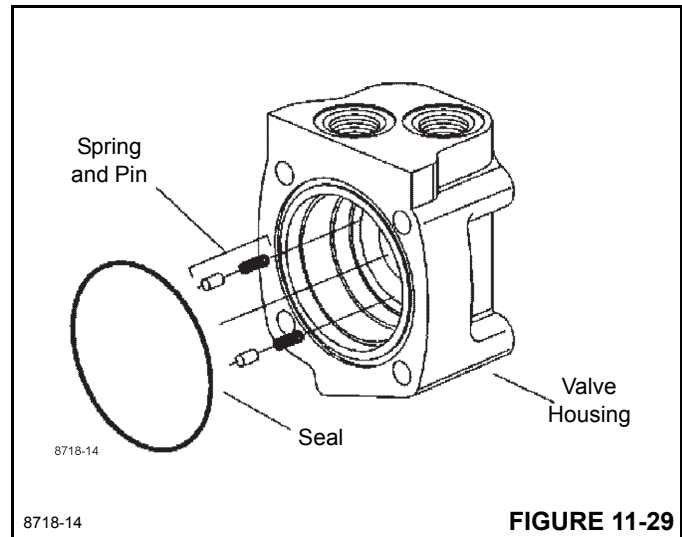
Timing Step # 2 — Locate the slot opening in the valve plate which is in line with the largest open pocket of the Geroler.



Timing Step # 3 — Locate any one of the side openings of the valve and align this opening with the open slot of the valve plate that is in line with the largest open pocket of the Geroler. Install the valve by rotating it clockwise until the spine teeth engage (1/2 spine tooth max.). This will provide the proper rotation when pressurized as shown in Figure 11-28.

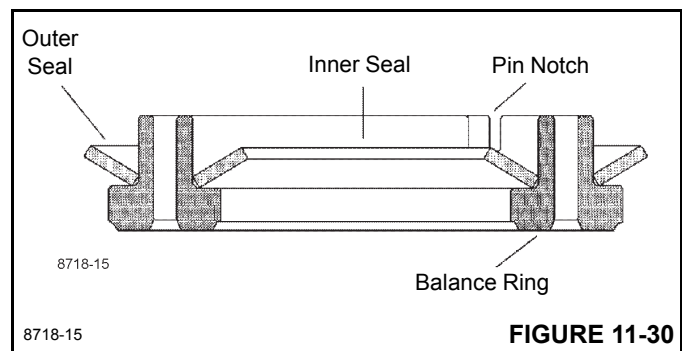


15. Install 2 springs and 2 pins in the holes located in the bore of the valve housing, as shown in Figure 11-29.
16. Apply a light film of petroleum jelly to the 76 mm (3 in) diameter seal. Install seal in the valve housing.

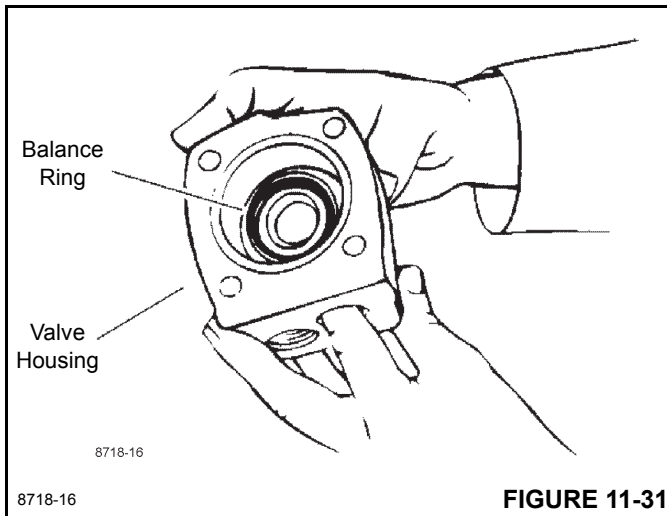


17. Apply petroleum jelly to inner and outer face seals. Install seals on balance ring as shown in Figure 11-30.

Important: Install face seals in the positions shown in Figure 11-30, or the motor will not operate properly. Do not force or bend the face seals. Any damage to these seals will affect the operation of the motor.

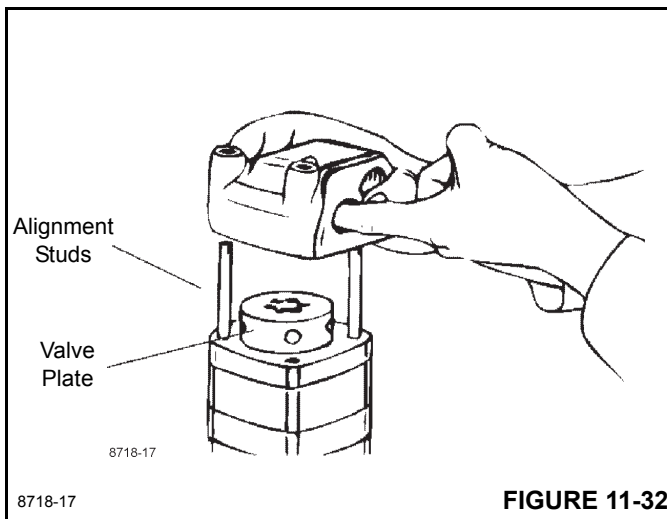


18. Align pin notches in balance ring with pins in bore of valve housing. Install balance ring assembly in valve housing.



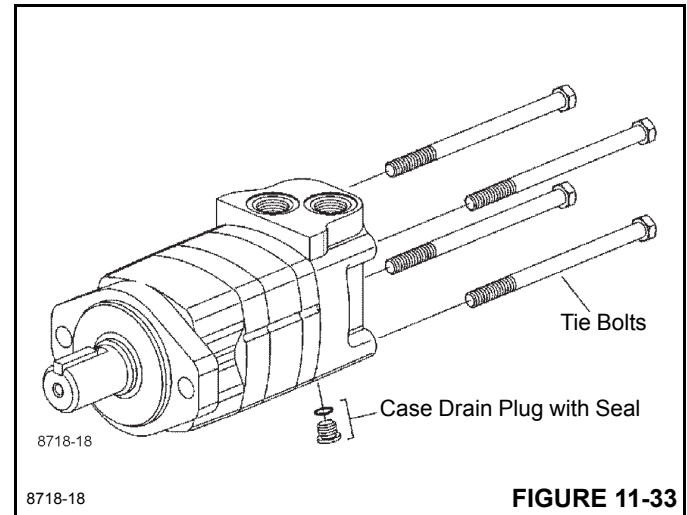
- 19.** Insert your finger through port of valve housing. Apply pressure to side of balance ring as shown in Figure 11-31. Hold ring in position until valve housing is in place against valve plate (see Figure 11-32).

NOTE: After installing the valve housing on the valve plate check for proper placement. Push down on the valve housing. You should get a slight spring action.



- 20.** Install tie bolts. If you use alignment Studs, install 2 bolts opposite the studs. Finger tighten the bolts. Remove the alignment studs and replace with the two remaining bolts. Torque all four bolts alternately to 50 Nm (450 lb-in).

- 21.** Install seal on case drain plug then install in valve housing. Torque to 6 Nm (50 lb-in).



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.

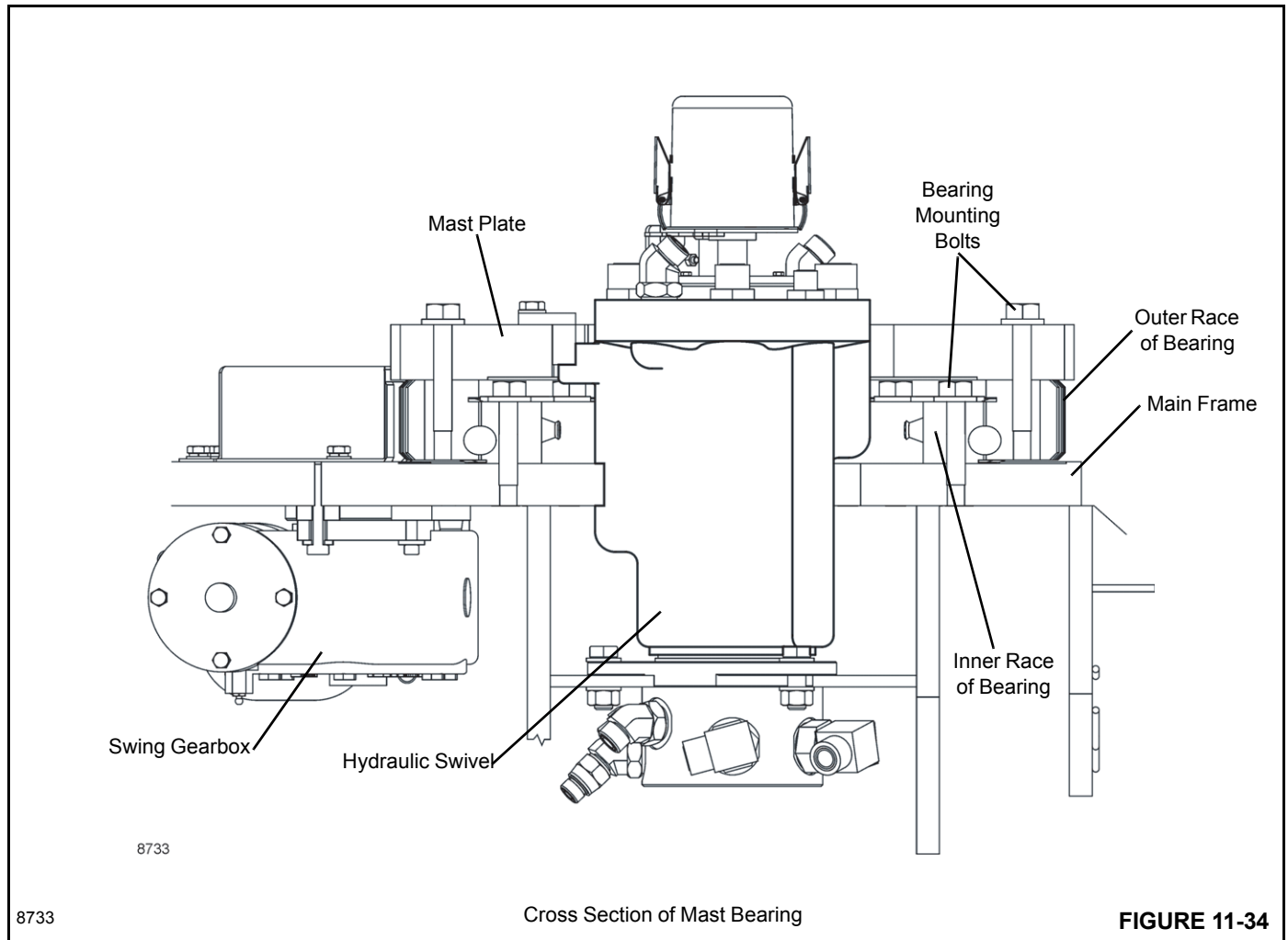
BEARING, MAST AND RELATED PARTS

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 11-34.

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.

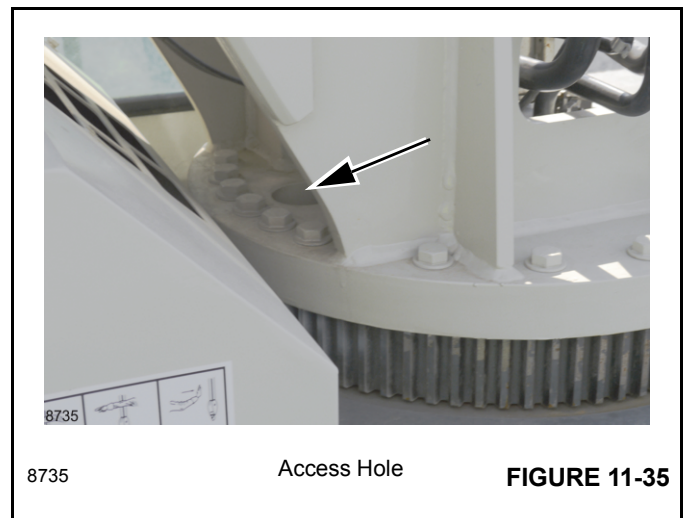


Mast Bearing

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 11-35) 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 old grease will be removed at the bottom of the bearing.



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 mast mounting bolt should be 312 to 339 Nm (230 to 250 lb-ft) (outer ring). Bearing mounting bolt torque should be 481-552 Nm (355-385 lb-ft) (inner ring).

Use the torque sequence shown in Figure 11-36 when checking the torque on the bolts.

NOTE: Use only special Grade 8 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.

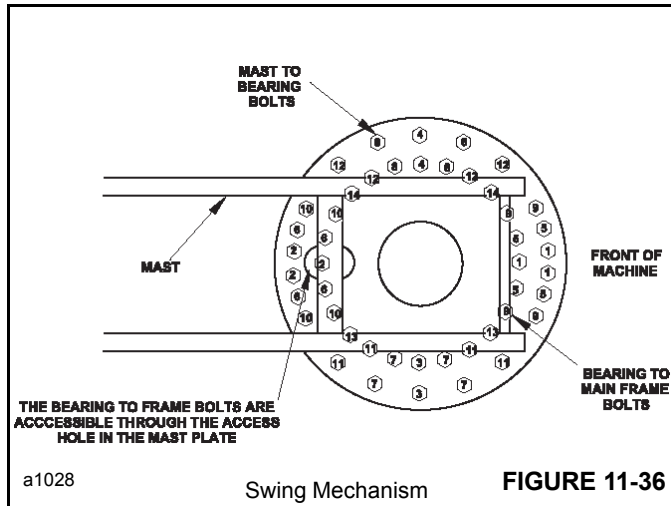


FIGURE 11-36

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 11-37.
- Set the dial indicator to zero.



FIGURE 11-37

- Raise the boom to its full raised position and record the amount of movement on the dial indicator.
- Lower the boom and then rotate it 180°. Repeat steps 2 through 4.
- 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

- Refer to boom removal in this section and remove the boom from the mast.
- Remove swivel stop from the bottom of the hydraulic swivel.
- 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 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 22 bolts and flat washers, which fasten the mast to the mast bearing.
8. Remove the mast and place it on blocks.
9. Remove the 24 bolts and flat washers and remove the mast bearing 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 11-39) in place on the bearing plate.
3. Install the bolts and flat washers to fasten the mast bearing to the bearing plate.
4. Figure 11-36 shows order of tightening the bolts. Each bolt must first be tightened to a torque of 481-552 Nm (355-385 lb-ft) and then loosened slightly. After which, each bolt must again be torqued to 481-552 Nm (355-385 lb-ft).
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 and washers.
7. Figure 11-36 shows the order for tightening the bolts. Each bolt must first be tightened to a torque of 312 to 339 Nm (230 to 250 lb-ft), and then loosened slightly. After which, each bolt must again be tightened to a torque of 312 to 339 Nm (230 to 250 lb-ft).
8. Install swivel stop to hydraulic swivel.
9. Connect the hydraulic lines to the hydraulic swivel.
10. Install counterweight 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

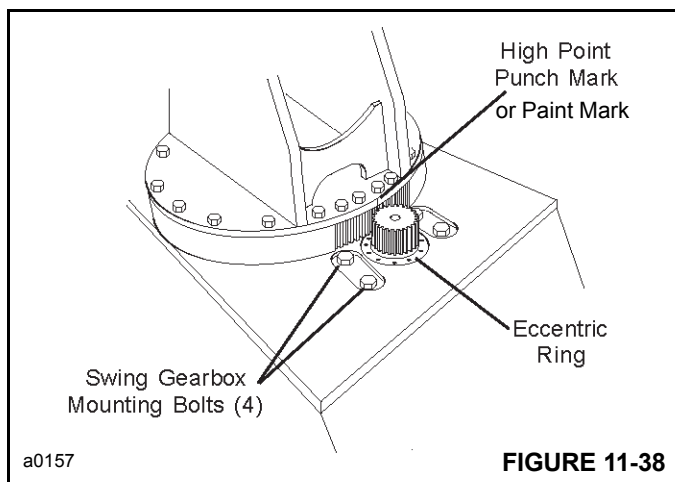
Check the backlash between the swing gear and the swing gearbox pinion every six months or after 1500 hours of operation, whichever occurs first.

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 11-38). 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

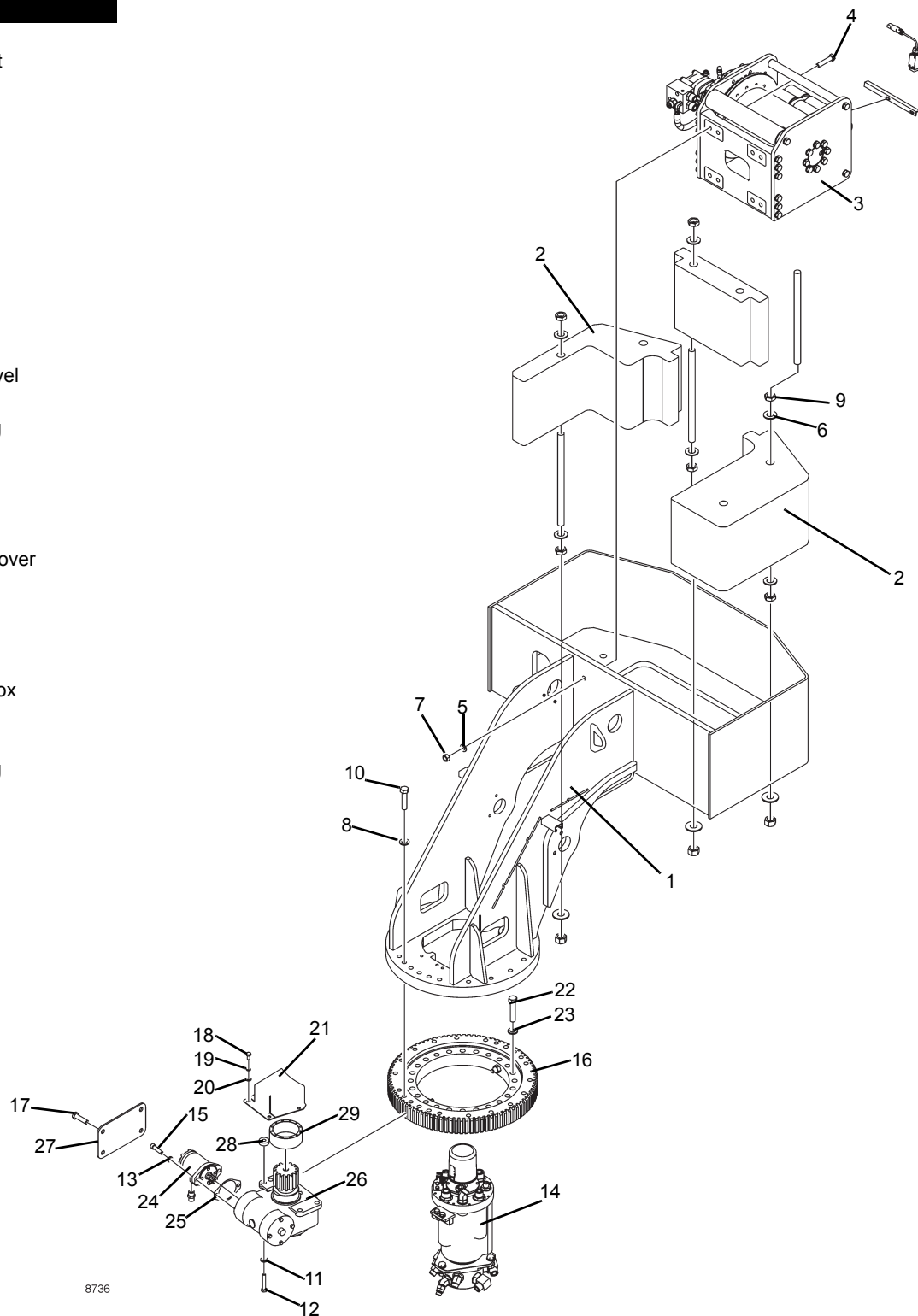
NOTE: Be sure the swing gear and pinion are aligned at the high spot of the swing gear.

1. Slightly loosen the four bolts securing the gearbox (Figure 11-38).
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.



Item	Description
------	-------------

- | | |
|----|-------------------|
| 1 | Mast |
| 2 | Counterweight |
| 3 | Hoist |
| 4 | Bolt |
| 5 | Washer |
| 6 | Washer |
| 7 | Nut |
| 8 | Washer |
| 9 | Nut |
| 10 | Bolt |
| 11 | Washer |
| 12 | Bolt |
| 13 | Lock Washer |
| 14 | Hydraulic Swivel |
| 15 | Bolt |
| 16 | Swing Bearing |
| 17 | Bolt |
| 18 | Bolt |
| 19 | Lock Washer |
| 20 | Washer |
| 21 | Pinion Gear Cover |
| 22 | Bolt |
| 23 | Washer |
| 24 | Swing Motor |
| 25 | Gasket |
| 26 | Swing Gear Box |
| 27 | Cover Plate |
| 28 | Spacer |
| 29 | Eccentric Ring |



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Mast Assembly

FIGURE 11-39

Swing Gearbox Repair

Removal

1. Rotate the boom slightly off center. Then, prevent the mast from turning, by blocking the boom or attach an overhead crane.
2. Remove the front cover over the swing pinion.
3. Install an eyebolt with 1/2 NF threads into the tapped hole on top of the swing pinion. Attach an overhead crane and chain to the eyebolt.
4. Clear any hoses or obstructions beneath the swing gearbox that would inhibit the gearbox from being lowered to the ground.
5. Remove four flat washers (11, Figure 11-39) and capscrews (12).
6. Using the overhead crane, lower the gearbox to the ground. Be sure to collect the four spacers (28) when the gearbox is lowered. The eccentric ring (29) will be removed with the gearbox.

Disassembly

1. Remove the swing motor (24) by removing two capscrews (15) and lockwashers (13). Remove gasket (25).
2. Clean the outside of the gearbox before disassembly.
3. Loosen and remove capscrews (11, Figure 11-40). Remove cover (6) and O-ring (10). Discard the O-ring.
4. Using a suitable puller, remove bushing (12) from cover (6).
5. Clean as much grease out of the gearbox housing as possible. Properly discard the grease.
6. Remove two capscrews (31) and then remove end cover (20) and O-ring (21).
7. Remove oil seal (28) from end cover (20).
8. Using a suitable puller, remove bevel gear (9). Remove two keys (14). Remove thrust washer (13).
9. Remove pinion gear shaft (3) along with bearing cone (15) and oil seal (7) out of housing (4). It may be necessary to use a soft mallet to drive the pinion shaft from the housing.

10. Using a suitable puller, remove bearing cone (15) from pinion gear shaft (3). Remove oil seal (7) from the pinion gear shaft.
11. Remove worm gear shaft (8) by removing it through the end cap opening on the housing. It may be necessary to use a soft mallet to drive the worm gear shaft from the housing.
12. Using a suitable puller, remove bearing cone (17).
13. If necessary, using a suitable puller remove bearing cups (1 and 24) from housing (4).

Inspection

Remove breather (34) and clean it in a suitable solvent. Clean all other parts. Make careful inspection of all parts, including gears, shafts and bearings.

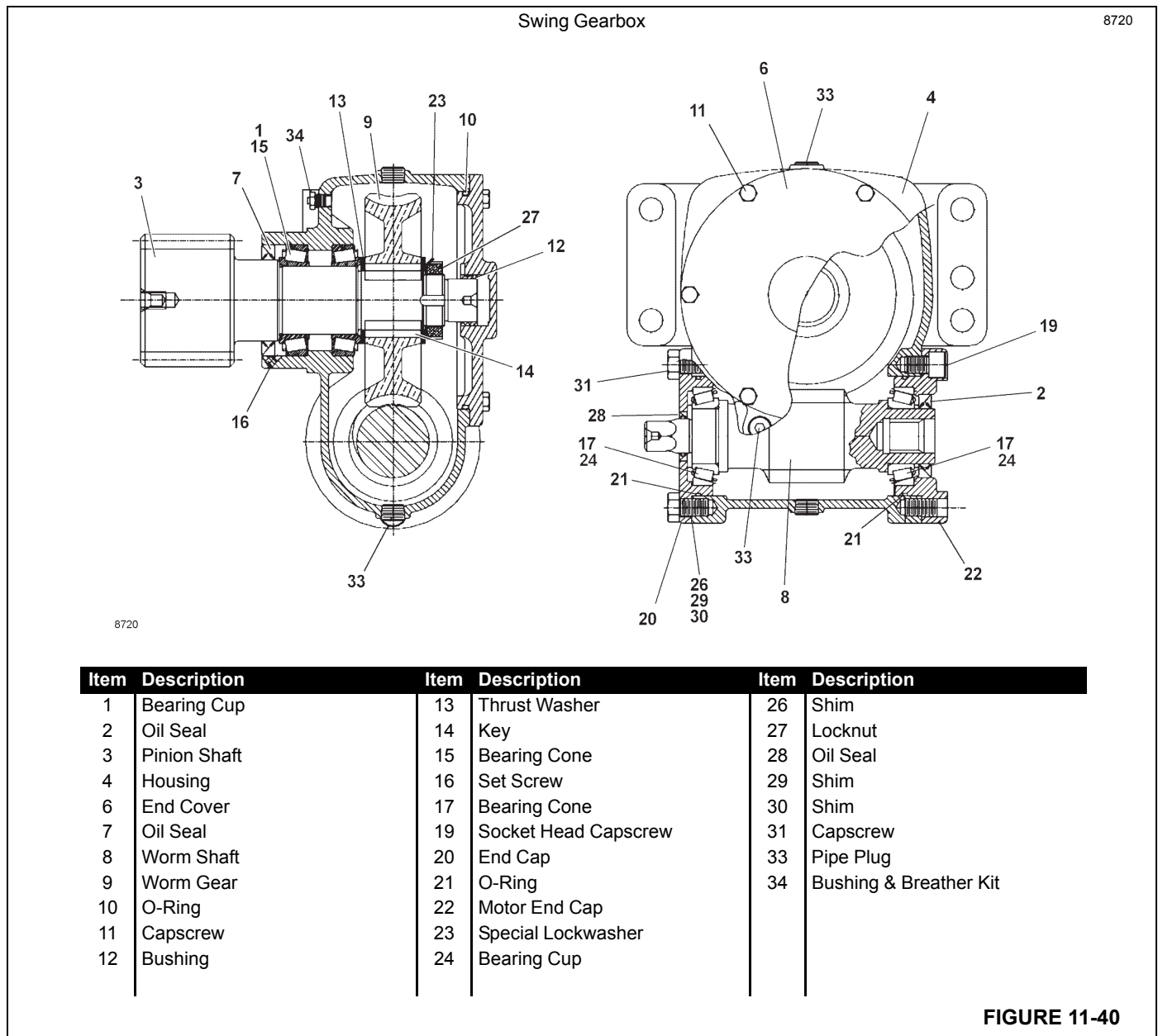
Replace all parts that have wear or damage. Make sure all parts are clean and smooth.

Replace all seals and gaskets.

Coat all seals with a Lithium Base, E.P. No. 2 bearing grease.

Assembly

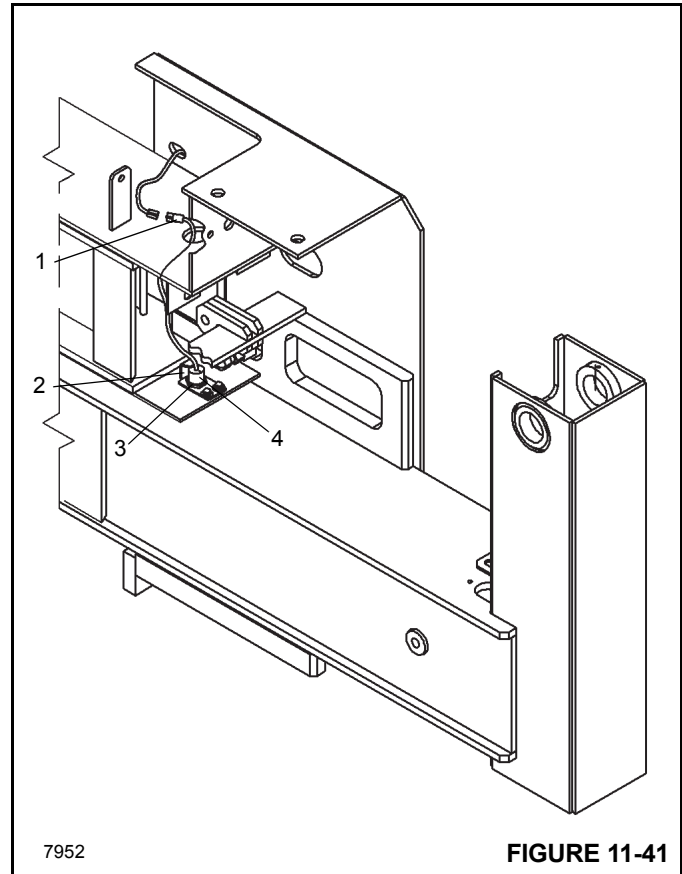
1. If removed, press new bearing cups (1 and 24, Figure 11-40) into housing (4).
 2. Coat a new oil seal (7) with grease and install it onto pinion gear shaft (3).
- NOTE:** Before installing any bearing cone, pack it with lithium based, E.P. No. 2 bearing grease.
3. Pack bearing cone (15) with grease and install it onto pinion gear shaft (3).
 4. Install pinion gear shaft (3) into housing (4). Be sure to seat oil seal (7) into the housing, being careful not to damage it.
 5. Pack bearing cone (15) with grease and install over pinion gear shaft (3) into housing (4).
 6. Insert worm gear shaft (8) into housing (4)



7. Pack bearing cones (17) with grease and install them over the ends of the worm gear shaft into housing (4).
8. Install thrust washer (13) over pinion shaft (3).
9. Install two keys (14) into the end of pinion gear shaft (3). Press bevel gear (9) onto pinion gear shaft (3). Align the teeth of the bevel gear with the teeth of the worm gear shaft.
10. Install thrust washer (11), washer (12) and lock nut (16). Do not tighten the lock nut at this time.
11. Install a new oil seal (2) into end cover (22).
12. If bushing (12) was removed, press a new bushing into cover (6).
13. Install end cap (6) and new O-ring (10) to housing (4) using capscrews (11).
14. Install a new O-ring (13) into cover (14).
15. Using six capscrews (11), install cover (6) onto housing (4).
16. Remove setscrew (16). Fill the gearbox with a lithium based, E.P. No. 2 bearing grease through the grease fitting located on the housing. Fill gearbox until grease flows from the setscrew hole.
17. Place a new gasket (25, Figure 11-39) between gearbox (26) and swing motor (24). Fasten the swing motor to the gearbox with two capscrews (15) and lockwashers (13).

Installation

1. Install an eyebolt with 1/2 NF threads into the tapped hole on top of the swing pinion.
2. Install the eccentric ring onto the gearbox.
3. Using an overhead crane and chain attached to the eye bolt, lift the gearbox into place.
4. Between the gearbox and frame install four spacers (28, Figure 11-39). Fasten the gearbox to the frame with four capscrews (12) and lock washers (11).
5. Connect the two hydraulic hoses to the swing motor.
6. Remove the overhead crane and chain. Remove the eyebolt.
7. Adjust the backlash between the pinion gear and ring gear. See *Swing Gearbox and Pinion*, page 11-43.
8. Coat the teeth of the swing pinion with open gear lubricant. See *Preventative Maintenance*, page 5-1.
9. Install the front cover over the swing pinion.
10. Remove blocking from boom.
11. Start the engine and slowly rotate the boom and mast in both directions to remove any air that may have entered the hydraulic circuit.

**OUTRIGGERS****Outrigger Monitoring System (OMS)
(Optional—Standard in North America)**

The Outrigger Monitoring System (OMS) proximity switches (if equipped) are mounted inside 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. Install bracket with switch onto outrigger mounting plate.
7. 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.
8. 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 (1, Figure 11-42) from the outrigger beam. Retract the horizontal cylinder.

3. Lower the jack outrigger just far enough to remove the load on the outrigger beam.
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 from the bulkhead elbow attached to the frame.
6. Use a hoist to remove the outrigger assembly from the frame.

Disassembly

1. Remove hoses (5, Figure 11-43) from check valve assembly (4). Plug all openings.
2. Remove capscrew (11) from check valve assembly (4). Remove the check valve assembly.
3. Remove capscrews (12) from the top of the jack tube. Remove the jack cylinder assembly from the jack tube.
4. Remove capscrew (16) from outrigger inner tube. Remove cylinder from outrigger inner tube.
5. Remove capscrew (9), then remove clamp (7).
6. Remove capscrew (10, Figure 11-42), slide cover (9) down carrier hoses.
7. Disconnect the carrier hoses from the elbow fittings (5). Remove the hoses (5, Figure 11-43).
8. Disconnect the hoses from the elbows (4) on the hydraulic cylinder (1).
9. Remove cotter pin (8, Figure 11-43), then remove clevis pin (6) from rod end of the hydraulic cylinder.

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 the jack cylinder into the inner tube and secure with a capscrew.

3. Lubricate the inside of outrigger beam box and the outside of the inner tube with STP Oil Treatment, "LUBAID NF", or bronze anti-seize compound.
4. Insert the cylinder and inner tube assembly into the outrigger beam and secure with two capscrews.
5. Install the check valve assembly and secure with capscrews.
6. Install hydraulic cylinder to the outrigger beam assembly using the clevis pin, secure the clevis pin with a cotter pin.
7. Install the jack cylinder hoses and secure with the clamp.
8. Connect the hoses to the jack cylinder.
9. Route the carrier hoses through the cover and connect them to the jack cylinder hoses.
10. Secure the cover to the beam with a capscrew.

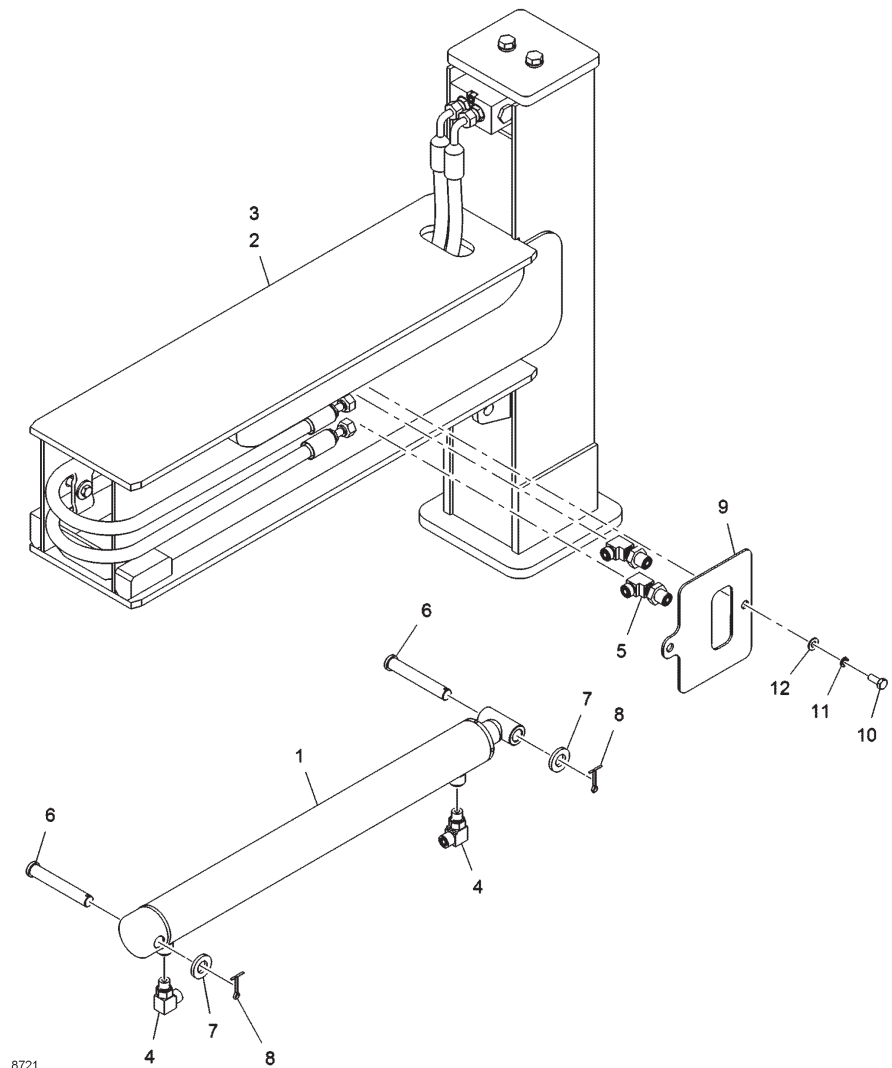
Installation

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 to the outrigger beam. Install pin and cotter pin.
4. Connect the outrigger proximity switches, if equipped.
5. 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.
6. Operate outrigger and check for correct installation. Stop the engine. Check for leakage at the hose connections.

Item	Description
------	-------------

- | | |
|----|-------------------------|
| 1 | Hydraulic Cylinder |
| 2* | Outrigger Beam Assembly |
| 3* | Outrigger Beam Assembly |
| 4 | 90 Degree Elbow |
| 5 | 90 Degree Elbow |
| 6 | Clevis Pin |
| 7 | Washer |
| 8 | Cotter Pin |
| 9 | Cover |
| 10 | Capscrew |
| 11 | Lock Washer |
| 12 | Flat Washer |

* See Figure 11-43 for parts breakdown.

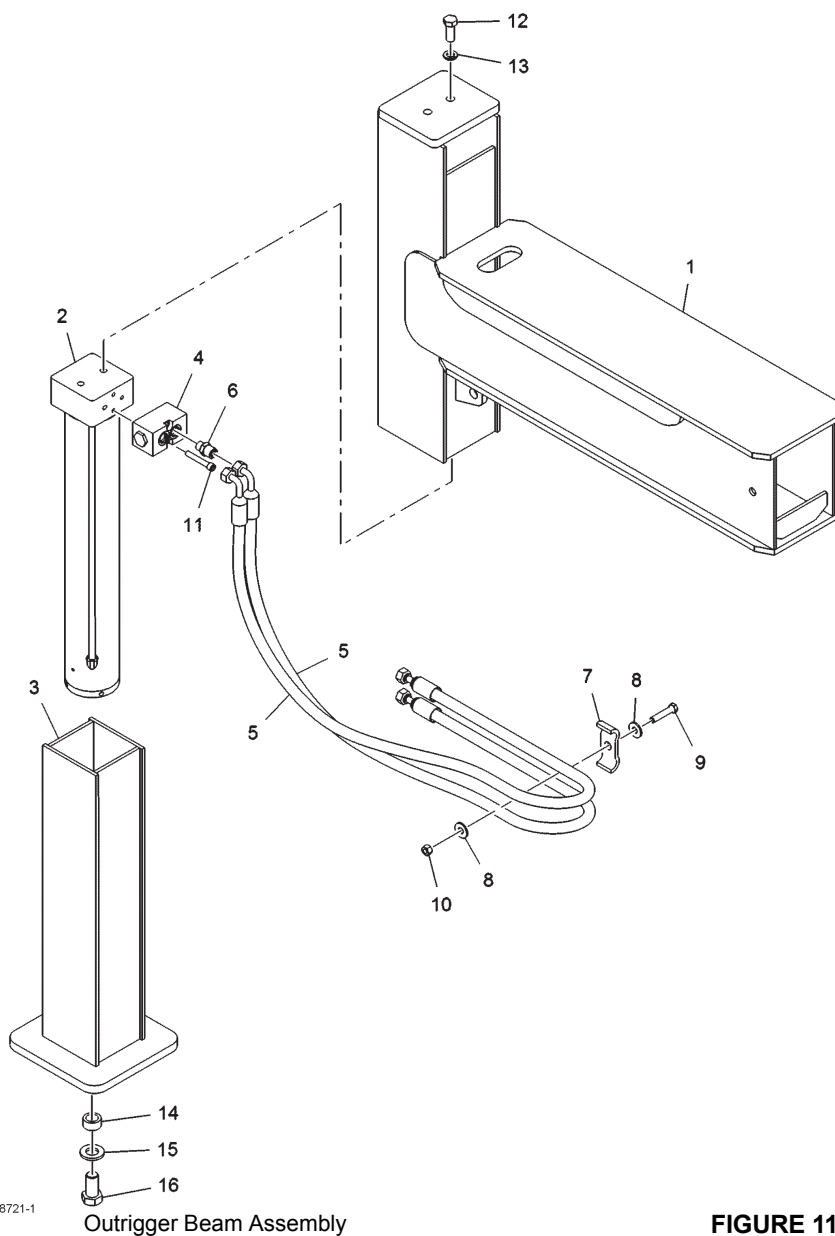


Outrigger Assembly

FIGURE 11-42

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Item	Description
1	Outrigger Beam
2	Hydraulic Cylinder
3	Outrigger Inner Tube
4	Check Valve Assembly
5	Hose Assembly
6	Straight Male Adapter
7	Clamp
8	Flat Washer
9	Capscrew
10	Locknut
11	Capscrew
12	Capscrew
13	Lock Washer
14	Spacer
15	Flat Washer
16	Capscrew



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Outrigger Beam Assembly

FIGURE 11-43

SECTION 12

SCHEMATICS/WIRING DIAGRAMS

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