CD15

Service Manual

8905-1

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.

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CHANGE OF OWNERSHIP FORM

Constant improvements, engineering progress or manufacturing information may arise after this crane has been in the field for several years that will make it necessary for us to contact future owners of this machine. It is important to you that Manitowoc Crane have up-to-date records of the current owners of the crane should the need arise for us to contact you. Manitowoc Crane is interested in safe efficient operation of its cranes for their lifetime. Therefore, if you are the second, third, or subsequent owner of this crane, please fill out the form below relating the new owner, model of crane and crane serial number information and e-mail or send to the below address.

PREVIOUS COMPANY NAME: ____

CURRENT COMPANY NAME: ____

CONTACT NAME: __________________________________

ADDRESS: ____

CITY/STATE:________________________________POSTAL CODE: ___________

TELEPHONE NUMBER: _____________________

EMAIL ADDRESS: ____

DATE PURCHASED________CRANE MODEL________CRANE SERIAL NUMBER_______

Please e-mail to: warranty.team@manitowoc.com or visit
https://www.manitowoc.com/support/change-ownership

CHANGE OF OWNERSHIP REGISTRATION

Product Support strives to maintain up-to-date contact information for crane owners so that we can readily communicate information about improvements and/or engineering developments for cranes that have been in the field for several years.

Product Support is pleased to announce that we have developed a QR code to allow the customer to register their crane remotely or re-register their crane if it was purchased used.

To register your crane scan the QR code below or visit https://www.manitowoc.com/warranty-registration-form to register your crane.

SERVICE MANUAL

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

CD15

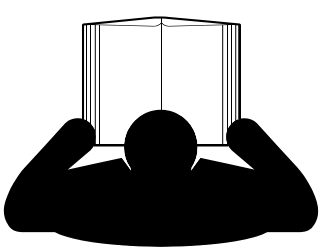
Crane Model Number

This Manual is Divided into the following Sections:

NOTICE

The crane serial number is the only method your Grove distributor or Product Support 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 Product Support.



⚠DANGER

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

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

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SECTION 1
INTRODUCTION

SECTION CONTENTS

GENERAL

This manual contains information on maintenance, service and repair of the CD15 crane. Major components and systems are included, except service on the engine. This information will be found in the engine manufacturer's service manual.

Before placing the crane into service, all operators and persons working around the crane must thoroughly read and understand the contents of the Operators Manual. Before moving a vehicle equipped with a crane, information relating to transporting the vehicle must be read and observed.

This manual must be retained with the machine for use by subsequent operating and maintenance personnel.

Information this manual does not replace federal, state or local regulations, safety codes or insurance requirements.

For detailed information concerning the operation and maintenance of the RCL system installed on this crane, see the manufacturer's manual supplied with the crane. Manufacturers of rated capacity limiters may refer to them in their manuals as a load moment indicator (LMI), a hydraulic capacity alert system (HCAS), a safe load indicator (SLI), or an ECS5; Grove refers to these systems as a rated capacity limiter (RCL) throughout its manuals.

The CD15 crane has been designed for maximum performance with minimum maintenance. With proper care, years of trouble-free service can be expected.

Grove reserves the right to make specification and equipment changes without notice because of product improvements.

Grove and its distributor network want to ensure your satisfaction with our products and customer support. Your local distributor is the best equipped and most knowledgeable to assist you for parts, service, and warranty issues. They have the facilities, parts, factory trained personnel, and the information to assist you in a timely manner. We request that you first contact them for assistance. If you feel you need factory assistance, please ask the distributor's service management to coordinate the contact on your behalf.

Supplemental Information

Supplemental information for options such as remote controls, augers, varying control configurations, baskets, grapples, etc. is included in separate manuals.

Whenever a question arises regarding your crane or this publication, please consult your Grove distributor for the latest information. Your Grove distributor is equipped with the proper tools, necessary CD15 parts, and trained service personnel to maintain and service your crane.

Safety Information

A Safety Compact Disc (CD) which includes sections on Operation, Safety and Maintenance for operators and owners is supplied when the crane is purchased new. Additional copies are available from your local distributor.

Basic Nomenclature

The nomenclature used to describe parts of a CD15 cranes are described in Figure 1-1. This nomenclature is used throughout this manual.

DIRECTIONAL REFERENCE

All directional references in this manual, unless otherwise noted, are viewed from the normal operator's working position at the controls. “LEFT” is the operator's left and “RIGHT” is the operator's right.

8905

Item	Description
1	Hook Block or Downhaul Weight
2	Optional Boom Extension (Jib)
3	Anti-Two-Block and RCL Device
4	Pivoting Boom Head
5	3rd Boom Section (4th section optional)
6	2nd Boom Section
7	1st Boom Section
8	Lift Cylinder
9	Hoist (load)
10	Counterweight (1-piece)
11	Engine Compartment
12	Carrier
13	Rear Axle (drive or non-drive)
14	Outrigger (qty 4)
15	Operator's Cab (open or enclosed with split door)
16	Front Drive Axle (steerable)
17	Optional Winch
18	Hook Tie-Back Sling
19	LED Lighting
20	Carry Deck
21	Main Control Valve Location
22	Swing Drive and Turntable Bearing
23	Mast

FIGURE 1-1

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IDENTIFICATION PLATES

When assistance is required for parts and service, be sure to include the model number and serial number (S/N) of the crane in the correspondence. The locations of serial number plates are shown below.

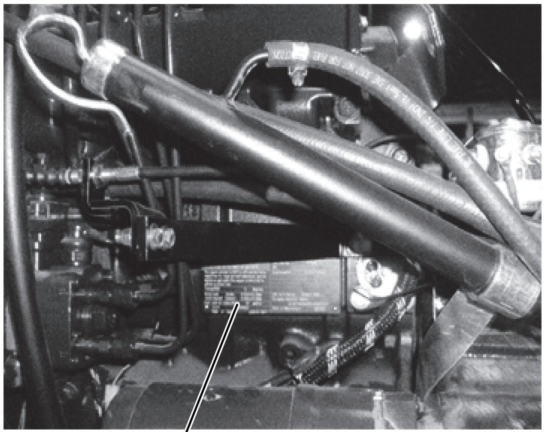
The locations can vary.

9058-1

Crane S/N Location on Wall Behind Operator Seat

FIGURE 1-2

p1878



Engine S/N Location

FIGURE 1-3

9059

Transmission S/N Location

FIGURE 1-4

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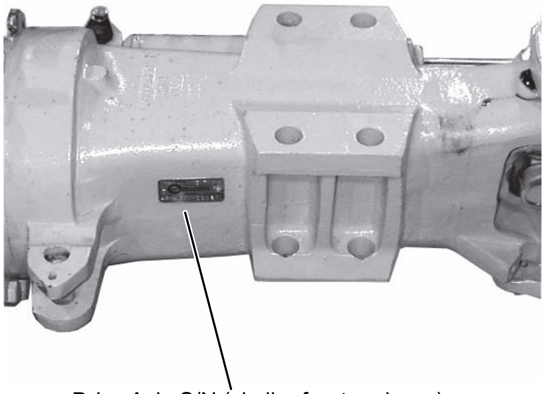


Drive Axle S/N (similar front and rear)
Non-Drive Axle does not have a S/N

FIGURE 1-5

GENERAL SPECIFICATIONS

Boom

3 Section Boom.......................................12.5 m (41 ft)
4 Section Boom.......................................15.4 m (50 ft)
Boom Extension (optional)...........................4.6 m (15 ft)
Boom Elevation.......................................0° to 72°

Electrical System

Rating ....12 VDC negative ground
Battery rating (qty 1, maintenance free).......................................1000 CCA @ -18°C (0ºF)
Alternator T3 ....135 amp
Alternator T4 and Dual Fuel ....145 amp

Engine

Tier 4 Diesel Engine

Make and model ....Cummins QSF3.8L-4 Cyl. Diesel Tier 4F
Type of aspiration.......................................Turbocharged
Horsepower ....74 hp @ 2200 rpm
Low idle engine speed ....900 rpm
No load engine speed ....2350 rpm
Full load engine speed ....2200 rpm

Tier 3 Diesel Engine

Make and model ....Cummins QSF3.8L-4 Cyl. Diesel
Type of aspiration.......................................Turbocharged
Horsepower ....99 hp @ 2200 rpm
Low idle engine speed ....900 rpm
No load engine speed ....2350 rpm
Full load engine speed ....2200 rpm

Dual Fuel (Gasoline/LP) Engine

Make and model ....GM 4.3L EFI V-6
Horsepower (Gasoline).......................................90 hp @ 2200 rpm
Horsepower (LP)....................................... 87 hp @ 2200 rpm
Low idle engine speed ....900 rpm
Maximum engine speed ....2200 rpm

Fuel Tank

Capacity.......................................100 L (26.4gal)

Hydraulic System

Primary Pump ....Axial Piston
65 cc - CW for 2-wheel drive
65 cc - CCW for 4-wheel drive
Swing Motor.......................................Single section, geroler-type
Hoist Motor.......................................Single section, geroler-type

Hydraulic Filter	One 5-micron in-line return
Hydraulic Cylinders	Double-acting cylinders for lift, telescope, steering and outriggers
Hydraulic Tank	130.6 L (34.5 gal), steel construction with internal baffle

Mast

Rotation	360°
Mast Bearing (Diameter)	860.65 mm (33.884 in)
Swing Drive Mechanism	Hydraulic motor driven gearbox
Swing Speed	2.1 rpm

Outriggers

Type	Hydraulic Cylinder each Corner
Construction	Oblique, Welded box

Tires

Size	385/65 D22.5
Air pressure	9 bar (125 psi)
Wheel nut torque	500 ft-lb (680 Nm)

Travel Speeds (approximate)

2-Wheel Drive, Two-Wheel Steer

1st gear forward	4.0 km/hr (2.5 mph)
2nd gear forward	8.9 km/hr (5.5 mph)
3rd gear forward	17.7 km/hr (11 mph)
4th gear forward	27.0 km/hr (16.8 mph)
1st gear reverse	4.0 km/hr (2.5 mph)
2nd gear reverse	8.7 km/hr (5.4 mph)
3rd gear reverse	17.2 km/hr (10.7 mph)

Weight (GVW)

Two Wheel Drive, 41’ Boom, 15’ Extension, Downhaul Weight, Hook Block, Enclosed Operator’s Cab with A/C, and Driver:

with T4 Engine	11,771 kg (25,950 lbs)
with Tier 3 Engine	11,673 kg (25,735 lbs)
with Dual Fuel Engine	11,609 kg (25,594 lb)

Wire Rope

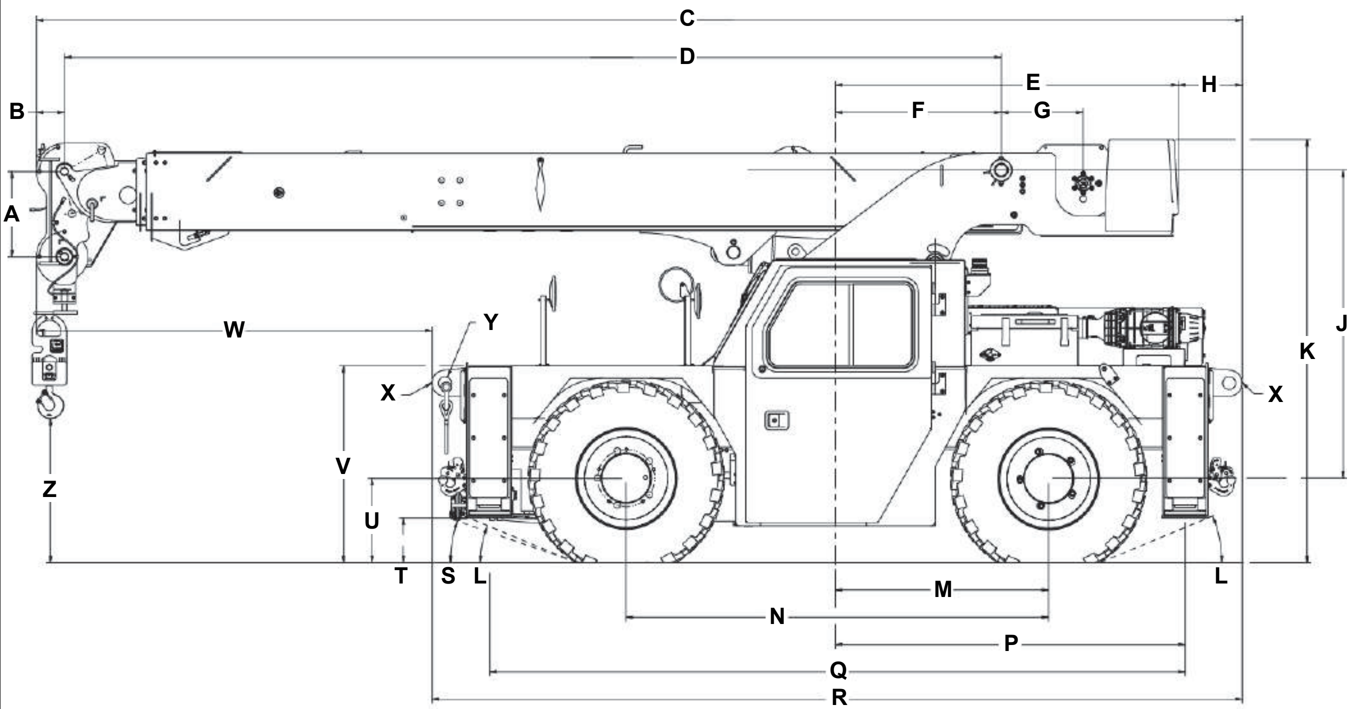
Main Hoist:

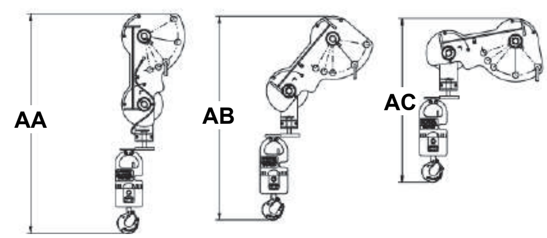
Size	14 mm (9/16 in) 6 x 19 EEIPS-IWRC
Length (41-ft boom)	72 m (235 ft)
Length (50-ft boom)	84.7 m (278 ft)
Line Pull	3856 kg (8,500 lb)

Optional Below Deck Winch:

Diameter	11.1 mm (7/16 in)
Length	35.1 m (115 ft)
Max Working Load	4536 kg (10,000 lb)

DIMENSIONS (SIDE VIEW)





Item	mm	ft	in	Comments
A	500	1	8	
B	165	0	7	
C	7066	23	2	41 ft Boom Retracted
	6853	22	6	50 ft Boom Retracted
D	5489	18	0	41 ft Boom Retracted
	12500	41	0	41 ft Boom Extended
	5277	17	4	50 ft Boom Retracted
	15253	50	1	50 ft Boom Extended
E	2009	6	7	
F	972	3	3	
G	480	1	7	
H	376	1	3	
J	1805	5	11	
K	2481	8	2	
L	22°			
M	1250	4	1	
N	2476	8	2	
P	2050	6	9	
Q	4075	13	5	
R	4747	15	7	
S	19°			Optional
T	262	0	11	
U	494	1	8	
V	1154	3	10	
W	2319	7	7	
X				
Y	76	0	3	4 lifting holes
Z	846	2	10	
AA	1613	5	4	0° Boom Head
AB	1495	4	11	40° Boom Head
AC	1200	3	11	80° Boom Head

NOTE 1: Lifting of the crane must be accomplished utilizing the specified fittings indicated at "X".

NOTE 2: Rigging personnel shall be responsible for proper selection and placement of all slings and load handling devices.

NOTE 3: Dimensions and heights shown are for largest configuration available.

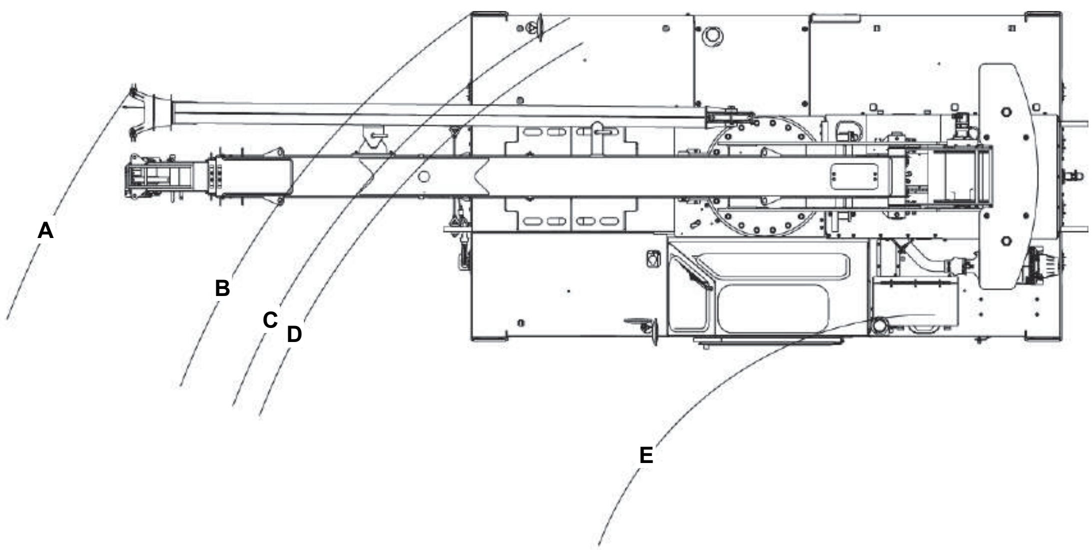
NOTE 4: Rigging personnel shall verify dimensions required for clearance.

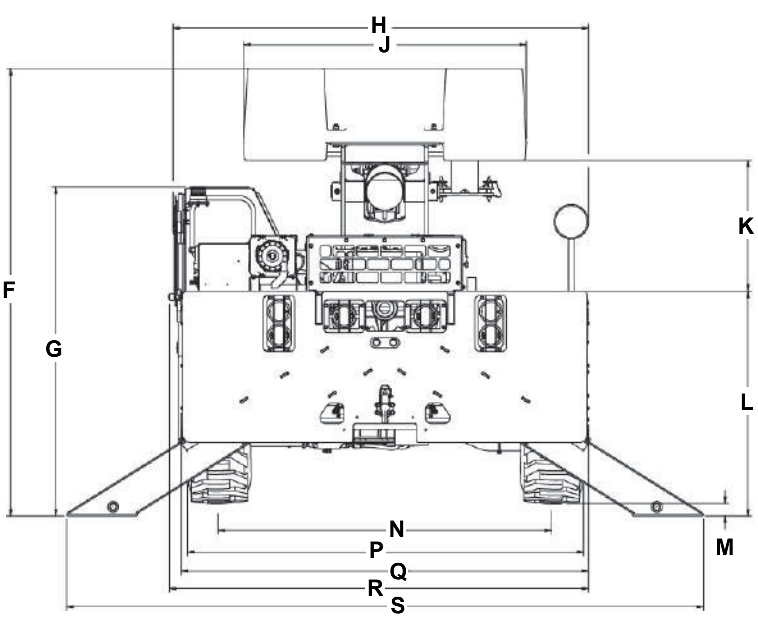
NOTE 5: Do not use pintle hooks or counterweight lugs for lifting or tie down of the crane.

Item	Qty	Lift	Tow	Tie Down	Capacity – Metric Ton (US Ton)				
					Lift	Tow	Tie Down		
							Fore Aft	Side	Down
X	4	OK	OK	OK	25.4 (28)	25.4 (28)	25.4 (28)	7.3 (8)	25.4 (28)

DIMENSIONS (TOP VIEW AND REAR VIEW)

Tire Size	Radius mm (ft-in)									
	A Boom Clearance	**B** Carrier Clearance	**C** Curb Clearance	**D** Outside Turn	**E** Inside Turn	**A** Boom Clearance	**B** Carrier Clearance	**C** Curb Clearance	**D** Outside Turn	**E** Inside Turn
385/65D22.5	7307 (24-0)	5939 (19-6)	5526 (18-2)	5318 (17-6)	2647 (8-8)	5210 (17-1)	3606 (11-10)	3175 (10-5)	2856 (9-5)	2068 (6-10)
	Two-Wheel Steer					Four-Wheel Steer				





Item	mm	ft	in
F	2635	8	8
G	1938	6	5
H	2444	8	0
J	1662	5	6
K	771	2	7
L	1325	4	4
M	74	0	3
N	1963	6	6
P	2329	7	8
Q	2396	7	11
R	2465	8	1
S	3747	12	4

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 1-6:

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

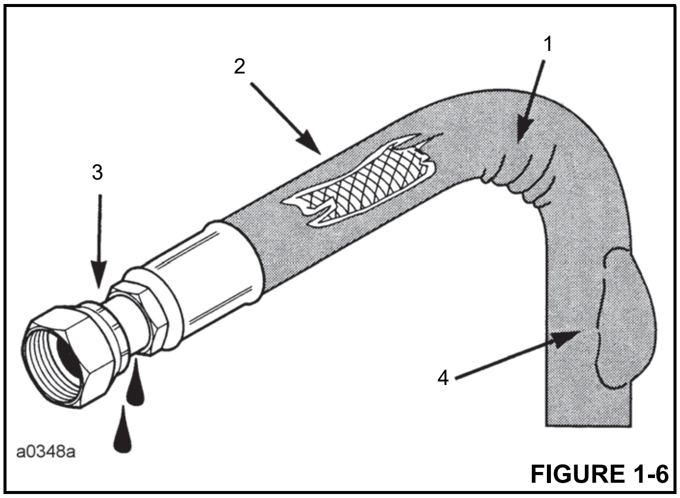


FIGURE 1-6

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 Grove Crane Care Parts Manual.

2. At the same service interval, visually inspect all other hydraulic components and valves for the following:

- Leaking ports.
- Leaking valve sections or manifolds and valves installed into cylinders or onto motors.
- Damaged or missing hose clamps, guards, or shields.
- Excessive dirt and debris around the hose assemblies.

If any of these conditions exist, address them appropriately.

3. All hydraulic hose assemblies are recommended to be replaced after 8000 hours of service life.

Table 1-1

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

4. Hydraulic hose assemblies operating in a temperature climate zone “C” Table 1-1 are recommended to be replaced after 8000 hours of service life.

5. Hydraulic hose assemblies operating in climate zones “A” and “B” with high ambient temperatures, could see hose service life reduced by 40 to 50%, therefore, it is recommended to replace these hoses after 4000 to 5000 hours of service life.

6. Hydraulic hose assemblies operating in climate zones “D” and “E” should expect a degradation of mechanical properties such as elasticity, therefore, it is recommended these hoses be inspected and addressed accordingly.

Electrical System

Harnesses, Wires, and Connectors

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

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

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

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

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

Fatigue of Welded Structures

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

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

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

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

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

Application of Medium Strength Loctite

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

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

Primer Application

NOTE: Primer is not required with Loctite #243.

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

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

Adhesive/Sealant Application

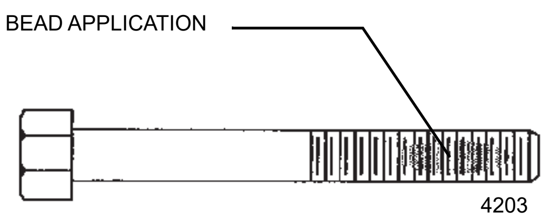


FIGURE 1-7

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 1-7).
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 Grove 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.

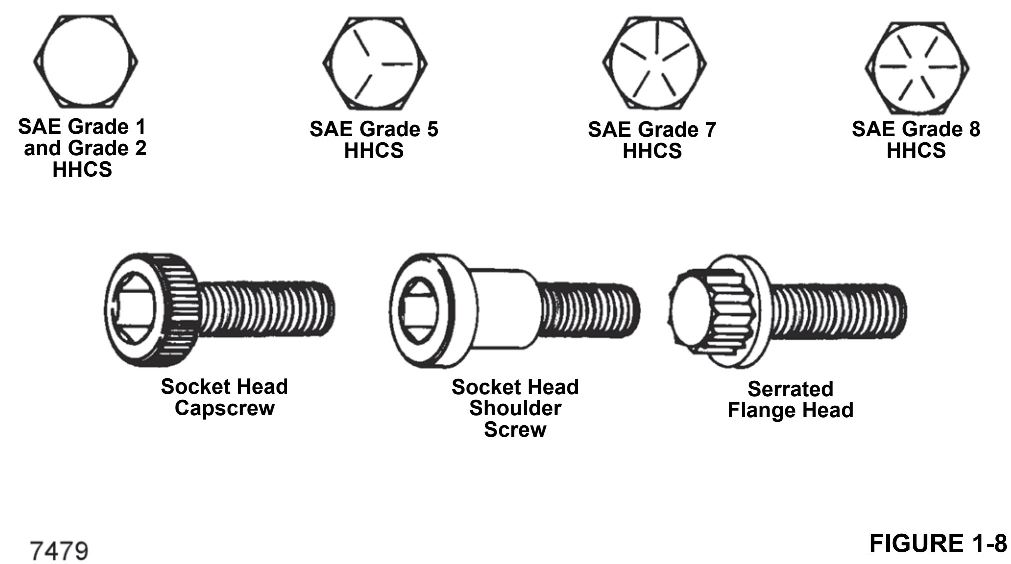


FIGURE 1-8

Table 1-2Inch Series with Coarse Threads (UNC) – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-20 UNC	5	6.6	6.4	6.2
	8	9.3	9.0	8.8
5/16-18 UNC	5	13.5	13.2	12.8
	8	19.1	18.6	18.1
3/8-16 UNC	5	24.0	23.4	22.8
	8	33.9	33.1	32.2
7/16-14 UNC	5	38.4	37.4	36.5
	8	54.3	52.9	51.5
1/2-13 UNC	5	58.6	57.1	55.7
	8	82.8	80.7	78.6
9/16-12 UNC	5	84.5	82.4	80.3
	8	119.4	116.5	113.5
5/8-11 UNC	5	116.6	113.7	110.8
	8	164.8	160.7	156.6
3/4-10 UNC	5	206.8	201.7	196.5
	8	292.3	284.9	277.6
7/8-9 UNC	5	333.8	325.4	317.1
	8	471.6	459.8	448.0
1-8 UNC	5	500.3	487.8	475.3
	8	707.0	689.3	671.6
1 1/8-7 UNC	5	624.0	608.4	592.8
	8	1001.4	976.4	951.4
1 1/4-7 UNC	5	880.5	858.5	836.5
	8	1413.1	1377.8	1342.5
1 3/8-6 UNC	5	1154.5	1125.6	1096.7
	8	1852.8	1806.5	1760.2
1 1/2-6 UNC	5	1532.0	1493.7	1455.4
	8	2458.8	2397.3	2335.8

Table 1-3 Inch Series with Fine Threads (UNF) – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28 UNF	5	7.5	7.3	7.1
	8	10.6	10.4	10.1
5/16-24 UNF	5	15.0	14.6	14.2
	8	21.1	20.6	20.1
3/8-24 UNF	5	27.2	26.5	25.8
	8	38.4	37.5	36.5
7/16-20 UNF	5	42.9	41.8	40.7
	8	60.6	59.1	57.6
1/2-20 UNF	5	66.0	64.4	62.7
	8	93.3	90.9	88.6
9/16-18 UNF	5	94.3	91.9	89.6
	8	133.2	129.9	126.6
5/8-18 UNF	5	132.1	128.8	125.5
	8	186.7	182.0	177.3
3/4-16 UNF	5	231.0	225.2	219.4
	8	326.4	318.2	310.1
7/8-14 UNF	5	367.7	358.5	349.3
	8	519.6	506.6	493.6
1-12 UNF	5	547.4	533.7	520.0
	8	773.5	754.2	734.8
1 1/8-12 UNF	5	700.0	682.5	665.0
	8	1123.5	1095.4	1067.3
1 1/4-12 UNF	5	975.0	950.6	926.2
	8	1564.8	1525.7	1486.5
1 3/8-12 UNF	5	1314.4	1281.5	1248.6
	8	2109.5	2056.7	2004.0
1 1/2-12 UNF	5	1723.9	1680.8	1637.7
	8	2766.8	2697.6	2628.4

Table 1-4 Metric Series with Coarse Threads – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M4x0.7	10.9	3.6	3.5	3.4
	12.9	4.2	4.1	4.0
M5x0.8	10.9	7.2	7.0	6.8
	12.9	8.4	8.2	8.0

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M6x1.0	8.8	8.3	8.1	7.9
	10.9	12.2	11.9	11.6
	12.9	14.3	13.9	13.6
M8x1.25	8.8	20.2	19.7	19.2
	10.9	29.6	28.9	28.2
	12.9	34.7	33.8	33.0
M10x1.5	8.8	40.0	39.0	38.0
	10.9	58.7	57.2	55.8
	12.9	68.7	67.0	65.3
M12x1.75	8.8	69.7	68.0	66.2
	10.9	102.4	99.8	97.2
	12.9	119.8	116.8	113.8
M14x2	8.8	111.4	108.6	105.8
	10.9	163.6	159.5	155.4
	12.9	191.5	186.7	181.9
M16x2	8.8	172.8	168.5	164.1
	10.9	253.8	247.4	241.1
	12.9	296.9	289.5	282.1
M18x2.5	8.8	246.2	240.1	233.9
	10.9	350.7	341.9	333.2
	12.9	410.4	400.1	389.9
M20x2.5	8.8	348.0	339.3	330.6
	10.9	495.6	483.2	470.8
	12.9	580.0	565.5	551.0
M22x2.5	8.8	474.4	462.6	450.7
	10.9	675.7	658.8	641.9
	12.9	790.7	770.9	751.2
M24x3	8.8	601.3	586.3	571.3
	10.9	856.4	835.0	813.6
	12.9	1002.2	977.1	952.1
M27x3	8.8	881.6	859.6	837.5
	10.9	1255.7	1224.3	1192.9
	12.9	1469.4	1432.7	1395.9
M30x3.5	8.8	1195.3	1165.5	1135.6
	10.9	1702.5	1659.9	1617.3
	12.9	1992.3	1942.4	1892.6

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M36x4	8.8	2089.8	2037.6	1985.3
	10.9	2976.4	2902.0	2827.6
	12.9	3483.0	3395.9	3308.9

Table 1-5 Metric Series with Fine Threads – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M8x1.0	8.8	21.6	21.1	20.5
	10.9	31.7	30.9	30.1
	12.9	37.1	36.2	35.3
M10x.75	8.8	46.8	45.6	44.4
	10.9	68.7	67.0	65.3
	12.9	80.4	78.4	76.4
M10x1.25	8.8	42.2	41.1	40.1
	10.9	62.0	60.4	58.9
	12.9	72.5	70.7	68.9
M12x1.0	8.8	79.5	77.5	75.5
	10.9	116.7	113.8	110.9
	12.9	136.6	133.2	129.8
M12x1.25	8.8	76.2	74.2	72.3
	10.9	111.8	109.0	106.3
	12.9	130.9	127.6	124.3
M12x1.5	8.8	72.9	71.1	69.2
	10.9	107.1	104.4	101.7
	12.9	125.3	122.1	119.0
M14x1.5	8.8	120.2	117.2	114.2
	10.9	176.5	172.1	167.7
	12.9	206.6	201.4	196.2
M16x1.5	8.8	184.4	179.8	175.2
	10.9	270.9	264.1	257.3
	12.9	317.0	309.1	301.2
M18x1.5	8.8	276.6	269.7	262.8
	10.9	394.0	384.2	374.3
	12.9	461.1	449.6	438.0
M20x1	8.8	405.7	395.5	385.4
	10.9	577.8	563.3	548.9
	12.9	676.1	659.2	642.3

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M20x1.5	8.8	386.0	376.3	366.7
	10.9	549.7	535.9	522.2
	12.9	643.3	627.2	611.1
M22x1.5	8.8	520.8	507.8	494.8
	10.9	741.7	723.2	704.7
	12.9	868.0	846.3	824.6
M24x2	8.8	655.8	639.4	623.0
	10.9	934.0	910.6	887.3
	12.9	1092.9	1065.6	1038.3
M27x2	8.8	951.4	927.6	903.8
	10.9	1355.0	1321.1	1287.2
	12.9	1585.6	1546.0	1506.3
M30x1.5	8.8	1369.2	1334.9	1300.7
	10.9	1950.0	1901.3	1852.5
	12.9	2281.9	2224.9	2167.8
M30x2	8.8	1324.6	1291.5	1258.4
	10.9	1886.6	1839.4	1792.2
	12.9	2207.7	2152.5	2097.3
M33x2	8.8	1784.5	1739.9	1695.3
	10.9	2541.6	2478.0	2414.5
	12.9	2974.2	2899.8	2825.4
M36x2	8.8	2340.1	2281.6	2223.1
	10.9	3332.8	3249.5	3166.2
	12.9	3900.2	3802.6	3705.1

Table 1-6 Metric Series Screws of STAINLESS STEEL A2-70/A4-70 with Coarse Threads

Size	Torque (Nm)
M2.5x0.45	0.4
M3x0.5	0.9
M4x0.7	1.5
M5x0.8	3.1
M6x1	5.3
M8x1.25	13
M10x1.5	27

Torque Values for fasteners **with lubrication** these torque values result in an 80% utilization of the yield strength.

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

Table 1-7 Inch Series Screws of STAINLESS STEEL 300 (18-8) with Coarse Threads

Size	Torque	
	lb-in	lb-ft
#5-40 (0.125)	6.9	-
#6-32 (0.138)	9	-
#8-32 (0.164)	18	-
#10-24 (0.190)	21	-
1/4-20	68	-
5/16-18	120	10
3/8-16	210	17.5

Torque Values for fasteners **with lubrication** these torque and preload values result in an 80% utilization of the yield strength.

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

Table 1-8 Inch Series Bearing Bolts – Untreated (black finish)

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
5/8-11 UNC	8	234	225	216
5/8-18 UNF	8	250	240	230
3/4-10 UNC	8	385	370	355
7/8-9 UNC	8	615	591	567
1-8 UNC	8	929	893	857
1 1/4-7 UNC	8	2043	1964	1885

Table 1-9 Metric Series Bearing Bolts– Untreated (black finish)

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (Nm)		
		Maximum	Nominal	Minimum
M20X2.5	12.9	756	727	698
M24X3	10.9	1089	1047	1005
M27X3	10.9	1591	1530	1469

Table 1-10 Inch Series with Coarse Threads (UNC) – Untreated (black finish)

Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-20	5	9.0	8.4	7.7
	8	12.5	12	11.5
5/16-18	5	19	18	17
	8	26	25	24
3/8-16	5	32	31	30
	8	48	46	44
7/16-14	5	52	50	48
	8	73	70	67
1/2-13	5	78	75	72
	8	120	115	110
9/16-12	5	114	110	106
	8	161	152	143
5/8-11	5	156	150	144
	8	234	225	216
3/4-10	5	270	259.5	249
	8	385	370	355
7/8-9	5	416	400	384
	8	615	591	567
1-8	5	606	583	560
	8	929	893	857
1 1/8-7	5	813	782	751
	8	1342	1288	1234
1 1/4-7	5	1141	1097	1053
	8	2043	1964	1885
1 3/8-6	5	1519	1461	1403
	8	2496	2396	2296
1 1/2-6	5	2028	1946.5	1865
	8	3276	3150	3024

Table 1-11 Inch Series with Fine Threads (UNF) – Untreated (black finish)

Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28	5	10	9.5	9
	8	14.5	14	13.5
5/16-24	5	21	20	19
	8	26	25	24
3/8-24	5	36	35	34
	8	53	51	49
7/16-20	5	57	55	53
	8	85	82	79
1/2-20	5	88	84.5	81
	8	125	120	115
9/16-18	5	126	121	116
	8	177	170	163
5/8-18	5	182	174.5	167
	8	250	240	230
3/4-16	5	312	299.5	287
	8	425	409	393
7/8-14	5	458	439.5	421
	8	672	646	620
1-12	5	658	632	606
	8	1009	970	931
1-14	5	670	644.5	619
	8	945	908.5	872
1 1/8-12	5	882	848	814
	8	1500	1440	1380
1 1/4-12	5	1251	1203	1155
	8	2092	2008.5	1925
1 3/8-12	5	1704	1638	1572
	8	2833	2719	2605
1 1/2-12	5	2288	2196.5	2105
	8	3640	3500	3360

Table 1-12 Metric Series with Coarse Threads – Untreated (black finish)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M4x0.7	8.8	3.1	2.9	2.8
	10.9	4.5	4.3	4.1
	12.9	5.4	5.2	4.9
M5x0.8	8.8	6.5	6.2	5.9
	10.9	9.2	8.9	8.5
	12.9	11	10.5	10
M6x1	8.8	11	10.5	10
	10.9	16	15	14
	12.9	19	18	17
M8x1.25	8.8	27	26	25
	10.9	38	36.5	35
	12.9	45	43.5	42
M10x1.5	8.8	53	51	49
	10.9	75	72	69
	12.9	89	86	83
M12x1.75	8.8	93	89	85
	10.9	130	125	120
	12.9	156	150	144
M14x2	8.8	148	142	136
	10.9	212	203.5	195
	12.9	248	238	228
M16x2	8.8	230	221	212
	10.9	322	310	298
	12.9	387	372	357
M18x2.5	8.8	319	306.5	294
	10.9	455	436.5	418
	12.9	532	511	490
M20x2.5	8.8	447	430	413
	10.9	629	605	581
	12.9	756	727	698
M22x2.5	8.8	608	585	562
	10.9	856	823	790
	12.9	1029	989	949
M24x3	8.8	774	744	714
	10.9	1089	1047	1005
	12.9	1306	1256	1206

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M27x3	8.8	1134	1090	1046
	10.9	1591	1530	1469
	12.9	1910	1836.5	1763
M30x3.5	8.8	1538	1479	1420
	10.9	2163	2080	1997
	12.9	2595	2495	2395
M36x4	8.8	2681	2578.5	2476
	10.9	3964	3812	3660
	12.9	4639	4461	4283

Table 1-13 Metric Series with Fine Threads – Untreated (black finish)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M8x1	8.8	29	28	27
	10.9	41	39.5	38
	12.9	49	47	45
M10x0.75	8.8	57	55	53
	10.9	81	78	75
	12.9	96	93	90
M10x1.25	8.8	57	55	53
	10.9	81	78	75
	12.9	96	93	90
M12x1	8.8	101	97.5	94
	10.9	150	144	138
	12.9	175	168	161
M12X1.25	8.8	100	96	92
	10.9	147	141.5	136
	12.9	172	165.5	159
M12x1.5*	8.8	100	96	92
	10.9	140	135	130
	12.9	168	162	156
M14x1.5	8.8	160	153.5	147
	10.9	229	220	211
	12.9	268	257	246
M16x1.5	8.8	248	238.5	229
	10.9	348	335	322
	12.9	418	402	386
M18x1.5	8.8	345	331.5	318
	10.9	491	471	451
	12.9	575	552	529
M20X1	8.8	471	453	435
	10.9	694	667.5	641
	12.9	812	781	750
M20x1.5	8.8	483	464.5	446
	10.9	679	653	627
	12.9	816	785	754
M22x1.5	8.8	657	632	607
	10.9	924	888.5	853
	12.9	1111	1068	1025

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M24x2	8.8	836	803.5	771
	10.9	1176	1130.5	1085
	12.9	1410	1356	1302
M27x2	8.8	1225	1171.5	1130
	10.9	1718	1652.5	1587
	12.9	2063	1983.5	1904
M30x1.5	8.8	1530	1471.5	1413
	10.9	2253	2166.5	2080
	12.9	2637	2536	2435
M30x2	8.8	1661	1597.5	1534
	10.9	2336	2246.5	2157
	12.9	2800	2695	2590
M33x2	8.8	2141	2059	1977
	10.9	3155	3034	2913
	12.9	3692	3550.5	3409
M36x2	8.8	2795	2688	2581
	10.9	4118	3960	3802
	12.9	4818	4634	4450

WELD STUDS

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

Table 1-14
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)

Grove 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

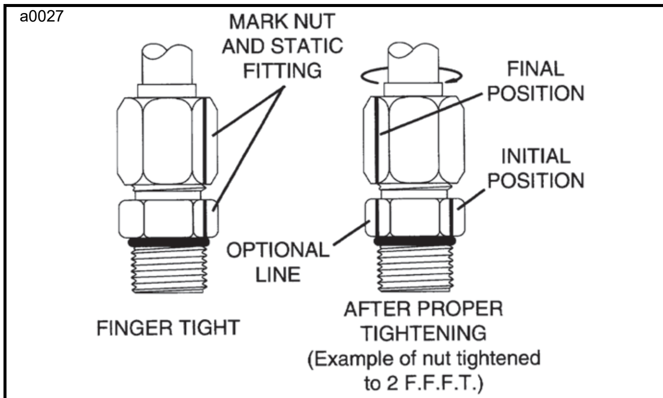


FIGURE 1-9

5. Tighten the joint by the number of flats (F.F.F.T.) as specified in Table 1-15 and 1-16 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 1-9).

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 1-15

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 1-16
Adjustable Straight Thread O-ring

T-2-6

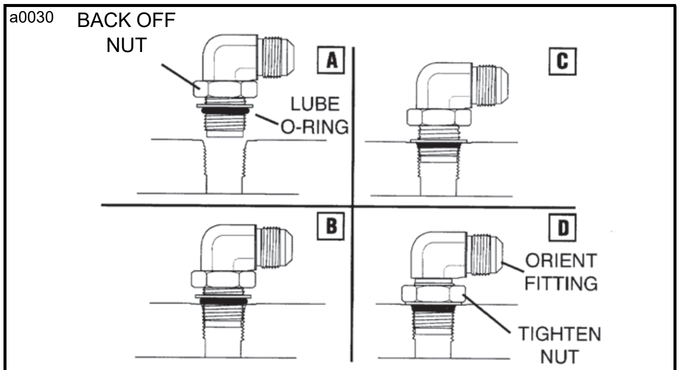
ADJUSTABLE STEEL STR. THREAD O-RING FITTINGS	
SAE SIZE	(F.F.F.T.)
2	1.0 ± 0.25
3	1.0 ± 0.25
4	1.5 ± 0.25
5	1.0 ± 0.25
6	1.5 ± 0.25
8	1.5 ± 0.25
10	1.5 ± 0.25
12	1.5 ± 0.25
14	1.5 ± 0.25
16	1.5 ± 0.25
20	2.0 ± 0.25
24	2.0 ± 0.25
32	2.0 ± 0.25

Thread O-ring Fitting - Fitting to Port (Table 1-16)

1. Inspect both mating parts for burrs, nicks, scratches, or foreign particles.
2. Lubricate O-ring with a light coat of clean oil (Figure 1-10A).
3. Back off locknut as far as possible (Figure 1-10A).
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 1-10B).
5. To orientate the fitting, unscrew the fitting the required amount, but not more than one full turn (Figure 1-10C).
6. Hold the fitting in the desired position and tighten the nut (Figure 1-10D) 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 1-17)

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 1-11).
3. Turn fitting until finger tight.
4. Using the assembly torque method, tighten to given torque for size from Table 1-17.

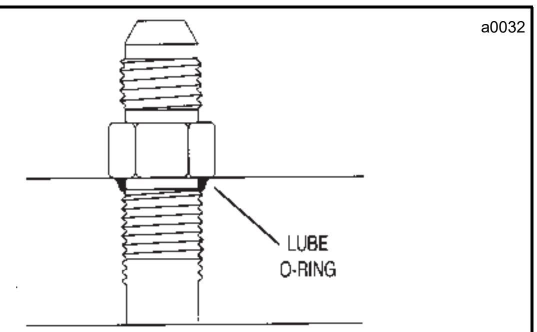


Adjustable Fitting to Port **FIGURE 1-10**

Table 1-17

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



Non-Adjustable Fitting to Port **FIGURE 1-11**

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 Grove. 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 it's 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 Grove. 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 1-12).

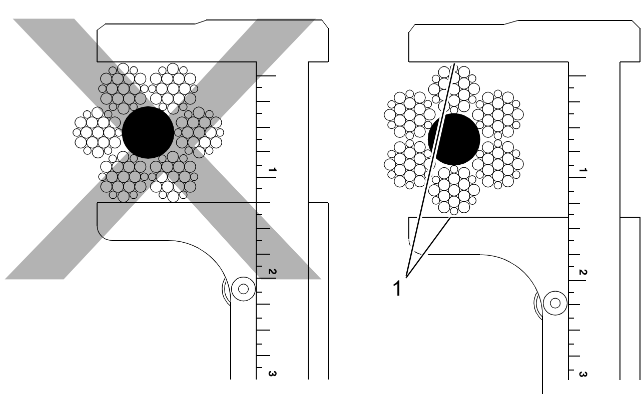


FIGURE 1-12

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

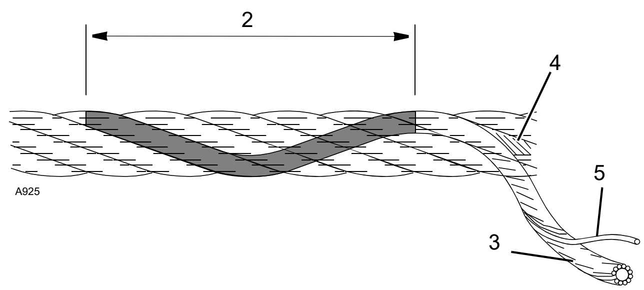


FIGURE 1-13

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 Grove 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 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 judgment 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 Grove. 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.
- Grove recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
- Grove 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 1-14, 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.

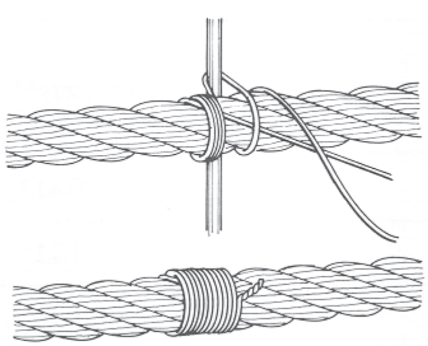


FIGURE 1-14

Method 2

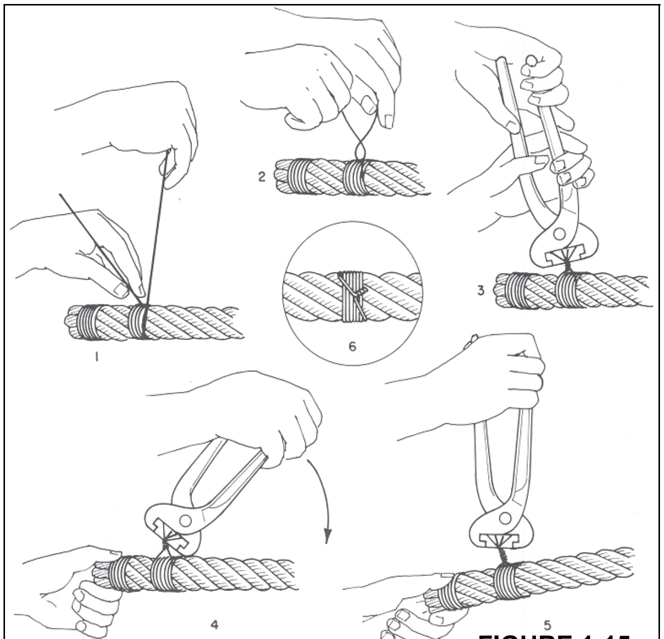


FIGURE 1-15

Wind a length of soft annealed wire Figure 1-15 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 1-16 should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).

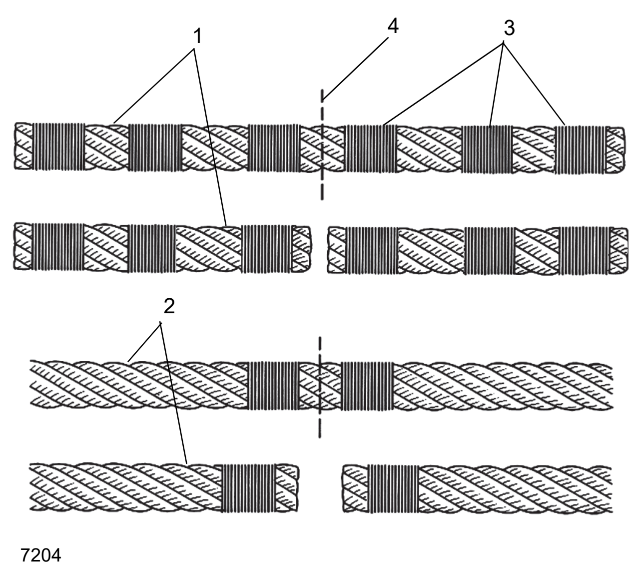


FIGURE 1-16

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 lock nuts 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

SECTION CONTENTS

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 load 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.
	Never stand under a suspended load.	Prevents serious injury or death.
Compressed Air	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.	What appears at first trivial could become painful and injurious.
	Make sure you know the location of the First Aid Box.	Results in quick application of aid procedures.
Cleanliness	Plug all hose ends and connections.	Ensures optimum performance.
	Clean exterior of all parts before repairing.	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.	Inhibits serious injury and/or death.
	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.	Inhibits serious injury and/or death.
	Do not attempt to start the engine while standing beside it.	Inhibits serious injury and/or death.
Hoists	Do not remove any hoist component unless the hook block or downhaul weight 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.	Inhibits serious injury and/or death.
	Be sure to remove the ignition key before working underneath the machine. Always apply the parking brake.	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 over inflate 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

SECTION CONTENTS

3

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 an 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 crane 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 red warning light in the gauge cluster on the instrument panel indicates when the alternator is not charging the battery.

Dielectric Grease

Dielectric grease was applied to the following connections at the factory when the crane was assembled. When servicing electrical connections, dielectric grease must be re-applied to these connections.

- All Deutsch Connectors
- All Valve Solenoid connections on Hydraulic valves and Transmissions
- All Harness Connections
- RCL Module Connections (except M12 and M8 connectors)

Excluded Connections

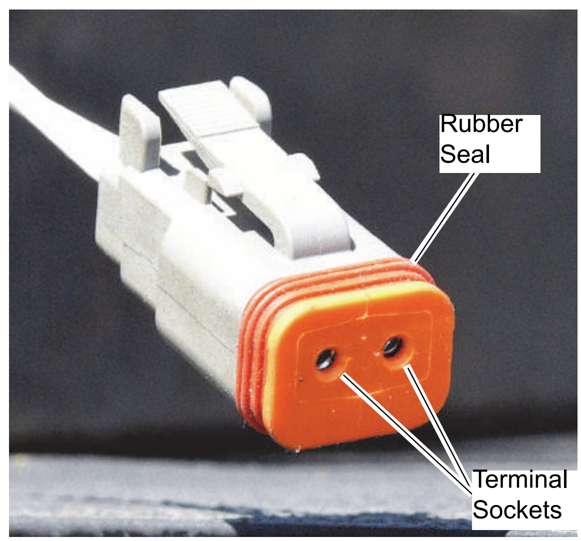
Do not apply dielectric grease to the following connections:

- All Connections Inside the Cab
- M12 and M8 Connectors
- Pin-type Contacts

Applying Dielectric Grease to an Electrical Connector

Use the following procedure to apply dielectric grease to an electrical connection. Grease should be applied immediately prior to securing the connector. Ensure that grease is applied to all terminal sockets (Figure 3-1).

1. Check the connection for moisture before application of the grease. If moisture is found, clean or replace the connector as necessary.
2. Screw a tip or trigger assembly on to the can of dielectric grease if necessary.
3. Apply the grease onto socket (female) contacts.



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Example. For illustration purposes only. Your connector may differ.

FIGURE 3-1

4. Use a clean towel to remove excess grease from the surface of the connector, and wipe grease into the terminal sockets (Figure 3-1).
5. Ensure grease is applied to each terminal socket. The towel with excess grease can be used to fill empty terminal sockets (Figure 3-1).
6. Ensure grease is applied to the entire surface of the connector's rubber seal (Figure 3-1).

NOTE: Do not allow grease to come in contact with any painted surface, or any other components.

7. If clean up is necessary, contact cleaner or petroleum distillates can be used.

Secure the connector when complete.

Wire Harnesses

Five wire harnesses connect the electrical system components:

- Instrument Panel Wire Harness
- Main Frame Wire Harness
- Engine Wire Harness
- Boom Wire Harness
- Cab Wire Harness

Refer to the CD15 Electrical Schematic at the end this Service Manual for circuits identification and troubleshooting.

Fuses

Two fuse boxes are located directly below the instrument panel. See Figure 3-2, Table 3-2, and Table 3-3 for fuse identification.

A third fuse box is located in the battery/relay compartment. Its fuses are identified in Figure 3-3 and Table 3-4 for fuse identification.

Always replace the fuse with one of the same rating.

Fuse and Relay Identification

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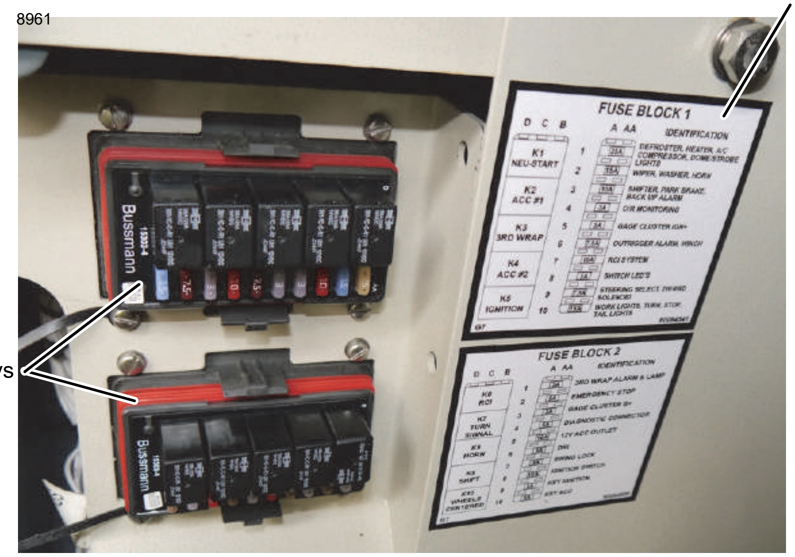

Fuses and Relays

Under Instrument Panel

FIGURE 3-2

Table 3-2 Fuse Box #1 Circuit Identification

Fuse	**Amps**	**Circuit**
1	25	Defroster, Heater, A/C Compressor Dome/Strobe Lights
2	15	Wipers, Washer, Horn
3	10	Shifter, Park Brake, Back Up Alarm
4	3	Outrigger Monitoring
5	3	Gauge Cluster, Ignition +
6	7.5	Outrigger Alarm, Winch
7	10	RCL/RCI
8	3	Switch LEDs
9	7.5	Steering Select, 2WD/4WD Solenoid
10	15	Work Lights, Turn, Stop, Tail Lights
Relay	**-**	**Circuit**
K1		Neutral Start
K2		Accessory #1
K3		3rd Wrap Indicator (hoist drum)

Fuse	Amps	Circuit
K4		Accessory #2
K5		Ignition

Table 3-3 Fuse Box #2 Circuit Identification

Fuse	Amps	Circuit
1	3	3rd Wrap Indicator Alarm and Lamp
2	5	Emergency Stop
3	3	Gauge Cluster B+
4	5	Diagnostic Connector
5	10	12V Accessory Outlet
6	3	DRI
7	5	Swing Lock
8	10	Ignition Switch
9	3	Key Ignition
10	5	Key ACC
Relay	**-**	**Circuit**
K6		RCL/RCI
K7		Turn Signal
K8		Horn
K9		Shifter
K10		Wheels

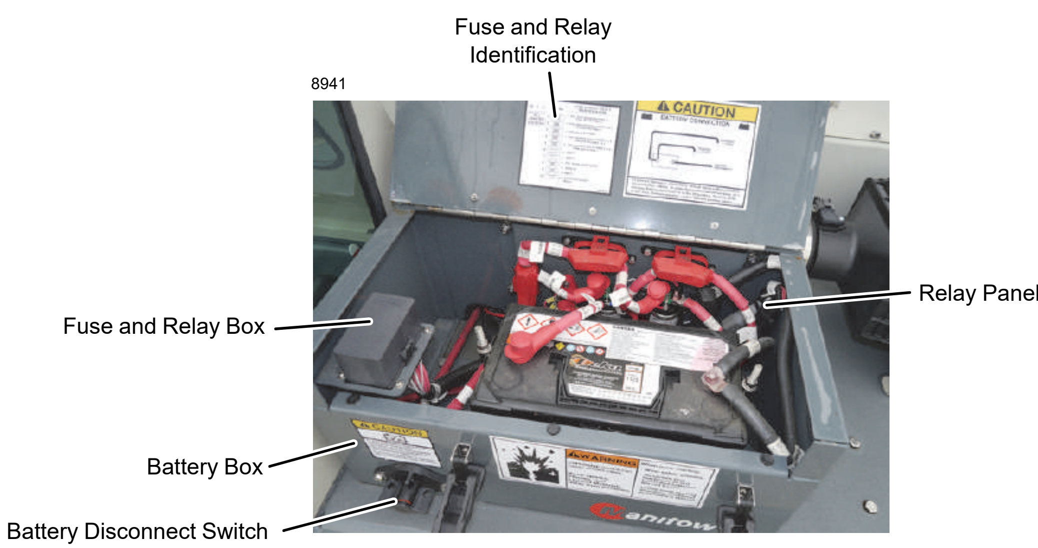

FIGURE 3-3

Table 3-4 Fuse Box #3 Circuit Identification

Fuse	Amps	Circuit
1	20	Fuse Box #1 Fuse 10, Fuse Box #2 Fuse 5
2	30	Fuse Box #1 Fuses 1 and 2, Fuse Box #2 Fuse 6
3	30	ECM Power
4	25	Fuse Box #1 Fuses 7, 8, and 9, Fuse Box #2 Fuses 1 and 4
5	15	Fuse Box #1 Fuses 3, 4, 6, and 7, Fuse Box #2 Fuse 7
6	-	Empty
7	-	Empty
8	5	Unloader Valve
9	-	Diode #6

Fuse	Amps	Circuit
10	-	Empty
Relay	-	**Circuit**
13		Starter Lockout

CHARGING SYSTEM

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

Alternator and Voltage Regulator

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

Batteries

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

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

Battery Disconnect Switch

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

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.

Voltmeter

The bar-type voltmeter is located in the gauge cluster on the cab instrument panel. The voltmeter is connected to the battery circuit, and has a range of 9 to 15V.

Special Precautions

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

Battery Maintenance and Charging

Jump Starting Hazard

Do not attempt to jump start the crane.

CAUTION

It is strongly recommended that the batteries not be "jumped" with a different vehicle, portable power pack, etc. The surge of power from these sources can irreparably damage the various electronic controls and computer systems. Jump starting the crane batteries with a different vehicle while the engine is running can damage the donor vehicle electronics as well if done improperly.

This crane has multiple computer systems (crane control, RCL, engine and transmission control) that are highly susceptible to voltage/amperage surges in the electrical system.

The batteries should be completely disconnected from the crane electrical system and charged using a battery charger of appropriate voltage level or replace the batteries with fully charged batteries. Refer to *Charging the Batteries*, page 3-6.

Charging the Batteries

When charging the batteries, do not turn on the battery charger until the charging leads have been connected to the battery(s). Also, if the battery(s) are found to be frozen, do not attempt to charge them. Remove the battery(s) from the crane, allow them to thaw, and then charge the battery(s) to full capacity.

"Slow charging" is preferred to "fast charging". Fast charging saves time but risks overheating the battery(s). Slow charging at six (6) amps or less develops less heat inside the battery and breaks up the sulfate on the battery plates more efficiently to bring the battery up to full charge. The use of a "smart charger" that automatically adjusts the charging amperage rate should be used.

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 chargers positive (+) wire. This procedure will decrease the possibility of explosion of hydrogen gas around the battery.

STARTING CIRCUIT

The starting circuit includes the battery, the starter motor and solenoid, the starter relay, the starter lockout relay, the neutral start relay, the park brake switch, the transmission shifter, and the ignition switch.

The starter will not engage unless the park brake switch is on and the transmission shifter is in the neutral position.

General Inspections

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

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

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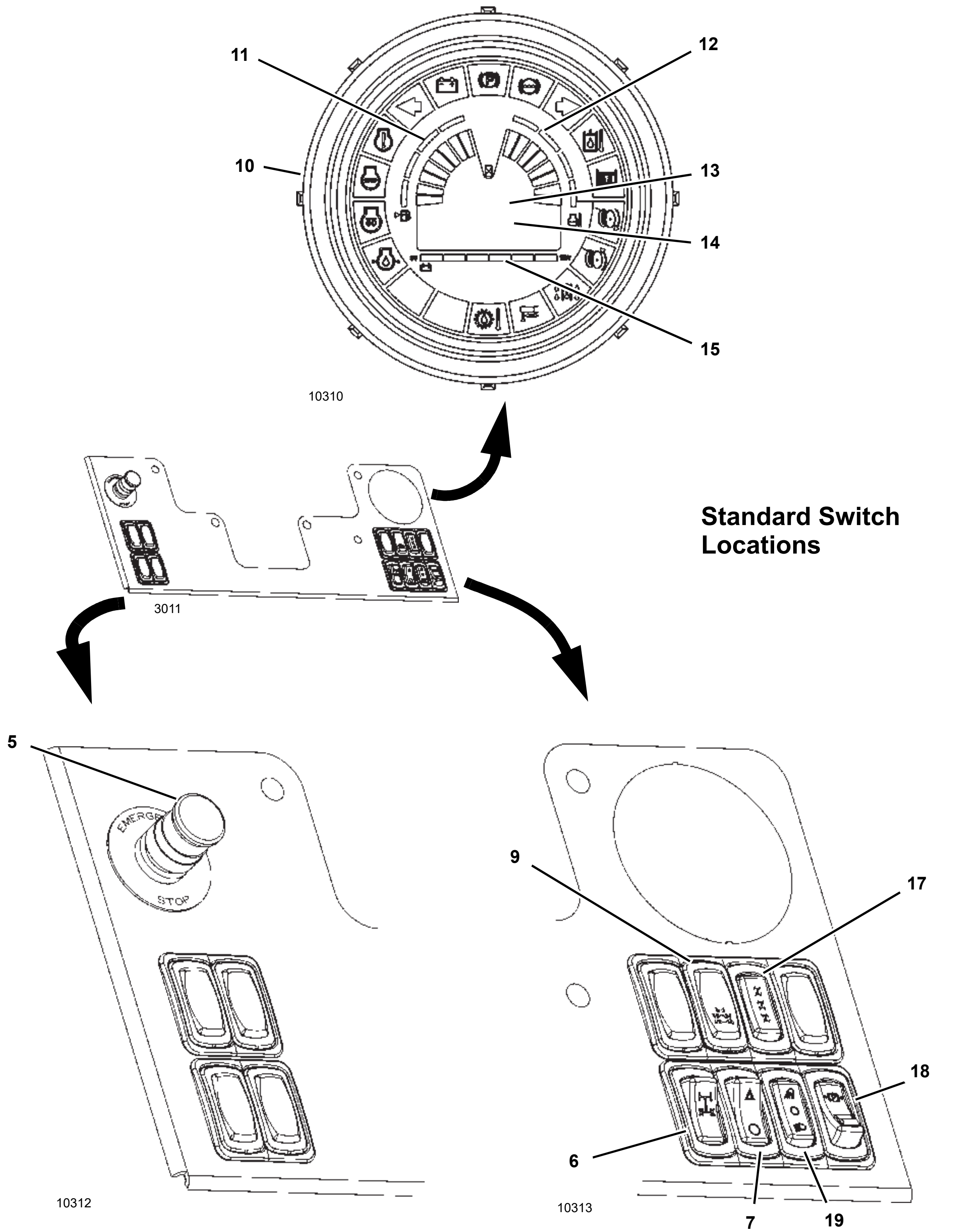

11
12
10
13
14
15
10310
3011
Standard Switch Locations
5
EMERGENCY
STOP
9
17
18
6
7
19
10312
10313

FIGURE 3-4

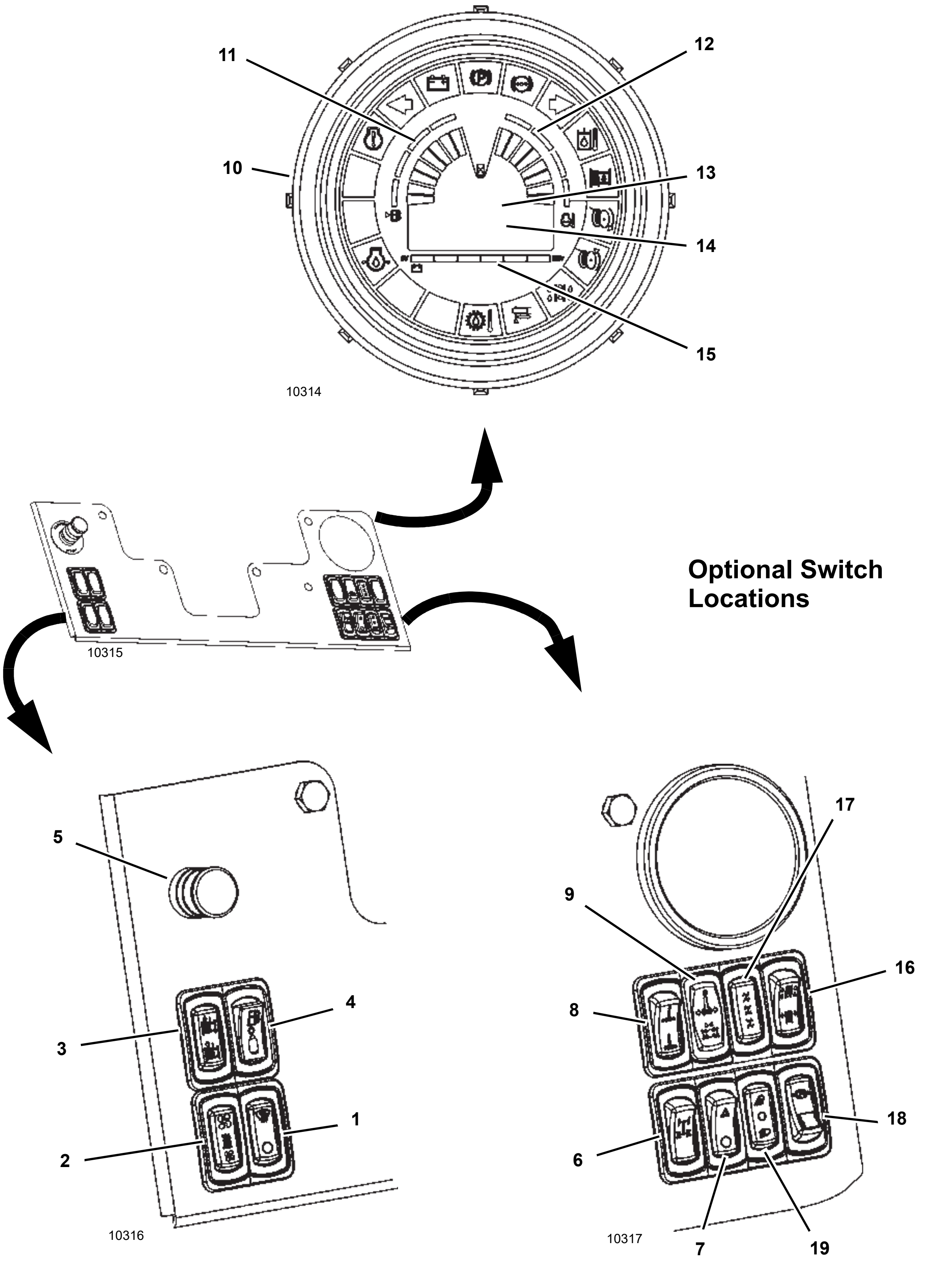


FIGURE 3-4 continued

Panel Switches, Gauges, and Indicators

Item numbers in following headings correspond to item numbers in Figure 3-4.

1 – Defroster Switch

This switch is used to start the defroster fans.

Top position – Fan **ON**.

Bottom position – Fan **OFF**.

2 – Heater Switch

This switch is used to operate the heater when equipped with the heat only option.

Top position – operate heater in **HIGH**.

Center position – heater **OFF.**

Bottom position – operate heater in **LOW**.

3 – Auxiliary Winch Switch

This switch operates the optional winch attached under the front end of the crane.

Top position (held down) – **UNWIND** rope from the winch drum.

Center position – **STOP** the winch drum.

Bottom position (held down) – **WIND** rope onto the winch drum.

4 – Dual Fuel Switch

This switch is used to select the fuel type when equipped with the dual-fuel engine option.

Top position – **GAS**.

Center position – **OFF.**

Bottom position – **PROPANE**.

5 – Emergency Stop Switch

Push knob DOWN to **STOP engine** only in an emergency — for example, if a crane function does not stop when the control handle is released to off or any other uncontrolled motion of a crane function is observed.

Beware — when the knob is pushed down, the engine stops, the brakes apply, and any ***functions being operated come to an abrupt stop***.

NOTE: The knob must be pulled up before the engine can be restarted.

Use the engine ignition switch to stop the engine for normal operating conditions.

6 – Steering Sync Switch

Top position held down – **FOUR-WHEEL** steer turned ON.

If the rear wheels not centered light comes on, use the steering sync switch to re-center the rear wheels. The steering sync switch will by-pass the steer select switch and place the steering in four-wheel steer mode allowing the operator to re-center the rear wheels with the steering wheel in the cab. The wheels not centered light will go off once rear wheels are centered,

7 – Emergency Flasher Switch

This switch flashes all four turn signals.

Top position – emergency flashers **ON**.

Bottom position – emergency flashers **OFF**.

8 – Swing Lock Switch

Top position – swing lock **APPLIED**.

Center position – swing lock **RELEASED**.

CAUTION

Avoid Crane Damage!

Do not apply the swing lock while swinging. Damage to the crane can occur.

Disengage the swing lock before swinging. Damage to the crane can occur.

---

9 – Swing Lock/Rear Wheels Not Centered Light

RED when the option swing lock is engaged.

AMBER when the rear wheels are not centered. To select one of three steering modes the rear wheels must be centered.

10 – Indicator Lights

See Figure 3-5 for identification of the indicator lights in the gauge cluster.

Take immediate corrective action when a red or amber warning light comes on.

11 – Fuel Gauge

Indicates the amount of fuel in the fuel tank.

12 – Engine Coolant Temperature Gauge

Indicates the engine coolant temperature.

13 – Hourmeter

Indicates the total hours the engine has been operating. Use this gauge to perform preventive maintenance scheduling.

14 – Tachometer

Indicates engine speed in rpm.

15 – Voltmeter

The voltmeter (battery gauge) indicates the voltage being supplied to or from the batteries.

16 – 2WD/4WD Switch

This switch is used to select either two wheel drive or four wheel drive.

Top position – **4WD**.

Bottom position – **2WD**.

17 – Steering Selection Switch

This switch is used to select one of three steering modes in which the crane can be steered. The wheels must be aligned in a straight forward direction before switching into another steering mode. See *Steering the Crane* for more information.

Top position – **CRAB** steer.

Center position – **TWO-WHEEL** steer.

Bottom position – **FOUR-WHEEL** steer.

Press the button on the end of the turn signal selector lever to sound the horn.Gauges and Indicators

18 – Parking Brake Switch

The parking brake switch is used to engage and disengage the parking brake.

Top position – **DISENGAGE** the parking brake

Bottom position – **ENGAGE** the parking brake.

CAUTION

Avoid Crane Damage!

Do not engage the parking brake while the vehicle is moving. Damage to the crane can occur.

Disengage the parking brake before driving. Damage to the crane can occur.

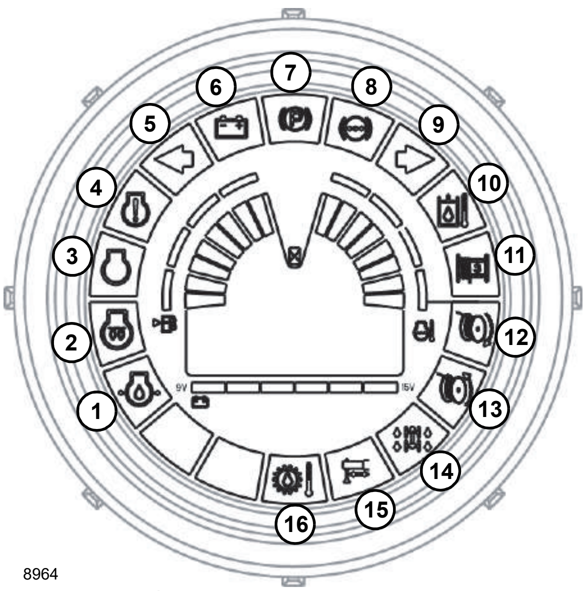
19 – Work Light/Head Light Switch

A three-position switch controls the crane's lights.

Top position – Turn **ON** work lights, head lights, tail lights, and instrument panel lights.

Center position – Turn **OFF** all lights.

Bottom position – Turn **ON** head lights, tail lights, and instrument panel lights.



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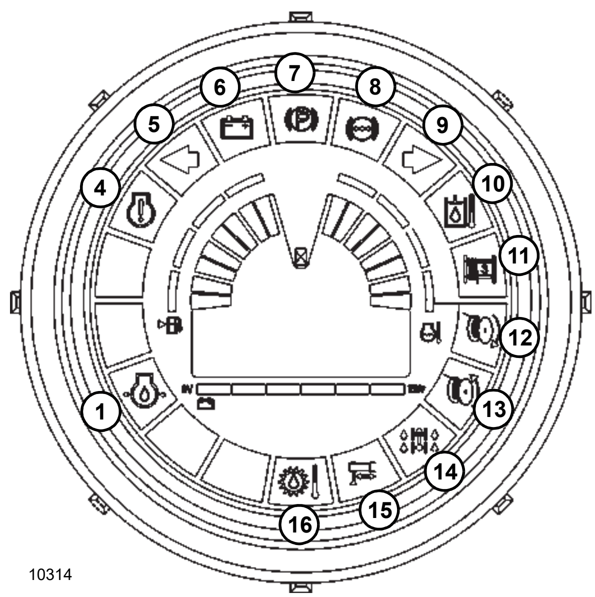
Gauge, Diesel Fuel Engines



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Gauge, Dual Fuel Engines

1	Engine Oil Pressure	Red
2	Wait To Start	Amber
3	Engine Stop	Red
4	Engine Warning	Amber
5	Left Turn Signal	Green
6	Battery	Red
7	Park Brake Activation	Red
8	Low Brake Pressure	Red
9	Right Turn Signal	Green
10	Hydraulic Oil Temp	Red
11	3rd Wrap Indicator (on hoist drum)	Red
12	Hoist UP	Green
13	Hoist DOWN	Green
14	4WD On	Amber
15	Outrigger Monitoring	Green
16	Transmission Oil Temperature	Red

FIGURE 3-5

Engine Diagnostic Connector

An engine diagnostic connector is provided below the instrument panel (see Figure 3-6).

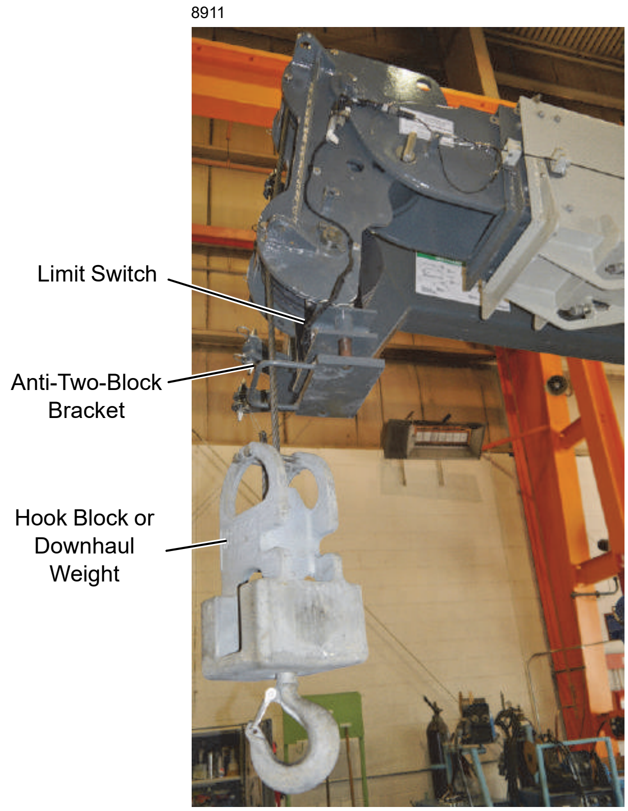
Engine WARNING and STOP lights are provided in the gauge cluster (Figure 3-5). If either light comes on at start-up or during operation, take immediate corrective action to prevent damage to engine. It will be necessary for a engine technician to determine the cause of the fault by connecting an engine ECM computer to the diagnostic connector.

Contact Product Support for assistance.

8978 **FIGURE 3-6**

Table 3-5: 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.	Problem in charging system. See Troubleshooting - Charging System.
	Stopped or low idle.	Normal battery charge.
12-14 volts	Above low idle.	Problem in charging system. See Troubleshooting - Charging System. Battery fully charged - no load.
14-15 volts	Stopped or low idle.	If 14 and 15 volts, the battery is newly charged. Overcharged battery.
More than 15 volts	Above idle.	Overcharge. See Troubleshooting - Charging System



Anti-Two Blocking System — Boom

Anti-Two Blocking System — Boom Extension

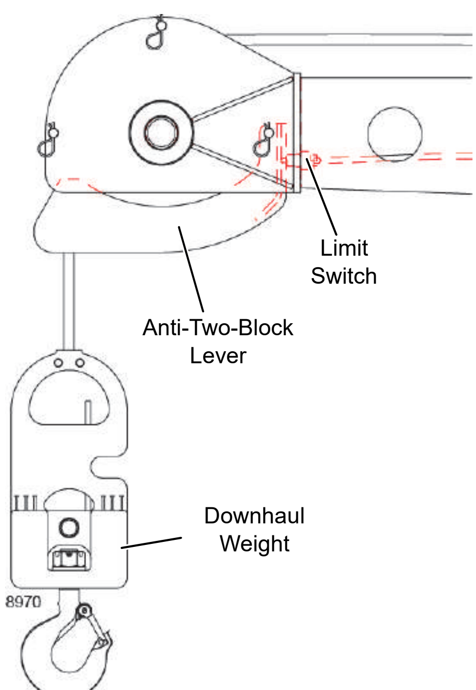


FIGURE 3-7

ACCESSORY CIRCUITS

Anti-Two Blocking System

See the Electrical Schematic at the end of this Service Manual.

General

The anti-two blocking mechanism (Figure 3-7) prevents the hook block or the downhaul weight from being pulled into the boom or boom extension while extending the boom, lowering the boom or hoisting the load. 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 or the downhaul weight away from the boom or boom extension, the operator must retract the boom, raise the boom, or lower the load.

Circuit Description

Power is made available through a 25 amp fuse to the circuit relay under the instrument panel in the operator's cab and to the limit switch in the boom or boom extension. When the hook block or the downhaul weight reaches the upper limit, the limit switch closes, energizing the relay. The energized relay activates the 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

See the Electrical Schematic at the end of this Service Manual.

Description

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

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

Operational Aid Malfunction

When crane operational aids such as the RCL/A2B system are inoperative with the display malfunctioning, override capabilities will be unavailable. All crane operations must be shut down until the problem is corrected. Contact a technician for consultation and repair. Repair and recalibrate the system before returning the crane to lifting service.

Heater

See the Electrical Schematic at the end of this Service Manual.

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.

Power is available through a 25 amp fuse to the heater/ defroster switch on the instrument panel when the ignition switch is ON. 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, and ammeter, ohmmeter.

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.

3

Table 3-6
Charging System Troubleshooting

Problem	Possible Cause	Solution
Alternator does not charge.	**1.** Alternator fuse blown.	**1.** Replace
	1. Alternator belt loose or broken.	**1.** Replace and/or tighten to specification.
	2. Worn brushes or open brush leads or connections.	**2.** Replace or repair alternator.
	3. Open circuit, short circuit or ground stator winding.	**3.** Replace alternator.
	4. Malfunction in alternator.	**4.** Replace.
	5. Short circuit or open circuit in rectifier diodes.	**5.** Replace or repair alternator.
	6. Open circuit or short circuit in rotor (field) winding.	**6.** Replace alternator.
	7. Wires connected wrong, loose, or broken.	**7.** See wiring diagram. Repair or replace wires.
High charging rate (battery at full charge).	**1.** Low electrolyte level in battery.	**1.** Add distilled water.
	2. Fault in wiring system.	**2.** Repair or replace faulty wiring.
	3. Loose or dirty connections.	**3.** Clean and tighten connections.
	4. Malfunction in alternator.	**4.** Replace.

Problem	Possible Cause	Solution
Low charging rate.	**1.** Loose or worn alternator belt.	**1.** Adjust or replace belt.
	2. Bad alternator.	**2.** Replace or repair.
	3. Bad battery.	**3.** Replace.
	4. Low electrolyte level.	**4.** Add distilled water.
	5. Short circuit in system.	**5.** Check and repair.
	6. Worn alternator.	**6.** Test, replace or repair alternator.
	7. Malfunctioning alternator.	**7.** Replace.
	8. Low engine speed.	**8.** Run engine at higher speed.
Alternator Noise.	**1.** Badly worn belt.	**1.** Replace belt and adjust.
	2. Pulleys out of alignment.	**2.** Align fan and alternator pulleys.
	3. Loose pulley.	**3.** Check for broken key or worn key way, if used. Tighten pulley nut.
	4. Worn bearings.	**4.** Replace or repair alternator.
	5. Short in rectifier diodes.	**5.** Replace or repair alternator.
Starter motor does not turn.	**1.** Transmission not in neutral.	**1.** Shift transmission to neutral.
	2. Open circuit, dirty or loose connections.	**2.** Clean and tighten connections at battery and starter. Check wiring and connections between ignition switch and starter solenoid.
	3. Bad starter relay.	**3.** Replace starter relay.
	4. Bad ignition switch.	**4.** Replace switch.
	5. Worn starter motor, bad starter solenoid, or internal problem in engine.	**5.** Repair or replace starter, replace solenoid, or see engine manual.
	6. Dead battery.	**6.** Recharge or replace battery.
	7. Parking brake not engaged.	**7.** Engage parking brake.
	8. Bad neutral start relay.	**8.** Replace relay.
Winch motor runs in only one direction.	**1.** Defective solenoid or stuck solenoid.	**1.** Jar solenoid to free contacts. Check by applying 12 volts to coil terminal (should hear an audible click when energized). Replace solenoid.
	2. Defective control switch.	**2.** Check and replace if necessary.
Winch motor runs extremely hot.	**1.** Long period of operation.	**1.** Cooling-off periods are essential to prevent overheating.
	2. Insufficient battery power.	**2.** Check battery terminal voltage under load. If 10 volts or less, replace the battery.
	3. Bad connection.	**3.** Check battery cables for corrosion, clean and grease.

Problem	Possible Cause	Solution
Winch motor runs but with insufficient power, or with slow line speed.	**1.** Insufficient battery power. **2.** Bad connection.	**1.** Check battery terminal voltage under load. If 10 volts or less, replace the battery. **2.** Check battery cables for corrosion, clean and grease.
Winch motor runs but drum does not rotate.	**1.** Clutch not engaged. **2.** Clutch engaged.	**1.** Engage clutch. **2.** Disassemble the hoist to determine cause and repair.
Winch motor will not operate.	**1.** Defective solenoid or stuck solenoid. **2.** Defective control switch **3.** Defective motor. **4.** Loose connections.	**1.** Jar solenoid to free contacts Check by applying 12 volts to coil terminal (should hear an audible click when energized). Replace solenoid. **2.** Check and replace if necessary. **3.** If solenoids operate, check voltage at armature post. Replace motor if defective. **4.** Tighten connections on bottom side of hood and on motor.

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SECTION 4
HYDRAULIC SYSTEM

SECTION CONTENTS

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.

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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 *Pump Margin (Stand-By) Pressure Check/Adjustment*, on page 4-9.
	Faulty pump.	Overhaul or replace pump.
No movement when system is first started.	Low oil level.	Check and add oil.
	Air or restriction in inlet line to pump pressure.	Check and tighten inlet line. Clear restriction.
	Cold oil or wrong weight of oil.	Use correct oil, follow normal warming procedure.
Loss of movement during operation.	Low oil level.	Check and add oil.
	Vacuum in hydraulic tank.	Clean tank filler/breather cap.
	Restriction or leakage in the relief valve.	Clean or replace the relief valve.
	Broken hydraulic line.	Replace.
	Bad seal in hydraulic swivel.	Replace seals.
	Broken gear or shaft in pump.	Overhaul or replace.
Overheating of hydraulic oil.	Wrong operation (running over the load sense relief pressure setting for long periods).	Change procedure of operation.
	Dirty filters.	Change filter.
	Oil too light.	Use correct oil.
	Low oil level.	Check and add oil.
	Dirty oil.	Change oil and filters. See Section 5 of this manual.
Foam in hydraulic oil tank.	Leak in system.	Check O-ring on pump inlet. Check for leak in system and correct.
	Wrong type of oil.	Use correct oil.
	Low oil level.	Check and add oil.
	Bad seal in pump, motor or cylinder.	Overhaul or replace.
Short life of pump bearings, shafts, etc.	Dirt in oil.	Change oil and filter more frequently.
	Wrong type of oil.	Use correct oil.
Pump leakage (external).	Bad seal on pump shaft.	Replace shaft seal.
	Bad seals between pump sections (Swing & Steering).	Replace seals.

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

Table 4-2
Lift Circuit Troubleshooting

Problem	Possible Cause	Remedy
Lift cylinder does not extend or retract.	Control valve not actuated.	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-two blocking electrical system.	See Electric System.
	Bad cartridge in anti-two 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 Section 5 of this manual.
	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-two blocking electrical system.	See Electric System.
	Bad cartridge in anti-two 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 Section 5 of this manual.

Table 4-4
Outrigger Circuit Troubleshooting

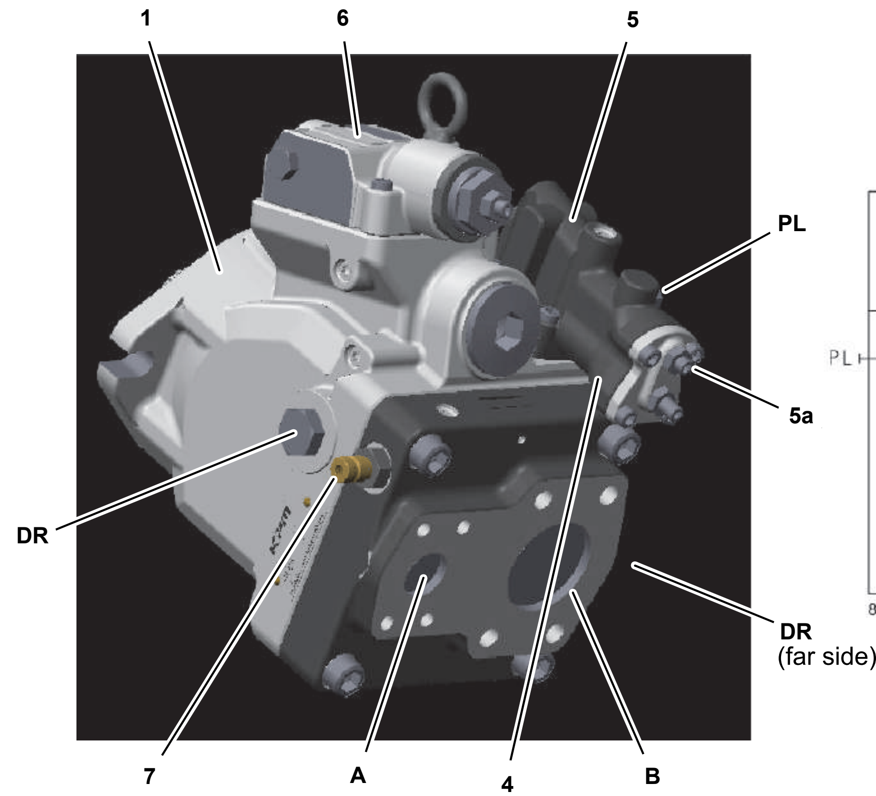
Problem	Possible Cause	Remedy
No movement all cylinders	Electrical problem.	See Section 3 of this manual.
	Dirt or restriction in the dump valve.	Clean or replace the dump valve.
	Dirt in relief valve keeping the valve off the valve seat.	Clean the relief valve.
	Relief valve setting too low.	Check and 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 Section 3 of this manual.
	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 Section 3 of this manual.
	Faulty selector valve.	Replace selector valve.
	Restriction or dirt between the outrigger valve spool and housing.	Remove and clean the outrigger valve spool.

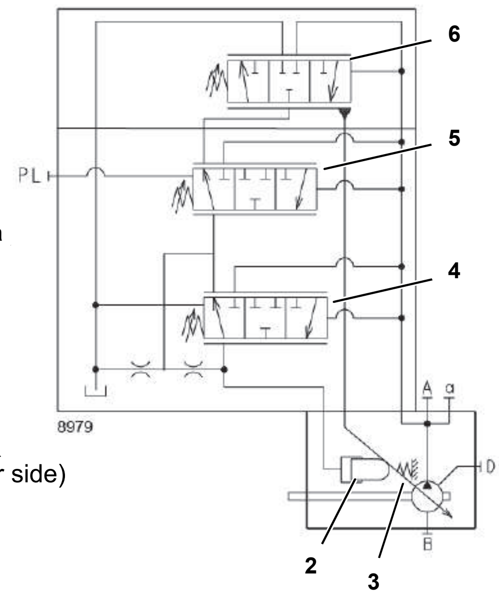
Table 4-5
Main Hoist Circuit Troubleshooting

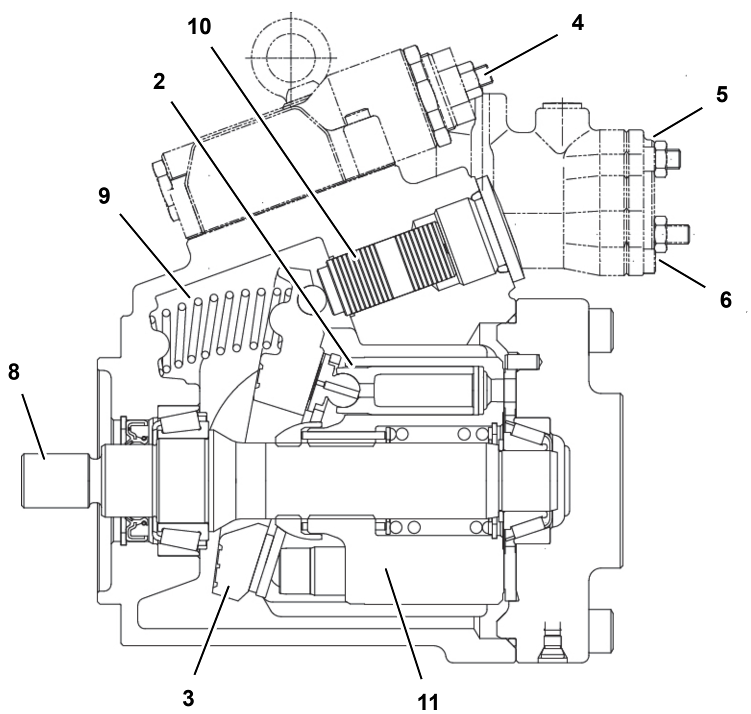
Problem	Possible Cause	Remedy
Hoist will not lift maximum (rated) load, considerable reduction in line speed.	Faulty load sense relief valve.	Replace the relief valve.
	Dirt in load sense relief valve, keeping the valve off the valve seat.	Remove and clean the relief valve. See Main Relief and Port Relief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







Item	Description
1	Axial Piston Pump
2	Piston
3	Swashplate
4	Cut-Off Pressure Spool
4a	Cut-Off Pressure Adjusting Screw (*)
5	Differential Pressure Spool
5a	Pump Margin (stand-by) Adjusting Screw (page 4-9)
6	Torque Limiter Spool
6a	Torque Limiter Adjusting Screw (*)
7	Test Coupling
8	Drive Shaft
9	Return Spring
10	Tilting Piston
11	Cylinder Block
A	Supply Port
B	Suction Port
Dr	Drain Port (qty 2)
PL	Pressure Limiter Port
*	DO NOT tamper with.

FIGURE 4-1

HYDRAULIC PUMP

See Figure 4-1 for the following description.

Description

The hydraulic system is powered by a variable displacement, axial piston pump driven by the crane's transmission.

- The 4-wheel drive pump has a counterclockwise rotation and provides a max flow of 159 Lpm (42 gpm).
- The 2-wheel drive pump has a clockwise rotation and provides a max flow of 140 Lpm (37 gpm).

The pump (1) consists of a housing, a piston (2), a drive shaft, a swash plate (3), a cut-off pressure spool (4), a differential pressure spool (5), and a torque limiter spool (6).

The load sense differential pressure spool controls pump displacement to best match the flow and pressure requirements of the load.

Pump delivery pressure is the sum of the load pressure, and the differential pressure.

When the pump discharge pressure reaches the preset value of the cut-off spool, the pump de-strokes to limit the outlet pressure to that setting. When the system requires no flow or pressure, the pump returns to an energy saving low pressure standby condition.

- The load sensing differential pressure setting is 24 bar (350 psi).
- The cut-off pressure is 283 bar (4,000 psi).

The torque limiter regulator controls pump displacement to best match the power available from the prime mover.

The torque limiter regulator monitors delivery pressure and the swashplate angle and adjusts pump displacement to limit input torque to a preset value. This prevents excessive load against the prime mover (prevents stalling).

- The torque limiter setting is 190 Nm (140 lb-ft).

Pump Output Test

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

Pump Margin (Stand-By) Pressure Check/ Adjustment

See Figure 4-1 for the following procedure.

It is necessary to access the hydraulic pump from under the crane for this procedure.

1. Raise the crane on outriggers or chock the tires.
2. PARK the crane.
3. STOP the engine and attach a pressure diagnostic quick disconnect (Parker PD240) with accurate hydraulic pressure gauge to the test coupling (7) on the pump.
4. Start and run the engine at idle.
5. The pressure gauge should read **24 ± 1.7 bar (350 ± 25 psi)**.
6. If pressure reading is correct, STOP the engine and disconnect the pressure gauge.
7. If pressure is incorrect:
   a. Loosen the lock nut on the pump margin (stand-by) adjusting screw (5a).
   b. Turn the adjusting screw in to increase pressure or out to decrease pressure until the specified pressure is obtained on the gauge.
   c. Hold the adjusting screw in position and securely tighten the lock nut.
   d. STOP the engine and disconnect the pressure gauge.

DUMP VALVE

See Figure 4-3, View A and the Hydraulic Schematic in Section 12 for the following description.

When the ignition switch is turned to the start position, the solenoid in load sense dump valve is energized, and the valve opens. This action dumps the load sensing pressure to tank, and the hydraulic pump de-strokes to zero flow, thereby reducing pump load on the engine during start-up.

When the ignition key is released after the engine starts, the solenoid in load sense dump valve is de-energized, and the valve closes. This action allows load sensing pressure to shift the hydraulic pump in the normal manner.

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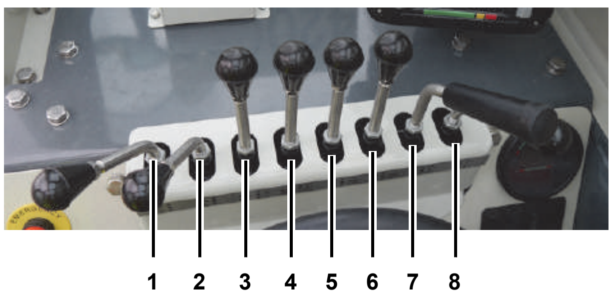
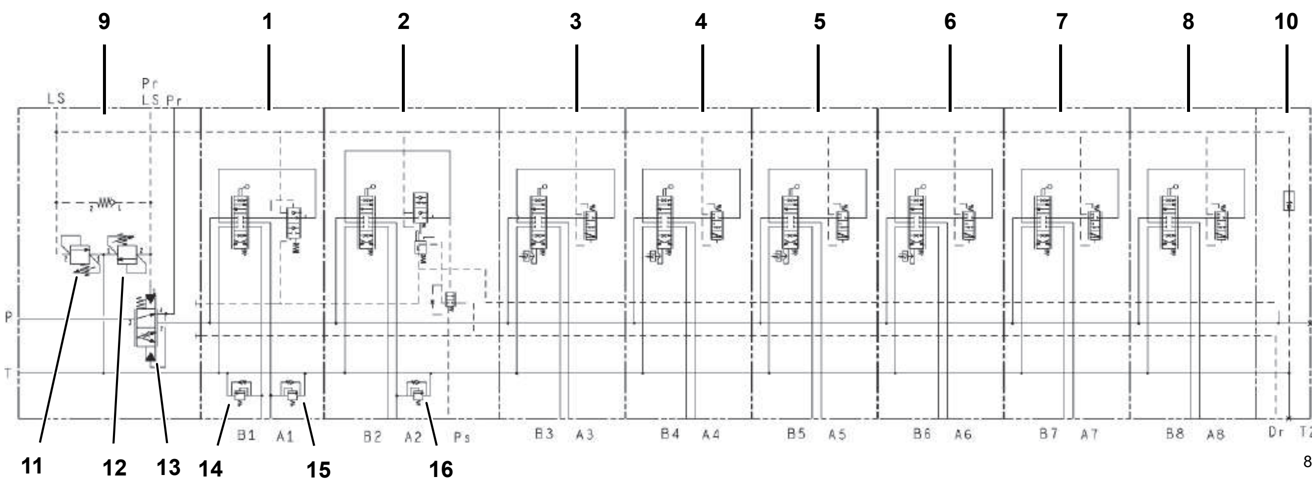


Working Port Identification

A1	Swing Left
B1	Swing Right
A2	Telescope In
B2	Telescope Out
A3	Left Rear Outrigger In
B3	Left Rear Outrigger Out
A4	Left Front Outrigger In
B4	Left Front Outrigger Out
A5	Right Front Outrigger In
B5	Right Front Outrigger Out
A6	Right Rear Outrigger In
B6	Right Rear Outrigger Out
A7	Hoist Up
B7	Hoist Down
A8	Boom Lift Up
B8	Boom Lift Down



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Item	Description	Item	Description
1	Swing Section	9	Inlet Section
2	Telescope Section	10	Outlet
3	Left Rear Outrigger Section	11	Load Sense Relief Valve
4	Left Front Outrigger Section	12	Priority Flow Load Sense Relief Valve
5	Right Front Outrigger Section	13	Priority Flow Control Valve
6	Right Rear Outrigger Section	14	Swing Right Relief Valve
7	Hoist	15	Swing Left Relief Valve
8	Boom Lift Section	16	Telescope Retract Relief Valve

FIGURE 4-2

MAIN CONTROL VALVE

General

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

Inlet Section

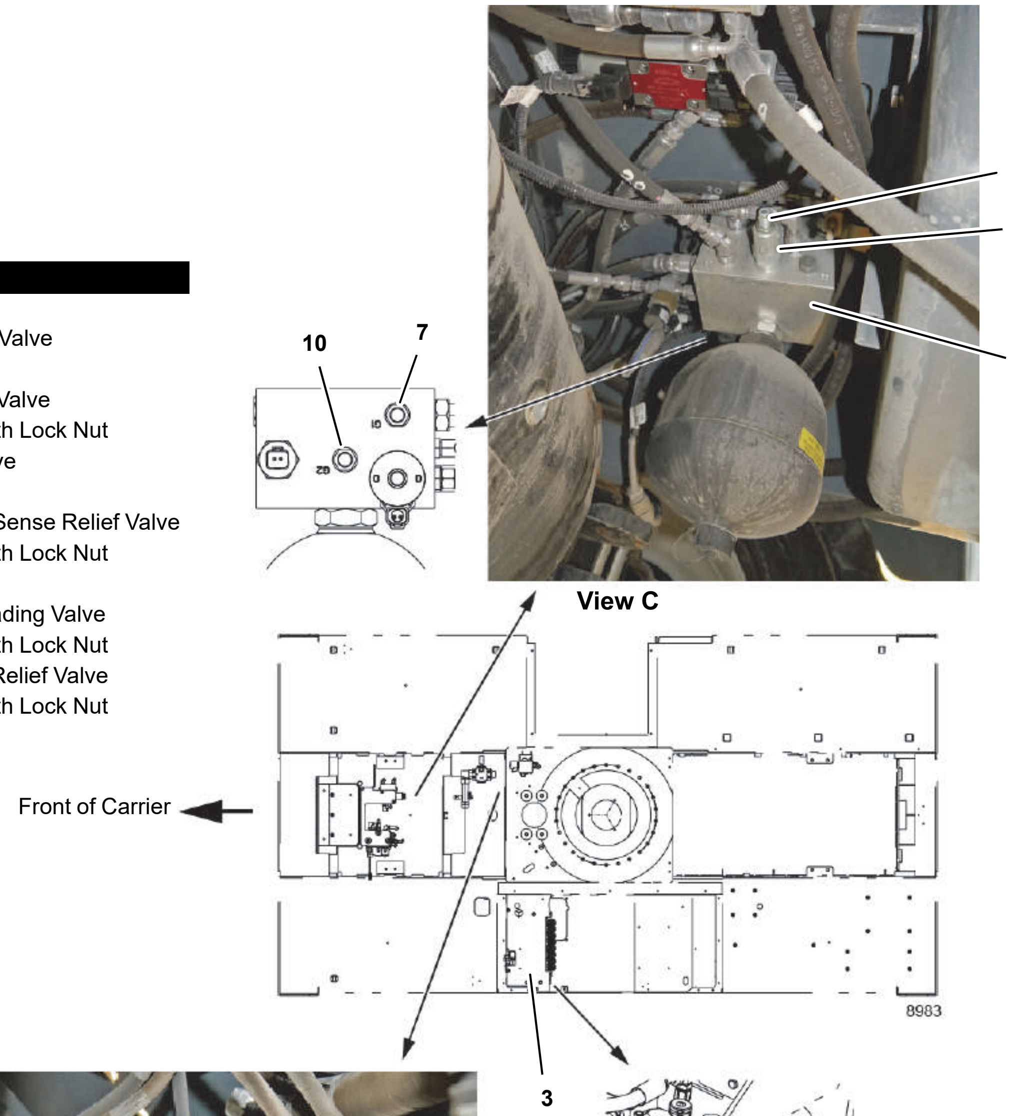
The inlet section is connected to the pressure side of the variable displacement pump. Items 11-13, Figure 4-2 are installed in the inlet section.

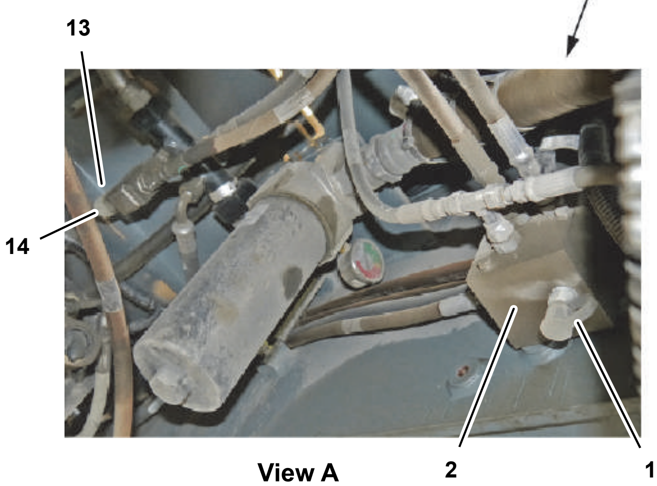
- The priority flow control valve limits pump flow to the main control valve until the needs of the steering and brake circuits are met.
- The load sense relief valve limits the available pressure to the main control valve functions.
- The priority flow load sense relief valve limits the pressure to the steering and brake circuits.

Working Valve Sections

There are eight working sections of the main control valve that receive hydraulic oil from the pump via the priority flow control valve. These sections control functions 1-8, Figure 4-2. 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 to the outlet port of the inlet section and then through the return filter to tank.

Item	Description
1	Test Coupling
2	Load Sense Dump Valve
3	Main Control Valve
4	Load Sense Relief Valve
5	Adjusting Screw with Lock Nut
6	Brake/Steering Valve
7	G1 Test Coupling
8	Priority Flow Load Sense Relief Valve
9	Adjusting Screw with Lock Nut
10	G1 Test Coupling
11	UP10 Piloted Unloading Valve
12	Adjusting Screw with Lock Nut
13	Telescope Extend Relief Valve
14	Adjusting Screw with Lock Nut





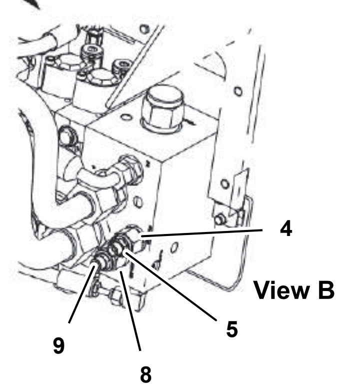


FIGURE 4-3

Load Sense Relief Valve Pressure Check/ Adjustment

See Figure 4-3 for the following procedure.

It is necessary to access the load sense dump valve from under the crane for this procedure.

1. Raise the crane on outriggers or chock the tires.
2. PARK the crane.
3. STOP the engine and attach a pressure diagnostic quick disconnect (Parker PD240) with accurate hydraulic pressure gauge to the test coupling (1, View A) on the on the load sense dump valve (2).
4. Start and run the engine at full throttle.
5. Fully lower the boom. Then, activate the boom down function to stall the system.
6. The pressure gauge should read **241 +/- 3.5 bar (3500 +/- 50 psi)**.

CAUTION

Avoid Parts Damage

Do not stall the system any longer than necessary to read the pressure. Excessive heat will be generated, possibly resulting in damage to parts.

7. If the pressure is correct, STOP the engine and disconnect the pressure gauge.
8. If the pressure is incorrect, adjust the load sense relief valve (4, View B):
   a. Loosen the lock nut on the adjusting screw (5, View B).
   b. Turn the adjusting screw in to increase pressure or out to decrease pressure until the specified pressure is obtained on the gauge.
   c. Hold the adjusting screw in position and securely tighten the lock nut.
9. STOP the engine and disconnect the pressure gauge.

Priority Flow Load Sense and Accumulator Relief Pressure Check/Adjustment

See Figure 4-3 for the following procedure.

It is necessary to access the brake/steering valve from under the crane for this procedure.

1. Raise the crane on outriggers or chock the tires.
2. PARK the crane.
3. STOP the engine and attach a pressure diagnostic quick disconnect (Parker PD240) with accurate hydraulic pressure gauge to the G1 test coupling (7, View C) on the on the brake/steering valve (6).
4. Start the engine and position the crane on a level surface with the outriggers fully extended.
5. PARK the crane so it cannot move.
6. Start and run the engine at full throttle.
7. Turn the steering wheel all the way to one side until the steering cylinders bottom out (stall system).
8. The pressure gauge should read **172 +/- 7.0 bar (2500 +/- 100 psi)**.

CAUTION

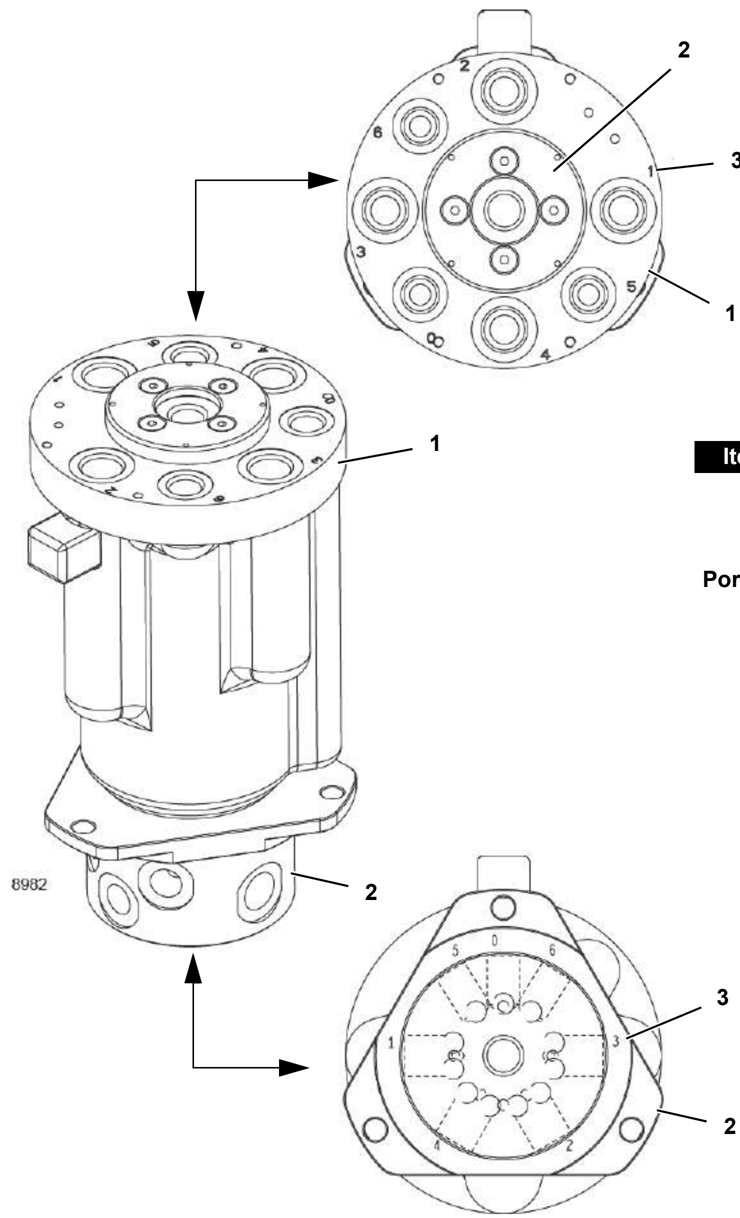
Avoid Parts Damage

Do not stall the system any longer than necessary to read the pressure. Excessive heat will be generated, possibly resulting in damage to parts.

9. If the pressure is correct, STOP the engine and disconnect the pressure gauge.
10. If the pressure is incorrect, adjust the priority flow load sense relief valve (8, View B):
    a. Loosen the lock nut on the adjusting screw (9, View B).
    b. Turn the adjusting screw in to increase pressure or out to decrease pressure until the specified pressure is obtained on the gauge.
    c. Hold the adjusting screw in position and securely tighten the lock nut.
11. STOP the engine and disconnect the pressure gauge.
12. If running, STOP the engine and attach a pressure diagnostic quick disconnect (Parker PD240) with accurate hydraulic pressure gauge to the G2 test coupling (10, View C) on the on the brake/steering valve (6).
13. Start and run the engine at idle.
14. Repeatedly depress the service brake pedal on the cab floor until the pressure gauge reads approximately **117 bar (1700 psi)**.
15. Once you have found the pressure, push the brake pedal again to recharge the valve. Watch the gauge and verify the low charging limit to be **110 +/- 7 bar (1600 +/- 100 psi)** (when it starts to recharge).
16. Then watch the gauge as the valve is charging. It should cut out at **138 +7/-0 bar (2000 +100/-0 psi).** If not, adjust the UP10 piloted unloading valve (11, View C):
    a. Loosen the lock nut on the adjusting screw (12, View C).
    b. Turn the adjusting screw in to increase pressure or out to decrease pressure until the specified pressure is obtained on the gauge.

c. Hold the adjusting screw in position and securely tighten the lock nut.

17. STOP the engine and remove the pressure gauge.



Item	Description
1	Housing
2	Spool
3	Port Number
Port No.	**Identification**
0	Hoist Motor Drain
1	Telescope Out
2	Hoist Down
3	Telescope In
4	Hoist Up
5	Boom Lift Down
6	Boom Lift Up

FIGURE 4-4

HYDRAULIC SWIVEL

See Figure 4-4 for this description.

General

The hydraulic swivel is located at the crane's center of rotation between the mast and the carrier. It allows oil to flow in either direction between the hydraulic components in the mast and boom and the hydraulic components in the carrier during 360° rotation of the mast.

The hydraulic swivel has seven passages. Grooves and ports in the spool align with ports in the housing. Seals between the grooves of the spool prevent leakage between the passages. The seals fit tightly against the housing. The housing rotates with the mast and the spool is stationary (fixed to carrier).

Functions

The port numbers are stamped in the top of the housing and in the bottom of the spool.

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.

BOOM LIFT CIRCUIT

Use the Hydraulic Schematic in Section 12 along with the following description of operation to understand how the boom lift circuit functions.

General

The boom lift circuit includes a double-acting cylinder, a holding valve, up and down ports in the hydraulic swivel, an anti-two block lockout solenoid valve, a valve section in the main control valve (item 8, Figure 4-2 on page 4-10), and inter-connecting hydraulic lines.

Oil Flow

When the main control valve spool is in the neutral position, both A and B ports are closed and oil is trapped in the circuit to prevent movement of the boom lift cylinder.

Raising the Boom

Pulling the joystick towards the operator connects the pump passage A in the control valve. Oil leaves control valve Port A and passes through swivel Port 6 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 swivel Port 5 and flows over the check valve in the anti-two block valve to the control valve Port B. From there, the oil is routed to the tank passage of the control valve assembly and returns through the return filter to the hydraulic oil tank.

Lowering the Boom

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

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 end of the cylinder 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 close to 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 suspected cylinder from the machine. See page 4-40.
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 4-40.

4

TELESCOPE CIRCUIT

Use the Hydraulic Schematic in Section 12 along with the following description of operation to understand how the lift circuit functions.

General

The telescope circuit includes the telescope cylinder, a holding valve, up and down ports in the hydraulic swivel, an anti-two block lockout solenoid valve, a valve section in the main control valve (item 2, Figure 4-2 on page 4-10), and inter-connecting hydraulic lines.

Oil Flow

Telescope Out

Pushing the joystick away from the operator connects the supply from the pump to Port B of the control valve section. Oil leaves Port B and is routed through the anti-two block solenoid valve, through the swivel Port 1 to Port P in the holding valve on the base end of the cylinder. 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 out Port R in the holding valve. The oil returns through the 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-two 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 the operator, routes oil out of valve Port A and through the swivel Port 3 to rod Port R in 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.

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

Holding Valve

The holding valve has three functions:

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

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

System Relief Valves

The telescope circuit is equipped with two relief valves:

- Extend relief valve (item 13, View A, Figure 4-3 on page 4-12).
- Retract relief valve (not adjustable) in the telescope section of the main control valve (Figure 4-2 on page 4-10).

Telescope Pressure Check/Adjustment

NOTE: Always check/set the pressure of the load sense relief valve (page 4-13) before checking the pressure on the other valves.

1. PARK the crane so it cannot move.
2. STOP the engine and attach a pressure diagnostic quick disconnect (Parker PD240) with accurate hydraulic pressure gauge to the test coupling (1, View A, Figure 4-3 on page 4-12) on the on the load sense dump valve (2).
3. Extend pressure procedure:
    a. Start and run the engine at full rpm.
    b. Operate the boom extend function to fully extend the boom and hold (stall system).
    c. The pressure gauge should be **224 +3.5/ -0 bar (3250 +50/-0 psi).**

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CAUTION

Avoid Parts Damage

Do not stall the system any longer than necessary to read the pressure. Excessive heat will be generated, possibly resulting in damage to parts.

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4. If the pressure is incorrect, adjust the telescope extend relief valve (13, View A, Figure 4-3 on page 4-12):
   a. Loosen the lock nut on the adjusting screw (14).
   b. Turn the adjusting screw in to increase pressure or out to decrease pressure until the specified pressure is obtained on the gauge.
   c. Hold the adjusting screw in position and securely tighten the lock nut.
5. Retract pressure procedure (non-adjustable):
   a. With the pressure gauge still connected to the test coupling (1, View A, Figure 4-3 on page 4-12) on the on the load sense dump valve (2) and the engine running at full rpm — operate the boom retract function to fully retract the boom and hold (stall system).
   b. The pressure gauge should read **152 ± 6.9 bar (2200 ± 100 psi).**

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CAUTION

Avoid Parts Damage

Do not stall the system any longer than necessary to read the pressure. Excessive heat will be generated, possibly resulting in damage to parts.

   c. If the specified pressure is not obtained, contact your Grove distributor or the Product Support Team for corrective action.
6. STOP the engine and remove the pressure gauge.

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 telescope retract hose (1, Figure 4-5) from the fitting in the end of the telescope cylinder. A little oil will drain from the hose and fitting.
5. Start the engine. Actuate the control lever in the extend direction. Check the amount of leakage from the fitting in the end of the telescope cylinder. If the leakage is more than a few drops per minute, replacement of the piston seals is necessary.

4

Item	Description
1	Telescope Retract Hose
2	Telescope Cylinder
3	Boom

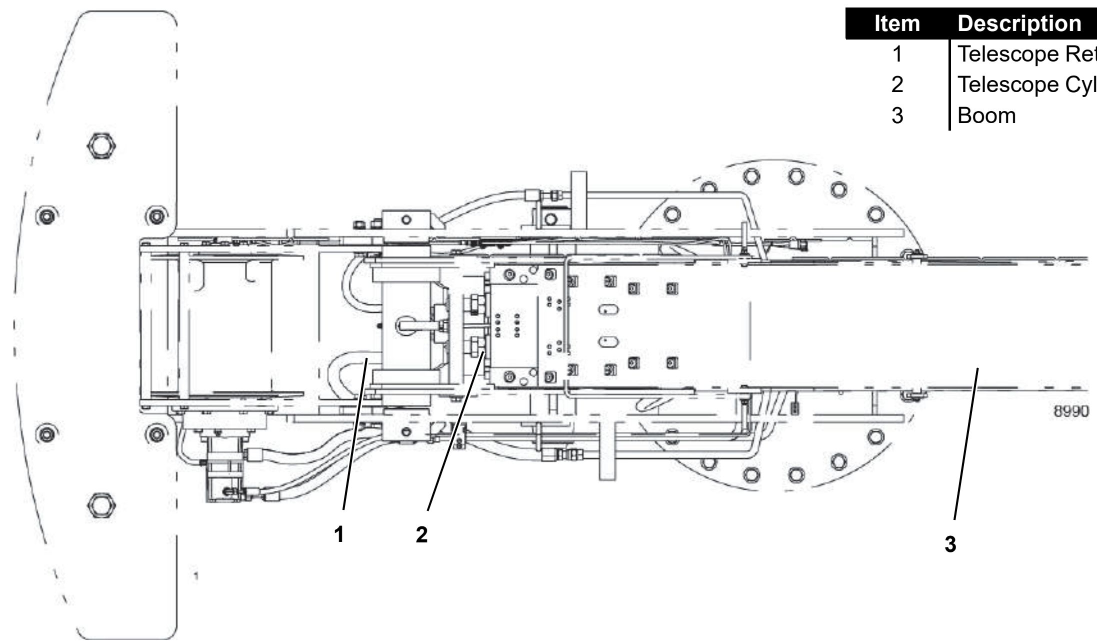
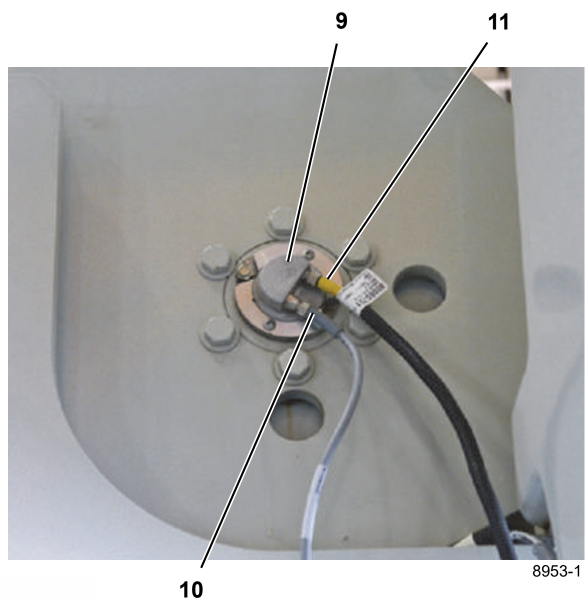


FIGURE 4-5

Item	Description
1	Hoist Assembly
2	Planetary Gearbox with Internal Disk Brake
3	Hydraulic Motor
4	Holding Valve (non-adjustable)
5	Case Drain Hydraulic Hose
6	Down Hydraulic Hose
7	Up Hydraulic Hose
8	Brake Hydraulic Hose
9	Drum Rotation and 3rd Wrap Sensor
10	CAN Electric Cable
11	Drum Rotation and 3rd Wrap Electric Cable



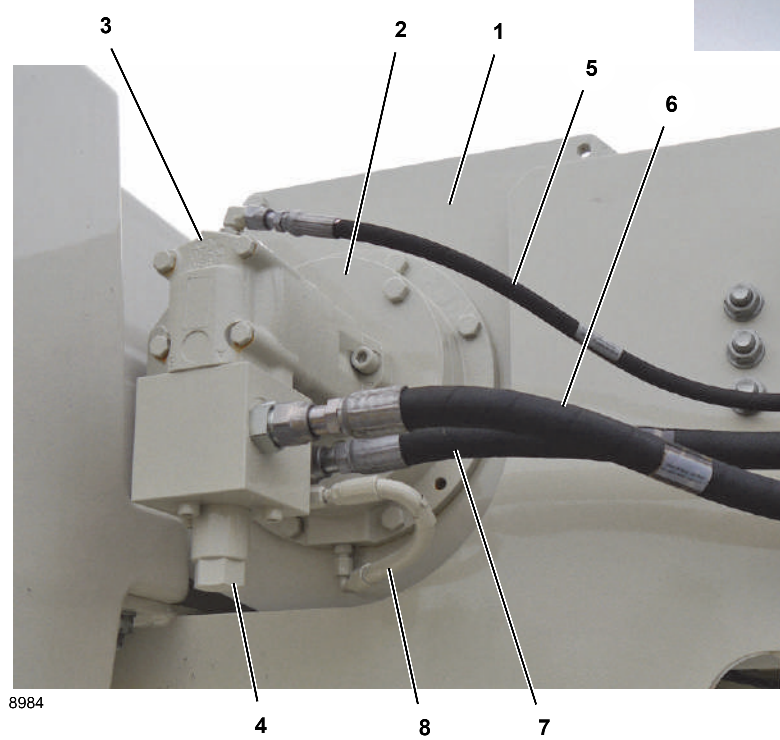


FIGURE 4-6

HOIST CIRCUIT

Use the Hydraulic Schematic in Section 12 along with the following description of operation to understand how the hoist circuit functions.

Also see Figure 4-6 for this description.

General

The hoist circuit includes the drum, a planetary gearbox with one-way clutch and disc brake, a hydraulic motor, a holding valve, a drum rotation/3rd wrap sensor, up and down ports in the hydraulic swivel, an anti-two block lockout solenoid valve, a valve section in the main control valve (item 7, Figure 4-2 on page 4-10), and inter-connecting hydraulic lines.

Oil Flow

When the valve spool is in the neutral position, both A and B ports are closed. Oil is trapped 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. From here the oil is routed through the anti-two block solenoid valve and swivel Port 4 to the brake holding valve. In this direction, the oil flows freely through the brake holding valve to the hoist motor.

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

The anti-two 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 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 brake holding 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.

Brake Holding Valve

The holding valve has three functions:

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

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

Faulty Hoist Operation

Do not adjust the holding valve setting. The valve is factory set and must mot be tampered with. Otherwise, faulty operation can occur

Drum Rotation/3rd Wrap Sensor

The drum rotation/3rd wrap sensor (8) is located on the left side of the hoist. It transmits a rotation signal to the hoist up and hoist down indicator lights in the gauge cluster on the instrument panel. It also activates the thumb thumper in the end of the hoist control handle.

The drum rotation/3rd wrap sensor is programmed to turn on a red light in the gauge cluster when there are three wraps of cable left on the hoist drum. See Section 11 of this manual for programming instructions.

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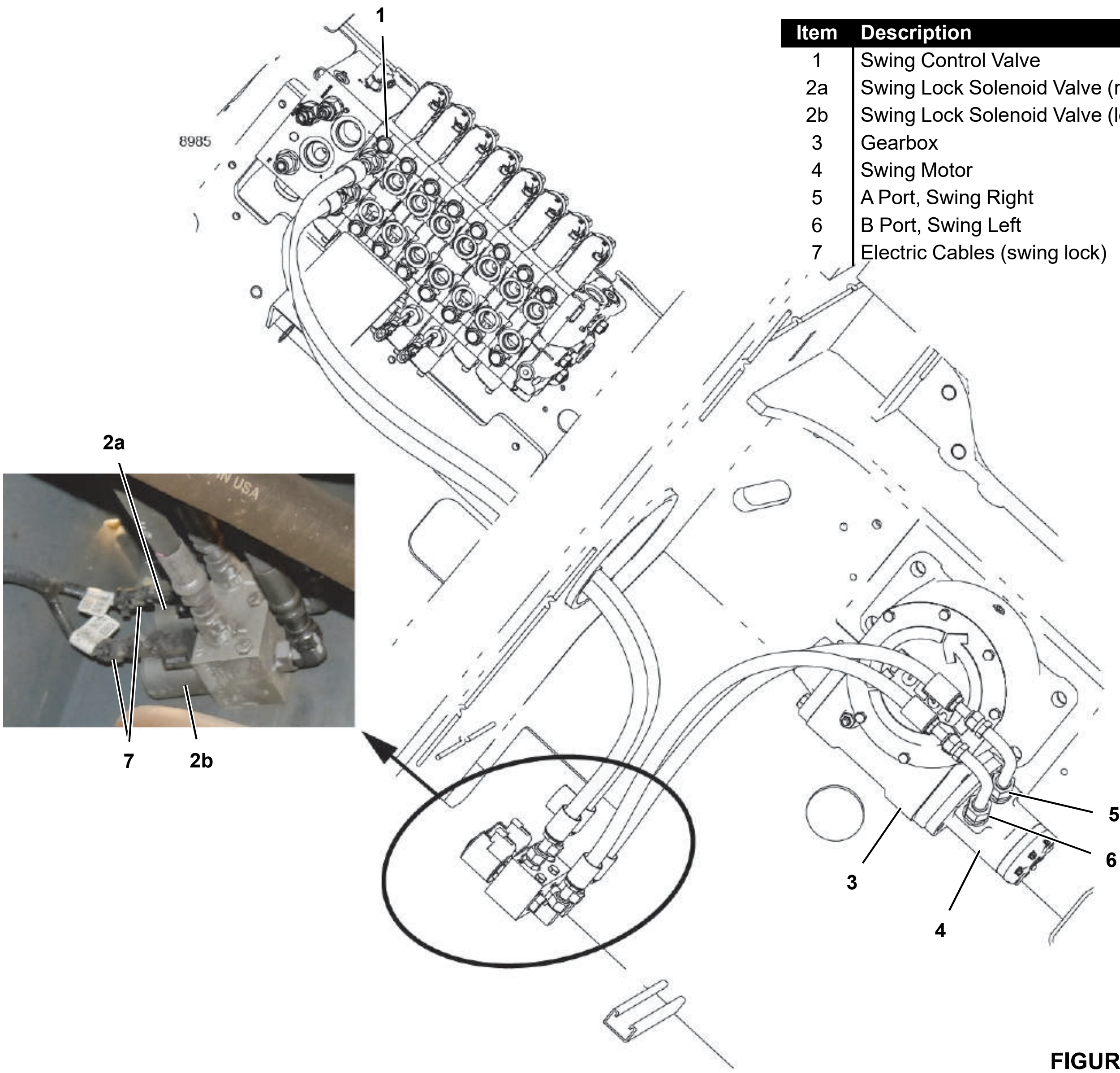


Item	Description
1	Swing Control Valve
2a	Swing Lock Solenoid Valve (right)
2b	Swing Lock Solenoid Valve (left)
3	Gearbox
4	Swing Motor
5	A Port, Swing Right
6	B Port, Swing Left
7	Electric Cables (swing lock)

FIGURE 4-7

SWING CIRCUIT

Use the Hydraulic Schematic in Section 12 along with the following description of operation to understand how the swing circuit functions.

General

The swing circuit includes a valve section in the main control valve (with internal port relief vales), optional swing lock solenoid valves (two each), a worm-drive gearbox with swing pinion, a hydraulic swing motor, and a slewing ring bearing with external ring gear.

Th inner ring of the of the slewing ring bearing is bolted to the carrier; the outer ring, to the mast.

Oil Flow

Neutral

In neutral, oil is trapped in the circuit and the hydraulic swing motor is prevented from turning.

Swing Right

Pushing the joystick away from the operator sends oil through Port B of the swing control valve (1), through the swing lock solenoid valve (2a, if equipped) to Port A of the hydraulic swing motor (4). The motor drives the gearbox (3) and the gearbox turns the swing pinion clockwise (viewed from below), causing the mast to rotate to the right. Oil from Port B of the hydraulic swing motor flows through the swing lock solenoid valve (2b, if equipped), through the Port A of the swing control valve, and returns to tank through the return filter.

Swing Left

Pulling the joystick toward the operator sends oil through Port A of the swing control valve (1), through the swing lock solenoid valve (2b, if equipped) to Port B of the hydraulic swing motor (4). The motor drives the gearbox (3) and the gearbox turns the swing pinion counterclockwise (viewed from below), causing the mast to rotate to the left. Oil from Port A of the hydraulic swing motor flows through the swing lock solenoid valve (2a, if equipped), through the Port B of the swing control valve, and returns to tank through the return filter.

Optional Swing Lock

If equipped, the optional swing lock circuit operates as follows:

Swing Lock Off

When the swing lock switch on the instrument panel is off, the swing lock solenoid valves are energized and shifted to the open position. This action allows oil to flow freely between the swing control valve and the swing motor.

Swing Lock On

When the swing lock switch on the dash is on, the swing lock solenoid valves are de-energized and shifted to the closed position. This prevents (locks) oil flow between the swing control valve and the swing motor.

Swing Pressure Check/Adjustment (without Swing Lock)

NOTE: Always check/set the pressure of the load sense relief valve (page 4-13) before checking the pressure on the other valves.

1. PARK the crane so it cannot move.
2. STOP the engine and attach a pressure diagnostic quick disconnect (Parker PD240) with accurate hydraulic pressure gauge to the test coupling (1, View A, Figure 4-3 on page 4-12) on the on the load sense dump valve (2).
3. Disconnect both of the hydraulic hoses from the swing motor (4, Figure 4-7). Cap the adapters and plug the hoses.
   - **a.** Operate the swing control lever fully forward or back and hold (stall swing system).
   - **b.** The pressure gauge should read **165 ± 10.2 bar (2400 ± 150 psi).**

.

CAUTION

Avoid Parts Damage

Do not stall the system any longer than necessary to read the pressure. Excessive heat will be generated, possibly resulting in damage to parts.

   - **c.** This pressure is not adjustable. If the specified pressure is not obtained, contact your Grove distributor or the Product Support Team for corrective action.
4. STOP the engine and remove the pressure gauge.
5. Reconnect the hydraulic hoses to the swing motor.

Swing Pressure Check/Adjustment (with Swing Lock)

NOTE: Always check/set the pressure of the load sense relief valve (page 4-13) before checking the pressure on the other valves.

1. PARK the crane so it cannot move.
2. STOP the engine and attach a pressure diagnostic quick disconnect (Parker PD240) with accurate hydraulic pressure gauge to the test coupling (1, View A, Figure 4-3 on page 4-12) on the on the load sense dump valve (2).
3. Disconnect the electric cable (7, Figure 4-7) from both swing lock solenoid valves (2a and 2b).
   - **a.** Operate the swing control level fully forward or back and hold (stall swing system).
   - **b.** The pressure gauge should read **165 ± 10.2 bar (2400 ± 150 psi).**

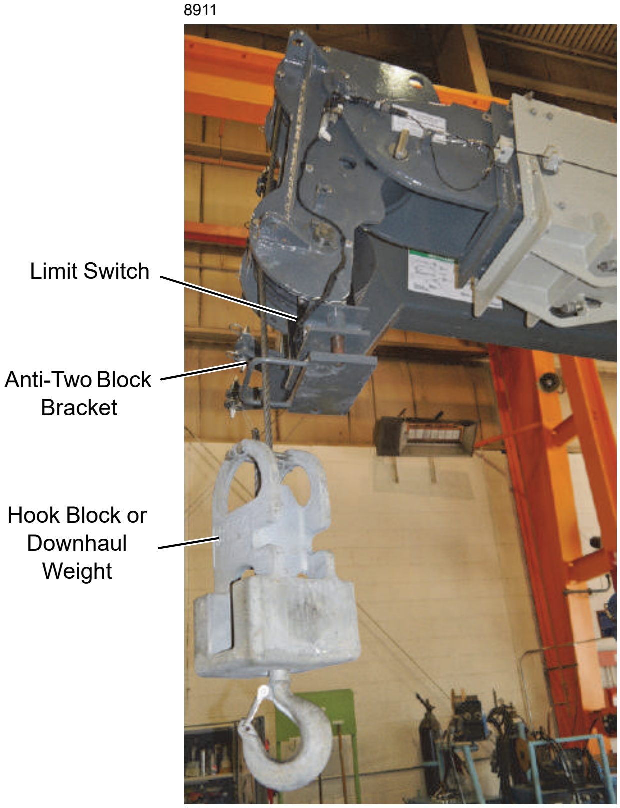
.

CAUTION

Avoid Parts Damage

Do not stall the system any longer than necessary to read the pressure. Excessive heat will be generated, possibly resulting in damage to parts.

   - **c.** This pressure is not adjustable. If the specified pressure is not obtained, contact your Grove distributor or the Product Support Team for corrective action.
4. STOP the engine and remove the pressure gauge.
5. Reconnect the electric cable (7, Figure 4-7) to both swing lock solenoid valves (2a and 2b).



Anti-Two Block System — Boom

Anti-Two Block System — Boom Extension

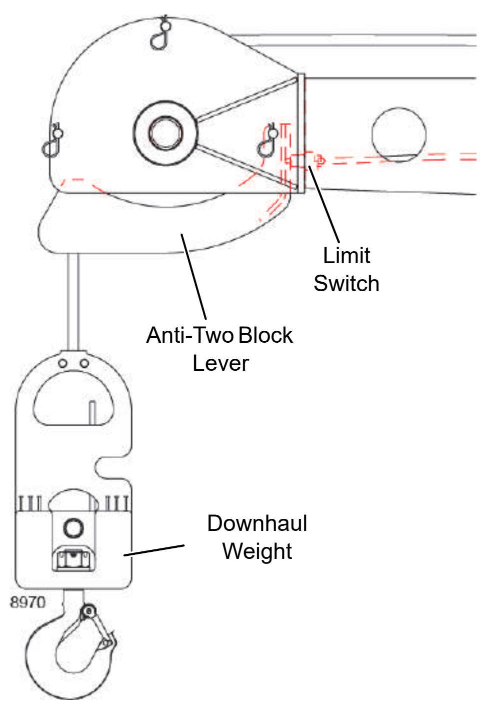
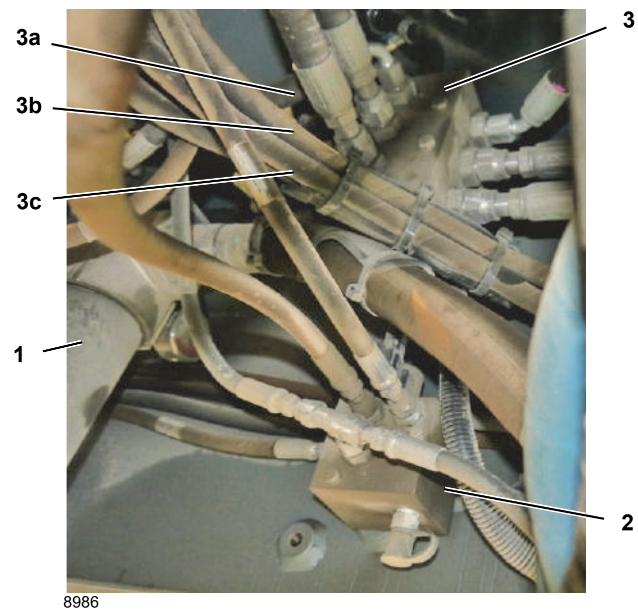


FIGURE 4-8



Item	Description
1	Hydraulic Return Filter
2	Load Sense Dump Valve
3	Lockout Solenoid Valve Manifold
3a	Boom Lift Down Solenoid Valve (top)
3b	Telescope Extend Solenoid Valve (middle)
3c	Hoist Up Solenoid Valve (down)

FIGURE 4-9

ANTI-TWO BLOCKING SYSTEM

See Figure 4-8 and Figure 4-9 for the following descriptions.

General

The anti-two block system prevents structural damage in the event the hook block or the downhaul weight contacts the boom head or the boom extension head, causing a two blocking situation. The anti-two block system includes the following:

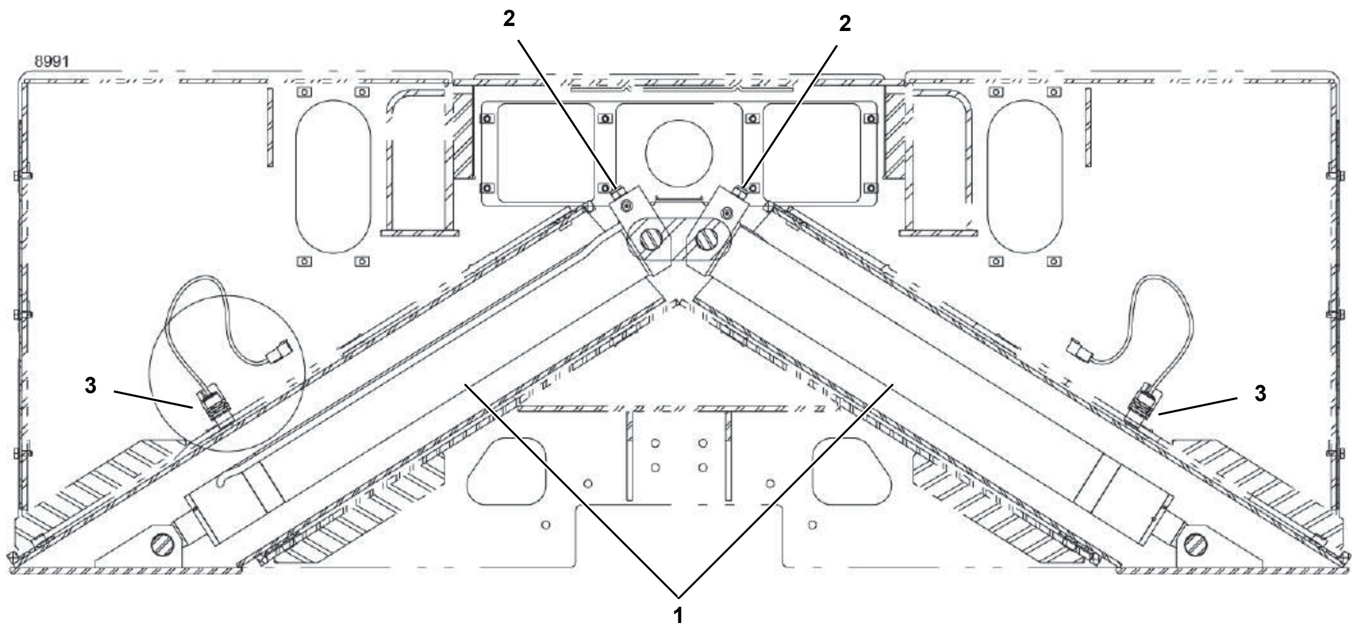
- Anti-two block bracket and limit switch at the end of the boom head.
- Anti-two block lever and limit switch at the end of the boom extension head.
- Lockout solenoid valve manifold under the carrier.

System Operation

During normal operation, the solenoid valves (3a, 3b, and 3c) are open (energized) to allow oil to flow freely from the main control valve to the boom lift down, the telescope out, and the hoist up circuits.

If the hook block or the downhaul weight contact the anti-two block bracket at the end of the boom head or the anti-two block lever at the end of the boom extension head, the corresponding limit switch is actuated. The limit switch, opens the electrical circuit to the solenoid valves, and the solenoid valves close to block oil flow to the boom lift down, the telescope out, and the hoist up circuits.

To return to normal operation, raise the boom, retract the boom, or lower the load.



Item	Description
1	Outrigger Cylinder (qty 4)
2	Pilot Operate Check Valve (qty 4)
3	Proximity Switch (qty 4)

FIGURE 4-10

OUTRIGGER CIRCUIT

Use the Hydraulic Schematic in Section 12 along with the following description of operation to understand how the outrigger circuit functions.

Also see Figure 4-10 for this description.

General

The outrigger circuit includes four valve sections in the main control valve (items 3-6, Figure 4-2 on page 4-10), a hydraulic cylinder at corner of the carrier, and a piloted operated check valve in the extend port of each cylinder.

Oil Flow

Neutral

When the outrigger valve spools are in the neutral position, the A and B ports of the valve spools are closed. Oil is trapped in the outrigger circuit, and the pilot operated check valves lock the outriggers in position.

Extending an Outrigger

Pushing an outrigger joystick away from the operator sends oil through Port B of the outrigger control valve, through the pilot operate check valve (2) to the extend port of the outrigger cylinder (1). The cylinder extends to raise the corresponding corner of the carrier. Oil from retract port of the cylinder (rod end) returns to Port A of the of the outrigger control valve, and returns to tank through the return filter.

Retract an Outrigger

Pulling an outrigger joystick toward the operator sends oil through Port A of the outrigger control valve to the rod end of the outrigger cylinder (1). Pressure in the rod end of cylinder opens the pilot operate check valve (2) allowing oil to exit the head end of the cylinder. The cylinder retracts to lower the corresponding corner of the carrier. Oil from extend port of the cylinder (head end) returns to Port B of the of the outrigger control valve, and returns to tank through the return filter.

Outrigger Monitoring System (OMS)

The OMS aids the operator by turning on a green indicator light in the gauge cluster on the instrument panel when all of the outriggers are fully extended. The light is controlled by the proximity switches (3, Figure 4-10) at the outrigger cylinders (1).

Each proximity switch senses the position of it’s respective outrigger beam when the beams are in the fully extended position.

When the green indicator light is on, lifts can be made using the Outriggers Fully Extended Load Chart.

Any outrigger beam not fully extended or functional failure of any proximity switch will cause the indicator to go off, indicating the outrigger beams are not fully extended and lifts can only be made using the On Rubber Load Charts.

UNDER DECK WINCH CIRCUIT

Use the Hydraulic Schematic in Section 12 along with the following description of operation to understand how the winch circuit operates.

General

The winch circuit includes a planetary winch with hydraulic motor mounted under the front of the carrier, a three-position solenoid operated control valve (Figure 4-11), a pressure reducing valve, and a three-position switch on the instrument panel.

Oil Flow

Neutral

When the winch switch (on instrument panel) is moved to the center position, the control valve solenoids are de-energized, and the valve spool shifts to the neutral position. The winch is locked in position by an internal clutch.

Pay Out

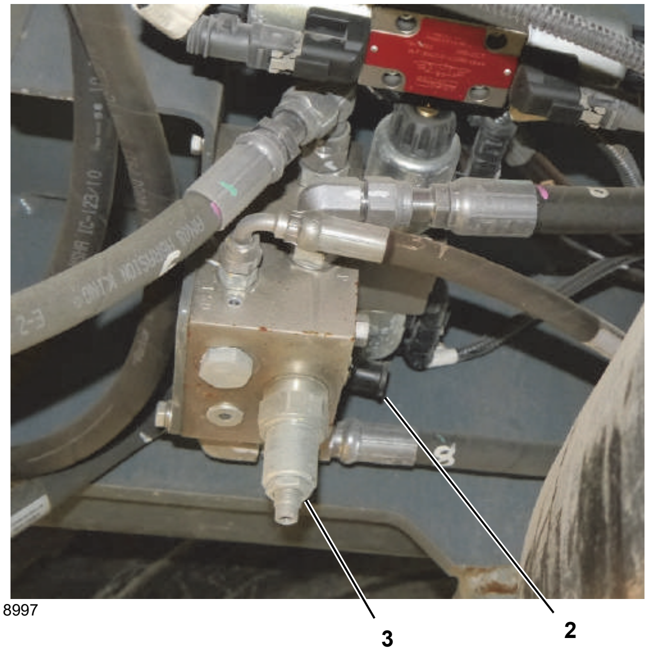
When the winch switch is held in the pay out position, the corresponding solenoid is energized, and the control valve spool shifts to direct oil flow to Port A of the winch motor.

The motor drives the winch drum in the pay out direction. Oil from motor Port B flows through the control valve and returns to tank.

Haul In

When the winch switch is held in the haul in position, the corresponding solenoid is energized, and the control valve spool shifts to direct oil flow to Port B of the winch motor.

The motor drives the winch drum in the haul in direction. Oil from motor Port A flows through the control valve and returns to tank.



Item	Description
1	Under Deck Control Valve
2	Test Coupling
3	Pressure Reducing Valve

FIGURE 4-11

Under Deck Winch Pressure Check/ Adjustment

NOTE: Always check/set the pressure of the load sense relief valve (page 4-13) before checking the pressure on the other valves.

1. Raise the crane on outriggers or chock the tires.
2. PARK the crane.
3. STOP the engine and attach a pressure diagnostic quick disconnect (Parker PD240) with accurate hydraulic pressure gauge to the test coupling (2, Figure 4-11).
4. Disconnect both of the hydraulic lines from the winch motor. Cap the adapters and plug the hoses.
   a. Move the under deck winch switch in either direction and hold (stall winch system).
   b. The pressure gauge should read **172 ± 3.5 bar (2500 ± 50 psi).**

CAUTION

Avoid Parts Damage

Do not stall the system any longer than necessary to read the pressure. Excessive heat will be generated, possibly resulting in damage to parts.

5. If the specified pressure is not obtained:
   a. Loosen the lock nut on the pressure valve (2).
   b. Turn the adjusting screw in to increase pressure or out to decrease pressure until the specified pressure is obtained on the gauge.
   c. Hold the adjusting screw in position and securely tighten the lock nut.
6. STOP the engine and remove the pressure gauge.
7. Reconnect the hydraulic hoses to the winch motor.

COMPONENT REPAIR

General

Manitowoc assumes that all repair procedures will be performed by qualified technicians who have been trained in the assembly, repair, and disassembly of hydraulic and electric components.

- Read Section 1 of this manual.
- Refer to the Parts Manual supplied with your crane for replacement part numbers. Contact your Grove distributor to order replacement parts.
- Always tag (label) hydraulic hoses and electric cables before disconnecting them so that thy can be reconnected to the proper locations.

Hydraulic Pump Repair

Removal

1. PARK the crane and STOP the engine.
2. Drain the hydraulic tank.
3. Tag and disconnect all of the hydraulic lines from the pump. Cap and plug all hoses and ports.
4. The pump weighs 28 kg (62 lb). Use an overhead crane and a sling or a support to hold the pump in position.
5. Note the position of the pump with relation to the transmission so the new/repaired pump can be installed in the position.
6. Remove the pump mounting cap screws and washers. 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. Thoroughly clean the mounting surface of the pump and the transmission.
2. Fill the pump housing through the case drain port with clean hydraulic oil to provided initial lubrication at start-up.
3. Align the spline of the pump shaft with the spline of the pump coupler on the transmission. Properly position the pump and install the washers and cap screws.
4. Tighten the cap screws to the required torque. See Section 1 of this manual.
5. Thoroughly clean all hydraulic fittings and install O-rings where needed.
6. Attach and securely tighten the hydraulic hose fittings.
7. 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.

8. The pump will fill with hydraulic oil when the tank is filled. The air in the pump will work itself back to tank.
9. 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 several minutes to release any air that might be in the hydraulic system.
3. Check for leakage and tighten fittings are needed.
4. Check the oil level in the hydraulic tank. If low, add only pre-filtered hydraulic oil.
5. Perform *Pump Margin (Stand-By) Pressure Check/ Adjustment*, on page 4-9.

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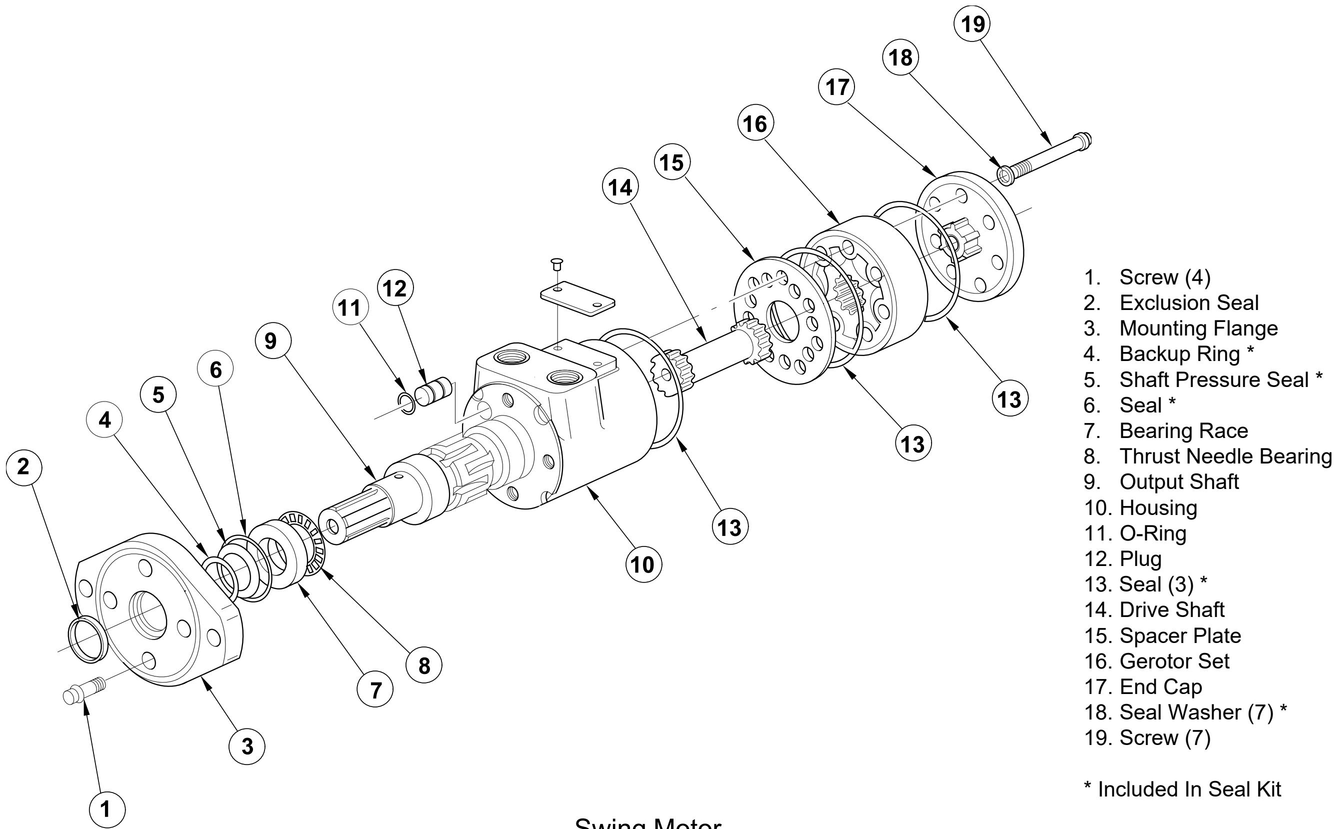


Swing Motor

FIGURE 4-12

Swing Motor

Removal

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

CAUTION

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

---

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

Disassembly

CAUTION

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

---

1. Place the motor in a vice and clamp across the edges of the flange Figure 4-13 with the output shaft facing down. When clamping use protective devices on the jaws, such as soft jaws, pieces of rubber or wood.

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

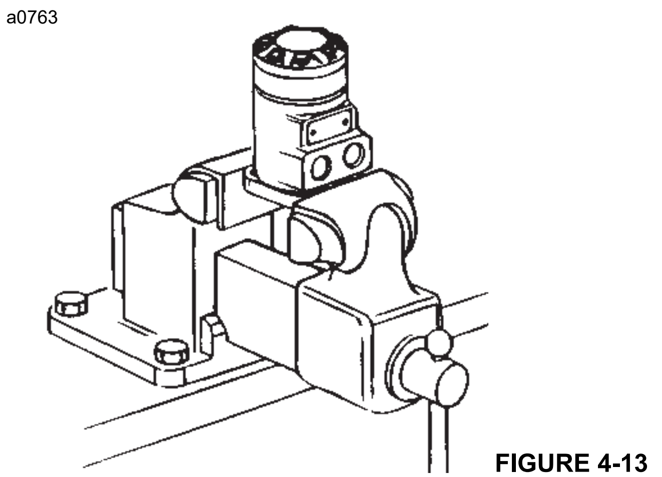


FIGURE 4-13

2. Remove seven capscrews (19) Figure 4-12 and seal washers (18).
3. Remove end cap (17). Remove and discard seal (13) from the end cap.
4. Remove gerotor (16). Remove and discard seal (13) from the gerotor.
5. Remove drive spacer, if applicable.
6. Remove drive shaft (14).
7. Remove spacer plate (15).
8. Remove seal 13 from housing (10).
9. Remove output shaft (9) from housing (10).
10. Remove needle thrust bearing (8) from shaft or housing.
11. Reposition the motor in the vice. Clamp across ports Figure 4-14. DO NOT clamp on housing. Excessive clamping pressure on side of housing causes distortion.

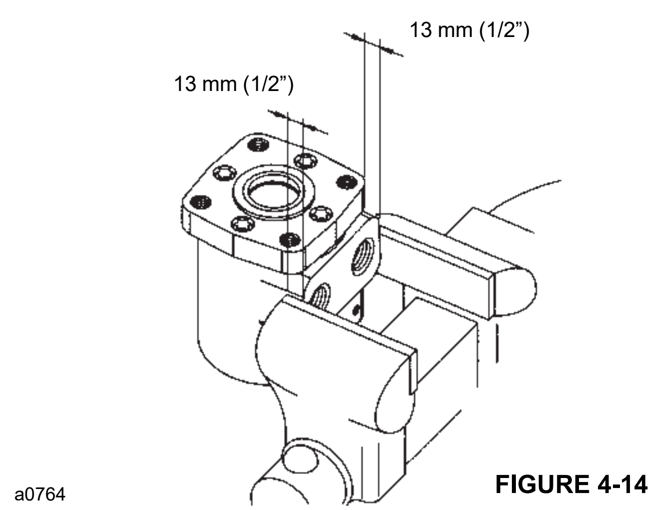


FIGURE 4-14

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

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

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

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

13. Carefully remove flange (3) Figure 4-12 from housing (10).

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

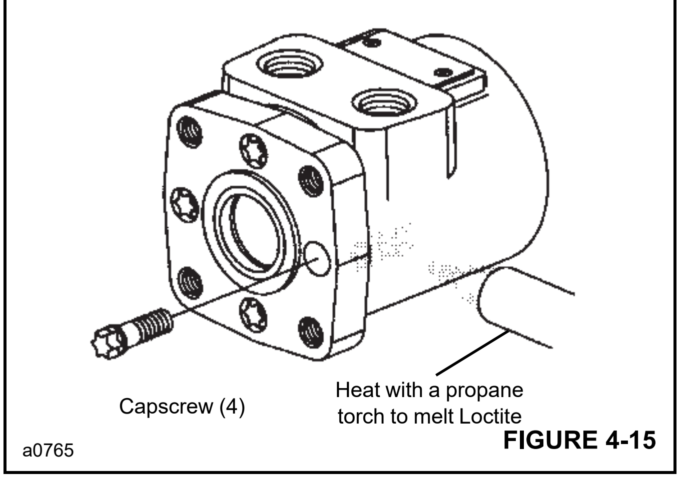


FIGURE 4-15

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

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

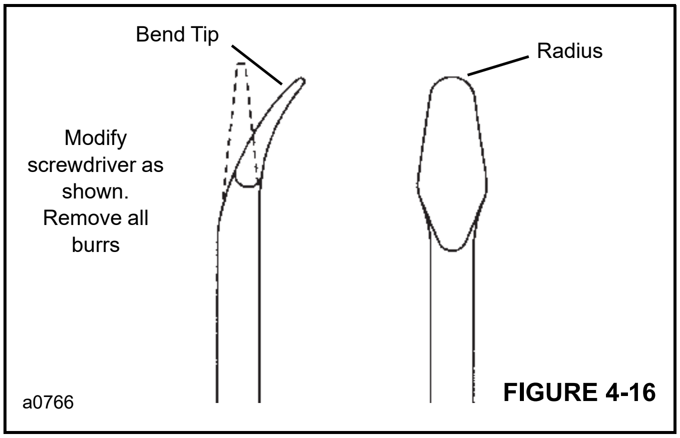


FIGURE 4-16

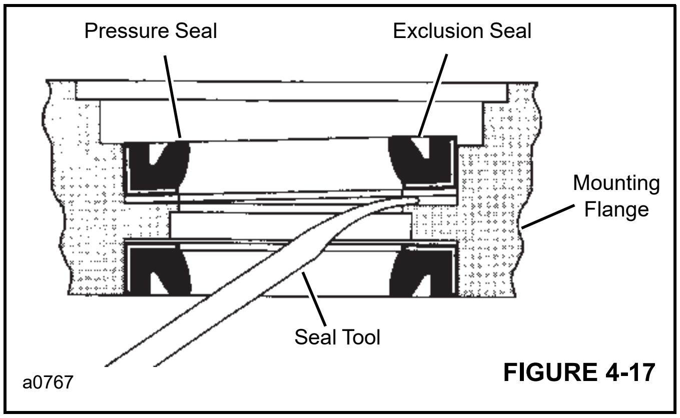


FIGURE 4-17

15. A metal plug (12) Figure 4-12, with O-ring (11), plugs a machined hole in the housing. It is not necessary to remove the plug and replace the O-ring unless leakage occurs around the plug. To remove the plug, insert a 5 mm (0.187 in) hex key through the port opening and push it out. The model 009 plug is not interchangeable with the 007 and 008 plugs.

Inspection/Cleaning

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

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

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

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

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

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

Assembly

Shaft End

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

CAUTION

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

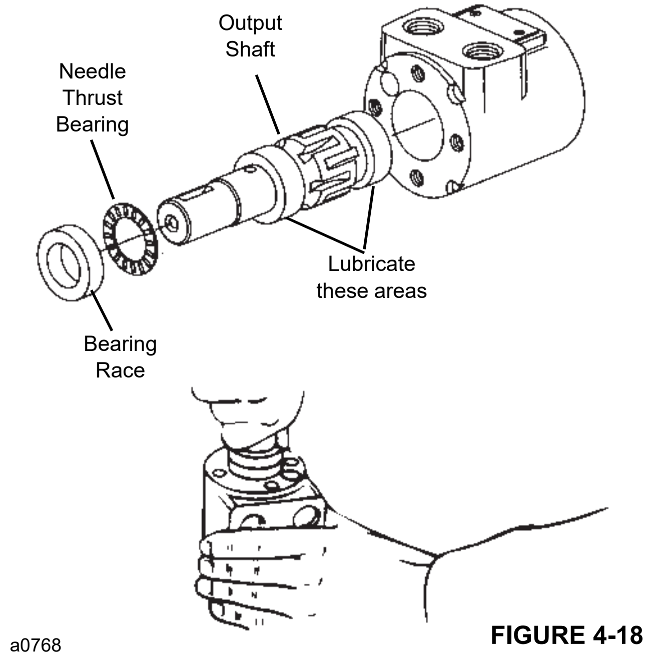


FIGURE 4-18

3. Install needle thrust bearing (8), then bearing race (7) on shaft (9). Pull shaft partially out of housing. Push all three parts in housing (10) together Figure 4-18. The bearing race must rotate freely when in position.
4. Install exclusion seal (2) Figure 4-12 in flange (3) with the lips of the seal facing out Figure 4-19. Carefully press the exclusion seal in place.
5. Visually check seal seats in the mounting flange for scratches or other marks that might damage the seals (5). Check for cracks in flange (3) that could cause leakage.

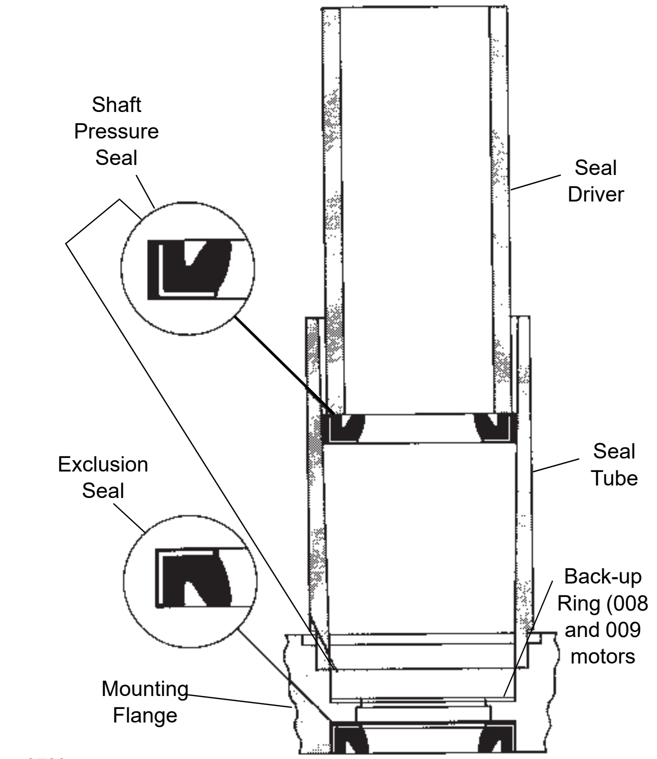


FIGURE 4-19

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

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

7. Install O-ring (6) Figure 4-12 into groove in flange (3).
8. It is recommended to apply a light coat of Loctite® Primer NF in tapped holes of housing 10. Allow the primer to air dry for at least 1 minute. Do not force dry with air jet; the primer will blow away.

   Use of primer is optional. With primer, Loctite® curing time is approximately 15 minutes. Without the primer the curing time is approximately 6 hours.
9. Apply 3 or 4 drops of Loctite sealant at the top of the threads for each of the four holes in the housing Figure 4-20. Do not allow parts with Loctite to come in contact with any metal parts other than those for assembly. Wipe off excess Loctite from housing face, using a non-petroleum base solvent.

   Do not apply Loctite to threads more than 15 minutes before installing screws. If the housing stands for more than 15 minutes, repeat application. No additional cleaning or removal of previously applied Loctite is necessary.

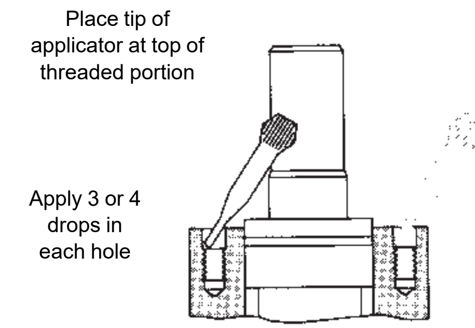


FIGURE 4-20

10. Before installing the flange and seal assembly over shaft (9) Figure 4-12, place a protective sleeve or bullet over the shaft. Then lubricate the space between exclusion seal (2) and pressure seal (5), as well as the lips of both seals Figure 4-21.

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

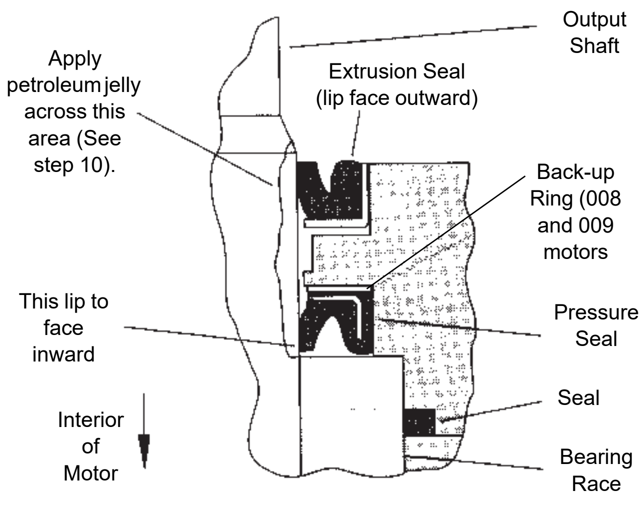


FIGURE 4-21

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.

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

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 cc (1 ounce) of clean hydraulic oil in the output shaft cavity.

14. Install O-ring (13) Figure 4-12 in the housing groove. Avoid twisting the seal.

Timing Procedure

15. Install drive shaft (14) Figure 4-12. Use a felt tip pen to mark one drive tooth. Align this mark with the timing dot on the output shaft Figure 4-22.

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

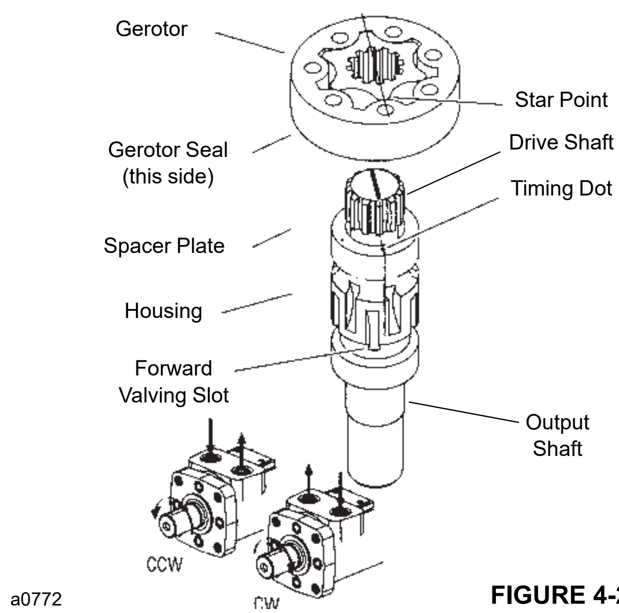


FIGURE 4-22

16. Install spacer plate (15).

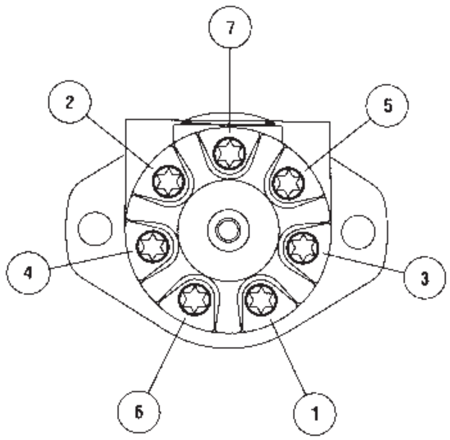
17. Install seal (13) in gerotor seal groove. Carefully place gerotor on spacer plate, seal side toward the spacer plate. Align any star point with tooth marked on drive shaft Figure 4-22.

18. Rotate gerotor (16) to line up with bolt holes. Be careful not to disengage star from drive or disturb the gerotor seal.

19. Install drive spacer if applicable.

20. Install seal (13) in end cap (17). Carefully place the end cap on gerotor (16).

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



a0773 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 gearbox. Install the swing motor to the gearbox with two socket head capscrews and lockwashers.
3. Connect the hydraulic lines and fittings to the swing motor.
4. Start the engine and slowly rotate the mast to remove any air in the swing hydraulic circuit. Check for leaks.

Item	Description
1	Hoist Assembly
2	Planetary Gearbox
3	Hydraulic Motor

FIGURE 4-24

Hoist Motor Repair

See Figure 4-24 for this procedure.

Removal

1. Lower the boom to horizontal and lower any load to the ground.
2. PARK the crane and STOP the engine.
3. Tag and disconnect all of the hydraulic lines from the motor. Cap and plug all hoses and ports.
4. Use an overhead crane and a sling to lift the motor.
5. Remove the motor mounting bolts and washers, and remove the motor from the hoist gearbox.

Disassembly

The hoist motor and counterbalance valve are not field serviceable. They must either be replaced or returned to your distributor for repair.

Installation

1. Thoroughly clean the mounting surface of the motor and the gearbox.
2. Install a new O-ring on the motor flange.
3. Fill the motor housing with clean hydraulic oil to provided initial lubrication at start-up.
4. Align the spline of the motor shaft with the spline in the gearbox.
5. Install the lock washers and cap screws.
6. Tighten the cap screws to the required torque. See Section 1 of this manual.
7. Connect all the hydraulic hoses and fittings to the motor.
8. Start the engine and slowly run the hoist through several cycles to remove any air in the system.
9. Check for hydraulic leaks and tighten fittings if needed.

Item	Description
1	Alignment Lug
2	Bracket (qty 2)
3	Slip Ring Assembly
4	Electrical Connectors (qty 2)
5	Hydraulic Swivel Assembly
6	Bolt with Washers and Nut (qty 3)
7	Electrical Connectors (qty 3)
8	Lifting Hole: M8 x 1.25 (qty 4)

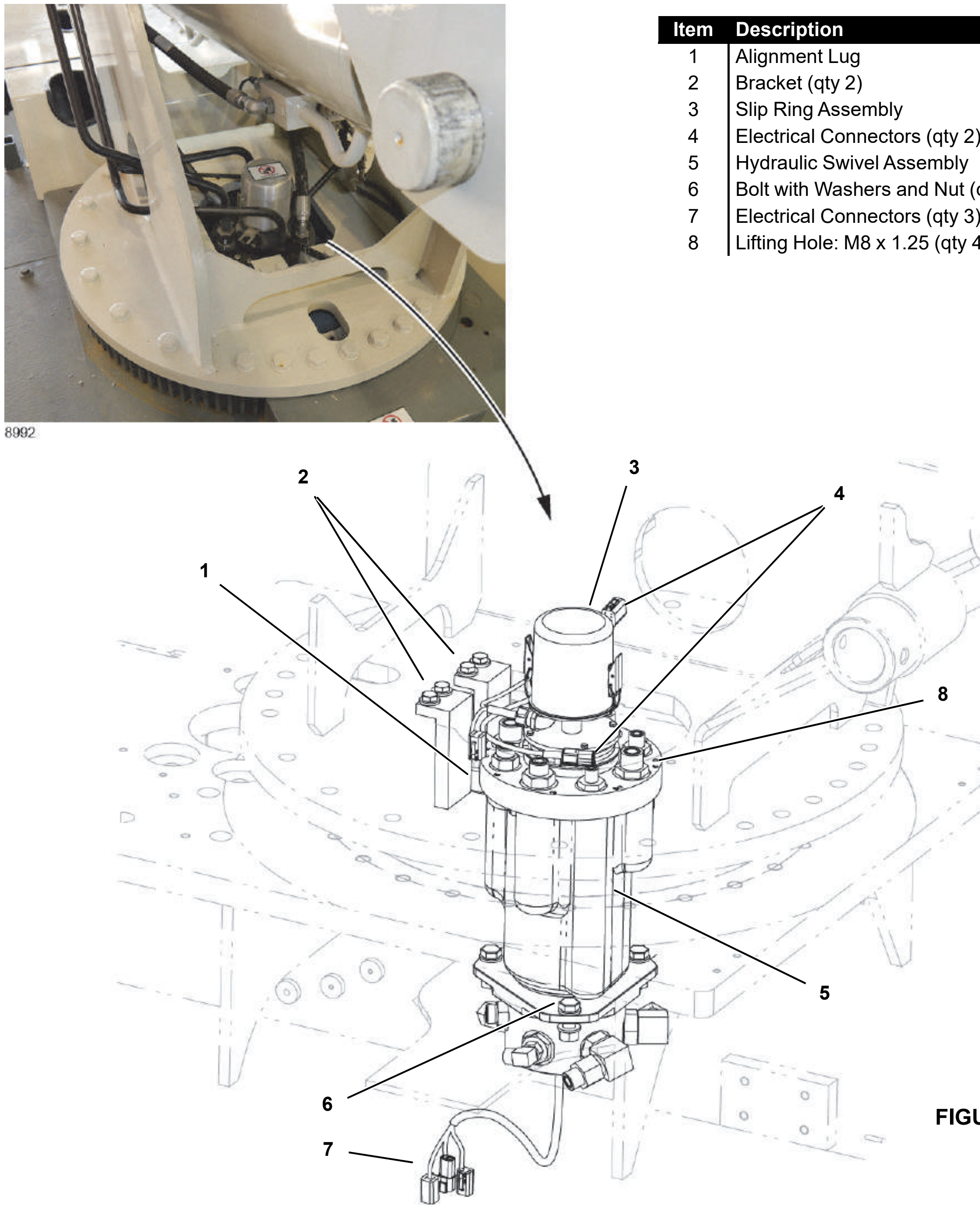


FIGURE 4-25

Hydraulic Swivel

Removal

See Figure 4-25 for this procedure.

1. Extend the outriggers to access the hydraulic swivel (5) from under the carrier.
2. Raise the boom as high as possible to provide access the hydraulic swivel (5) from under the boom.
3. PARK the crane and STOP the engine.
4. Move the controls in both directions to release any pressure in the hydraulic circuits.
5. From under the carrier:

a. Place an oil pan under the hydraulic swivel to catch drained oil.

b. Tag and disconnect the hydraulic lines from the carrier at the swivel port fittings. Cap and plug all hoses and ports.

c. Tag and disconnect the electrical connectors (7) extending from the swivel at the electrical connectors on the carrier wiring harness.

d. Remove the mounting bolts (6).

6. From under the boom:

NOTE: It is not necessary to remove the slip ring (3) from the hydraulic swivel (5). They can be removed as an assembly unit.

a. Tag and disconnect the hydraulic lines from the mast at the swivel port fittings. Cap and plug all hoses, tubes, and ports.

b. Move the hydraulic tubing to the side.

c. Tag and disconnect the electrical connectors (7) extending from the slip ring (3) at the electrical connectors on the mast wiring harness.

d. Fasten two lifting eyes with M8 x 1.25 threads to the lifting holes (8) in the swivel.

e. Attach lifting slings from an assist crane or other hoist to the lifting eyes. The swivel weighs 95 kg (209 lb).

f. Using extreme care not to damage parts, lift the hydraulic swivel out of the carrier and mast.

7. Move the hydraulic swivel (5) with slip ring (3) to a suitable work area.

Disassembly/Assembly

Disassemble/ and assemble the slip ring and the hydraulic swivel using Figure 4-26 as a guide.

CAUTION

Take care not to damage the seals and O-rings during assembly.

Orient the spool and housing as shown in Figure 4-27.

Installation

See Figure 4-25 for this procedure.

NOTE: The slip ring (3) from the hydraulic swivel (5) can be installed as an assembled unit.

1. From under the boom:

a. Using extreme care not to damage parts, lift the hydraulic swivel into position over the hole in the mast and carrier.

b. Slowly lower the hydraulic swivel through the hole in the carrier and mast so the alignment lug on the swivel housing engages the alignment lugs on the mast.

c. Make sure all connections are clean and O-rings are installed where required and connect the hydraulic lines from the mast to the swivel port fittings.

d. Make sure all connections are clean and connect the electrical connectors (7) extending from the slip ring (3) to the electrical connectors on the mast wiring harness.

2. From under the carrier:

a. Apply medium strength thread locking compound to the threads of the mounting bolts (6).

b. Install the mounting bolts (6) with washers and nuts and tighten the nuts to the required torque. See Section 1 of this manual.

c. Make sure all connections are clean and O-rings are installed where required and connect the hydraulic lines from the carrier to the swivel port fittings.

d. Make sure all connections are clean and connect the electrical connectors extending from the swivel to the electrical connectors on the carrier wiring harness.

3. Start the engine and move the hydraulic oil through the swivel. Visually, check for leaks. Tighten connections are required.

CAUTION

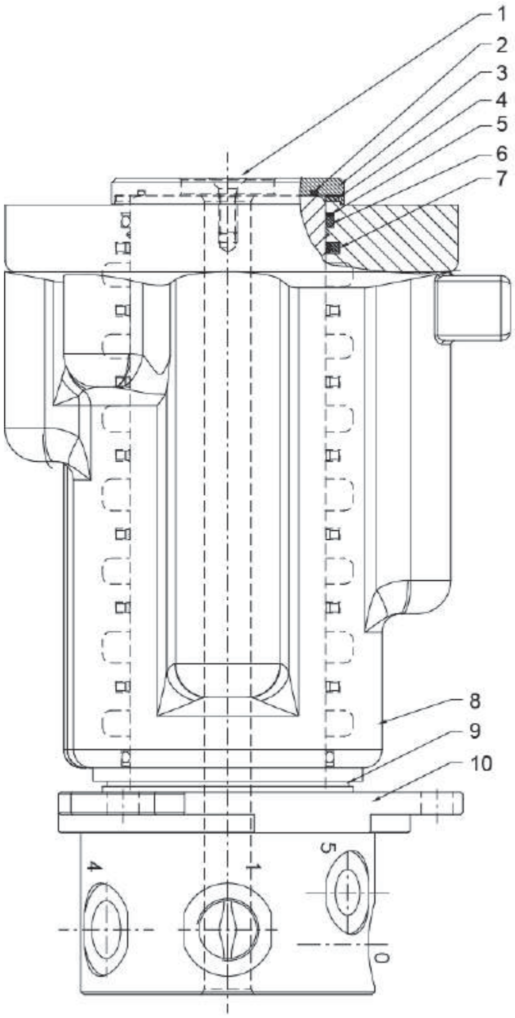
Do not rotate the mast until the oil has moved through the hydraulic swivel for several minutes.

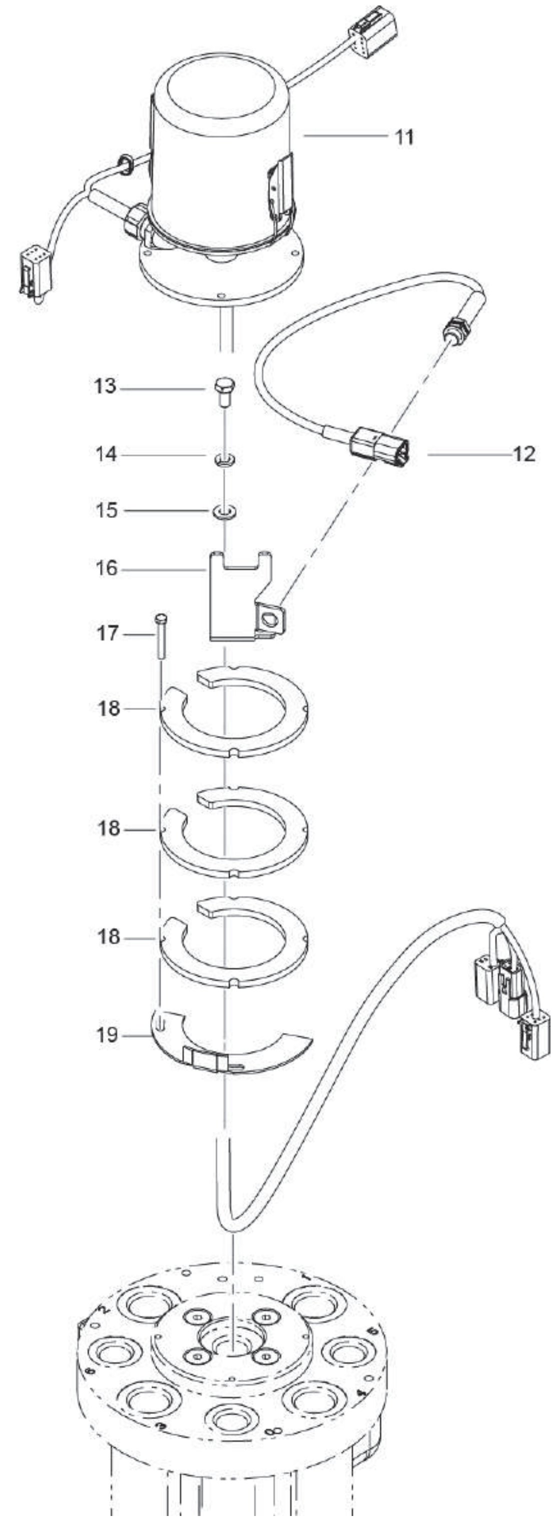
Test

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

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

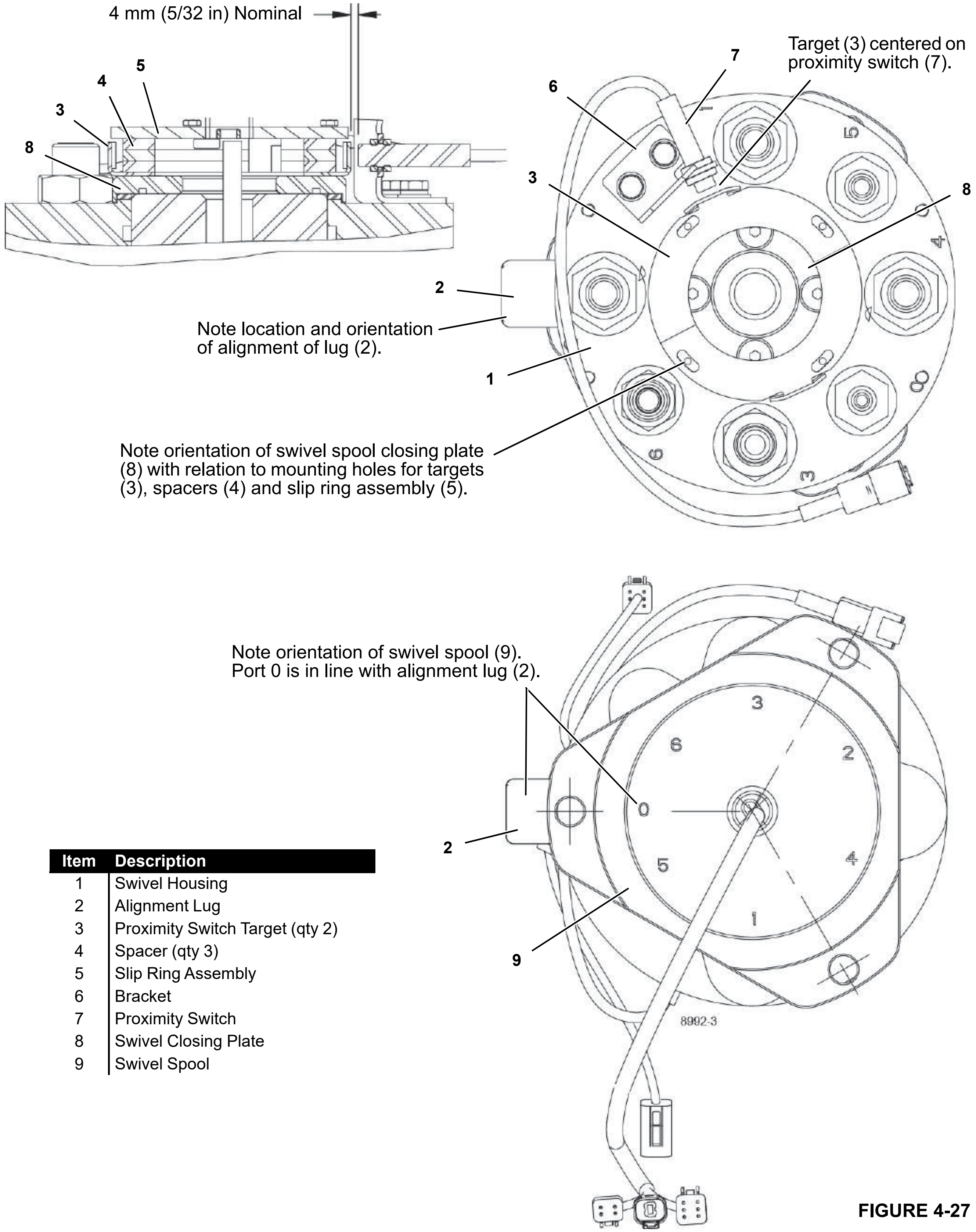
4





1 Screw (qty 4)
2 O-Ring
3 Closing Plate
4 Anti-seizure Ring
5 Back-Up Ring (qty 2)
6 O-Ring (qty 2)
7 Ring Seal Assembly (qty 7)
8 Housing
9 Anti-seizure Ring
10 Spool
11 Slip Ring Assembly
12 Proximity Switch
13 Cap Screw - M8 (qty 2)
14 Lock Washer (qty 2)
15 Flat Washer (qty 2)
16 Bracket
17 Cap Screw - M5 (qty 4)
18 Spacers (qty 3)
19 Proximity Target Plat (qty 2)

FIGURE 4-26



Item	Description
1	Swivel Housing
2	Alignment Lug
3	Proximity Switch Target (qty 2)
4	Spacer (qty 3)
5	Slip Ring Assembly
6	Bracket
7	Proximity Switch
8	Swivel Closing Plate
9	Swivel Spool

FIGURE 4-27

Hydraulic Cylinders

Removal

NOTE: The following removal instructions are general and should be modified to suit the cylinder being removed.

- Refer to Section 10 for steering cylinder removal instructions.
- Refer to Section 11 for telescope cylinder removal instructions.

1. Put a support under the component to which the cylinder is fastened. ***Make sure the component cannot fall when 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 procedure 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 4-7 in both directions as directed in steps 2 through 5.

Table 4-7 Cylinder Test Pressures

CYLINDER	TEST PRESSURE
Boom Lift	241 bar (3500 psi)
Telescope Retract	152 bar (2200 psi)
Telescope Extend	224 bar (3250 psi)
Outrigger	241 bar (3500 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 4-7 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 4-7 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. Tighten the mounting to the required torque. See Section 1 of this manual.
3. Connect the hydraulic lines.
4. Lubricate the cylinder grease fittings with recommended grease.
5. Check hydraulic oil level in the hydraulic oil reservoir. Add oil if necessary.
6. 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.
7. Check oil level in the hydraulic tank and fill if necessary.

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SECTION 5
PREVENTATIVE MAINTENANCE

SECTION CONTENTS

5

INTRODUCTION

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

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

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

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

The intervals in the Maintenance Schedule are for average operating conditions, and must be understood as the **MINIMUM** maintenance necessary for the crane. Decrease these intervals if the crane is operated in conditions that are below average (for example, in dust, in high or low temperatures, with heavy loads or frequent starting and stopping).

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

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

Spark Arresting Mufflers

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

Safety List

Inspect the following safety equipment daily:

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

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

COVERS - Keep all protective covers in place.

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

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

LUBRICANTS

Cummins Oil Registration List

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

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

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

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.

MAINTENANCE

Preparation

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

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

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

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

Hydraulic System Maintenance Precautions

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

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

Disassemble and reassemble hydraulic components on a clean surface.

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

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

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

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

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

Label Parts when Disassembling

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

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

Hydraulic Oil Recommendations

For the hydraulic oil specifications, Reference *Replace the Hydraulic Oil*, page 5-32.

Draining and Flushing

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

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

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

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

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

CAUTION

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

10. Disconnect the return line from the telescope cylinder and fully extend the boom.
11. Connect the return line and retract the boom. Replenish the hydraulic tank oil level as necessary.
12. Disconnect the return lines from steer cylinders and turn the wheels to the extreme right.

13. Connect the return lines and turn the wheels to the extreme left and then back to center. Replenish the hydraulic tank oil level as necessary.

14. Raise the crane on outriggers.

15. Disconnect the return line from the main hoist motor and fully hoist up the hoist.

16. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the hydraulic tank oil level as necessary.

17. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.

18. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the hydraulic tank oil level as necessary.

CAUTION

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

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

Removing Air From the Hydraulic System

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

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

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

CAUTION

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

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

CAUTION

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

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

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

Parts Replacement

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

SPECIAL MAINTENANCE

Delivery Inspection

Fuel Tank

- Fill with correct fuel.

Engine

- Check oil in crankcase
- On diesel engines 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.

Swing Gearbox

- Check and tighten mounting bolts.

Turntable Bearing

- 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.

After First 100 Hours of Operation (New Cranes)

Transmission

- 4WD – Replace oil, replace filter, and clean strainer (see page 5-29)
- 2WD – Replace oil and filter (see page 5-29)

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.

MAINTENANCE SCHEDULE AND CHECKLIST

The hour intervals in the following maintenance chart show the correct time for service. The hourmeter located in the operator's cab indicates the total hours the crane has been running.

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

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

Service Check	Daily before operation	50 Hours Weekly	100 Hours Two Weeks	175 Hours	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							
Service air cleaner	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 cables		x						
Clean air cleaner duct cup		x						
Lubricate parking brake fitting		x						
Inspect engine fan belts			x					
Check wheel nut torque			x					
Replace the transmission oil and filter and clean the 4WD strainer *			x					
Replace engine crane oil and filter (dual fuel engine)				x				
Lubricate the swing gear and pinion					x			
Lubricate the drivelines					x			
Lubricate the wire rope					x			
Inspect the boom cables					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	175 Hours	250 Hours Monthly	500 Hours Three Months	1000 Hours Six Months	2000 Hours Yearly
Check axle wheel hub lubricant level (4)						x		
Check axle housing lubricant level (2)						x		
Check hoist gearbox and brake oil level						x		
Lubricate the outrigger slides						x		
Add grease to swing gearbox						x		
Lubricate the drivelines						x		
Replace fuel filter elements (diesel)						x		
Replace fuel filter elements (Dual Fuel)						x		
Inspect the parking brake pads						x		
Inspect tires for damage						x		
Add rust inhibitor to engine cooling system						x		
Replace transmission oil filter						x		
Check swing gear to pinion backlash							x	
Replace the transmission oil and filter							x	
Clean 4WD transmission strainer							x	
Replace the axle wheel hub lubricant							x	
Replace the axle housing lubricant							x	
Replace the hoist gearbox lubricant							x	
Replace the hydraulic oil							x	
Replace the hydraulic oil filter							x	
Replace the engine coolant								x
Inspect the crane structure and boom for damage								x
Test the Rated Capacity Limiter (RCL)-optional								x

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

* = Service after first 100 hours of operation only.

** = May require replacement more often under extremely dirty conditions.

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LUBRICATION SCHEMATIC

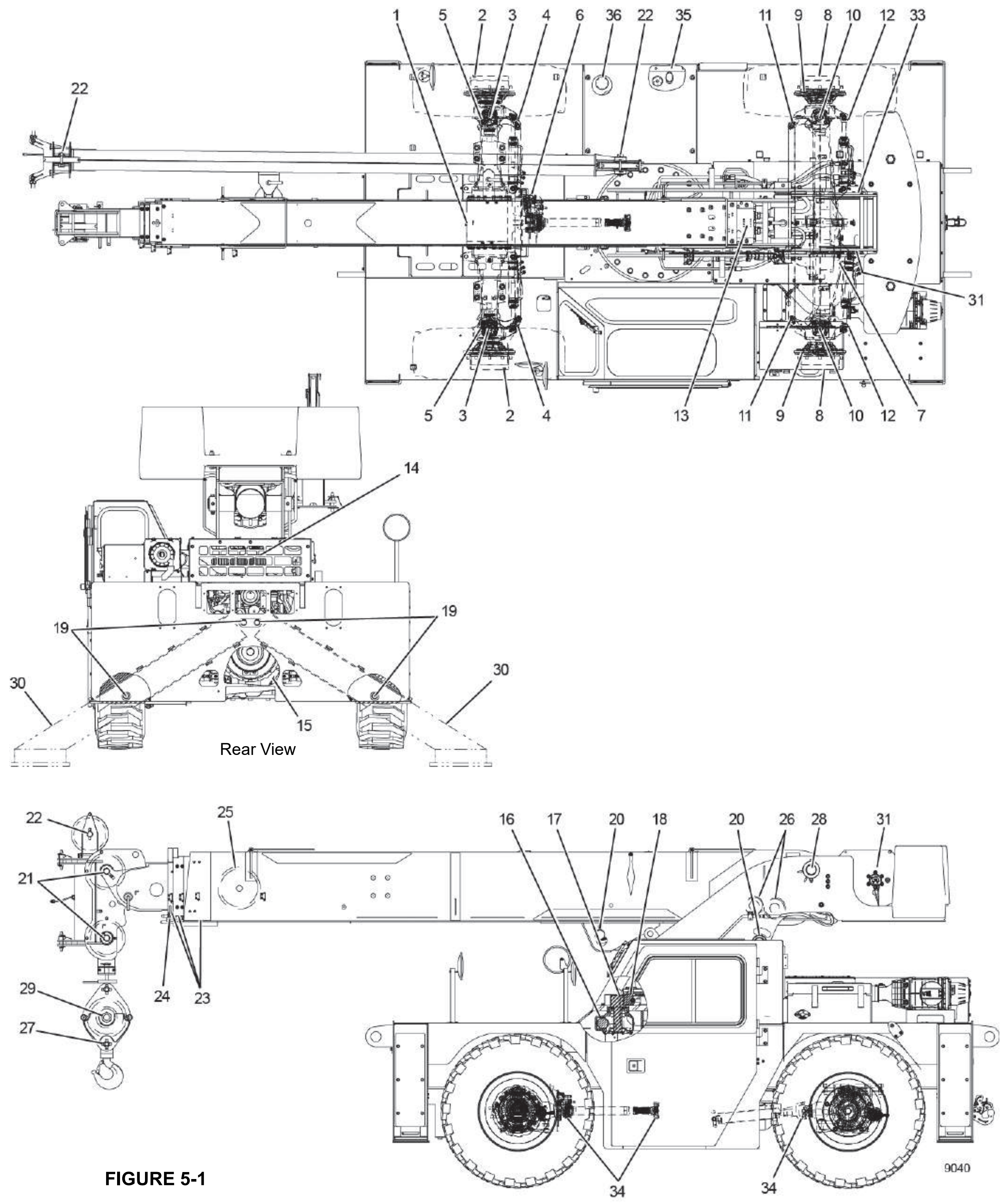

FIGURE 5-1

Lubrication Symbols

Lube Symbol	Description	Grove Spec
EP-MPG	EP-MPG- Multipurpose Grease	A6-829-003477
AFC	AFC- Anti-freeze/coolant	A6-829-101130
HYDO	Hydraulic Oil	A6-829-006444
HTF	Hydraulic Transmission Fluid	80057784
EO-15W-40	Engine Oil Tier 3	A6-829-003483
EO-15W-40	Engine Oil Tier 4	A6-829-104182
EO-10W-30	Engine Oil Dual Fuel	A6-829-003480
ASC	Anti-Seize Compound	A6-829-003689
EP-OGL	Open Gear Lube (Ceplattyn 300 Spray)	A6-829-102971
EPGL-5	EPGL-Gear Lubricant	A6-829-003479
TransSynd	Synthetic Transmission Fluid	A6-829-101690

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Lubrication Legend

Item	Location Nam	Capacity	Lube Symbol	Instruction
		Front Drive/steer Axle		
1	Differential	16.0 L (4.2 gal)	HYDO	
2	Planetary Hub Gears	2.0 L (2.1 qt)	HYDO	
3	Kingpin Bearings		EP-MPG	
4	Steer Cylinder Bearing		EP-MPG	
5	Universal Joints		EP-MPG	
6	Brake Caliper		EP-MPG	
		Rear Drive/Steer Axle		
7	Differential	18.0 L (4.8 gal)	HYDO	See Note 1
8	Planetary Hub Gears	2.0 L (2.1 qt)	HYDO	
9	Hub Bearings		EP-MPG	
10	Kingpin Bearings		EP-MPG	
11	Steer Linkage Bearing		EP-MPG	
12	Steering Cylinder		EP-MPG	
		Engine & Trans.		
13	Engine Crankcase Tier 3 and 4	5.5-7.0 L (5.8-7.4 qt)	EO-15W-40	See Note 2
13	Engine Crankcase KEM-4.3L Dual Fuel	4.3 L (4.5 qt)	EO-10W-30	See Note 2
14	Engine Coolant Tier 3	22.8 L (6.0 gal)	AFC	See Notes 2, 3, 4
14	Engine Coolant Tier 4	20.0 L (5.3 gal)	AFC	See Notes 2, 3, 4
14	Engine Coolant KEM-4.3L Dual Fuel	16.3 L (4.3 gal)	AFC	See Notes 2, 3, 4
15	Transmission 4 Wheel Drive	20.8 L (5.5 gal)	HTF	
15	Transmission 2 Wheel Drive	16.6 L (4.4 gal)	HYDO	

Item	Location Nam	Capacity	Lube Symbol	Instruction
		Turntable		
16	Swing Gear Box		EP-MPG	
17	Swing Gear & Pinion		EP-OGL	
18	Turntable Bearing		EP-MPG	
		Cylinders		
19	Outrigger Cylinder Pins		ASC	See Note 5
20	Boom Lift Cylinder Pins		ASC	See Note 5
		Boom		
21	Boom Nose Sheaves		EP-MPG	
22	Boom Extension Sheaves		EP-MPG	
23	Boom Sections		EP-MPG	See Note 6
24	Telescope Cylinder Wear Pads		EP-MPG	
25	Boom Extend Sheave		EP-MPG	
26	Boom Retract Sheave		EP-MPG	
27	Hook Block Swivel Bearing		EP-MPG	
28	Boom Pivot Pin		ASC	See Note 5
29	Hook Block Sheaves		EP-MPG	
		Outriggers		
30	Outrigger Box		EP-MPG	See Note 7
		Hoist		
31	Hoist Gearbox	1 L (1 qt)	EPGL-5	
32	Hoist Brake	0.24 L (0.25 qt)	TranSynd	
33	Not Used			
		Misc.		
34	Driveline Joints		EP-MPG	
35	Fuel Tank	104.4 L (27.6 gal)		
36	Hydraulic Tank	130.6 L (34.5 gal)	HYDO	See Notes 2 & 8

Lubrication Notes

1 4 wheel drive option only.

2 Adjust final fluid levels using dipsticks, level gauges, markings, or filler plugs.

3 Use a mixture of 50% AFC and 50% water.

4 Engine coolant capacity listed is the combined capacity for coolant in the engine and radiator.

5 Apply to pins prior to assembly.

6 Lubricate all surfaces in contact with wear pads.

7 Apply to all sides.

8 Make sure hydraulic oil meets or exceed Grove cleanliness spec 6829014631;

9 Oil or grease all points requiring periodic lubrication as required during assembly.

10 Lubricate all movable control links and clevis pins during assembly.

LUBRICATION POINTS

Apply grease to the following fittings after the first 20 hours of operation. Thereafter every 50 hours of operation. Use a Lithium Based, EP2 grease, or equivalent. Apply enough grease to remove the old grease.

Boom and Main Frame	
Location	**QTY**
Turntable Bearing (Figure 5-2)	2
Boom Head Sheaves (Figure 5-3)	2
Boom Extend Sheave (Figure 5-3)	1

Drive Train	
Location	**QTY**
Steering Knuckles (Figure 5-7)	2 Each Knuckle
Steering Link (Figure 5-7)	2 each Link
Steering Cylinder Pivot Pins (Figure 5-7)	2 each Cylinder
Rear Axle Pivot Pin (Figure 5-7)	2

Optional Equipment and Accessories	
Location	**QTY**
Hook Block (see Figure 5-4)	As Required (if equipped)
Boom Extension Sheave (see Figure 5-5)	1
Boom Extension Deflector Sheave (see Figure 5-6)	1
Anti-Two-Block Bracket Guide Pins (Figure 5-3)	2 (coat with anti-seize compound)

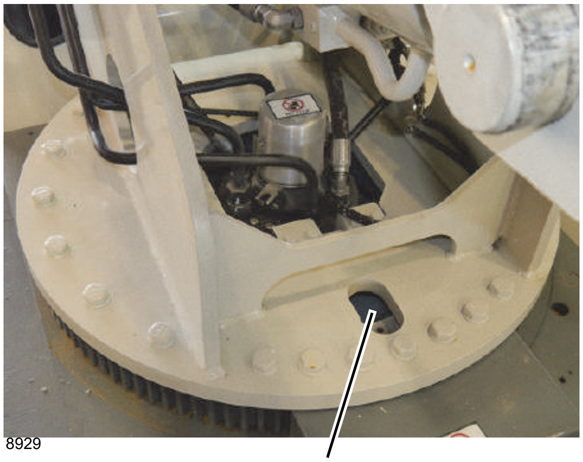

FIGURE 5-2

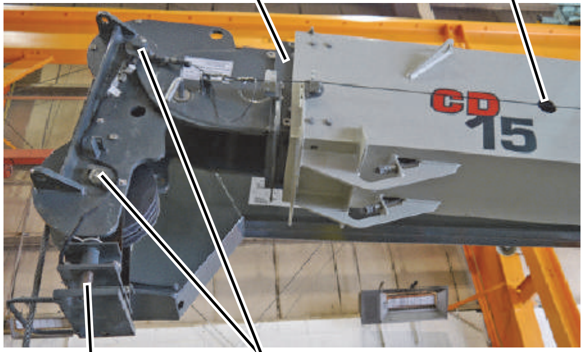

FIGURE 5-3

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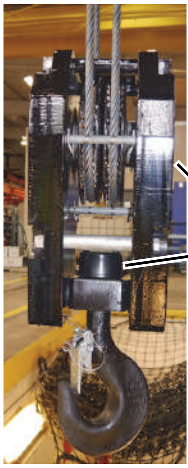

FIGURE 5-4

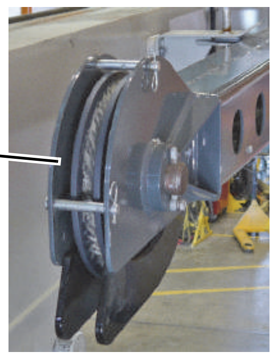

FIGURE 5-5

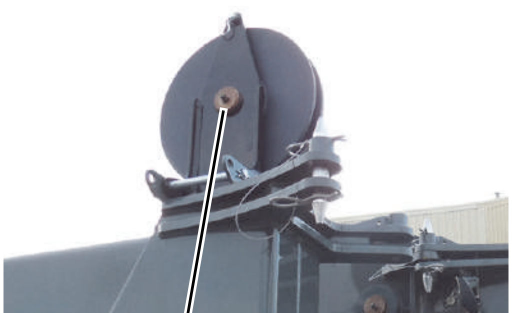

FIGURE 5-6

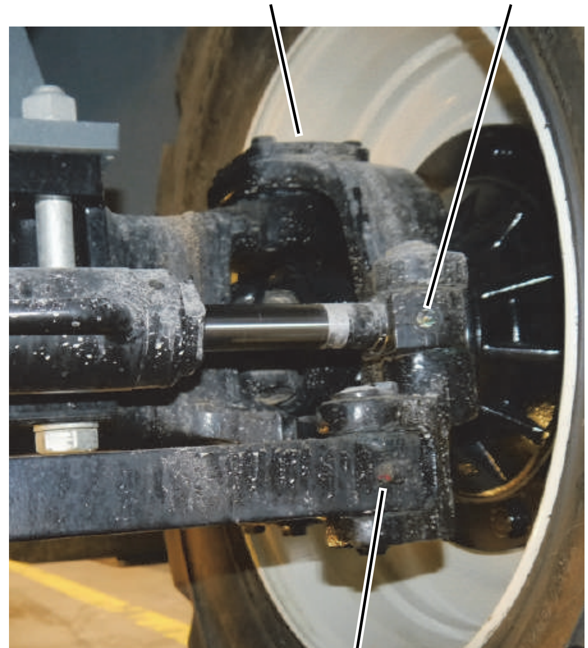

FIGURE 5-7

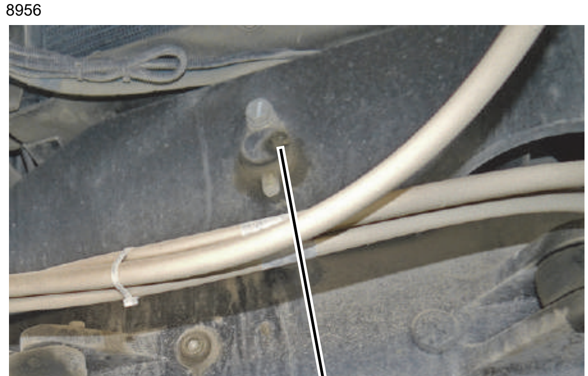

FIGURE 5-8

SCHEDULED MAINTENANCE

Daily (Walk-around) Inspection

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

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

Inspections

Inspect the Anti-Double Blocking System

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

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

Lower the hoist block and the alarm will stop.

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

If necessary, apply anti seizing compound to the anti-two-block bracket guide pins

Inspect the Wire Rope

Each day before beginning operation, visually inspect the wire rope for damage. See Wire Rope Inspection 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 Diesel or Gasoline Fuel Level

Check the fuel level 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 (Figure 5-13) 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.

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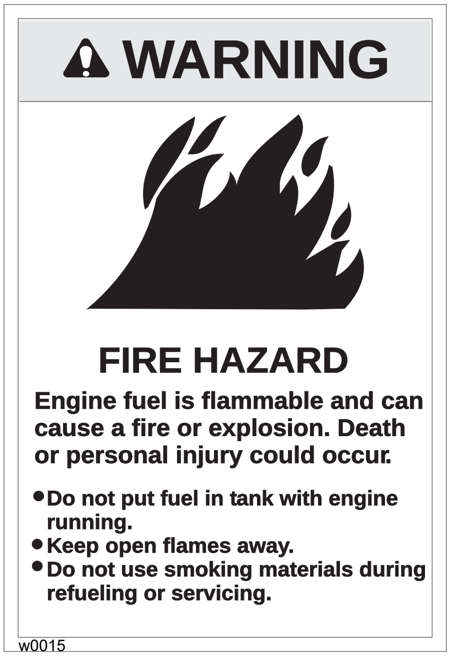

Maintain control of the hose nozzle when filling the fuel tank. Do not allow fuel to spill. Clean up spilled fuel immediately. Dispose of clean up materials properly.

Do not fill the fuel tank to capacity. Allow room for fuel expansion.

Check LP Gas Fuel Level

The LP gas tank is owner supplied. The crane owner should purchase a tank equipped with a fuel gauge. Check the fuel level daily before operation.

Check the Engine Crankcase Oil Level

1. Level the crane, engage the parking brake and stop the engine.
2. Open the engine compartment cover.
3. Remove the engine oil dipstick (see Figure 5-9) and check the oil level. Oil should be visible within the crosshatched mark area on the dipstick.
4. If the oil is low, add recommended oil to bring the level up to the crosshatch area of the dipstick. When full, install the dipstick and close the engine compartment cover.

Check the Transmission Oil Level

1. Check the oil level when the oil is cold. Level the crane, engage the parking brake and stop the engine.
2. Open the engine compartment cover. Remove the dipstick (Figure 5-9) 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.

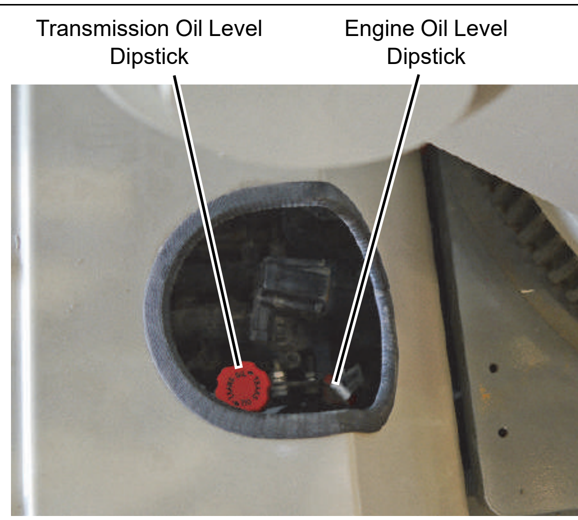

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FIGURE 5-9

Check Engine Coolant Level

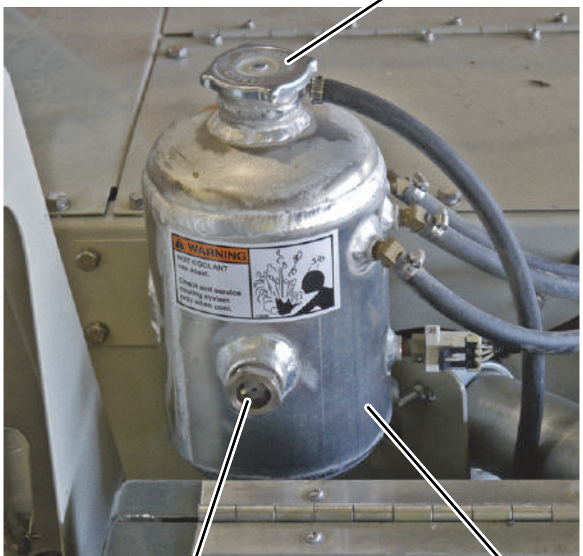
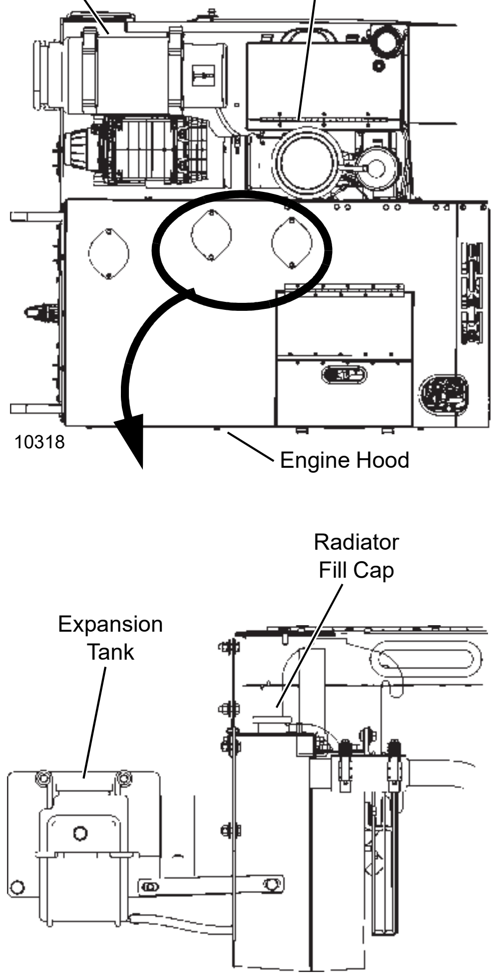
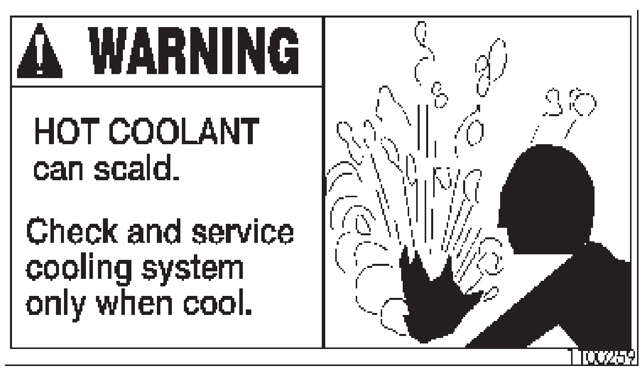


FIGURE 5-10



Dual Fuel Engine

FIGURE 5-11



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Never remove the fill cap while the cooling system is hot. Check the 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 stop the engine.
2. For Diesel Engine (Figure 5-10):
   a. Check the coolant level in the overflow bottle. It should be half way up the sight gauge.
   b. If the level is low, **BE SURE THE ENGINE IS COOL —below 50° C (120° F)**, then slowly loosen the fill cap to the first stop. Allow all pressure to release. Completely remove the fill cap.
   c. Add a 50/50 mixture of glycol antifreeze and water to the proper level. Do not add only water as this could cause rust to form in the radiator and engine.
   d. Securely reinstall the fill cap.
3. For Dual-Fuel Engine (Figure 5-11):
   a. **BE SURE THE ENGINE IS COOL —below 50° C (120° F)**, then slowly loosen the fill cap to the first stop. Allow all pressure to release. Completely remove the fill cap.
   b. The coolant level should be up to the bottom of the fill tube in the radiator.
   c. If the level is low, add a 50/50 mixture of glycol antifreeze and water to the proper level. 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, refer to the engine manual that came with your crane.

Drain Water from Engine Fuel Filter

1. Engage the parking brake and stop the engine.
2. See the engine manual furnished with the crane and follow the water draining instructions from the fuel/water separator (Figure 5-12).

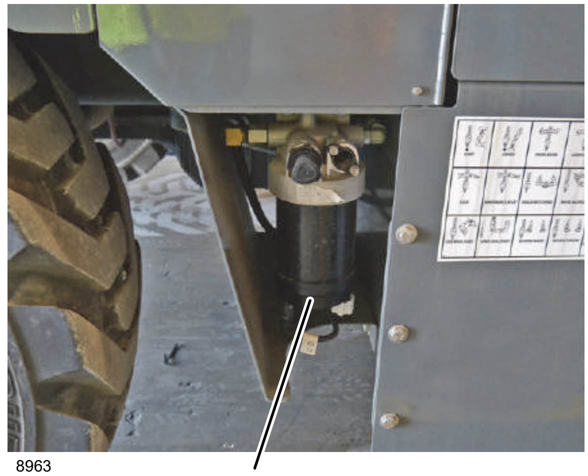


FIGURE 5-12

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 stop the engine.
3. Visually check the oil level on the hydraulic oil level sight gauge (Figure 5-13). 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 (Section 8).

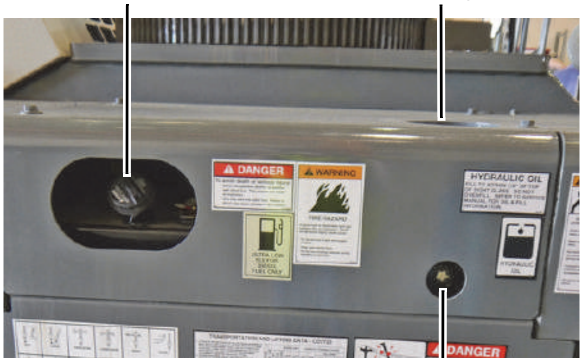


FIGURE 5-13

Service Dual Fuel Air Cleaner

Inspecting Air Cleaner Indicator

The Tier 3 and dual-fuel air cleaner is equipped with a restriction indicator (1, Figure 5-14) that gives a visual indication when it is time to change the air cleaner elements.

Check the indicator with the engine running. The yellow stem in the indicator window extends as the air cleaner elements become plugged. Change the air cleaner elements when the yellow stem reaches the red zone of the window.

The yellow stem remains locked in place when the engine is stopped. The reset button on the top of the indicator can be pressed at any time. When the engine is started, the indicator stem returns to the proper reading.

Do not remove the elements for inspection. This will do more harm than good. Ridges of dirt on the gasket sealing surface can drop onto the clean filter side when the gasket is released.

Tier 3 Air Cleaner Shown.
Dual Fuel Air Cleaner Similar.

FIGURE 5-14

Removing Air Cleaner Elements

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

1. Release the latch (2) to unlock the air cleaner cover.
2. Rotate the cover counterclockwise and remove it.
3. Remove the primary element as gently as possible until you get it outside of the housing.
4. Remove the secondary element.
5. 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 new elements.
6. 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 all hardened ridges are completely removed.

Installing Air Cleaner Elements

1. Install the secondary element into the housing and slide it all the way in.
2. Install the primary element 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

5

the housing is clean, or if the element is the right model number. It may be too short for the housing.

4. Install the air cleaner housing cover.
5. Reset the restriction indicator (Figure 5-14) by pushing in the reset button.

Service Tiers 3 and 4 Engine Air Cleaner

The Tier 4 engine has the Cummins AIRM communications system. The AIRM calculates real-time air filter restriction at operational flow rate using the temperature and pressure input from the TBAP sensor (Figure 5-15).

Fault code (FC 5576) is initiated at the dirty filter restriction level, generating a blinking “Check Engine” light for 30 seconds at every key on until the intake air restriction drops below the dirty filter restriction threshold.

Severe warning fault code (FC 3341) is initiated if the maintenance condition degrades to a severe restriction level for a given time period, generating a solid amber “Check Engine” light and initiating a progressive engine derate to protect the engine from damage until the intake restriction drops below the dirty filter restriction threshold.

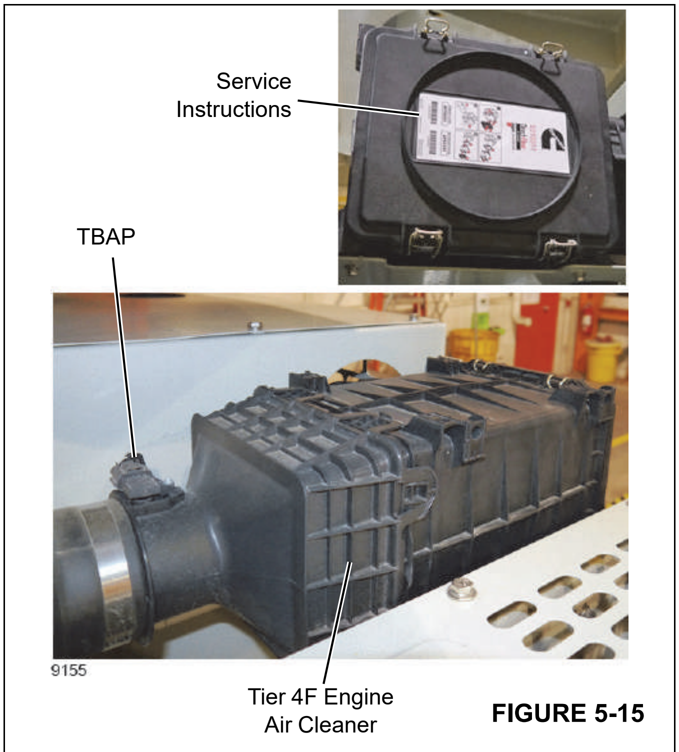


FIGURE 5-15

Removing Air Cleaner Elements

See Figure 5-15.

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

1. Release the four latches to unlock the air cleaner cover.
2. Remove the primary element as gently as possible until you get it outside of the housing.
3. Remove the secondary 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 new elements.
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.

Installing Air Cleaner Elements

1. Install the secondary element in the housing and slide it all the way in.
2. Install the primary element 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.
4. Install the air cleaner housing cover.

Check Tire Pressure

Check the air pressure in the crane’s four tires. Correct pressure is 9 bar (125 psi).

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 Section 2 of this manual, before performing any operation or maintenance procedures.

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

Clean the Air Cleaner Dust Cup

Squeeze the dust cup (Figure 5-16) to remove any accumulation of dust or debris.

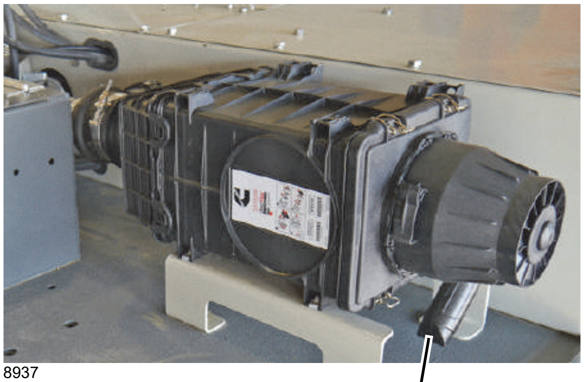


FIGURE 5-16

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.

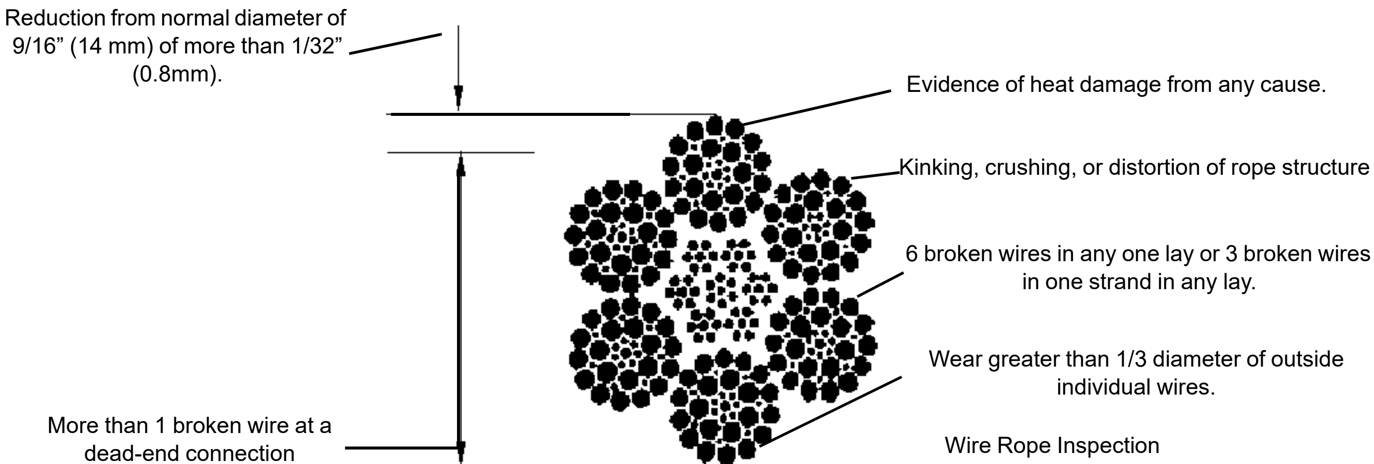
If you are not familiar with wire rope inspection, information on how to inspect wire rope, sheaves and drums is available from your distributor. Order Wireco Report No. 107.

General Inspection

NOTE: Always wear gloves when working with wire rope to inhibit 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 5-17 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.



Wire Rope Inspection Criteria

FIGURE 5-17

Grease Fittings

Lubricate all points indicated under the heading Lubrication Points on page 5-11.

Lubricate Parking Brake

Apply grease to the fitting on the parking brake (Figure 5-18).

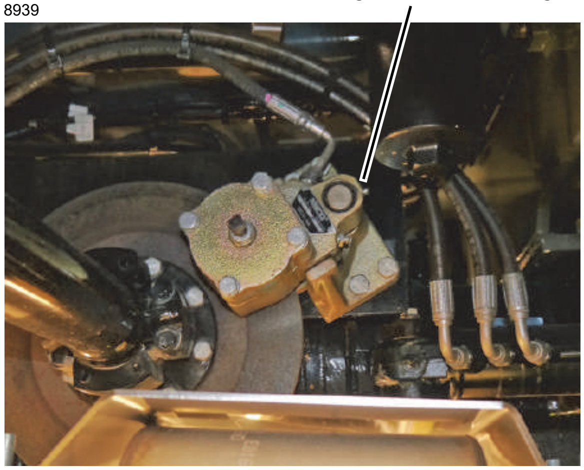


FIGURE 5-18

Lubricate the Boom Slides

1. Extend the outriggers. Lower the boom and then extend it to its maximum out position.
2. Engage the parking brake and stop the engine.
3. Clean the old lubricant from the boom sections.
4. Brush Lithium Based, EP2 grease, or equivalent, to the sliding surfaces (Figure 5-19) on all boom sections. Only use a small amount of lubricant for best results.

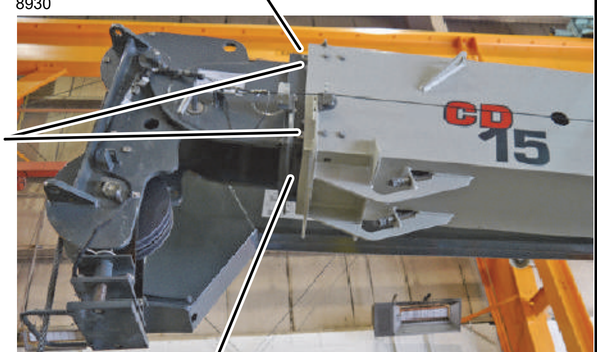


FIGURE 5-19

100 Hours of Operation (Two Weeks)

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

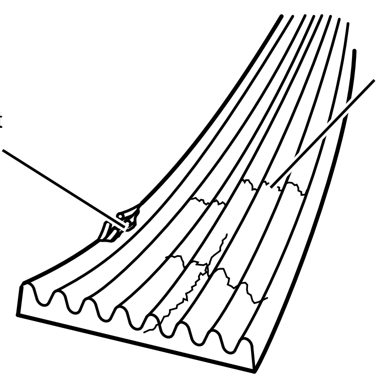
For additional engine maintenance guidelines, see the engine manual furnished with this crane.

Inspect the Fan Belts

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

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

Check ribbed belts for intersecting cracks. Cracks across the belt are acceptable. Cracks along the length of a ribbed belt are not acceptable. Ribbed belts with cracks along their length should be replaced. See Figure 5-20.



Ribbed Belt Inspection-General

FIGURE 5-20

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 a crisscross pattern. Wheel nut torque should be 500 lb-ft.

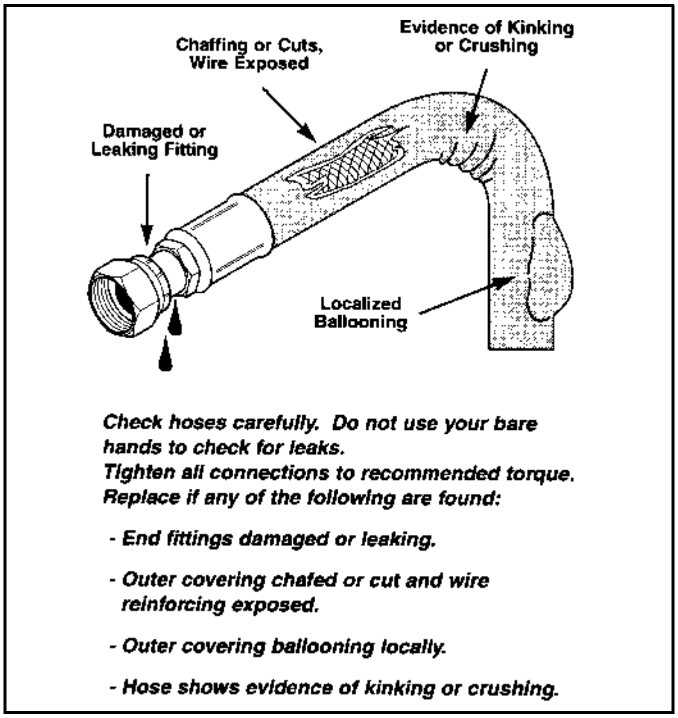
175 Hours of Operation

If equipped with a dual-fuel engine, replace the engine oil and filter as instructed in the engine manufacturer's manual.

250 Hours of Operation (Monthly)

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. Open the battery box cover (Figure 5-21).

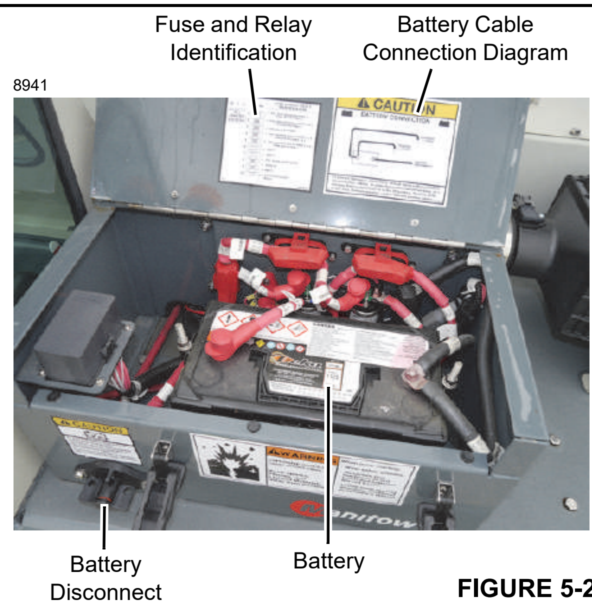


FIGURE 5-21

2. Tighten all battery hardware to keep the battery securely in place.
3. Disconnect the battery cables.
4. Sprinkle the batteries with baking soda to neutralize the acid. Rinse with water. Be careful not to get water inside the battery.
5. Coat the battery posts and the battery cable connections with battery-terminal protector and reconnect the battery cables.
6. Coat the frame grounds, the starter connections, and the alternator connections battery-terminal protector.
7. Close and latch the battery box cover.

Clean the Radiator

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

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

Lubricate the Wire Rope

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

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

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

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

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

Lubricate the Swing Gear and Pinion

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

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

3. Using a brush, apply open gear lube to the pinion and swing gear teeth (Figure 5-22).

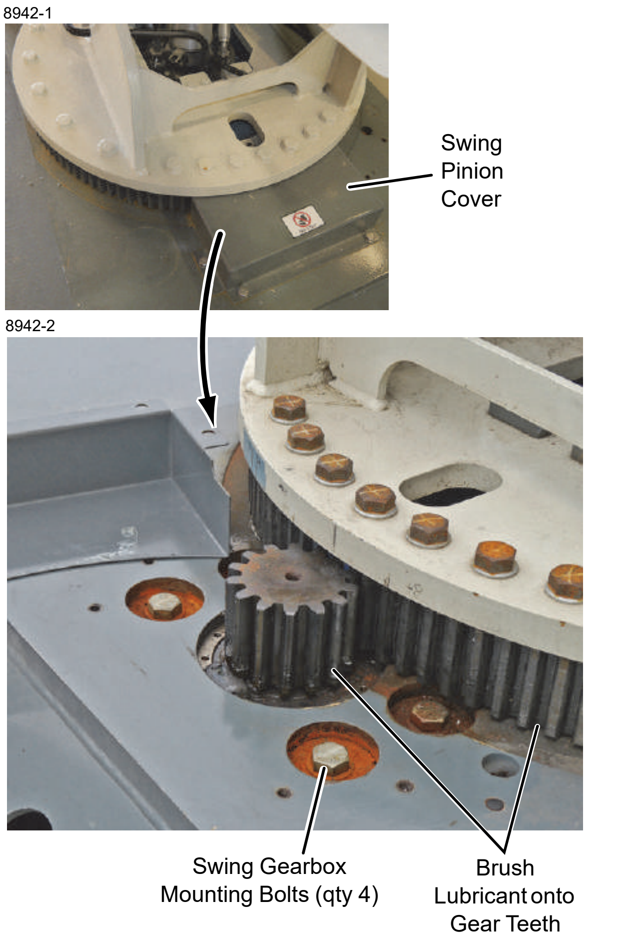


FIGURE 5-22

4. Start the engine and rotate the mast until a non-lubricated portion of the swing gear is exposed. Keep hand away from rotating pinion and gear.
5. Stop the engine.
6. Using a brush, 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. Stop the engine
3. Place a suitable container under the engine drain plug. Remove the oil drain plug (see Figure 5-34).
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 to the proper mark on the dipstick (see Figure 5-9).
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 machine.

Hoist Gearbox Mounting Bolts

See Figure 5-23.

Apply medium strength thread locking compound to all threads.

- Tighten the M16 mounting bolts to 247 Nm.
- Tighten the M20 mounting bolts to 483 Nm.

FIGURE 5-23

Swing Gearbox Mounting Bolts

Apply medium strength thread locking compound to all threads.

Torque the 3/4 in swing gearbox mounting bolts (Figure 5-22) to 202±5 lb-ft. If the bolts are loose, check gear backlash.

Mast Mounting Bolts (Turntable)

Because of the cyclic loading on the turntable bolts, it is important that these bolts be checked at the intervals specified in Section 11 of this manual.

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 mast bolt (inner and outer) is 727±29 Nm.

NOTE: Use only M20 Class 12.9 replacement 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.

Front Axle Mounting Bolts

Tighten the 1 in front axle mounting bolts to 689±17 lb-ft. See Figure 5-24.

Rear Axle Mounting Bolts

Tighten the M20 rear axle mounting bolts to 339±8 Nm (drive and non-drive axle). See Figure 5-24.

FIGURE 5-24

500 Hours of Operation (3 Months)

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

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

Replace the Transmission Filter

- 4WD – Replace the oil filter (see page 5-29)
- 2WD – Replace the oil filter (see page 5-29)

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 5-25). 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.

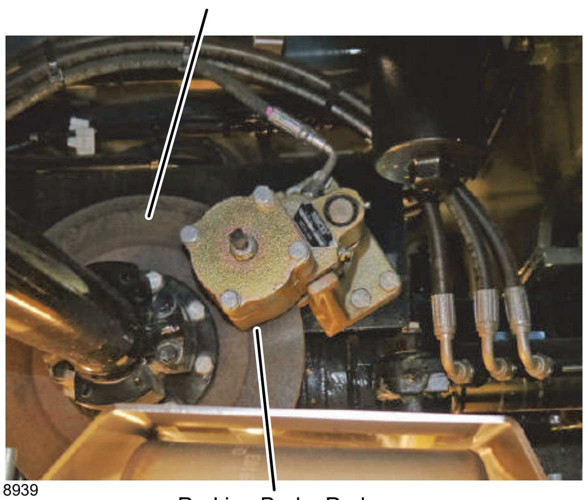


FIGURE 5-25

Replace Fuel Filter (Diesel Engine)

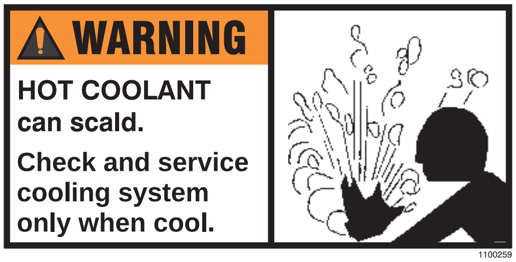
See the engine operator's manual furnished with the crane and follow the replacement procedures.

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 fuel Filter (Dual Fuel Engine)

Service the dual fuel engine per the instructions in the engine manual provided with your crane.

Add SCA to Engine



For maximum protection of the engine, add Supplemental Coolant Additive to the cooling system as instructed in the Engine Manual.

Lubricate the Outrigger Slides

1. Lower the outriggers.
2. Clean the tops of the outriggers with a suitable solvent.
3. Apply Lithium Based, EP2 grease, or equivalent to the areas shown in Figure 5-26. Do not over lubricate. Raise and lower the outriggers several times to spread the grease.

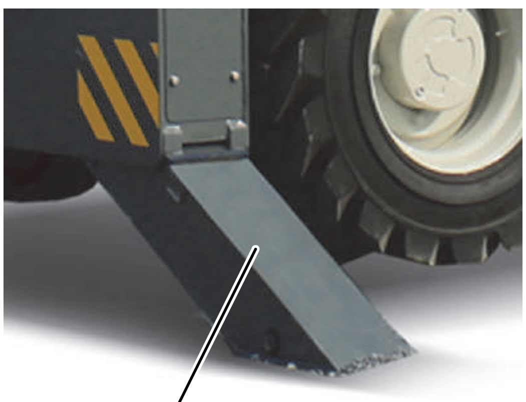


FIGURE 5-26

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 stop the engine. Remove the ignition key.
2. Clean the grease fitting and check plug (Figure 5-27).
3. Remove the check plug.
4. Apply Lithium Based, EP2 grease, or equivalent to the fitting. Fill gear box until grease exits the check plug hole. Install the check plug.

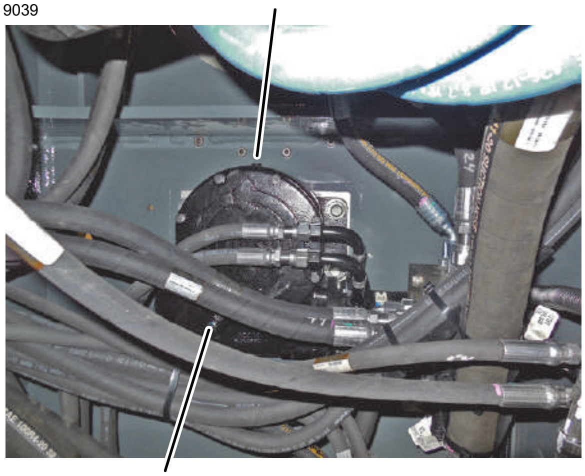


FIGURE 5-27

Lubricate Drivelines

1. Engage the parking brake and stop the engine. Remove the ignition key.
2. Clean the grease fittings (Figure 5-28).
3. Apply Lithium Based, EP2 grease or equivalent to the fittings.

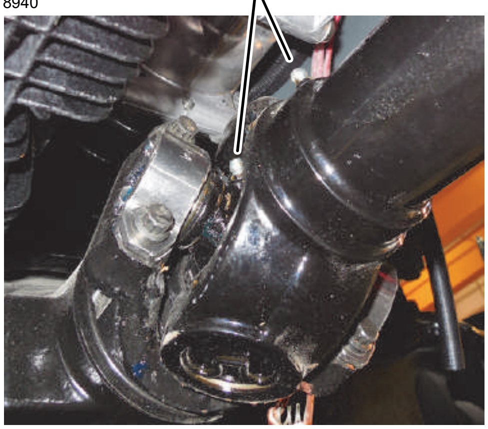


FIGURE 5-28

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. At either axle, clean around the axle housing fill/check plug (Figure 5-29 or Figure 5-30) and remove it.

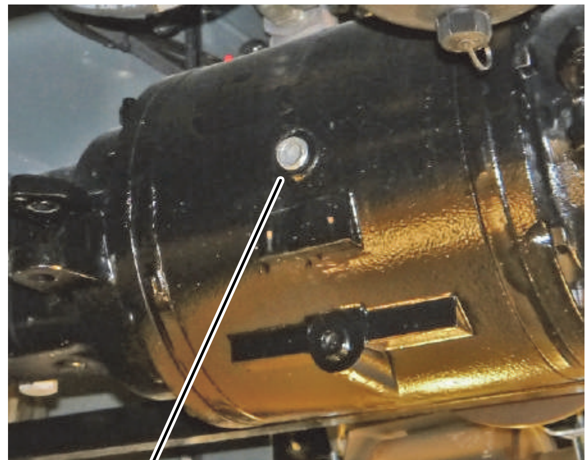


FIGURE 5-29

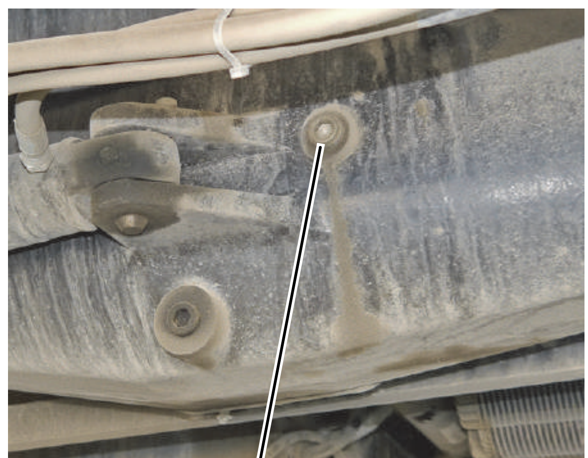


FIGURE 5-30

2. Check the lubricant level. It should be even with the bottom of the plug hole.
3. If necessary, add the proper type of oil (specified in Section 8 of this manual) until the oil is even with the bottom of the plug hole.
4. Repeat the steps for the other axle.

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 wheel hubs until the fill/check plug is horizontal with the ground (Figure 5-31).

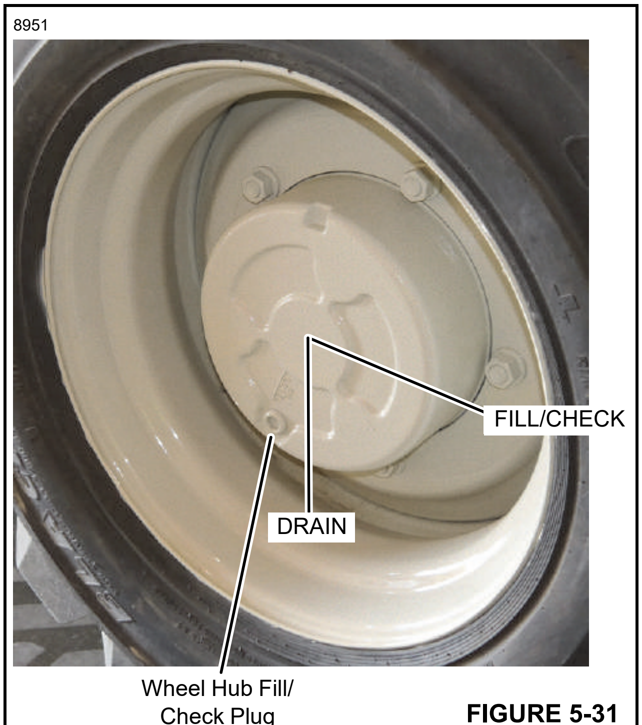


FIGURE 5-31

4. Clean around the fill/check plug and remove it.
5. Check the lubricant level. It should be even with the bottom of the plug hole.
6. If necessary, add the proper type of oil (specified in Section 8 of this manual) until the oil is even with the bottom of the plug hole.
7. Reinstall the plug.
8. Repeat the steps for the other three wheel hubs.

Check Hoist Gearbox and Brake Lubricant Levels

1. Lower the boom to its lowest position.
2. Service the hoist gearbox as follows:
   a. Rotate the hoist drum until the plug (Figure 5-32) is in the fill/check hole in the hoist frame.
   b. Engage the parking brake and stop the engine
   c. Clean the area around the plug and remove it.
   d. Check the lubricant level. It should be even with the bottom of the plug hole.
   e. If necessary, add the proper type of oil (specified in Section 8 of this manual) until the oil is even with the bottom of the plug hole.
   f. Reinstall the plug.

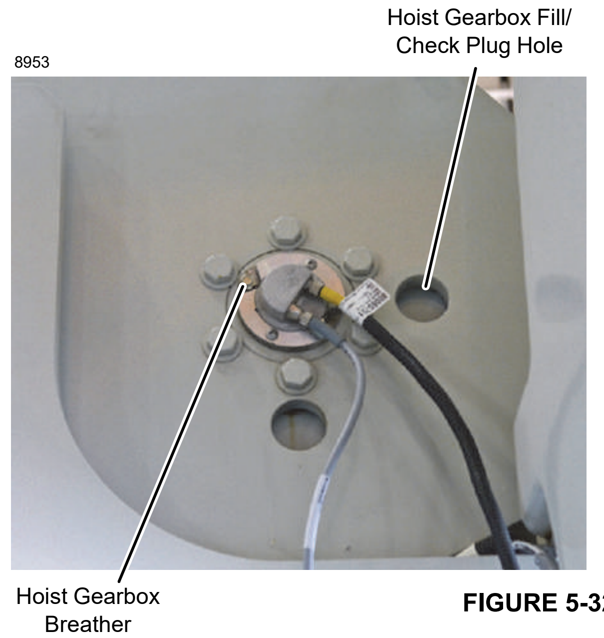


FIGURE 5-32

3. Service the hoist brake as follows:
   a. Clean the around of the brake breather/check/fill plug (Figure 5-33) and remove it.
   b. Check the lubricant level. It should be even with the bottom of the plug hole.

WARNING

DO NOT use EP type gear lubes in the brake section of this hoist. EP lubes may prevent the clutch from locking up, causing the load to fall and resulting in property damage, personal injury or death.

   c. If necessary, add the proper type of oil (specified in Section 8 of this manual) until the oil is even with the bottom of the plug hole.
   d. Install the breather/fill/check plug.

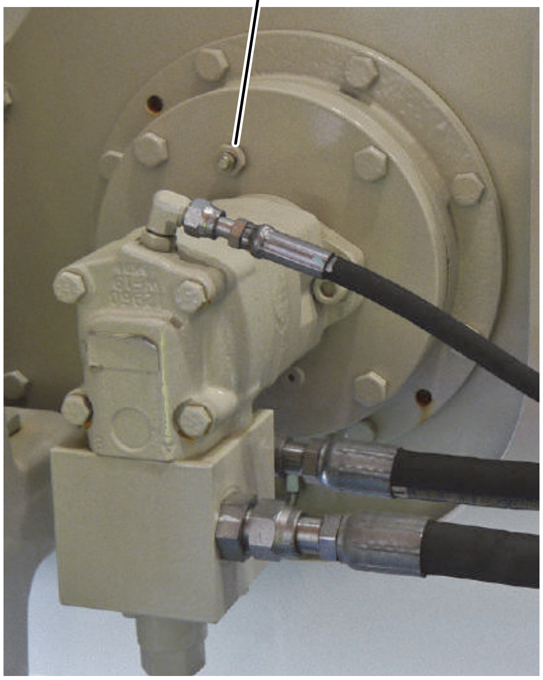
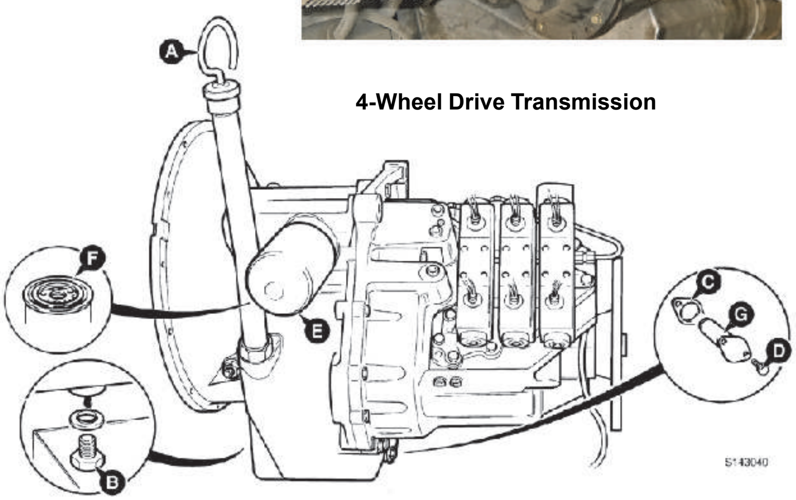


FIGURE 5-33

A	Dipstick
B	Drain Plug
C	Gasket
D	Bolt (qty 2)
E	Filter
F	Filter Seal
G	Strainer



4-Wheel Drive Transmission

2-Wheel Drive Transmission

FIGURE 5-34

1000 Hours of Operation (6 Months)

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

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

Replace the Transmission Oil and Filter — 4WD

NOTE: It is necessary to climb under the crane to drain the transmission oil (Figure 5-34). Be sure the parking brake is engaged, the engine is off, the ignition key is removed, and chock blocks are in place before climbing under the crane.

When the strainer (G) is loosened/removed, oil will gush out. Keep to one side when you remove the strainer.

Before removing the strainer, be sure you have a new strainer gasket. The old strainer gasket will be damaged during removal of the strainer, and if it is installed with the strainer, leakage will occur. It is recommended that three gaskets be kept in supply at all times. This will cover a years maintenance and one for emergency maintenance.

1. Place a suitable container under the strainer (G). Remove the strainer and gasket and drain the oil into the container. Discard the gasket.
2. Place the container under the drain plug (B), remove the drain plug, and drain any oil left in the transmission into the container.
3. Securely reinstall the drain plug (B).
4. Clean the strainer in a suitable solvent.
5. Install the cleaned strainer and new gasket. Tighten the strainer mounting bolts to a torque of 10 Nm (7.4 lb-ft).
6. Remove the transmission oil filter (E) by unscrewing it from the filter housing. The filter is mounted remotely.
7. Properly discard the filter.
8. Coat the seal (F) of the new filter with clean transmission oil.
9. 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.
10. Fill the transmission through the dipstick tube (Figure 5-9) with the proper type and amount of oil specified in Section 8 of this manual.
11. Fill the transmission to the high mark on the dipstick.
12. Start the engine and let it run at idle speed for a period not exceeding five minutes to fill the transmission filter, the torque converter, and the hoses with oil.
13. Stop the engine, wait approximately one minute and then check the oil level. If low, add oil to high mark on the dipstick. **DO NOT OVERFILL.**

Replace the Transmission Oil and Filter — 2WD

NOTE: It is necessary to climb under the crane to drain the transmission oil (Figure 5-34). Be sure the parking brake is engaged, the engine is off, the ignition key is removed, and chock blocks are in place before climbing under the crane.

1. Place a suitable container under the drain plug, remove the drain plug, and drain the oil into the container.
2. Securely reinstall the drain plug.
3. Remove the transmission oil filter by unscrewing it from the filter housing. The filter is mounted remotely.
4. Properly discard the filter.
5. Coat the seal of the new filter with clean transmission oil.
6. 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.
7. Fill the transmission through the dipstick tube (Figure 5-9) with the proper type and amount of oil specified in Section 8 of this manual.
8. Fill the transmission to the low mark on the dipstick.
9. Start the engine and let it run at idle speed to fill the transmission filter, torque converter, and hoses with oil.
10. Recheck the level with the engine running at low idle and bring the oil to the low mark on the dipstick.
11. Once the oil is hot — 82 to 93°C (180 to 200°F), bring the oil to high mark on the dipstick. **DO NOT OVERFILL.**

Replace the Axle Housing Oil

NOTE: It is necessary to climb under the crane to drain the axle housing lube. Be sure the parking brake is engaged, the engine is off, the ignition key is removed, and chock blocks are in place before climbing under the crane.

1. Clean around the fill plug (Figure 5-35 or Figure 5-36) and remove it.
2. Place a suitable container under the drain plug, remove the drain plug, and drain the oil into the container.
3. Install the drain plug.
4. Clean the front axle breather (Figure 5-35) with a suitable solvent. Be sure that the hole in the breather tube is facing toward the axle hub (toward the right).

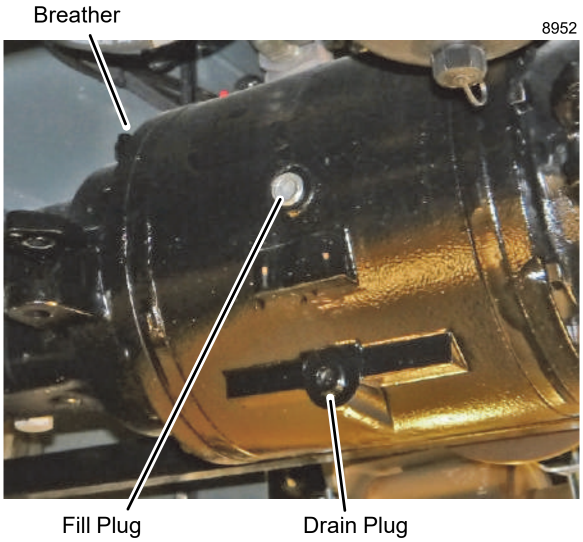


FIGURE 5-35

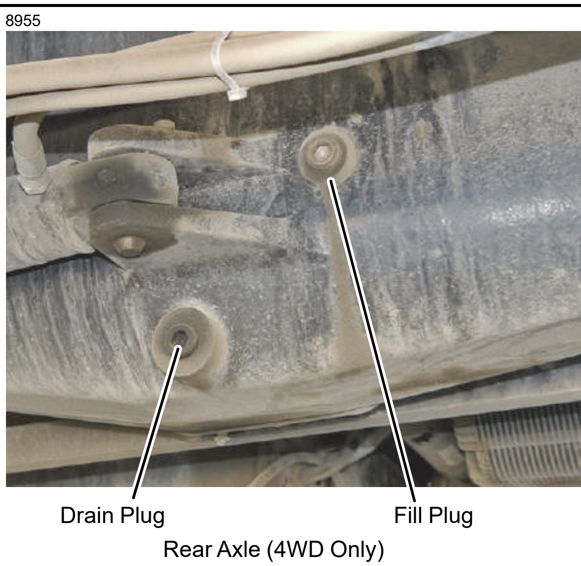


FIGURE 5-36

5. Fill the axle housing with the proper type and amount of oil (specified in Section 8 of this manual) until the oil is even with the bottom of the fill plug hole.
6. Install the fill plug.
7. Repeat the steps at both axles.

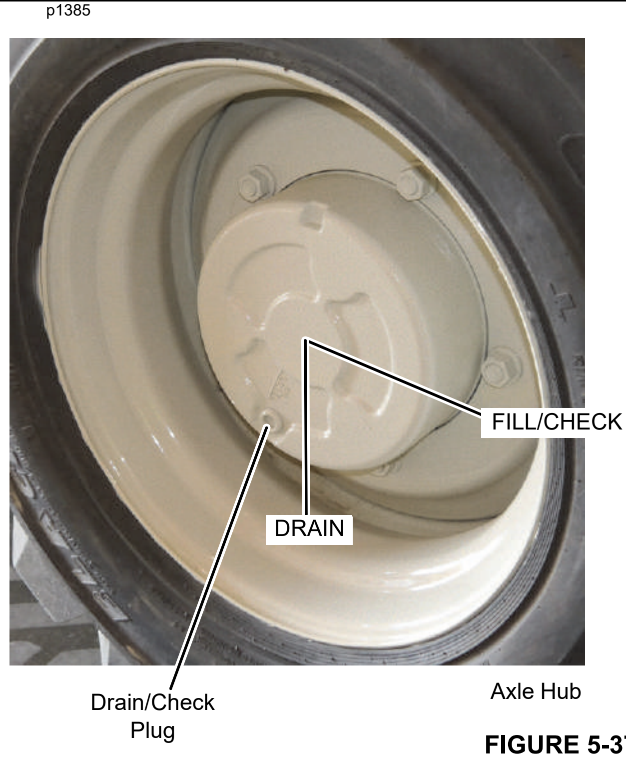


FIGURE 5-37

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 (Figure 5-37) until the drain plug is located at the bottom of the wheel hub.
4. Place a suitable container under the drain plug.
5. Clean around the drain plug, remove it, and drain the wheel hub oil into the container.
6. Turn the wheel hub until the drain/check hole is horizontal (Figure 5-37).
7. Fill the wheel hub with the proper type and amount of oil (specified in Section 8 of this manual) until the oil is even with the bottom of the plug hole.
8. Install the drain/check plug.
9. Repeat the above steps for the other three wheel hubs.

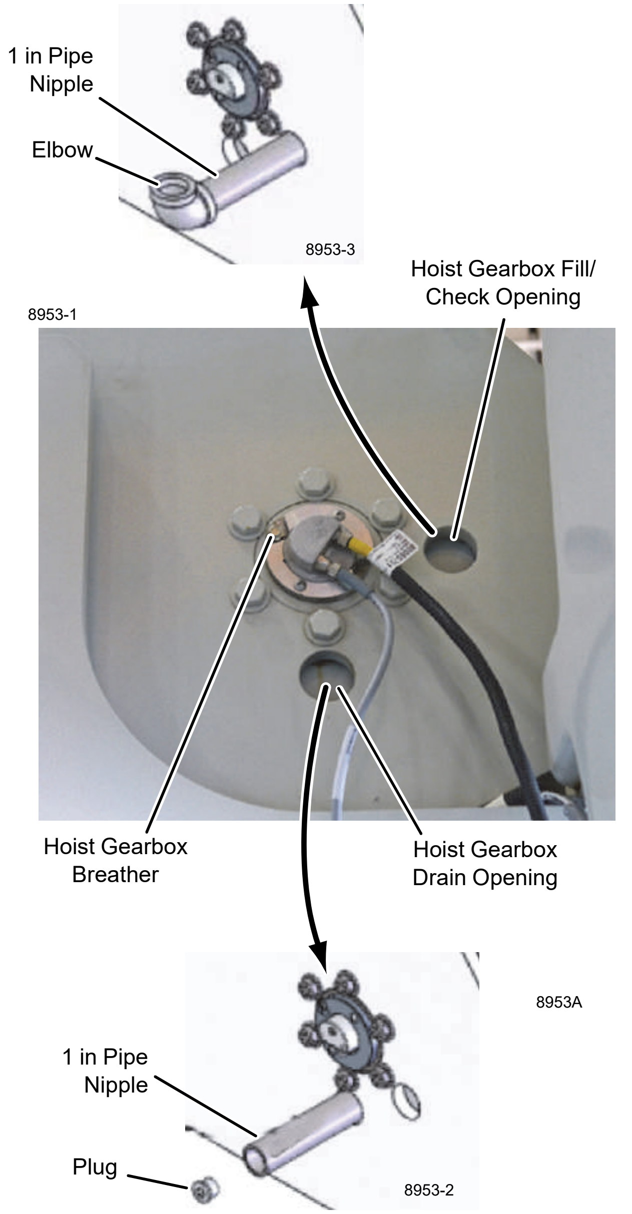


FIGURE 5-38

Replace the Hoist Gearbox Oil

1. Lower the boom to its lowest position, engage the parking brake.
2. Rotate the hoist drum (Figure 5-36) so the plug in the drum is visible through the drain opening in the hoist frame.
3. Screw a 1 inch pipe nipple into the hole in the hoist drum.
4. Place a suitable container under the pipe nipple.
5. Using a hex wrench with an extension, remove the plug through the pipe nipple.
6. Allow the oil 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.
7. Remove the pipe nipple.
8. Rotate the drum so the plug hole is visible through the fill/check opening in the hoist frame.
9. Screw the pipe nipple and an elbow into the hole in the hoist drum.
10. Fill the hoist drum with the proper type and amount of oil (specified in Section 8 of this manual) until the oil is even with the bottom of the plug hole.
11. Remove the elbow and pipe nipple.
12. Make sure the o-ring on the plug is not damaged (replace if necessary) and install the plug.
13. Remove and clean the hoist gearbox breather with a suitable solvent. Then reinstall it.

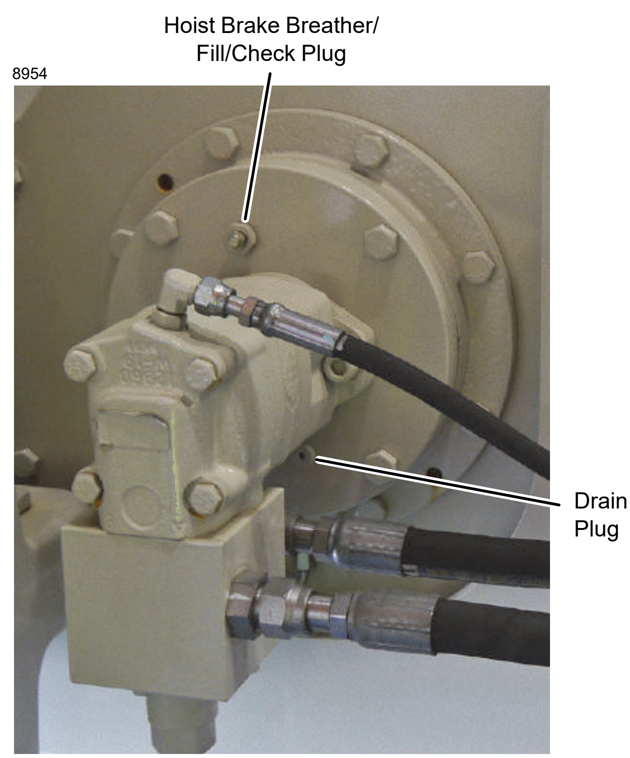


FIGURE 5-39

Replace the Hoist Brake Oil

1. Lower the boom to its lowest position and engage the parking brake. Leave the engine running.
2. Clean around the hoist brake breather/fill/check plug (Figure 5-37) and remove it.
3. Place a suitable container under the hoist brake drain plug.

4. Remove the drain plug to drain the oil.
5. Install the drain plug.
6. Clean the breather with a suitable solvent.
7. Fill the hoist brake with the proper type and amount of oil (specified in Section 8 of this manual) until the oil is even with the bottom of the plug hole.
8. Install the breather/fill/check plug.

Replace the Hydraulic Oil

NOTE: ISO (International Standards Organization) #46/68 Hydraulic Oil (Mobil Fluid #424) is recommend for year-round use in the hydraulic system.

In very cold temperatures, SAE 5W or SAE 5W-20 oils can be used if the viscosity of the oil will not be less than 60 SUS (Saybolt Universal Seconds) at maximum operating temperature. It may be necessary to use a pre-heater and a longer than normal warming period at low operating speed to heat the oil to operating temperature.

To change the hydraulic oil:

1. Fully retract and lower the boom.
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, stop the engine and remove the ignition key.
5. Place a suitable container under the hydraulic tank drain plug (Figure 5-40).

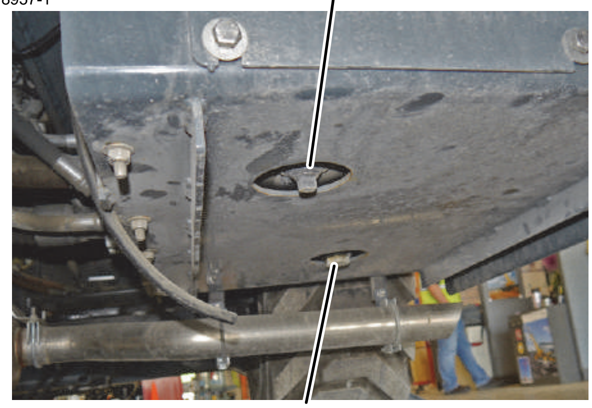


FIGURE 5-40

6. Remove the drain plug and drain the hydraulic tank.
7. Install the drain plug.

   If the oil/tank is extremely dirty, the tank can be flushed and cleaned by removing the cleanout cover from the top of the tank. It will be necessary to remove the deck plate to perform this step.
8. Replace the hydraulic oil filter.
9. Remove the breather and fill the hydraulic tank with the proper type and amount of oil (specified in Section 8 of this manual) to 3 mm (0.125 in) from the top of the sight gauge.
10. Discard the breather and install a new one.
11. After the tank is filled, start the engine and operate each function until all of the cylinders and lines are filled.
12. Fully retract and lower the boom and retract the outriggers. Check the hydraulic oil level. The oil must be 3 mm (0.125 in) from the top of the sight gauge. Add hydraulic oil if necessary.

13. Visually check for leaks.

Replace the Hydraulic Oil Filter

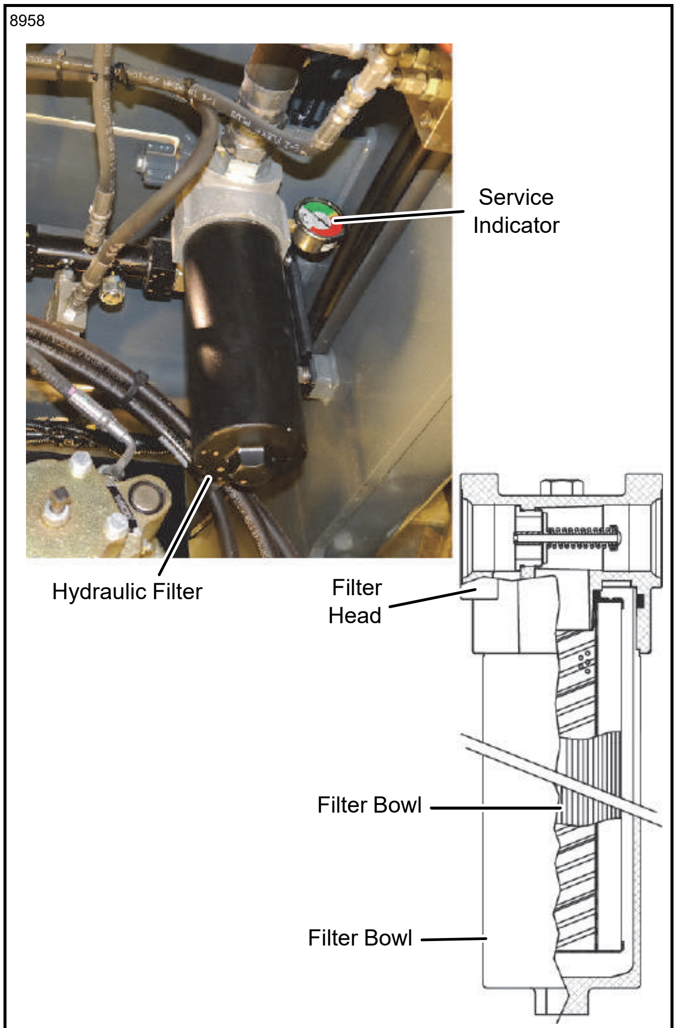


FIGURE 5-41

1. Replace the hydraulic filter element (Figure 5-41) when the service indicator is in the red area.
2. Engage the parking brake and stop the engine.

NOTE: It is necessary to climb under the crane to replace the hydraulic oil filter. Be sure engine is off, the ignition key is removed, and chock blocks are in place before climbing under the crane.

3. Locate the hydraulic oil filter under the crane.
4. Place a suitable container under the filter to catch oil.
5. Replace the filter element:
   - **a.** Using a wrench, turn the filter bowl off the head.
   - **b.** Remove and properly discard the filter element.
   - **c.** Clean the filter bowl and the mounting surface on the filter.
   - **d.** Make sure the seal in the filter head and on the new element are not damaged.
   - **e.** Apply a small amount of clean hydraulic oil to the seals.
   - **f.** Install the new filter element on the filter head.
   - **g.** Install and tighten the filter bowl to 54 Nm (40 lb-ft).
   - **h.** Start the engine and check for leaks around the filter.

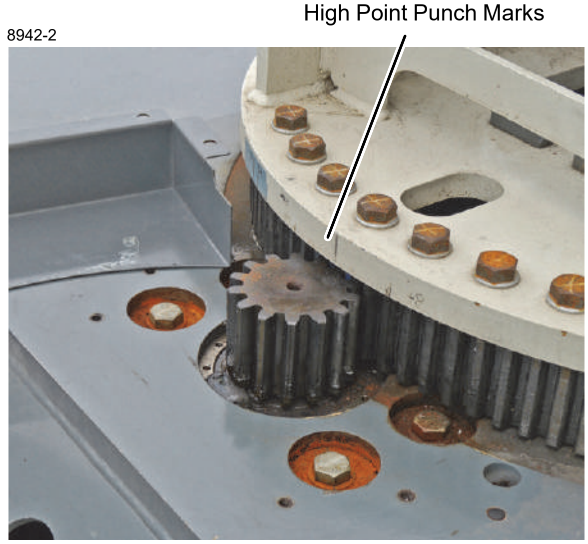
Check Swing Gear/Pinion Backlash

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 5-42).

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 as instructed in Section 11 of this manual.



Swing Gear Backlash Check

FIGURE 5-42

Service Dual Fuel Engine

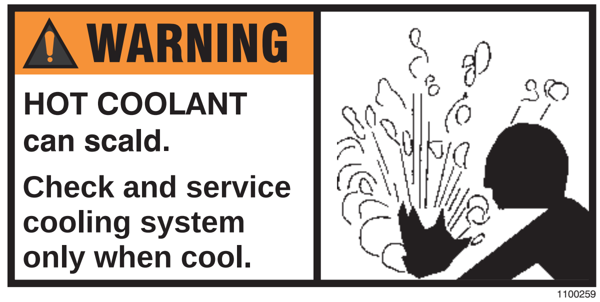
Service the dual fuel engine per the instructions in the engine manual provided with your crane.

2000 Hours of Operation (Yearly)

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

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

Replace the Engine Coolant



1. Open the engine compartment cover.
2. **BE SURE THE ENGINE IS COOL** and follow the cooling system draining and filling procedures in the engine manual furnished with the crane.

   See Figure 5-43 for the location of the vent and drain petcocks.
3. After the coolant is replaced, close the engine compartment cover.

FIGURE 5-43

Inspect the Crane Structure and Boom for Damage

Thoroughly inspect the crane structure and boom for the following:

1. Inspect for loose mounting hardware. Tighten any loose hardware.
2. Inspect for cracked or broken welds. Do not operate the crane if a critical weld is cracked or broken until the weld is repaired. Contact your Grove distributor.
3. Inspect for missing or unreadable warning decals. Replace if necessary.

4. Inspect for excessive rust or corrosion on crane structure and boom. Paint any areas with excessive rust or corrosion.
5. Inspect for missing items. Replace if necessary.
6. 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 (RCL) manual furnished with this crane and test the RCL according to instructions in the manual.

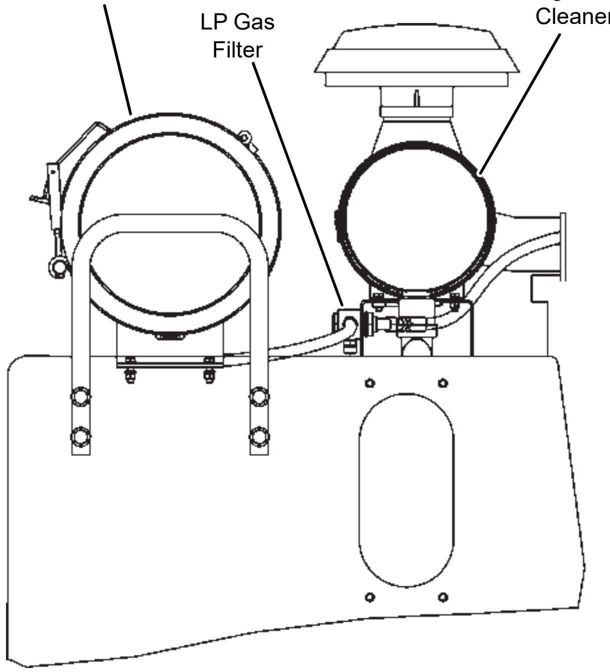


FIGURE 5-44

Replace LP Gas Filter

If equipped with the LP gas option, replace the filter (Figure 5-44).

Service Dual Fuel Engine

Service the dual fuel engine per the instructions in the engine manual provided with your crane.

MISCELLANEOUS MAINTENANCE

Air Conditioner

An air conditioner compressor motor is installed on the left side of the engine. When servicing the air conditioning system, observe the following specifications:

- Minimum Evacuation Time — 30 minutes
- Refrigerant Charge Levels — 3.0 pounds (± 0.5 oz)
- Additional Pag Oil Required Above the 6 ounces in Compressor — 6.0 ounces

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:

Normal Operating Ranges

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

For more information, see Charging System on page 3-5.

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 gasing 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 Replacement

Refer to Figure 5-45 for the location of the fuses on this crane.

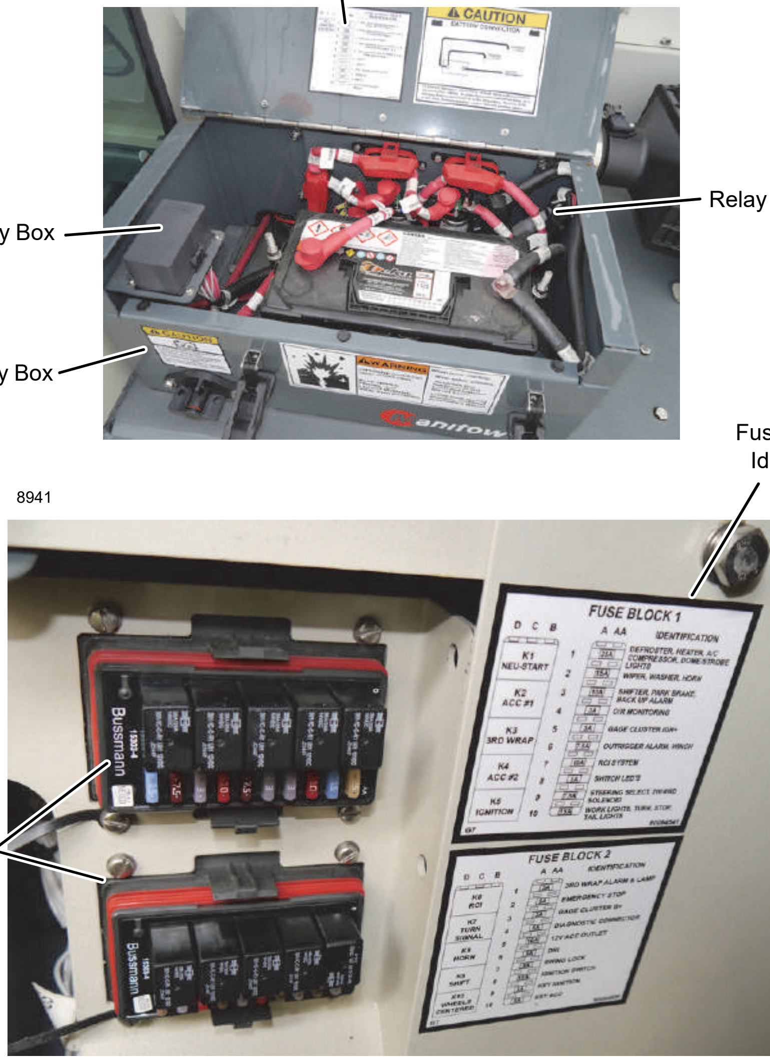


FIGURE 5-45

CARWELL® RUST INHIBITOR

Protecting Cranes From Rusting

Manitowoc Crane Group's cranes are manufactured to high quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, we are also doing our part to help prevent premature corrosion of cranes.

Grove cranes will be treated with a rust inhibitor called Carwell® T32-CP-90. While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on Grove cranes that are treated with this product.

Carwell® is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29 CFR 19 10.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents.

Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

Once applied, treatment can appear to leave a slightly “oily” residue on painted surfaces and until the red tinting fades could initially be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it must be removed using standard steam-cleaning techniques.

This treatment works in various ways: (1) it eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface; (2) the film creates a barrier to repel further moisture from coming in contact with the metal; and (3) it penetrates crevices.

In addition to the factory-applied treatment, Grove crane owners must provide proper maintenance and care to help ensure long-term protection of their crane against corrosion. This procedure provides information and guidelines to help maintain the paint finish on Grove cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

While the surfaces of the crane that are easily seen have the biggest impact on the appearance of the crane, particular attention should be given to the undercarriage of the crane to minimize the harmful effects of corrosion.

Exercise special care and increase the frequency of cleanings if the crane is operated:

- on roads where large quantities of salt or calcium are applied to treat icy and snowy road surfaces;
- in areas that use dust control chemicals;
- anywhere there are increased levels of wetness - especially near salt water;
- during prolonged periods of exposure to damp conditions (e.g., moisture held in mud), where certain crane parts may become corroded even though other parts remain dry; or
- in high humidity, or when temperatures are just above the freezing point.

Cleaning Procedures

To help protect against corrosion of Industrial cranes, Product Support recommends washing the crane at least monthly to remove all foreign matter. More frequent cleanings may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

NOTE: Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

Inspection and Repair

- Immediately following cleaning, Product Support recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

NOTE: Product Support recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.

CAUTION

To the extent any damage is structural in nature, Product Support must be contacted and consulted as to what repairs may be required.

For scratches and marks in highly visible areas:

- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat of paint using accepted blending techniques. Use of original paint colors is recommended to insure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

Application

Depending upon the environment in which a crane is used and/or stored, the initial factory application of Carwell T32-CP-90 should help inhibit corrosion for up to approximately 12 months.

It is recommended that the treatment be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments (such as islands, coastal regions, industrial areas, areas where winter road salt is regularly used, etc.), reapplication of treatment is recommended sooner than 12 months, e.g., repeat treatment in 6-9 months.

- Do not apply to recently primed and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

NOTE: Crane must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Crane should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged on the crane.
- Use of pressure pots to apply the treatment to the crane being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Product Support (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Product Support should you have any questions.

Areas of Application

Refer to FIGURE 5-46 continued

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; valves, hose end and fittings, swivel, pumps, axles, drivelines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Mast applications are; hose ends and fittings, wire rope on hoist roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.
- Boom application areas are; pivot pins, hose ends and fittings, boom extension pins and shafts, all bare metal surfaces, hook block/downhaul weight pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.

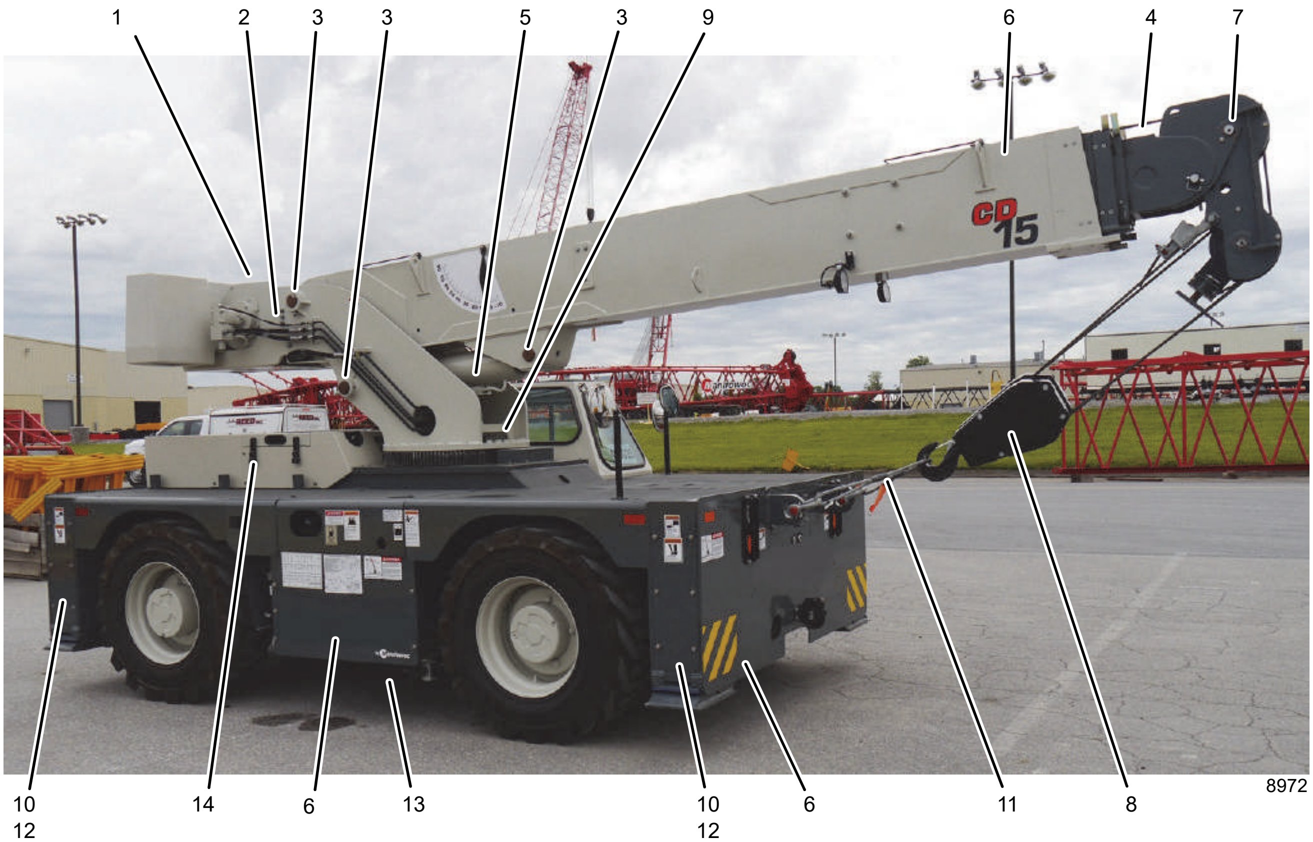


FIGURE 5-46

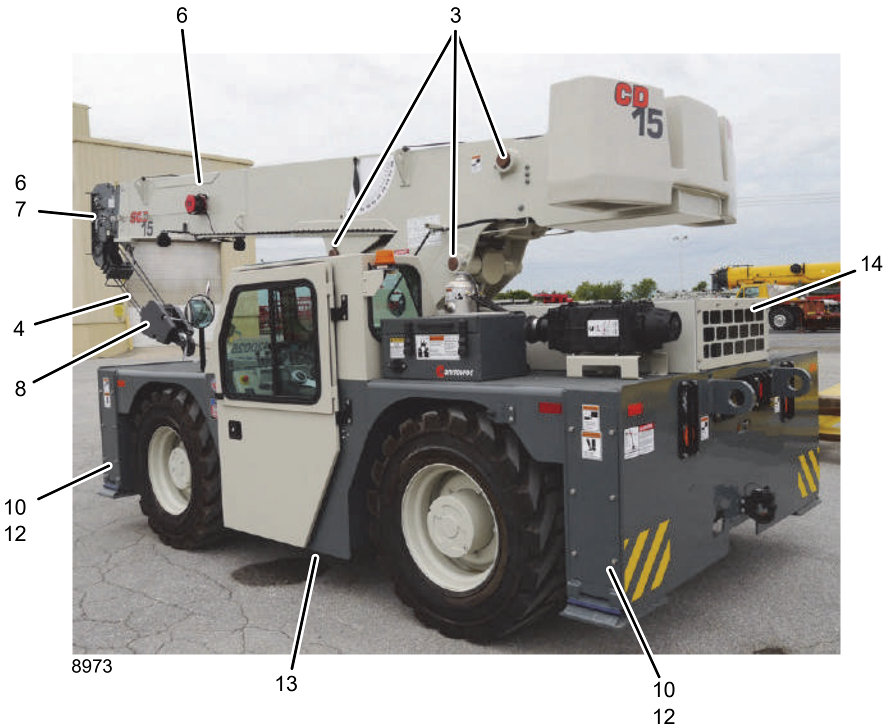


FIGURE 5-46 continued

Item	Description
1	Hoist Tension Spring
2	Hoist Hose Connections
3	Pivot Shaft
4	Wire Rope
5	Hose Connections inside turntable
6	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
7	Boom Nose Pins, Clips

Item	Description
8	Hook Block or Downhaul Weight
9	Turntable Bearing Fasteners
10	O/R Pins, Clips
11	Hook block Tie Down Cable
12	O/R Hose Connections
13	Entire underside of Unit
14	Power Train Hardware Inside Compartment
15	Boom Extension Pins, Clips - Option
16	Boom Extension Hanger Hardware - Option

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SECTION 6
ENGINE AND ENGINE SYSTEMS

SECTION CONTENTS

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

Three engine options are available:

- Cummins QSF 3.8 T4F
- Cummins QSF 3.8 T3
- KEM 4.3L Dual Fuel

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, page 5-1.

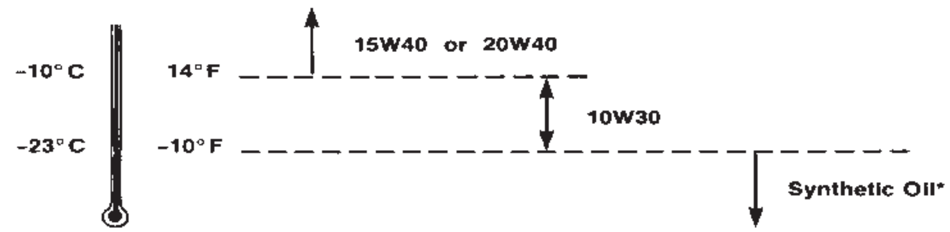
Crankcase Oil Data

Use oil viscosity based upon the expected air temperature range during the period between oil changes.

Oil Performance Recommendations

CC/SF for use in naturally aspirated engines and in engines that operate in light duty service including standby and emergency operation (equivalent to MIL-L-2104B).

Sulfated Ash Limit of 1.85% by weight is recommended. Oils with higher ash count may produce deposits on valves that can progress to guttering and valve burning.



a0103 Oil Viscosity Recommendations - Diesel Engine **FIGURE 6-1**

Do not use “break-in” lubricating oils in new or rebuilt engines. Only use lubricating oils specified for normal engine operation.

Oil Viscosity Recommendations

The use of a multigrade lubricating oil improves oil consumption control and improves engine cranking in cold temperatures while maintaining lubrication at high operating temperatures. A multigrade oil is therefore recommended with the viscosity grades shown in the Figure 6-1. The use of single grade lubricating oils is not recommended, except for synthetic oils used in Arctic conditions.

Arctic Operation

NOTE: *SAE 5W viscosity grade synthetic oil may be used when operating the engine in ambient temperatures below -23°C (-10°F) provided it meets the minimum viscosity at 100°C (212°F).*

When there is no provision to keep the engine warm when operating in ambient temperatures consistently below -23°C (-10°F), use a lubricating oil that meets the following requirements:

Table 6-1: Arctic Oil Recommendations

Parameter (Test Method)	Specification
Performance	API Classification CC -Naturally Aspirated API Classification CC/CD - Turbocharged
Viscosity Maximum	10,000 mPa°s at *-35°C (*-31°F*)* 0.16 inch *(3.1 mm*) Squared Minimum at *100°C (*212°F*)*
Pour Point (ASTM D-97)	Maximum of *5°C (*41°F*)* Below the Lowest Expected Ambient Temperature
Sulfated Ash Content	Maximum of 1.85% by weight (ASTM D-874)

ENGINE COOLING SYSTEM

The engine cooling system consists of the coolant passages in the engine, a thermostat, water pump, hoses and radiator.

The engine is cooled by the circulation of coolant through the passages in the engine block and head. Circulation is by a thermo-siphon action assisted by a water pump driven by a belt from the crankshaft pulley.

The water pump bearings are packed with a special grease during assembly and do not require attention in maintenance.

Coolant Requirements

The quality of coolant will determine the efficiency and life of the cooling system.

1. Check the antifreeze concentration several weeks before the beginning of the cold season or hot season. The antifreeze must have an ethylene glycol (ethanediol) base. Use a low silicone antifreeze that conforms to one of the standards below, or which contains no more than 0.1% anhydrous alkali metasilicate.

   U.S.A. - Engineering Standard GM6038-M.

   U.K. - BS3151: 1959: Ethandiol antifreeze type B with sodium nitrate inhibitors.

   Australia - AS 2108-1977: Antifreeze compounds and corrosive inhibitors for engine cooling systems.

2. There is an advantage to using antifreeze even when frost protection is not necessary. Antifreeze protects against corrosion and also raises the boiling point of the coolant. A 50% concentration of antifreeze is preferred, but if this much protection is not preferred, a 33% concentration can be used. Never use more than a 65% concentration under any conditions. Where frost protection will never be required, use a ***non-chromate corrosion inhibitor*** and clean soft water. Change the water/corrosion inhibitor every 12 months, or 500 hours, or to manufacturer’s recommendation.

   Do not use hard water in the cooling system. Hard water, or water with high levels of calcium and magnesium ions, encourages silica gel formations, especially after a number of heating and cooling cycles. These gel formations can result in loss of cooling or heating in radiators and cab heater cores by coating and plugging the tubes. The formations usually deposit in the cooler sections of the cooling system, such as the radiator bottom tank.

Use soft water, distilled water or deionized water to reduce the potential and severity of silicate dropouts.

NOTE: If you use water without a corrosion inhibitor, rust will form and plug the small holes in the head gasket. These holes are orifices and their size is critical. Do not enlarge the size of the orifices. To do so will disturb the coolant flow and will not solve any overheating problem. If you use water without a corrosion inhibitor for even a short period, the cup plugs will rust through, allowing coolant leakage. An incorrect or malfunctioning radiator cap can result in the loss of coolant and engine running hot. Any sudden loss of coolant from a heavily loaded engine can result in severe damage to the pistons and cylinder bore.

NOTE: Some corrosion inhibitor mixtures contain soluble oil which can have an adverse effect on some types of water hoses.

Radiator Cap and Overflow Bottle (Dual Fuel Engines)

The cooling system is designed to use a radiator cap to prevent the boiling of coolant. The radiator cap is set to open at 0.97 bar (14 psi). When it does open it allows coolant to be expelled into the overflow bottle and as soon as the engine cools the overflow fluid is sucked back into the radiator. An incorrect radiator cap can result in a great loss of coolant and the engine running hot.

Keep the overflow bottle at least half full of coolant at all times.

Thermostat

A malfunctioning thermostat can result in the engine running hot or cold. If it becomes necessary to replace the thermostat see the engine manual furnished with the crane.

ENGINE FUEL SYSTEM

Diesel Engine Fuel System Description

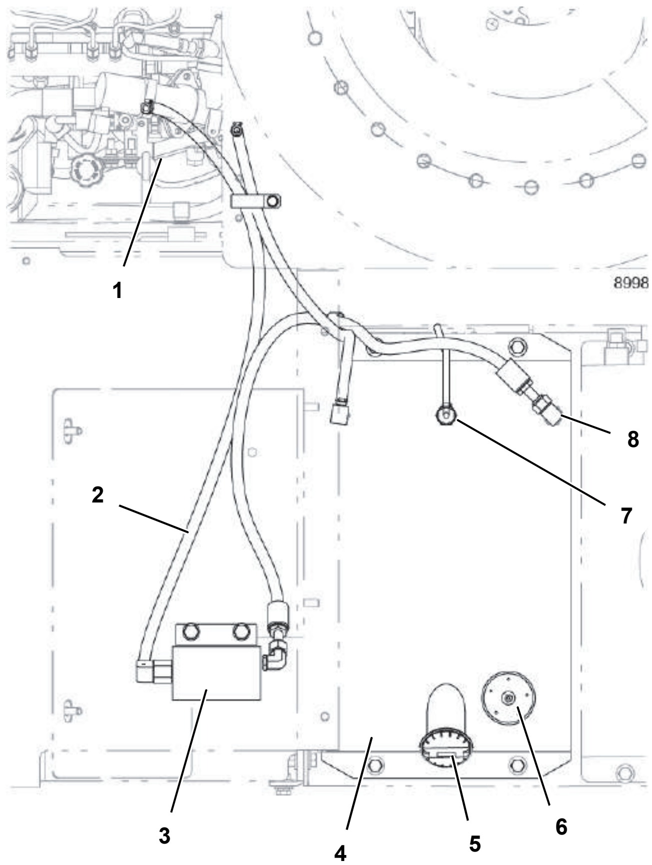
The diesel engine fuel system is a closed-loop fuel system which includes a fuel tank, an engine fuel filter, an engine fuel pump and the fuel lines.

A fuel supply line carries fuel from the bottom of the fuel tank to the engine fuel pump Figure 6-2. A line carries the fuel from the engine fuel pump to the engine fuel filter. Fuel that has been filtered flows to the fuel injector pump.

Fuel is distributed to the fuel injectors from the fuel injector pump. Excess fuel from the fuel injector pump is returned to tank.

Fuel Tank

The fuel tank is located on the right side of the crane. It is a welded box construction with a suction tube installed in the fuel support port. The tube inhibits sediment and water from being picked up off the bottom and sent to the engine.



Item	Description
1	Engine
2	Fuel Supply Line
3	Fuel/Water Separator
4	Fuel Tank
5	Fill Cap
6	Level Sender
7	Vent
8	Fuel Return Line

FIGURE 6-2

Fuel Level Sender and Gauge

The fuel level sender and gauge are described in the Section 11, Electrical System.

Fuel Pump

The fuel pump is installed internally in the engine and is used to pump fuel from the fuel tank and send it under pressure to the fuel filters and injection pump.

The fuel pump includes a priming button. This button is used to bleed the fuel system if one of the following should occur:

- The fuel filter is not filled prior to installation.
- The injection pump is replaced.
- High pressure fuel line connections are loosened or lines are replaced.
- Initial start up or start up after an extended period of time.
- The fuel tank has run empty.

Refer to the diesel operator's manual furnished with this crane for bleeding procedures.

Fuel Filter

The filter is used to collect contaminants and water that has accumulated in the fuel and is not picked up by the sediment bowl. It must be serviced at regular intervals. See Section 5, Preventive Maintenance for maintenance intervals.

Fuel Injection Pump

The fuel injection pump is a distributor-type pump with a mechanical flywheel-type governor. The pump is flange mounted and is driven from the engine timing case.

Fuel Injectors

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

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 6-3. Correct diesel fuel grade (A, B) is shown next to the scale.

Fuel Range Diagram

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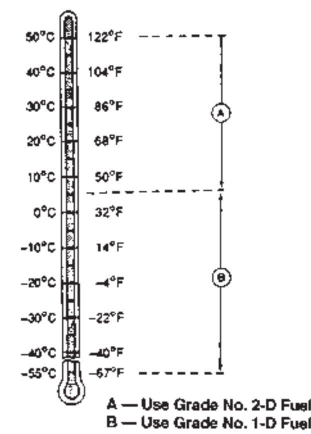


FIGURE 6-3

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.

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 FUMES CAN BE FATAL. When operating in enclosed areas with a gasoline or diesel engine, provide adequate ventilation.

w0002

FIGURE 6-4

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 cab. 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.

6

Table 6-2: Engine Troubleshooting Chart

Problem	Probable Cause	Action
Engine hard to start or will not start.	**1.** Improper starting procedure.	**1.** Review starting procedure in Engine Operator's Manual.
	2. No fuel.	**2.** Check fuel gauge.
	3. Air in fuel line.	**3.** Bleed the fuel line.
	4. Crankcase oil too heavy.	**4.** Use oil with proper viscosity.
	5. Improper type of fuel.	**5.** User proper fuel for operating conditions.
	6. Water, dirt or air in fuel system.	**6.** Drain, flush, fill and bleed system.
	7. Clogged fuel filter.	**7.** Replace the filter element.
Engine runs irregularly or stalls frequently.	**1.** Low coolant temperature.	**1.** Remove and check thermostat.
	2. Clogged fuel filter.	**2.** Replace filter element.
	3. Water dirt or air in fuel system.	**3.** Drain, flush, fill and bleed.
	4. Dirty or faulty fuel injection nozzles.	**4.** Have authorized distributor or distributor check the nozzles.
	5. Clogged air filter.	**5.** Replace the filter elements.
Below normal engine temperature.	**1.** Defective thermostat.	**1.** Remove and check thermostat.
	2. Defective temperature gauge.	**2.** Check gauge, sender and all connections.
Lack of power.	**1.** Engine overload.	**1.** Reduce the load.
	2. Intake air restriction.	**2.** Service air cleaner.
	3. Clogged fuel filters.	**3.** Replace fuel filters.
	4. Overheated engine.	**4.** Refer to Engine Operator's Manual. Check for plugged radiator/oil cooler fins.
	5. Below normal engine temperature.	**5.** Remove and check thermostat.
	6. Faulty engine.	**6.** Refer to Engine Operator's Manual.
Low oil pressure.	**1.** Low oil level.	**1.** Add oil.
	2. Faulty gauge or sender.	**2.** Check gauge, sender and connections.
	3. Improper type of oil.	**3.** Drain and fill crankcase with proper viscosity and quality.
Engine overheats	**1.** Engine overloaded.	**1.** Reduce the load.
	2. Low coolant level.	**2.** Fill radiator to proper level, check radiator and hoses for loose connections or leaks.
	3. Plugged radiator/oil cooler fins.	**3.** Clean fins.
	4. Faulty radiator cap.	**4.** Replace radiator cap.
	5. Cooling system needs flushing.	**5.** Flush cooling system.
	6. Defective thermostat.	**6.** Replace thermostat.
	7. Defective temperature gauge or sender.	**7.** Check and replace.

REMOVAL AND INSTALLATION

Removal

WARNING

A raised and badly supported crane can fall on you causing sever injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

1. Raise and support the frame far enough to remove the rear axle assembly.
2. Remove the engine cover and rear deck cover plate.
3. Disconnect the ground cable and battery cable from the battery.
4. Disconnect the frame electrical wire harness from the engine electrical wire harness.
5. Disconnect the transmission high temperature switch from the frame electrical wire harness.
6. Disconnect the transmission electrical wire harness from the instrument panel wire harness.
7. Drain the radiator. Disconnect the upper and lower hoses from the radiator.
8. Disconnect the transmission cooling lines from the radiator. Put plugs and caps on all lines to keep dirt out of the system.
9. Disconnect the hot water heater hoses from the engine.
10. Remove the radiator.
11. Remove the air cleaner and intake hose(s).

NOTE: Have a fire extinguisher handy and know how to use it before performing the next step.

12. Disconnect the fuel lines from the fuel tank. Plug or cap the lines to prevent leakage.
13. Disconnect the drive shaft(s) from the transmission. See Section 7.
14. Disconnect the exhaust pipe from the exhaust manifold of the engine.
15. Drain the hydraulic tank.
16. Disconnect the hydraulic hoses from the four sections of the hydraulic pump.
17. Disconnect the suction hose from the hydraulic tank and the hydraulic pump suction manifold.
18. Disconnect the throttle linkage from the engine.
19. If equipped, remove the optional cold start kit from the bracket inside the chassis frame.
20. Disconnect the engine ground cable from the engine or the engine flywheel.
21. Remove the rear axle.
    a. Attach a chain to the front engine lifting lug and attach to a hoist. Use the hoist to support the engine while the rear axle is removed.
    b. Loosen and remove the wheel lug nuts and remove both rear wheels.
    c. Disconnect and plug the hydraulic hoses at the steering cylinders.
    d. Disconnect and cap and plug the brake hoses from the axle.
    e. Support the axle on a trolley jack.
    f. Remove the front engine mounting hardware.
    g. With the engine and rear axle both supported, remove the eight bolts and flat washers securing the engine/axle mounting bracket to the chassis.
    h. Lower and remove the axle clear of the chassis
22. Remove the rear engine support mounting bolts, washers, rubber mounts and nuts.
23. Using a trolley jack, raise the transmission so it can be removed out the rear of the chassis.
24. Using the hoist, slowly pull the engine and transmission rearward enough to attach a sling around the torque converter housing. At the same time, check that all items are free for engine removal. Attach a pull jack to the sling and hoist.
25. Slowly raise the engine and check that all lines and components which can possibly cause interference with the engine removal have been removed. Carefully lift the engine and transmission out the rear of the frame at about a 30° angle.
26. If a new engine is to be installed, remove all parts from the old engine not provided with the new engine and install them on the new engine.

Installation

1. Attach a hoist to the engine the same way removal was accomplished.
2. Lift the engine into place over the chassis. Tilt the engine at about a 30° angle to insert the engine into the chassis. Lower the engine into the chassis and set the transmission on a trolley jack. Remove the sling and pull jack.
3. Move the engine and transmission into the chassis until the rear mounting bolts, washers, rubber mounts and nuts can be installed and tightened.
4. Install the rear axle.
   a. Locate the rear axle under its mounting location. Raise the axle and mounting bracket into position and install the eight mounting bolts and flat washers.
   b. Install the front engine mounting hardware.
   c. Connect the brake lines to the axle.
   d. Connect the hydraulic hoses to the steering cylinders.
5. Connect the suction hose to the hydraulic tank and the hydraulic pump suction manifold.
6. Connect the hydraulic hoses to the four sections of the hydraulic pump.
7. Fill the hydraulic tank.
8. Connect the engine ground cable to the engine.
9. If equipped, install the cold start kit.
10. Connect the throttle linkage to the engine.
11. Connect the exhaust pipe to the engine manifold. If a gasket is used, install a new gasket.
12. Connect the drive shaft(s) to the engine. See Axles/Drive Shafts/Wheels and Tires, Section 8.
13. Connect the fuel lines to the fuel tank.

NOTE: The diesel fuel supply fuel line must be bled of air before engine can be started. Refer to the engine operator’s manual furnished with this crane, for bleeding procedure.

14. Install the air cleaner and intake hose.
15. Install the radiator in place on the chassis.
16. Connect the transmission cooling lines to the radiator. Connect the upper and lower radiator hoses.
17. Connect the hot water heater hoses to the engine.
18. Fill the radiator with recommended coolant.
19. Connect the transmission wire harness to the instrument panel wire harness.
20. Connect the transmission high temperature switch lead to the switch.
21. Connect the engine wire harness to the frame wire harness.
22. Install the engine cover and rear cover plate.
23. Connect the battery cables to the battery.
24. Check complete installation to be sure all components are installed and secure.
25. Fill the engine and transmission with recommended oil.
26. Start the engine. Continue to add transmission fluid until transmission cooling lines are full. Add fluid as needed to fill the cooling system.
27. Adjust the throttle control, if necessary.
28. Steer the rear wheels in both directions several times to remove air from the steering circuit.
29. Bleed air from brake lines. Refer to Section 9.
30. Stop the engine and check for leaks. Tighten fittings if necessary.

SECTION 7
TRANSMISSION AND TORQUE CONVERTER

SECTION CONTENTS

7

FOUR-WHEEL DRIVE (4WD) TRANSMISSION

Refer to page 7-25 for Two-Wheel Drive (2WD) Transmission

4WD General Technical Data

Description . . . . . Full electro-hydraulic transmission unit with input, reverse, four wheel drive and mainshaft clutch packs. Torque converter is integral.

Designation PS754

Weight (dry): . . . . . 265 kg (584 lb)

Gear Ratios:

- 1st 6.58:1
- 2nd 3.71.1
- 3rd 1.77:1
- 4th 1.00:1

Torque Converter Dia. . . . . . 279 mm (11 in)

Torque Converter at Stall. 2.40:1

Torque Converter Color Code Identification:

- Color Coded Dots . . . . . 2 Orange
  1 Green

Minimum Engine RPM at Converter Stall:

- 2^{nd} Gear . . . . . 2075 rpm
- 3^{rd} Gear . . . . . 2050 rpm

Converter IN pressure (neutral) at 50°C (122°F)

- 1000 rpm . . . . . 2.8 – 4.1 bar (40 – 60 psi)
- 2000 rpm . . . . . 4.8 – 6.2 bar (70 – 90 psi)

Converter OUT pressure (neutral) at 50°C (122°F)

- 1000 rpm . . . . . 1.9 – 2.3 bar (27 – 33 psi)
- 2000 rpm . . . . . 2.3 - 2.7 bar (33 – 39 psi)

Converter Inlet Relief Valve Pressure (Max.) . . . . . 6.5 bar (95 psi)

Converter Inlet Relief Valve Lubrication Pressure (in neutral) at 50°C (122°F)

- 1000 rpm . . . . . 0.14 - 0.28 bar (2.0 – 4.0 psi)
- 2000 rpm . . . . . 0.28 – 0.55 bar (4.0 – 8.0 psi)

Converter Mainline Pressure (in neutral) at 50°C (122°F)

- 1000 rpm . . . . . 9.0 - 10.0 bar (135 – 145 psi)
- 2000 rpm . . . . . 9.7 – 11.0 bar (140 – 160 psi)

Flow Rates (in neutral) at 50°C (122°F)

- Cooler (1000 rpm) . . . . . 10.4 – 13.6 L/min (2.8 – 3.6 gpm)
- Cooler (2000 rpm) . . . . . 14.5 – 20.0 L/min (3.8 – 5.3 gpm)
- Pump (1000 rpm) . . . . . 11.0 – 15.0 L/min (2.9 – 4.0 gpm)
- Pump (2000 rpm) . . . . . 22.5 – 29.5 L/min (6.0 – 7.8 gpm)

The following clutch pressures should be the same as the Mainline Pressure to within 7 bar (101 psi):

- Input Clutch Pressure (high and low ratio)
- Forward Clutch Pressure (high and low ratio)
- Layshaft Clutch Pressure
- Mainshaft Clutch Pressure

4WD Clutch Solenoid Technical Data

Type	4 way, 3 position, directional control
Operating Flow	40 L/min (9.85 gpm)
Operating Pressure	10 bar (145 psi)
Leakage (maximum	50 cc/min @ 40° C, 10 bar (14 in./min. @ 104° F, 145 psi)
Fluid Type	ATF 210
Fluid Cleanliness	ISO 22/17
Waterproof Specification	IP 67
Coil Operating Voltage	+12 V DC nominal (10.8 to 13.2 V)
Pull-in Voltage	+10.5 V (max.) @ 25°C (77°F) air, after energized for 10 minutes at 16 V and off for 10 seconds
Dropout Voltage	+1.5 V (min.) at 20°C (68°F) air
Peak Voltage	+26 V DC for 5 minutes at 0°C (32°F)
Coil Resistance	4.9 ohms ± 5% @ 20°C (68°F)
Operating Temperature Range:	
Air	-40°C to +43°C (-40°F to +109°F)
Oil	-40°C to +100°C (-40°F to +212°F)
Diode Protection	3 amps minimum, 50 ns maximum reverse recovery time

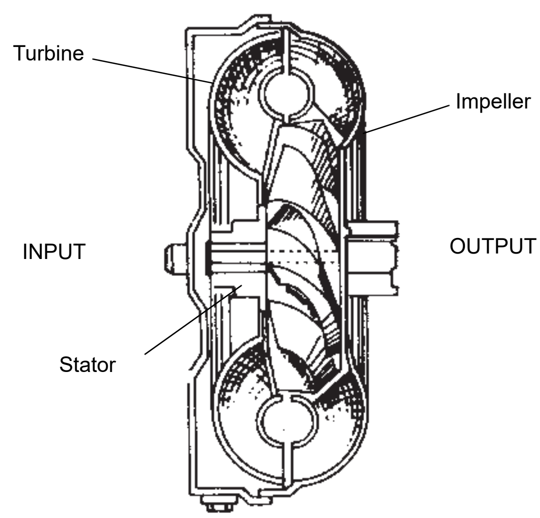
4WD Description of Operation

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.



Torque Converter Cross-Section
a0230 **FIGURE 7-1**

The **turbine** is opposite the impeller and is connected by splines to the input shaft of the Powershift Transmission. The turbine receives oil at the outer diameter and releases the oil to the stator at the inner diameter. The movement of oil from the impeller to the turbine makes a multiplication of torque possible. The torque converter gives maximum torque when the turbine is at zero (0) rpm.

The **stator** is between and at the center of the impeller and turbine. The stator changes the direction of the oil which leaves the turbine so the oil will enter correctly again into the impeller.

The torque converter and transmission have a common hydraulic system. Figure 7-3 shows the arrangement of the system.

CAUTION

Normal operating temperature is 82° - 88°C (180° - 190°F). High temperatures will cause damage and leakage in the seals and gaskets of the torque converter. Do not continue operation if the temperature increases above 82° - 88°C (180° - 190°F). A warning light on the cab instrument panel will illuminate when the temperature rises above a safe temperature. Put the transmission in “neutral” position and let the engine run at low RPM until the temperature returns to normal and the warning light goes out. If temperature does not return to normal, check for restriction in the lubrication and cooling lines of the torque converter.

Transmission

The Powershift Transmission is an electo-hydraulic transmission unit. Gear shifting and direction selection are controlled using multi-disc clutch packs.

Electrically operated solenoid valves divert pressurized oil (provided by pump **Q** Figure 7-2) to the selected clutch packs.

A combined lever/swivel switch (travel select lever) on the steering column actuates both gear ratio and direction solenoids.

The Powershift transmission consists of a torque converter **A** Figure 7-2, input clutch assembly **B**, forward clutch **C**, layshaft assembly **E**, and a mainshaft assembly **D**.

The torque converter is a fluid coupling bolted to a drive plate which is bolted to the engine flywheel. As the engine crankshaft begins to rotate, the torque converter gives a smooth power takeoff gradually increasing the torque transmitted. This torque is transferred from the torque converter assembly to the clutch/gear assemblies via the input shaft **H**.

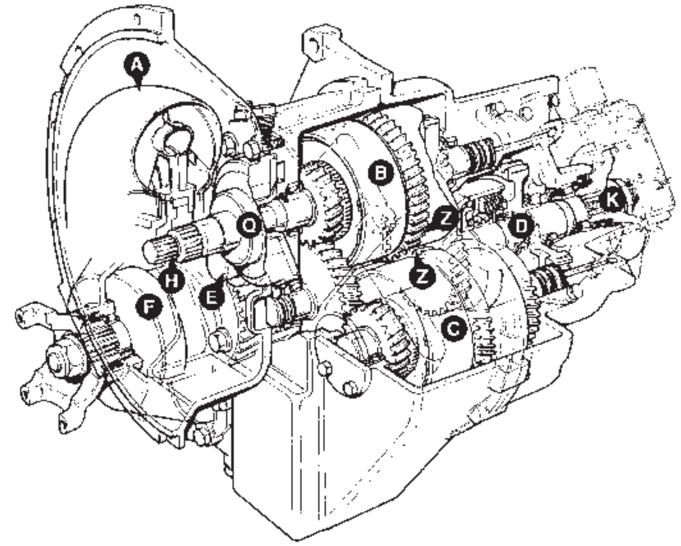
The input clutch assembly **B** contains two hydraulically operated clutches; one clutch provides reverse low ratio drive and other a reverse high ratio drive. The three-position solenoid **G**, when energized, directs pressurized oil to either the reverse low or reverse high clutch.

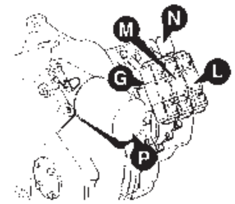
The forward clutch assembly **C** is similar to the input clutch assembly. It contains two hydraulically operated clutches; one clutch provides forward low ratio drive and the other forward high ratio drive. The three-position solenoid valve **L**, when energized, directs pressurized oil either to the forward low or forward high clutch.

Forward drive is transmitted via constant meshing of spur gears **Z**.

Both the mainshaft and the layshaft assemblies have a single clutch each. The three-position solenoid **M**, when energized, directs pressurized oil to either the mainshaft clutch or the layshaft clutch.

The 4 wheel drive unit (used on four-wheel drive cranes) has a single clutch **F**. In normal operation the clutch is spring loaded and therefore engages to give four-wheel drive. The 2/4 wheel drive solenoid **N** is not used on this crane.



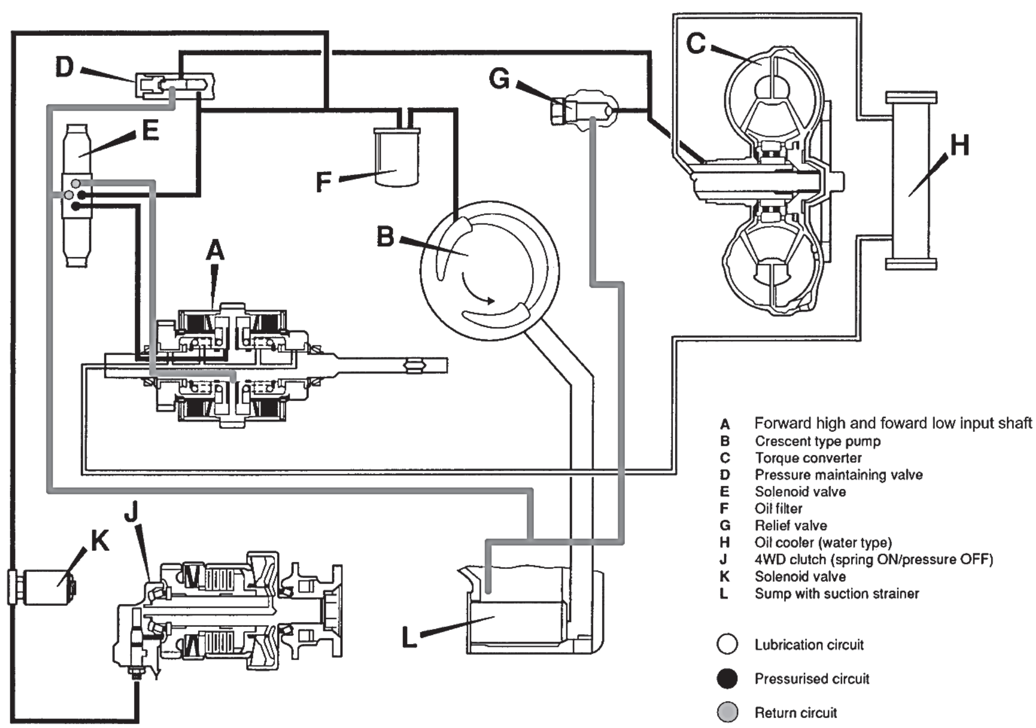


NOTE: The filter is not used on this transmission. A remote filter installation is used.

A - Torque Converter
B - Input Shaft Assembly
C - Forward Clutch Assembly
D - Main Shaft Assembly
E - Layshaft Assembly
F - 4 WD Clutch Assembly
G - 3 Position Solenoid Valve (Reverse)
H - Input Shaft
K - Spined Output Shaft
L - 3 Position Solenoid Valve (Forward)
M - 3- Position Solenoid Valve (Mainshaft/Layshaft
N - 2/4 Wheel Drive Solenoid (Not used)
P - Hydraulic Filter
Q - Pump
Z - Spur Gears

a0231

FIGURE 7-2



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Four-Wheel Drive Transmission Hydraulic Circuits - Typical

FIGURE 7-3

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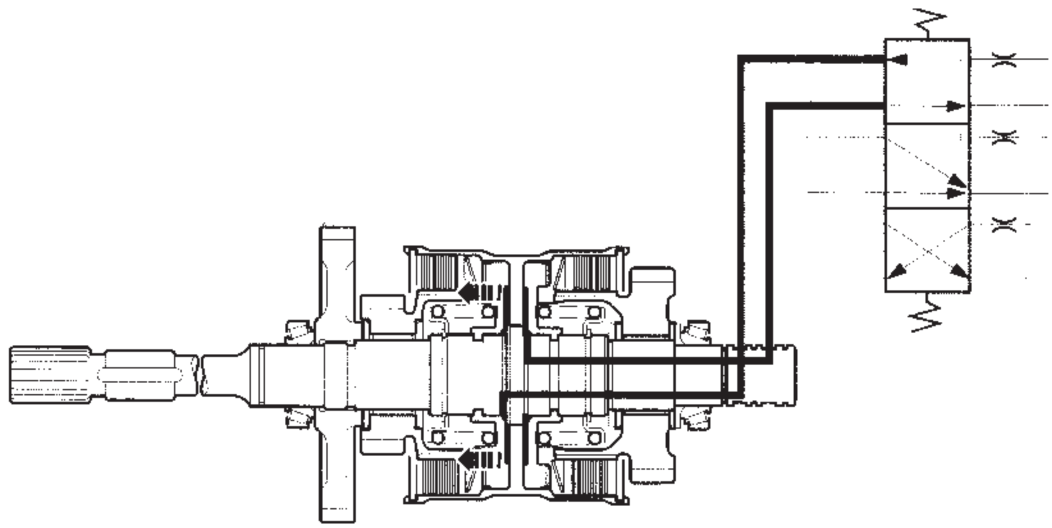

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Forward High and Low Clutch Operation - Typical

FIGURE 7-4

Hydraulic Operation

The solenoid adapter block also houses a solenoid valve **K** for the four-wheel drive clutch Figure 7-3. Oil under pressure is directed to the solenoid where it stopped. The purpose of the solenoid is to change the transmission from four-wheel drive mode to two-wheel drive mode. In four-wheel drive mode the solenoid valve is not actuated and the clutch pack **J** is spring applied. **Although the solenoid is furnished with the cranes with four-wheel drive, the two-wheel drive option is not available** and the transmission is always in four-wheel drive.

Clutch Operation

The transmission reverse high and reverse low clutch assemblies (Figure 7-4) are operated by the double solenoid valve.

In neutral, the solenoid valve blocks the flow of pressurized oil to the clutches.

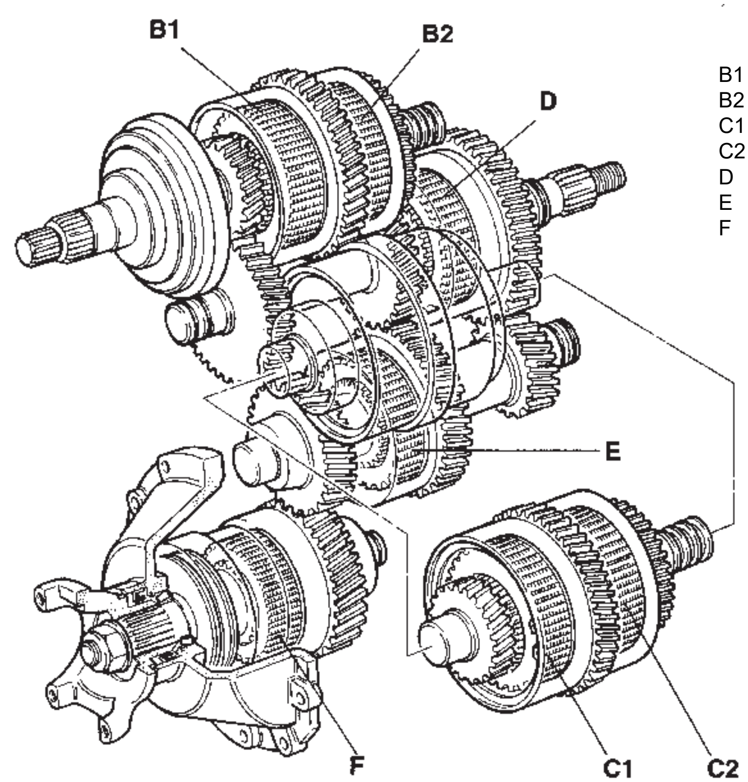
When energized, the solenoid valve, depending on which coil is energized, diverts pressurized oil by way of the shaft to the appropriate clutch in the unit. Pressure from the other clutch is vented to the sump by way of the solenoid valve spool.

NOTE: The forward high and forward low clutch unit operates in a similar manner.

The mainshaft and layshaft assemblies each have a single clutch. The principle of operation similar to the forward/ reverse, high/low clutch assemblies i.e., the mainshaft/ layshaft solenoid valve diverts oil to either the mainshaft clutch or the layshaft clutch.

4WD Clutch Identification

See Figure 7-5



B1 Reverse Low Ration Clutch
B2 Reverse High Ratio Clutch
C1 Forward Low Ratio Clutch
C2 Forward High Ratio Clutch
D Mainshaft Clutch
E Layshaft Clutch
F 4WD Clutch

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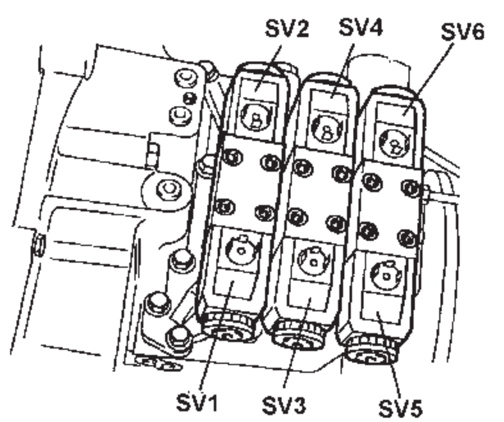
FIGURE 7-5

4WD Solenoid Identification

See Figure 7-6



SV1 Reverse Low
SV2 Reverse High
SV3 Layshaft
SV4 Mainshaft
SV5 Forward High
SV6 Forward Low

a2278

FIGURE 7-6

4WD General Troubleshooting

Problem	Possible Cause	Remedy
Lack of Power.	**1.** Poor engine condition.	**1.** Check and if necessary repair the engine.
	2. Low oil level.	**2.** Add oil to transmission.
	3. Worn pump.	**3.** Check, repair or replace the pump.
	4. Torque converter damaged.	**4.** Check, repair or replace the torque converter.
	5. Low mainline pressure.	**5.** See fault "Low Mainline Pressure."
	6. Clutches slipping.	**6.** Check clutch pressures, check clutch piston rings.
	7. Internal leakage.	**7.** Check internal cored passages and the casting for porosity.
	8. High stall speeds.	**8.** See fault "High Stall Speeds" (on all clutches).
	9. Low stall speeds.	**9.** See fault "Low Stall Speeds" (on all clutches).
	10. Overheating.	**10.** See fault "Overheating."
Low Mainline Pressure.	**1.** Worn pump.	**1.** Check, repair or replace the pump.
	2. Blocked suction strainer.	**2.** Clean suction strainer.
	3. Pressure maintaining valve sticking or leaking.	**3.** Free sticking valve or replace valve.
	4. Foaming oil.	**4.** Internal leakage (cored passages) - inspect transmission. Dirty suction strainer - clean strainer. High oil level - drain to proper level. Incorrect grade of oil - drain and refill with correct oil.
High Stall Speed (on all clutches).	**1.** Damaged torque converter blades.	**1.** Check, repair or replace the torque converter.
	2. Clutches slipping clutch friction/ counter.	**2.** Remove, inspect and install new plates.
	3. Internal leakage.	**3.** Check internal passages and casing for porosity.
Low Stall Speeds (on all clutches).	**1.** Poor engine condition.	**1.** Check and repair engine.
	2. Torque converter reaction member clutch slipping.	**2.** Check and repair the torque converter.

Problem	Possible Cause	Remedy
Low Converter Out Pressure.	**1.** Low mainline pressure.	**1.** See fault “Low Mainline Pressure.”
	2. Converter internal leakage.	**2.** Check and replace the torque converter.
	3. Converter relief valve faulty.	**3.** Check and replace the relief valve.
Low Pump Flow.	**1.** Low oil level.	**1.** Add oil to transmission.
	2. Blocked suction strainer.	**2.** Clean suction strainer.
High Converter Out Pressure.	**1.** Oil cooler/lines blockage.	**1.** Clean cooler, remove blockage.
Low Lubrication Pressure.	**1.** Low mainline pressure.	**1.** See fault “Low Mainline Pressure.”
	2. Oil cooler/lines blockage.	**2.** Clean cooler, remove blockage.
	3. Ruptured lubrication lines.	**3.** Repair line.
	4. Converter internal leakage.	**4.** Check and replace the torque converter.
	5. Converter relief valve faulty.	**5.** Check, repair or replace the relief valve.
Overheating.	**1.** Low oil level.	**1.** Add oil to transmission.
	2. High oil level.	**2.** Drain oil to correct level.
	3. Trapped or kinked hoses in cooler system.	**3.** Repair or replace hoses.
	4. Low converter out pressure relief valve.	**4.** Repair or replace the torque converter and flow rate.
	5. Oil cooler blockage.	**5.** Clean the oil cooler.
	6. Operating in wrong gear ranges.	**6.** Select correct gears to suit working conditions.
	7. Engine cooling system overheating.	**7.** Find and repair engine cooling problems.
	8. Foaming oil.	**8.** See fault “Low Mainline Pressure.”
	9. Clutch pistons sticking on return stroke.	**9.** Check and repair clutch piston(s) and seal(s).
	10. Passages on front housing pump mounting face are the wrong depth (indicated with an excessively low pressure and flow on the converter out cooling line).	**10.** Replace front housing (or repair existing housing). a0442  **FIGURE 7-7**
	11. Leakage across pump mounting face and front case.	**11.** Check for damaged surface on both components and loose pump mounting bolts.

7

4WD Electrical Troubleshooting

System Operation

Each powershift transmission is provided with electrical safety locks which inhibit inadvertent operation of the crane while in an unsafe condition.

When the parking brake is ENGAGED the crane is prevented from moving by “dumping” oil in the transmission’s oil system to the internal oil reservoir. No oil is directed to any of the drive mechanisms, thereby inhibiting crane movement. When DISENGAGED the crane will only start when the shift control lever is in the NEUTRAL position.

Change of crane travel direction is accomplished by moving the shift control lever, located on the steering column, from Neutral (center) position up to the FORWARD position or down to the REVERSE position. Change of speed range is accomplished by rotating the shift control handle COUNTERCLOCKWISE to increase the travel speed range or CLOCKWISE to decrease the travel speed range.

Movement of the shift control lever and rotation of the shift control handle energizes combinations of solenoid valves through the ECU, which are connected to two shafts located in the transmission (See Table 7-1).

Transmissions are furnished with six solenoid valves (SV1, SV2, SV3, SV4, SV5 and SV6) See arrangement in Figure 7-8. Two of the solenoid valves control speed ranges while the remaining four control speed and the direction of travel.

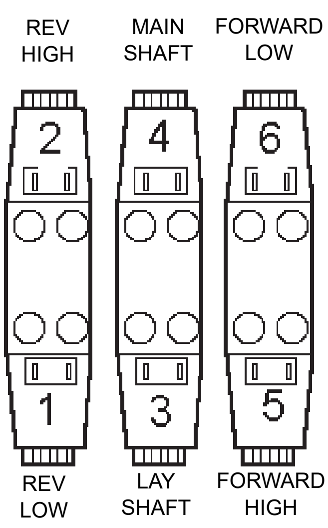


FIGURE 7-8

The solenoids are controlled by the transmission Electronic Control Unit (ECU) and are connected through the wire harness.

Table 7-1 shows which solenoid valves are energized for the four speeds and two directions of travel.

Table 7-1: Solenoid Valve Energizing Sequence

GEAR	DIRECTION	VALVES
First	Forward	SV6 and SV3
Second	Forward	SV5 and SV3
Third	Forward	SV6 and SV4
Fourth	Forward	SV5 and SV4
First	Reverse	SV1 and SV3
Second	Reverse	SV2 and SV3
Third	Reverse	SV1 and SV4
Fourth	Reverse	SV2 and SV4

Electronic Control Unit (ECU)

The Electronic Control Unit (ECU) is designed to do two things Figure 7-9:

- To control the selection of gears and direction of travel.
- To protect the gearbox from damage due to incorrect use of the controls.

It is a microprocessor controlled unit which is mounted in the battery compartment. A wire harness connects the ECU to the transmission harness, which connects to the solenoids, the oil pressure switch and a speed sensor, on the transmission. A second harness connects the unit to various switches and selectors in the cab.

The unit receives signals from the gear/direction and other switches in the cab and operates the appropriate transmission solenoids accordingly. Built-in software prevents potentially damaging (and dangerous) selections from being made. The control features provided by the ECU software are listed below:

1. **Downshift Inhibit -** prevents too low of a gear being selected for a given speed.
2. **Kickdown -** operated by a button on the shift lever in the cab - changes down a gear (from 2nd, 3rd or 4th) for a period of 6 seconds before reverting to the selected gear.
3. **Reverse Inhibit -** prevents directional changes if the speed is too high.
4. **Neutral Start -** the machine will only start with the shift control handle in neutral, irrespective of gear selection (speed) position.

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View Under Engine Hood at Rear of Crane

FIGURE 7-9

Electrical Troubleshooting Chart

Problem	Possible Cause	Remedy
No drive at engine start up	**1.** Blown ECU fuse. **2.** ECU connector loose.	**1.** Check ECU fuse (also check fuse to shift lever). **2.** Check that connector is mating correctly with ECU.
No drive and continuous warning buzzer.	**1.** Attempting to select drive with parking brake engaged.	**1.** Release parking brake.
No drive.	**1.** Faulty shift control. **2.** Parking brake sticking. **3.** Faulty transmission harness.	**1.** Check control and wiring. **2.** Check parking brake assembly. **3.** Check harness continuity and connector.
Missing gears.	**1.** Faulty solenoid(s). **2.** Faulty shift control. **3.** Low oil pressures.	**1.** Check solenoid(s) and wiring. **2.** Check control and wiring. **3.** Check clutch pack and mainline pressures.
No 4th gear.	**1.** Faulty speed signal.	**1.** Check speed sensor and wiring. **2.** Check speed sensor installation (i.e., distance from transfer case).
Down speed protection does not seem to be working.	**1.** Faulty speed signal.	**1.** Check speed sensor and wiring.
Will not downshift and repeating double beep sounded.	**1.** Speed too high for selected downshift.	**1.** Slow crane with brakes. Deselect downshift.
Lower gear than lever selected.	**1.** Kickdown engaged.	**1.** Check kickdown switch and wiring.
Kickdown will not engage and double beep sounded.	**1.** Speed too high to engage lower gear.	**1.** Slow crane and try kickdown again.
Kickdown not operating.	**1.** Faulty kickdown input.	**1.** Check kickdown switch and wiring.

7

Problem	Possible Cause	Remedy
Machine will not perform a reversal of direction and repeating double beep sounded.	**1.** Speed too high for reversal of direction.	**1.** Slow crane with brakes. Deselect reversal.
Sporadic gear changes.	**1.** Moisture in ECU connectors.	**1.** Check that connector seals are installed and are in good condition.

Finding Electrical Problems

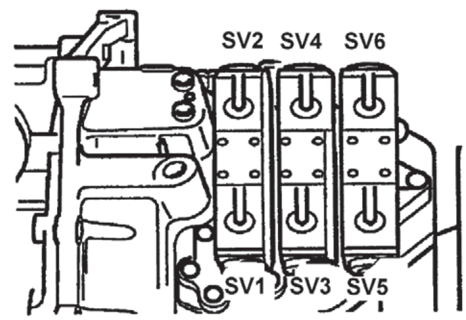
It is possible to carry out a large portion of the ECU diagnostics with basic workshop tools, such as a test lamp and/or voltmeter.

CAUTION

Never check for voltage directly across any pins on the ECU. Internal damage can result from shorting pins.

Checking Solenoid Operation

Gear Selection	Solenoids
Forward 1st	Forward Low (SV6) and Layshaft (SV3)
Forward 2nd	Forward High (SV5) and Layshaft (SV3)
Forward 3rd	Forward Low (SV6) and Mainshaft (SV4)
Forward 4th	Forward High (SV5) and Mainshaft (SV4)
Reverse 1st	Reverse Low (SV1) and Layshaft (SV3)
Reverse 2nd	Reverse High (SV2) and Layshaft (SV3)
Reverse 3rd	Reverse Low (SV1) and Mainshaft (SV4)
Reverse 4th	Reverse High (SV2) and Mainshaft (SV4)



SV1Reverse Low
SV2Reverse High
SV3Layshaft
SV4Main Shaft
SV5Forward High
SV6Forward Low

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FIGURE 7-10

The correct operation can be confirmed as follows:

1. Chock the wheels.
2. Disable the crane neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located under the instrument panel Figure 7-11.

Neutral Start Relay

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View Under Left End of Instrument Panel

FIGURE 7-11

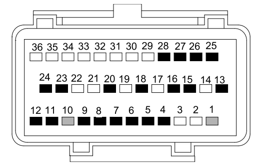
3. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
4. Select the desired gear on the shifter control lever.
5. Identify the two solenoids which give the required gear Figure 7-10.
6. Check the magnetic attraction on the ends of the solenoid using a feeler gauge or small screwdriver.
7. If solenoid(s) are not being energized, check that they are receiving power.
8. If the wrong solenoids are being energized for the gear selection check the wire harness for proper connections.
9. If the solenoids are being energized correctly and the problem persists, the problem may be in the transmission itself or a stuck spool in the solenoid.

If the problem seems to be intermittent (e.g. transmission dropping to neutral), select a gear and place a small washer on the ends of the energized solenoids. The washers will be held in place by the magnetic attraction. Drive the crane around without changing gear or direction. If the problem reappears examine the washers. If one or both of the washers have dropped off, it is a good indication that there is an electrical problem. In this case, examine the wire harness and ECU further. If both washers are still in place the problem lies elsewhere (possibly in the transmission itself).

Table 7-2: Instrument Panel Wire Harness Check

Key

✔ Full Battery Charge
– No voltage measured with key ON
NC Pin not connected



Pin No.	Function	Forward Gears				Reverse Gears			
		F1	F2	F3	F4	R1	R2	R3	R4
1	Jumps To 1	–	–	–	–	–	–	–	–
2	NC								
3	NC								
4	Reverse	–	–	–	–	✔	✔	✔	✔
5	4th Gear	–	–	–	✔	–	–	–	✔
6	Kickdown	–	–	–	–	–	–	–	–
7	2nd Gear	–	✔	–	–	–	✔	–	–
8	Parking Brake	–	–	–	–	–	–	–	–
9	Alarm Buzzer	–	–	–	–	–	–	–	–
10	Jumps to 1	–	–	–	–	–	–	–	–
11	GND	–	–	–	–	–	–	–	–
12	GND	–	–	–	–	–	–	–	–
13	Low Oil Pressure Switch	✔	✔	✔	✔	✔	✔	✔	✔
14	NC								
15	3rd Gear	–	–	✔	✔	–	–	✔	✔
16	Forward	✔	✔	✔	✔	–	–	–	–
17	NC								
18	1st Gear	✔	–	–	–	✔	–	–	–
19	NC								
20	Neutral	–	–	–	–	–	–	–	–
21	NC								
22	NC								
23	+12V	✔	✔	✔	✔	✔	✔	✔	✔
24	+12V	✔	✔	✔	✔	✔	✔	✔	✔
25	GRN Psion	Factory Use Only							
26	RX Psion	Factory Use Only							
27	TX Psion	Factory Use Only							
28	CTS Psion	Factory Use Only							
29	NC								
30	NC								
31	NC								
32	NC								
33	NC								
34	NC								
35	NC								
36	NC								

1. ECU operation - The application of the parking brake de-energizes all solenoids except when in 4th gear (to enable stall testing.

2. ECU Operation - Pressing the kickdown button places the transmission in the next lowest gear, i.e., 4th gear goes to 3rd, 3rd goes to 2nd, 2nd goes to 1st. This lasts until the timer runs out or another gear or direction is selected.

Checking for (+ V) Supply to Solenoids

1. Chock all four tires, or lower all outriggers.
2. Disable the machine neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located under the instrument panel Figure 7-11.
3. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
4. Select the desired gear on the shift control lever.
5. Identify the two solenoids which give the required gear Figure 7-10.
6. Remove the electrical connector on the solenoids relating to gear selection.
7. Test across the connector terminals with a test lamp or voltmeter.

   When using a voltmeter for the above check, the following results can be seen.

   - Energized solenoid (ON) = full battery charge.
   - De-energized solenoid (OFF) = reduced voltage (Typically 5 - 9 V).

This reduced voltage should not be interpreted as a problem. When an electrical load is placed across the terminals this voltage drops to zero.

Checking the Main Frame Harness

NOTE: The following checks should be carried out with the parking brake DISENGAGED.

1. Chock the four tires, or lower all outriggers.
2. Disable the crane neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located under the instrument panel Figure 7-11.
3. Disconnect the main frame wire harness from the ECU. The main frame wire harness connector is the larger of the two ECU connectors.
4. Check the condition of the connector and socket for signs of water entry. Check the condition of the rubber seal in the instrument panel wire harness connector.
5. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
6. Test the voltages on the pins in the harness connector **(DO NOT check the ECU pins)** using a test lamp or voltmeter. Refer to Table 7-2 for pin identification.
7. If the lamp illuminates, or the voltmeter shows full battery charge, where indicated in the table, then the integrity of the harness and power supply to the ECU is verified.

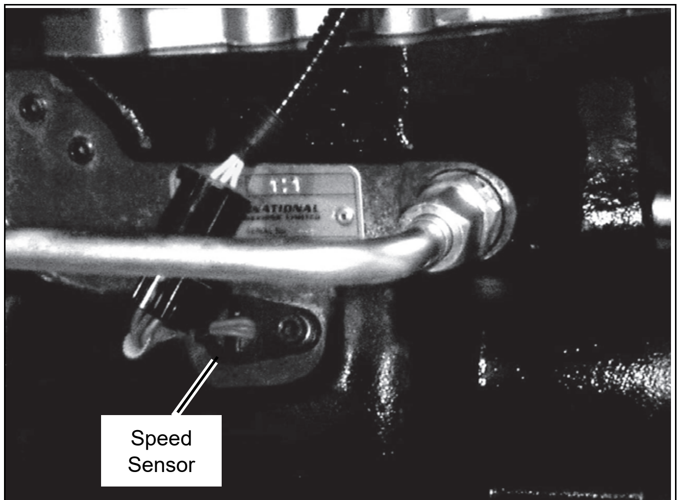
Checking Parking Brake Switch

The correct operation of the parking brake can be checked using either of the following tests:

1. Check continuity between **pin 8** and ground (**pin 11** or **12**) when parking brake is applied.
2. Connect a test lamp between **pin 23** or **24** and **pin 8**. The lamp will illuminate when the parking brake is applied.

Checking Sensor Operation

The speed sensor Figure 7-12 detects the speed of rotation of the output shaft for the transfer gear and sends this information to the ECU.



p0716 **FIGURE 7-12**

The ECU requires a speed signal to determine the operating speed of the crane. Some gear selections will not be permitted if the speed signal is too high (i.e. downshifts).

NOTE: The ECU is designed to inhibit 4th gear selection if the speed sensor fails to send a signal.

A test lamp should be used to check operation of the speed sensor, as follows:

1. Park the crane on a firm, level ground. Engage the parking brake and set the forward/reverse lever to the neutral position.
2. Turn off the engine and remove the ignition key.
3. Disconnect the speed sensor from the wire harness.
4. Remove the speed sensor from the transmission. Place a suitable container underneath to catch the oil.
5. Check that the sensor is working by connecting a volt/ ohm meter to the pins in the speed sensor connector

and checking the voltage reading. Connect the positive (+) meter lead to the pin for the RED wire and the negative (-) meter lead to the pin for the BLUE wire. Move a piece of metal in front of the sensor. When the metal passes the front of the sensor, the meter should be registering 12 VDC. If it does not register 12 VDC, replace the speed sensor.

6. While the sensor is removed, check the sensor for damage.
7. If the sensor is working properly, the problem is most likely in the harness itself. Repair or replace the harness.

Speed Sensor Depth

The speed sensor depth is not adjustable and is set at time of manufacturing during case machining.

Tips On Common Problems

ECU Mounting

If the ECU mounting capscrews are overtightened the ECU and internal components can be damaged. Hand tighten the capscrews only.

Speed Sensors

Generally speed sensors do not fail. Most problems seen are caused by physical damage due to transit, installation or faulty wiring.

Occasionally sensors are out of tolerance or installed incorrectly.

Harnesses

By far the most troublesome cause of ECU inoperability are the wire harnesses. The integrity of the electrical connectors and components is paramount to problem free operation.

It has been noticed that water entry into the shift control assembly can occur if the control is damaged (replace the control). This is particularly important on open cab cranes. It is possible that the water can short internal switches providing false signals to the ECU. If water is trapped in the control it can corrode internal switch contacts making them stick on or off.

Moisture or contamination trapped in connectors is a probable cause of many faults.

However effective an electrical connector, it can not be expected to sustain direct steam cleaning using high pressure hoses. It is recommended that operators should make themselves aware of connectors which are vulnerable to a direct jet from a steam cleaner and avoid continued contact.

Poor ground of electrical components can cause problems. Check that the grounding to the ECU, shift control and other switches is sound.

No 4th Gear

There are two main causes for this problem:

- The speed sensor is inoperable (Check speed sensor and installation).
- Shift control switch contact or wiring problems.

Erratic/Sticking Gears

It is possible that a mechanical issue is the cause of this problem. A known problem is if the transmission has at some point suffered coolant failure and water has entered the transmission. If the original plastic clutch pistons are still being used then there is a risk that they will stick.

Testing

Solenoid Identification

When testing individual clutch pressures page 7-17, it is necessary to isolate the clutch being tested. For instance, to check the layshaft clutch, you could select 1st gear forward. This would energize the layshaft and forward low clutches. Because we only want to check the layshaft clutch pressure and not the forward low clutch pressure, remove the electrical connector to the forward low clutch BEFORE selecting 1st gear.

Use the tables below to determine which solenoid electrical connectors should be removed when pressure-testing individual clutches. Table 7-3 identifies the solenoid connectors and Table 7-4 and Figure 7-13 identifies which clutches are engaged when the various gears are selected.

NOTE: Travel directions as described are the actual travel directions of the crane.

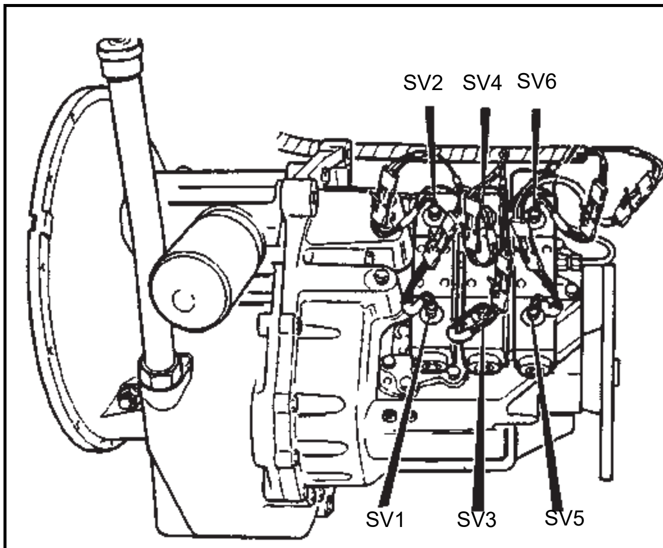


FIGURE 7-13

Table 7-3: Solenoid Descriptions

Item	Solenoid Description
SV1	Reverse Low
SV2	Reverse High
SV3	Layshaft
SV4	Mainshaft
SV5	Forward High
SV6	Forward Low

Table 7-4: Solenoid Valve Energizing Sequence

Gear	Direction	Clutches Engaged Solenoids
First	Forward	Forward Low & Layshaft SV6 and SV3
Second	Forward	Forward High & Layshaft SV5 and SV3
Third	Forward	Forward Low & Mainshaft SV6 and SV4 (SV4 only used on six solenoid transmissions)
Fourth	Forward	Forward High & Mainshaft SV5 and SV4 (SV4 only used on six solenoid transmissions)
First	Reverse	Reverse Low & Layshaft SV3 and SV1
Second	Reverse	Reverse High & Layshaft SV3 and SV2
Third	Reverse	Reverse Low & Mainshaft SV4 and SV1
Fourth	Reverse	Reverse High & Mainshaft SV4 and SV2

Test for Clutch Leakage

WARNING

DO NOT go under the crane with the engine running. Turn off the engine, apply the parking brake, chock the wheels and remove the ignition key before going underneath the crane.

Isolating A Suspect Clutch

Stop the engine, connect a 0-20 bar (0-300 psi) pressure gauge to the test connector A Figure 7-14 (mainline pressure test point).

Make sure that both sides of all four wheels are chocked. Apply the foot brake and the parking brake.

Start the engine and run at 1000 rpm. Engage 1st gear forward. Record the pressure reading. Repeat the test for all rear ratios in forward drive and record the pressure readings as shown below.

Example Only:

Gear Selected	Ratio Clutch	Mainshaft or Layshaft Clutch	PSI	Bar
First	Forward Low	Layshaft	140	9.62
Second	Forward High	Layshaft	125	8.62
Third	Forward Low	Mainshaft	140	9.65
Fourth	Forward High	Mainshaft	125	8.62

Readings should not vary between clutches by more than 0.7 bar (10 psi). In the example shown, we can see that pressure is low when 2nd and 4th gear forward is selected, indicating clutch leakage.

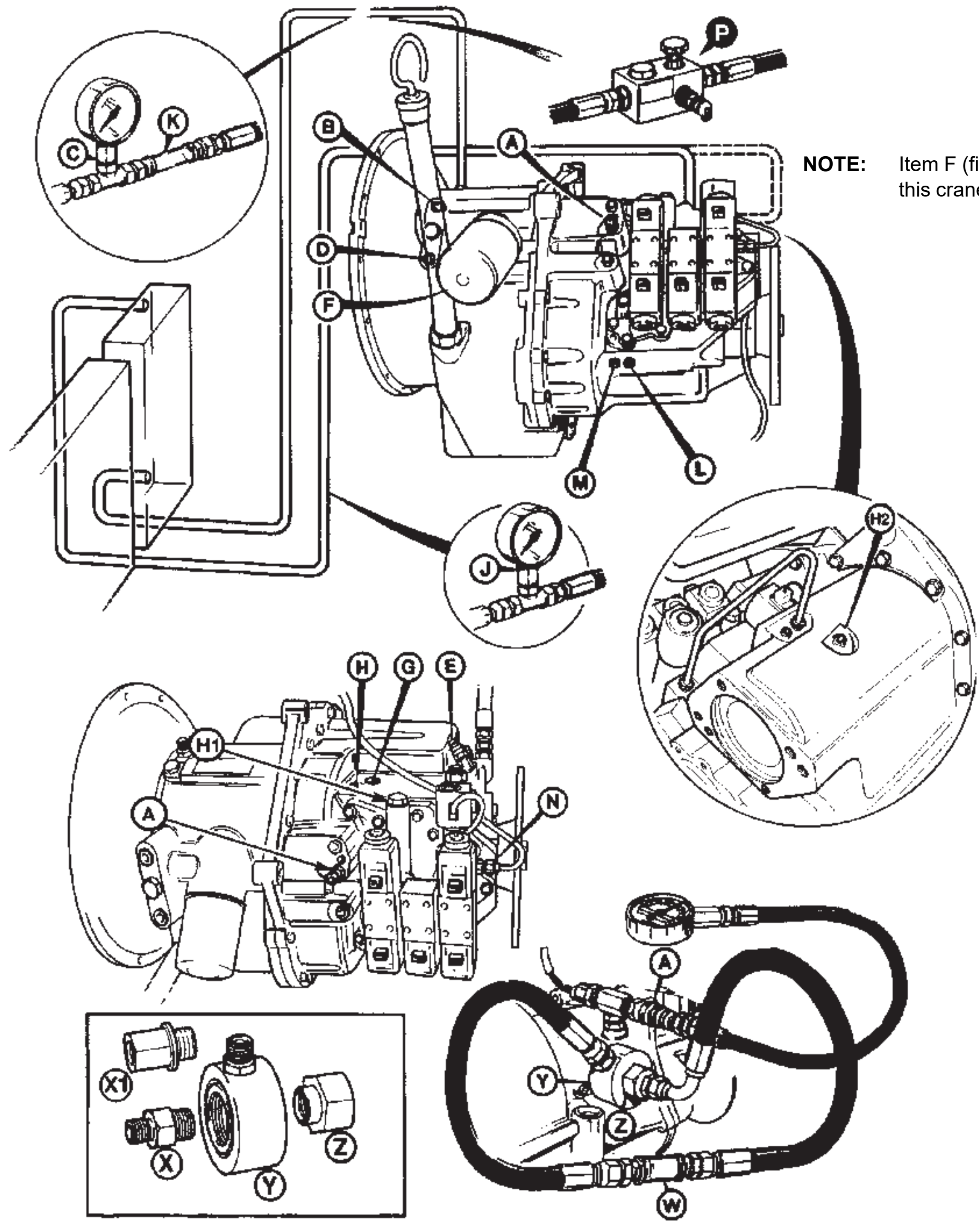
From the example you can see that the forward clutch high is used for selection of both 2nd and 4th gear forward. We know from the table that the mainshaft and layshaft clutches are working normally (1st and 3rd gear selection shown normal operating pressures). So it can be assumed that the forward high clutch is leaking.

We can now confirm the forward reverse clutch is leaking by completing an “Individual Clutch Leakage Test.”

NOTE: Repeat the above procedure using reverse ratios if necessary.

Individual Clutch Leakage Test

In the following procedures the forward high clutch is tested, therefore, in Step 2 a pressure gauge is connected to the forward high clutch test point.



NOTE: Item F (filter) is remote mounted on this crane.

TEST POINTS

A - Mainline Pressure
B - Converter inlet/converter relief valve pressure
C - Converter outlet pressure
D - Mainshaft clutch pressure
E - Layshaft clutch pressure
F - Pump flow (remove filter and fit adapters)
G - Reverse high ratio clutch pressure
H - Reverse low ratio clutch pressure
J - Lubrication Pressure
K - Cooler flow (flowmeter in line from cooler to transmission)
L - Forward high ratio clutch pressure
M - Forward low ratio clutch pressure
N - 5- wheel drive clutch pressure
P - Load valve

a2279

FIGURE 7-14

When testing other suspect clutches, connect a gauge to the relevant suspect clutch pressure test point. See Figure 7-14 for position of individual clutch pressure test points. Because the forward high clutch is suspect, a gear must be selected that will use the forward high clutch, in this instance 2nd gear forward.

1. Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to test connector **A**, Figure 7-14 (mainline pressure test point).
2. Connect a 0-20 bar (0-300 psi) pressure gauge to test connector **L** (forward high ratio clutch test point).

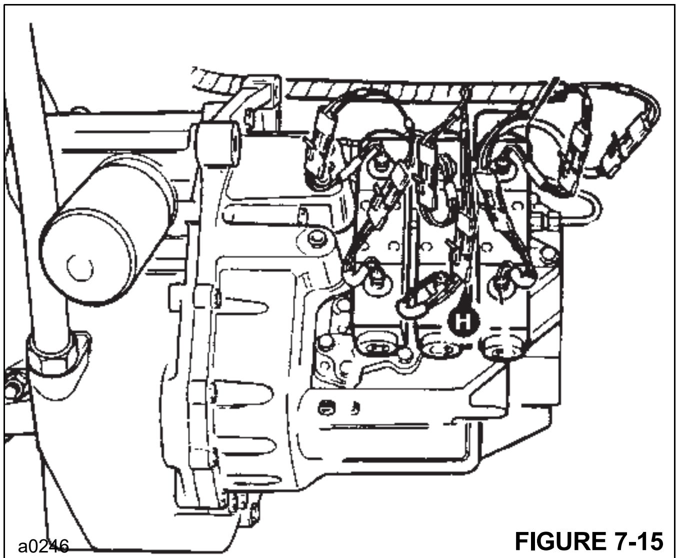


FIGURE 7-15

3. Remove the layshaft clutch solenoid feed connector **H**, Figure 7-15. This ensures only the forward high clutch is energized when 2nd gear forward is selected.

NOTE: See Figure 7-14 for identification and position of solenoid feed connectors when testing other suspect clutches.

4. Make sure that both sides of all four wheels are chocked. Apply foot brake and parking brake.
5. Start the engine and run at 1000 rpm, select 2nd gear forward. Note the pressure readings on both gauges, which should not vary more than 0.7 bar (10 psi). If the difference on the gauges is greater than 0.7 bar (10 psi) do the following:
   a. Stop the engine and interchange the gauges.
   b. Start the engine and run at 1000 rpm. Select 2nd gear forward. If the difference on the gauges is still greater than 0.7 bar (10 psi), service the forward high clutch.
   c. If after interchanging the gauges, the readings are different than in step 4, have the gauges calibrated and repeat the test procedure.

Converter Stall Test

NOTE: Engine speed must be recorded during this test. This machine is not equipped with a tachometer. One must be installed to perform this test.

CAUTION

DO NOT stall the converter longer than 10 seconds or the transmission fluid will overheat. Make sure that the oil level is correct and at normal operating temperature.

Before completing the following test, remove the transmission dipstick. If there is any sign of smoke emitting from the dipstick tube, **STOP THE TEST IMMEDIATELY** and service the transmission.

1. Ensure that the engine and transmission are at normal working temperatures. Run the engine at maximum speed and check the **No Load Speed (High Idle Specs)**. See Engine Technical Data in the engine operator's manual.
2. Apply the parking brake and the foot brake firmly. If necessary, set the machine against a fixed obstruction.
3. Select 2nd gear forward and run engine at maximum rpm. Record the engine speed from the tachometer. Repeat the test for 3rd gear forward and record the speed reading.
4. Repeat step 3, except this time select 2nd gear reverse and 3rd gear reverse respectively. Record the speed readings.

NOTE: Using 2nd and 3rd gears in forward and reverse will ensure that all clutches are energized during the test.

5. All recorded readings should be as specified in Torque Converter Stall in technical data.

If the engine speed is below the stated figures, either the engine is loosing power and should be serviced/overhauled or the torque converter reaction member clutch is slipping.

To check the engine, select Neutral, open the throttle fully, and raise the booms fully to bring the main relief over relief. The engine speed should fall slightly above the Maximum Governed Speed. If engine speed is correct, the torque converter reaction member is slipping.

If engine speed is higher than the Maximum Governed Speed, check the transmission for clutch slippage or internal leakage. To isolate a suspected clutch, tabulate the recorded readings as shown in the example below.

Gear Selected	Direction Clutch	Mainshaft or Layshaft Clutch	RPM
Second	Forward High	Layshaft	2060
Third	Forward Low	Mainshaft	1990
Second	Reverse High	Layshaft	1985
Third	Reverse Low	Mainshaft	1980

In the example shown, the engine speed is abnormally high when 2nd gear forward is selected, indicating a slipping clutch.

From the example, it is evident that the layshaft clutch is working normally (2nd gear reverse indicates 1985 rpm). Therefore, it follows that the suspect clutch is the forward high. Assuming all other possible faults have been eliminated (see Troubleshooting), this clutch should be serviced.

Pressure and Flow Tests

WARNING

Fine jets of hydraulic oil at high pressure can penetrate the skin. Do not use your hand to check for hydraulic leaks. Do not put your face close to suspected leaks. Hold a piece of cardboard close to suspected leaks and inspect the cardboard for signs of hydraulic oil. If hydraulic oil penetrates your skin, get medical help immediately.

If the machine to be raised has a 4WD transmission installed, make sure all four wheels are off the ground. If only the front or rear tires are raised, the crane could still drive through the wheels on the ground.

Take care when disconnecting hydraulic hoses and fittings. The oil will be hot and could cause burns.

DO NOT go under the crane with the engine running. Turn the engine off, apply the parking brake and remove the ignition key before going underneath the crane.

Before completing any transmission pressure/flow tests, make sure that the oil level is correct and is at normal operating temperature.

Pump Flow

NOTE: Special adapters are required to perform the following test. Contact Product Support.

Stop the engine. Remove the filter adapter from the transmission. Install a special test adapter **X** or **X1** (depending on the filter head adapter) onto the threaded spigot Figure 7-14. Install special test adapter **Y** and secure with adapter **Z**. Connect flowmeter **W**.

Start the engine and run at 1000 rpm. With the transmission in neutral, the flowmeter will show the pump flow. Compare this reading with the pump flow specification on page 7-3. A low reading indicates a worn pump or blocked suction strainer.

Repeat the test and note the gauge reading with the engine running at 2000 rpm.

Stop the engine and remove all test adapters. Install the filter or the adapter.

Mainline Pressure

Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to the test connector **A** Figure 7-14.

Start the engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will show the mainline pressure. Compare this pressure reading with the one listed on page 7-3. Either a faulty pressure maintenance valve or a worn pump can cause a low reading. A high reading may indicate a faulty pressure maintenance valve.

Repeat the test and note gauge reading with engine running at 2000 rpm.

Stop the engine and remove the test gauge.

Converter Out Pressure/Oil Cooler Flow Rate

Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge and flowmeter into the converter out line as shown at **C** and **K** respectively Figure 7-14.

Run the engine at 1000 rpm with the transmission in neutral. The pressure gauge indicates the converter out pressure and the flowmeter indicates the oil cooler flow rate. Compare both readings with the specifications on page 7-3. A blocked oil cooler could cause a high pressure together with a low flow.

Repeat step 2 and note the gauge reading with engine running at 2000 rpm.

Stop the engine, remove the test gauge and flowmeter and install hoses to original position.

Converter In Pressure

1. Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to test point **B** Figure 7-14.
2. Start the engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will show "Converter In Pressure". Compare the gauge reading with the figures listed in the General Technical Data on

page 7-2. A high or low reading could indicate a faulty converter relief valve.

3. Remove the pressure test gauge.

Converter Relief (Safety) Valve Pressure

1. Connect a 0-20 bar (0-300 psi) pressure gauge to test point **B** Figure 7-14.
2. Install a load valve **P** into the converter out line.

NOTE: Make sure the load valve is in the OPEN position (the adjusting knob screwed fully out) before starting the following pressure test. If the load valve is not fully open, damage to the converter seals will occur.

CAUTION

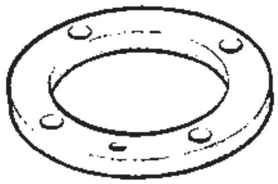
DO NOT allow the pressure to exceed 10.34 bar (150 psi) or damage to the converter seals will occur.

3. Start the engine and run at 1000 rpm. With the transmission in neutral, slowly screw down the load valve **P** while observing the gauge reading which should rise to the converter relief valve setting specified on page 7-2.
4. If the reading is higher than specified the converter relief valve is faulty. A low reading indicates a leaking pump seal or faulty converter relief valve.
5. Stop the engine and remove the test gauges and install hoses to original position.

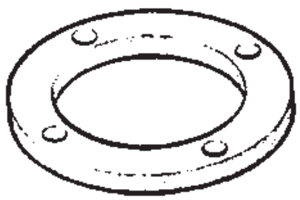
Lubricating Pressure

1. Stop the engine and connect a suitable pressure gauge into the return line from the oil cooler to the transmission as shown in **J** Figure 7-14.
2. Start the engine and run at 1000 rpm. With the transmission in neutral, the pressure gauge will indicate the lubricating pressure. Compare the pressure reading with the specification on page 7-2.
3. Repeat step 2 and note the pressure with the engine running at 2000 rpm.
4. Stop the engine and remove the pressure gauge.

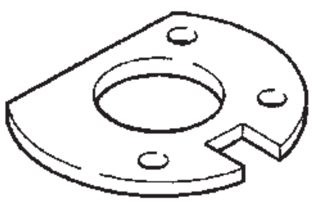
4WD Transmission Repair Tools



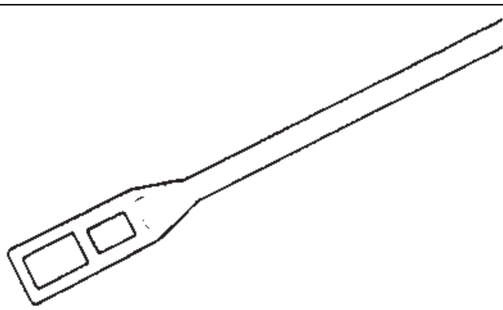
a0254 End Float Setting Tool **FIGURE 7-16**



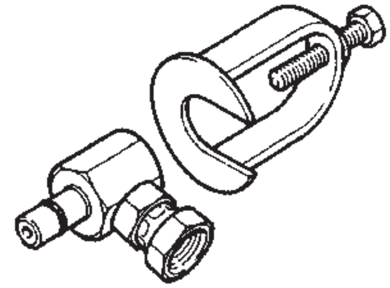
a0249 Reverse Clutch End Float Setting Tool **FIGURE 7-17**



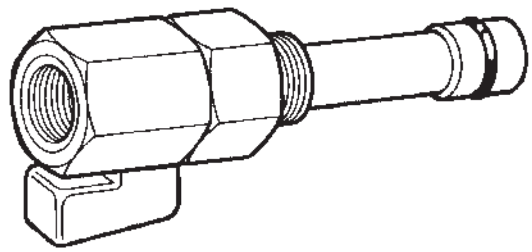
a1397 End Float Setting Tool **FIGURE 7-18**



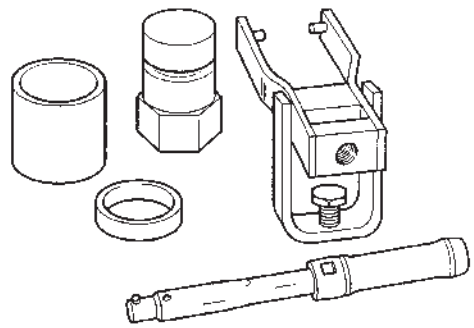
a0180 Drive Coupling Spanner for Yoke Couplings **FIGURE 7-19**



a1518 4WD Pressure Test Kit **FIGURE 7-20**



a1411 Mainshaft Air Line Adapter **FIGURE 7-21**

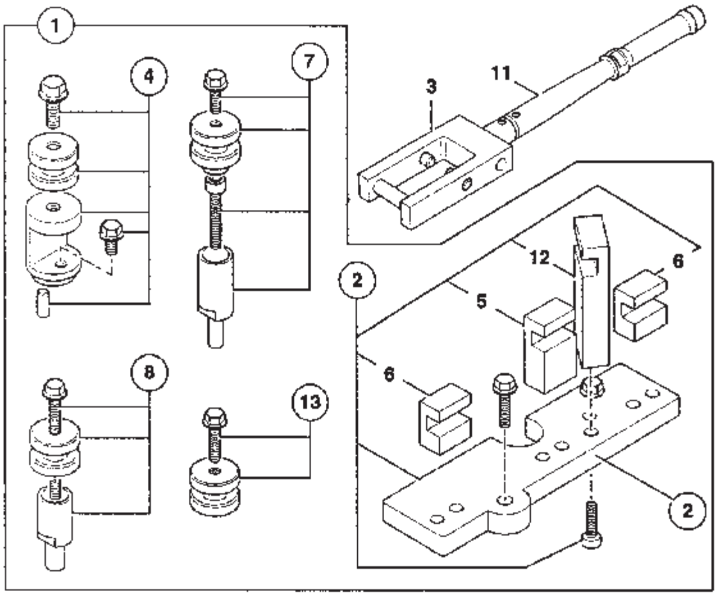


Seal
Stake Nut
Setting Tool Kit
Torque Wrench
Spacer Kit (Includes spacers listed below:

Spacer - 12,75 mm	Spacer - 13,40 mm
Spacer - 13,80mm	Spacer - 13,45 mm
Spacer - 13,85 mm	Spacer - 13,50 mm
Spacer - 13,90 mm	Spacer - 13,55 mm
Spacer - 13,95 mm	Spacer - 13,60 mm
Spacer - 13,00 mm	Spacer - 13,65 mm
Spacer - 13,05 mm	Spacer - 13,70 mm
Spacer - 13,10 mm	Spacer - 13,75 mm
Spacer - 13,15 mm	Spacer - 13,80 mm
Spacer - 13,20 mm	Spacer - 13,85 mm
Spacer - 13,25 mm	Spacer - 13,90 mm
Spacer - 13,30 mm	Spacer - 13,95 mm
Spacer - 13,35 mm	Spacer - 14,00 mm

a1386 Setting Tool Kit **FIGURE 7-22**

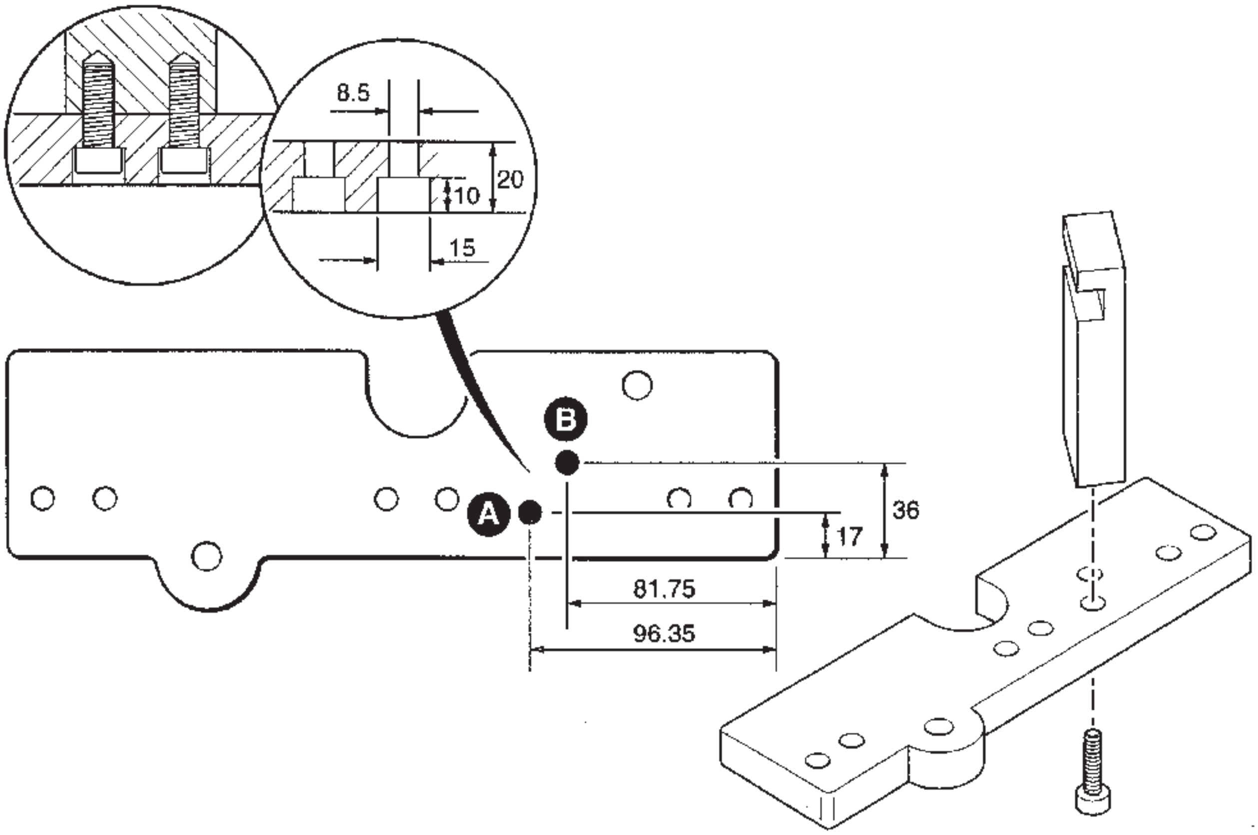
1. End Play Checking Kit (Includes Items 2 - 13)
2. Base Plate and Bolts
3. Yoke
4. Mainshaft Adapter
5. Pillar (20,75 mm)
6. Pillar (45,75 mm)
7. Setting Body (54 mm)
8. Setting Body (64 mm)
9. Setting Tool (12 mm)
10. Setting Tool (10 mm)
11. Setting Wrench - 0-100 Nm (0 - 74 lb-ft
12* Pillar, Input Shaft
13* Setting Body



Torque Converter Removal/Installation

a1398

* If these items are not in your kit, they may be ordered separately, but base plate **2** will have to be drilled to secure item **12**, see **A** and **B.** Dimensions in mm.



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End Play Checking Kit

FIGURE 7-23

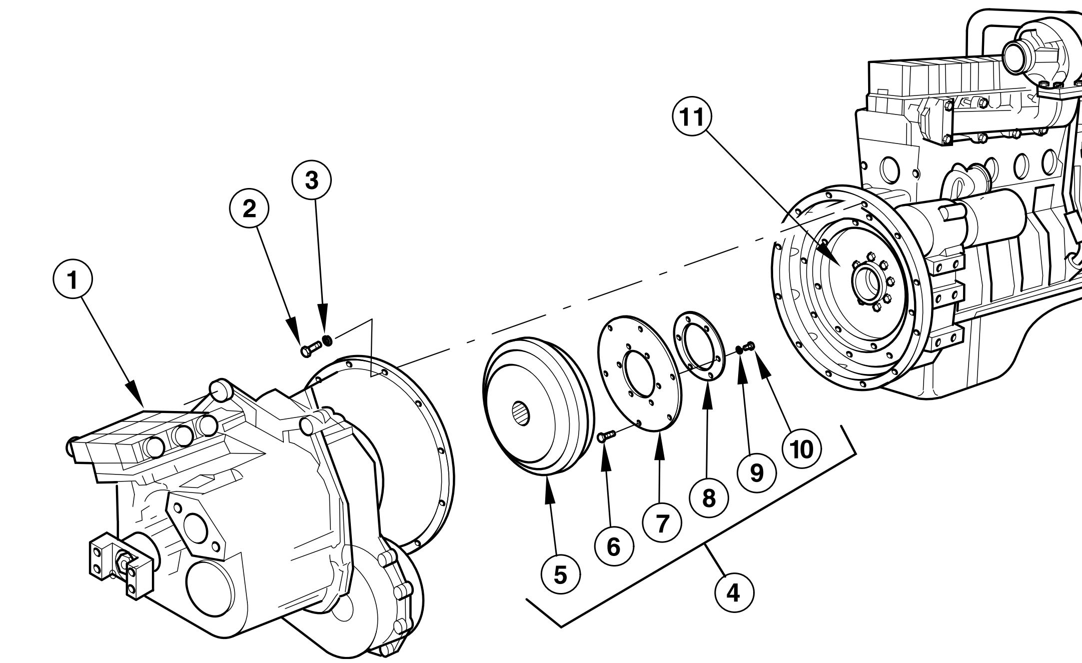


FIGURE 7-24

Servicing Torque Converter

Removal

1. Remove complete power unit. See Section 6.
2. Fasten engine to an engine stand.
3. Use a hoist and chains to support the weight of the transmission, which must be removed to gain access to the torque converter.

CAUTION

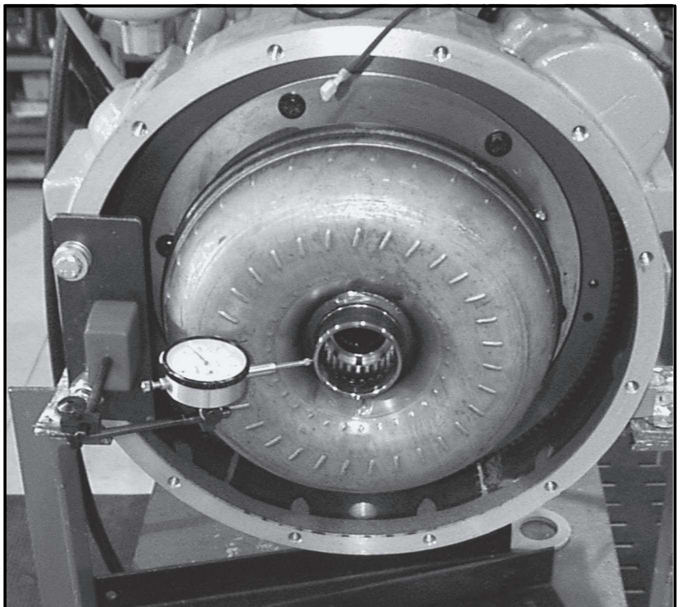
The transmission is very heavy and could cause personal injury if not supported properly when it is removed.

4. Remove the 12 bolts **2** Figure 7-24 and lockwashers **3** that fasten the transmission/torque converter housing **1** to the engine flywheel housing **11**. Remove the transmission and torque converter assembly **4** and place in a clean, work area where the torque converter can be removed. It is recommended that the transmission be mounted in the service fixture.
5. The torque converter assembly **4** is fastened to the engine flywheel **11** through a drive plate **7**. Remove the six drive plate mounting screws **6** to remove the torque converter and drive plate.
6. Remove the six bolts **10** and lockwashers **9** securing torque converter **5** to drive plate **7** and remove the drive plate and its reinforcement **8**.
7. Replace the complete torque converter. The parts are not serviced separately. Replace drive plate if there is distortion or damage.

NOTE: It is recommended that the torque converter be replaced any time system contamination occurs. It is not possible to completely clean the torque converter by flushing to remove the contamination. Replacement of the complete assembly is necessary to prevent early failure of other components in the system.

Installation

1. Assemble the drive plate **7** Figure 7-24 and reinforcing plate **8** to the torque converter **5** using bolts **10** and lockwashers **9**. Apply Loctite® 243 to threads of bolts **10** and tighten to a torque of 40 Nm (30 lb-ft).
2. Clean the pilot bore of the engine flywheel.



p0162 Checking Centering FIGURE 7-25

3. Install the torque converter and drive plate assembly **4** to the engine flywheel using six bolts **6**. Check the alignment of the torque converter to the flywheel using a dial indicator held in position against the converter hub Figure 7-25. The torque converter must be centered on the flywheel within 0.15 mm (0.006 in).

NOTE: If the alignment should exceed 0.15 mm (0.006 in), remove the torque converter and check the spline shaft for burrs, remove the drive shaft and rotate it 180° on the torque converter and repeat step 3.

4. Apply Loctite® 243 to drive plate mounting bolts **6** and tighten to a torque of 19 Nm (14 lb-ft).
5. Clean and lubricate the splines of the transmission input shaft.
6. Align the transmission input shaft splines with the splines of the torque converter impeller and assemble the transmission/torque converter housing to engine flywheel housing. Install the 12 bolts and lockwashers and tighten to proper torque of 39 Nm (28 lb-ft).
7. Install the power unit into the crane.
8. Connect all removed hydraulic lines, electrical harnesses, cables, etc. Fill the transmission with recommended transmission fluid. Refer to Section 5, Preventive Maintenance.

TWO-WHEEL DRIVE (2WD) TRANSMISSION

Refer to page 7-2 for Four-Wheel Drive (4WD) Transmission

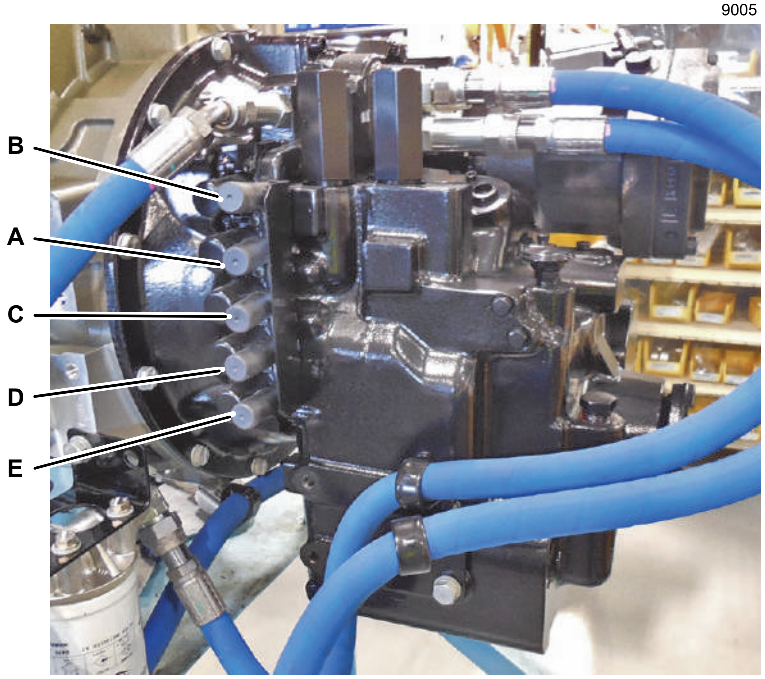
2WD General Technical Data

Description	Electro-hydraulic 4-speed transmission with integral torque converter.
Designation	T12000 Short Drop
Weight (dry)	152 kg (584 lb)
Clutch	Multiple discs, hydraulically actuated, spring released, automatic wear compensation, and no adjustments. The inner clutch discs are friction; the outer, steel.
Charge Pump	14 gpm at 2000 rpm
Pump Drive	High Capacity (0.97:1) SAE B Drive, 2-Bolt Mounting Rotation is Same Direction as Input
Gear Ratios:	
Forward/Reverse 1st	4.47:1
Forward/Reverse 2nd	2.05.1
Forward/Reverse 3rd	1.00:1
Forward 4th	0.56:1
Output Rotation	in Forward is Opposite of Input
Torque Converter	SAE #3 Dry Mounting Wheel Group: 12.25 Stall Ratio: 2.78 PA Curve: 269

Controls	Five 12V Solenoids
Transmission Outlet Pressure	with outlet oil temperature at 82-93° C (180-200°F) and transmission in **NEUTRAL** — Minimum pressure: 172 kPa (25 psi) at 2000 rpm Maximum pressure: 689 kPa (100 psi) with engine operating at no-load governed speed
Clutch Pressure	1276 kPa (185 psi) minimum with parking brake applied (see NOTE), oil temperature at 82-93°C (180-200°F) and engine speed at idle. All clutch pressures must be equal to within 34 kPa (5 psi). If the pressure in any clutch varies more than specified, repair the clutch. Normal operating pressure: 1655-1931 kPa (240-280 psi) at 2000 rpm NOTE: Always use parking brake when making clutch pressure checks. Using the service brakes can result in fault readings.

2WD Solenoid Valve Engagement

See Figure 7-26



Solenoid Engagement						
Direction	Gear	**A**	**B**	**C**	**D**	**E**
Forward	1	X			X	X
	2	X				X
	3	X				
	4	X		X		
Reverse	1		X		X	X
	2		X			X
	3		X			

FIGURE 7-26

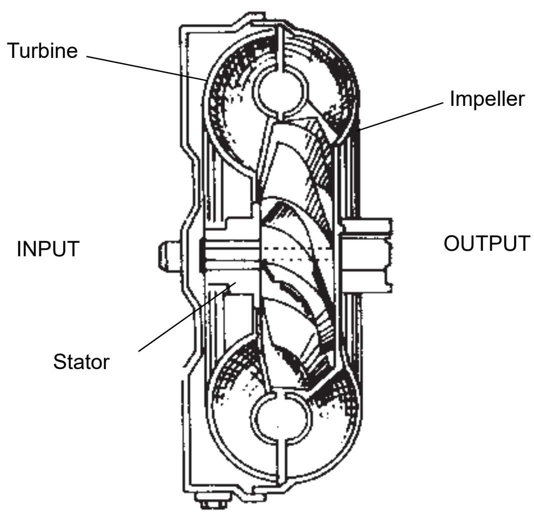
2WD Transmission Description of Operation

Torque Converter

The torque converter Figure 7-27 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.



a0230 Torque Converter Cross-Section FIGURE 7-27

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.

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

With the engine running, the transmission-charging pump draws oil from the transmission sump through the oil suction tube and screen and directs it through the pressure regulating valve and oil filter.

The pressure-regulating valve maintains pressure to the transmission solenoid valves for actuating the direction and speed clutches. This regulator valve consists of a hardened valve spool operating in a closely fitted bore. The valve spool is spring loaded to hold the valve in the closed position. When a specific pressure is achieved, the valve spool works against the spring until an exhaust port is exposed along the side of the bore.

This sequence of events provides the proper system pressure. This requires a small portion of the total volume of oil used in the system.

The remaining volume of oil is directed out through an external oil cooler and into the lube inlet port. From the lube inlet port oil goes through the forward-reverse shaft, lubricating the forward and reverse clutches, with the remainder going to the torque converter. After entering the converter, the oil is directed through the converter blade cavity and exits in the passage between the turbine shaft and impeller hub. The oil then lubes the impeller hub bearing with the remainder going to the 3rd-4th clutch shaft and 1st-2nd clutch shaft to lubricate those clutches and shaft bearings. The oil then gravity drains to the transmission sump.

The hydraulic torque converter consists basically of three elements and their related parts to multiply engine torque. The engine power is transmitted from the engine flywheel to the impeller element through the impeller cover. This element is the pump portion of the hydraulic torque converter and is the primary component which starts the oil flowing to the other components which results in torque multiplication. This element can be compared to a centrifugal pump in that it picks up fluid at its center and discharges at its outer diameter.

The torque converter turbine is mounted opposite the impeller and is connected to the output shaft of the torque converter. This element receives fluid at its outer diameter and discharges at its center. Fluid directed by the impeller out into the particular design of blading in the turbine and reaction member is the means by which the hydraulic torque converter multiplies torque.

The reaction member of the torque converter is located between and at the center of the inner diameters of the impeller and turbine elements. Its function is to take the fluid which is exhausting from the inner portion of the turbine and change its direction to allow correct entry for recirculation into the impeller element.

The torque converter will multiply engine torque to its designed maximum multiplication ratio when the output shaft is at zero R.P.M. Therefore, we can say that as the output shaft is decreasing in speed the torque multiplication is increasing.

With the engine running and the electric shift control lever in neutral position, oil pressure from the regulating valve is blocked at the solenoid control valves, and the transmission is in neutral. Movement of the control lever will energize the forward or reverse solenoid valves and selected range (gear) solenoid, directing oil under pressure to the selected direction and range (gear) clutches.

7

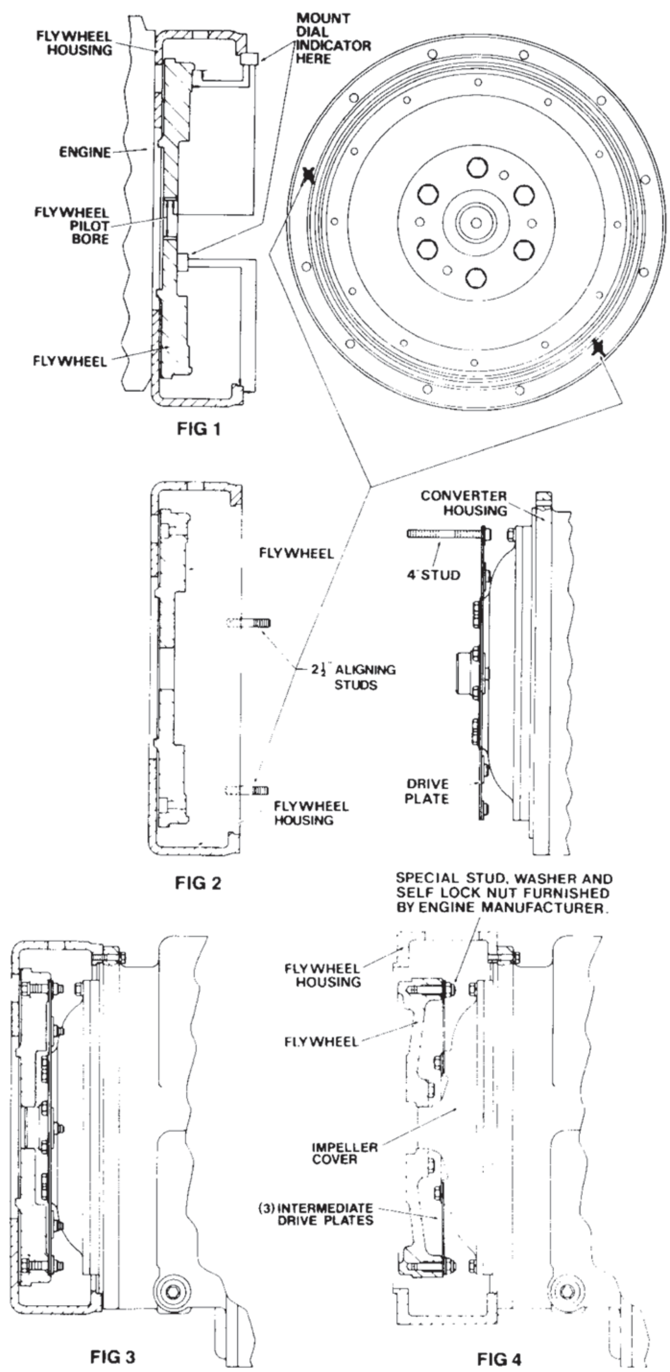
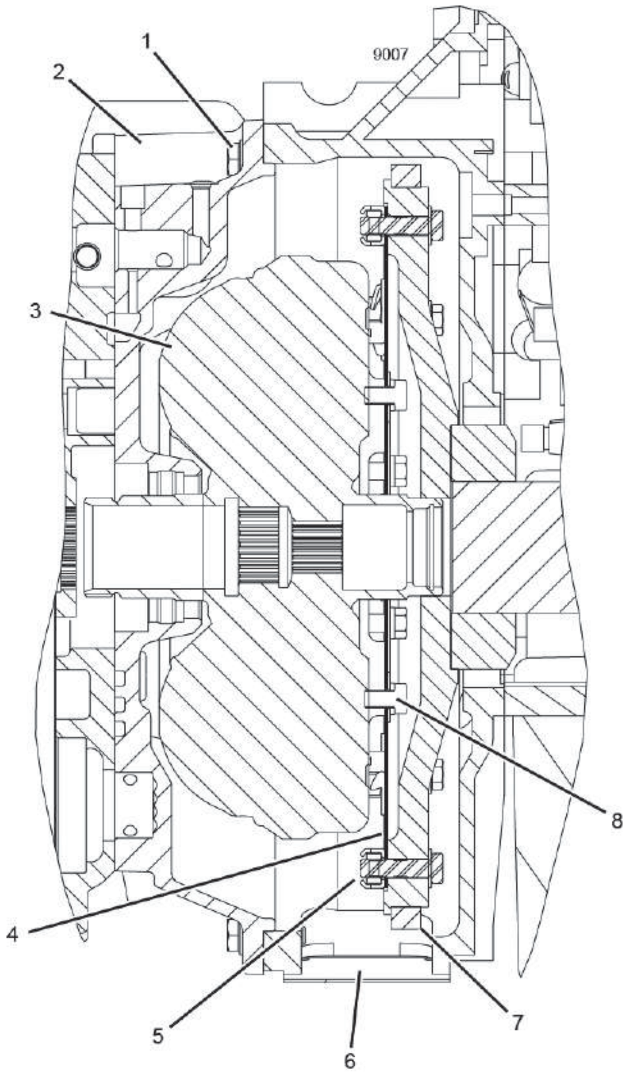


FIGURE 7-28

2WD Transmission to Engine Installation Procedure

See Figure 7-27 and Figure 7-28 for the following procedure.

1. Remove all burrs from the flywheel mounting face and nose pilot bore. Clean drive plate surface with solvent.
2. Check the engine flywheel and housing for conformance to standard SAE No.3 per SAE J927 and J1033 tolerance specifications for pilot bore size, pilot bore run out and mounting face flatness. Measure and record engine crankshaft end play.
3. Install two 63.5 mm (2.50 in) long transmission to flywheel housing guide studs (M10, 8.8) 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 1219 mm (4.00 in) long drive plate locating stud (3/8 in x 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 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 3. Locate the transmission on the flywheel housing. Aligning the drive plate to flywheel and transmission to flywheel housing guide studs, install the transmission to the flywheel housing screws. Tighten the screws to the specified torque. Remove the transmission to engine guide studs. Install the remaining screws and tighten to the specified torque.
6. Remove drive plate locating stud.
7. Install a drive plate attaching screw and washer. Snug the screw but do not tighten it. 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 flywheel to drive plate attaching screws. Snug the screws but do not tighten them. After all eight screws are installed, tighten them to the specified torque. This will require tightening each screw and rotating the engine flywheel until all eight screws have been tightened to the specified torque.
8. Measure engine crankshaft end play after transmission has been completely installed on engine flywheel. This value must be within 0.025 mm (0.001 in) of the end play recorded in step 2.



Item	Description
1	Transmission to Flywheel Housing Screws • Apply Medium Strength Thread Locker • Torque to 39 Nm
2	Transmission
3	Torque Converter
4	Drive Plate
5	Drive Plate to Flywheel Screws with Washers • Apply Medium Strength Thread Locker • Torque to 19-21 ft-lb
6	Access Cover
7	Flywheel
8	Drive Plate to Torque Converter Screws • Apply Medium Strength Thread Locker • Torque to 26-29 ft-lb

FIGURE 7-29

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 fill the transmission with recommended oil:
   - 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 82.2-93.3° C (180-200° F).
   - 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, lint-free 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 magnaflux 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.

2WD Troubleshooting

Problem	Possible Cause	Remedy
Low Clutch Pressure	**1.** Low oil level.	**1.** Fill to proper level.
	2. Clutch pressure regulating valve stuck open.	**2.** Clean valve spool and housing.
	3. Faulty charging pump.	**3.** Replace pump.
	4. Broken or worn clutch shaft or piston sealing rings.	**4.** Replace sealing rings.
	5. Clutch piston bleed valve stuck open.	**5.** Clean bleed valves thoroughly.
Low Charging Pump Output	**1.** Low oil level.	**1.** Fill to proper level.
	2. Suction screen plugged.	**2.** Clean suction pump.
	3. Defective charging pump.	**3.** Replace pump.
Overheating	**1.** Worn oil sealing rings.	**1.** Remove, disassemble, and rebuild converter assembly.
	2. Worn charging pump.	**2.** Replace.
	3. Low oil level.	**3.** Fill to proper level.
	4. Dirty oil cooler.	**4.** Clean cooler.
	5. Restriction in cooler lines.	**5.** Change cooler lines.

Problem	Possible Cause	Remedy
Noisy Converter	**1.** Worn charging pump. **2.** Worn or damaged bearings.	**1.** Replace. **2.** A complete disassembly will be necessary to determine what bearing is faulty.
Lack of Power	**1.** Low engine RPM at converter stall. **2.** See "Overheating" and make same checks.	**1.** Tune engine check governor. **2.** Make corrections as explained in "Overheating."

SECTION 8
AXLES/DRIVE SHAFTS/WHEELS AND TIRES

SECTION CONTENTS

8

DESCRIPTION

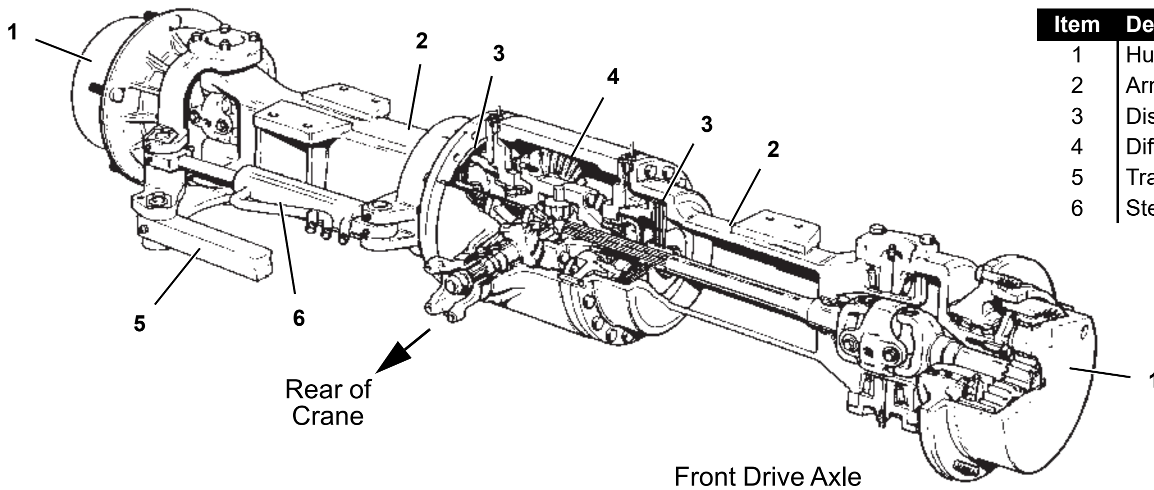
Front Axle

The front drive axle (Figure 8-1) is a rigidly mounted to the carrier frame by eight bolts, washers and nuts.

Rear Axle

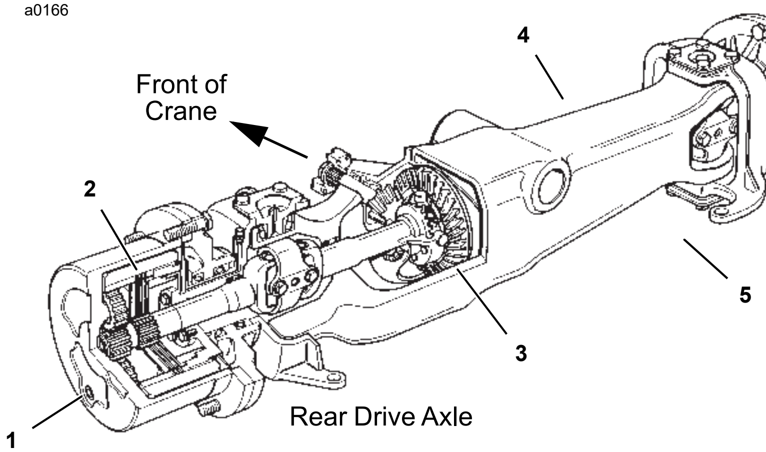
The crane can be equipped either with a rear drive axle or a rear non-drive axle (Figure 8-2).

- The rear drive axle is pin mounted to the carrier frame, allowing it to pivot 1-1/2° in both directions.
- The rear non-drive axle is rigidly mounted to the carrier frame by eight bolts, washers and nuts.

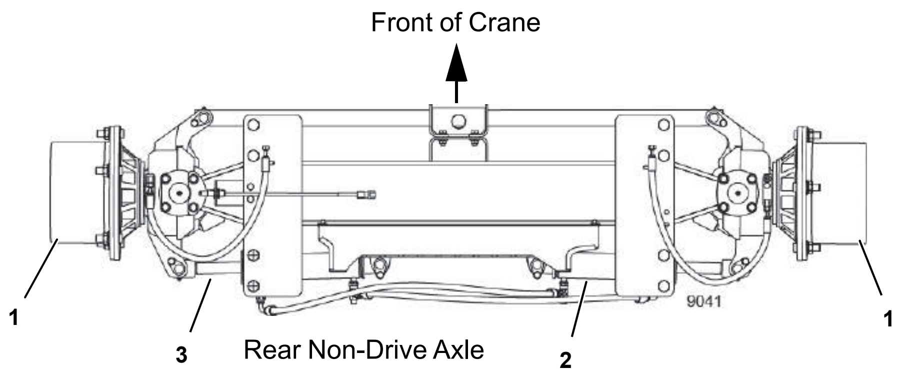


Item	Description
1	Hub
2	Arm
3	Disc Brake
4	Differential
5	Track Rod
6	Steering Cylinder (2)

FIGURE 8-1



Item	Description
1	Hub
2	Disc Brake
3	Differential
4	Track Rod (not shown)
5	Steering Cylinder (2, not shown)



Item	Description
1	Hub with Disc Brake
2	Track Rod (not shown)
3	Steering Cylinder (2, not shown)

FIGURE 8-2

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)	436 kg (961 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 4 Wheel Drive	15.78:1
Overall ratio 2 Wheel Drive	24.98:1
Crownwheel and pinion ratio 4 Wheel Drive	2.92:1
Crownwheel and pinion ratio 2 Wheel Drive	4.63:1
Number of teeth:	
Crownwheel 4 Wheel Drive	38
Crownwheel 2 Wheel Drive	37
Pinion 4 Wheel Drive	13
Pinion 2 Wheel Drive	8

Rear Drive Axle

Type	Spiral bevel input with epicyclic hub reduction
Installation	Center pivot pin mount
Number of steering cylinders	2
Weight (dry, with no steering cylinders and without wheels)	525 kg (1157 lb) approximate
Hub brakes	3 plate (each hub) standard retraction type.
Input type	1480 half yoke
Oscillation (Both Directions)	1-1/2°
Toe-in	0°
Caster angle	0°
Camber angle	1°
King pin inclination	0°
Hub reduction	5.4:1
Overall ratio	24.975:1
Crownwheel and pinion ratio	4.625:1
Number of teeth:	
Crownwheel	37
Pinion	8

8

Rear Non-Drive Axle

Installation	Rigid pad mount
Number of steering cylinders	2
Weight (dry, with no steering cylinders and without wheels)	452 kg (996 lb) approximate
Hub brakes	3 plate (each hub) 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

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. Remove the drive shaft from the axle. See Front Axle Drive Shaft Removal on page 8-33.
3. Disconnect parking brake hydraulic line from the parking brake. Plug and cap hose and fitting.
4. Disconnect the hydraulic hoses to the steering cylinders. Plug and cap hose and fitting.
5. Disconnect the brake lines from the front axle. Plug and cap hose and fitting.
6. Disconnect the electric cables from the receptacles on the axle: brake pressure switch and steering proximity switch.
7. Support the axle on a trolley jack.
8. Loosen and remove the eight mounting bolts and nuts.
9. Remove the axle from the machine.

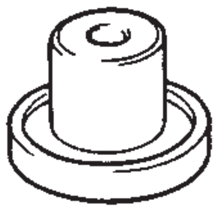
Installation

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 in Section 1 of this manual.
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 electric cables to the receptacles on the axle: brake pressure switch and steering proximity switch.
8. Install the front drive shaft. See Front Axle Drive Shaft Installation on page 8-34.
9. Bleed the air from both service and parking brake system. See Section 9 of this manual.
10. Bleed the air from the steering circuit. See Section 10 of this manual.
11. Install the wheels to the axle. Lower the crane. Torque the lug nuts to 680 Nm (500 lb-ft).

Special Tools

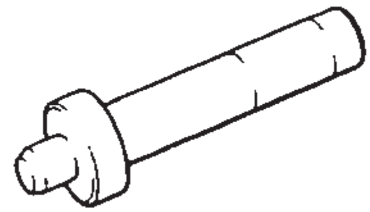
To completely disassemble and assemble the front drive axle, special service tools are required. Unless you have these or similar tools DO NOT service the axle.

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



a0167

Driver - Crownwheel Bearing and Differential Bearing Cones

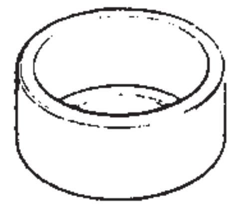


a0174

Bearing Pad Driver

a0168

Adapter - Steer/Drive Axle Pinion Bearing Cone

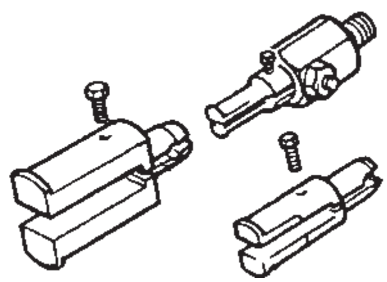


a0171

Measuring Cup - Pinion Head Bearing

a0169

Spacer - Pinion Bearing Pre-load



a0172

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

0173

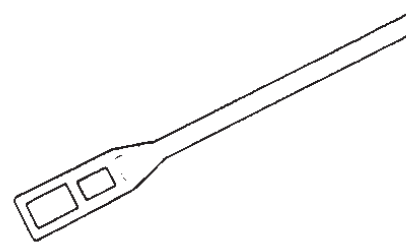
17 mm A/F x 3/4 in. square drive

a0175

Driver - Pinion Head Bearing Cup

a0179

Impulse Extractor Set for Hub Bearing Seals



a0180

Drive Coupling Spanner for Axle York Couplings

FIGURE 8-3

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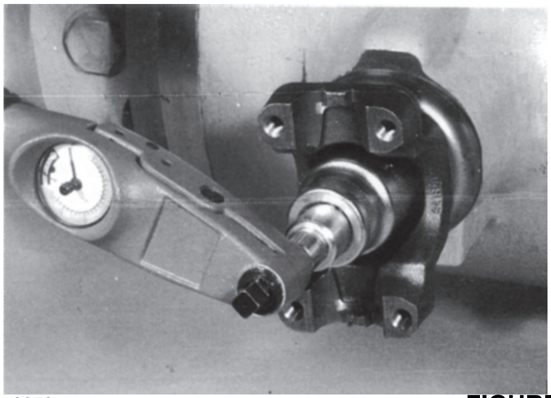
Replacing the Pinion Oil Seal

WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

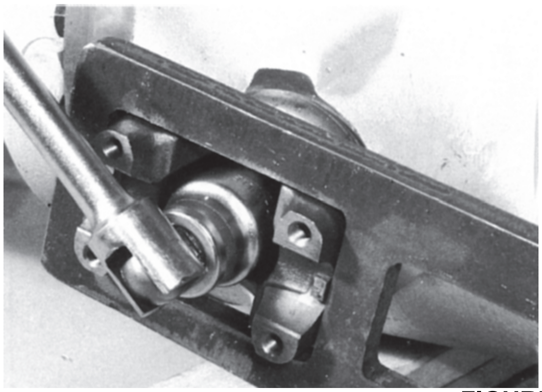
1. Remove the wheel and tires and disconnect the axle drive shaft. Measure the axle rolling torque and record the reading Figure 8-4.



p0078 **FIGURE 8-4**

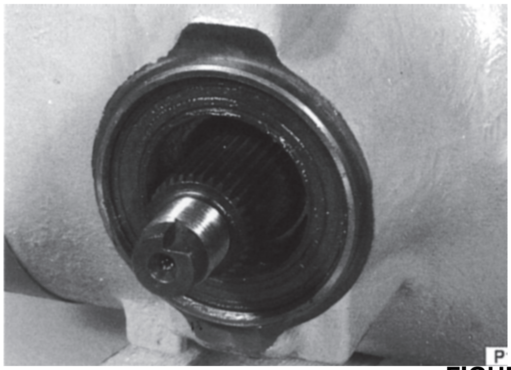
2. Mark the position of the coupling yoke on the splined shaft. Using the drive coupling spanner, remove the coupling yoke Figure 8-5 together with its stake nut and washer.

NOTE: On later axles, the stake nut and washer are combined. The separate nut and washer should be discarded and replaced with the new combined nut and washer.



p0079 **FIGURE 8-5**

3. Remove the seal Figure 8-6 and install a new one. Pack the lips of the new seal with grease before installing.



p0080 **FIGURE 8-6**

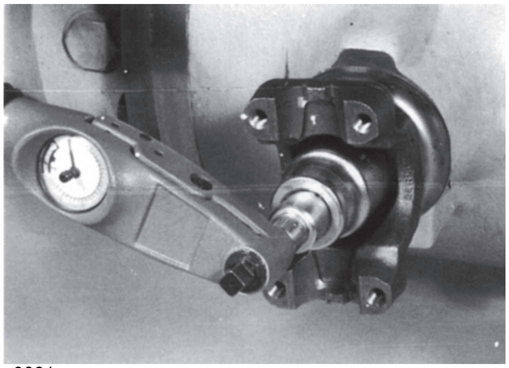
NOTE: Take care not to damage the housing when removing the old oil seal.

4. Align the locating marks on the yoke and the splined shaft. Install the coupling yoke and a new combined stake nut and washer.

5. Using the drive coupling spanner Figure 8-10, tighten the nut to a torque of 250 Nm (184 lb-ft).

6. Measure the rolling axle torque Figure 8-9. The reading should be the 0.5 to 1 Nm (0.37 to 0.74 lb-ft) more than that recorded in Step 1.

If necessary, progressively tighten the nut to achieve the correct rolling torque.



p0081 **FIGURE 8-7**

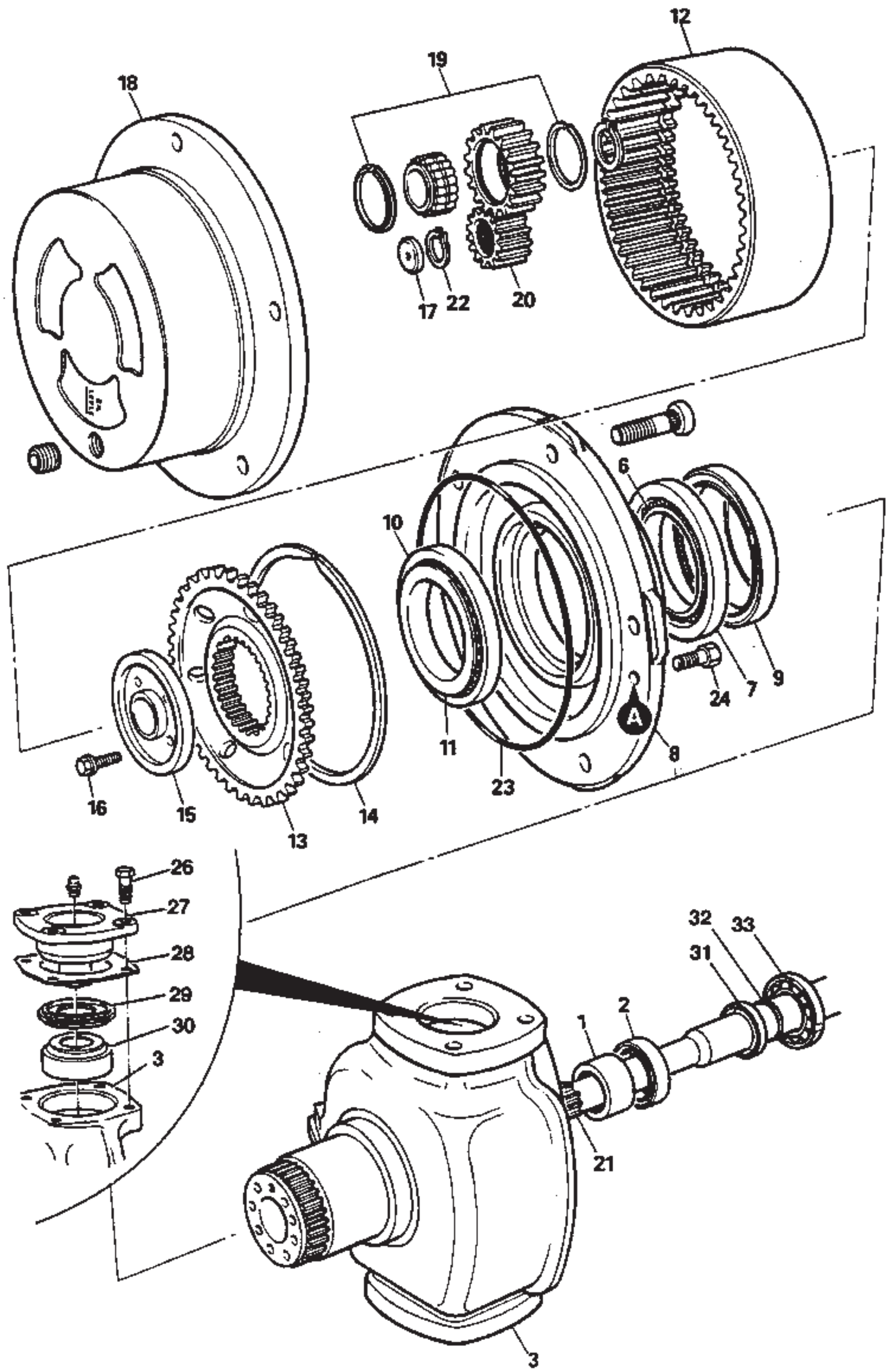
CAUTION

If the rolling torque value (new pinion seal installed) exceeded the reading in Step 1 by 1 Nm (0.74 lb-ft) or more, then the collapsible spacer mounted on the axle pinion MUST be replaced.

7. Stake the nut using a square ended staking tool.

8

1. Bearing
2. Oil Seal
3. Hub Swivel
4. Snap Ring
6. Wheel Bearing Cone
7. Wheel Bearing Cup
8. Bearing Carrier
9. Combination Seal
10. Wheel Bearing Cone
11. Wheel Bearing Cup
12. Annulus Ring
13. Brake Carrier
14. Retaining Ring
15. Retainer Plate
16. Verbus Ripp Bolts (4)
17. Thrust Pad
18. Planetary Gear Carrier
19. Planet Gear Assembly (3)
20. Sun Gear
21. Drive Shaft
22. Snap Ring (3)
23. O-Ring
24. Capscrew (2)
26. Trunnion Bolts (8)
27. Trunnion (2)
28. Shim
29. Seal (2)
30. Bearing (2)
31. Oil Seal
32. Retaining Ring
33. Bearing



a0181

FIGURE 8-8

Axle Hub Repair

Disassembly

NOTE: The axle does not have to be removed to disassemble the axle hub.

1. Drain the oil from the axle hub.
2. Remove screws **24** Figure 8-8.
3. Using a soft-faced mallet, tap the planet gear carrier **18** to “crack” the joint between the carrier and the bearing carrier **8**. Then pry the planet gear carrier from the bearing carrier. Remove and discard O-ring **23**.
4. Remove a planet gear **19** only if it is defective. A planet gear can only be replaced as an assembly, which consists of the pinion, a bearing and two “L” shaped retaining rings. To remove a planet gear, first remove the retaining ring **4**, then pull off the planet gear.
5. The drive shaft thrust pad **17** is drilled and taped M6 for removal purposes. Remove the drive shaft thrust pad from planet gear carrier.
6. Remove the external retaining ring **22** and sun gear **20**.
7. Remove the Verbus Ripp bolts **16**. These bolts are very tight and care must be taken not to distort the bolt heads. Use as short of an extension as possible. Discard the Verbus Ripp bolts.
8. Using two metric bolts jack the annulus assembly **12, 13 & 14** off bearing carrier **8**.

NOTE: Be sure annulus ring position is marked for reassembly.

Fretting between the hub swivel and annulus carrier mating surfaces might be evident. This condition is normal, do not attempt to repair.

If the hub swivel and annulus carrier are to be replaced, they must be replaced as a pair not individually.

9. Remove internal retaining ring **14** to separate the annulus ring **12** from the annulus carrier **13**.
10. Pull off bearing carrier **8** together with the outer wheel bearing cone **10** and cup **11**. Remove combination seal **9**. Remove the inner bearing cup **7** from the inboard side of the carrier.
11. Pull off inner wheel bearing **6**.

NOTE: Earlier type axles may have an O-ring and wear ring installed in place of combination seal **9**. These parts should be discarded.

12. On later units, remove and discard combination seal **9**.
13. Disconnect the track rod and steering cylinder from the axle steering knuckles.

NOTE: If the track rod is removed completely, identify R.H. and L.H. ends to ensure correct assembly.

The top and bottom trunnions are very similar (bottom trunnion not shown), the only difference being that shims **28** are installed to the top trunnion only.

14. Mark the position of the top and bottom trunnions **27**, remove bolts **26** and remove the trunnions. Retain shims **28** with top trunnion. Remove hub swivel **3**.

NOTE: Trunnions may be removed easily and without damage to the shims by pumping grease through the grease fitting.

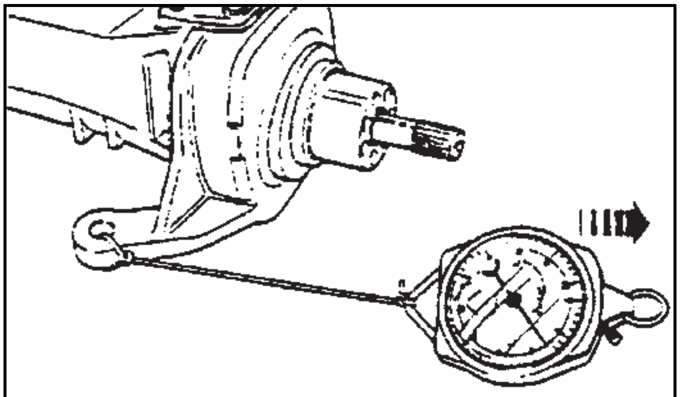
15. Remove top and bottom trunnion seals **29** and bearings **30**.
16. Remove drive shaft **21** from the axle casing.
17. Pry out drive shaft inner oil seal **2**.
18. Using a bearing puller, remove bearing **1**.
19. Pry out drive shaft inner seal **31B.**
20. Remove retaining ring **32**.
21. Using a bearing puller, remove bearing **33**.
22. If there has been a component failure, remove all traces of debris and clean the magnetic drain plug.

Assembly

NOTE: The top and bottom trunnions are very similar (bottom trunnion not shown), the only difference being that shims **28** are installed to the top trunnion only.

1. Tap the drive shaft inner bearing **33** Figure 8-8 into position in the hub swivel drive shaft bore. Secure with retaining ring **32**.
2. Install a new oil seal **31** Pack grease between lips of the seal.
3. Install drive shaft **21**, taking care to locate inner end into the splines of the differential gears.
4. Tap drive shaft outer bearing **1** into position in the hub swivel.
5. Install new oil seal **2**. Pack grease between the lips of the seal.
6. Press new top and bottom oil seals **29** into position followed by bearings **30**. Grease bearings and oil seal before installing in axle.
7. Locate hub swivel **3** and install bottom trunnion **27**. Apply Loctite® 243 to the threads of the bottom trunnion bolts **26** and then tighten to a torque of 56 Nm (42 lb-ft). Install top trunnion **27** with normal 0.25 mm (0.10 in) shim **28** and leave top trunnion bolts **26** finger tight).

8. Attach a spring balance (Figure 8-9) to track rod swivel and turn the swivel. Tighten the top trunnion bolts **26** to eliminate end float but without bearing pre-load, that is, no increase in spring balance reading.



a0182 **FIGURE 8-9**

9. Measure the gap at the top trunnion and subtract 1 mm (0.040 inches) to give shim thickness (bearing pre-load). For example:

Gap = 1.55 mm (0.061 inches)

less = 1.00 mm (0.040 inches)

Shim = 0.55 mm (0.021 inches)

NOTE: If the gap measures 1 mm (0.040 inches), then no shim is required.

If after installing the shims, the bearing pre-load is not attainable, install new bearings.

10. Reinstall the top trunnion. Apply Loctite® 243 to the top trunnion bolt threads, install and tighten to a torque of 56 Nm (42 lb-ft).

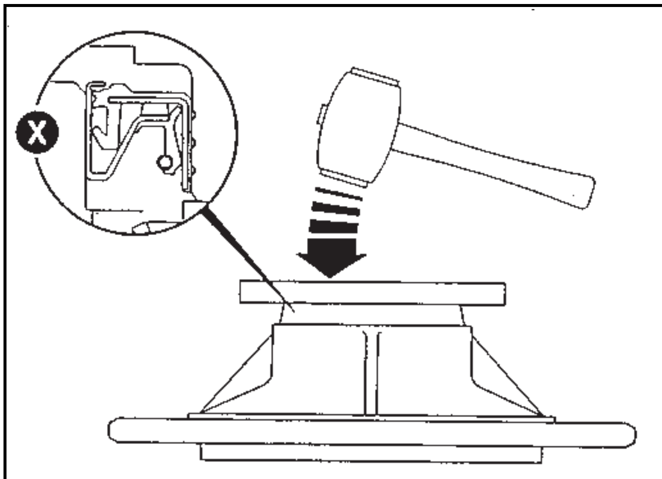
Check the spring balance reading which should be 4.5 kg (10 lb) more than the reading recorded in step 8.

11. Connect the track rod and steering cylinder to the axle steering knuckle. Tighten the track rod nut to a torque of 135 Nm (100 lb-ft), then continue to tighten to next castellation and insert the pin.

12. Lightly oil the inner wheel bearing **6** and its cup **17**. Then install them into bearing carrier **8**.

13. Install a new combination seal **9** into the bearing carrier **8**.

Do not lubricate before installing. Drive the seal squarely into the bearing carrier **8** until the locating lip is flush, as shown in **X** Figure 8-10.



a0496 **FIGURE 8-10**

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

14. Install the cup of outer wheel bearing **10** Figure 8-8 into the bearing carrier **8**. Grease the bore of the combination seal **9** and the surface of the hub.

15. Install the bearing carrier **8** onto hub swivel **3**.

16. Lightly oil the bearing race of outer wheel bearing **11**. Install the bearing onto the axle arm. Rotate the carrier **8** (and therefore the bearing) during installation.

17. Assemble annulus ring **12** to annulus carrier **13**. Secure with retaining ring **14**.

18. Install the annulus assembly in the same angular position as removal (see Note after step 9 on page 8-8) using new Verbus Ripp bolts **16**. Do not fully tighten the bolts but allow the bearing carrier to rock slightly.

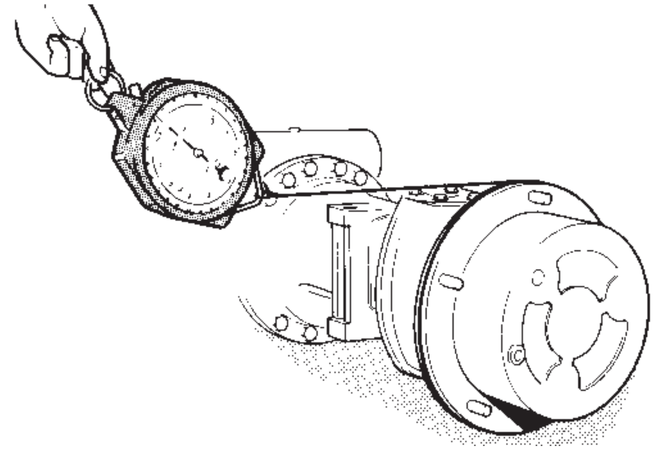
CAUTION

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

19. Check the bearing carrier rolling force:

a. Use a spring balance and cord wrapped around the planet carrier bolts Figure 8-8. Pull the spring balance so that the hub rotates. Do this several times to set the seal and then record the reading.

b. Remove the planet gear carrier **18** Figure 8-8 and tighten the new Verbus Ripp bolts **16** to 166 Nm (122 lb-ft).



a0186 **FIGURE 8-11**

c. Repeat steps 19 and 19A and record the reading.

d. To get the rolling force, subtract the seal drag rolling force (Step 19 A) from reading obtained at step 19C. The result should be 1.4 to 15.3 kg (3 to 34 lb).

If the resulting force is outside these limits check that seal **19** is installed correctly and/or replace bearings (**6** and **11**).

NOTE: A high rolling force reading may indicate that the oil seal was damaged during installation.

20. Press the drive shaft thrust pad **17** (chamfered side down) into the recess in planet gear carrier **18**.

21. Install new planet gears **19** in place of any that were removed (see Step 4 in Disassembly). Secure with retaining ring **4**.

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

22. Slide sun gear **20** onto the drive shaft and secure with retaining ring **22**.

23. Install a new O-ring **23**.

24. Install planet gear carrier **18** onto bearing carrier **8** turning it slightly to engage the gear teeth and aligning the two tapped holes **A** Figure 8-8 in the planet gear carrier. (The tapped holes are diametrically opposite one another). Ensure that the gear carrier butts fully against the bearing carrier.

NOTE: Do not strike the center of planet gear carrier **18** when installed, as this may dislodge drive shaft thrust pad **17**.

25. Install screws **24** and tighten to a torque of 56 Nm (41.3 lb-ft).

26. Fill the axle hub with oil. See *Preventative Maintenance on page 5-1*.

Drive Head Repair

The following procedures can only be carried out with the axle removed from the crane. See “Removal”, on page 8-4.

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

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

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

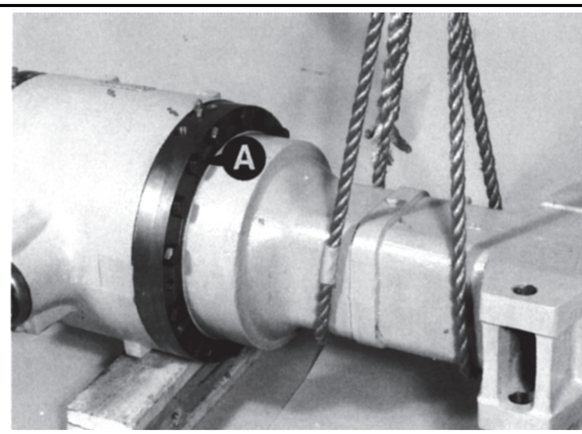
Disassembly

1. Before disassembling the axle, drain the oil from the axle into a suitable container.

2. Remove the steering cylinders and track rod.

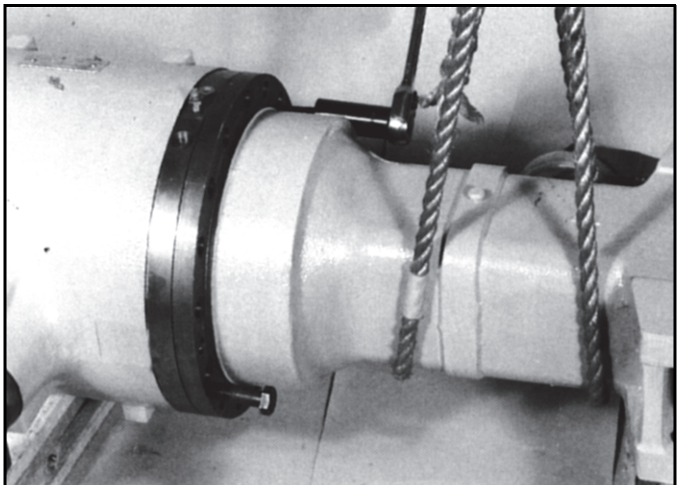
3. Remove both axle arms.

a. Support the axle arm and remove bolts **A** Figure 8-12.



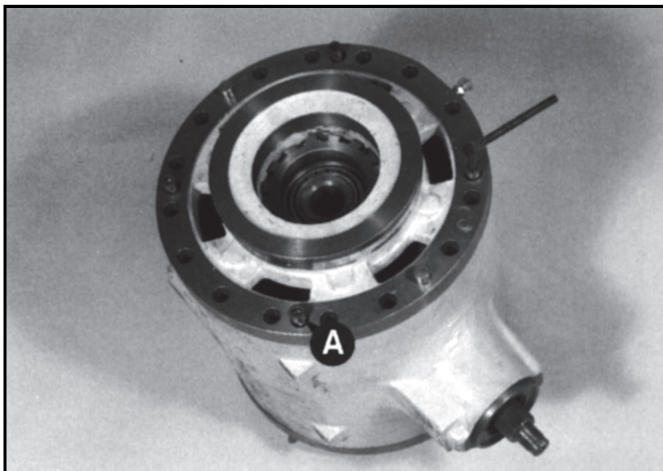
a0187 **FIGURE 8-12**

b. Jack the axle arm off of the drive head, using the drive head securing bolts Figure 8-13. Remove all traces of gasket material from the mating surfaces.



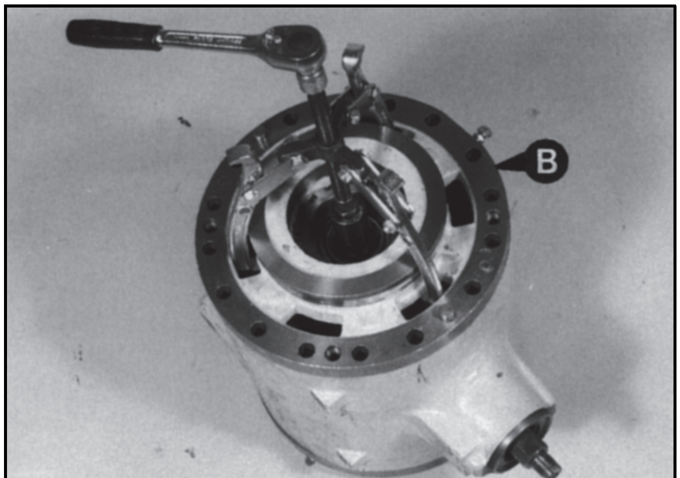
a0188 FIGURE 8-13

4. Remove the drive shaft coupling. See Replacing the Pinion Oil Seal on page 8-7.
5. Position the drive head as shown in Figure 8-14, with the crownwheel at the top. Remove capscrews **A**.



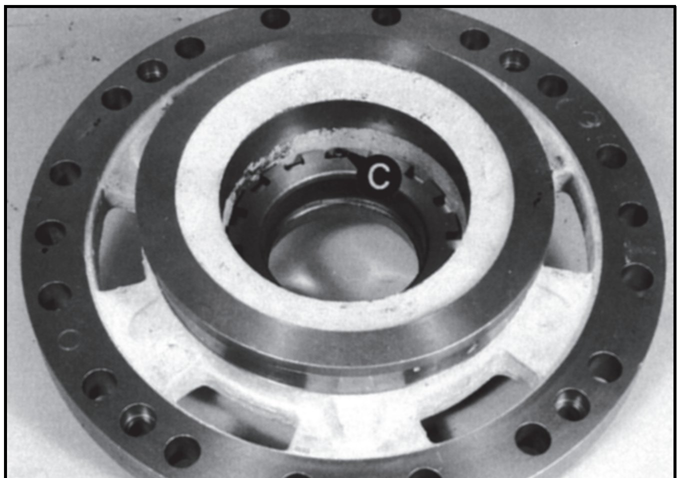
a0189 FIGURE 8-14

6. Match - mark the brake piston housing **B** Figure 8-15 and the drive head. Pull off the brake piston housing.



a0190 FIGURE 8-15

7. Drive out the differential side nut locking pin **C** Figure 8-16, to allow readjustment upon assembly. Remove the other brake piston housing only if damaged, but remove its locking pin **C** regardless (to allow side load adjustment upon assembly).



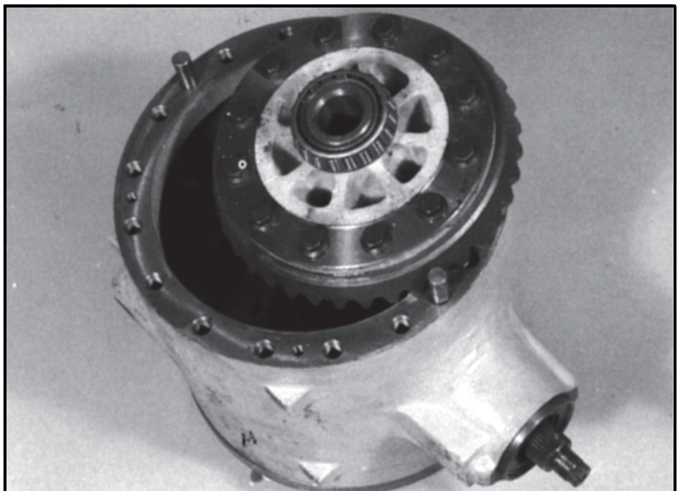
a0191 FIGURE 8-16

CAUTION

METAL SPLINTERS. You can be injured by flying metal splinters when driving metal pins in and out. Use a soft faced hammer or drift to remove and install metal pins. Always wear safety glasses.

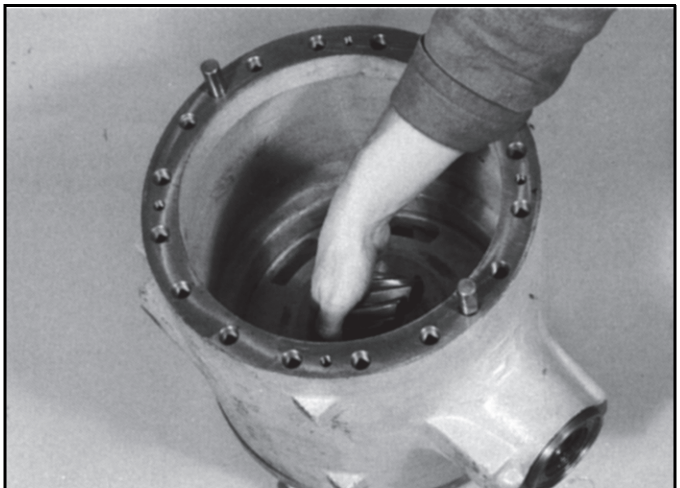
8. Lift out the crownwheel/differential assembly Figure 8-17.

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



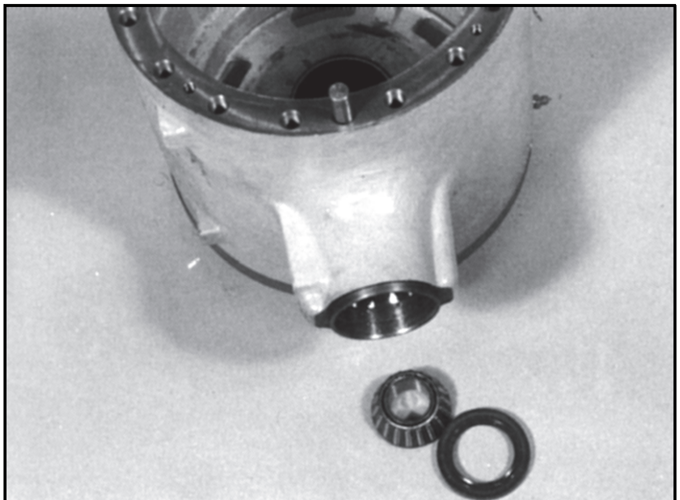
a0192 **FIGURE 8-17**

9. Using a soft hammer, hit the pinion end shaft until the pinion is free from its front bearing. Remove the pinion Figure 8-18.



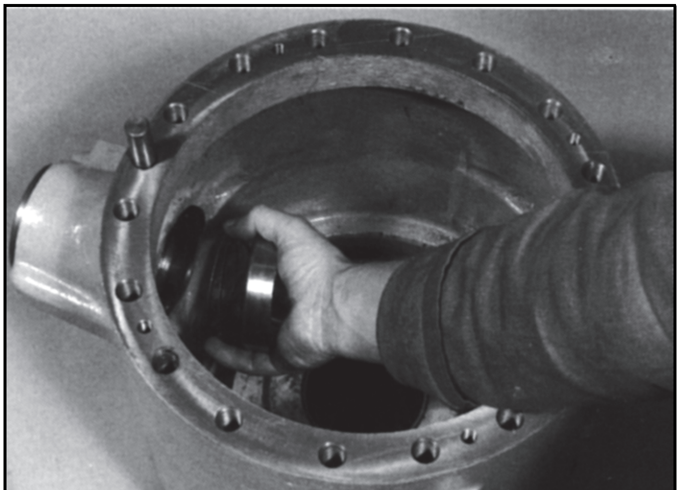
a0193 **FIGURE 8-18**

10. Remove the pinion seal and outer bearing cone Figure 8-19.



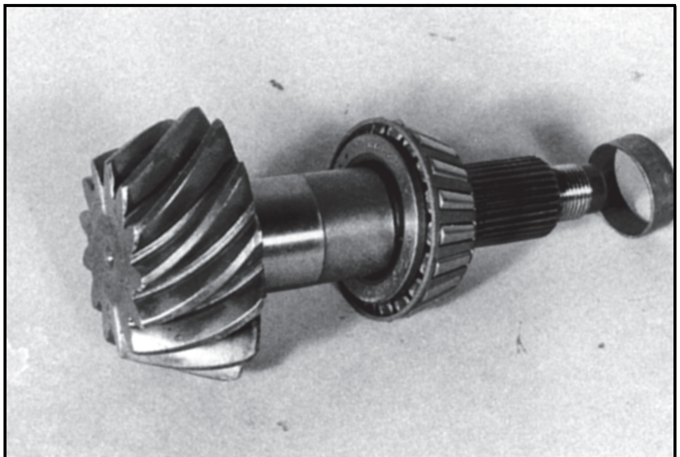
a0194 **FIGURE 8-19**

11. If necessary, drive out the pinion inner bearing cup and shims Figure 8-20. Discard the shims. Repeat for the outer bearing cup, if required. There are no shims for the outer bearing cup.



a0195 **FIGURE 8-20**

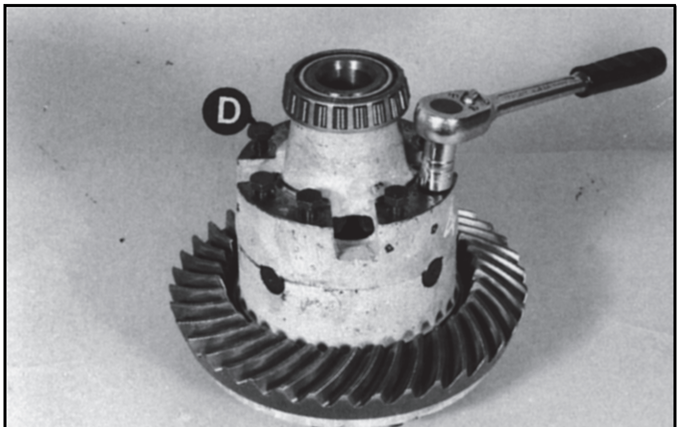
12. Remove and discard the pinion collapsible spacer Figure 8-21. Pull off the bearing cone.



a0196 **FIGURE 8-21**

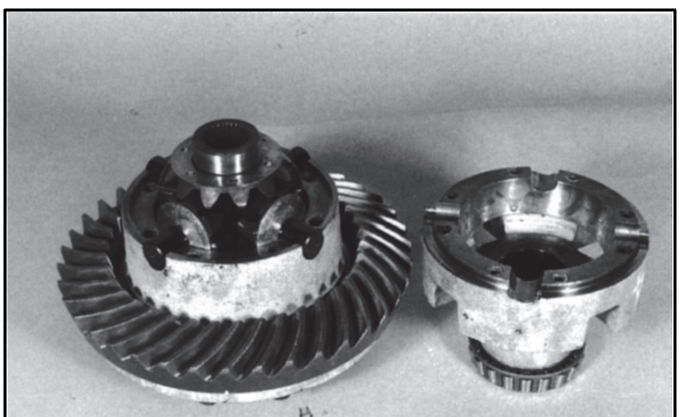
13. To dismantle the differential assembly:

a. Remove bolts **D** Figure 8-22.



a0197 **FIGURE 8-22**

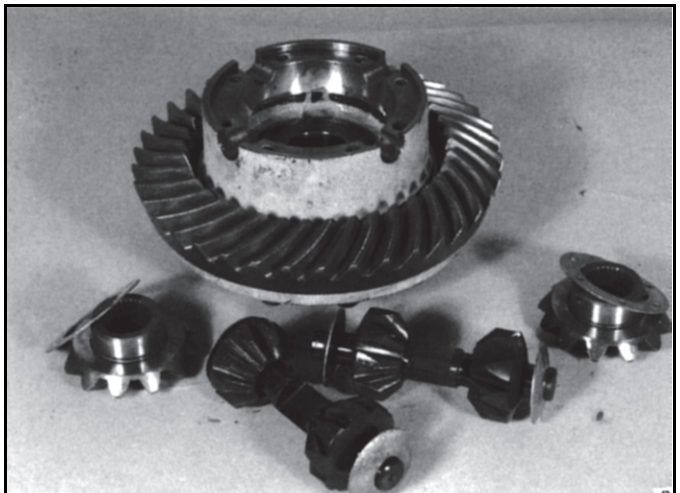
b. Lift off the top half housing Figure 8-23.



a0198 **FIGURE 8-23**

c. Remove the differential gears and spherical washers Figure 8-24. Pull off both differential bearing cones.

If required, remove the crownwheel to differential case half retaining bolts and remove the crownwheel.



a0199 **FIGURE 8-24**

Assembly

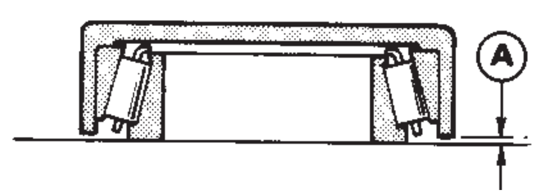
Pinion Depth Setting Procedure

Determine the pinion depth setting as follows:

NOTE: See page 8-15 for general guidance on crownwheel and pinion adjustment.

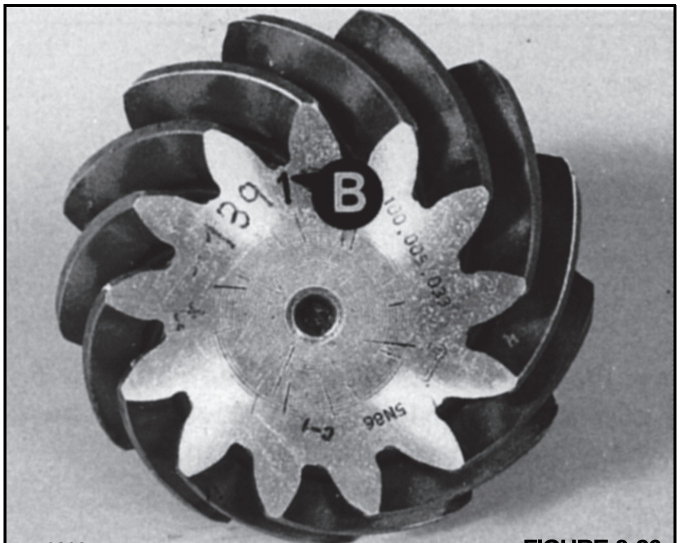
1. Assemble the pinion inner bearing and its cup on a flat surface.

2. Place the pinion bearing measuring cup over the bearing assembly Figure 8-25. Measure gap A. Add tool depth of 30.1 mm (1.18 in) to gap A to give bearing depth.

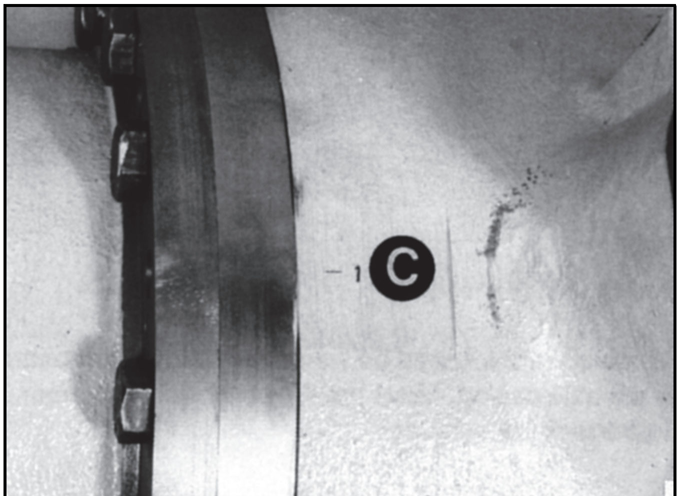


a0201 **FIGURE 8-25**

3. Find the mounting distance value **B** Figure 8-26 on the pinion and deviation **C** Figure 8-27 on the drive head housing. Both units are in millimeters. To convert millimeters to inches, multiply millimeters by 0.03937.



a0202 FIGURE 8-26



a0203 FIGURE 8-27

4. If dimension **B** is positive, add it to the bearing depth. If dimension **B** is negative, subtract it from the bearing depth. See example Crownwheel and Pinion Adjustment on page 8-15.
5. If dimension **C** is positive, subtract it from the total. If dimension **C** is negative, add it to the total. See example Crownwheel and Pinion Adjustment on page 8-15.
6. Subtract the result from the standard value of 31.19 mm (1.23 inches) to give the required shim thickness. See example Crownwheel and Pinion Adjustment on page 8-15.

Example:

Dimensions in Millimeters

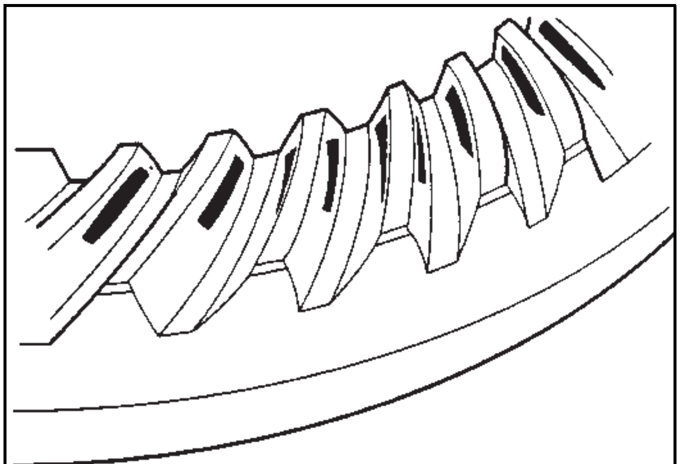
Dimension A	0.25
Add to depth	+30.01
Total	**30.26**
Add dimension B, if positive. (Subtract if negative)	+0.01
Total	**30.27**
Add dimension C if negative. Subtract if positive	(+) -0.01
Total	**30.28**
Standard Value	31.19
Less Calculated total from above	-30.28
Shim Thickness	**0.91**

Crownwheel and Pinion Adjustment

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

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

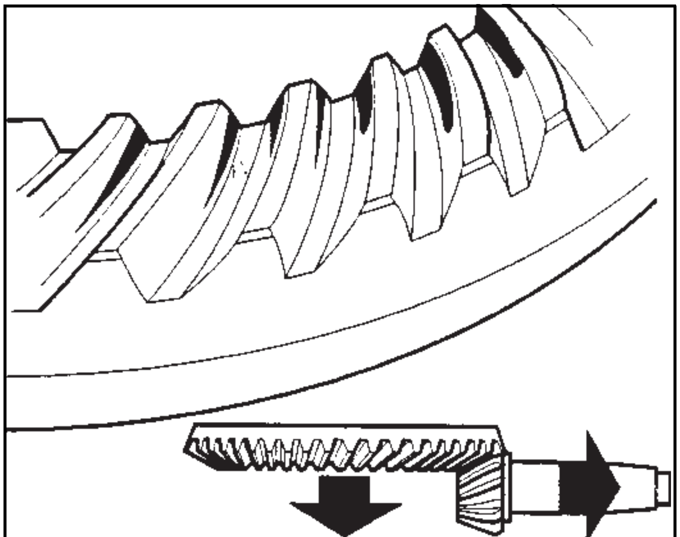
Correct teeth marking Figure 8-28



a0204 FIGURE 8-28

Pinion too deeply in mesh Figure 8-29

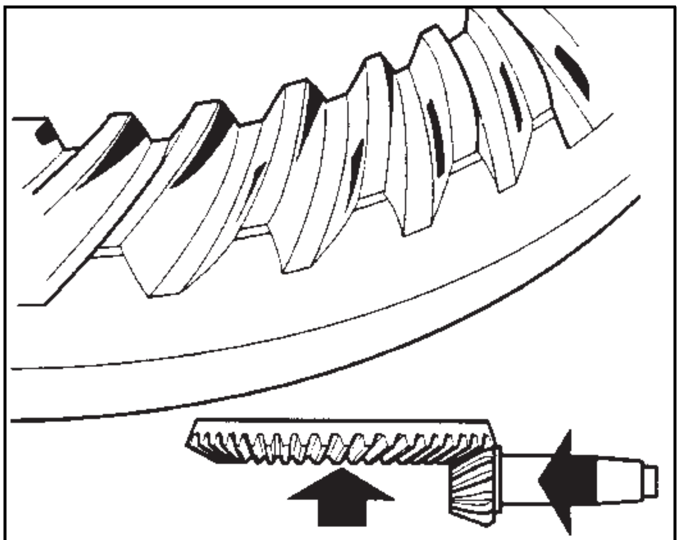
Decrease the shim thickness between the pinion inner bearing cup and the axle casing. Move the crown wheel towards the pinion to correct the backlash.



a0205 FIGURE 8-29

Pinion too far out of mesh Figure 8-30.

Increase the shim thickness between the pinion inner bearing and the axle casing. Move the crownwheel away from the pinion to correct the backlash.



a0206 FIGURE 8-30

Assembly Procedures

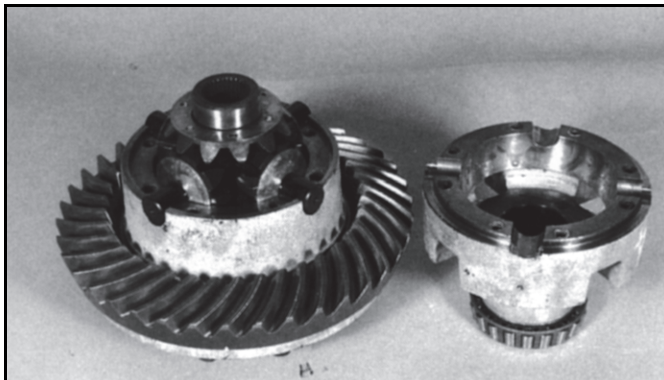
NOTE: The crownwheel and pinion are matched and should be replaced as a set, if either one is damaged or excessively worn.

The two differential case halves are also matched, as are the differential side gears and planet gears. Do not use unmatched case halves or gears.

NOTE: Make sure all bearings are lightly oiled before installing and setting. Make sure to rotate bearings while setting.

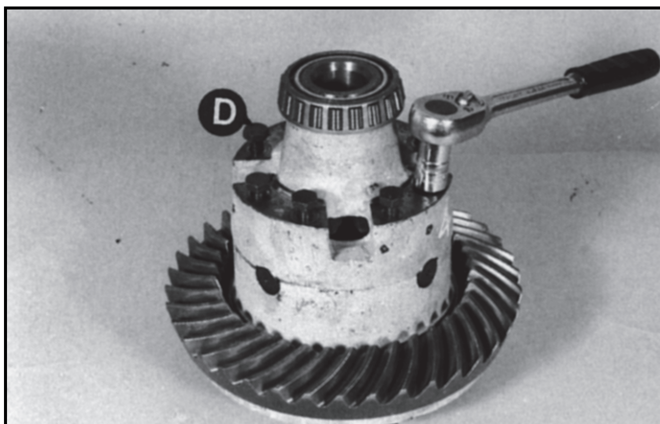
1. If required, install the crownwheel to the differential case half. Tighten the crownwheel retaining bolts to a torque of 166 Nm (122 lb-ft).

   Assemble the differential gears and their spherical washers into the bottom half housing Figure 8-31. Install the differential bearing cones.



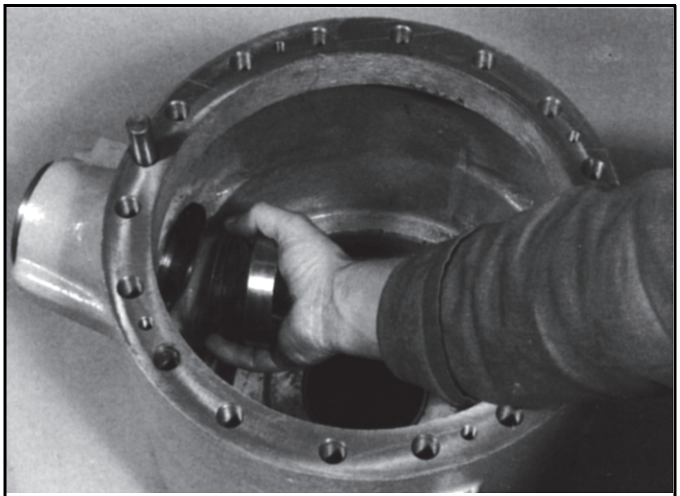
a0198 FIGURE 8-31

2. Position the top half housing onto the differential, aligning the match mark letters. Apply Loctite® 243 to the threads of bolts **D** Figure 8-32. Install the bolts and tighten to a torque of 56 Nm (42 lb-ft). Check the gears for free rotation.



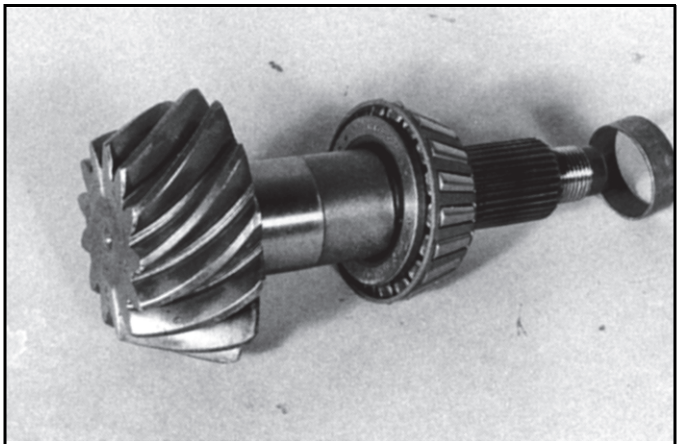
a0197 FIGURE 8-32

3. Install the pinion bearing cup Figure 8-33, together with the required thickness of shims to give correct pinion depth (see Pinion Depth on page 8-14). To ensure that cup is installed square, use a suitable puller assembly. Do not use a hammer. Install the outer bearing cup.



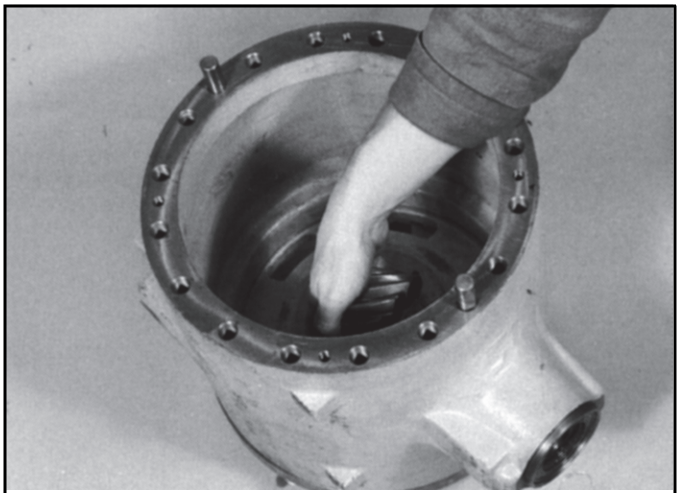
a0195 FIGURE 8-33

4. Install the pinion inner bearing cone Figure 8-34 and a new collapsible spacer.



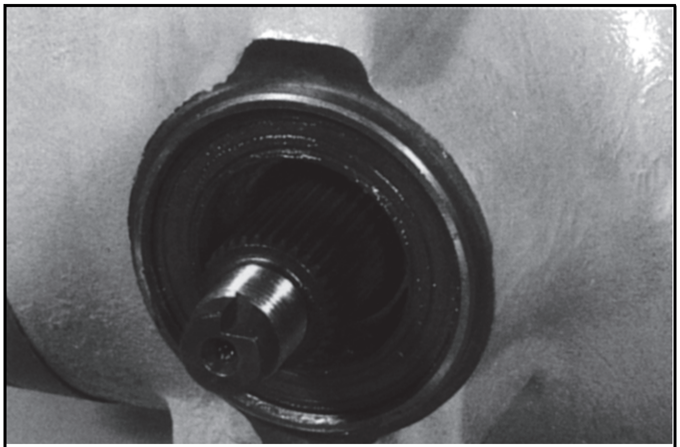
a0196 FIGURE 8-34

5. Insert the pinion into its bore Figure 8-35. Before inserting, ensure that the pinion matches the crownwheel. The code numbers etched on the pinion end face and the crownwheel perimeter should be the same.



a0193 FIGURE 8-35

6. Install the outer bearing cone Figure 8-36 and the seal. Pack grease between the lips of the seal before installing.



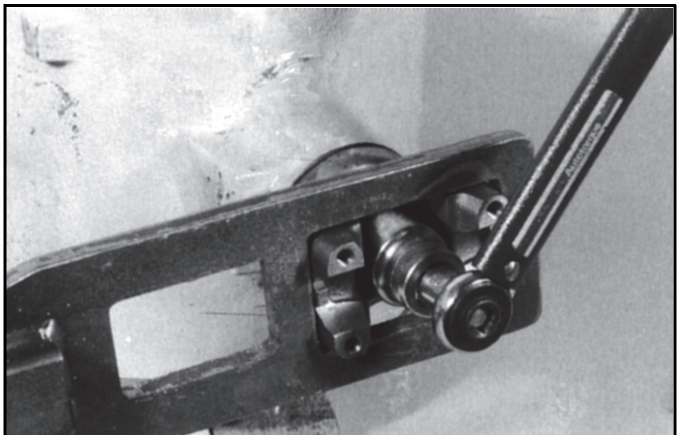
a0207 FIGURE 8-36

7. Install the drive coupling yoke and secure it with a new stake nut and washer.

   Hold the yoke Figure 8-37 with the drive coupling spanner. Tighten the stake nut until end float is almost zero, then check the seal drag torque. It should be between 0,40 to 1,0 Nm (3.5 to 8.9 lb-in).

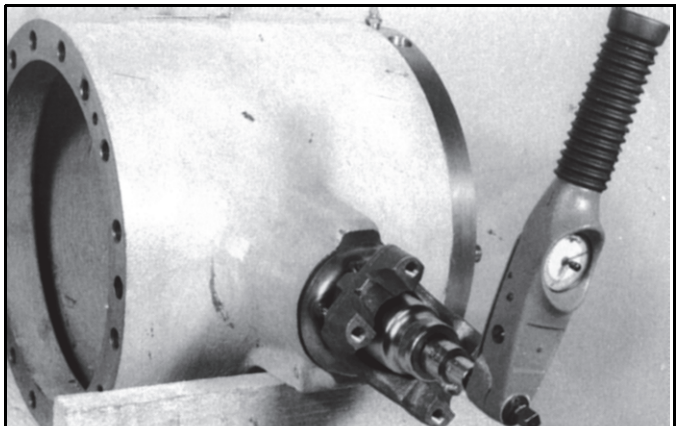
   Continue to tighten the stake nut to achieve the correct rolling torque as described in Step 8. If the nut is overtightened, the collapsible spacer must be replaced.

8



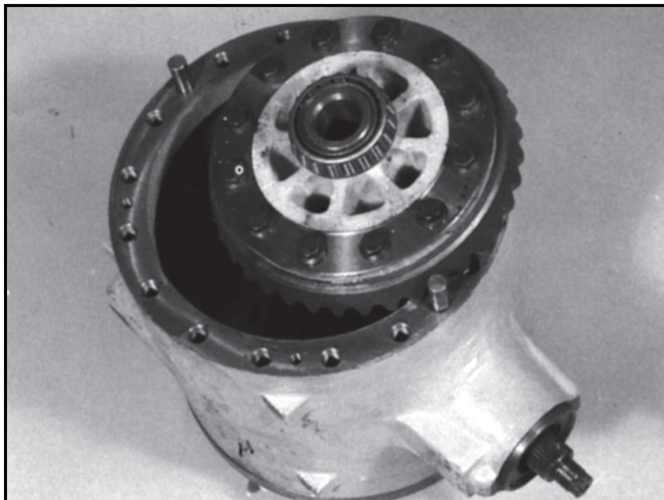
a0208 **FIGURE 8-37**

8. Measure the rolling torque Figure 8-38, which should be 1.7 to 2.8 Nm (1.3 to 2.1 lb-ft) excluding seal drag. When the torque is correct, stake the nut to the pinion shaft using a square-ended staking tool.



a0210 **FIGURE 8-38**

9. If both brake piston housings were removed, install one at the opposite end of the crownwheel Figure 8-39, using the procedure in Step 10. Then install the crownwheel/ differential assembly into the drive head.

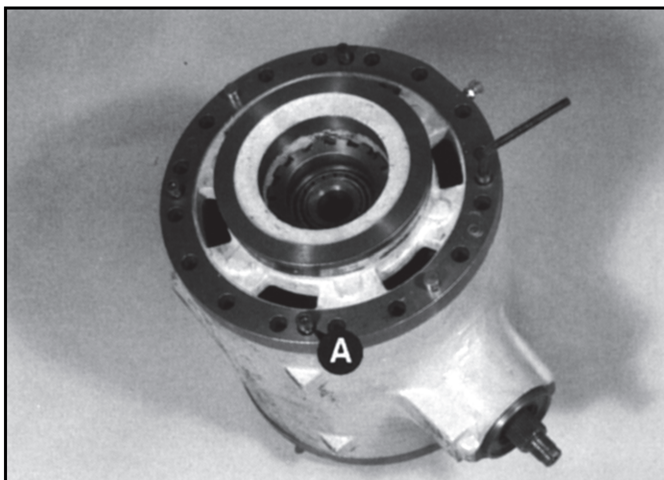


a0192 **FIGURE 8-39**

10. Apply Loctite® 275 to the drive head mating face. Install the brake piston housing. Ensure that the match marks made during disassembly are aligned. Install capscrews **A** Figure 8-40 (see Note) and tighten to a torque of 56 Nm (42 lb-ft). Torque applies to both piston housings.

NOTE: If the old capscrews are to be used, clean the threads with a wire brush and then coat the threads with Loctite® 243. Install and tighten to a torque of 56 Nm (42 lb-ft).

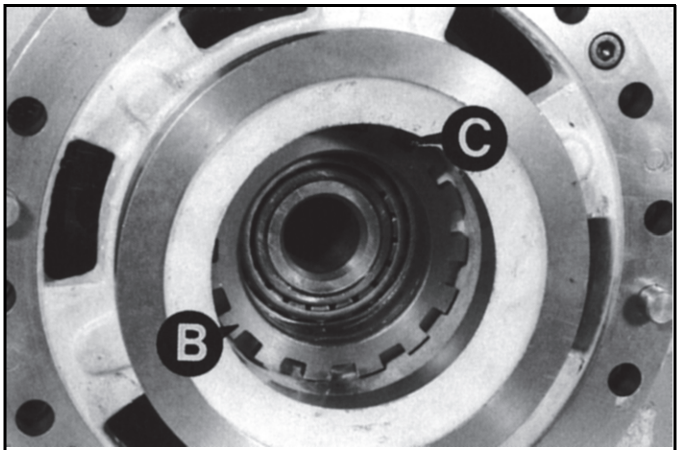
New capscrews are encapsulated and do not require cleaning or manually coating with sealant.



a0189 **FIGURE 8-40**

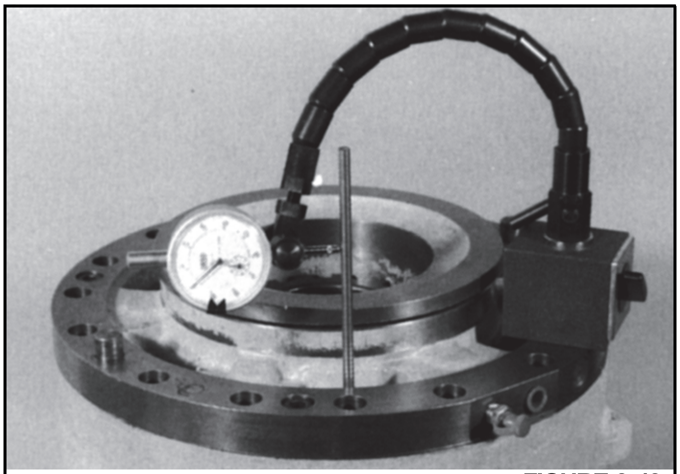
11. Adjust differential side nuts **B** Figure 8-42 to give a bearing pre-load of 1,36 to 2,5 Nm (1.0 to 1.84 lb-ft).

    Measure the pre-load by taking another rolling torque reading and subtracting the torque value measured at Step 8. The difference is the bearing pre-load.



a0211 **FIGURE 8-41**

12. Measure the crownwheel backlash, which should be 0,13 to 0,2 mm (0.005 to 0.008 in) Figure 8-42. Adjust the differential side nuts by equal amounts when altering backlash. When backlash and pre-load are both correct, install the side nut locking pins **C** Figure 8-41. Verify crownwheel, pinion and pre-load are set properly. See Crownwheel and Pinion Adjustment on page 8-15.



a0209 **FIGURE 8-42**

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REAR 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 and raise and support the crane on axle stands or blocks positioned under the chassis frame. Remove the wheels.
2. For a drive axle only, remove the drive shaft. See Front Axle Drive Shaft Removal on page 8-33.
3. Disconnect and plug the hydraulic hoses to the steering cylinder.
4. Disconnect, cap and plug the brake hoses from the axle.
5. Disconnect the electric cable to the steering proximity switch.
6. Support the axle on a trolley jack.
7. For a rear **drive axle**:
    a. Remove the bolts, washers, and rod ends securing the axle pivot pin (Figure 8-43).
    b. Remove the rear axle pivot pin.

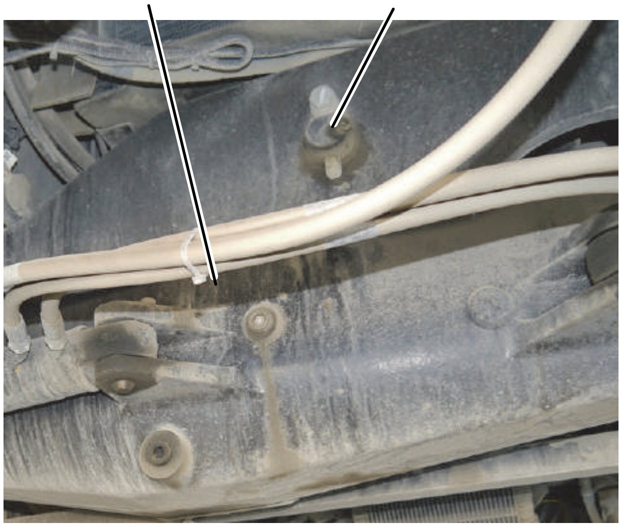


FIGURE 8-43

8. For a rear **non-drive axle,** remove the eight mounting bolts, nuts, and washers.
9. Lower the axle clear of the mounting bracket and remove it from the crane.

Installation

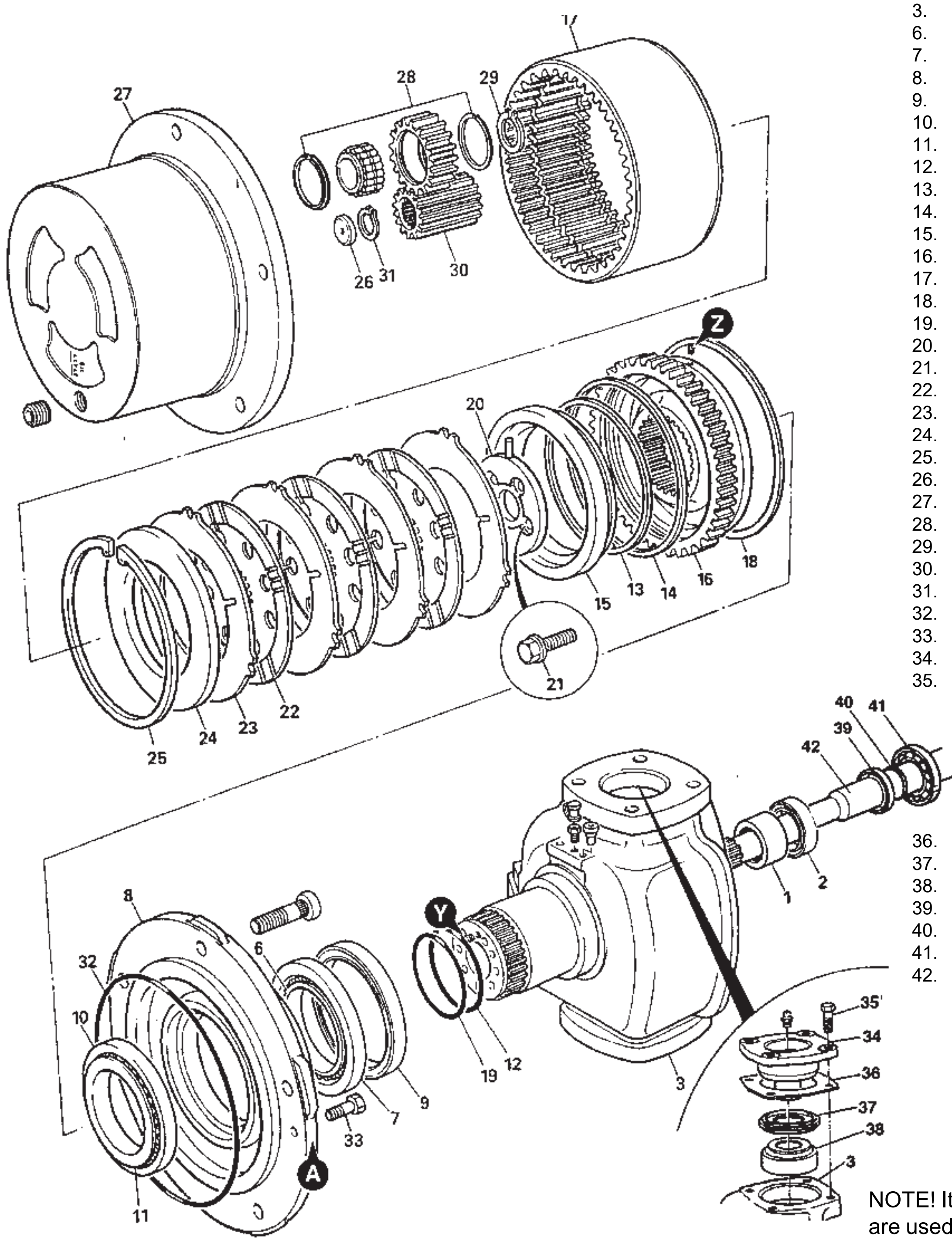
1. Place the axle on a trolley jack and position it under the crane frame.
2. Raise axle and position it in the mounting frame.
3. For a rear **drive axle**:
    a. Install the rear axle pivot pin (Figure 8-43).
    b. Install the rod ends, bolts and washers and secure the axle pivot pin. Tighten the bolts to the torque valve specified in Section 1 of this manual.
    c. Grease the axle pivot pin through two grease fittings.
4. For a rear **non-drive axle,** install the eight mounting bolts, nuts, and washers. Tighten the bolts to the torque valve specified in Section 1 of this manual.
5. For a drive axle only, install the drive shaft. See Rear Axle Drive Shaft Removal on page 8-34.
6. Connect the electric cable to the steering proximity switch.
7. Connect the brake lines and the steering lines to the axle.
8. Bleed the air from the brake system. See Section 9 of this manual.
9. Bleed the air from the steering circuit. See Section 10 of this manual.

Service Tools

To completely disassemble and assemble the rear axle, special tools are required. Unless you have the tools illustrated Figure 8-3, DO NOT service the axle.

Replacing the Pinion Oil Seal

The procedure for replacing the pinion or seal on the rear drive axle is the same as the front drive axle. Refer to page 8-7 for replacement procedures.



1. Bearing
2. Oil Seal
3. Hub Swivel
6. Wheel Bearing Cone
7. Wheel Bearing Cup
8. Bearing Carrier
9. Combination Seal
10. Wheel Bearing Cone
11. Wheel Bearing Cup
12. Brake Seal
13. Seal
14. Seal
15. Brake Piston
16. Brake Carrier
17. Annulus Ring
18. Retaining Ring
19. Brake Seal
20. Retainer Plate
21. Verbus Ripp Bolts (4)
22. Friction Plate (3)
23. Counter Plate (4)
24. Pressure Plate
25. Retaining Ring
26. Thrust Pad
27. Planet Gear Carrier
28. Planet Gear Assembly (3)
29. Snap Ring (3)
30. Sun Gear
31. Snap Ring
32. O-ring
33. Bolt (2)
34. Trunnion (2)
35. Bolt (8)
36. Shim
37. Seal (2)
38. Bearing (2)
39. Oil Seal
40. Retaining Ring
41. Bearing
42. Drive Shaft

NOTE! Items 39, 40 and 41 are used on drive axles only.

a2284

FIGURE 8-44

Axle Hub Repair

Disassembly Figure 8-44

WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Disconnect the track rod and steering cylinders.

NOTE: If the track rod is removed completely, identify R.H. and L.H. ends to ensure correct assembly.

2. Drain all oil from the hub.

3. Remove screws **33** Figure 8-44.

4. Pry off planet gear carrier **27** at the pry points. Remove and discard O-ring **32**.

5. Remove planet gears **28** only if defective. Note that gears can only be removed as assemblies, which consist of the gear, the bearing and two “L” shaped retaining rings. To remove the planet gear, remove the external retaining ring **29**.

6. Pull off the planet gear **28**.

7. The drive shaft thrust pad **26** is drilled and tapped M6 for removal purpose. Remove the thrust pad from gear carrier **27**.

8. Remove retaining ring **31** to allow sun gear assembly **30** to be slid off the drive shaft **42.**

9. Remove retaining ring **25** to allow the brake pack assembly to be slid off the drive shaft **42.**

10. Remove brake pressure plate **24**, counter plates **23** and friction plates **22**.

NOTE: If the brake pack is to be reused, note the position of the plates before removing.

11. Examine the friction plates. Wear limit of the friction plates is to the depth of the crosshatching Figure 8-45. Check all plates for flatness and damage. (Some scoring of the counter plates is normal.) Completely replace the brake pack if it is worn or damaged. Do not replace individual plates.

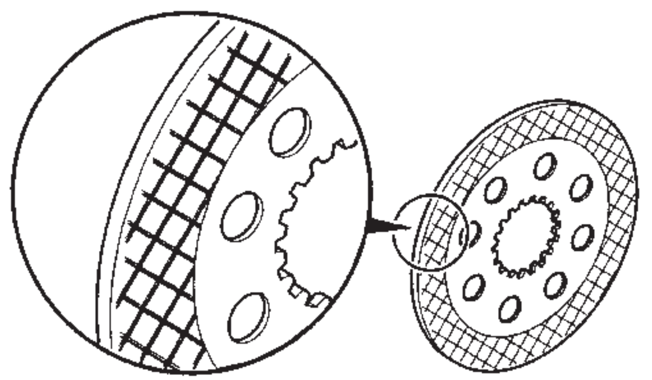

a2283

FIGURE 8-45

NOTE: Excessive wear of the brake and counterplates can indicate sticking brakes or possible residual pressure in the braking system. See Section 9, Brakes.

12. Remove Verbus Ripp bolts **21** Figure 8-44 and retaining plate **20**. These bolts are very tight and care must be taken not to distort the bolt heads. Use as short of extension as possible with a six sided socket. Discard the Verbus Rip bolts after removal.

CAUTION

Do **NOT** reuse Verbus Ripp bolts. They must be replaced throughout the assembly.

13. Remove brake seal **19**, then mark the relationship between the annulus carrier **16**, annulus ring **17** and the hub swivel. Remove the annulus carrier with the annulus ring from the hub swivel.

14. Remove retaining ring **18** to separate the annulus ring from the annulus carrier. Remove brake seal **12** from the hub swivel.

15. If removal is necessary, carefully remove the brake piston **15** from its housing. A hydraulic hand pump can be used to force the piston out of the housing.

16. Remove and discard seals **13** and **14**. Inspect the housing bore for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.

17. Pull off bearing carrier **8** together with outer bearing **11**.

18. Pull off inner bearing **6**.

19. Remove and discard combination seal **9**.

NOTE: Earlier axles may have an O-ring and wear ring installed. These parts should be discarded.

NOTE: The top and bottom trunnions are very similar (bottom trunnion is not illustrated in Figure 8-44)

8

the only difference being that shims **36** are installed to the top trunnion.

20. Mark the position of the top and bottom trunnions **34**, remove bolts **35** and remove the trunnions. Keep shims **36** with the top trunnion. Remove hub swivel **3**.

NOTE: Trunnions may be removed easily and without damage to the shims by pumping grease through the grease fitting.

On non-drive axles the short drive shaft will be removed with the hub swivel.

21. Remove top and bottom trunnion seals **37** and bearings **38**.

22. Remove drive shaft **42** from the hub swivel on non-drive axles and from the axle casing on drive axles.

23. Pry out the drive shaft outer oil seal **2**.

24. Remove bearing **1** using an impulse extractor adapter.

NOTE: Steps 25 through 27 are for drive axles only.

25. Pry out drive shaft inner seal **39**.

26. Remove retaining ring **40**.

27. Using an impulse extractor remove bearing **41**.

28. If there has been a component failure, remove all traces of debris and clean the magnetic drain plug.

Assembly

NOTE: The top and bottom trunnions are very similar (bottom trunnion is not illustrated in Figure 8-44, the only difference being that shims **36** are installed to the top trunnion.

NOTE: Steps 1 through 3 are for drive axles only.

1. Tap the drive shaft inner bearing **41** into position in the axle casing.

2. Install retaining ring **40**.

3. Install new oil seal **39**. Pack grease between the lips of the seal.

4. Tap drive shaft inner bearing **1** into position in hub swivel **3** drive shaft bore.

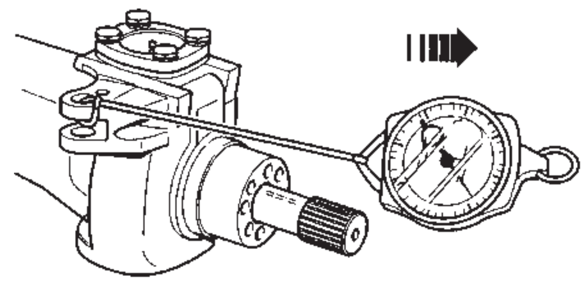
5. Install new oil seal **2**. Pack grease between the lips of the seal.

6. Install drive shaft **42**. Take care to locate inner end into splines of differential gears on the drive axle.

7. Press new top and bottom trunnion seals **37** into position, followed by bearings **38**.

8. Locate hub swivel **3** and install the bottom trunnion **34**. Apply Loctite® 243 to threads of bottom trunnion bolts **35** and then tighten to a torque 56 Nm (42 lb-ft). Install top trunnion **34** with normal 0.25 mm (0.010 inch) shim **36** and leave top trunnion bolts **35** finger tight.

9. Attach a spring balance Figure 8-46 to track rod swivel and turn the swivel. Tighten the top trunnion bolts **35** to eliminate end play, but without bearing pre-load, i.e. no increase in spring balance reading.



a2283 **FIGURE 8-46**

10. Measure the gap at the top trunnion and subtract 1 mm (0.040 inches) to give shim thickness (bearing pre-load). For example:

Gap = 1.55 mm (0.061 inches)

less = <u>1.00 mm (0.040 inches</u>

Shim = 0.55 mm (0.021 inches)

NOTE: If the gap measures 1.00 mm (0.040 inches), then no shim is required.

If, after installing the shims, the bearing pre-load is not attainable, install new bearings.

11. Reinstall the top trunnion. Apply Loctite® 243 to the top trunnion bolt threads, install and tighten to a torque of 56 Nm (42 lb-ft).

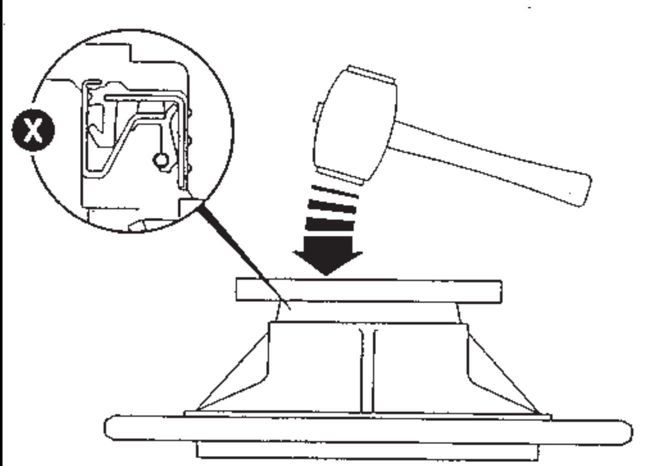
12. Check the spring balance reading which should be 4.5 kg (10 lb) more than the reading recorded in step 9.

13. Connect the track rod and steering cylinder to the axle steering knuckle. Tighten the track rod nut to a torque of 135 Nm (100 lb-ft), then continue to tighten to next castellation and insert the pin.

14. Lightly oil the inner wheel bearing **6** and its cup **7**. Then install them into bearing carrier **8**.

15. Install a new combination seal **9** into the bearing carrier. Figure 8-47.

Do not lubricate before installing. Drive the seal squarely into carrier until locating lip is flush as shown at **X**.



a0496 FIGURE 8-47

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

16. Install the cup **10** of outer wheel bearing **11** into the bearing carrier **8**. Grease the bore of the seal and the surface of the hub.

17. Install the bearing carrier **8** onto hub swivel **3**.

18. Install new brake seal **12** to the hub swivel.

19. Install new seals **13** and **14** into the grooves in the brake piston **15** and annulus carrier **16**.

20. Carefully press piston **15** all the way into the annulus carrier housing.

21. Align relationship marks made on disassembly. Assemble annulus ring **17** to annulus carrier **16** and secure with retaining ring **18**. Make sure the two blanking plugs **Z** Figure 8-44 are installed to the annulus carrier. Apply Loctite® 243 to threads.

NOTE: Inspect the inside of the annulus carrier and piston for marks. Any sign of scoring on a seal contact surface can cause leaks.

Make sure blanking screw **Y** are installed. Apply Loctite 243 to threads.

22. Install the annulus assembly onto the splined hub. Check that the relationship marks align. Push the annulus assembly into the splined hub until the splines of the annulus assembly are flush with the end of the splined hub. Fit brake seal **19** onto the hub swivel.

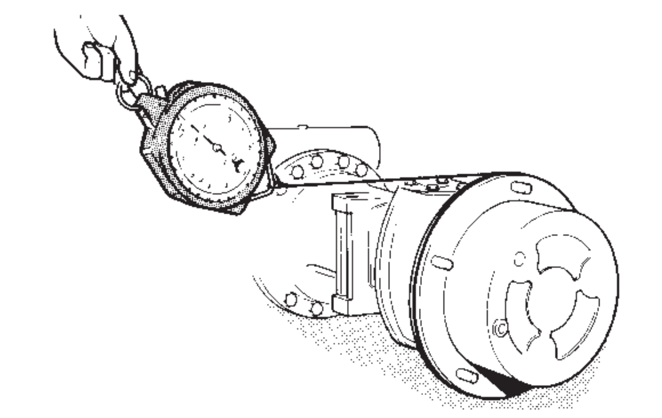
23. Install retainer plate **20**, making sure the breather hole and brake galleries align. Secure using Verbus Ripp bolts **21** and tighten until the annulus assembly just rocks.

24. Check the seal drag rolling force:

a. Use a spring balance and cord wrapped around the planet carrier flange Figure 8-48. Pull the spring balance so that the hub rotates. Do this several times to set the seal and then record the reading.

b. Remove the planet gear carrier and tighten the new Verbus Ripp bolts **21** to 166 Nm (122 lb-ft).

c. Repeat steps 24 and 24A and record the reading.



a2283 FIGURE 8-48

d. To get the rolling force, subtract the seal drag rolling force (Step 24 A) from reading obtained at step 24C. The result should be 1.4 to 15.3 kg (3 to 34 lb).

If the resulting force is outside these limits check that seal **9** is installed correctly and or replace bearings **6** and **11**.

NOTE: A high rolling force reading may indicate the oil seal was damaged during installation.

25. Assemble friction plates **22** and counter plates **23** onto the carrier **16**. If the original brake pack is being used, return the plates to their original positions (see Disassembly, step 10). Soak new friction plates in gear oil before assembly.

26. Assemble the brake friction plate **24**. Install retaining ring **25**.

27. If axle is attached to the machine, bleed the brake system. With the engine running, gently apply the brakes and then release them. Check that the piston activates and retracts correctly and does not stick in the applied position before installing planet gear carrier **27**.

If the brake piston has not retracted, the brake seal or piston assembly may have been assembled incorrectly. Alternatively, there may be residual pressure holding the piston. Unscrew the brake bleed nipple with the engine running and check that the piston retracts when the pressure is released. Investigate the cause if the piston remains in the applied position. See Residual Brake System Pressure in Section 9.

28. Press drive shaft thrust pad **26** (chamfered side down) into the recess in planet carrier **27**.

29. Install new planet gears **28** in place of any that were removed. Secure with retaining ring **29**.

NOTE: The large radius at the end of the bearing bore installs on the pin first.

30. Install sun gear **30** onto the drive shaft and secure with external retaining ring **31**. Install new O-ring **32**.

31. Install planet gear carrier **27** onto bearing carrier **8**, turning it slightly to engage the gear teeth and align the two tapped holes **A** Figure 8-44 in the bearing carrier. (The tapped holes are diametrically opposite each other.) Ensure that the planet gear carrier butts fully against the bearing carrier.

NOTE: Do not strike the center of the planet gear carrier **27** when installed, as this may dislodge drive shaft thrust pad **26**.

32. Install screws **33** and tighten to a torque of 56 Nm (41.3 lb-ft).

33. Fill the axle hub with oil. See *Preventative Maintenance on page 5-1*.

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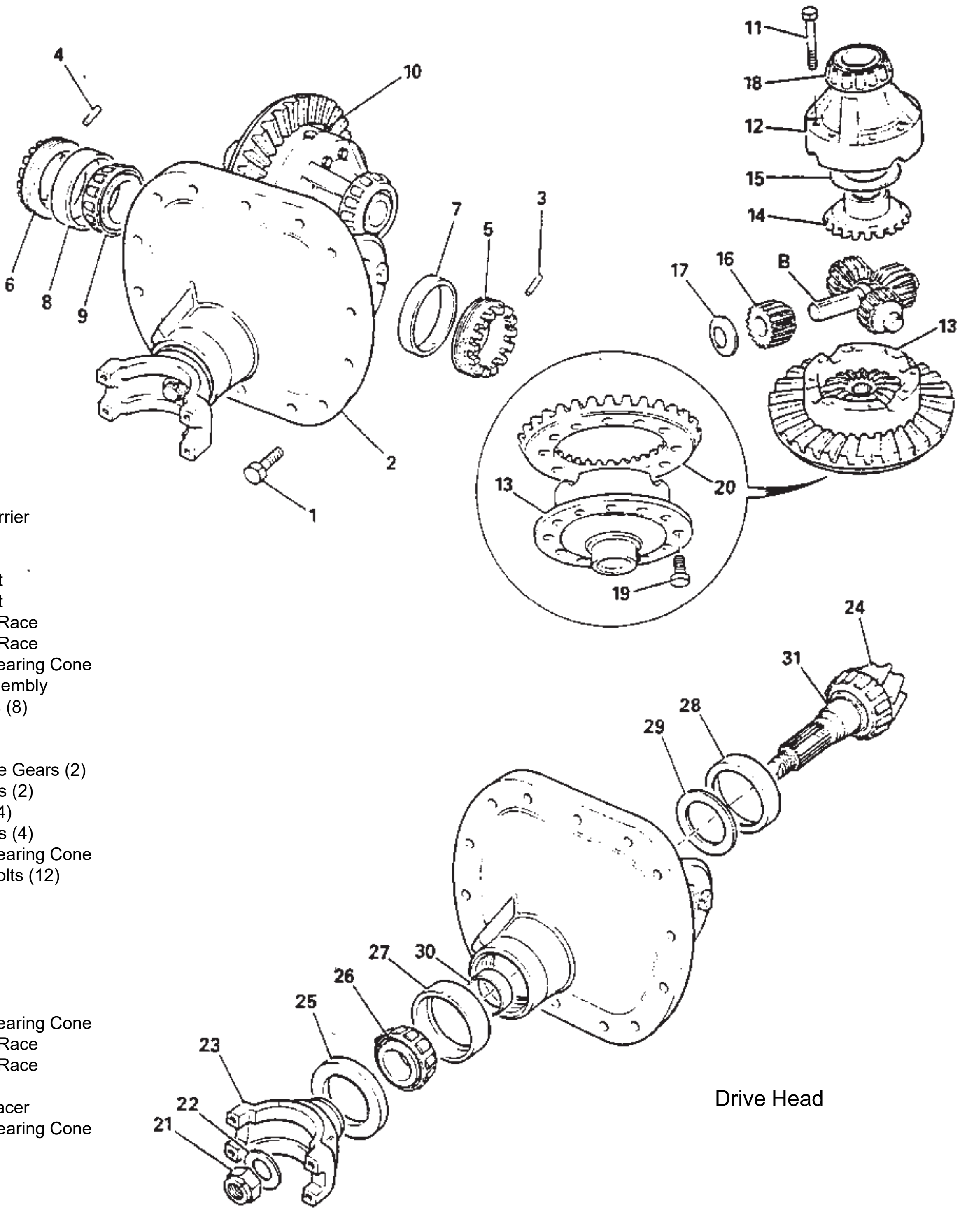
a0213



1. Bolts (16)
2. Drive Head Carrier
3. Tension Pin
4. Tension Pin
5. Castellated Nut
6. Castellated Nut
7. Outer Bearing Race
8. Outer Bearing Race
9. Taper Roller Bearing Cone
10. Differential Assembly
11. Retaining Bolts (8)
12. Case Half
13. Case Half
14. Differential Side Gears (2)
15. Thrust Washers (2)
16. Planet Gears (4)
17. Thrust Washers (4)
18. Taper Roller Bearing Cone
19. Verbus Ripp Bolts (12)
20 Crownwheel
21. Pinion Nut
22. Washer
23. Drive Yoke
24. Pinion
25. Pinion Oil Seal
26. Taper Roller Bearing Cone
27. Bearing Outer Race
28. Bearing Outer Race
29. Shims
30. Collapsible Spacer
31. Taper Roller Bearing Cone

Drive Head

FIGURE 8-49

Drive Head Repair (Drive Axles Only)

Disassembly Figure 8-49

NOTE: The axle need not be removed to disassemble the drive head.

1. Drain the oil from the axle center casing. Remove the rear drive shaft from the axle.
2. Remove both hub assemblies with drive shafts (see page 8-8).
3. Mark the installation position of the drive head carrier **2** Figure 8-49.
4. Remove bolts **1** and remove drive head carrier **2** from the axle casing.
5. Clean the drive head carrier and axle casing mating surfaces.
6. Pull out tension pins **3** and **4** and remove castellated nuts **5** and **6**.
7. Remove bearing outer races **7** and **8**.
8. Drive off the taper roller bearing cone **9** from the crownwheel differential case half.
9. Remove differential assembly **10** from the carrier.
10. Remove retaining bolts **11** and separate case halves **12** and **13**.
11. Remove the two differential side gears **14** and thrust washers **15**.
12. Remove the four planet gears **16** and thrust washers **17** from trunnion pins (**B**).
13. Pull off taper roller bearing cone **18** from differential case halve **12**.
14. Remove Verbus Ripp bolts **19** and separate the crownwheel **20** from differential case halve **13**.

CAUTION

Do NOT reuse Verbus Ripp bolts. They must be replaced throughout the assembly.

15. Use a drive coupling spanner to prevent drive yoke **23** from rotating. Remove pinion nut **21** and washer **22**. Remove the drive yoke.

NOTE: On later axles, pinion nut **21** and washer **22** are combined. The separate nut and washer should be discarded and replaced with the new combined nut and washer.

16. Press pinion **24** from drive head carrier **2**.
17. Pull out pinion oil seal **25** and taper roller bearing cone **26**. If necessary remove bearing outer race **27**.
18. If necessary, drive out pinion bearing outer race **28** and shim(s) **29** from inner side of the drive head carrier.
19. Remove the collapsible spacer **30** and taper roller bearing cone **31** from pinion **24**.

Assembly

NOTE: The crownwheel **20** Figure 8-49 and pinion **24** are matched and should be replaced as a pair if either one is damaged or excessively worn. The differential case halves **12** and **13** are also matched as are gears **14** and **16**. Do not use unmatched halves or gears.

Make sure all bearings are lightly oiled before installing and setting. Make sure bearings are rotated while being set.

1. Install pinion bearing outer race **28** Figure 8-49 to drive head carrier **2** together with required thickness of shims **29** to give correct pinion depth. (See Pinion Depth Setting Procedure on page 8-14). Install the shims behind the outer race Figure 8-49.
2. Install new taper roller bearing cone **31** and a new collapsible spacer **30** onto pinion **24**.
3. Install outer race **27** to drive head carrier **2**.
4. Insert pinion **24** into its bore. (Before inserting verify that the pinion matches the crownwheel. The code numbers etched on the pinion end face and the crownwheel perimeter must be the same).
5. Install new taper roller bearing cone **26**. Pack the cavity between the lips of new oil seal **25** with grease and install the seal to the drive head carrier **2**.
6. Install the drive coupling yoke **23** and secure it with a new combined stake nut **21** and washer **22**.
   a. Hold the yoke with a drive coupling spanner.
   b. Tighten the stake nut until end float is almost zero then check the seal drag torque which should be between 0,40 to 0,75 Nm (3.5 to 6.6 lb-ft).
   c. Continue to tighten the stake nut to collapsible spacer **30** and give a rolling torque of 1,7 to 2,8 Nm (1.3 to 2.1 lb-ft) excluding seal drag, crownwheel not installed.

      IF THE STAKE NUT IS OVERTIGHTENED, THE COLLAPSIBLE SPACER MUST BE REPLACED.

      Make sure that yoke **23** is rotated in both directions to fully seat the bearings before measuring rolling torque.
   d. When the torque is correct, stake the nut to the pinion shaft, using a square ended staking tool.
7. Install crownwheel **20** to case halve **13**, tighten the Verbus Ripp bolts **19** to a torque of 166 Nm (122 lb-ft).

8

8. Assemble the four planet gears **16** and thrust washers **17** onto the trunnion pins. Install the planet gear assembly and two differential side gears **14** and thrust washers **15** into case half **13**.

9. Position top case half **12** onto bottom half assembly **13** aligning the match mark letters (see Note on page 8-8). Apply Loctite® 243 to the threads of bolts **11**, then install them and tighten to a torque of 56 Nm (32 lb-ft). Check the gears for free rotation.

10. Press taper roller bearing cone **18** onto the spigot of case half **12**.

11. Install the differential assembly **10** into the drive head carrier **2**.

12. Press taper roller bearing cone **9** onto the spigot of case half **13**.

13. Install bearing outer races **7** and **8**, castellated nuts **5** and **6** to drive head carrier **2**.

14. Adjust castellated nuts **5** and **6** to give bearing pre-load (see Note) of 1.36 to 2.5 Nm (1.0 to 1.84 lb-ft).

NOTE: Measure the pre-load by taking another rolling torque reading and subtract the torque figure measured at step 6C. The difference is the bearing pre-load.

15. Measure the crown wheel backlash, which should be 0.13 to 0.20 mm (0.005 to 0.008 in). Adjust castellated nuts **5** and **6** by equal amounts when altering backlash. When backlash and pre-load are both correct, install tension pins **3** and **4**.

16. Verify that the crownwheel and pinion are set correctly: use an engineers marker on three of the pinion teeth and check markings on the crownwheel are as indicated on page 8-15. Adjust if necessary.

17. Apply Loctite® 275 to the drive head carrier mating face and then install the axle casing (the carrier assembly locates on two dowels). Make sure the assembly is installed in the same match-mark position (see step 3, Disassembly of page 8-11).

18. Apply Loctite® 243 to bolts **1** and install. Tighten the bolts to a torque indicated in Chapter 1, Fasteners and Torque Values.

19. Assemble both hubs and drive shafts and install the rear drive shaft.

20. Fill the axle with recommended oil. See *Preventative Maintenance on page 5-1*.

NOTE: Tightening torque depends on bolt type. The grade is stamped on the bolt head. If standard grade 8 bolt, tighten to a torque of 98 Nm (72 lb-ft).

If Verbus Ripp 12.9 grade bolt is used, tighten to a torque of 166 Nm (122 lb-ft).

Use heavy duty socket.

CAUTION

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

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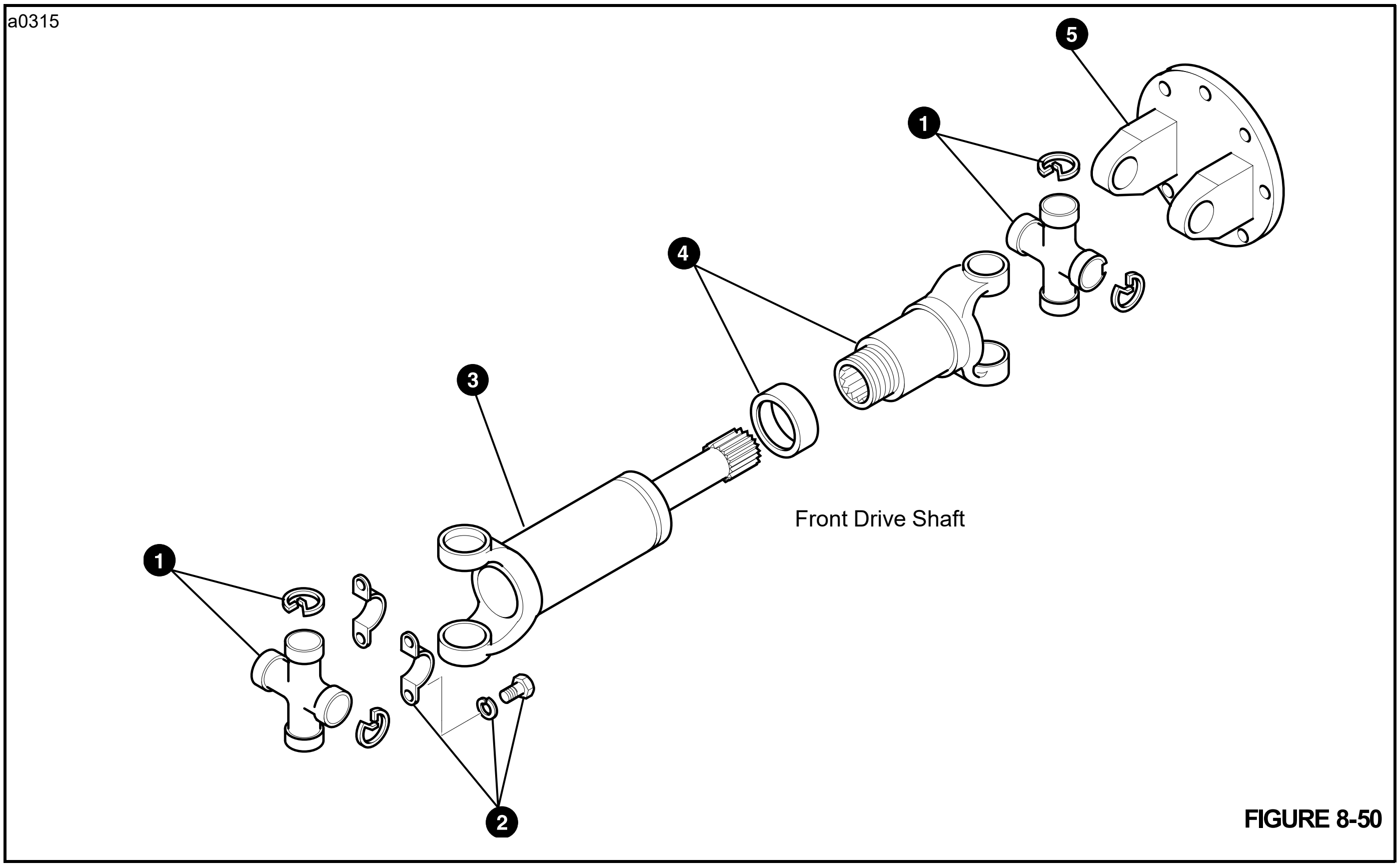

FIGURE 8-50

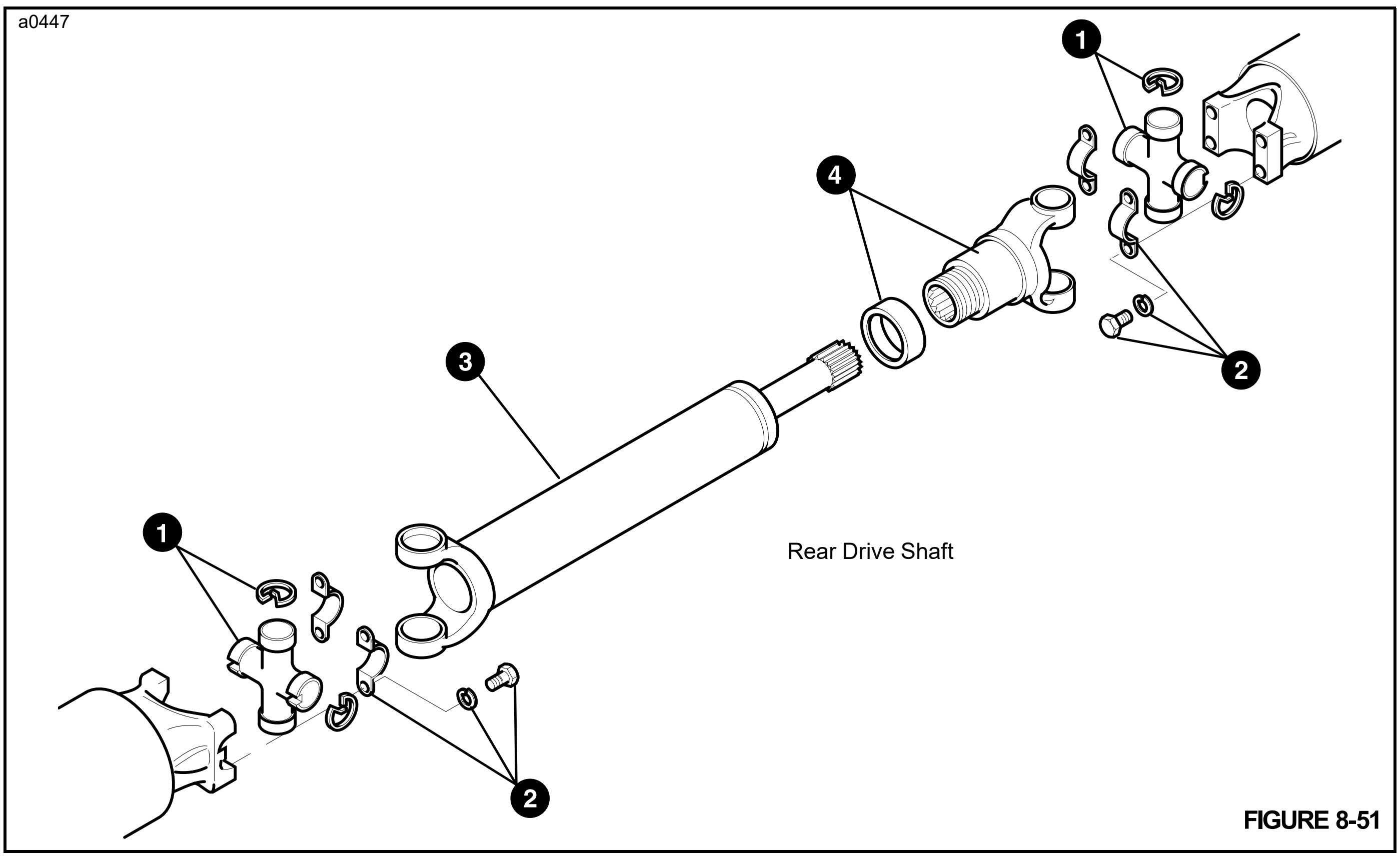

FIGURE 8-51

DRIVE SHAFTS

Removal

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

The retaining straps **2** Figure 8-50 and Figure 8-51 stretch with use, therefore these straps must always be replaced with new ones.

Front Axle Drive Shaft

1. Remove bolts, lockwashers and mounting straps **2** Figure 8-50 from transmission.
2. Remove flange **5** from the parking brake disc.

Rear Axle Drive Shaft

1. Remove bolts, lockwashers and mounting straps **2**, Figure 8-50 from transmission.
2. Remove bolts, lockwashers and mounting straps **2** from rear axle.

Disassembly

Front Axle Drive Shaft

1. Put the flange yoke **5** Figure 8-50 in a vice. Using pliers, remove two snap rings from the bearing caps in the flange yoke.
2. Apply force on the drive shaft in the direction of the bearings to push the bearings out of the flange yoke. When the bearings are removed, tilt the journal cross to permit removal of the universal joint.
3. Disassemble the journal crosses **1** from the drive shaft using the procedure in step 2. After the snap rings are removed, use a soft drift with a flat face slightly smaller than the diameter of the bearing to remove the bearings.
4. To disassemble the sleeve yoke (3) from the slip yoke (4), turn the dust cap counterclockwise. When the dust cap is free, pull the sleeve yoke and dust cap free of the slip yoke.

Rear Drive Shaft

1. Remove two snap rings from the bearing caps in the slip yoke **4** Figure 8-51.
2. After the snap rings are removed, use a soft drift with a flat face slightly smaller than the diameter of the bearing to remove the bearings.
3. Repeat steps 1 and 2 to the sleeve yoke end.
4. To disassemble the sleeve yoke **3** from the slip yoke **4**, turn the dust cap assembly counterclockwise. When the dust cap assembly is free, pull the sleeve yoke and dust cap free of the slip yoke.

Inspection

Clean all parts with a suitable solvent. Remove all rough areas from any finished surfaces. Make sure the bearing surfaces on the journal crosses are smooth. Do not disassemble the needle bearings. Clean with a brush and compressed air. Apply a small amount of SAE 140 oil into each bearing cap and rotate the bearing on the trunnion to check for wear. If there is any indication of wear or damage to the needle bearings, bearing cap or journal crosses, replace the journal and bearings as an assembly.

Check for damage to the splines of the sleeve yoke. Make sure the splines are clean and smooth. Look for damage or distortion of the drive shaft tube. Damage can cause failure of the drive shaft under high torque loads. The drive shaft must be straight to inhibit vibration during operation. Replace the drive shaft if there is damage.

Assembly

Front Axle Drive Shaft.

1. If new journal and bearings are not being installed, inspect the seals in the bearing retainers. If they are damaged in any way, replace the complete journal and bearing assembly.
2. Install the journal cross into the yoke of the sleeve yoke. The relief must be towards the sleeve yoke.
3. Apply a small amount of SAE 140 oil to the trunnions on the journal cross. Press the bearings and cap assemblies into place. Use care not to cause damage to the bearings or caps. Install the snap rings. Make sure the snap rings are engaged fully in the groove.
4. Repeat steps 1 through 3 on opposite end of drive shaft.
5. Repeat steps 1 through 3 to install the flange yoke to the drive shaft.
6. Apply SAE 140 oil to splines on the sleeve yoke **3** Figure 8-50 and Figure 8-51. Assemble the dust cap assembly to the sleeve yoke. Slide the sleeve yoke into the slip yoke (4). Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.

Rear Axle Drive Shaft

1. If new journal and bearings are not being installed, inspect the seals in the bearing retainers. If they are damaged in any way, replace the complete journal and bearing assembly.
2. Install the journal cross into the yoke of the sleeve yoke. The relief must be towards the sleeve yoke.

8

3. Apply a small amount of SAE 140 oil to the trunnions on the journal cross. Press the bearings and cap assemblies into place. Use care not to cause damage to the bearings or caps. Install the snap rings. Make sure the snap rings are engaged fully in the groove.
4. Repeat steps 1 through 3 on opposite end of drive shaft.
5. Apply SAE 140 oil to splines on the sleeve yoke **3** Figure 8-50 and Figure 8-51. Assemble the dust cap assembly to the sleeve yoke. Slide the sleeve yoke into the slip yoke **4**. Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.

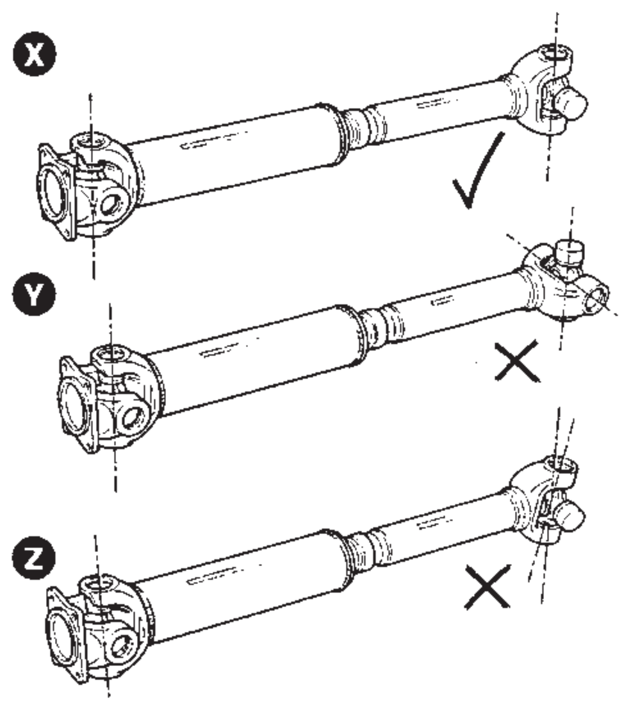

FIGURE 8-52

Installation

Front Axle Drive Shaft

1. Fasten the flange yoke **5** Figure 8-50 to the parking brake disc on the front axle with eight bolts, lockwashers and nuts.

NOTE: The drive shaft must have both ends exactly on the same plane as shown in **X** Figure 8-52. The yokes must not be at right angles as at **Y** or at an intermediate angle as at **Z**.

2. Fasten the other end to the transmission using a new strap kit.

NOTE: The retaining straps (2) stretch with use, therefore these straps must always be replaced with new ones.

3. Apply grease with a grease gun to the fittings on the journal crosses and on the slip joint. Apply grease until it exists through the seals. See *Lubrication Procedure on page 8-34*.
4. Check the drive shaft for correct balance before the crane is put into operation. Lower the outriggers to lift the wheels off the ground. Operate the drive train and check for vibration. If vibration is found, stop the engine and check the drive shaft. Make sure the drive shaft yokes are in the same plane.

Rear Axle Drive Shaft

1. Fasten cross **1** Figure 8-51 to the front axle yoke using a new strap kit **2**.

NOTE: The retaining straps **2** stretch with use, therefore these straps must always be replaced with new ones.

2. Fasten the other end cross **1** to the transmission yoke with a new strap kit **2**.

NOTE: The drive shaft must have both ends exactly on the same plane as shown in **X** Figure 8-52. The yokes must not be at right angles as at **Y** or at an intermediate angle as at **Z**.

3. Apply grease with a grease gun to the fittings on the journal crosses and on the slip joint. Apply grease until it exists through the seals. See Lubrication Procedure on this page.
4. Check the drive shaft for correct balance before the machine is put into operation. Lower the outriggers to lift the wheels off the ground. Operate the drive train and check for vibration. If vibration is found, stop the machine and check the drive shaft. Make sure the drive shaft yokes are in the same plane.

Lubrication Procedure

The drive shaft is an important part of the drive train and needs regular maintenance. There is a grease fitting on the slip joint and on each journal cross. Apply grease to these fittings every week or 50 hours of operation, whichever occurs first. Use Lithium based, E.P. No. 2 bearing grease. Always apply enough grease to the fitting to remove old grease. On the slip joint, apply grease to the fitting until the grease comes through the hole in the end off the shaft. Put your finger over the hole Figure 8-53 and continue to apply grease until the grease shows at the seal on slip joint.

At each lubrication, check the drive shaft for side movement. As wear in the bearings increases, the side movement will increase. Movement must be to minimum to prevent vibration during operation.

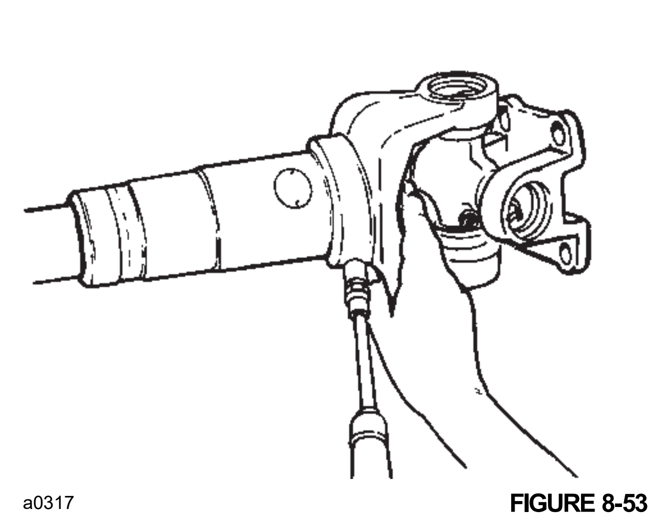

FIGURE 8-53

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 Size/Tread	Pressure
385/65 D22.5 Outrigger R4	9 bar(125 psi)

Wheel Lug Nuts

Tighten the lug nuts in the sequence shown in Figure 8-54. Check the tightness of the lug nuts weekly or after every 50 hours of operation, whichever occurs first.

Tighten the lug nuts to 500 ft-lb.

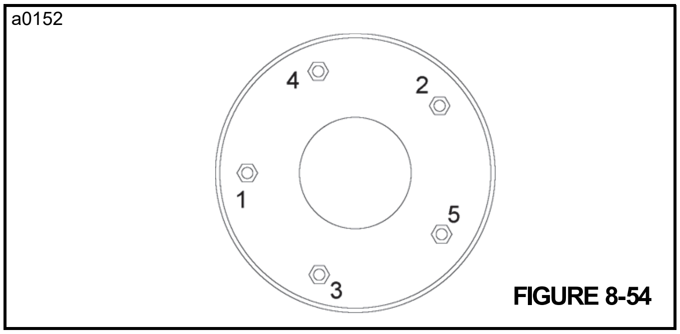

FIGURE 8-54

Tire Mounting

Mount the tires on the wheels so the tread pattern points in the forward travel direction as shown in Figure 8-55. The tires are directional and must be installed on the proper side of the crane.

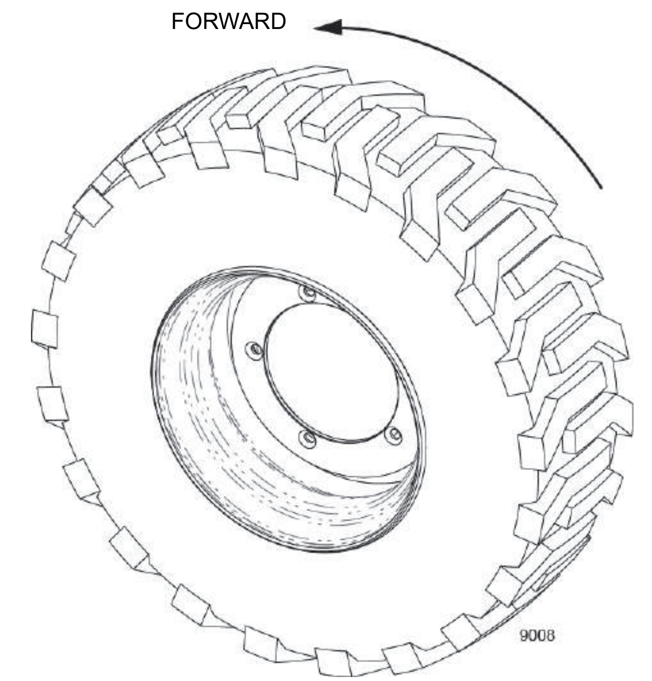

FIGURE 8-55

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SECTION 9
BRAKE SYSTEM

SECTION CONTENTS

9

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TECHNICAL DATA

Front Axle Brakes

Type . . . . Oil-immersed multi-plate disc
Actuation . . . . Hydraulic
Location . . . . Two Inboard - Axle center casing (5 discs per set)
Piston Operation . . . . Standard retraction

Rear Axle Brakes

Type . . . . Oil-immersed multi-plate disc
Actuation . . . . Hydraulic
Location . . . . Outboard - Axle hubs (3 discs per hub)
Piston Operation . . . . Standard retraction

Accumulator

Type . . . . Diaphragm
Volume . . . . 1999 cm^3 (122 in^3)
Nitrogen Recharge Pressure . . . . 52 +3.4 -0 bar (750 +50 -0 psi)

Accumulator Charging Valve

Nominal High Limit . . . . 138 +7 -0 bar (2000 +100 -0 psi)
Nominal Low Limit. . . . . 110 ± 7 bar (1600 ± 100 psi)

Priority Flow Control Valve

Priority Flow Set At . . . . 12.3 L/min (3.25 gpm)
Relief Valve Setting. . . . . 172 ± 7 bar (2500 ± 100 psi)

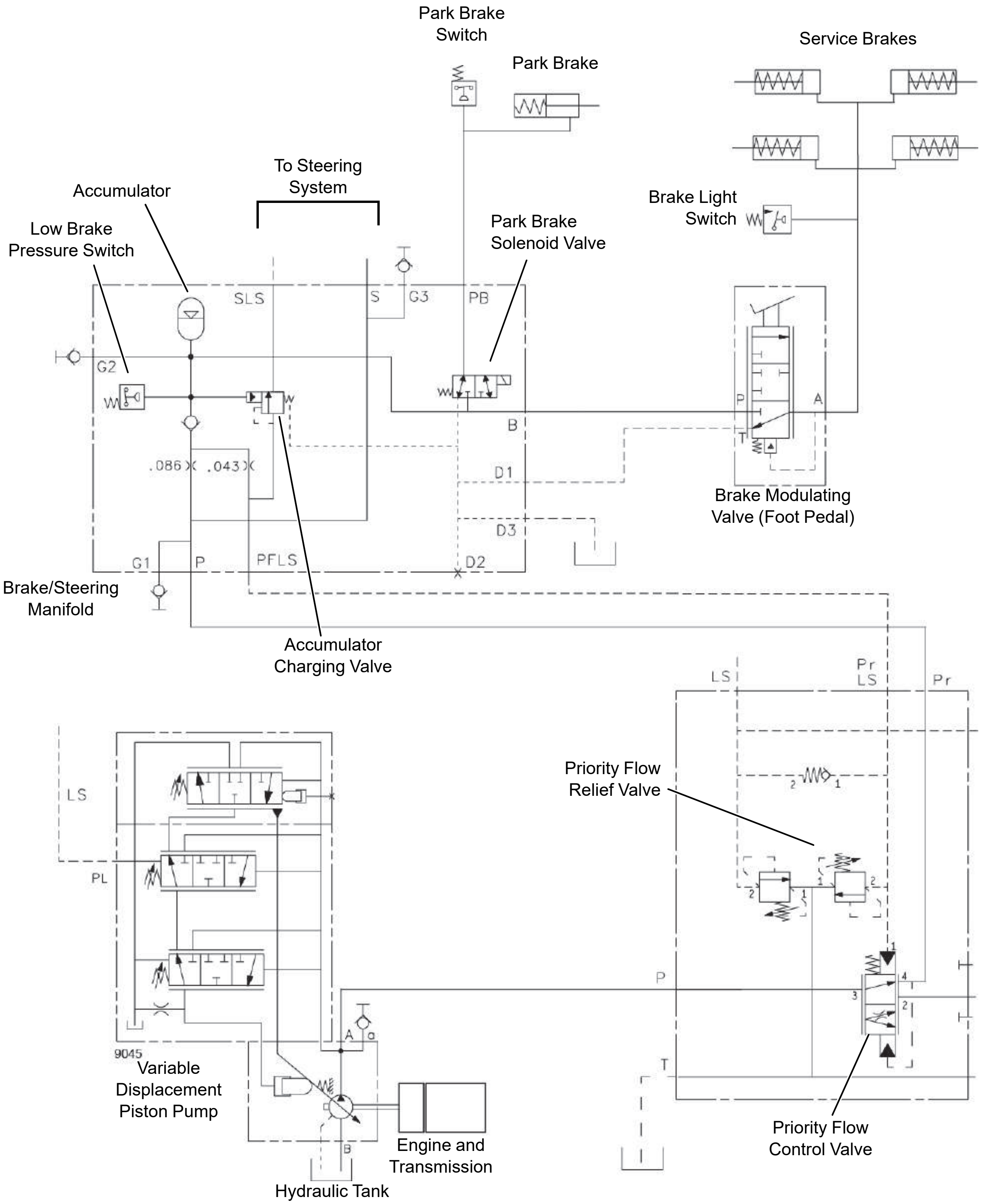
Park Brake Switch
Park Brake
Service Brakes
To Steering System
Accumulator
Low Brake Pressure Switch
Brake Light Switch
Park Brake Solenoid Valve
SLS
S
G3
PB
G2
P
A
B
T
.086
.043
D1
D3
D2
G1
PFLS
Brake Modulating Valve (Foot Pedal)
Brake/Steering Manifold
Accumulator Charging Valve
LS
Pr LS
Pr
Priority Flow Relief Valve
PL
P
T
9045
Variable Displacement Piston Pump
Engine and Transmission
Hydraulic Tank
Priority Flow Control Valve

FIGURE 9-1

DESCRIPTION

This crane has two brake systems:

- Service brake system (hydraulically applied, spring released)
- Parking brake system (spring applied, hydraulically released)

Service Brake System Operation

The service brake system Figure 9-1 consists of the hydraulic pump, priority flow control valve and relief 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.

Hydraulic Pump

The hydraulic pump supplies hydraulic oil flow to the priority flow control valve.

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 Brake Pressure Warning Switch

The low pressure warning switch illuminates a red light on the instrument panel when the brake pressure goes below 69 bar (1000 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, bladder-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.

Brake Modulating Valve

The brake modulating valve is a closed-center spool design. When the brake pedal is up, 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 cab 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.

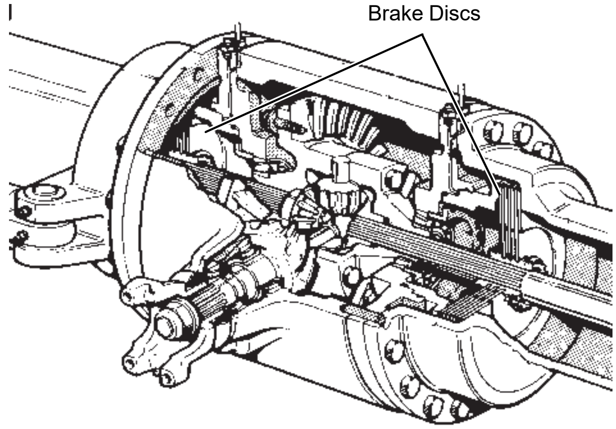

FIGURE 9-2

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Rear Axle Brakes

The rear brakes are self-adjusting, oil immersed and are located in each axle hub Figure 9-3. Each brake assembly consists of three friction plates and four counter plates. The brakes are applied when the brake pedal in the operator's cab is actuated. Brake fluid is forced from the master cylinder through the brake lines to both of the axle brakes. The brake fluid under pressure reacts against the brake pistons, forcing the friction plates against the counter plates, slowing and/or stopping the crane.

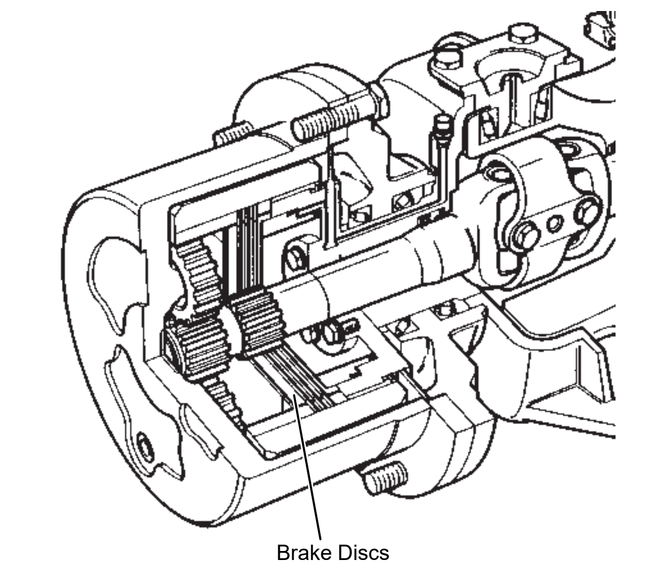

FIGURE 9-3

Parking Brake System Operation

The parking brake system consists of a two-way switch on 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 caliper disc brake Figure 9-4. The brake disc is attached to the input shaft of the front axle. The caliper 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.

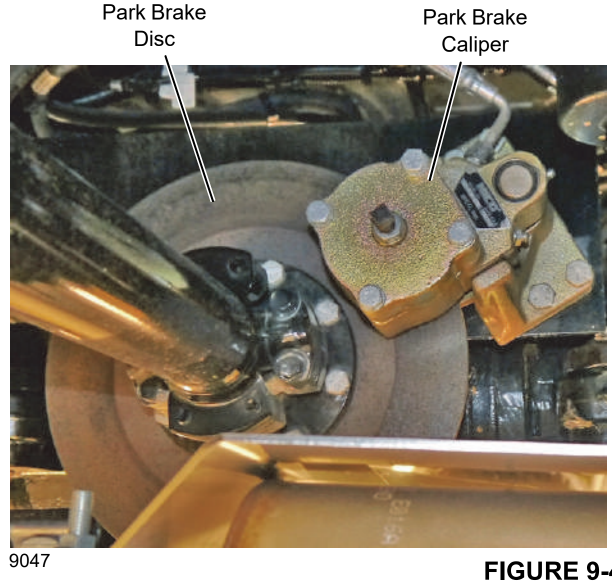

FIGURE 9-4

Parking Brake Solenoid Valve

The parking brake solenoid valve Figure 9-5 is activated by the parking brake switch in the operator's instrument panel. It is a normally-closed solenoid valve. When the switch is placed in the ENGAGE position, no current is sent to the solenoid valve, thus the solenoid valve remains closed and the parking brake is engaged.

When the parking brake switch is placed in the DISENGAGE position, electrical current is sent to the solenoid valve. The solenoid shifts the spool in the valve to open the circuit to the parking brake. The hydraulic fluid, under pressure, disengages the brake pads from the brake disc. Even though the parking brake switch may be in the DISENGAGE position, in the event of a loss of pressure in the accumulator below what it takes to apply the service brakes, the parking brake will engage.

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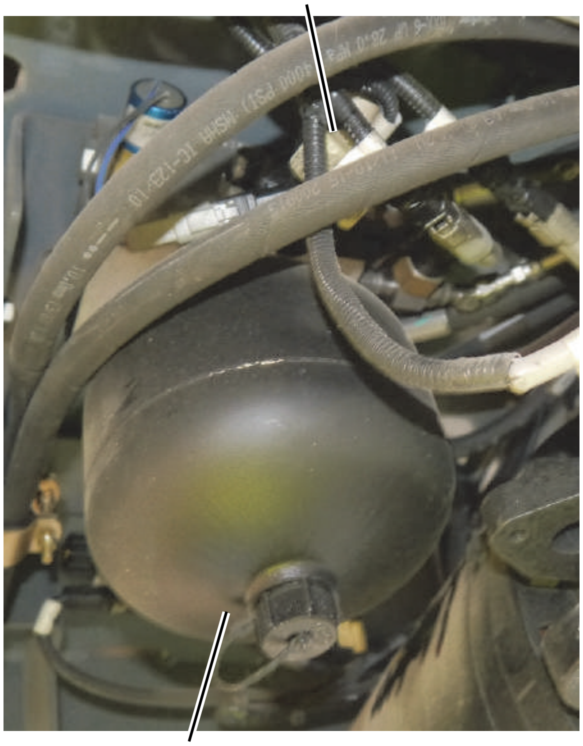


FIGURE 9-5

MAINTENANCE AND ADJUSTMENTS

Service Brake Bleeding

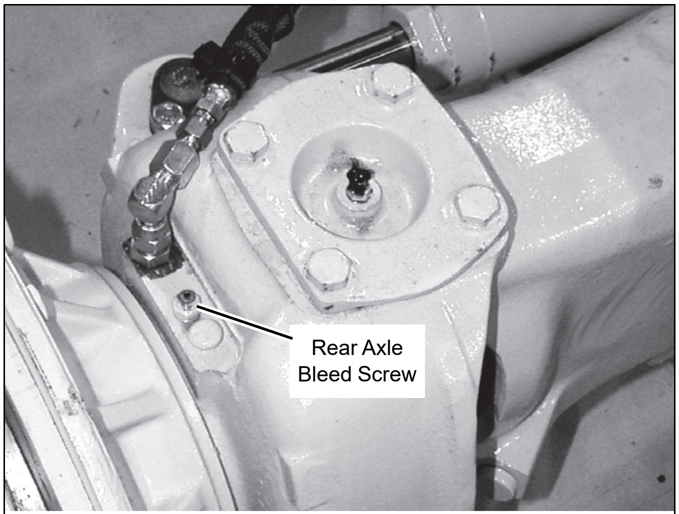
When a brake line is disconnected, the brake system must be bled to remove any trapped air. Air in the brake lines will cause the brakes to be spongy.

NOTE: Before working on the brake system, make sure the crane is on level ground and that all four wheels are chocked.

The accumulator must be charged before this operation can be performed. If you are not sure the accumulator is charged, engage the parking brake, start the engine and let it run for several minutes.

Rear Axle

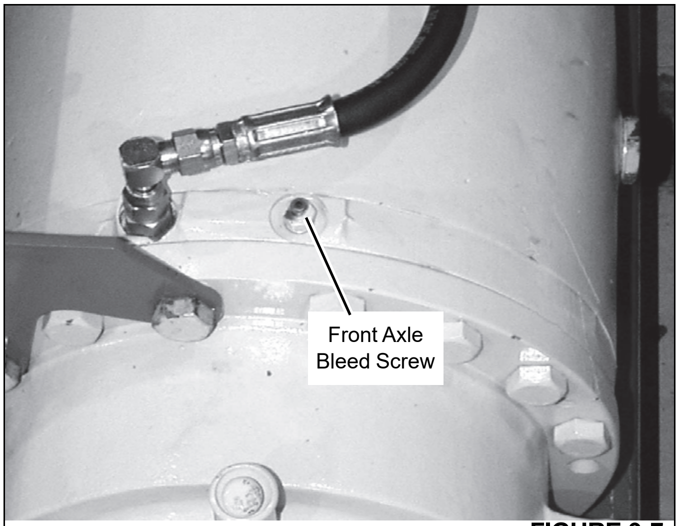
1. Engage the parking brake and shut off the engine. Block the rear wheels on both sides.
2. Attach a tube to the right hand bleed screw **A** Figure 9-6 ensuring that the free end of the tube is immersed in fluid contained in a suitable container.
3. Open the brake bleeder screw and apply full pedal strokes of the brake pedal until all air is expelled.
4. Close the brake bleed screw with the pedal fully depressed.
5. Repeat steps 2 through 4 using the left hand bleed screw.



p0085 FIGURE 9-6

Front Axle

1. Engage the parking brake and shut off the engine. Block the rear wheels on both sides.
2. Attach a tube to one of the wheel bleed screws Figure 9-7 ensuring that the free end of the tube is immersed in fluid contained in a suitable container.
3. Open the brake bleeder screw and apply one rapid stroke of the pedal followed by three rapid short strokes from the pedal half way down. After the third short stroke allow the pedal to return quickly to its stop.
4. Continue bleeding normally until all air is expelled. Close the brake bleed screw with the pedal fully depressed.
5. Repeat steps 2 through 4 for the other side.



p0086 FIGURE 9-7

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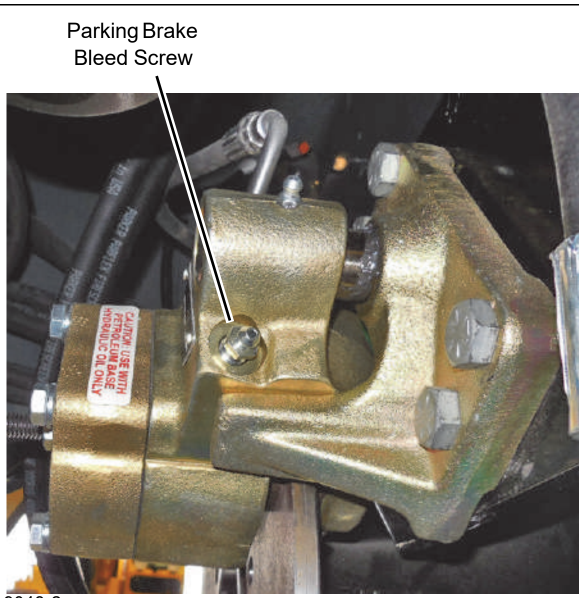
Parking Brake Bleeding

NOTE: Before working on the brake system, make sure the crane is on level ground and that all four wheels are chocked.

The accumulator must be charged before this operation can be performed. If you are not sure the accumulator is charged, engage the parking brake, start the engine and let it run for several minutes.

1. Engage the parking brake and shut off the engine. Block all wheels on both sides.
2. Attach a tube to the bleed screw on the parking brake Figure 9-8 and place the other end in a suitable container.
3. Open the bleed screw, then disengage the parking brake.
4. Observe the fluid exiting the hose. When there is no air or fluid being released, close the bleed screw with the parking brake still disengaged.
5. Engage the parking brake.
6. Repeat steps 3-5 as needed until no air is release from the fluid.



9048-2

FIGURE 9-8

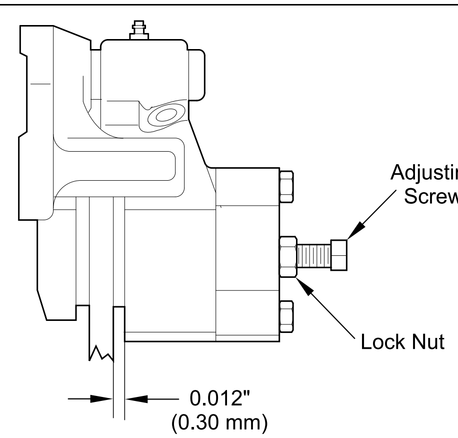
Parking Brake Adjustment

WARNING

Before adjusting the parking brake discs, make sure that the machine is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the adjustment.

When the parking brake is engaged and it will not hold the crane in position it may be necessary to adjust the parking brake disc pads.

1. Shut off the engine and place chock blocks in front and behind all four wheels. Release the parking brake. Check that the brake moves freely on the guide/slide pin.
2. Loosen the lock nut and adjusting screw Figure 9-9.
3. Place a 0.030 mm (0.012 in) feeler gauge between the disc and one of the linings.
4. Tighten the adjusting screw until it is just possible to remove the feeler gauge.
5. Tighten the jam nut while holding the adjusting screw with a wrench. Remove the feeler gauge.
6. Engage the parking brake. Then, release the parking brake and recheck that the brake moves freely on the guide/slide pin.



a0608

FIGURE 9-9

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 ± 2.75 bar (750 ± 40 psi).

Residual Brake System Pressure

If residual pressure is greater than the pressure required to overcome the brake retraction springs in the axle, brake piston retraction will not occur resulting in excessive heat and wear on the brake components,

If the residual pressure in the braking system is above 0.35 bar (5 psi) in the hot condition, the system should be checked to identify the cause of the problem.

NOTE: Pressure cannot build up in the hydraulic tank until the oil is hot, or if the pressure is vented by removing the tank cap/breather.

Checking For Residual Pressure

The following should be done with the engine running and the hydraulic oil at working temperature.

1. Apply and release the brakes. Check that the brakes release immediately.
2. If the brakes do not release immediately, place a container under the axle hub to collect any spilled oil. Unscrew the bleed nipple on the axle to release any residual pressure.

NOTE: The same effort should be needed to rotate the hub with bleed nipple either open or closed. If the problem affects only one hub, disassemble and inspect the affected hub.

3. If the brakes release immediately, residual pressure should be suspected.
4. If the brakes do not release immediately, tighten the bleed nipple and check the following:
   a. Operation of the hydraulic tank breather.
   b. Foot brake valve operation.
   c. Hydraulic tank is overfilled.

TESTS

Brake Piston Seal Leakage Test (Front Axle Only)

The following test procedure explains how to check if a brake piston is severely damaged/destroyed or if the seals have a small cut or nick. The test procedure must only be done when the axle is COLD.

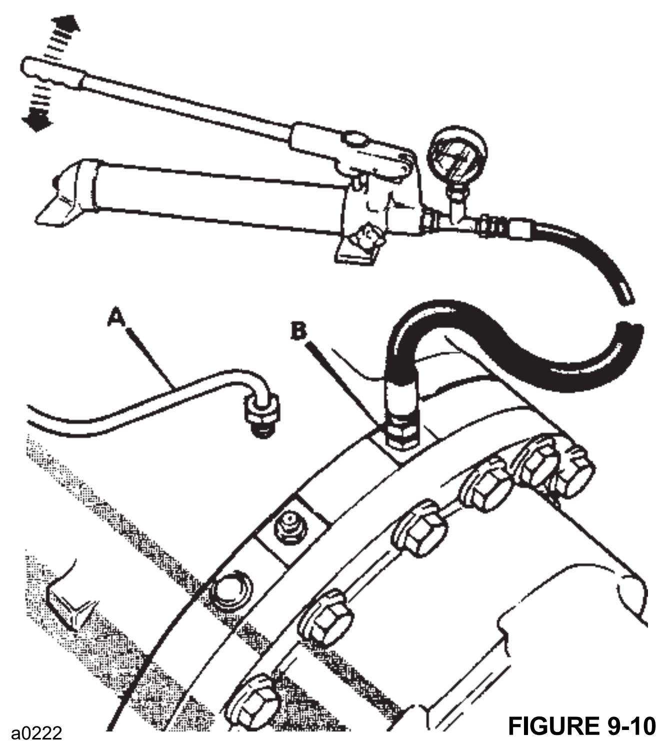
NOTE: Before working on the brake system make sure the crane is on level ground and chock all four wheels.

Do not drive the crane with any part of the brake system disconnected. When the test has been completed, reconnect all brake lines and bleed the brake system using recommended procedures, page 9-6.

1. With the engine shut off and the parking brake engaged, actuate the brake foot pedal until no resistance is felt and the system pressure has been released.

NOTE: Do not disconnect any lines until the brake circuit pressure has been released.

2. Remove and cap the brake piston feed line **A** Figure 9-10.



a0222 **FIGURE 9-10**

3. To check for severe piston seal damage:
   a. Fill the housing of hand pump with Mobil fluid 424, or equivalent hydraulic oil.
   b. Install the hand pump fitted with a 0 to 68.90 bar (0 to 1000 psi) pressure gauge to port **B** Figure 9-10.

NOTE: The hand pump MUST be filled with Mobil fluid 424 or equivalent hydraulic oil. System pressure is 37.90 bar (550 psi) DO NOT exceed 41.34 bar (600 psi).

   c. Use the hand pump to generate a pressure in the brake piston housing.
   d. If the pressure falls off rapidly, or if no pressure reading can be obtained, the seals are severely damaged and must be replaced.

4. If pressure falls off slowly, the piston seals may have small cuts or nicks. To verify for small cuts or nicks in the piston seals perform the following test:

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a. Install an adapter fitted with a piece of clear tube (approximately 120 mm (4.75 in) long to the brake piston port **B** Figure 9-11.

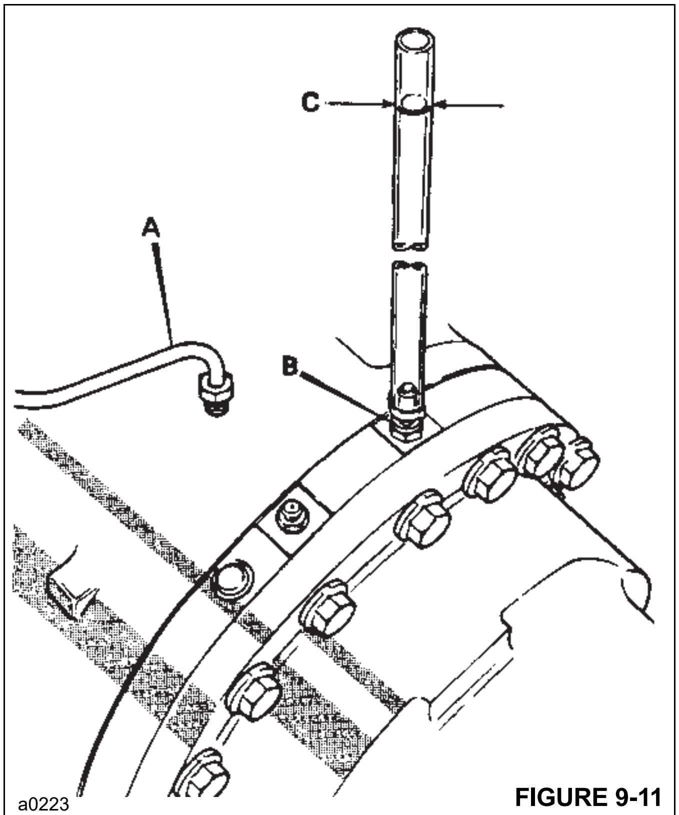


FIGURE 9-11

NOTE: The tube must be kept vertical during the test. Use tape to attach the tube to the side of machine.

b. Fill the tube until it is approximately three quarters full with Mobil fluid 424 or equivalent hydraulic oil.

c. Using a suitable pen, mark the level line (**C**) of the fluid in the tube.

d. After approximately 1/2 hour, check if the level has dropped below the original marked line. If it has then check the brake piston seals for slight nicks, cuts or general wear.

5. Repeat steps 3 through 5 for the opposite brake piston seals.

6. Reconnect all brake lines and bleed the brake system as recommended on page 9-7.

SERVICE BRAKE REPAIR

Front Axle Brakes

NOTE: It is recommended that the axle be removed from the machine when disassembling the front axle brakes. See Servicing the Front Axle in Section 8.

Disassembly

1. Support the axle arm Figure 9-12 and remove bolts **A**.

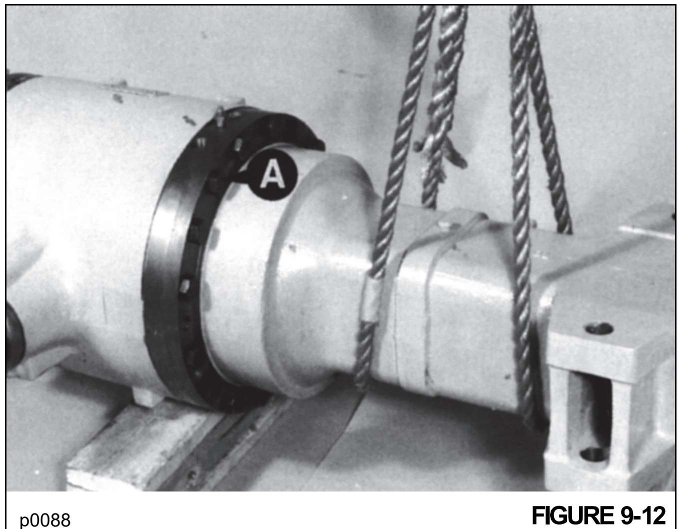


FIGURE 9-12

2. Jack the axle arm off the drive head, using drive head securing bolts Figure 9-13. Remove all traces of gasket from the mating surfaces.

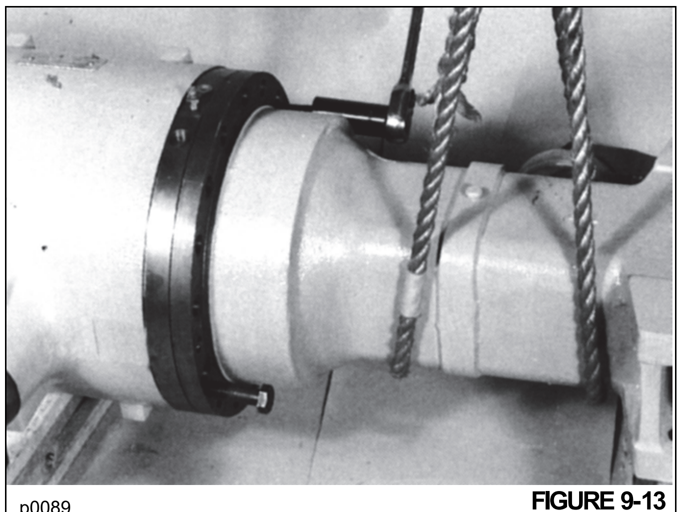
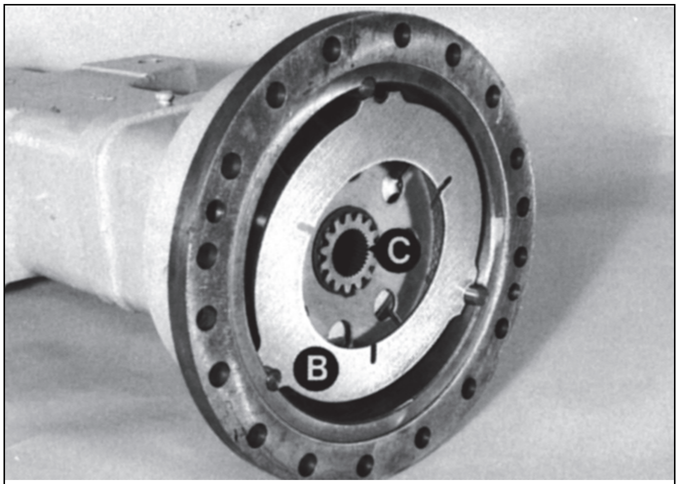


FIGURE 9-13

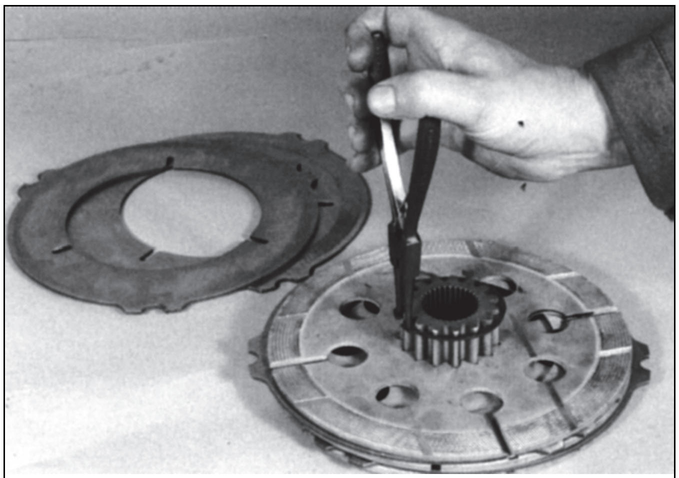
3. There are two counterplates **B** Figure 9-14 one at each end of the brake pack, which are secured to the plate carrier **C**. If the plates are to be reused, note their position and which way round they are then remove the brake pack.



p0090 **FIGURE 9-14**

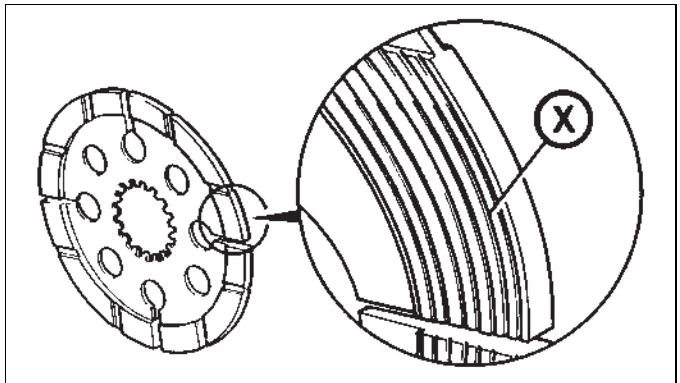
4. Remove the retaining ring Figure 9-15. If the brake pack is to be reused, note the position of the plates before removing them.

NOTE: The planet carrier has an internal chamber at the end which faces away from the drive head.



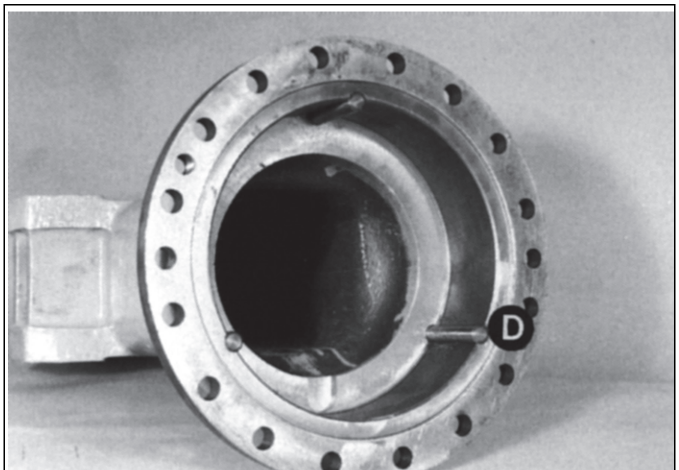
p0091 **FIGURE 9-15**

5. Wear limit of friction plates is to the depth of the circumferential grooves **X** Figure 9-16. Check all plates for flatness and damage. (Some scoring of the counterplates is normal.) Completely replace the brake pack if worn or damaged. Do not replace individual plates.



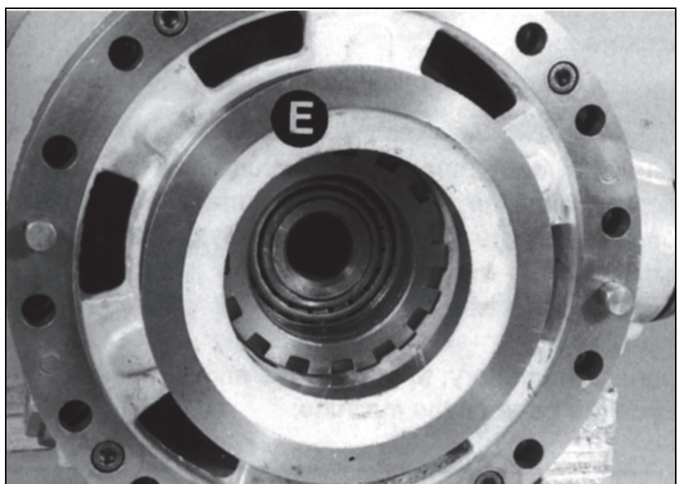
a0228 **FIGURE 9-16**

6. Remove the three reaction pins **D** Figure 9-17. Inspect for damage.



p0092 **FIGURE 9-17**

7. Carefully remove brake piston **E** Figure 9-18 from its housing, if removal is necessary. A hydraulic hand pump can be used to force the piston out of the housing.



p0093 **FIGURE 9-18**

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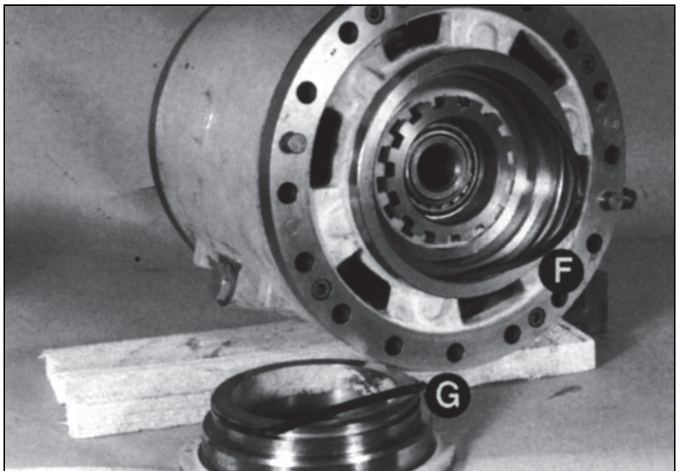
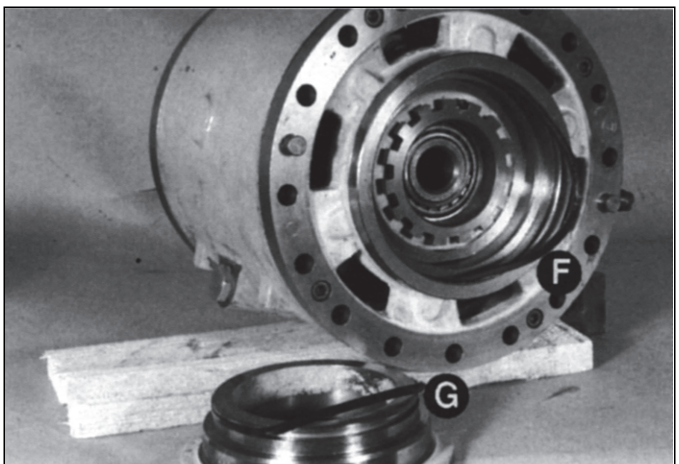
8. Remove and discard seals **F** and **G** Figure 9-19. Inspect the housing for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.



p0094 **FIGURE 9-19**

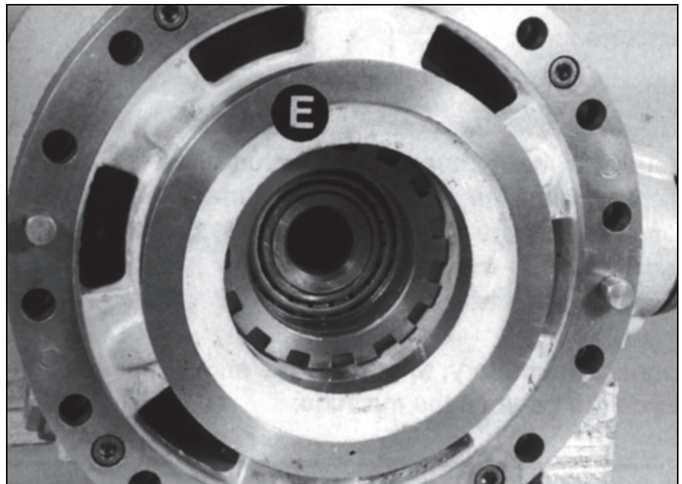
Assembly

1. Install new seals **F** and **G** Figure 9-20. Make sure they seat squarely in their grooves.



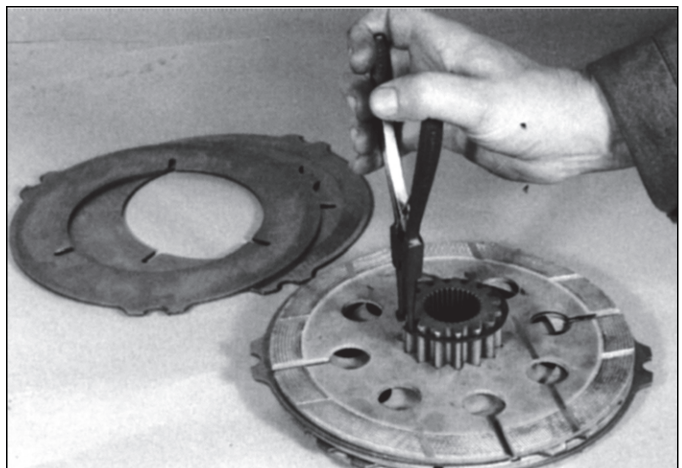
p0094 **FIGURE 9-20**

2. Carefully press piston **E** Figure 9-21 all the way into its housing.



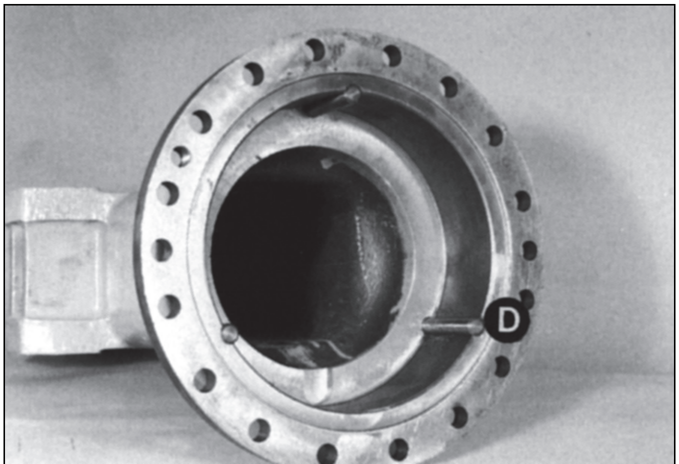
p0093 **FIGURE 9-21**

3. Assemble the friction plates and counterplates onto the carrier. If the original brake pack is being reused, return the plates to their original positions (see Disassembly step 3). Soak new friction plates in gear oil before assembly. Install retaining ring Figure 9-22.



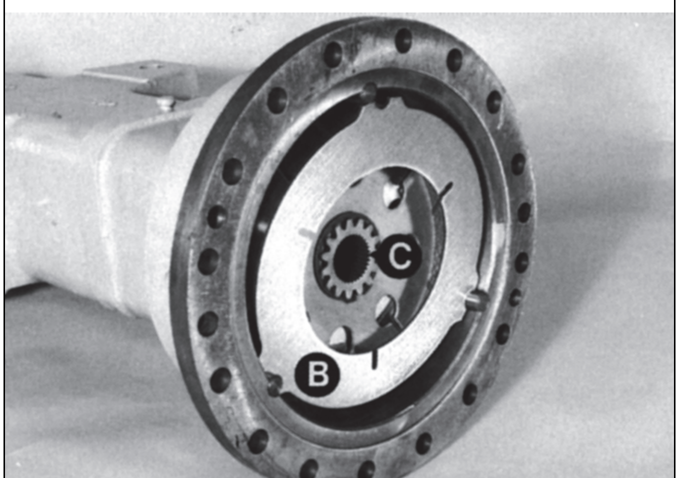
p0091 **FIGURE 9-22**

4. Locate the three reaction pins **D** Figure 9-23 into their grooves, securing them with grease. Push the pins fully into their location holes in the housing.



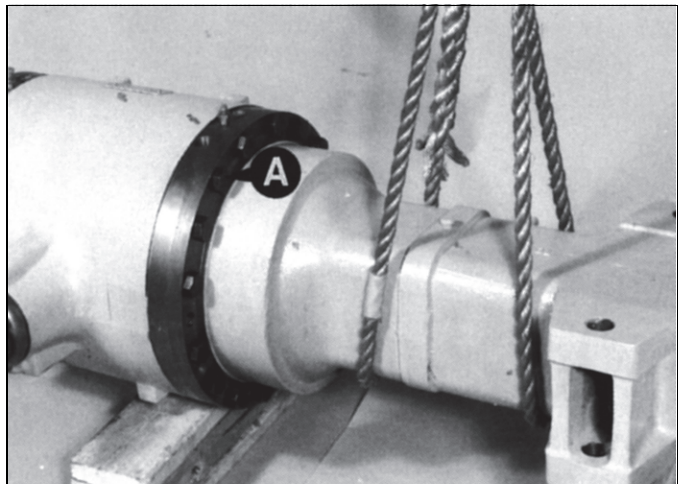
p0092 FIGURE 9-23

5. Install one counterplate **B** Figure 9-24 into the housing, then the brake pack, then the other counterplate. Ensure that the chamfered end of the brake carrier **C** faces away from the drive head. Return reused counterplates to their original positions. Push the brake pack fully home.



p0090 FIGURE 9-24

6. Apply Loctite® 275 to the mating face of the drive head. Locate the axle arm onto the drivehead, with the embossed word “TOP” on the axle arm up most.



p0088 FIGURE 9-25

7. Install bolts **A** Figure 9-25 and tighten to a torque of 244 Nm (178 lb-ft).

NOTE: Check the grade of bolts installed. Grade 8.8 should be tightened to a torque of 244 Nm (178 lb-ft). Grade 12.9 bolts should be tightened to a torque of 400 Nm (295 lb-ft).

8. Fill the axle with recommended lubricant. See *Preventative Maintenance on page 5-1*.

9. Install the axle to the crane’s frame. Refer to *Axles/Drive Shafts/Wheels and Tires on page 8-1*.

Rear Axle Brakes

Refer to Section 8 of this manual for Rear Axle Hub Repair. The service instructions include disassembly, replacement and assembly of the rear axle brakes.

PARKING BRAKE REPAIR

Lining Kit Replacement

WARNING

Before replacing the parking brake linings, make sure that the crane is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the repair.

NOTE: The new linings must be kept free of grease, oil, etc.

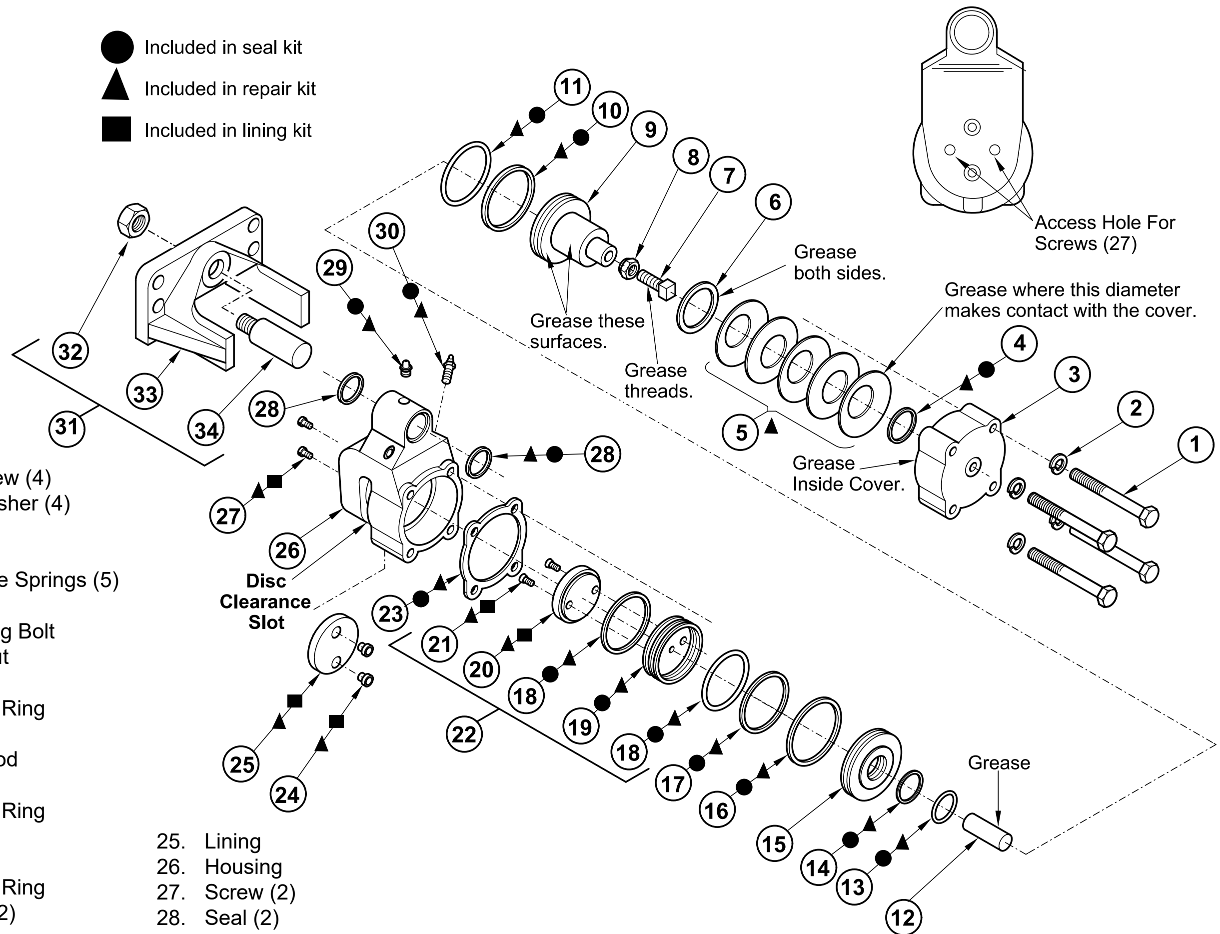
The lining kit is indicated in Figure 9-26 with a ■ symbol.

1. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
4. Loosen lock nut **8** Figure 9-26 and back off adjusting bolt **7**.
5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake.
6. Separate the mounting bracket assembly **31** from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the clearance slot facing straight up.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

8. Remove two screws **27** through access holes in housing **26**. Using a thin blade tool, pry lining **25** from housing **26** and remove the lining and two bushings **24** through the disc clearance slot.
9. Rotate lining assembly **22** until screws **21** are aligned with the access holes in housing **26**. Remove the two flat head screws **21**. Pry lining **20** from piston **19** and remove the lining through the disc clearance slot.
10. Install new lining **20** into piston **19** through the disc clearance slot. Install new flat head screws **21** and tighten to a torque of 3,4 - 4,5 Nm (30-40 lb-in).
11. Insert new bushings **24** into new lining **25**. Install the new lining into housing **26** through the disc clearance slot. Line up the holes with the housing and fasten with two new screws **27**. Tighten to a torque of 2,5 - 3,2 Nm (22-28 lb-in).
12. Assemble the brake assembly onto mounting bracket **31**. Install the parking brake assembly onto the frame of the crane. Attach the hydraulic hose.
13. Adjust the lining clearance as described on page 9-8.
14. Open the accumulator needle valve and then bleed air from the system as described on page 9-7.

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.



1. Capscrew (4)
2. Lockwasher (4)
3. Cover
4. Seal
5. Belleville Springs (5)
6. Washer
7. Adjusting Bolt
8. Lock Nut
9. Piston
10. Backup Ring
11. O-Ring
12. Push Rod
13. O-Ring
14. Backup Ring
15. Piston
16. O-Ring
17. Backup Ring
18. O-ring (2)
19. Piston
20. Lining
21. Screw (2)
22. Lining Assembly
23. Gasket
24. Bushing (2)
25. Lining
26. Housing
27. Screw (2)
28. Seal (2)
29. Grease Zerk
30. Bleeder Screw
31. Mounting Bracket Assembly
32. Nut
33. Bracket
34. Pin

a0779

FIGURE 9-26

Repair Kit Installation

The parking brake has a repair kit available. It includes all the parts necessary to rebuild the brake. These parts are indicated in Figure 9-26 with a ▲ symbol.

WARNING

Before repairing the parking brake, make sure that the crane is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the repair.

NOTE: When removing seals and backup rings be careful not to scratch or mar the pistons.

The new linings must be kept free of grease, oil, etc.

1. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
4. Loosen lock nut **8** Figure 9-26 and back off adjusting bolt **7**.

5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake assembly.
6. Separate the mounting bracket assembly **31** from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the cover **3** in a vertical position.

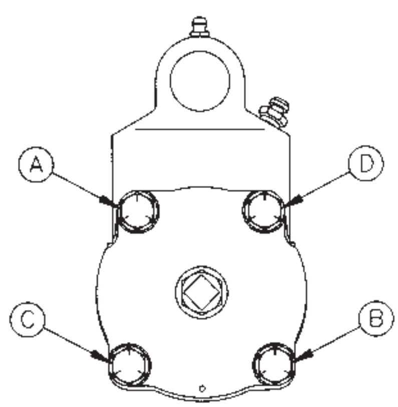
NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

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

WARNING

Cap (3) is under spring pressure. Use care when removing the cap to prevent personal injury.

10. Loosen but do not remove four capscrews **1**. Loosen screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-27 until spring pre-load is released.



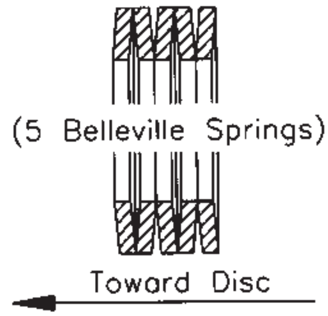
a0783

FIGURE 9-27

11. Remove capscrews **1** Figure 9-26, lockwashers **2**, cover **3** and gasket **23**. Using a thin blade screw driver, remove seal **4** from cover **3**.
12. Remove belleville springs **5** and if present, washer **6**. When removing the belleville springs take note of the stacking sequence.
13. Remove piston **9** from housing **26** bore. Remove O-ring **11** and backup ring **10** from the piston. Push rod **12** should also come out with piston **9**.
14. Remove piston **15** from housing **26** bore. Remove O-rings **13** and **16** and backup rings **14** and **17** from piston **15**.
15. Remove lining and piston assembly **22** from housing **26** bore. Holding assembly on a flat surface, separate lining **20** and piston **19** by removing two flat head screws **21**. Remove O-rings **18** from piston **19**.
16. Loosen vice jaws and rotate the brake so that the disc clearance slot is facing upward. Remove pan head screws **27**, lining **25** and bushings **24** from housing **26**.
17. Lubricate all rubber components (NOT THE BRAKE LININGS) in clean hydraulic oil. Use the same type as used in the hydraulic system.
18. Clean all parts (EXCEPT LININGS) and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the hydraulic system. Keep all parts free of contaminants, dirt and debris.

NOTE: Coat the surfaces indicated Figure 9-26 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

19. Install new lining **25** Figure 9-26 in housing **26** using new bushings **24** and pan head screws **27**. Tighten the screws to 2.5 - 3.3 Nm (22-28 lb-in).
20. Install new lining **20** on piston **19** using new flat head screws **21**. Tighten screws to a torque of 3.4 - 4.5 Nm (30-40 lb-in). Install new O-rings **18** on piston **19** and insert lining and piston assembly **22** into housing **26** bore.
21. Carefully install two new seals **28** in housing **26**. Be sure to install the seals the same direction as they were removed.
22. Install bleed screw **30**. Tighten to a torque of 12.2 - 20.3 Nm (9-15 lb-ft).
23. Install new O-rings **13** and **16** and new backup rings **14** and **17** on piston **15**. Be sure they are installed in the correct order.
24. Install piston **15** into housing **26** bore. Be sure piston is installed in the correct direction. Be careful not to pinch the O-rings on the inlet ports.
25. Install new backup ring **10** and new O-ring **11** on piston **9**. Be sure they are installed in the proper order. Install push rod **12** in bore of piston **9**. Install piston into housing **26** bore.
26. Fully lubricate the threads of adjusting screw **7** and lock nut **9** and install into cover **3**.
27. Install washer **6**, if used, and new belleville springs **5** over end of piston **9**. Follow the stacking sequence Figure 9-28.



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28. Install new seal **4** in cover **3**. Be sure inside of cover is coated with grease.
29. Install new gasket **23**, cover **3**, lockwashers **2** and capscrews **1**. Tighten the screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-27. When installed, tighten each screw to a torque of 29.8 - 36.6 Nm (22-27 lb-ft).
30. Assemble the brake assembly onto the mounting bracket **31**.
31. Install the parking brake assembly onto the frame of the crane.
32. Attach the hydraulic hose.
33. Adjust the lining clearance as described on page 9-8.
34. Open the accumulator needle valve and then bleed air from the system as described on page 9-7.

Seal Kit Installation

The parking brake has a seal kit available. It includes all the parts necessary to replace all the seals in the brake. These parts are indicated in Figure 9-26 with a ● symbol.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

WARNING

Before replacing the parking brake seals, make sure that the crane is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the repair.

NOTE: When removing seals and backup rings be careful not to scratch or mar the pistons.

The linings must be kept free of grease, oil, etc.

1. This will shut off hydraulic pressure to the parking brake. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
4. Loosen lock nut **8** Figure 9-26 and back off adjusting bolt **7**.
5. Remove the bolts and nuts used to fasten the brake mounting bracket to the crane. Remove the parking brake assembly.
6. Separate the mounting bracket **31** from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the cover **3** in a vertical position.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

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

WARNING

Cover **3** is under spring pressure. Use care when removing the cap to prevent personal injury.

9. Loosen but do not remove four capscrews **1**. Loosen screws evenly in the order of **A**, **B, C** and **D** Figure 9-27 until spring pre-load is released.
10. Remove capscrews **1** Figure 9-26, lockwashers **2**, cover **3** and gasket **23**. Using a thin blade, remove seal **4** from cover **3**.
11. Remove belleville springs **5** and if present, washer **6**. When removing the belleville springs take note of the stacking sequence.
12. Remove piston **9** from housing **26** bore. Remove O-ring **11** and backup ring **10** from piston. Push rod **12** should also come out with piston **9**.
13. Remove piston **15** from housing **26** bore. Remove O-rings **13** and **16** and backup rings **14** and **17** from piston **15**.

9

14. Remove lining and piston assembly **22** from housing **26** bore. Remove O-rings **18** from the lining and piston assembly.

15. Lubricate all rubber components in clean hydraulic oil. Use the same type as used in the hydraulic system. Keep the linings free of oil, grease and solvents.

16. Clean all parts and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the hydraulic system. Keep all parts free of contaminants, dirt and debris.

NOTE: Coat the surfaces Figure 9-26 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

17. Install new O-rings **18** on lining and piston assembly **22** and insert the assembly into housing **26** bore.

18. Carefully install two new seals **28** in housing **26**. Be sure to install the seals the same direction as they were removed.

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

20. Install piston **15** into housing **26** bore. Be sure piston is installed in the correct direction. Be careful not to pinch the O-ring on the inlet ports.

21. Install new backup ring **10** and new O-ring **11** on piston **9**. Be sure they are installed in the proper order. Install push rod **12** in bore of piston **9**. Install piston into housing **26** bore.

22. Fully lubricate the threads of adjusting screw **7** and lock nut **8** and install into cover **3**.

NOTE: Completely lubricate belleville springs with a light coat of Lithium Base, E.P. No. 2 bearing grease.

23. Install washer **6**, if used, and belleville springs **5** over end of piston **9**. Follow the stacking sequence Figure 9-28.

24. Install new seal **4** in cover of **3**. Be sure inside of cover is coated with grease.

25. Install new gasket **23**, cover **3**, lockwashers **2** and capscrews **1**. Tighten the screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-27. When installed, tighten each screw to a torque of 29,8 - 36,6 Nm (22-27 lb-ft).

26. Assemble the brake assembly onto the mounting bracket **31**.

27. Install the parking brake assembly onto the frame of the crane.

28. Attach the hydraulic hose.

29. Adjust the lining clearance as described on page 9-8.

30. Open the accumulator needle valve and then bleed air from the system as described on page 9-7.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

BRAKE MODULATING VALVE REPAIR

Removal

WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane's hydraulics or jacks to support the crane when working under it.

Disconnect the battery cables while you're under the crane to prevent the engine from being started.

1. Raise the crane by lowering the outriggers.

2. Install jack stands under the frame of the crane.

3. Shut off the engine and set the parking brake.

4. Press the foot brake pedal (brake modulating valve) as many times as it takes to release any pressure remaining in the brake system.

5. From underneath the operator's cab, disconnect the hydraulic hoses from the fittings. Plug the hoses to prevent contaminating the hydraulic system.

6. Remove the three capscrews and self-locking nuts securing pedal mounting plate to the cab floor. Remove the brake modulating valve and pedal assembly.

Disassembly

1. Remove the brake modulating valve from the pedal assembly, by removing two capscrews **13** Figure 9-29.

2. Remove boot **1** from piston **2** and housing **12**.

3. Remove piston **2**, springs **3**, **4** and **5**, shims **6** and retainer assembly **7** from housing **12**.

NOTE: Observe and take note of the number of shims **6** being removed from the housing.

4. Carefully remove cup **14** and seal **15** from housing **12** bore. Be careful not to scratch or mar the bore.

5. Remove end plug **8** and spring **10** from housing **12**. Remove O-ring **9** from plug **8**.
6. Carefully remove spool **11** from end plug **8** end of housing **12**.

NOTE: Be careful not to damage the spool or housing bore as they are a matched set and not sold separately.

Assembly

A seal kit is available for repair of the valve. It consists of the items indicated with a ● in Figure 9-29.

NOTE: Lubricate all rubber components in repair kit with clean hydraulic oil of the same type used in the hydraulic system.

1. Clean all parts before assembling. Use a suitable solvent.
2. Lubricate spool **11** Figure 9-29 with clean hydraulic oil and carefully slide into plug end of housing **12**.

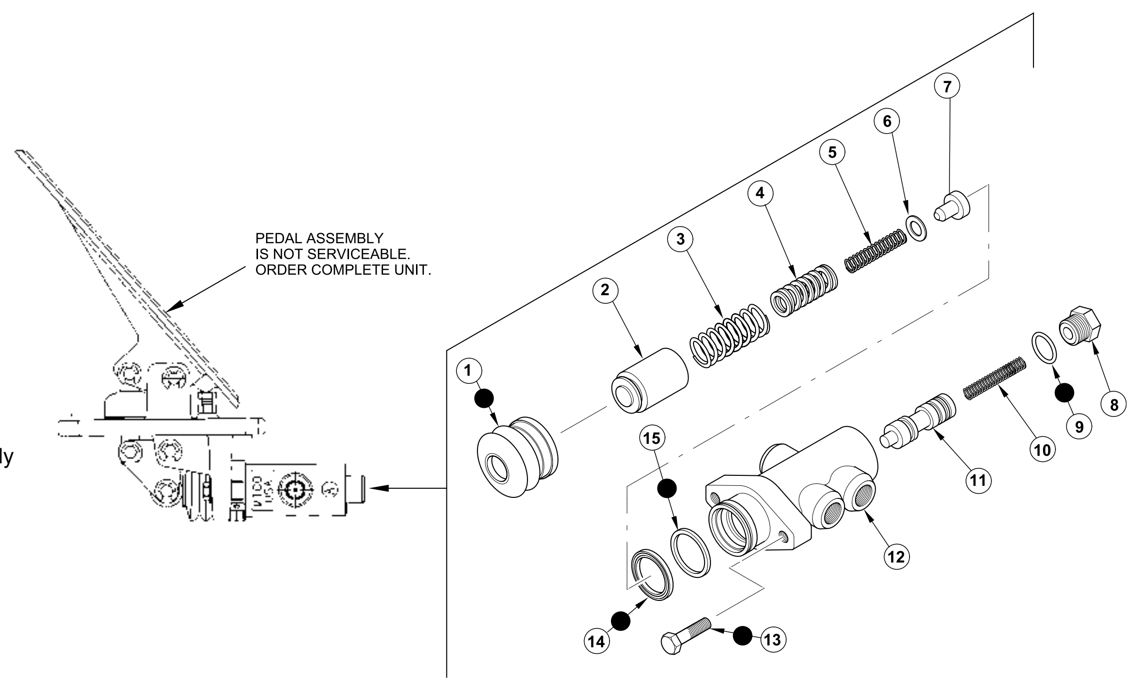
NOTE: The spool must slide freely into the bore. If either part is damaged, a new valve assembly may be required.

3. Install new O-ring **9** on end plug **8**.
4. Install spring **10** and end plug **8** into housing **12**. Tighten to a torque of 54.2 - 67.8 Nm (40 - 50 lb-ft).
5. Carefully install new cup **14** and new seal **15** into bore of housing **12**. Make sure they are installed in the proper order and direction. Take care when installing not to scratch or mar the housing bore.
6. Assemble springs **3**, **4** and **5**, shims **6** and retainer assembly **7** into piston **2**.
7. Carefully install piston **2** assembly into bore of housing **12**.
8. Install new boot **1** on housing **12** and piston **2**.
9. Install the valve assembly onto the pedal assembly with new capscrews (13). Tighten to a torque of 24.4 - 29.8 Nm (18 - 22 lb-ft).
10. After final assembly, the valve must develop a pressure of 37.92 ± 3.45 bar (550 ± 50 psi).

Installation

1. Place the brake modulating valve and pedal assembly in location in the operator's cab. Secure to the cab floor with three capscrews and self-locking nuts.
2. Connect the three hydraulic hoses to the valve.
3. Open the accumulator needle valve and then start the engine. Allow pressure to build in the brake system.
4. Bleed air from the brake system. See page 9-7.

1. Boot
2. Piston Assembly
3. Spring
4. Spring
5. Spring
6. Shim
7. Retainer Assembly
8. End Plug
9. O-ring
10. Spring
11. Spool
12. Housing
13. Screw
14. Cup
15. Seal



Brake Modulating Valve

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FIGURE 9-29

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

SECTION DETAILS

DESCRIPTION

General

The main components of the steering system (Figure 10-1) are:

- Hydraulic pump
- Priority flow control valve
- Brake/steering manifold
- Steering orbital and steering wheel (in cab)
- Steering selector switch (on instrument panel)
- Steering selector valve
- Steering cylinders

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 steering orbital.

Oil from the hydraulic pump is then distributed through the priority flow control valve, the brake/steering manifold, and a check valve to the steering orbital.

When a turn is made, oil is distributed from the steering orbital directly through the steering select valve and/or to the steering cylinders.

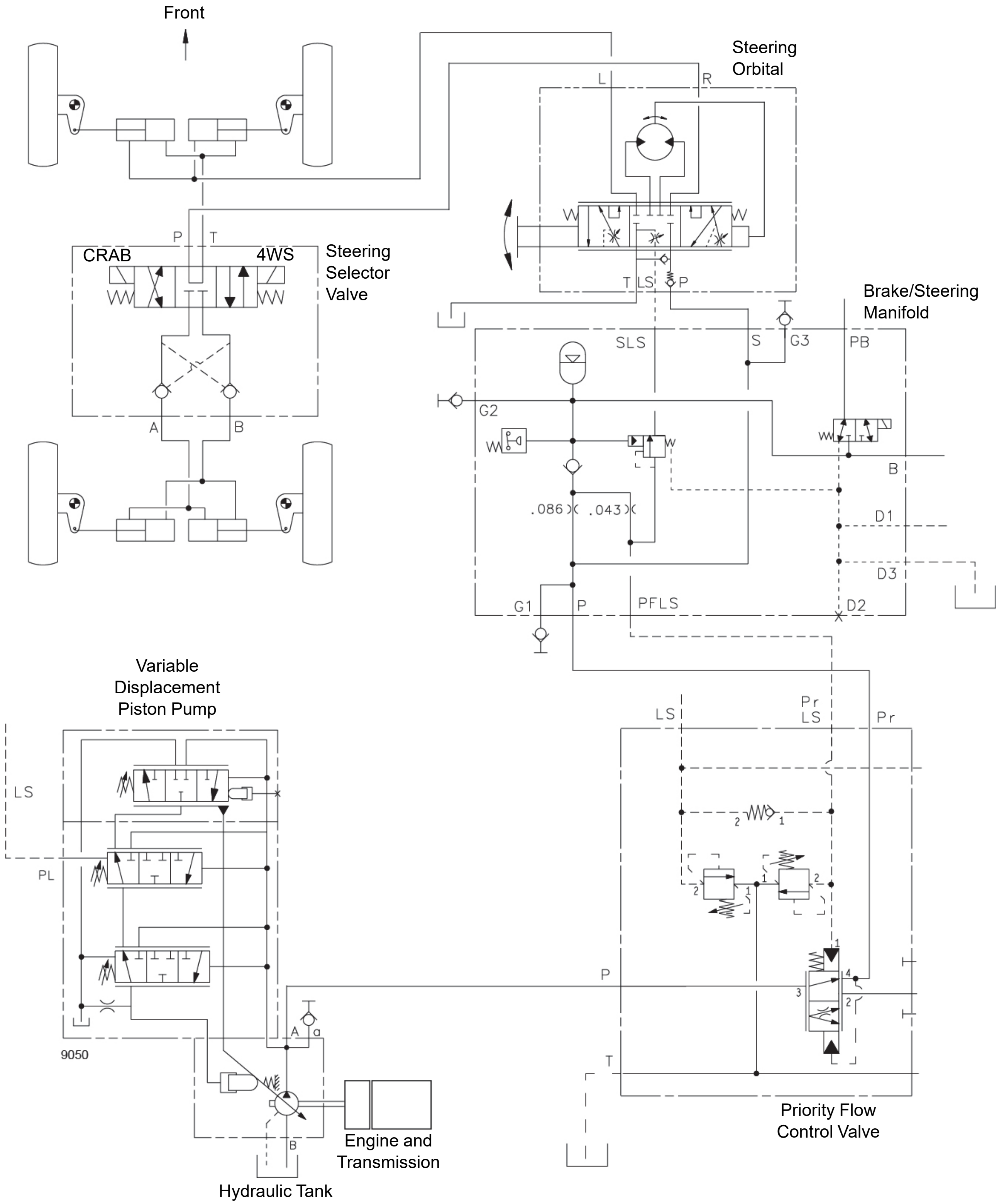
When the steering orbital is neutral, the load sense signal is blocked and full pump flow is distributed to the main control valve circuits through the priority flow control valve.

Maximum steering system pressure is controlled by a relief valve in the priority flow control valve.

Steering Modes

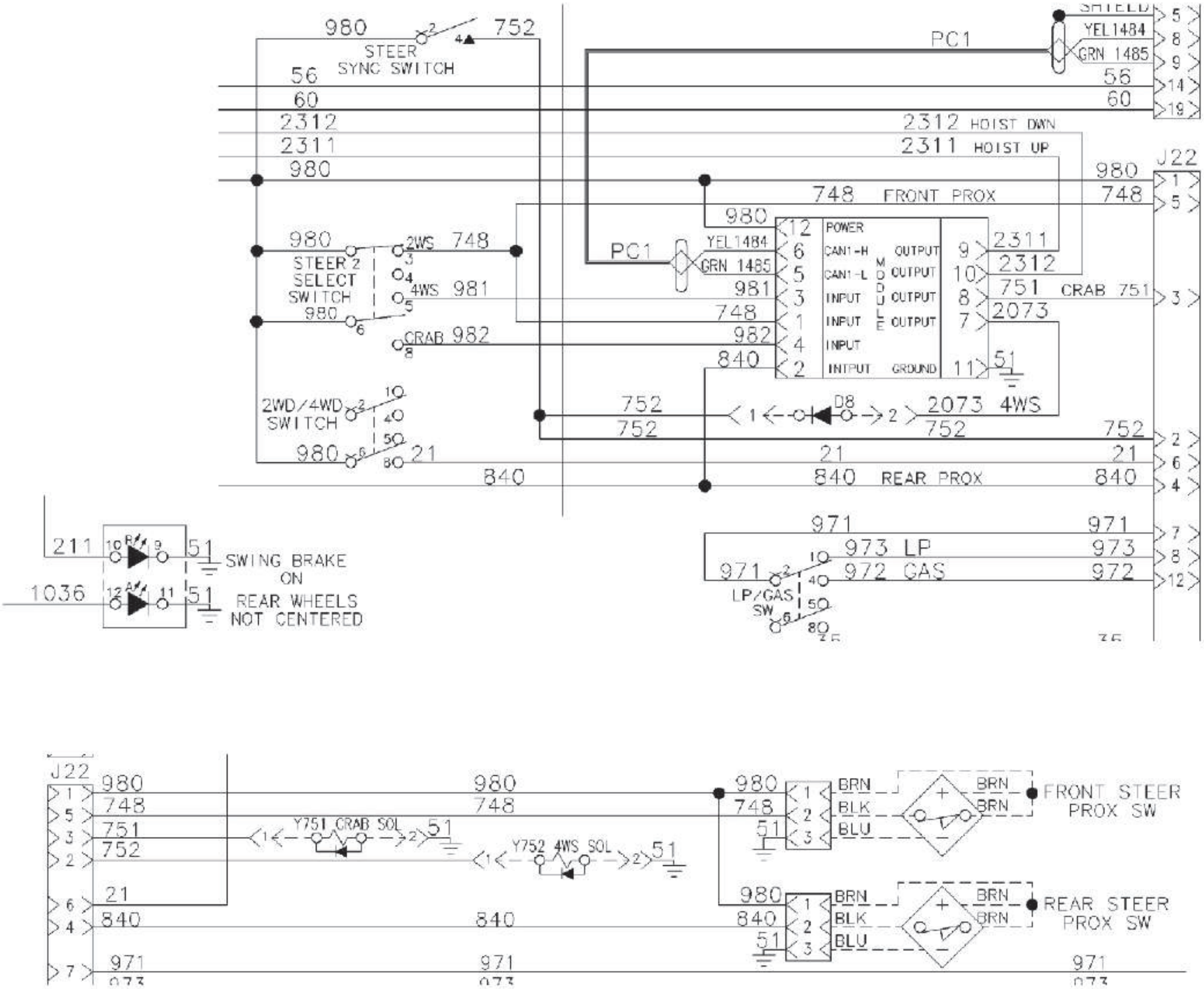
The crane can be operated in three steering modes. These modes are selected using the steering selector switch. The three modes are:

- Two-wheel steering
- Four-wheel steering
- Crab steering



Steering System Hydraulic Schematic

FIGURE 10-1



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Steering System Electric Schematic

FIGURE 10-2

Two-Wheel Steering

See Figure 10-1 on page 10-2.

During two-wheel steering, the front wheels steer in the same direction the steering wheel turns. The rear wheels remain fixed in the forward position.

With the steering selector switch in the 2-wheel steer position, the solenoids on the steering selector valve are de-energized, and the valve remains in the centered position.

When turning to the right:

- Hydraulic oil under pressure from the pump flows through the priority flow control valve, through port S of the brake/steering manifold, to port P of the steering orbital. When the steering wheel is turned to the right, hydraulic fluid flows through port R of the steering orbital to port P of the steering selector valve.
- Oil flows out port T of the steering selector valve to the appropriate ends of the front steering cylinders. The the right-front steering cylinder retracts and left-front steering cylinder extends to the turn the wheels to the right. Return oil from the steering cylinders flows to port L of the steering orbital and is directed back to tank through port T.

When turning to the left:

- Hydraulic oil under pressure from the pump flows through the priority flow control valve, through port S of the brake/steering manifold, to port P of the steering orbital. When the steering wheel is turned to the left, hydraulic fluid is directed through port L of the steering orbital to the appropriate ends of the front steering cylinders.
- The right-front steering cylinder extends and the left-front steering cylinder retracts to the turn the wheels to the left. Return oil from the steering cylinders flows through the porting of the steering selector valve to port R of the steering orbital and is directed back to tank through port T.

Four-Wheel Steering

See Figure 10-1 on page 10-2.

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.

With the steering selector switch in the 4-wheel steer position, the 4WS solenoid on the steering selector valve is energized, and the valve shifts to the 4-wheel steer position.

When turning to the right:

- Hydraulic oil under pressure from the pump flows through the priority flow control valve, through port S of the brake/steering manifold, to port P of the steering orbital. Hydraulic fluid is directed through port R of the steering orbital to port P of the steering selector valve. Oil flows over the check valve and out port A of the steering selector valve to the appropriate ends of the rear steering cylinders.
- The right-rear steering cylinder extends and the left-rear steering cylinder retracts to the turn the rear wheels to the left.
- At the same time, pressure opens the check valve in port B port of the steering select valve. The oil from the return side of the rear steering cylinders flows over the check valve, through port T of the steering selector valve, to the appropriate ends of the front steering cylinders.
- The right-front steering cylinder retracts and the left-front steering cylinder extends to the turn the front wheels to the right.
- The return oil from the front steering cylinders flows to port L of the steering orbital and is directed back to tank through port T.

When turning to the left:

- Hydraulic oil under pressure from the pump flows through the priority flow control valve, through port S of the brake/steering manifold, to port P of the steering orbital. Hydraulic fluid is directed through port L of the steering orbital to the appropriate ends of the front steering cylinder.
- The right-front steering cylinder extends and the left-front steering cylinder retracts to the turn the front wheels to the left.
- The return oil from the front steering cylinders flows to port T of steering selector valve, over the check valve, and out port B to the appropriate ends of rear steering cylinders.
- The right-rear steering cylinder retracts and the left-rear steering cylinder extends to the turn the rear wheels to the right.
- At the same time, pressure opens the check valve in port A of the steering selector valve. The oil from the return side of the rear steering cylinders flows through port A of the steering selector valve, over the check valve, and out port P.
- The return oil flows to port L of the steering orbital and is directed back to tank through port T.

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.

With the steering selector switch in the crab position, the CRAB solenoid on the steering selector valve is energized, and the valve shifts to the crab position.

When crabbing to the right:

- Hydraulic oil under pressure from the pump flows through the priority flow control valve, through port S of the brake/steering manifold, to port P of the steering orbital. Hydraulic fluid is directed through port R of the steering orbital to port P of the steering selector valve. Oil flows over the check valve and out port B of the steering selector valve to the appropriate ends of the rear steering cylinders.
- The right-rear steering cylinder retracts and the left-rear steering cylinder extends to the turn the rear wheels to the right.
- At the same time, pressure opens the check valve in port A port of the steering select valve. The oil from the return side of the rear steering cylinders flows through port T of the steering selector valve to the appropriate ends of front steering cylinders.
- The right-front steering cylinder retracts and the left-front steering cylinder extends to the turn the front wheels to the right.
- The return oil from the front steering cylinders flows to port L of the steering orbital and is directed back to tank through port T.

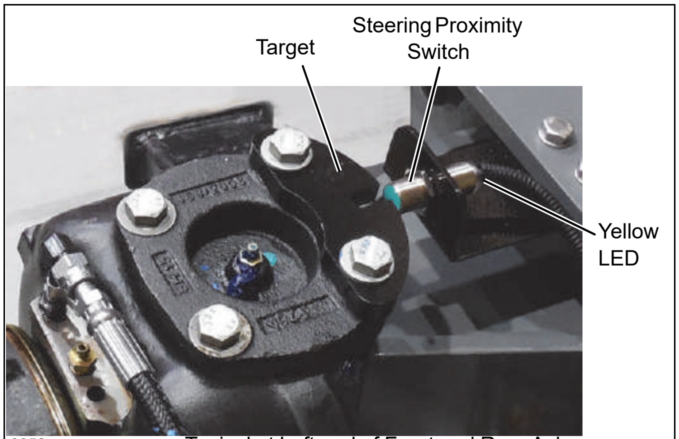
When crabbing to the left:

- Hydraulic oil under pressure from the pump flows through the priority flow control valve, through port S of the brake/steering manifold, to port P of the steering orbital. Hydraulic fluid is directed through port L of the steering orbital to the appropriate ends of the front steering cylinder.
- The right-front steering cylinder extends and the left-front steering cylinder retracts to the turn the front wheels to the left.
- The return oil from the front steering cylinders flows to port T of steering selector valve, over the check valve and out port A, to the appropriate ends of the rear steering cylinders.
- The right-rear steering cylinder extends and the left-rear steering cylinder retracts to the turn the rear wheels to the left.
- At the same time, pressure opens the check valve in port B of the steering selector valve. The oil from the return side of the rear steering cylinders flows through port B of the steering selector valve and out port P.
- The return oil flows to port L of the steering orbital and is directed back to tank through port T.

STEERING PROXIMITY SWITCHES

Proximity Switch Operation

The steering proximity switches (Figure 10-3) prevent the steering mode from being changed until all wheels are aligned straight forward. A proximity switch is mounted on the left end of both axles. The switches are activated by the target on the steering yoke of both axles.



Typical at Left end of Front and Rear Axles

FIGURE 10-3

The steering system electrical circuit (Figure 10-2) includes two proximity switches, a selector switch, a solenoid valve at each end of the steering selector valve, a rear wheels not centered light, and a steering sync switch.

The position of the selector switch controls the steering modes: two-wheel steer, four-wheel steer, or crab steer.

The rear wheels not centered light comes on if the rear wheels are not centered. To select a steering mode the rear wheels must be centered. If the light comes on, use the steering sync switch to re-center the rear wheels. The steering sync switch will by-pass the steer select switch and place the steering in the four-wheel steer mode allowing the operator to re-center the rear wheels with the steering wheel in the cab. The wheels not centered light will go off once rear wheels are centered.

If a steering mode cannot be properly selected, perform the following indexing procedure:

1. Switch to the four-wheel steer mode.
2. Turn the steering wheel until the rear wheels are aligned.

3. Once the rear wheels are aligned, switch to the two-wheel steer mode.
4. Next, switch back to the four-wheel steer mode or to the crab steer mode.

   The steering selector valve will shift to the four-wheel steer mode or to the crab steer mode once the steering wheel is turned so that the front wheels are aligned. This will allow the user to align the wheels for the desired steering mode.

NOTE: If the rear wheels happen to get out of alignment while in the two-wheel steer mode, the user will not be able to switch back to four-wheel steer mode or to the crab steer mode without using the steer synchronize switch.

This will manually switch the steering mode valve to the four-wheel steer mode, allowing the user to align the rear wheels while in two-wheel steer mode. After this, the steer synchronize switch can be released and the steer mode switch can then be changed to four-wheel steer mode or to the crab steer mode.

Proximity Switch Operational Check and Adjustment

Both proximity switches must be working and spaced properly for the steering selection to function properly.

Operational Check

1. Using the outriggers, raise the crane.
2. Stop the engine but leave the ignition switch in the ON position to energize the steering circuit.
3. Remove the front and rear wheels on the left side (cab side) of the crane to obtain access to the proximity switches.
4. Using a piece of metal, pass it within 4 mm (5/32 in) to 6mm (15/64 in) in front of the switch. A yellow LED (Figure 10-3) will illuminate, indicating that the switch is functioning.
5. If the sensor is working properly, check the spacing between the proximity switches and the target. Adjust if necessary.
6. If the sensor is malfunctioning, replace it and adjust the sensor spacing.

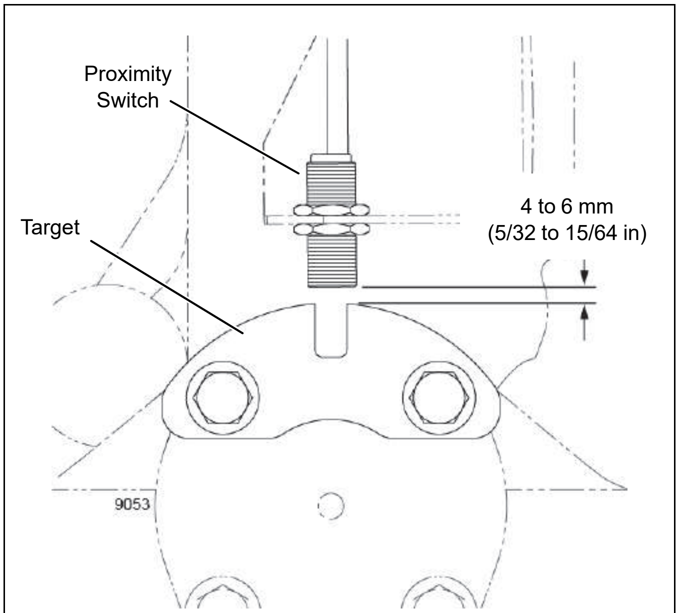


FIGURE 10-4

Spacing Adjustment

See Figure 10-4 for this procedure.

1. Turn the steering wheel so the notch in each target is centered with the end of each proximity switch.
2. If necessary, loosen the nuts and adjust each proximity switch and the gap between the sensor and the edge of the target is between 4 mm (5/32 inch) and 6 mm (15/64 inch). The yellow LED in the end of each switch should be on.
3. Securely tighten the nuts to lock the adjustment.
4. Turn the wheels to verify proper operation. The yellow LED should go off when the wheels are turned. The yellow LED should come on when the wheels are centered.

STEERING ORBITAL

Description

General

The steering orbital (Figure 10-5) provides directional control and metering of oil for precise steering control. 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.

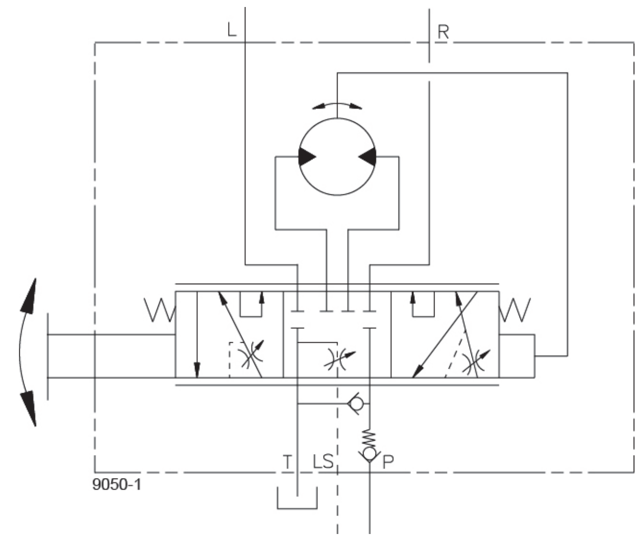


FIGURE 10-5

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 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 in the orbital 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.

orbital Repair

Special Tools

The following special tools are required to assemble the orbital:

Holding tool

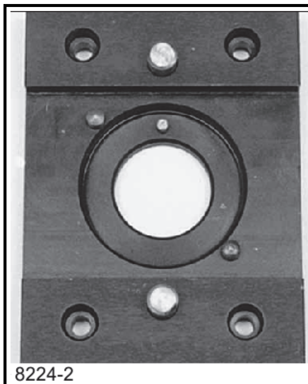


FIGURE 10-6

Guide Ring

FIGURE 10-7

Assembly tool for O-ring and Kin-ring/Roto Glyd

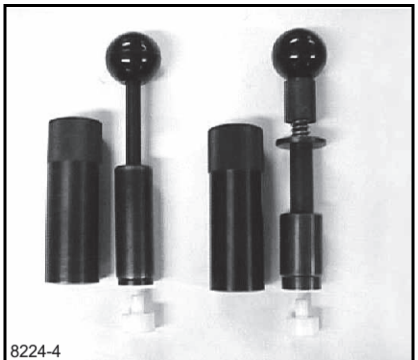


FIGURE 10-8

Assembly tool for lip seal

10

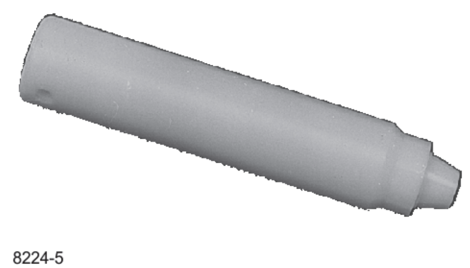


FIGURE 10-9

Assembly tool for cardan shaft

FIGURE 10-10

Assembly tool for dust seal

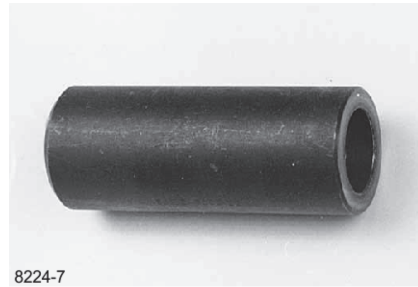
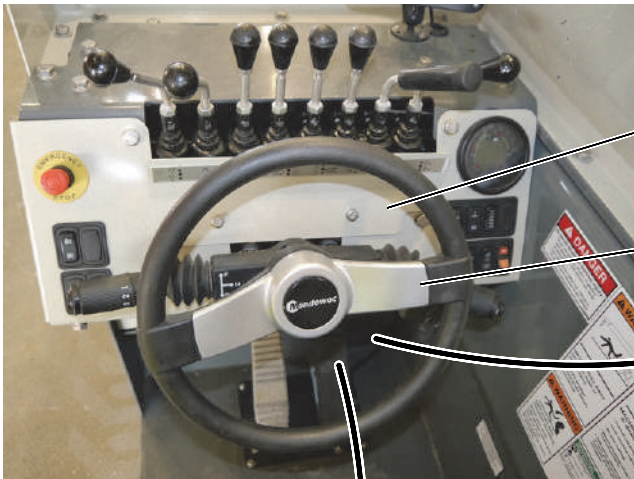


FIGURE 10-11



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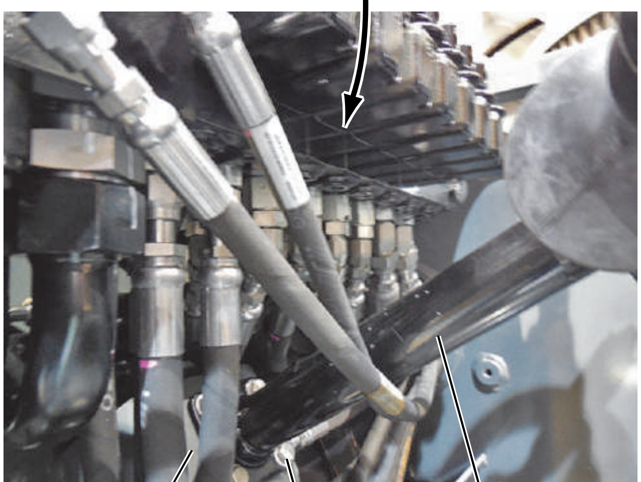
9056-2

2



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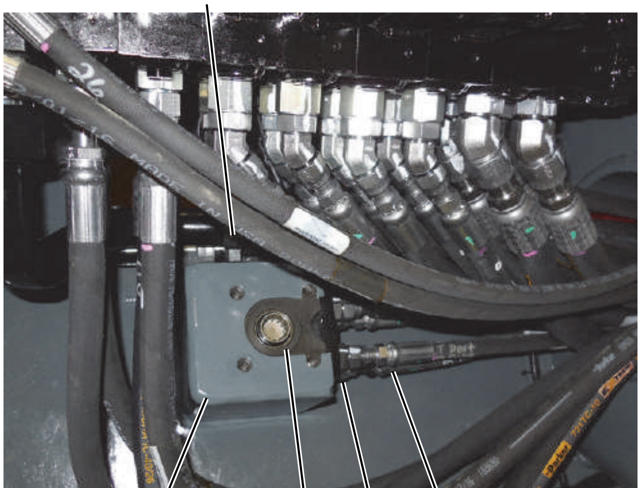
8



9055

5 9 7 6

Item	Description
1	Controls Cover Plate
2	Lower Cover Plate
3	Steering Column
4	Mounting Bracket
5	Cap Screw with Flat Washer (qty 4)
7	Adapter (qty 4)
8	Elbow
9	Steering Orbital

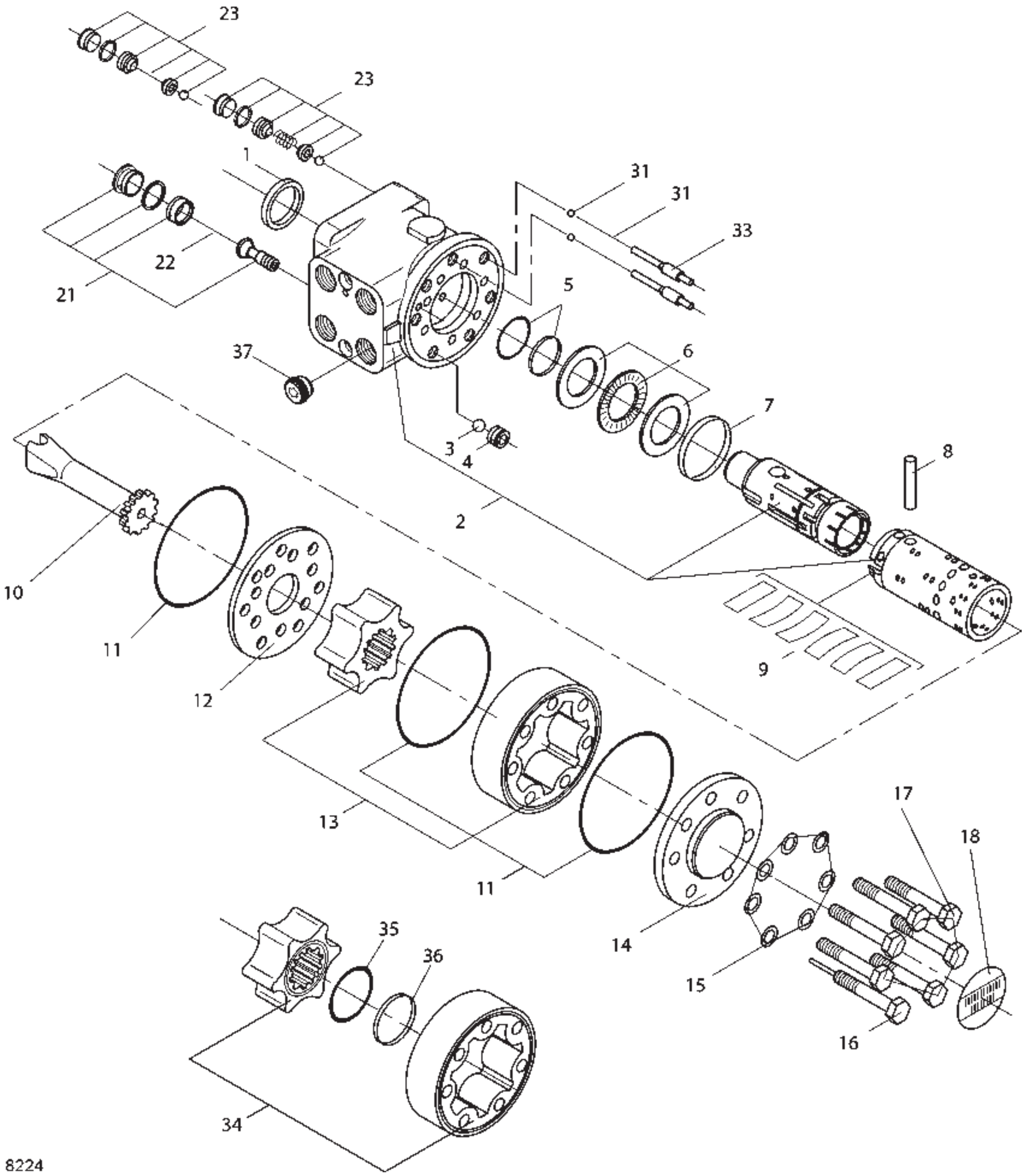
FIGURE 10-12

10

Orbital Removal

See Figure 10-12 for the following procedure.

1. Turn the steering wheel so all four wheels are aligned straight.
2. Park the crane and stop the engine.
3. Lock out/tag out the controls to prevent unauthorized starting of the engine.
4. Rotate the steering wheel a small amount in each direction several times to release pressure in the hydraulic lines at the steering orbital. Then release the steering wheel to the center position.
5. Remove the controls cover plate (1) and the lower cover plate (2) from the instrument panel.
6. Also remove the front cover plate (not shown) from the front side of the of the operator’s cab.
7. Unplug two electric cables from the steering column (3).
8. Completely clean around the area of the steering orbital.
9. Mark the position of the steering column (3) with relation to the mounting bracket (4).
10. Support the steering column and remove the four cap screws and flat washers.
11. Lift the steering column out of the operator’s cab.
12. Tag the hydraulic hoses (6) to the steering orbital (9) for proper identification at installation.
13. Be prepared to catch oil leakage as the hydraulic hoses are disconnected.
14. Slowly loosen the hydraulics hoses (6) from the adapters (7) and elbow (8) to release any remaining pressure.
15. Disconnect the hydraulic hoses.
16. Plug the hoses and cap the adapters and elbow to prevent contamination.
17. Remove the steering orbital (9) from the mounting bracket (5).



1. Dust Seal Ring
2. Housing, Spool and Sleeve
3. Ball
4. Threaded Bushing
5. O-Ring & Kin-ring
6. Bearing Assembly
7. Kin-ring
8. Cross Pin
9. Neutral Position Springs
10. Cardan Shaft
11. O-ring
12. Distributor Plate
13. Gearwheel Set
14. End Cover
15. Washer
16. Special Screw
17. Screw
18. Name Plate
21. Relief Valve
22. Spring
23. Shock Valve
31. Ball & Spring
33. Suction Valve Pins
34. Gearwheel Set
35. O-ring
36. Kin-ring
37. Bushing

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Steering Orbital

FIGURE 10-13

10

Orbital Disassembly

Cleanliness is extremely important when repairing a steering orbital. Work in a clean area. Use a wire brush to remove foreign materials and debris from around exterior joints of the unit.

1. Place the steering unit in the holding tool. Screw out the screws in the end cover (6 standard plus one special screw).

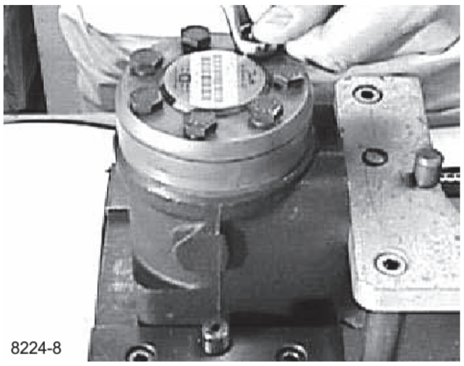


FIGURE 10-14

2. Remove the end cover.
3. Lift the gearwheel set (with spacer if fitted) off the unit. Take out the two O-rings.

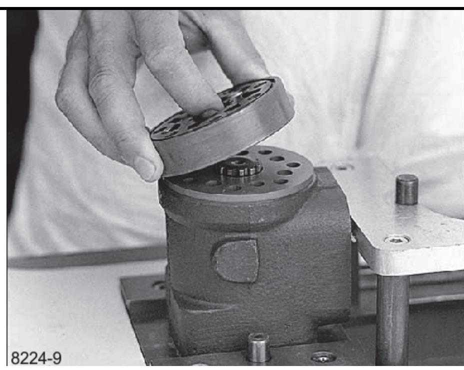


FIGURE 10-15

4. Remove cardan shaft (10, Figure 10-13).
5. Remove distributor plate (12).
6. Remove the threaded bushing (4) over the check valve.
7. Remove the O-ring (11).
8. Shake out the check valve ball and suction valve pins and balls (Figure 10-16).

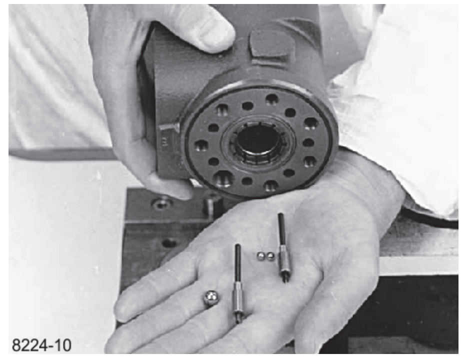


FIGURE 10-16

9. Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and needle bearing will be pushed out of the housing together (Figure 10-17).

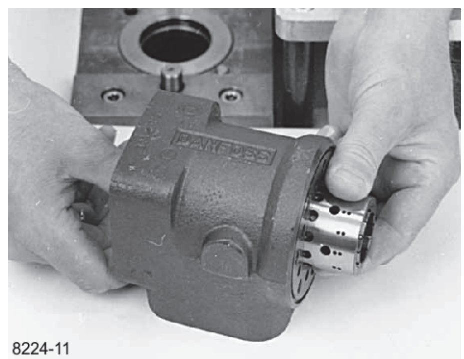


FIGURE 10-17

10. Take ring, bearing races and needle bearing from sleeve and spool. The outer (thin) bearing race can sometimes “stick” in the housing, therefore check that it has come out (Figure 10-18).

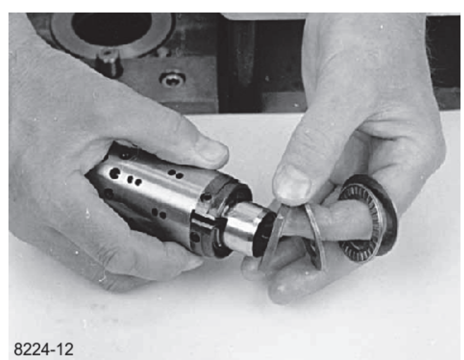


FIGURE 10-18

11. Press out the cross pin. Use the special screw from the end cover (Figure 10-19).

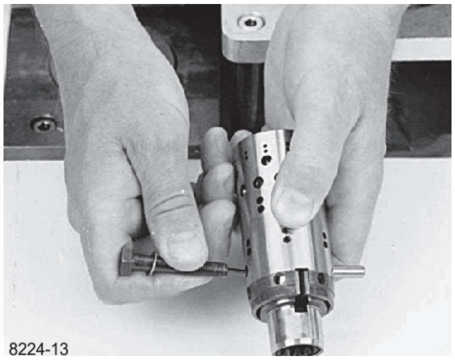


FIGURE 10-19

12. A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs (Figure 10-20). If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are dismantled.

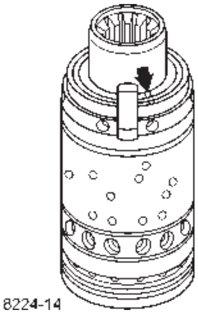


FIGURE 10-20

13. Carefully remove the spool out of the sleeve (2, Figure 10-13).

14. Press the neutral position springs (9) out of their slots in the spool.

15. Remove dust seal and O-ring / Kin-ring / Roto Glyd (Figure 10-22).

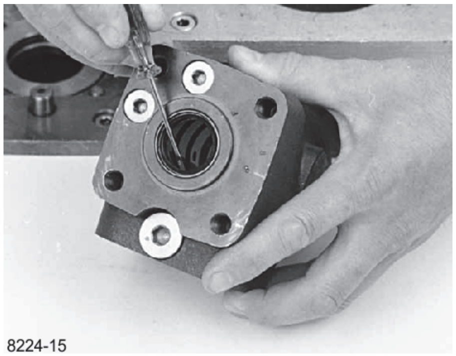


FIGURE 10-21

16. Remove plugs from shock valves using a 6 mm Allen wrench (Figure 10-22).

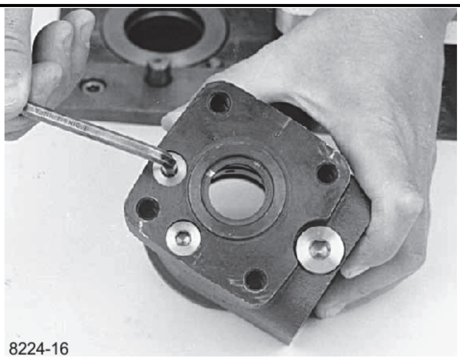


FIGURE 10-22

17. Remove seal washers (Figure 10-23).

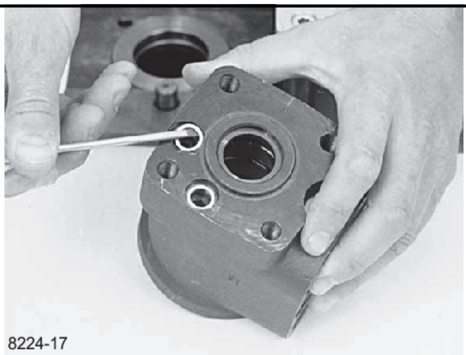


FIGURE 10-23

18. Unscrew the setting screws using a 6 mm Allen wrench (Figure 10-24).

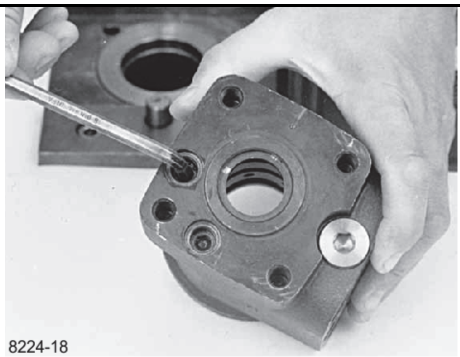


FIGURE 10-24

19. Shake out the two springs and two valve balls into your hand (Figure 10-25). The valve seats are bonded into the housing and cannot be removed.

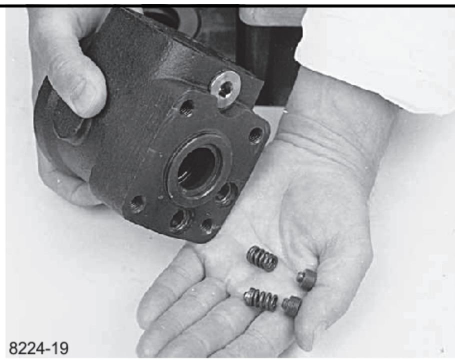


FIGURE 10-25

20. Remove the plug using and 8 mm Allen wrench. Remove seal washers (Figure 10-26).

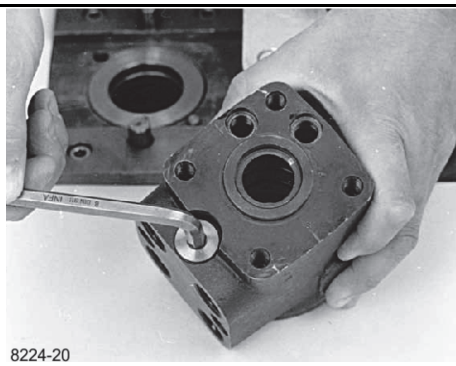


FIGURE 10-26

21. Unscrew the setting screw using an 8 mm Allen wrench (Figure 10-27).

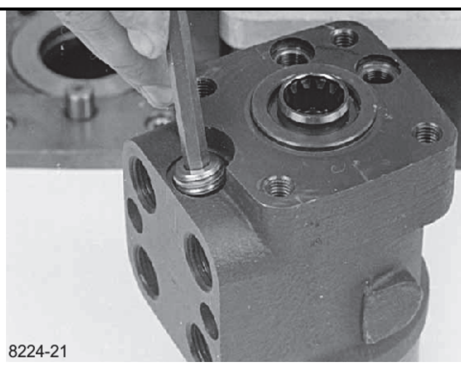


FIGURE 10-27

22. Shake out spring and piston (Figure 10-28). The valve seat is bonded into the housing and cannot be removed.

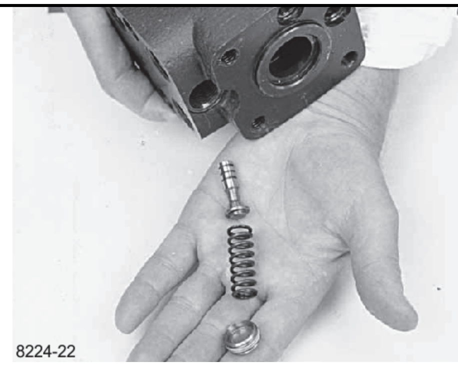


FIGURE 10-28

Orbital Inspection

Check all mating surfaces. Replace any parts that have scratches or burrs that could cause leakage or binding. Clean all metal parts in a clean solvent. Blow dry with air. Do not wipe dry with a cloth or paper towel, because lint or other matter can get into the hydraulic system and cause damage. Do not use a coarse grit emery cloth or try to file or grind any parts.

Replace all seals when assembling the unit. Lubricate all seals with clean petroleum jelly before assembling. DO NOT use excessive lubricant on seals for the meter section.

Orbital Assembly

1. Place the two flat neutral position springs in the slot. Place the curved springs between the flat ones and press them into place. Center the springs in the spool (Figure 10-29).

FIGURE 10-29

2. Assemble the spool/sleeve and make sure the marks on spool and sleeve are opposite each other (see Figure 10-20).

3. Press the springs together and push the neutral position springs into place in the sleeve. Line up the springs and center them.

4. Guide the ring down over the sleeve (Figure 10-30).

NOTE: The ring should be able to move free of springs.

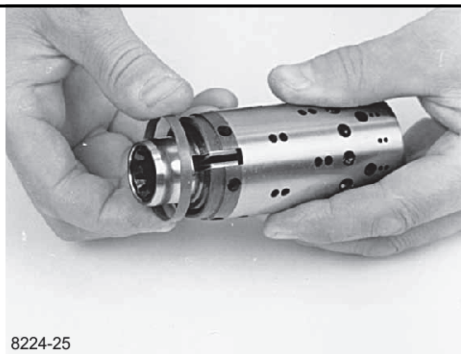


FIGURE 10-30

5. Fit the cross pin into the spool/sleeve (Figure 10-31).

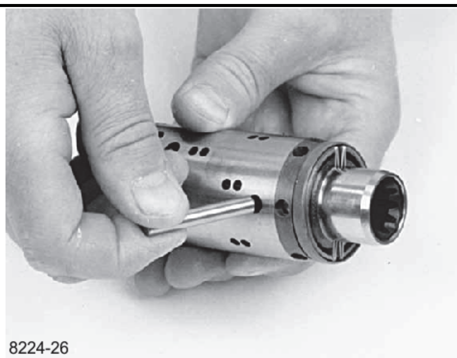


FIGURE 10-31

6. Fit bearing races and needle bearings as shown in Figure 10-32 or Figure 10-33.

1. Outer bearing race
2. Needle bearing
3. Inner bearing race
4. Spool
5. Sleeve

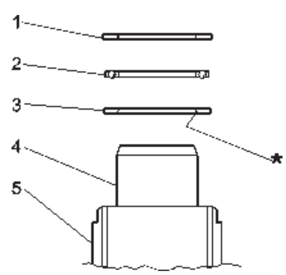


FIGURE 10-32

1. Washer for axial bearing
2. Outer needle bearing
3. Outer bearing race
4. Spool
5. Sleeve
6. Inner needle bearing
7. Inner bearing race

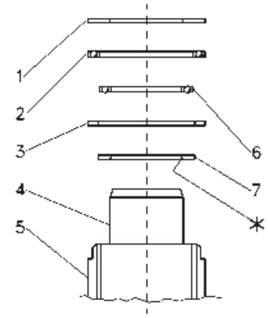


FIGURE 10-33

7. Turn the steering unit until the bore is horizontal. Guide the outer part of the assembly tool into the bore for the spool/sleeve (Figure 10-34).

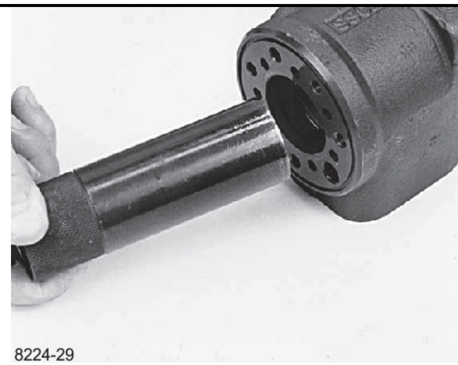


FIGURE 10-34

8. Grease O-ring and kin-ring/roto Glyd with hydraulic oil and place them on the tool (Figure 10-35).

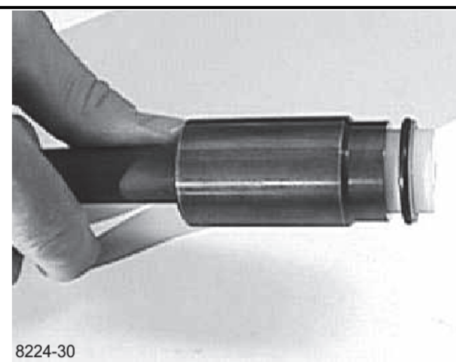
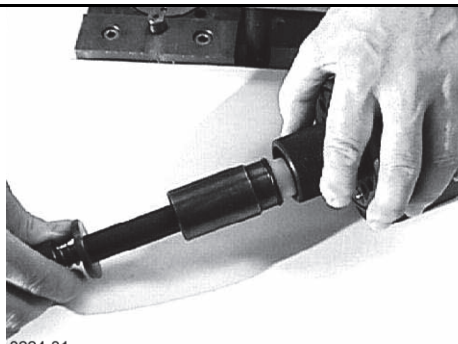


FIGURE 10-35

9. Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom (Figure 10-36).

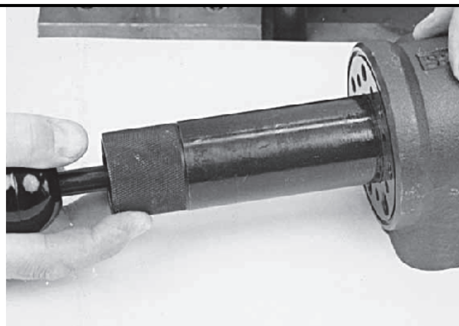


8224-31

FIGURE 10-36

10. Press and turn the O-ring/kin-ring into position in the housing.

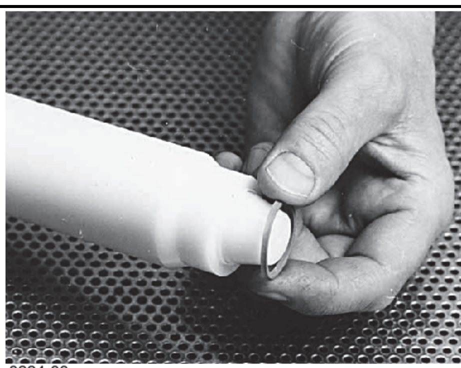
11. Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore (Figure 10-37).



8224-32

FIGURE 10-37

12. Lubricate the lip seal with hydraulic oil and place it on the assembly tool (Figure 10-38).



8224-33

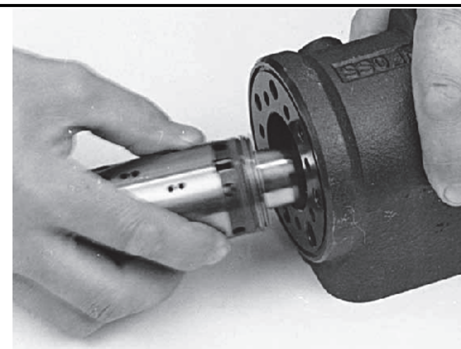
FIGURE 10-38

13. Insert the assembly tool fully to the bottom. Press and turn the lip seal into place in the housing (Figure 10-39).

8224-35

FIGURE 10-39

14. With a light turning movement, guide the spool and sleeve into the bore. Fit the spool assembly holding the cross pin horizontal (Figure 10-40).



8224-34

FIGURE 10-40

15. The spool assembly will push out the assembly tool guide. The O-ring and kin-ring/roto Glyd are now in position (Figure 10-41).

8224-36

FIGURE 10-41

16. Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole shown (Figure 10-42).

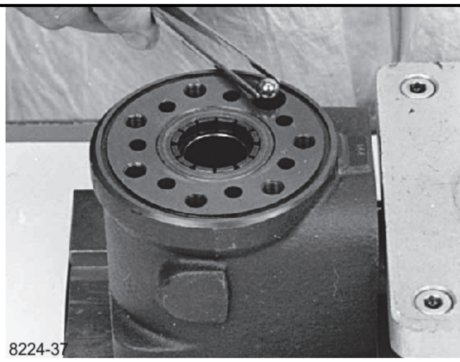


FIGURE 10-42

17. Screw the threaded bushing lightly into the check valve bore. The top of the bushing must lie just below the surface of the housing.

18. Place a ball in the two holes indicated (Figure 10-43).

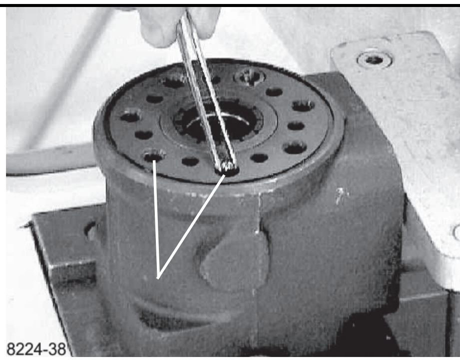


FIGURE 10-43

19. Place a new pin in the same two holes. In some cases a spring has to be fitted on the pin before it is placed in the housing.

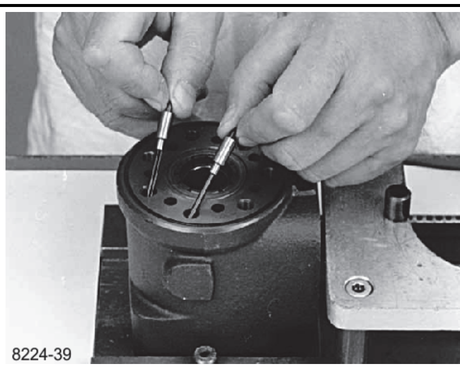


FIGURE 10-44

20. Lubricate an O-ring (11, Figure 10-13) with petroleum jelly and install in groove.

21. Place the distributor plate so that the channel holes match the holes in the housing.

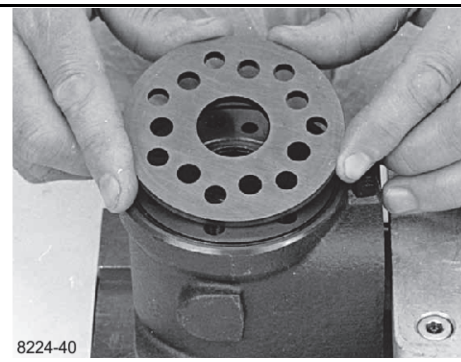


FIGURE 10-45

22. Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.

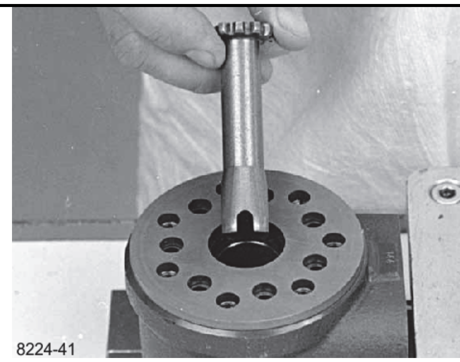


FIGURE 10-46

23. Place the cardan shaft as shown - so that it is held in position by the mounting fork.

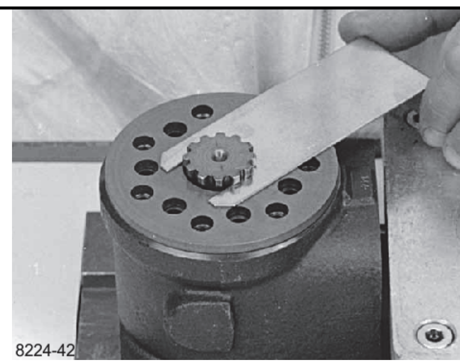


FIGURE 10-47

24. Grease the two O-rings with petroleum jelly and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft (Figure 10-48).

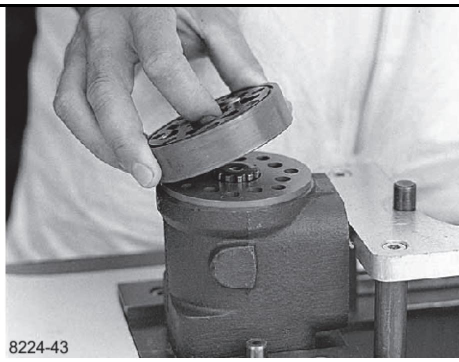


FIGURE 10-48

25. Fit the gearwheel (rotor) and cardan shaft so that a tooth base in the rotor is positioned in relation to the shaft slot as shown. Turn the gear rim so that the seven through holes match the holes in the housing.

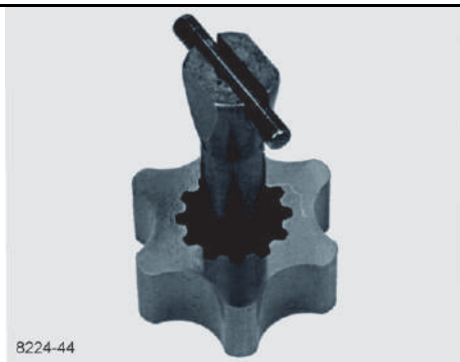


FIGURE 10-49

26. Fit the spacer, if any.

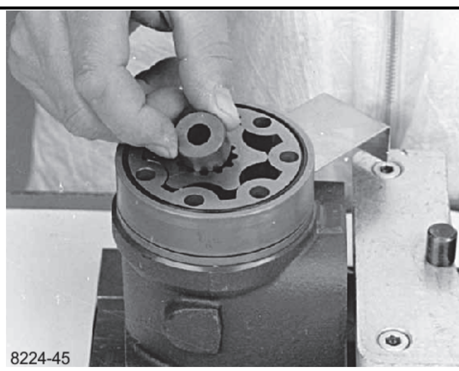


FIGURE 10-50

27. Place the end cover in position.

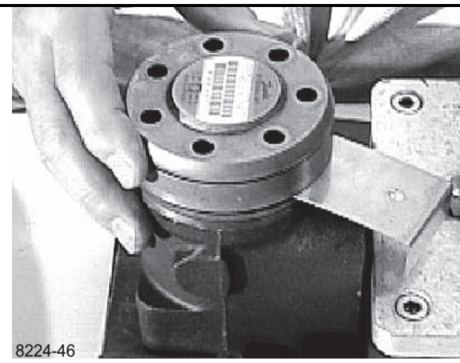


FIGURE 10-51

28. Fit the special screw with washer and place it in the hole shown.

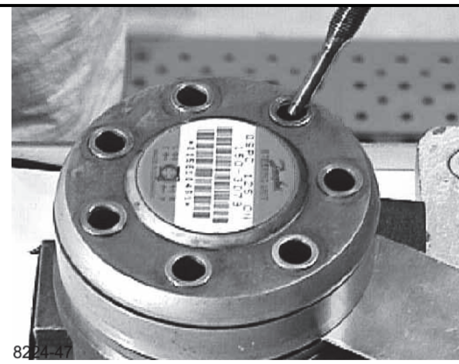


FIGURE 10-52

29. Fit the six screws with washers and insert them. Cross-tighten all the screws with a torque of 30 ±6 Nm (265.5 ± 53 lb-in).

30. Install the piston and spring (Figure 10-53).

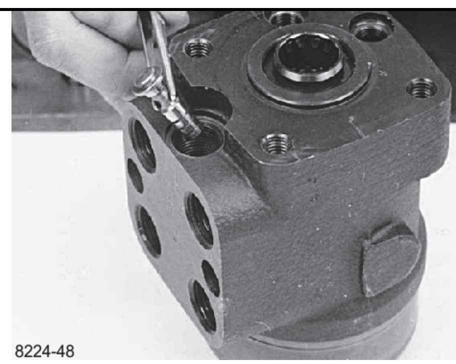


FIGURE 10-53

31. Screw in the setting screw with an 8 mm Allen wrench. Make the pressure setting on a panel or the vehicle.

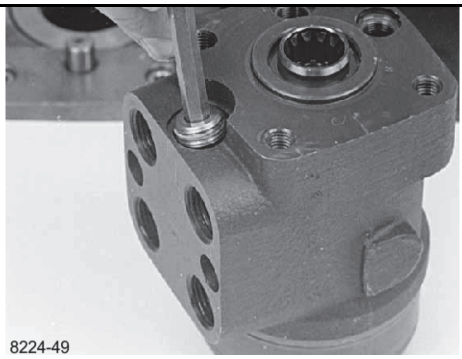


FIGURE 10-54

32. Screw plug with dust seal into the housing using an 8 mm Allen wrench. Tightening torque: 65 ±5 Nm (575.3 ± 44.2 lb-in).

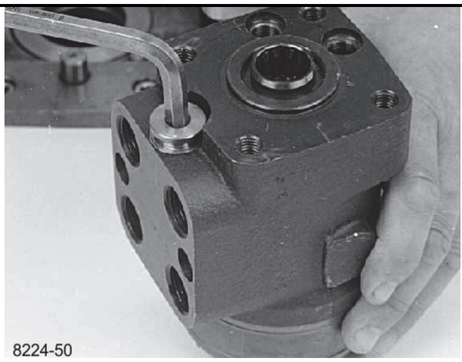


FIGURE 10-55

33. Put a ball in the two holes indicated.

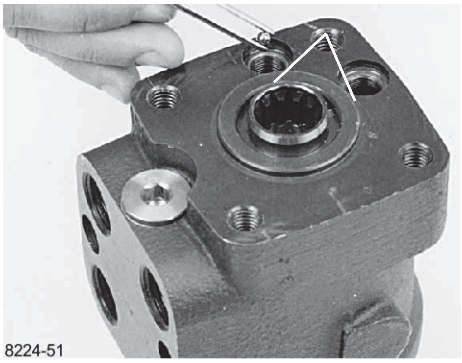


FIGURE 10-56

34. Place springs and valve cones over the two balls.

NOTE: The blue spring applies to setting range 90-180 bar (1305-2610 psi). The untreated spring applies to setting range 170-260 bar (2465-3770 psi).

35. Screw in the two setting screws using a 6 mm Allen wrench. Make the pressure setting on a panel or the vehicle.

36. Screw plugs with seal rings into the two shock valves and tighten them with a torque of 30 +10 Nm (265.5 + 88.5 lb-in) using a 6 mm Allen wrench.

37. Fit the dust seal ring in the housing using special tool and a plastic hammer.

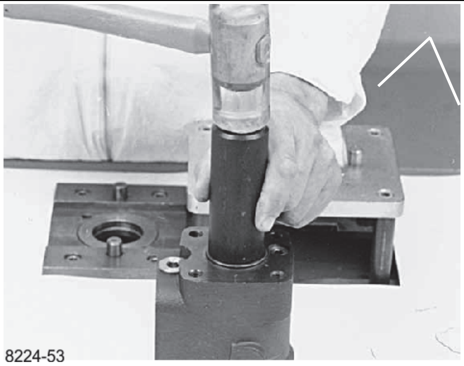


FIGURE 10-57

Orbital Installation

See Figure 10-12 for the following procedure.

1. Thoroughly clean all hydraulic fittings before connecting.
2. Make sure the elbow (8) and the adapters (7) are properly installed with O-rings and securely tightened to the ports of the steering orbital.
3. Remove the caps and plugs from the fittings and hoses.
4. Mount the steering orbital (9) in the mounting bracket (5).
5. Thoroughly clean all hydraulic fittings.
6. Connect and properly tighten the hydraulic hoses to the steering orbital fittings.
7. Lift the steering column (3) into position so the splines on the steering column engage the splines in the steering orbital.
8. Install the flat washers and cap screws (5) and tighten them to the torque value specified in Section 1 of this Service Manual.
9. Connect two electric cables to the steering column.
10. Check the hydraulic oil level in the reservoir. Fill if necessary.
11. Start the engine and turn the steering wheel in both directions to fill the lines with hydraulic oil and to bleed air from the system. Check for leaks and repair if necessary.
12. Check the hydraulic oil level in the reservoir. Fill if necessary.
13. Install the cover plates on the instrument panel and the operator’s cab.

STEERING CYLINDER

The following instructions apply to the front and rear steering cylinders.

Special Tools

The following special tools are required.

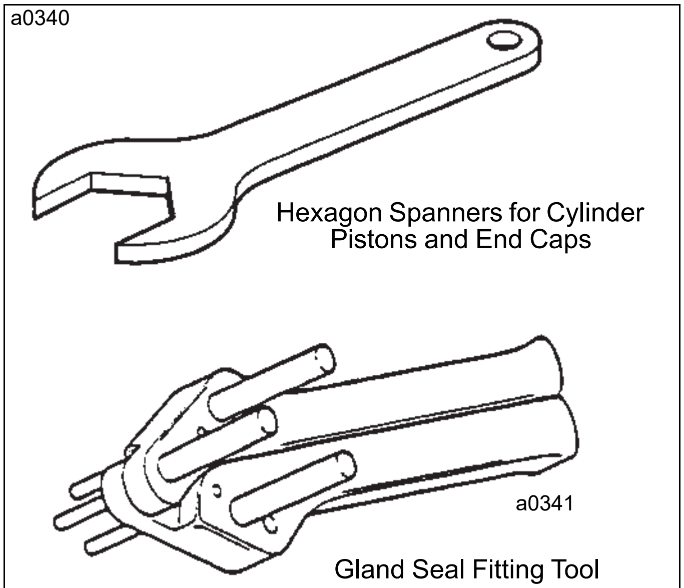


FIGURE 10-58

Cylinder Repair

Cylinder 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 either 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. Turn the steering wheel so all four wheels are aligned straight.
2. Raise and support the crane to gain access to the steering cylinder.
3. Park the crane and stop the engine.
4. Lock out/tag out the controls to prevent unauthorized starting of the engine.
5. Rotate the steering wheel a small amount in each direction several times to release pressure in the hydraulic lines to the steering cylinder.
6. Tag the hydraulic hoses at the steering cylinder for proper identification at installation.
7. Be prepared to catch oil leakage as the hydraulic hoses are disconnected.
8. Slowly loosen the hydraulics hoses to release any remaining pressure in the cylinder.
9. Disconnect the hydraulic hoses.
10. Plug the hoses and cap the cylinder fittings to prevent contamination.
11. Remove the locking bolt (A) Figure 10-59 and the pivot pin (B) from both ends of the steering cylinder.
12. Remove the steering cylinder from the axle.

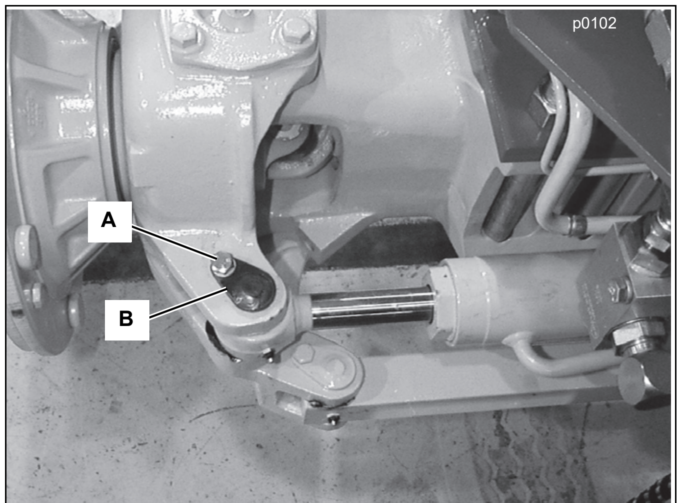


FIGURE 10-59

Cylinder Disassembly

1. Remove the caps from the cylinder ports and drain remaining oil from the cylinder.
2. Secure the cylinder. If a vice is used, clamp only on the base end of the cylinder, DO NOT clamp across the cylinder tube.
3. Loosen end cap **13** Figure 10-60 using a special spanner wrench (See Special Tools, above) and remove the piston rod assembly **16** from the cylinder barrel.

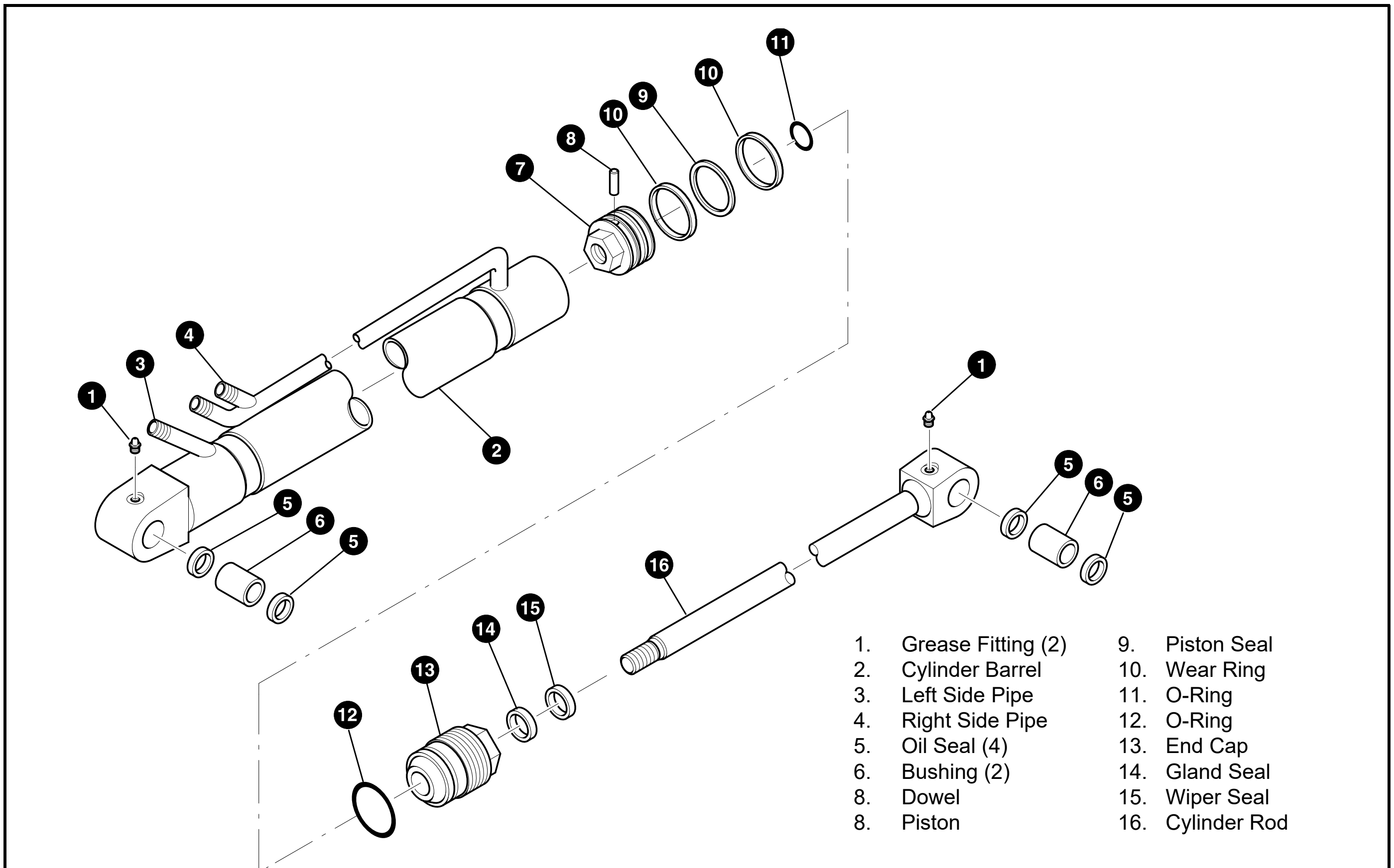


FIGURE 10-60

CAUTION

If air or hydraulic pressure is used to force out the piston assembly, ensure that the end cap is securely installed. Severe injury can be caused by a sudden release of the piston rod.

4. Fasten the bushing end of the cylinder rod in a vice. Do not clamp a vise on the cylinder rod.
5. Remove and discard piston seal **9** and wear rings **10** from piston **7**.
6. Remove dowel **8** from piston head **7** using a metric screw threaded into the extraction hole in the dowel.
7. Using a special spanner wrench (See *Special Tools on page 10-20*) remove the piston **7** from rod **16**.
8. Remove and discard O-ring **11**.
9. Remove cap end **13** from cylinder rod **16**.
10. Remove and discard O-ring **12**, seal gland **14** and wiper seal **15** from cap end **13**.
11. Remove and discard the oil seals **5** from both the rod end and base ends of the cylinder.

Inspection

1. Clean all parts in a suitable solvent. Dry with compressed air. Make sure threads of piston rod, piston, end cap and cylinder are thoroughly cleaned using a wire brush to remove grease, hydraulic oil and Loctite.
2. Inspect cylinder rod for rust, distortion, pitting or damage to the chrome. If there is damage to the cylinder rod, replace it. Do not try to straighten a bent cylinder rod.
3. Inspect inside of the cylinder barrel for grooves, distortion or other damage. Use a light to illuminate the cylinder bore for careful inspection. Replace any cylinder barrel if there is distortion or damage.
4. Inspect the piston for damage to the lands.
5. Inspect rod and barrel bushings for wear or damage.
6. Replace all seals and rings.

10

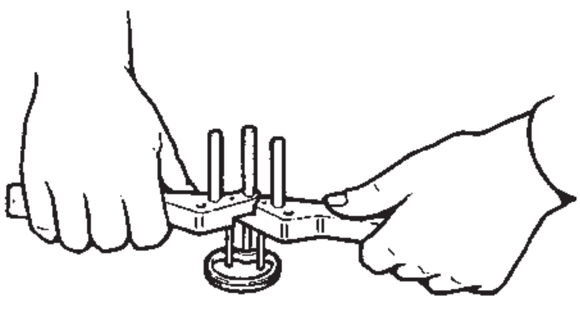
Cylinder Assembly

1. Install new gland seal **14** Figure 10-60 using the special installation tool as follows:

NOTE: The size (diameter) and position of pins is determined by the diameter and radial width of the gland seal being installed.

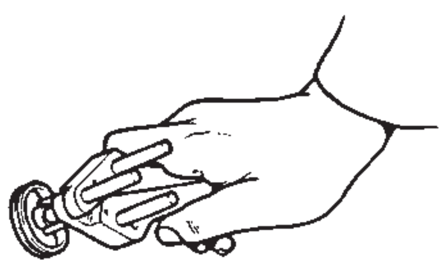
The pins are screwed into threaded holes in the tool body, the spacing of the holes is designed to fit small and large diameter gland seals.

a. Open the tool Figure 10-61 and insert the new gland seal. The seal must be installed behind the two front pins but in front of the rear pin as shown.



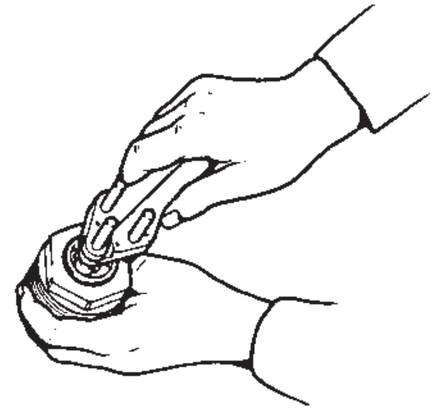
a0343 **FIGURE 10-61**

b. Close the tool Figure 10-62. The seal must form a kidney shape.



a0344 **FIGURE 10-62**

c. Locate the seal in the end cap groove Figure 10-63. When the seal is in position, open the tool to release the seal. Make sure the seal is correctly installed in its groove then remove the tool.



a0345 **FIGURE 10-63**

2. Install a new wiper seal **15** Figure 10-60 and new O-ring **12** to end cap **13**. The lip of the wiper seal must be facing out.

3. Apply Loctite Activator T to threads of the end cap and cylinder barrel. Allow the activator to dry for 15 minutes before bringing in contact with Loctite.

NOTE: Be sure that lubricants used during assembly do not come in contact with Loctite.

4. Cover the threads on the cylinder rod to prevent lubricant from contacting the Loctite.

5. Apply petroleum jelly to the inside bore of the end cap. Carefully slide the end cap assembly over the end of the piston rod.

6. Install O-ring **11** into piston **7**.

7. Install piston **7** onto cylinder rod **16**. Tighten to a torque of 405 Nm (300 lb-ft).

8. New cylinder rod and piston installed.

If both are required, the following procedure should be followed:

a. Drill through the piston into the cylinder rod at the dimension Figure 10-64. Use an undersize drill first as a guide, drill to a depth of 24 mm (0.94 in). Then using a 6 mm drill bit, drill the hole for the dowel.

b. Remove all debris and contamination. Insert dowel **8** Figure 10-60 into drilled hole. Make sure threaded extractor hole is to the outside.

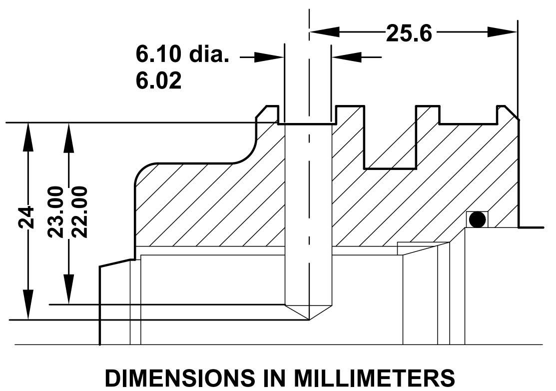


FIGURE 10-64

9. New piston on a predrill cylinder rod.
   a. Re-drill and dowel BOTH the piston and cylinder rod at 90° from the existing drilled dowel hole in the cylinder rod. Follow procedures in step 8.
10. New cylinder rod installed to a predrilled piston.

    Use the predrilled hole in the piston. Care must be taken not to elongate the existing hole in the piston.
   a. Using a 6 mm drill make a center mark in the cylinder rod. DO NOT drill the cylinder rod at this time.
   b. Use an undersized diameter drill bit to drill a guide hole to the depth of 24 mm (0.94 in) Figure 10-64. Make sure the drill bit is centered correctly on the center mark made in Step a.
   c. Use a 6 mm drill bit and drill a hole to the depth of the guide hole.
   d. Remove all debris and contamination. Install dowel **8** Figure 10-60.
11. Install wear ring **10** and piston seal **9** onto piston **7**.
12. Carefully insert the assembled cylinder rod into the cylinder barrel. Use care to prevent damage to the piston seal and wear ring during installation. Work the piston rod straight into the cylinder barrel.
13. Apply Loctite 932 to the first three threads of the end cap. Slide the end cap into the cylinder barrel and engage the threads. Tighten the end cap with the spanner wrench to a torque of 678 Nm (500 lb-ft).

NOTE: If hydraulic oil contacts uncured Loctite a weakening of the bond will result. Cure times vary according to the ambient temperature and the type of activator used. The curing time for Loctite 932 and Activator T at an ambient temperature of 20°C (68°F) is two hours. Do not apply oil to the cylinder before this time.

14. Fill and test the cylinder.

Cylinder Installation

1. Locate the steering cylinder on the axle.
2. Apply anti-seize compound to the pivot pins.
3. Install the locking bolt (A) Figure 10-59 and the pivot pin (B) on both ends of the steering cylinder.
4. Thoroughly clean all hydraulic fittings.
5. Connect and properly tighten the hydraulic hoses to the cylinder fittings.
6. Lubricate the cylinder grease fittings with Lithium based, E.P. No. 2 bearing grease.
7. Check the hydraulic oil level and add oil if necessary.
8. Start the engine and operate the cylinder(s) through several complete cycles to remove air from the system. Operate the cylinders slowly and do not let them hit bottom until movement is positive in both directions. After the circuit is filled with oil, the cylinders can be operated normally.
9. Check for leaks and repair if necessary.
10. Check the hydraulic oil level and fill if necessary.

STEERING SYSTEM TROUBLESHOOTING

Symptom	Probable Cause	Action
Slow steering, hard steering, or loss of power assist.	**1.** Worn or malfunctioning pump.	**1.** Repair or replace the pump.
	2. Priority valve not operating correctly.	**2.** Check for stuck spool. Repair or replace. Check load sense line for leaks or poor connection.
	3. Malfunctioning relief valve.	**3.** Replace the priority valve.
	4. Overloaded steering axle.	**4.** Reduce the load.
	5. Air in hydraulic system.	**5.** Bleed system - bleed the load sense line.
	6. Malfunctioning steering orbital.	**6.** Remove and inspect.
	7. Malfunctioning steering mode valve.	**7.** Check if spools are sticking. Repair or replace. Check if solenoids are operating. Replace if needed.
	8. Mechanical failure.	**8.** Check for damaged axle components, such as cylinders, tie rods, linkages, etc.
Steering wheel turns on its own.	**1.** Dirt in steering orbital (causing sleeves to stick open).	**1.** Clean and inspect unit.
	2. Steering actuator centering springs damaged or broken.	**2.** Check orbital. Repair or replace.
	3. Steering actuator - position of rotor to shaft slot incorrect.	**3.** See page 10-7. Correct if required.

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Symptom	Probable Cause	Action
Crane will not turn when the steering wheel is turned.	**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 orbital. **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 orbital.	**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.	**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.	**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.	**1.** Air in system. **2.** Worn steering linkage. **3.** Loose steering cylinder piston. **4.** Severe wear in steering orbital.	**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 orbital.
Slip - A slow movement of steering wheel fails to cause any movement in steering wheels.	**1.** Leakage of cylinder piston seals. **2.** Worn steering orbital.	**1.** Repair or replace cylinder. **2.** Repair or replace orbital.

Symptom	Probable Cause	Action
Erratic steering.	**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.	**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.	**1.** Air in hydraulic system. Most likely air trapped in cylinders or lines. **2.** Low fluid level.	**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.	**1.** Steering column shaft is loose or damaged. **2.** Lower splines of column may be disengaged or broken. **3.** Steering orbital 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.	**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.	**1.** Loose steering wheel nut. **2.** Steering column shaft worn or damaged.	**1.** Tighten the nut. **2.** Repair or replace the steering wheel connection or column.
Excessive free play at steered wheels.	**1.** Leaky steering cylinder seals.	**1.** Replace cylinder seals.
Binding or poor centering of steering wheel.	**1.** Large dirt particles can cause binding between orbital spool and sleeve.	**1.** Clean the orbital. Repair or replace if necessary. If another component has failed, generating contaminants, flush the hydraulic system while bypassing the orbital.
Steering orbital locks up.	**1.** Large particles of contamination in metering section. **2.** Severe wear and/or broken pin.	**1.** Clean the orbital. Repair or replace if necessary. **2.** Repair or replace the orbital.

SECTION 11
STRUCTURALS

SECTION CONTENTS

11

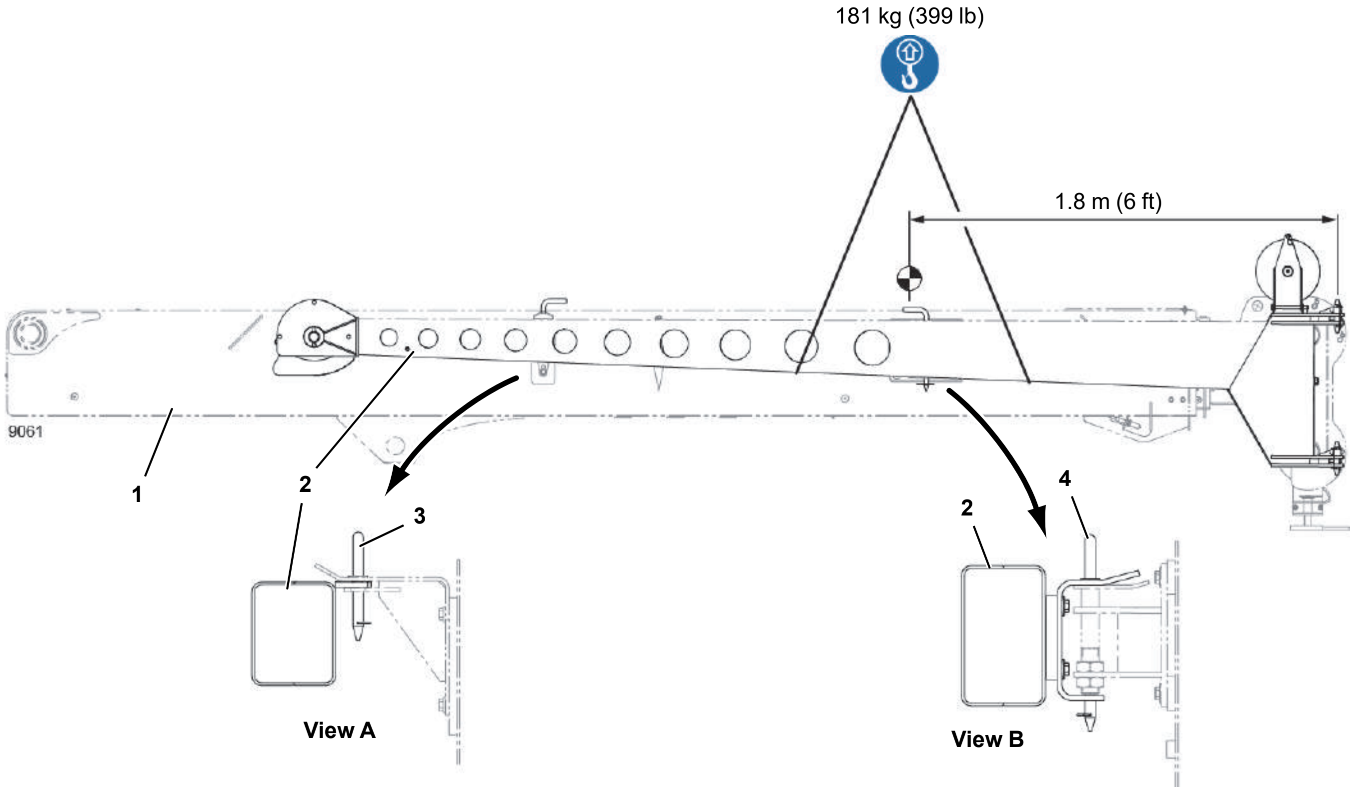


FIGURE 11-1

Item	Description
1	Boom
2	Boom Extension
3	Rear Storage Pin with Retaining Clip
4	Front Storage Pin with Retaining Clip

SAFETY

Read and understand the Safety Practices in Section 2 of this Service Manual.

WARNING

Falling Load Hazard!

To prevent lifting equipment from failing and a load from falling, the crane owner/user shall verify the following prior to each lift identified in this section:

- All lifting equipment (shackles, hooks, slings, blocks) has been properly maintained and is safe for use.
- All lifting equipment has a capacity equal to or greater than the load to be lifted.

WARNING

Crush Hazard!

Some of the procedures in this section require personnel to work under the crane.

A raised and badly supported crane can fall on personnel causing severe injury or death. Position the crane on a firm, level surface before extending the outriggers. Block the carrier deck once the outriggers are extended. 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.

BOOM EXTENSION ASSEMBLY

The following instructions assume that the boom extension is in the stored position on the right side of the boom (Figure 11-1).

The following owner furnished lifting equipment is required for boom extension removal and installation:

- An assist crane or overhead hoist capable of handling the load specified in Figure 11-1
- Synthetic lifting slings

Take every precaution to prevent damaging the boom extension during lifting. If wire rope or chain lifting slings are used, install protective covering (such as sections of rubber tire) between the slings and the boom extension.

Boom Extension Removal

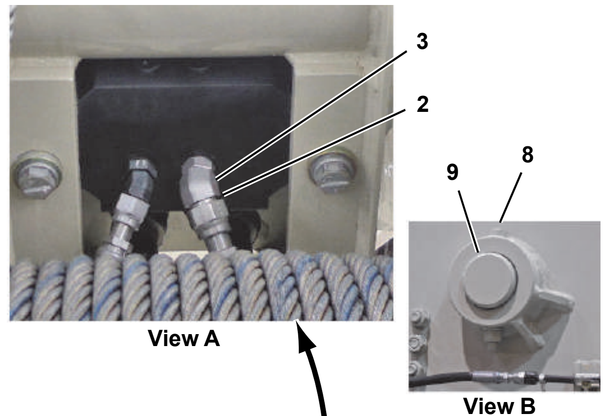
1. If not already done, store the boom extension (2). See the instructions in Section 5 of the CD15 Operator Manual.
2. Lower the boom (1) to horizontal.
3. Stabilize and level the crane using the outriggers.
4. Park the crane and stop the engine.
5. Install the lifting slings around the boom extension (2) and connect them to the hook of the assist crane. The center of gravity is located at the dimension given in Figure 11-1.
6. Tighten the lifting slings so they are supporting the boom extension.
7. Remove the rear and front storage pins (3 and 4).
8. Lift the boom extension clear of the boom and place the boom extension on blocking in the desired storage/work area.
9. Store the storage pins in the brackets on the boom extension.
10. Disconnect the lifting slings.

Boom Extension Installation

1. Lower the boom (1) to horizontal.
2. Stabilize and level the crane using the outriggers.
3. Park the crane and stop the engine.
4. Install the lifting slings around the boom extension (2) and connect them to the hook of the assist crane. The center of gravity is located at the dimension given in Figure 11-1.
5. Remove the rear and front storage pins (3 and 4) from the storage brackets on the boom extension.
6. Lift the boom extension into position along the right side of the boom so that the mounting holes in the storage brackets on the boom extension are aligned with the mounting holes in the storage brackets on the boom (Views A and B).
7. Install the rear and front storage pins (3 and 4).
8. Disconnect the lifting slings.

Item	Description
1	Boom
2	Hydraulic Hose (qty two)
3	Hydraulic fitting (qty 2)
4	Electric Cable (qty varies)
5	Boom Lift Cylinder
6	Keeper Pin with Flat Washer and Screw
7	Rod End Pin
8	Keeper Bolt with Flat Washers and Nut
9	Boom Pivot Pin

Item	Description	Boom
L1 D1	1400 kg (3084 lb) 2.6 m (8 ft 8 in)	12 m (41 ft)
L2 D2	2105 (4640 lb) 1.8 m (8 ft)	15 m (50 ft)



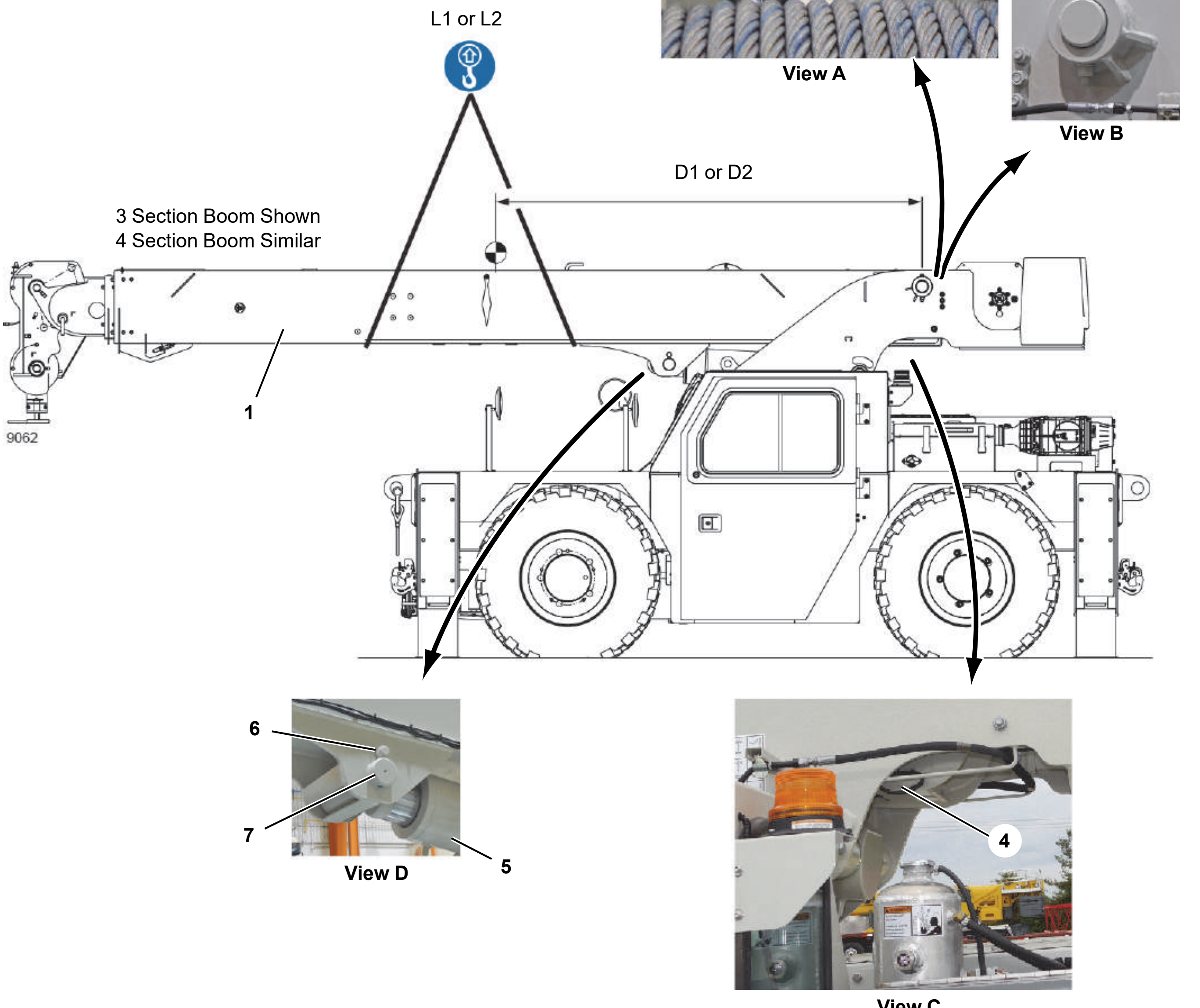


FIGURE 11-2

BOOM

Two boom options are available:

- 3 section, 12 m (41 ft)
- 4 section, 15 m (50 ft)

Both booms are hydraulically extended and retracted by a telescope cylinder inside the boom.

The following owner furnished lifting equipment is required for boom removal and installation:

- An assist crane or overhead hoist capable of handling the load (L1 or L2) specified in Figure 11-2
- Synthetic lifting slings

Take every precaution to prevent damaging the boom during lifting. If wire rope or chain lifting slings are used, install protective covering (such as sections of rubber tire) between the slings and the boom.

Boom Removal

See Figure 11-2 for this procedure.

1. Lower the boom (1) to horizontal.
2. If not already done, remove the boom extension. See Boom Extension Removal on page 11-3.
3. Remove the load block or the downhaul weight.
4. Spool the wire rope onto the hoist drum and secure it so it cannot fall off the hoist.
5. Stabilize and level the crane using the outriggers.
6. Park the crane and stop the engine.
7. Be prepared to catch oil leakage at the end of the boom (View A).
8. Tag the hydraulic hoses (2, View A) for proper installation and disconnect them from the fittings (3).
9. Cap the fittings and plug the hoses to prevent contamination.
10. Tag the electric cables (4, View C) between the boom and the mast for proper installation and disconnect them. Cut wire ties as needed.
11. Securely block the boom lift cylinder (5, View D) so it cannot fall when the rod end pin (7) is removed.
12. Install the lifting slings around the boom (1) and connect them to the hook of the assist crane. The center of gravity is located at the dimension (D1 or D2) given in Figure 11-1.
13. Tighten the lifting slings so they are supporting the boom.
14. Remove the keeper pin (6, View D) and the rod end pin (7). Use a brass drift pin to hammer the shaft out.
15. Remove the keeper bolt (8, View B) and the boom pivot pin (9). Use a brass drift pin to hammer the shaft out.
16. Carefully lift the boom clear of the boom lift cylinder and the mast.
17. Place the boom on blocking in the desired storage/work area.
18. Store the keeper pin, the keeper bolt, and the shafts so they are not lost during boom repair.
19. Disconnect the lifting slings.

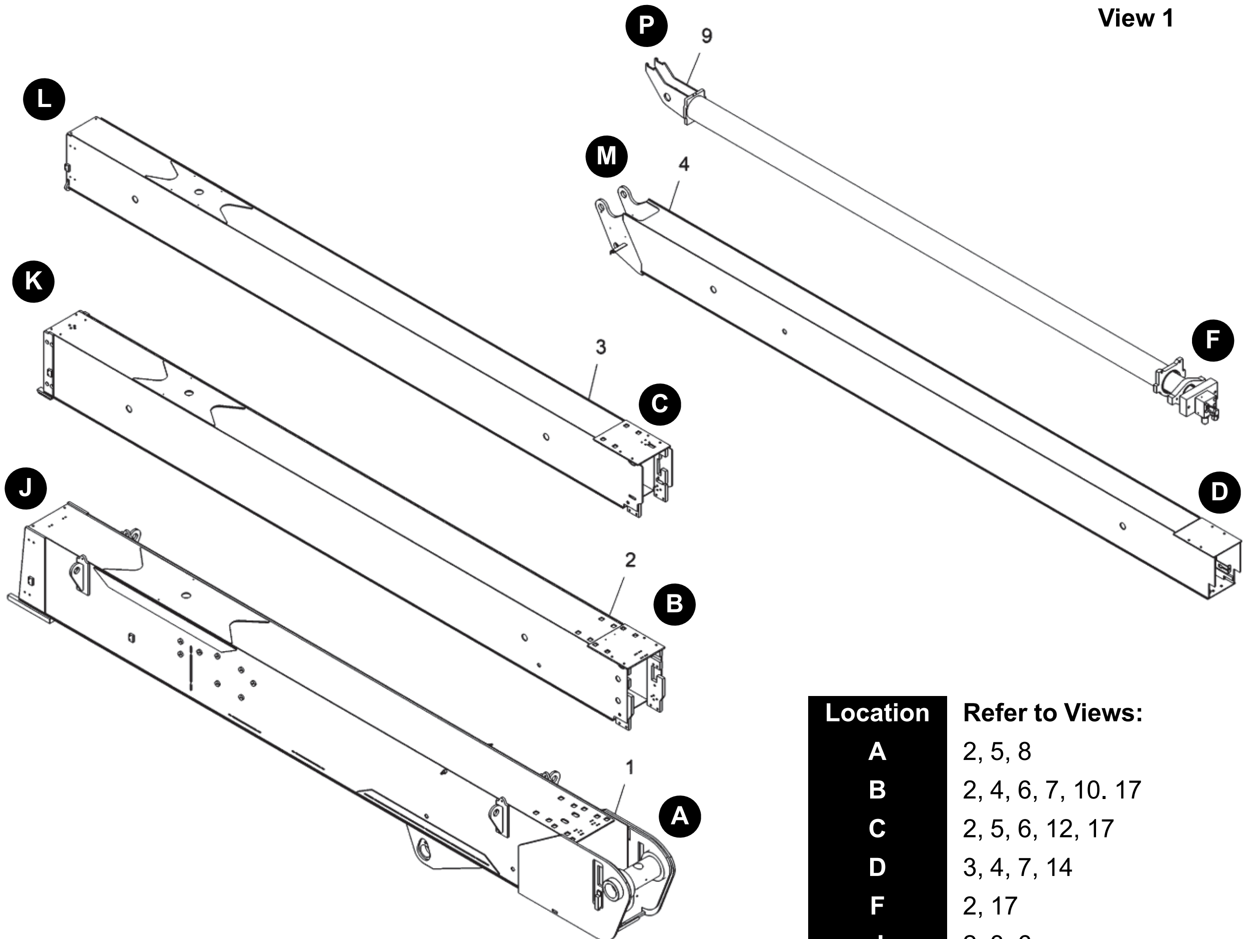
Boom Installation

See Figure 11-2 for this procedure.

1. Install the lifting slings around the boom (1) and connect them to the hook of the assist crane. The center of gravity is located at the dimension (D1 or D2) given in Figure 11-1.
2. Lift the boom into position so the mounting holes in the boom are aligned with the rod end hole of the boom lift cylinder (View D) and the boom hinge holes in the mast (View B).
3. Make sure the mounting holes and shafts are clean, and apply a light coat of anti-seize compound to the mounting holes and to the shafts as they are installed in the following steps.
4. Install the boom pivot pin (9, View B) and retain it with the keeper bolt (8), flat washer, and nut.
5. Install the rod end pin (7, View D) and retain it with the keeper pin (6), flat washer, and screw.
6. Tighten the hardware to the torque values specified in Section 1 of this manual.
7. Disconnect the lifting slings.
8. Remove the caps and plugs from the hydraulic fittings and hoses and thoroughly clean the hydraulic connections.
9. Connect and properly tighten the hydraulic hoses (2, View A) to the hydraulic fittings (3).
10. Connect the electric cables (4, View C) between the mast and the boom. Wire tie the cables, as required, to the tie bars on the mast and the boom.
11. Check the oil level in the hydraulic tank. Fill if necessary.
12. Start the engine and operate the boom slowly in all directions (in/out and up/down) to fill the lines with hydraulic oil and to bleed air from the system. Check for leaks and repair if necessary.
13. Check the oil level in the hydraulic tank. Fill if necessary.
14. Install the wire rope, the hook block, or the downhaul weight.

Boom Assembly Drawing

View 1

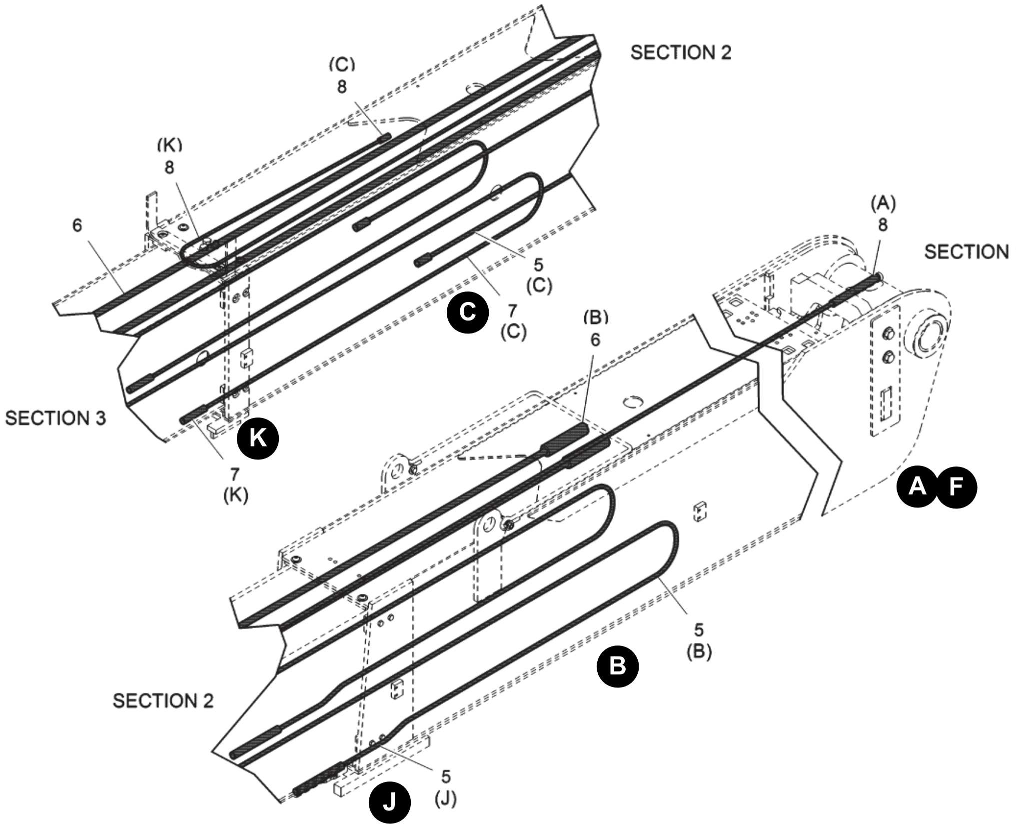


Location	Refer to Views:
A	2, 5, 8
B	2, 4, 6, 7, 10. 17
C	2, 5, 6, 12, 17
D	3, 4, 7, 14
F	2, 17
J	2, 3, 6
K	2, 5, 7, 11
L	3, 13
M	15, 16
P	4, 18

For Cables: See Views 2 through 7
For Boom Sections: See Views 8 through 16
For Cylinder: See Views 17 and 18

FIGURE 11-3

View 2



View 3

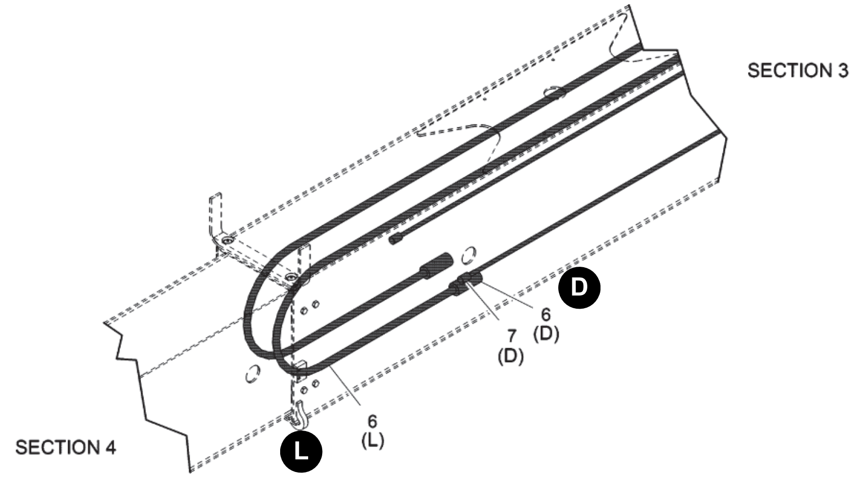


FIGURE 11-3 continued

11

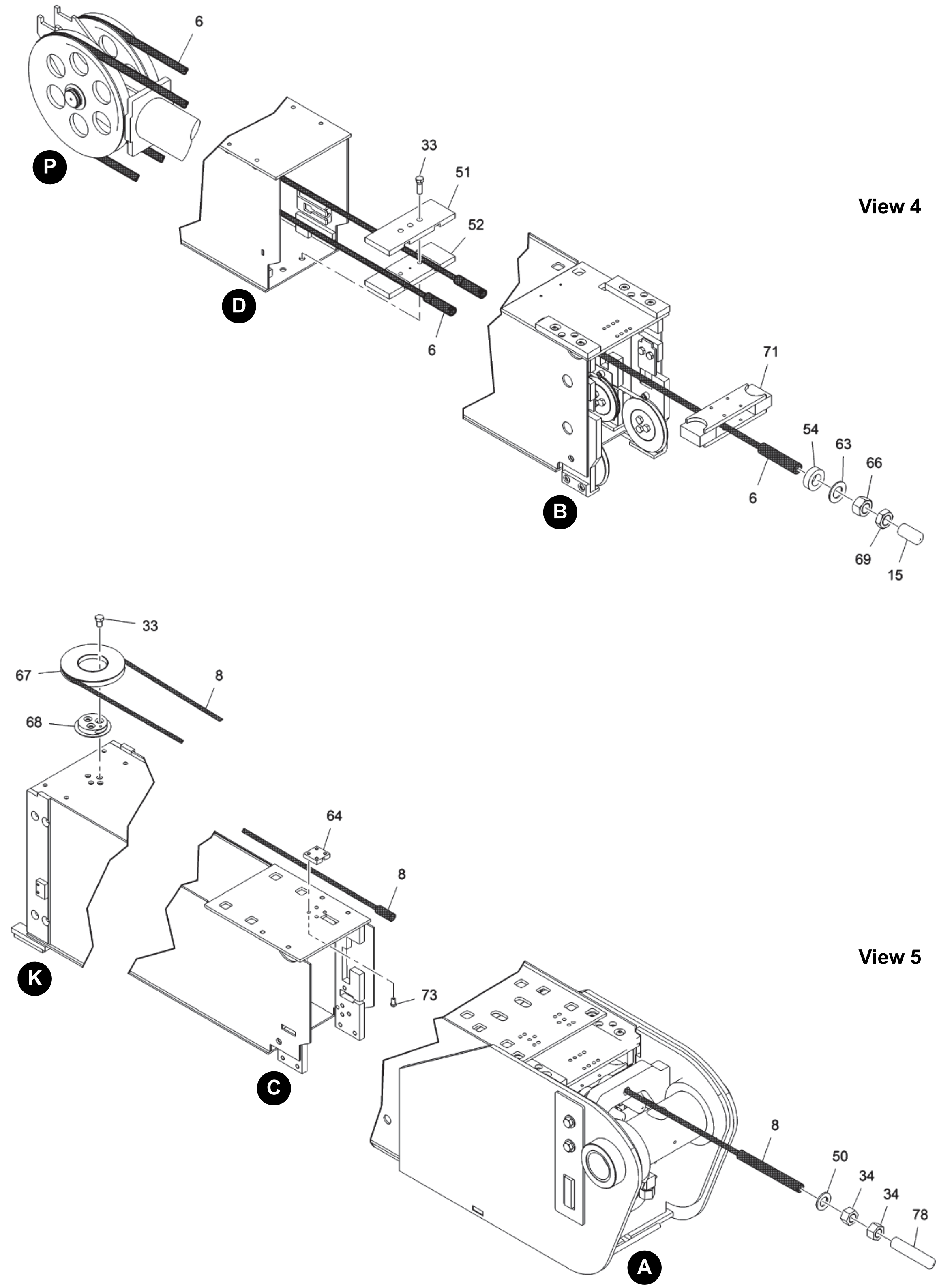
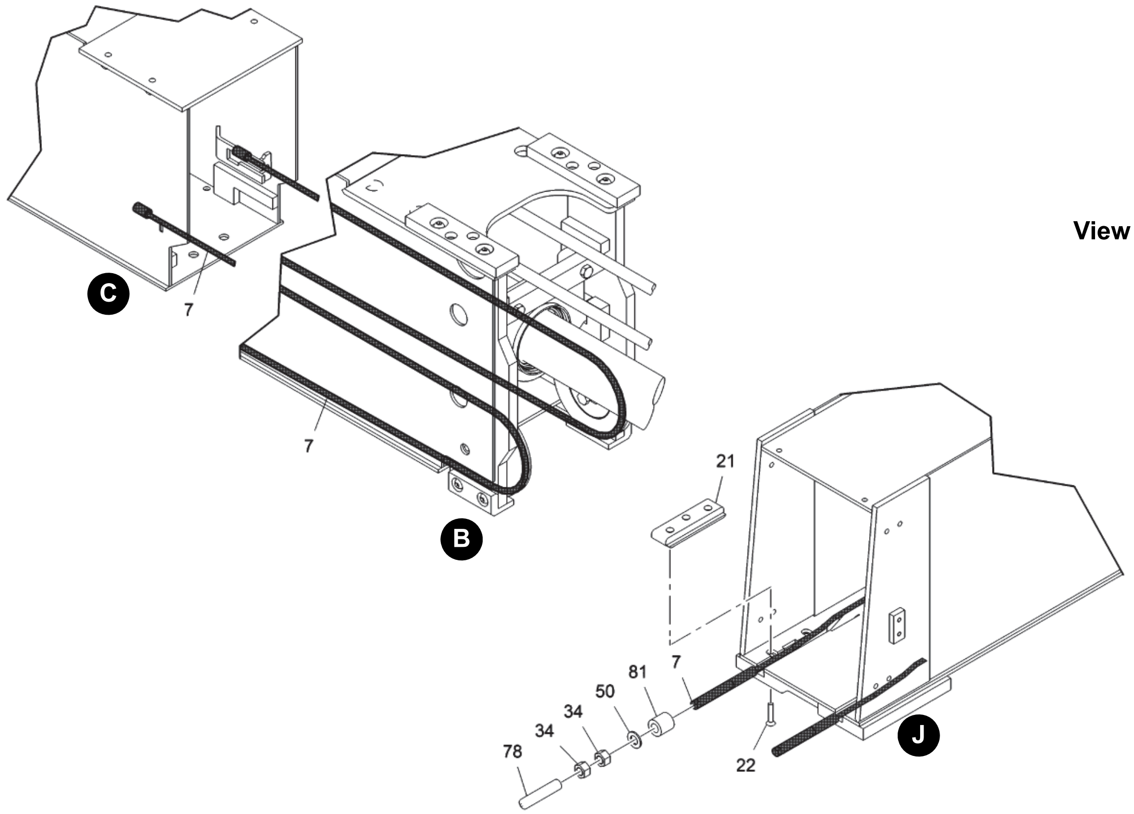
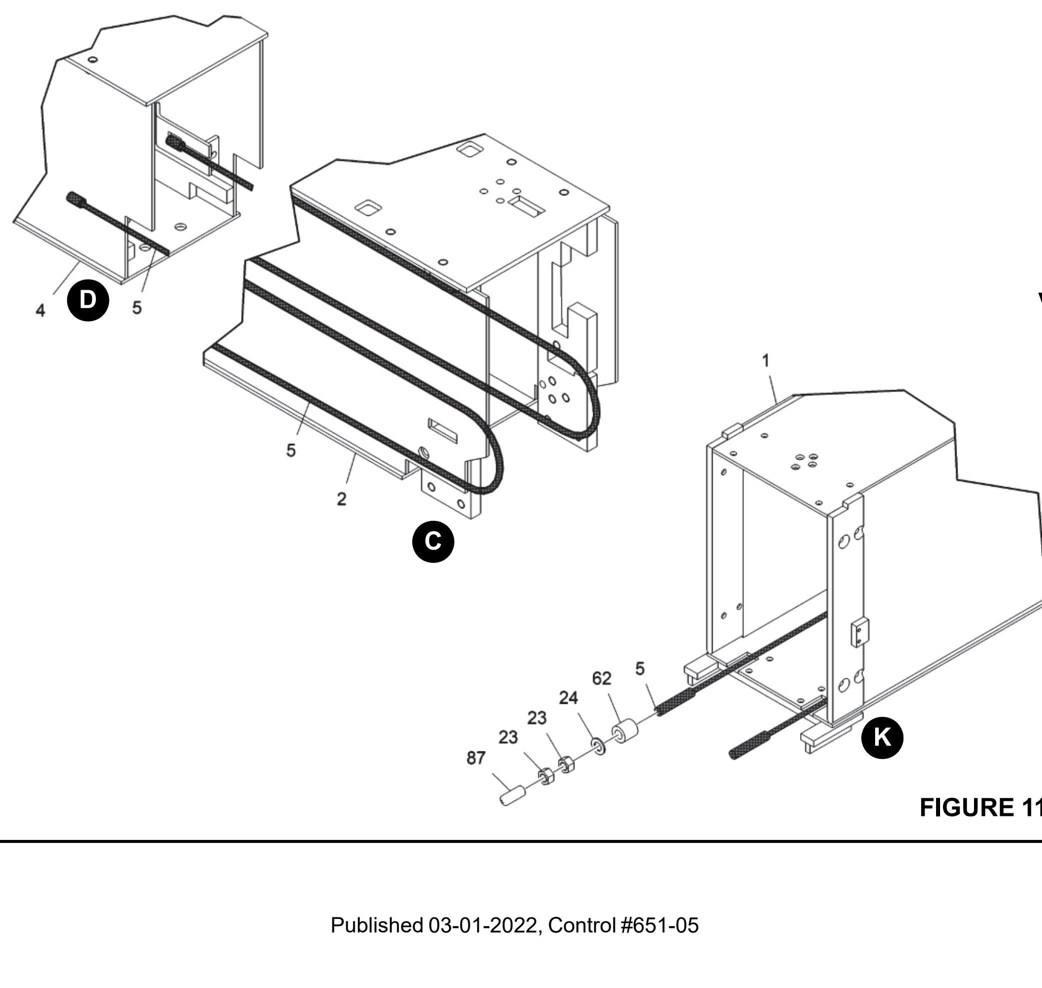


FIGURE 11-3 continued



View 6



View 7

FIGURE 11-3 continued

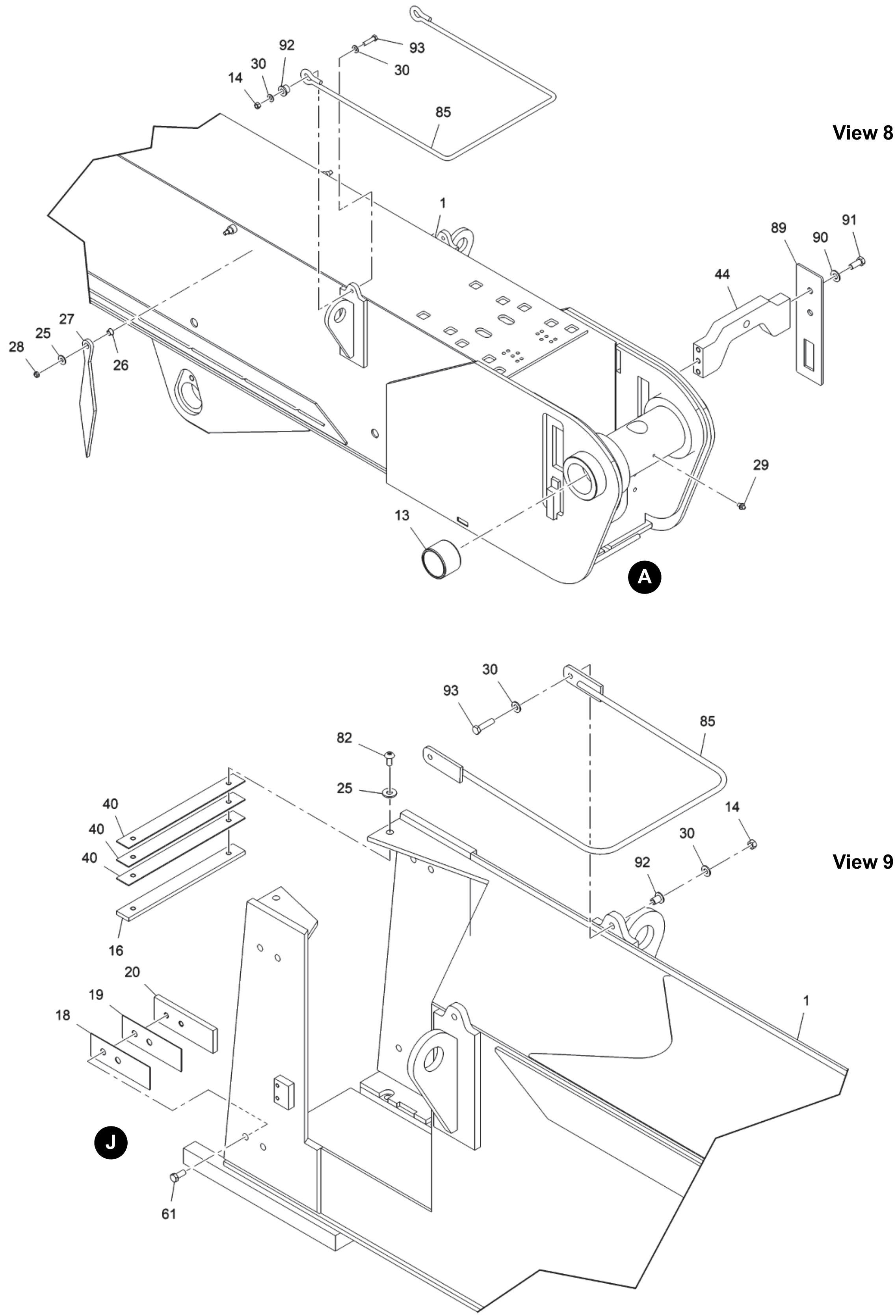


FIGURE 11-3 continued

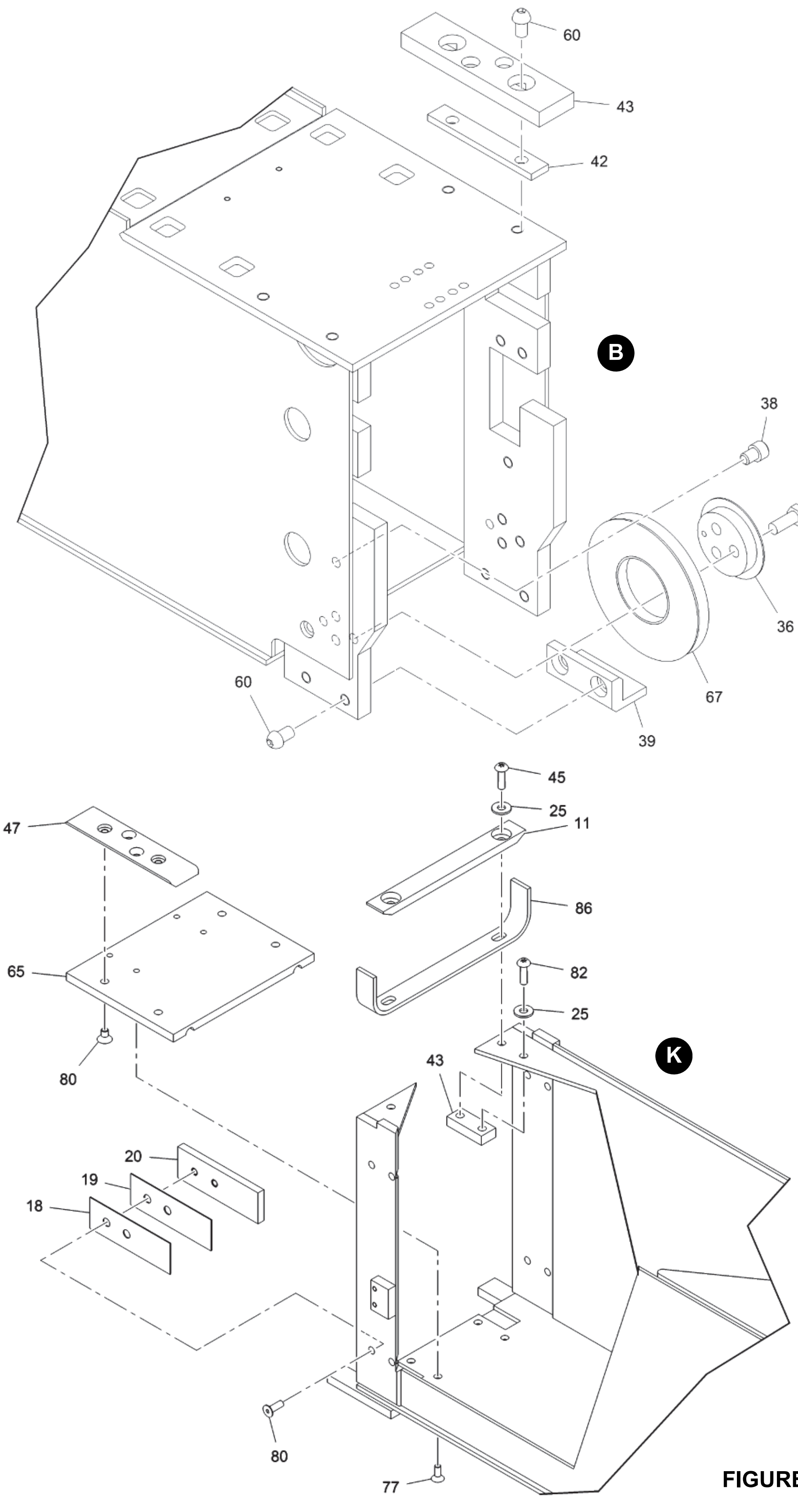


FIGURE 11-3 continued

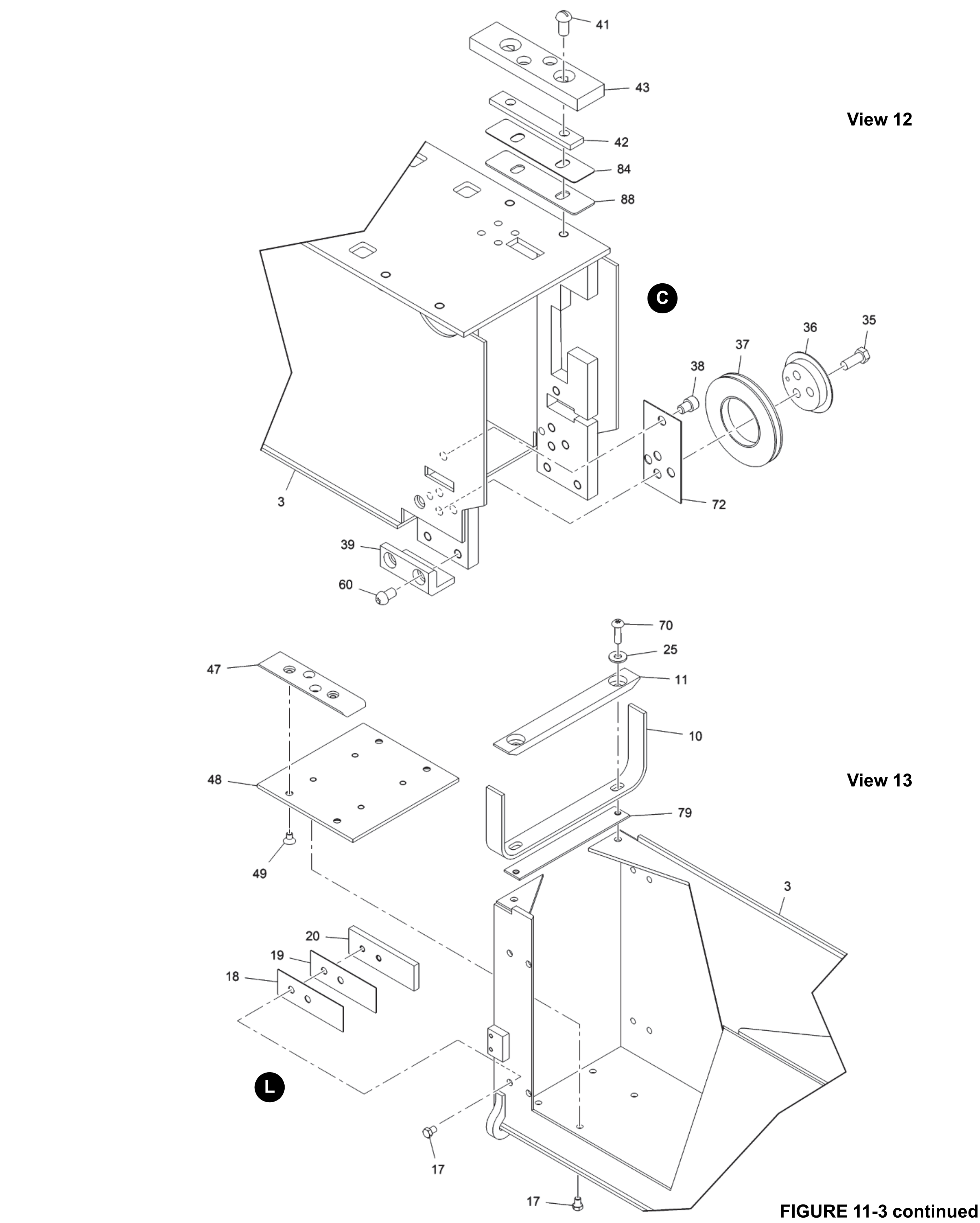


FIGURE 11-3 continued

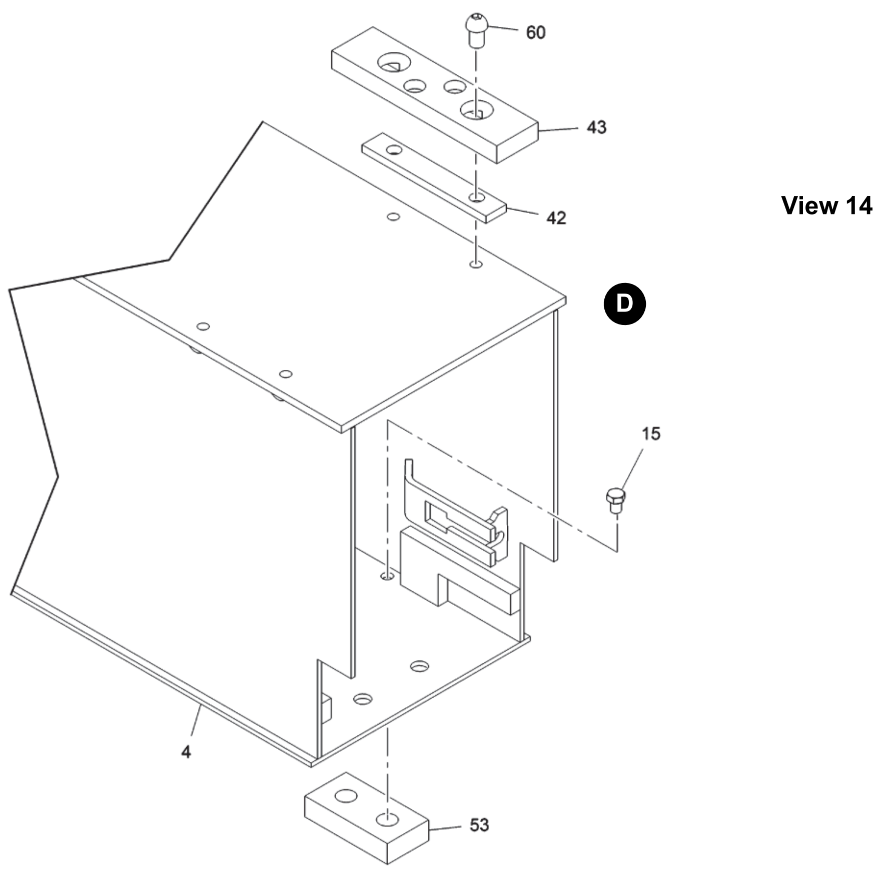


FIGURE 11-3 continued

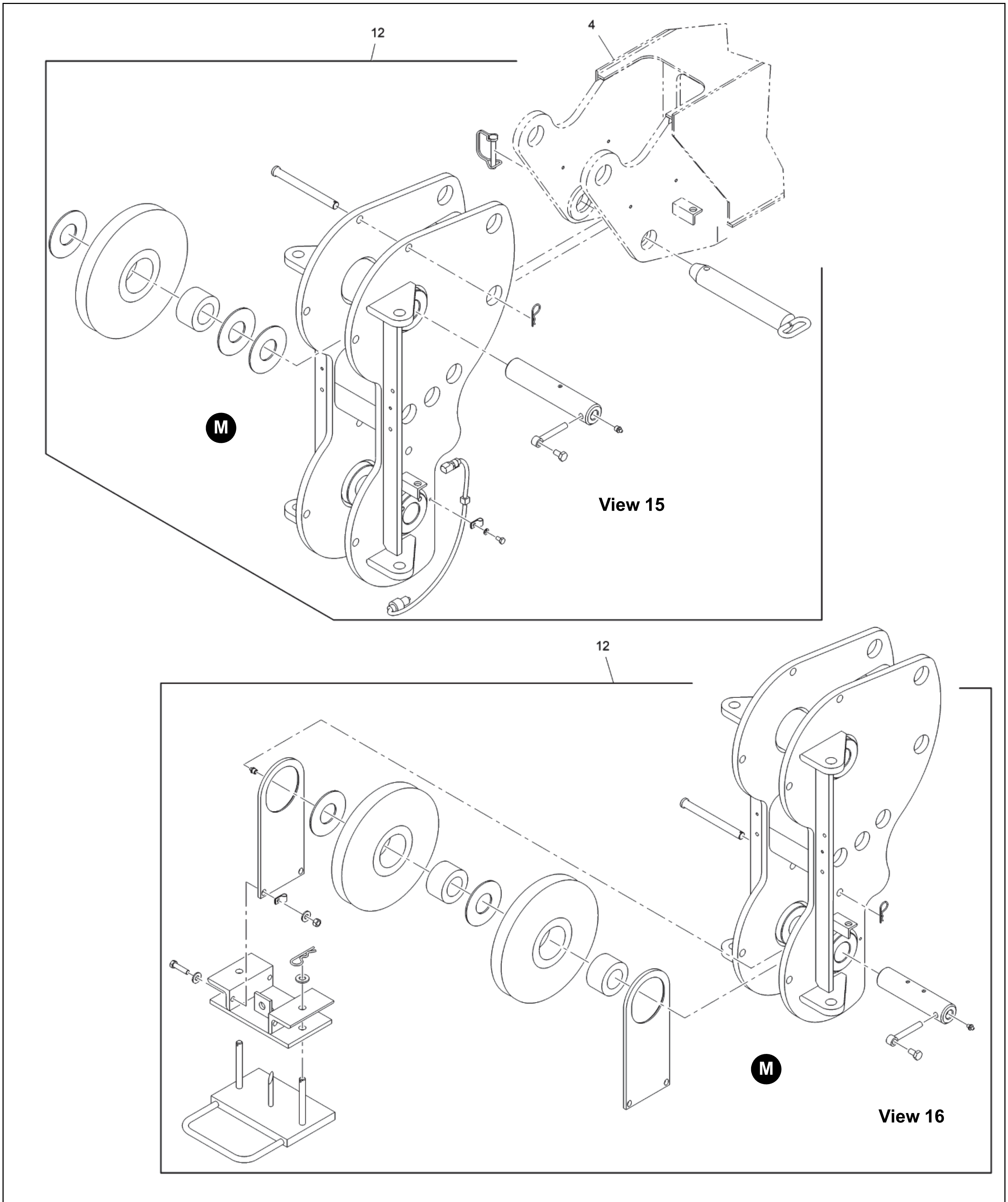
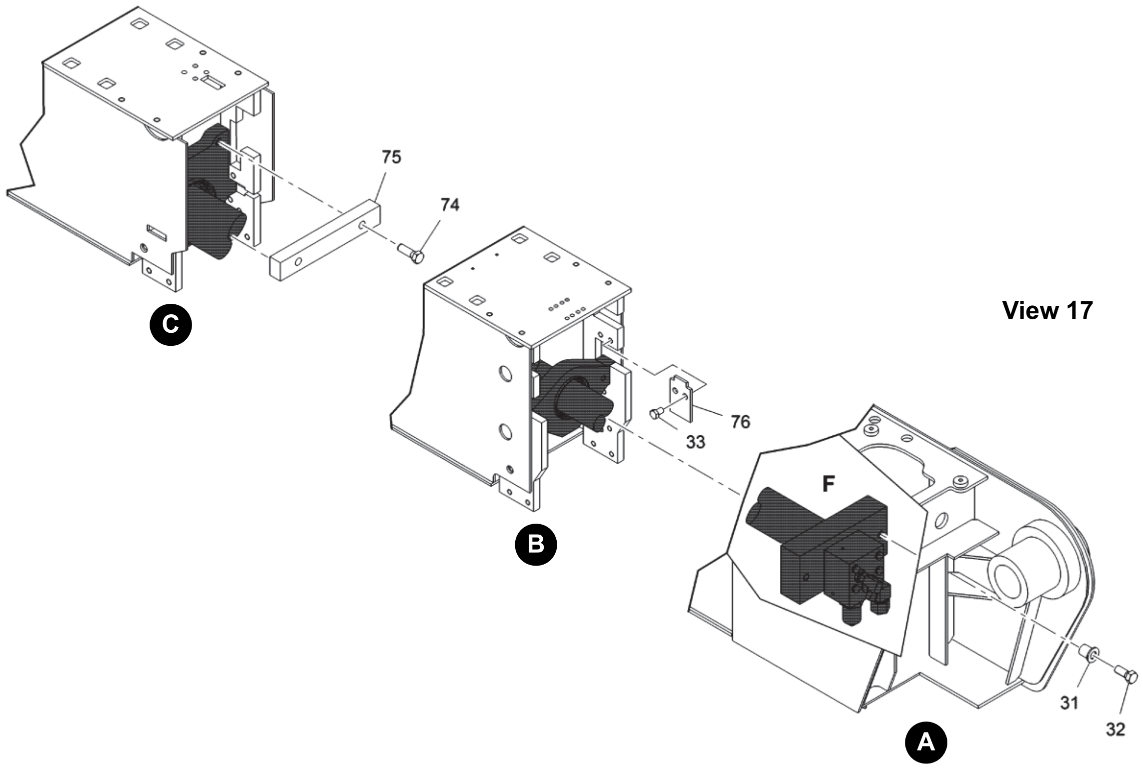


FIGURE 11-3 continued



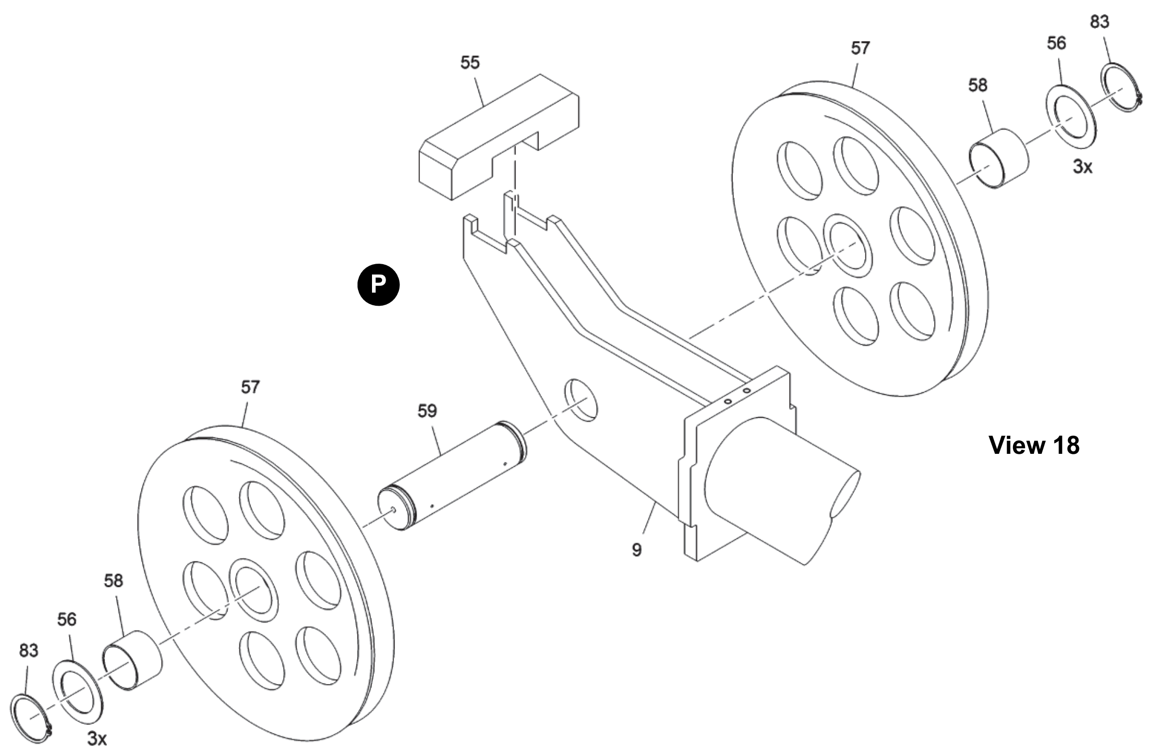


FIGURE 11-3 continued

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Boom Assembly Drawing Legend

Item	Description	Qty
1	Boom Section (1 (base)	1
2	Boom Section 2	1
3	Boom Section 3	1
4	Boom Section 4	1
5	Cable, Retract	2
6	Cable, Extend	2
7	Cable, Retract	2
8	Cable, Extend	1
9	Telescope Cylinder	1
10	Cable Guide, Tall	1
11	Wear Pad	2
12	Pivoting Boom Nose	1
13	Bearing	2
14	Hex Nut: 3/8-16UNC SAE 5.2	4
15	Protector, Cable	2
16	Wear Pad	1
17	Hex Cap Screw: 3/8-16UNC X 1/2 Grade 8	16
18	Shim	12
19	Shim	12
20	Wear Pad	12
21	Wear Pad Assy	2
22	Cap Screw, TORX Flat Head	4
23	Hex Jam Nut: 5/8-11UNC SAE 2	4
24	Washer, Hardened	2
25	Flat Washer: 3/8, Wide	10
26	Flanged Bearing	2
27	Pendulum	2
28	Locknut	2
29	Zerk, 90 Degrees Grease	1
30	Flat Washer: 3/8, Narrow	18
31	Spacer	2
32	Hex Cap Screw: 5/8-11UNC X 2-1/4 Grade 8	2
33	Hex Cap Screw: 1/2-13UNC X 3/4 Grade 8	7
34	Hex Jam Nut: 3/4-10UNC SAE 2	5
35	Hex Cap Screw:	14
36	Pin	4
37	Wheel, Sheave	2
38	Socket Head Cap Screw: 1/2-13UNC X 5/8	54
39	Wear Pad	4
40	Shim	1
41	Socket Button Head Cap Screw 1/2-13UNC X 1	84
42	Plate	6
43	Wear Pad	6
44	Anchor Plate	1
45	Cap Screw, TORX Button Head	2
46	Cable Keeper	2
47	Wear Pad	4
48	Plate	1
49	Cap Screw, TORX Flat Head	64

Item	Description	Qty
50	Flat Washer, Hardened	3
51	Plate, Anchor	1
52	Plate, Anchor	1
53	Wear Pad	2
54	Spacer	2
55	Wear Pad	1
56	Flat Washer: 2x3x0.7 St-zn	6
57	Wheel, Sheave	2
58	Bearing	2
59	Pin	1
60	Socket Button Head Cap Screw 1/2-13UNC X 3/4	16
61	Hex Cap Screw: 3/8-16UNC X 7/8 Grade 8	8
62	Spacer	2
63	Flat Washer, Hardened	2
64	Clamp	1
65	Plate	1
66	Hex Jam Nut: 1-1/4 7UNC SAE 2	2
67	Wheel, Sheave	3
68	Pin, Sheave	1
69	Jam Nut: 1-1/4 7UNC	2
70	Cap Screw, TORX Button Head	2
71	Anchor	1
72	Plate, Anchor	2
73	Hex Cap Screw: 3/8-16UNC X 3/4 Grade 5	4
74	Hex Cap Screw: 1/2-13UNC X 1-1/2 Grade 5	2
75	Bar, Lock	1
76	Plate	2
77	Hex Cap Screw: 3/8-16UNC X 1-1/4 Grade 5	44
78	Cable Protector	3
79	Plate	1
80	Cap Screw, TORX Flat Head	12
81	Spacer2	
82	Cap Screw, TORX Button Head	4
83	Ring, Snap	2
84	Shim	2
85	Cable Guide	2
86	Cable Guide, Short	1
87	Cable Protector	2
88	Shim	2
89	Retainer Plate	2
90	Flat Washer: 5/8, Narrow	14
91	Hex Cap Screw: 5/8-11UNC X 1-1/2 Grade 5	4
92	Bushing	4
93	Hex Cap Screw: 3/8-16UNC X 1-3/4 Grade 5	4
94	Hex Socket Set Screw 1/2-13UNC X 1/2	42
95	Jam Nut	1
96	Hex Socket Set Screw #10-24UNC X 1/4	1
101	Wear Pad Kit, 15 Ton	1
102	Kit, 49 ft Arctic Boom Group	1

Boom Disassembly

1. Loosen the front top and bottom side wear pads on boom section 1.
2. Remove the cap screws securing the telescope cylinder to section 1.
3. Remove the hardware attaching the cable to the anchor plate.
4. Remove the hardware securing the retainer plate to the anchor plate.
5. Remove the bolts and lock washers securing the wear pad retainer plates to the front of boom section 1, remove the retainer plates.
6. Raise up on the boom section 2 assembly and remove the wear pads from the boom section 1.
7. Slide the assembly out of the boom section 1.
8. As necessary, remove the following items from the boom section 1:
    - **a.** Wire rope guide.
    - **b.** Boom angle indicator.
    - **c.** Anti-two-block and RCL components.
    - **d.** Boom extension attachment brackets.
    - **e.** Upper rear cable wear pad.
    - **f.** Boom pivot pin bushings.
    - **g.** Remove the front top and bottom side wear pads, plugs and set screws.
9. Remove the hardware securing the cable anchor to boom section 2.
10. Remove the hardware securing the sheave wheels to the side and top of boom section 2.
11. Remove the top rear wear pads from boom section 2.
12. Remove the hardware securing the telescope cylinder bracket to the rear of boom section 2.
13. Loosen the front top and bottom side wear pads on boom section 2.
14. Remove the bolts and lock washers securing the wear pad retainer plates to the front of boom section 2, remove the retainer plates.
15. Lift up on boom section 3 assembly and remove the wear pads from boom section 2.
16. Slide the assembly out of boom section 2.
17. As necessary, remove the following items from boom section 2:
    - **a.** Remove the bolts and lock washers securing the lower rear wear pads, remove the wear pads.
    - **b.** Remove the front top and bottom side wear pads, plugs and set screws.
18. Remove the top rear wear pads from boom section 3.
19. Remove hardware securing sheave wheels to side of boom section 3.
20. Raise up on boom section 4 assembly and remove the bolts and lock washers securing the front bottom wear pads and remove the wear pads from boom section 3.
21. Slide boom section 4 assembly out of boom section 3.
22. As necessary, remove the following items from boom section 3:
    - **a.** Remove the bolts and lock washers securing the lower rear wear pad, remove the wear pad.
    - **b.** Remove the wire rope guide.
    - **c.** Remove the bolts and lock washers securing the two long wear bars in the bottom of the section and remove the wear bars.
    - **d.** Remove the bolts and lock washers securing the bumper to the bracket in the front of the section and remove the bumper and shim(s).
    - **e.** Remove the bolt, lock washer and washer securing the holding bracket to the side of the boom section and remove the bracket.
    - **f.** Remove hardware securing the cable anchor plate to the bottom of boom section 3.
    - **g.** Slide the telescope cylinder assembly out of the boom section.

NOTE: The following steps pertain to the disassembly of boom section 4 of the four section boom and section 3 of the three section boom.

23. Remove the top rear wear pads from boom section 4.
24. As necessary, remove the following items from the boom section:
    - **a.** On the three section boom only, remove the bolts and lock washers securing the rear bottom wear pad and remove the wear pad.
    - **b.** On the boom nose, remove the four pins and clevis pins.
    - **c.** On the four section boom, remove the retract adjuster.
    - **d.** Remove the bolt securing the upper sheave pin and remove the pin, sheave and two nylatron washers.
    - **e.** Remove the bolt securing the lower sheave pin, and remove the pin, two sheaves and three nylatron washers.

Boom Assembly

NOTE: During assembly, apply:

- Loctite® 243 (blue) to all fastener threads

- Grease to all wear pad contact surfaces
- Anti-seize compound to all pins and to the shafts of the anti-two block guide pins

Steps 12 through 15 pertain to the assembly of boom section 4 of the four section boom and section 3 of the three section boom.

1. As necessary, install the following items on the boom section:

a. On the three section boom only, install the rear bottom wear pad and secure with the bolts and lock washers.

b. On the boom nose, install the four clevis pins and pins.

c. On the four section boom, install the retract adjuster using two nuts.

d. Replace the bearings in the sheaves as necessary.

e. Install the upper sheave and two nylatron washers. Install the upper sheave pin and secure with a bolt.

f. Install the lower sheave and three nylatron washers. Install the lower sheave pin and secure with a bolt.

2. Install the top rear wear pads on the boom section.

NOTE: Steps 3 through 6 pertain only to the assembly of boom section 3 of the four section boom.

3. Slide the telescope cylinder assembly into boom section 3.

4. As necessary, Install the following items on boom section 3:

a. Install the lower rear wear pad and secure with the bolts and lock washers.

b. Install the wire rope guide, two bolts, washers (4), lock washers, and nuts.

c. Install the sheave wheel and cable and secure with hardware.

d. Install the anchor plates and cables and secure with hardware.

e. Install the front wear pads and secure with hardware.

5. Slide the assembly into boom section 3.

6. Raise up on boom section 4 assembly and install the front bottom wear pads in boom section 3. Install the bolts and lock washers securing the wear pads.

7. Install the top rear wear pads on boom section 3.

8. As necessary, install the following items on boom section 2:

a. Install the lower rear wear pads and secure with the bolts and lock washers.

b. Install the front top and bottom side wear pads, plugs and set screws. Do not tighten the set screw at this time.

9. Slide the assembly into boom section 2.

10. Install the sheave wheels and secure with hardware.

11. Install the anchor and cables and secure with hardware.

12. Raise up on boom section 3 assembly and install the front lower wear pads in boom section 2.

13. Install the wear pad retainer plates to the front of boom section 2 and secure with the bolts and lock washers.

14. Install the top rear wear pads on boom section 2.

15. Tighten the front top and bottom side wear pad set screws on boom section 2 to center the assembly in boom section 2.

16. As necessary, install the following items on the boom section 1:

a. Wire rope guide.

b. Boom angle indicator.

c. Anti-two-block and RCL components.

d. Boom extension attachment brackets.

e. Upper rear cable wear pad.

f. Boom pivot pin bushings.

g. Install the front top and bottom side wear pads, plugs and set screws. Do not tighten set screws at this time

17. Slide the assembly into the boom section 1.

18. Raise up on the boom section 2 assembly and install the front lower wear pads in the boom section 1.

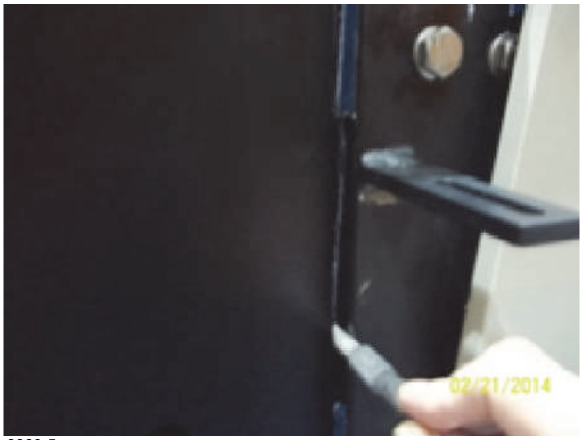
19. Install the wear pad retainer plates to the front of boom section 1 and secure with the bolts and lock washers.

20. Install the anchor plate and secure with hardware.

21. Secure the telescope cylinder with hardware.

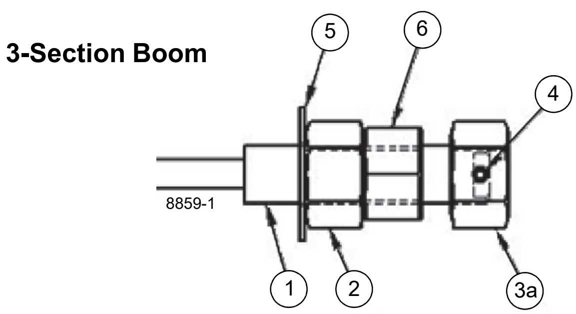
22. At the rear of the assembly, install the hoses and fittings to the telescope cylinder.

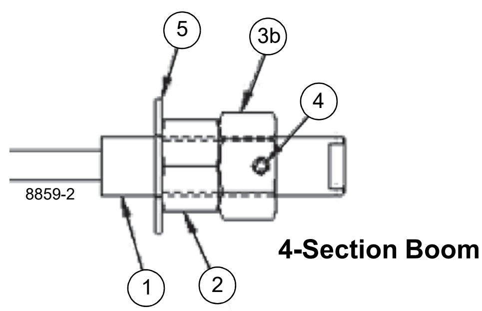
23. Tighten the front top and bottom side wear pad set screws on boom section 1 to center the assembly in boom section 1.


8860-5


8860-6

FIGURE 11-4





Item	Description
1	Threaded Cable End
2	Nut (Adjustment)
3a	Nut (Positive Lock)
3b	Nut (Torqued and Positive Lock)
4	Set Screw
5	Washer
6	Nut (Torqued)

FIGURE 11-5

Table 11-1 Cable Hardware Torque Values

Cable end Thread Size	Minimum Nut Strength GRADE	Nut Type	Torque ft lbf
5/8-11	SAE 2	Hex Jam (half)	31
3/4-10	SAE 2	Hex Jam (half)	47
1 1/4-7	SAE 2	Hex Jam (half)	203
Cable end Thread Size	**Minimum Nut Property Class**	**Nut Type**	**Torque Nm**
M16x2	5	Hex Jam (thin)	26

BOOM CABLE TENSIONING

A boom assembly is considered properly timed when the telescoping sections extend equally relative to each other and bottom out simultaneously at full retraction and do not spring back out after retract pressure is returned to neutral.

Extend cylinder construction dictates which extendable section will be the driver that the other extend sections will need to be adjusted to, utilizing the cable adjustment.

- A single stage cylinder will control the first extendable section.
- A dual stage cylinder will control the second extendable section.

The timing sequence of the cables depends on the number of sections and the extend cylinder construction.

The design intent of the cable tensioning is to balance the preload of the extend and retract cables for each extendable section. In addition, sequencing of the sections during retraction requires the retract cables of every section to be indexed relative to each other.

Tensioning Procedure for all Booms

1. Tensioning must be done with the boom in the horizontal position.
2. Refer to Figure 11-5 for cable hardware arrangements.
3. When tightening/loosening the first (adjustment) nuts on the cables, secure the cables using the wrench flats at the front of the cable ends to prevent cable twist.
4. CAUTION: Do not use an impact wrench to tighten the cables. Excess cable twisting can cause premature failure.
5. Once the boom is completely assembled and fully retracted, mark the front of each section with a chalk line as indicated in Figure 11-4.
6. After the cable adjustment procedure is completed for the entire boom assembly. The second (torqued) nut must be installed on all retract and extend cables.
7. The second nut should be hand tightened until it comes in contact with the back of the first nut.
8. Use a standard combination wrench to hold the first (adjustment) nut stationary and a crow foot wrench adapter attached to a calibrated torque wrench to tighten the second (torqued) nut against the first (adjustment) nut to the values indicated in Table 11-1.
9. For the 3-section boom, the third (positive lock) nut must be installed on each of the extend cables. The retract cables do not require the third (positive lock) nut.
10. The third nut should be hand tightened until the tapped hole for the set screw is tangent to the end face of the wrench flat on the cable.
11. Install the set screw into the third nut and tighten it to the torque specified in Section 1 of this manual.

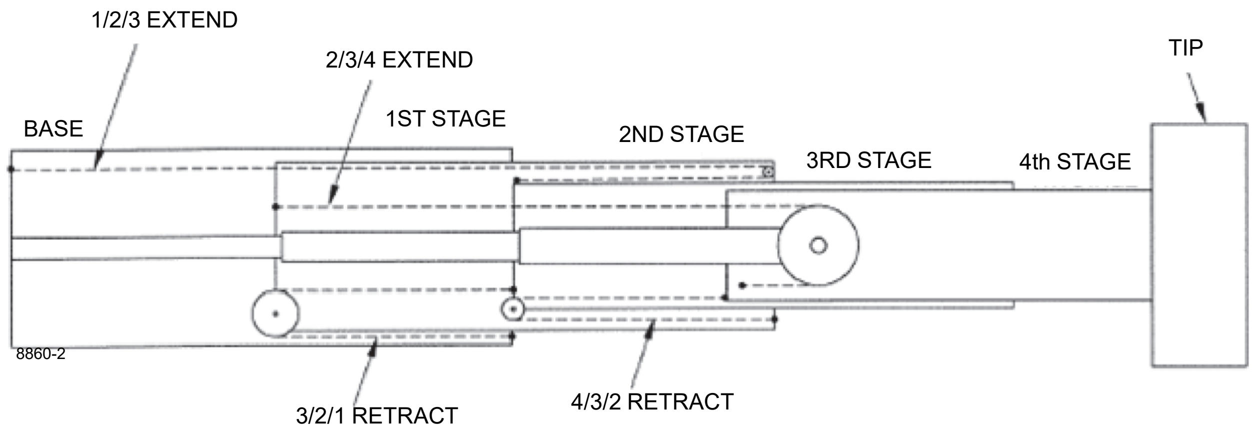


FIGURE 11-6

Tensioning Procedure for 4 Section Boom

See Figure 11-6 for this procedure.

1. Retract the boom fully so that all sections are bottomed out on the stops at the back end of each section. Ensure all sections are fully bottomed out and do not spring back.
2. Mark white lines on the side plate of each section (Figure 11-4).
3. Extend and retract the boom several times to establish the working state of the cables.
4. Extend the boom so the scribed lines are exposed by approximately 305 mm (12 in).
5. Measure the extension gaps between each boom section and the scribed line and note the values.
6. Retract the boom so the scribed lines are exposed by approximately 152 mm (6 in).
7. Measure the retraction gaps between each boom section and the scribed line and note the values.
8. Balance the control cables.

321 and 123 cable balancing

Extension

1. Measure the extension gaps between the first and second section and the second and third section.
2. If the extension gap between the first and second section is less than the extension gap between the second and third section, proceed as follows:
   - Tighten the **321** retract cable (located at the front bottom of the base section) the difference in the extension gap measurements.
   - Extend and retract the boom a few times and then repeat measuring the extension gaps.
   - The second section should have moved out.
   - Keep tightening until the extension gap between the first and second section and the extension gap between the second and the third section is equal.
   - If, when tightening the **321** retract cable, the third section starts to go out with the second section the **123** synchronizing cable (located at the top back of the base section) may need to be loosened.

Retraction

1. Measure the retraction gaps between the first and second section and the second and third section.
2. If the retraction gap is greater between the first and second section than the retraction gap between the second and third section, proceed as follows:
   - Tighten the **123** synchronizing cable (located at the back of the base section) the difference in the retraction gap measurements.
   - Extend and retract the boom a few times and then repeat measuring the retraction gaps.
   - The third section should have moved out.
   - Keep tightening until the retraction gap between the first and second section and the retraction gap between the second and the third is equal.
   - At this time, the second and first extendable sections should extend and retract equally and bottom out against the stops simultaneously.

234 and 432 cable balancing

Extension

1. Measure the extension gaps between the third and fourth section and the second and third section.
2. If the extension gap between the third and fourth section is less than the extension gap between the second and third section, proceed as follows:
   - Tighten the **234** extend cable (located at the back top of the second section) the difference in the extension gap measurement.
   - Extend and retract the boom a few times and then repeat measuring the extension gaps.
   - The fourth section should have moved out.
   - Keep tightening until the extension gap between the third and fourth section is equal to the extension gap between the second and third section.

Retraction

1. Measure the retraction gaps between the second and third section and the third and fourth section.
2. If the retraction gap is greater between the third and fourth section than the retraction gap between the second and third section, proceed as follows:
   - Tighten the **432** retract cable (located at the front bottom of the second section) the difference in the retraction gap measurement.
   - Extend and retract the boom a few times and then repeat measuring the retraction gaps.
   - The fourth section should have moved in.
   - Keep tightening until the retraction gap between the third and fourth section is equal to the retraction gap between the second and third section.
   - At this time, all extendable sections should extend and retract equally and bottom out against the stops simultaneously.

3-Section Boom w/ 2 Stage Cylinder

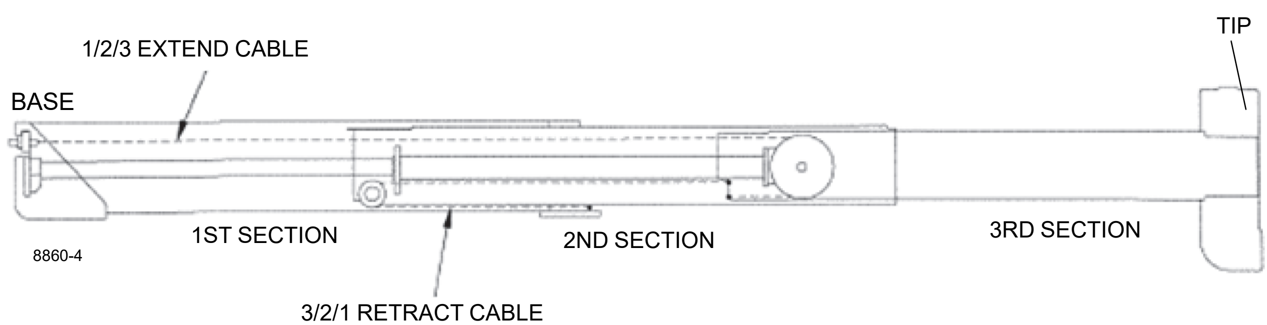


FIGURE 11-7

Tensioning Procedure for 3-Section Boom

See Figure 11-7 for this procedure.

1. Retract the boom fully so that all sections are bottomed out on the stops at the back end of each section. Ensure all sections are fully bottomed out and do not spring back.
2. Mark lines on the side plate of each section (Figure 11-4).
3. Extend and retract the boom several times to establish the working state of the cables.
4. Extend the boom so the scribed lines are exposed by approximately 305 mm (12 in).
5. Measure the extension gaps between each boom section and the scribed line and note the values.
6. Retract the boom so the scribed lines are exposed by approximately 152 mm (6 in).
7. Measure the retraction gaps between each boom section and the scribed line and note the values.
8. Balance the control cables.

321 and 123 cable balancing

Extension

1. Measure the extension gaps between the first and second section and the second and third section.
2. If the extension gap between second and third section is less than the extension gap between the first and second section, proceed as follows:

11

- Tighten the **123** extend cable (located at the back top of the base section) the difference in the extension gap measurement.
- Extend and retract the boom a few times and then repeat measuring the extension gaps.
- The third section should have moved out.
- Keep tightening until the extension gap between the first and second section and the extension gap between the second and the third section is equal.

Retraction

1. Measure the retraction gaps between the first and second section and the second and third section.
2. If the retraction gap is greater between the second and third section than the retraction gap between the first and second section, proceed as follows:
    - Tighten the **321** retract cable (located at the front bottom of the base section) the difference in the retraction gap measurement.
    - Extend and retract the boom a few times and then repeat measuring the retraction gaps.
    - The third section should have moved in.
    - Keep tightening until the retraction gap between the first and second section and the retraction gap between the second and the third section is equal.
    - At this time, all extendable sections should extend and retract equally and bottom out against the stops simultaneously.

BOOM WEAR PAD ADJUSTMENT

4-Section Boom

Do not force the shims. Use the same amount of shims on both sides of each boom section.

Front Side Wear Pad Adjustments

Adjust the front side wear pads so that each wear pad is within 1.5 mm (0.06 in) of the side plate on the next inner section.

Rear Wear Pad Adjustment

Position the rear wear pads to minimize the clearance between each wear pad and the side of the next section. ***Interference between a wear pad and the next section is not allowed***.

3-Section Boom

Do not force the shims. Use the same amount of shims on both sides of each boom section.

Front Side Wear Pad Adjustment

Adjust the front side wear pads so that each wear pad is within 1.5 mm (0.06 in) of the side plate on the next inner section.

Rear Wear Pad Adjustment

Adjust the rear wear pads so that each wear pad is within 1 mm (0.04 in) of the side plate on the next outer section.

Top Wear Pad Adjustment

Adjust the top wear pads so that each wear pad is within 2 mm of the top plate on the next outer section.

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 11-8): (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.

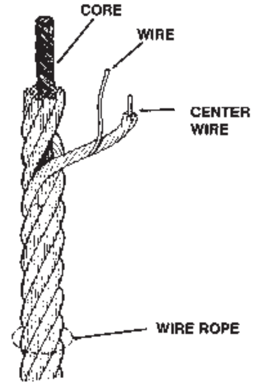


FIGURE 11-8

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 looses strength and work capability. Abuse and misuse increases the rate of loss.
3. The NOMINAL STRENGTH, sometimes called CATALOG strength, of a wire rope applies ONLY to a NEW, UNUSED rope.
4. The Nominal Strength of a wire rope SHOULD BE CONSIDERED the straight line pull which will ACTUALLY BREAK a NEW UNUSED rope. The Nominal Strength of a wire rope SHOULD NEVER BE USED AS ITS WORKING LOAD.
5. WIRE ROPES WEAR OUT. The strength of a wire rope begins to decrease when the rope is put to use and continues to decrease with each use.
6. NEVER OVERLOAD A WIRE ROPE. This means NEVER use the wire rope where the load applied to it is greater than the working load determined by the rope manufacturer.
7. NEVER “SHOCK LOAD” a wire rope. A sudden application of force or load can cause both visible external and internal damage. There is no practical way to estimate the force applied by shock loading a rope. The sudden release of a load can also damage a wire rope.
8. Lubricant is applied to the wires and strands of a wire rope when it is manufactured. The lubricant is depleted when the rope is in service and should be replaced periodically. See Preventative Maintenance, for lubrication intervals and procedures.
9. In the U.S.A., regular INSPECTIONS of the wire rope and keeping of PERMANENT RECORDS SIGNED BY A QUALIFIED PERSON ARE REQUIRED BY OSHA FOR ALMOST EVERY WIRE ROPE APPLICATION. The purpose of the inspection is to determine whether or not a wire rope may continue to be safely used on the application. Inspection criteria, including number and location of broken wires, wear and elongation, have been established by OSHA, ANSI, ASME and similar organizations.

   IF IN DOUBT, REPLACE THE ROPE. An inspection should include verification that none of the specified removal criteria for this usage are met by checking for such things as:

   - Surface wear; nominal and unusual.
   - Broken wires; number and location.
   - Reduction in diameter.
   - Rope stretch (elongation).
   - Integrity of end attachments.
   - Evidence of abuse or contact with another object.
   - Heat damage.
   - Corrosion.

   In addition, an inspection should include condition of sheaves, drums and other apparatus with which the wire rope makes contact.
10. When a wire rope has been removed from service because it is no longer suitable for use, it must not be reused on another application.
11. Every wire rope user should be aware of the fact that each type of fitting attached to a wire rope has a specific efficiency rating which can reduce the working load of

the wire rope assembly or rope system, and this must be given due consideration.

12. Some conditions that lead to problems in wire rope systems include:

- Sheaves that are too small, worn or corrugated can cause damage to a wire rope.
- Broken wires mean a loss in strength.
- Kinks permanently damage a wire rope and must be avoided.
- Wire ropes are damaged by knots. Wire rope with knots must never be used.
- Environmental factors such as corrosive conditions and heat can damage a wire rope.
- Lack of lubrication can significantly shorten the useful life of a wire rope.
- Contact with electrical wires and resulting arcing will damage a wire rope.

Wire Rope Inspection

Inspect entire length of wire rope for any conditions listed in Figure 11-9. 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.

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Wire Rope Inspection

REPLACE WIRE ROPE WHEN ANY OF THE FOLLOWING CONDITIONS EXIST:

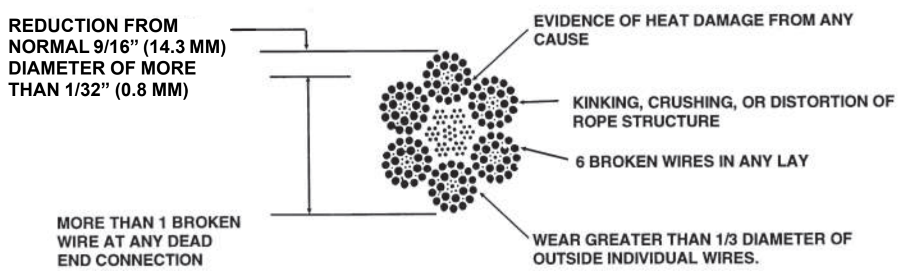


FIGURE 11-9

Sheave Inspection

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

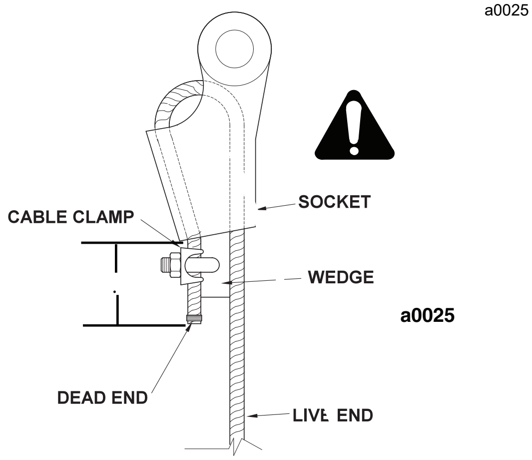
Always connect the socket so that the load is pulled on the same line as the socket (See Figure 11-10).

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 11-10.

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



X = A MINIMUM OF 6 ROPE DIAMETERS, BUT NOT LESS THAN 6 INCHES *(152 MM).*

FIGURE 11-10

Installation of 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 11-11. 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.

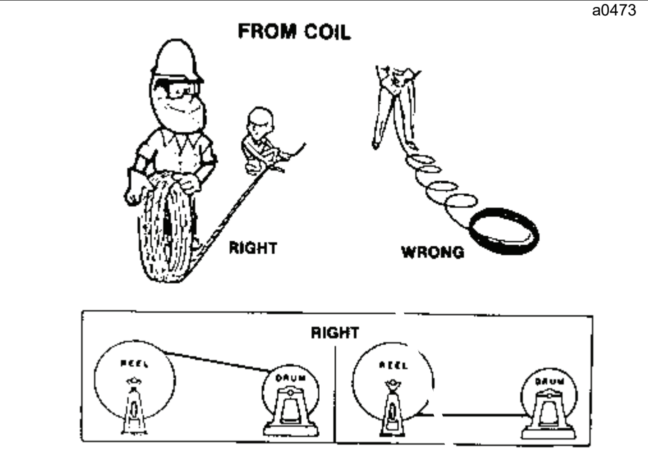


FIGURE 11-11

3. Operate the hoist slowly to move the wire rope directly from the reel to the hoist drum. Keep the wire rope under tension and make sure the wire rope winds correctly on the drum. Loose windings will increase wear on the wire rope and cause bad performance.

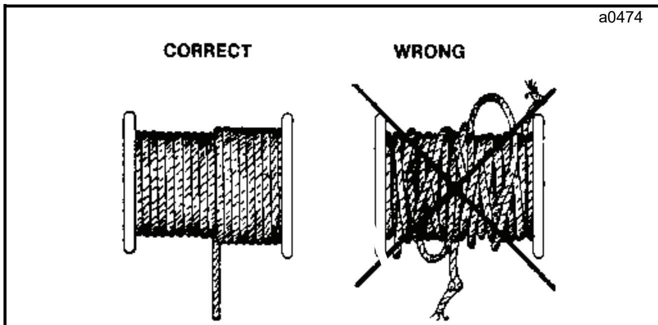
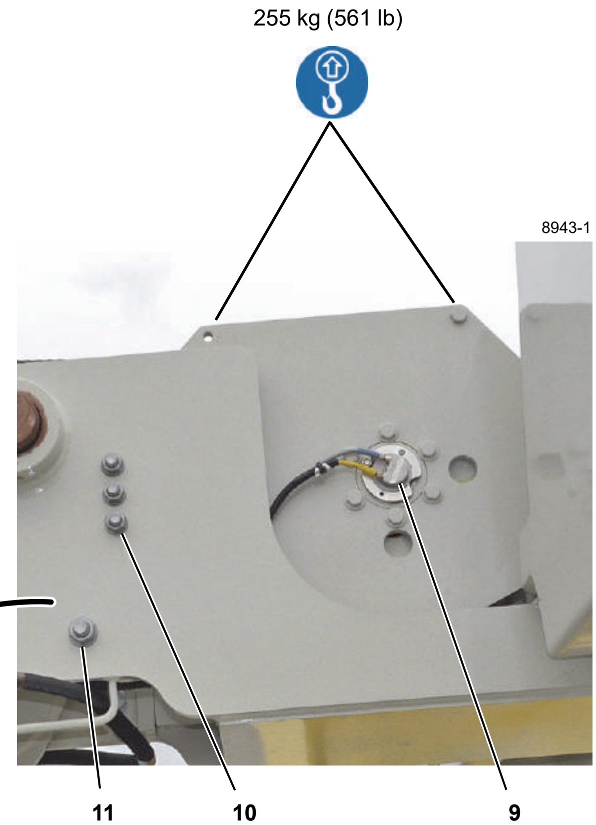
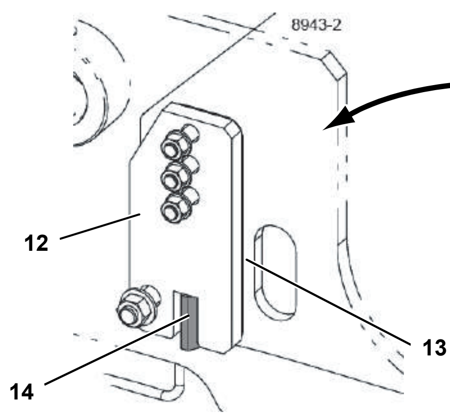


FIGURE 11-12

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.

Item	Description
1	Hoist
2	Planetary Gearbox with Internal Disk Brake
3	Hydraulic Motor
4	Case Drain Hydraulic Hose
5	Down Hydraulic Hose
6	Up Hydraulic Hose
7	Brake Hydraulic Hose
8	Holding Valve (non-adjustable)
9	Drum Rotation and 3rd Wrap Sensor
10	M16 Mounting Bolts with Nuts and Washers (qty 6)
11	M20 Mounting Bolts with Nuts and Washers (qty 2)
12	Plate (qty 2)
13	Shim (as required)
14	Alignment Lug (qty 2)





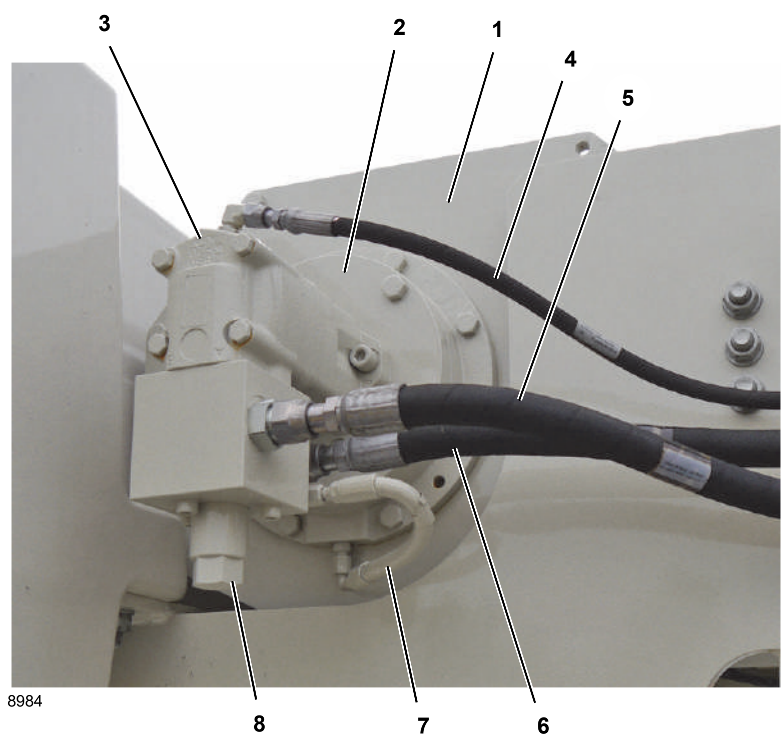


FIGURE 11-13

HOIST

Description

The hoist consists of the components shown in Figure 11-13.

The multiple disc brake is spring applied and hydraulically released through a port in the brake housing. An overrunning clutch allows the hoist to raise the load without releasing the brake while at the same time holding the load until there is sufficient pressure to release the brake when lowering the load.

Hoist 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 Section 5 of this Service Manual for Preventative Maintenance.

Inspect the hoist from the deck of the crane. Do not stand on the mast.

⚠ 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.

Hoist 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 to circulate oil through the planetary gear sets.

Hoist Lifting Equipment

The following owner furnished lifting equipment is required for hoist removal and installation:

- An assist crane or overhead hoist capable of handling 255 kg (561 lb)
- Synthetic lifting slings
- Shackles

Hoist Removal

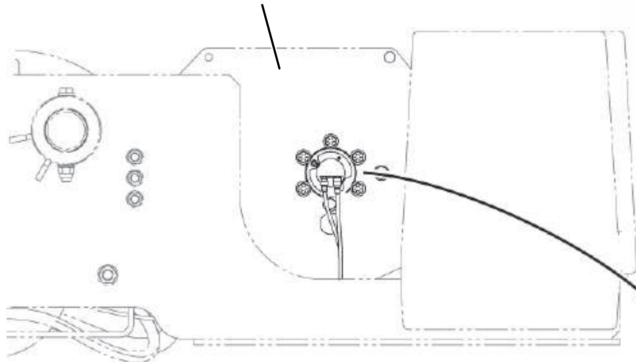
See Figure 11-13 for this procedure.

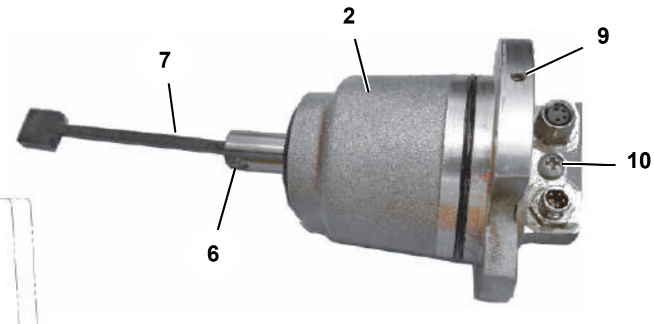
1. Spool the wire rope onto the hoist drum and secure it so it cannot fall off the hoist (1).
2. Be prepared to catch the oil leakage when the hydraulic hoses are disconnected.
3. Tag the hydraulic hoses (4, 5, and 6) for proper installation and disconnect them.
4. Cap the fittings and plug the hoses to prevent contamination.
5. Disconnect the electric cables from the drum rotation and 3rd wrap sensor (9).
6. Attach lifting slings to the hoist (1) and to the hook of the assist crane.
7. Hoist just enough to tighten the lifting slings.
8. Remove the mounting bolts (10 and 11).
9. Remove the hoist from the crane and place it in the desired storage/work area.
10. Store the plates (12) and the shims (13).
11. Disconnect the lifting slings.

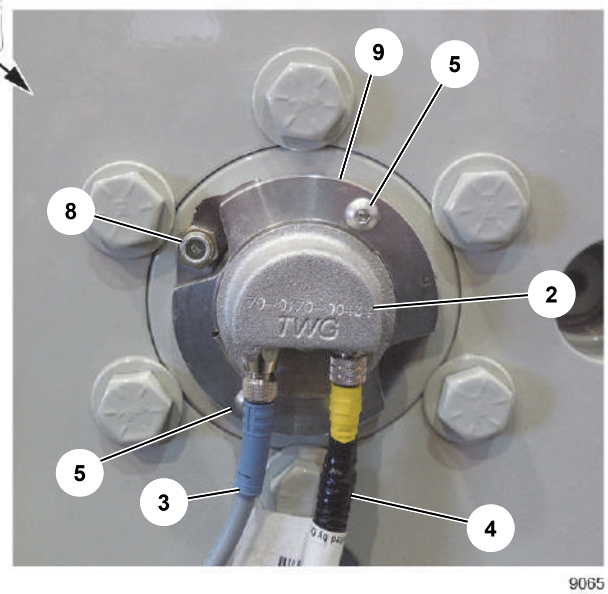
Hoist Installation

See Figure 11-13 for this procedure.

1. Position the plates (12) and the shims (13) on the alignment lug (14) on both sides of the mast.
2. Attach lifting slings to the hoist (1) and to the hook of the assist crane.
3. Lift the hoist (1) into position on the alignment lugs (14) and align the mounting holes. The shims (13) and plates (12) must be on the outboard sides of the hoist frame.
4. Install the mounting bolts (10 and 11), washers, and nuts and tighten them to the torque specified in Section 1 of this Service Manual.
5. Disconnect the lifting slings.
6. Remove the caps and plugs from the hydraulic fittings and hoses (4, 5, and 6) and thoroughly clean the hydraulic connections.
7. Connect and properly tighten the hydraulic hoses (4, 5, and 6) to the hydraulic fittings.
8. Connect the electric cables to the drum rotation and 3rd wrap sensor (9).
9. Check the oil level in the hydraulic tank. Fill if necessary.
10. Start the engine and operate the hoist slowly in both directions to fill the lines with hydraulic oil and to bleed air from the system. Check for leaks and repair if necessary.
11. Check the oil level in the hydraulic tank. Fill if necessary.
12. Install the wire rope and the hook block or the downhaul weight.







Item	Description
1	Hoist Assembly
2	Sensor Assembly
3	Electric Cable (4 pole)
4	Electric Cable (5 pole)
5	Retaining Screw (qty 2)
6	Set Screw
7	Shaft
8	Breather
9	Set Screw (qty 2)
10	Access Screw

FIGURE 11-14

DRUM ROTATION/3RD WRAP INDICATOR

The drum rotation (DRI)/3rd Wrap indicator (Figure 11-14) is located on the left side of the hoist. It serves the following purposes:

- The sensor transmits a rotation signal (DRI) to a solenoid (thumb thumper) located in the end of the hoist control lever in the cab.
- The sensor also turns on the 3rd wrap alarm (warning buzzer and 3rd wrap red warning light) on the instrument panel when there are three wraps of cable left on the drum.

Replacing the DRI/3rd Wrap Sensor

Unless otherwise specified, see Figure 11-14 for this procedure.

Tools Required

- 3/16 in Allen wrench
- 1/16 in Allen wrench
- Phillips screw driver

Sensor Removal

1. Disconnect the electric cables (3 and 4).
2. Remove the two retaining screws (5).
3. Remove the sensor assembly (2) from the hoist.
4. Loosen the set screw (6) and remove the shaft (7) from the sensor assembly (2).

Sensor Installation

1. Install the shaft (7) into the sensor assembly (2) and tighten the set screw (6) to 7 in-lb.
2. Liberally apply silicone sealant on the set screw to prevent oil from getting into the electronics.
3. Carefully insert the sensor assembly (2) into the drum so the shaft (7) engages the drive inside the drum.
4. Align the notch in the sensor assembly (2) with the breather (8).
5. Secure the sensor assembly (2) with two retaining screws (5).Tighten to 16 in-lb.
6. Loosen two set screws (9) in the sensor flange.
7. Rotate the sensor center section so the electrical connectors point down.
8. Tighten the set screws (9) to 2 in-lb.
9. Securely attach the electric cables to the connectors.

WARNING

Moving Machinery Hazard!

It is necessary to operate the hoist while programming the 3rd wrap indicator.

Stay clear of the drum and the wire rope while it is being operated. Death or serious injury may result.

Programming the 3rd Wrap Indicator

1. Start the engine.
2. Operate the hoist until there are five wraps of wire rope on the first layer of the drum. This is the first set point to deactivate the alarm.
3. Disconnect the electric cable (4) to turn off power to the sensor assembly.
4. Remove the access screw (10) to the programming button.

NOTE: During the programming steps, use an Allen wrench or other small tool with a flat, blunt end approximately 1.5 mm (1/16 in) in diameter and at least 76 mm (3 in) long.

DO NOT use a pointed or sharp tool. A faulty setting or damage can occur. Also, excess force can cause damage.

5. Insert the programming tool into the access hole.
6. Gently press and hold the programming button and reconnect the electric cable (4) to turn on power to the sensor assembly.
7. Hold the programming button for at least 2 seconds, but less than 15 seconds, after power is on, then release the button.
8. Operate the hoist until there are TWO wraps of wire rope on the first layer of the drum. This is the second set point to activate the 3rd wrap alarm.
9. Gently press and hold the programming button for 1-2 seconds. Then release the button. The 3rd wrap alarm should come on.
10. Install the access screw (10) and tighten to 7 in-lbs.

NOTE: Failing to install the access screw could effect operation of the 3rd wrap indicator.

11. The 3rd wrap setup routine is complete.

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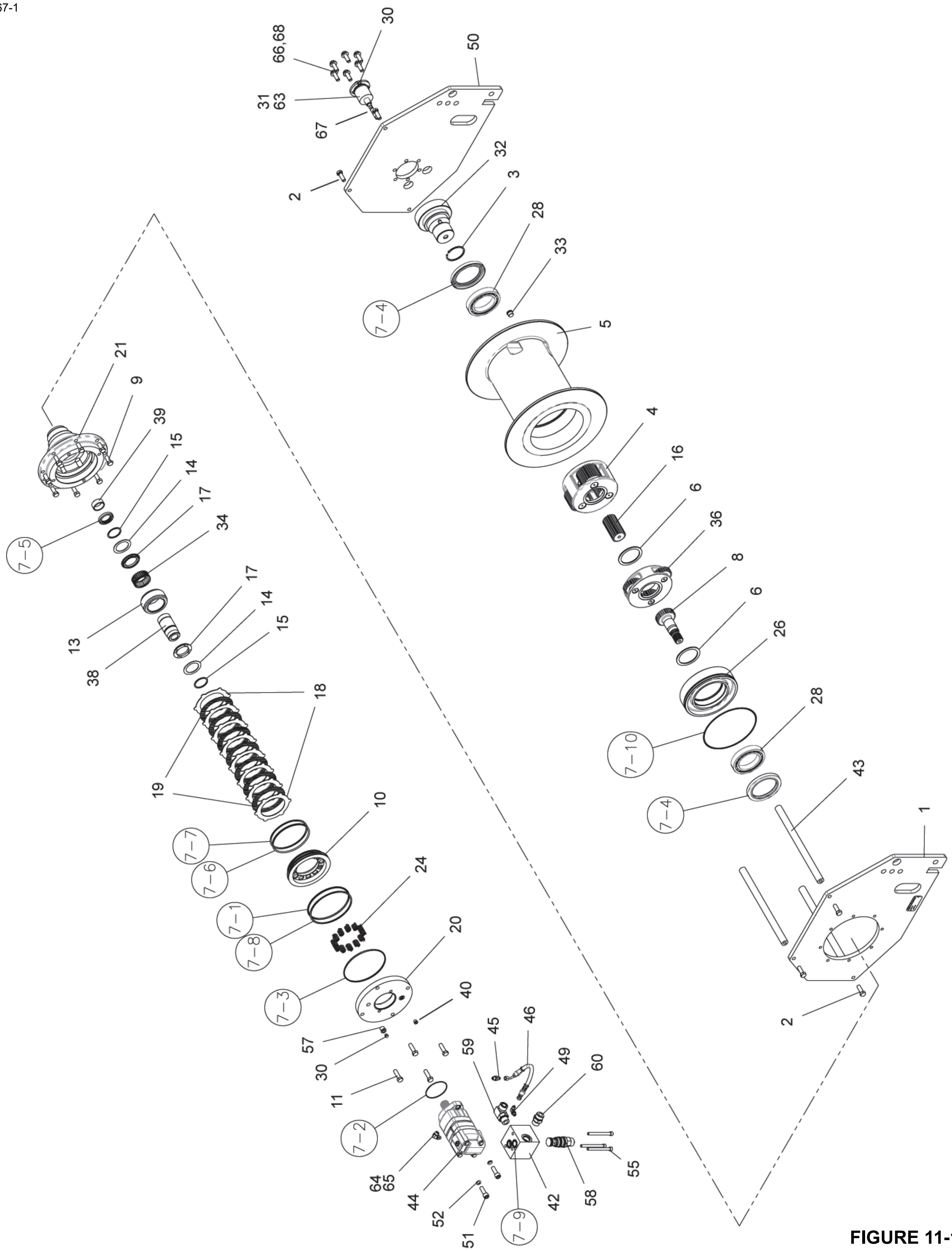

FIGURE 11-15

Hoist Assembly Legend

Item	Description	Qty
1	Plate, Motor Side	1
2	Cap Screw	6
3	Ring, Retaining	1
4	Gear Set, Output Planet	1
5	Drum	1
6	Washer, Thrust	2
7	Kit, Seal	1
8	Gear, Input Sun	1
9	Cap Screw	8
10	Piston, Brake	1
11	Cap Screw	4
13	Driver, Brake	1
14	Race	2
15	Ring, Retaining	2
16	Gear, Output Sun	1
17	Bushing, Thrust	2
18	Disc, Friction	7
19	Plate, Stator	8
20	Cover, Brake	1
21	Housing, Brake	1
24	Spring, Brake	12
26	Carrier, Bearing	1
28	Bearing, Ball	2
30	Breather	2
31	Sensor, DRI/LWI	1
32	Shaft, Output	1
33	Plug, O-ring	1
34	Clutch, Sprag	1
36	Gear Set, Input Planet	1
38	Driver, Input	1
39	Bushing	1
40	Plug, Socket Head, O-Ring	1
42	Block, Valve	1
43	Rod, Support	2
44	Motor, Hydraulic	1
45	Adapter, Straight	1
46	Hose	1
49	Adapter, 90°	1
50	Plate, Side	1
51	Cap Screw	2
52	Lock Washer	2
55	Cap Screw	3
57	Bushing, Pipe	1
58	Valve, Counterbalance	1
59	Adapter, 90°	1
60	Adapter, Straight	1
63	Screw, Button Head	2
64	Adapter, 90°	1
65	Cap, Threaded Plastic	1
66	Washer, Flat	6
67	Shaft	1
68	Cap Screw	6
	Seal Kit	
7-1	O-Ring	1
7-2	O-Ring	1
7-3	O-Ring	1
7-4	Seal, Oil	2
7-5	Seal, Oil	1
7-6	O-Ring	1
7-7	Ring, Back-Up	1
7-8	Ring, Back-Up	1
7-9	O-Ring	2
7-10	O-Ring	1

Hoist Disassembly

See Figure 11-15 for this procedure.

1. Drain the oil from the gearbox and brake sections.
2. Orient the hoist on its side with the motor pointing up.
3. Disconnect the hose (46) connected to the brake housing (21). Remove the motor and counterbalance valve assembly from the hoist by removing two cap screws (51). See Servicing Hoist Motor on page 11-34 for motor and counterbalance valve disassembly.
4. Remove the brake subassembly from the hoist by removing eight bolts (9) holding the brake housing to the side plate (1). Reinstall two of these bolts into the two extra tapped holes and tighten them evenly until the brake housing comes loose from the side plate. See Servicing Brake on page 11-35 for brake repair.
5. Remove the side plate (1) by removing three cap screws (2).
6. Lift the bearing carrier (26) out of the drum (5). Inspect the bearing (28) for signs of pitting or spalling and if necessary, replace the bearing, seal (7-4) and o-ring (7-10).
7. Remove the thrust washer (6) and input sun gear (8) from the input planet gear set (36). Inspect for damage and replace if needed.
8. Remove the input planet gear set (36) from the drum. Inspect the gear set for wear and repair as needed. See

Servicing Planetary Sets on page 11-35 for disassembly and repair.

9. Remove the thrust washer (6) and output sun gear (16). Inspect for damage and replace if needed.

10. Remove the output planet gear set (4) from the drum (5). Inspect the gear set for wear and repair as needed. See Servicing The Planetary Set section on page 13 for disassembly and repair.

11. Remove the drum (5) by lifting straight up and off of the output shaft (32). Inspect the gear teeth for excessive wear and replace if necessary. Inspect the ball bearing (28) for signs of spalling or pitting and, if necessary, replace the bearing and seal (7-4).

12. Inspect the retaining ring (3) on the output shaft to ensure that it is still in the groove and is not bent, and replace if necessary.

13. Inspect the output shaft (32) for wear or damage and, if necessary, remove it from the side plate (50) by removing six cap screws (68).

Hoist Assembly

See Figure 11-15 for this procedure.

1. Thoroughly clean all parts. Replace those that show wear or damage.

2. Inspect the drum (5) for structural integrity and the gear teeth for excessive wear, then replace if necessary.

3. Attach the output shaft (32) to the side plate (50) with six cap screws and washers (66 and 68), making sure the breather (30) is oriented properly, then tighten them securely.

4. Install the retaining ring (3) onto the output shaft (32).

5. Attach the rods (43) to the side plate (50) with three cap screws (2) and securely tighten.

6. If necessary, install a new ball bearing (28) and oil seal (7-4) into the drum.

7. Lay the unit down so that the rods (43) are pointing up. Set the drum (5) onto the output shaft (32) being careful not to damage the seal (7-4), seating the drum on the bearing (28).

8. Install the output planet gear set (4) into the drum (5), making sure it's installed correctly onto the output shaft (32).

9. Put a light coating of grease on the thrust washer (6) to keep it in place. Install the thrust washer into the output gear set (4), and then insert the output sun gear (16). The slot in the sun gear must be installed facing the output shaft.

10. Install the input planet gear set (36) into the drum (5), making sure it's installed correctly onto the output sun gear (16).

11. Put a light coating of grease on the thrust washer (6) to keep it in place. Install the thrust washer into the input gear set (36), and then insert the input sun gear (8).

12. Install a new o-ring (7-10) and, if necessary, a new bearing (28) and seal (7-4) into the bearing carrier (26). Grease the o-ring and seal and install the bearing carrier into the drum.

13. Position the motor side plate (1) on top of the rods (43). Attach the side plate with three cap screws (2) and tighten them securely.

14. Install the brake subassembly into the side plate (1), making sure that the pilot of the brake housing (21) aligns with the bearing (28) and seal (7-4) in the bearing carrier (26) and that the holes for the motor are in the correct orientation. Also, make sure that the level and vent plugs in the cover are properly oriented. Install eight cap screws (9) and tighten them securely.

15. Install a new o-ring (7-2) on the face of the motor and re-install the motor/counterbalance valve assembly. Install two bolts & washers (51 and 52) and tighten them to securely.

16. Reconnect the hose (46) to the brake housing (21).

17. Fill both the gearbox and the brake section with the proper amount and type of oils as instructed in Section 5 of this Service Manual.

Servicing Hoist Motor

See Figure 11-15 for this procedure.

1. Remove the counterbalance valve (58) from the valve block (Item 42) and inspect the small metering hole located on the side of the valve to make sure it is not obstructed.

2. Also, inspect the O-rings for damage and replace if necessary.

3. The motor and counterbalance valve are not serviceable in the field. Return them to an authorized distributor for service or replacement

Servicing Brake

See Figure 11-15 for this procedure.

1. Evenly remove the four cap screws (11) holding the brake cover (20) in place. Spring pressure will raise the cover as the cap screws are loosened. Remove the cover from the brake housing.
2. Remove the springs (24) from the piston and check the free height. Each spring should measure at least 30 mm (1.200 in) with no force on them.
3. Remove the brake piston (10) by installing two pieces of 3/8 in-16UNC all-thread in the bottom of two spring pockets. Using jam nuts, screw the all-thread pieces in evenly until the piston is clear of the housing. An alternate way of removing the piston is to use a portable power unit or shop air to slowly pressurize the brake cavity until the piston is out of the bore.
4. Remove the brake driver/clutch assembly (13, 14, 15, 17, 34, and 38) from the brake housing (21).
5. Remove the stator plates (19) and friction discs (18) from the brake housing and check them for excessive wear, then replace if necessary. Additionally, check the top stator plate for scoring caused by the removal tools and polish if necessary. Friction discs should measure no less than 14 mm (0.055 in) thick and stator plates should measure no less than 1.6 mm (0.064 in) thick.
6. If necessary, with a hook wire or pry bar, remove the seal (7-5) from the brake housing.
7. Examine the bushing (39) in the brake housing for wear and, if worn, replace it.
8. If the brake housing (21) is removed from the hoist, examine the journal on the brake housing where the seal (7-4) runs for wear. If severely worn, replace the brake housing.
9. Carefully disassemble the brake driver/clutch and note the side in which the markings on the clutch (34) are facing. The clutch assembly must be re-assembled with the markings facing the proper direction in order for the hoist to function properly. Inspect the surface on the input and brake drivers (Items 13 & 38) where the clutch (34) runs. If there is any pitting or spalling on the drivers then both it and the clutch must be replaced.
10. Re-assemble the driver/clutch assembly, making sure that the clutch is installed properly.
11. Install a new seal (7-5) into the brake housing. If the brake housing is removed from the hoist, temporarily install the input sun gear (8) into the brake housing and slide the driver/clutch assembly onto the sun gear spline.
12. Install the stator plates (19) and friction discs (18) into the brake housing starting with a stator and alternating friction discs and stator plates. There is one more stator plate than friction disc so you will finish with a stator plate.
13. Coat the new o-rings and backup rings (7-1, 7-6, 7-7, and 7-8) with light oil and install onto the piston (10, Figure 11-16).

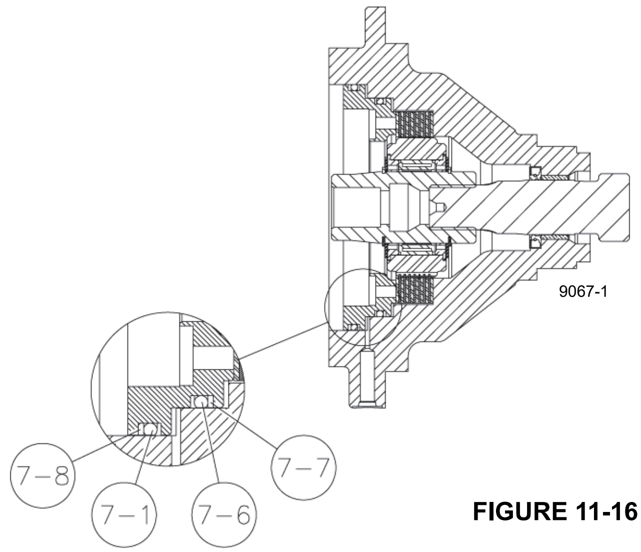

FIGURE 11-16

14. Carefully install the piston (10) into the brake housing (21) and gently tap it down until it is seated.
15. Install the springs (24) into the spring pockets of the piston. If working in a horizontal position, coat the bottom of each spring with chassis lube to keep it in position.
16. Coat the new o-ring (7-3) with light oil and install it into the groove on the brake cover (20).
17. Install the cover (20) onto the brake housing (21) and draw it down evenly, alternating between opposite cap screws (11). Make sure that the cover is aligned properly with the brake housing in order to correctly orient the motor and vent/drain plugs.
18. Check the brake release with a portable hydraulic pump. Full release should be obtained at 23 bar ±10% (330 psi ±10%).

Servicing Planetary Sets

The planetary sets are not serviceable in the field. Return them to an authorized distributor for service or replacement.

HOIST TROUBLESHOOTING

Problem	Cause	Solution
Hoist does not hold load	Excessive back pressure in the system.	Check the system for restrictions and reduce the back pressure.
	Brake discs are worn out.	Replace brake discs.
	Hoist clutch is slipping.	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.	Increase relief valve pressure setting.
	Load being lifted may be more than the hoist's rating.	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.	Check plumbing and connect lines properly.
	The cartridge in the brake valve may have a plugged metering hole.	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.	Replace this seal and reduce back pressure if high pressure caused the shaft seal to fail.
	Brake piston seals may have failed.	Service the brake section and replace worn parts.

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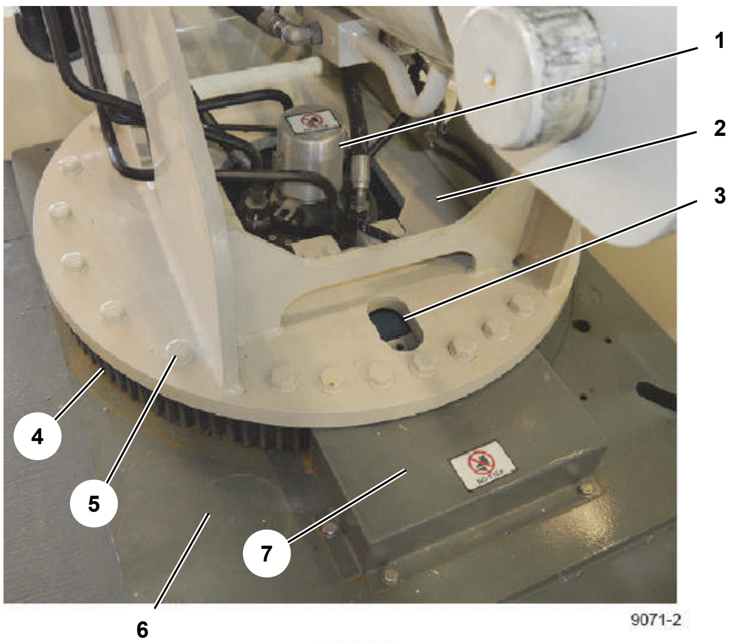
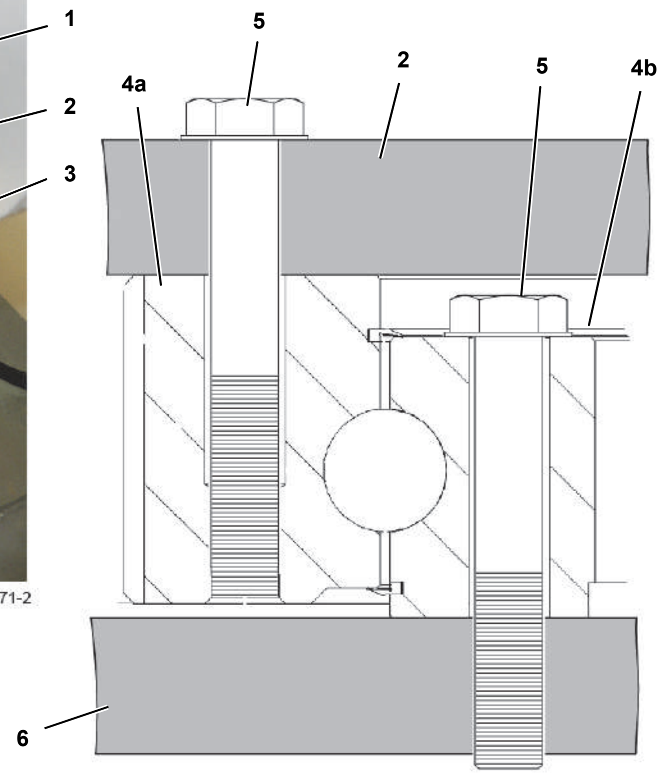
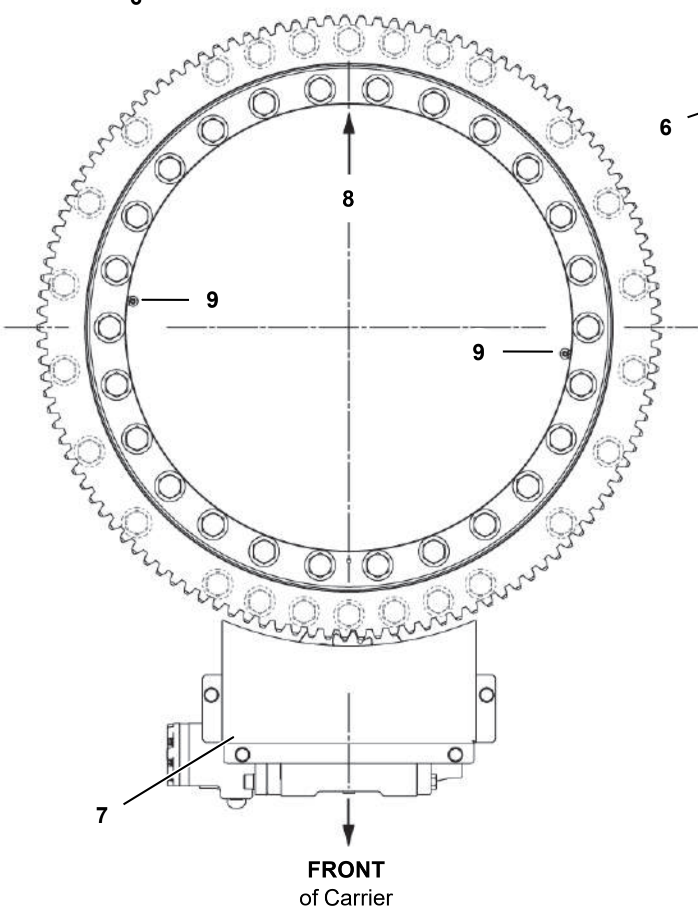






Item	Description
1	Swivel
2	Mast
3	Access Hole
4	Turntable Bearing
4a	Outer Race (with gear)
4b	Inner Race
5	Bolt with Flat Washer (qty 52)
6	Carrier Deck
7	Swing Drive Cover
8	Bearing Fill Plug
9	Grease Fitting (2)

FIGURE 11-17

TURNTABLE BEARING

The mast is fastened to the carrier deck through a turntable bearing as shown in Figure 11-17.

The inner race of the bearing is fastened to the carrier deck and the outer race of the bearing is fastened to the mast.

The outer race of the bearing has a ring gear which meshes with the swing pinion.

Bearing Lubrication

The bearing has two grease fittings (9, Figure 11-17) 180° apart in the inner race. A slotted hole (3) in the mast plate provides access to the inner race bolts and to the grease fittings.

Apply grease weekly or every 50 hours of operation, whichever occurs first. Use a Lithium based, E.P. No. 2 bearing grease, or equivalent.

Rotate the mast until the access hole aligns with either grease fitting. Apply grease to the bearing. Rotate the mast through several rotations and then repeat the procedure with the other grease fitting. The excess grease will extrude out of the bearing seal.

Bearing Bolt Torque

Very high stress is put on the turntable bearing 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 the correct torque after the second check, remove and replace the bolt. A loose bolt indicates possible failure of the bolt.

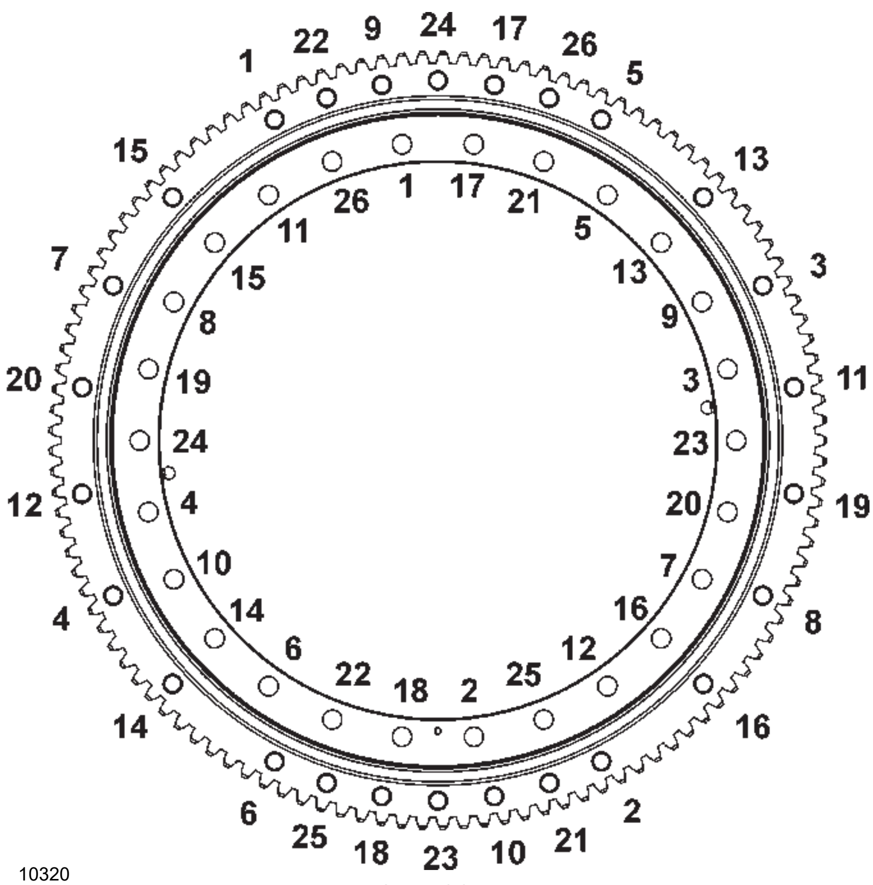
The correct torque for each bolt is 727±29 Nm (not oiled)

Use the 180° diametrically-opposed pattern shown in Figure 11-18 when checking the torque of the bolts.

NOTE: Use only M20 x 2.5 Class 12.9 unfinished (black) bolts for replacement of the turntable bearing 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.



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FRONT of Carrier

FIGURE 11-18

Bearing Wear

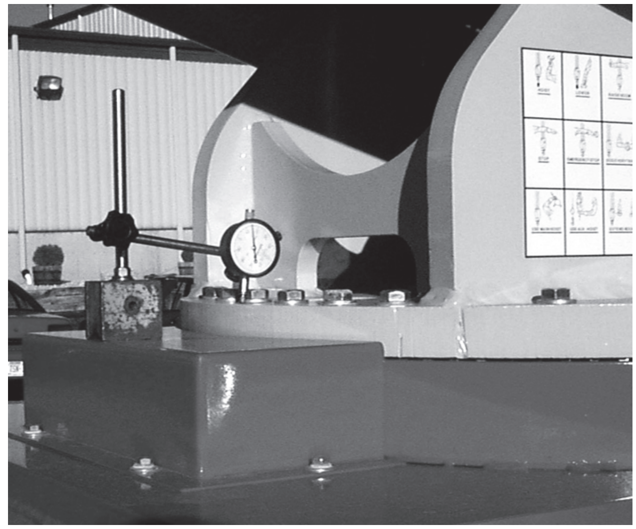
Because of conservative design parameters, static loading and slow intermittent rotation, there are very few turntable bearings that ever see their full design use.

However, the turntable 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 turntable bearing wear are:

- **a.** Metal particles in the grease around the seal.
- **b.** Increased drive power required.
- **c.** Noisy rotation.
- **d.** Rough rotation.

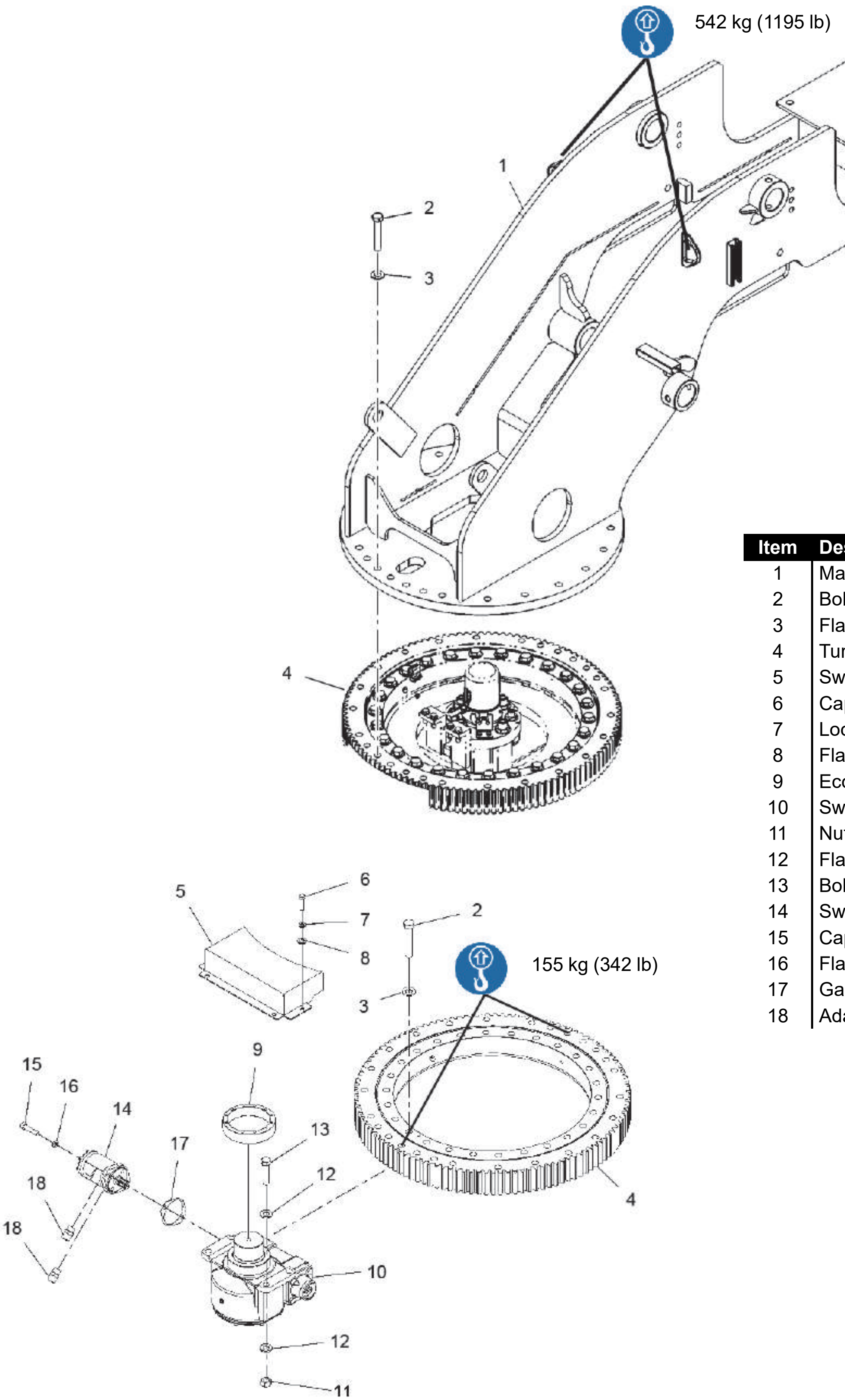
If one or more of the above symptoms are present, the following procedure should be used to test the bearing for excessive wear.

1. On a level, hard packed surface, set the machine up on its outriggers.
2. 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 11-19.
3. Set the dial indicator to zero.



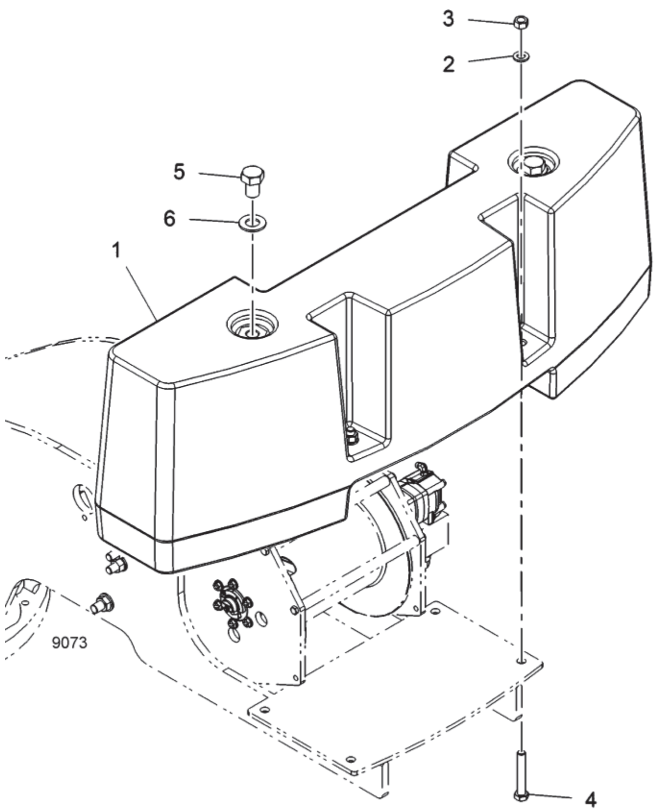
p0222 **FIGURE 11-19**

4. Raise the boom to its full raised position and record the amount of movement on the dial indicator.
5. Lower the boom and then rotate it 180°. Repeat steps 2 though 4.
6. Average the two readings. The maximum allowable movement is 1.52 mm (0.060 in). The turntable bearing must be replaced if the movement is greater than specified.



Item	Description
1	Mast
2	Bolt: M20x2.5, 12.9 (qty 52)
3	Flat Washer (qty 52)
4	Turntable Bearing
5	Swing Drive Cover
6	Cap screw (qty 4)
7	Lock Washer (qty 4)
8	Flat Washer (qty 4)
9	Eccentric Ring
10	Swing Gearbox
11	Nut (qty 4)
12	Flat Washer (qty 4)
13	Bolt (qty 4)
14	Swing Motor
15	Cap Screw (qty 2)
16	Flat Washer (qty 2)
17	Gasket
18	Adapter (qty 2)

FIGURE 11-20



Item	Description
1	Counterweight: 1588 kg (3500 lb)
2	Flat Washer (qty 4)
3	Nut (qty 4)
4	Bolt (qty 4)
5	Capscrew (1-1/4 in 7 UNC)
6	Flat Washer

FIGURE 11-21

Bearing Replacement

Preparation

1. Position the crane on a level surface.
2. Lower the boom to horizontal and fully retract it.
3. Stabilize and level the crane using the outriggers.
4. Park the crane and stop the engine.

Lifting Equipment

The following owner furnished lifting equipment is required for bearing removal and installation:

- An assist crane or overhead hoist capable of handling:
    - Boom, 41 ft: 1400 kg (3084 lb)
    - Boom, 50 ft: 2105 (4640 lb)
    - Boom Lift Cylinder: 171 kg (377 lb)
    - Boom Extension: 181 kg (400 lb)
    - Counterweight: 1588 kg (3500 lb)
    - Hoist with Wire Rope: 255 kg (561 lb)
    - Mast: 542 kg (1195 lb)
    - Searcher Hook: 33 kg 73 lb)
    - Turntable Bearing: 155 kg (342 lb)
- Lifting slings
- Lifting eyes (qty 2) (M20x2.5, 12.9)

Removal

1. Remove the boom extension. See Boom Extension Removal on page 11-3.
2. Remove the searcher hook, if installed. See Section 5 of your CD15 Operator Manual.
3. Remove the boom. See Boom Removal on page 11-5.
4. Remove the counterweight (see Figure 11-21):
    a. Remove capscrews (5) and flat washers (6) and install owner furnished lifting eyes in their place.
    b. Attach owner furnished lifting slings to the lifting eyes and to the hook of an assist crane.
    c. Tighten the lifting slings and remove nuts (3), flat washers (2), and bolts (4).
    d. Lift the counterweight (10) off the mast and store it.
5. Remove the boom lift cylinder.
6. Remove the hoist. See Hoist Removal on page 11-29.
7. Be prepared to catch oil leakage when the hydraulic lines are disconnected.
8. Tag the hydraulic tubes with the swivel port number to which they connect.
9. Disconnect the hydraulic tubes from the adapters in the top of the hydraulic swivel.
10. Cap the adapters and plug the tubes to prevent contamination.
11. Disconnect two electric cables from the slip joint in the top of the hydraulic swivel.

See Figure 11-20 for the remaining steps.

12. Attach owner furnished lifting slings to the lifting lugs on the mast (1) and to the hook of an assist crane.
13. Tighten the lifting slings and remove the 26 bolts (2) and flat washers (3) which fasten the mast to the turntable bearing (4).
14. Remove the mast and place it on blocks.
15. Disconnect the lifting slings.

16. Install owner furnished lifting eyes 180° apart in two holes of the turntable bearing outer race.
17. Attach the lifting slings to the lifting eyes. The bearing weighs 155 kg (342 lb).
18. Remove the 26 bolts (2) and flat washers (3) which fasten the turntable bearing to the carrier.
19. Remove the turntable bearing.

Installation

1. Using a suitable solvent, thoroughly clean the bearing mounting surface and bolts holes in the carrier deck. Remove all residue with compressed air.
2. Thoroughly clean the mounting surfaces and bolts holes in the turntable bearing.
3. Prepare the swing gearbox, as follows (see Figure 11-22):
    a. Remove the swing pinion cover (1).
    b. Slightly loosen the four swing gearbox mounting bolts (4).
    c. Rotate the eccentric ring (6) with a spanner wrench to provide the maximum distance between the swing pinion (3) and the swing gear (2).
4. Install two lifting eyes 180° apart in two holes of the turntable bearing outer race.
5. Attach lifting slings from the assist crane.
6. Lift the turntable bearing into position on the carrier deck and make sure the turntable bearing is positioned as shown in Figure 11-17:
    - The bearing fill plug (8, Figure 11-17) must be toward the rear of the carrier deck.
    - The high spot on the outer ring gear teeth must be toward the front of the carrier deck (in mesh with swing pinion). The high spot of the ring gear is marked with blue lines on the gear teeth, a white dot, or punch marks.
7. Install the bolts (2, Figure 11-20) and flat washers (3) finger tight to fasten the inner race of the turntable bearing to the carrier deck.
8. Tighten the bolts using the 180° diametrically-opposed pattern shown in Figure 11-17 to 582 Nm (80% of the final torque).

    Final torque = 727±29 Nm
9. Then tighten the bolts in the recommended pattern to the final torque.
10. Adjust the swing gearbox, as follows (see Figure 11-22):
    a. Using a spanner wrench, rotate the eccentric ring (6) with a spanner wrench so the swing pinion (3) is in complete contact with the swing gear (2).
    b. Tighten the four swing gearbox mounting bolts (4) to 202±5 ft-lb.
    c. Install the swing pinion cover (1).

NOTE: For ease of lubrication, apply grease to the grease fittings (9, Figure 11-17) with the mast removed. See Bearing Lubrication on page 11-39.

11. Using a suitable solvent, thoroughly clean the bearing mounting surface and bolts holes in the underside of the mast. Remove all residue with compressed air.
12. Thoroughly clean the mounting surface and bolt holes in the turntable bearing.
13. Attach owner furnished lifting slings to the lifting lugs on the mast (1, Figure 11-20) and to the hook of an assist crane.
14. Lift the mast into position and align the mounting holes as shown in Figure 11-17.
15. Install the bolts (2, Figure 11-20) and flat washers (3) finger tight to fasten the mast to the outer race of the turntable bearing.
16. Tighten the bolts using the 180° diametrically-opposed pattern shown in Figure 11-17 to 582 Nm (80% of the final torque).

    Final torque = 727±29 Nm
17. Then tighten the bolts in the recommended pattern to the final torque.
18. Remove the caps and plugs from the hydraulic adapters on the swivel and the tubes on the mast. Thoroughly clean the hydraulic connections.
19. Connect and properly tighten the hydraulic tubes to the adapters on the hydraulic swivel.
20. Connect two electric cables from the mast to the slip joint in the top of the hydraulic swivel.
21. Install the hoist. See Hoist Installation on page 11-29.
22. Install the counterweight (see Figure 11-21):
    a. Attach owner furnished lifting slings to the lifting eyes and to the hook of an assist crane.
    b. Lift the counterweight (10) onto the mast and align the connecting holes.
    c. Install the bolts (4), the flat washers (2), and the nuts (3). Tighten the nuts to the torque specified in Section 1 of this Service Manual.
    d. Disconnect the lifting slings.

  e. Remove the lifting eyes and install the capscrews (5) and flat washers (6) in their place.

23. Install the boom lift cylinder.

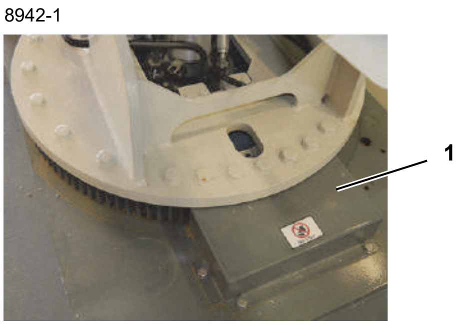
24. Install the boom. See Boom Installation on page 11-5.

25. Install the boom extension. See Boom Extension Installation on page 11-3.

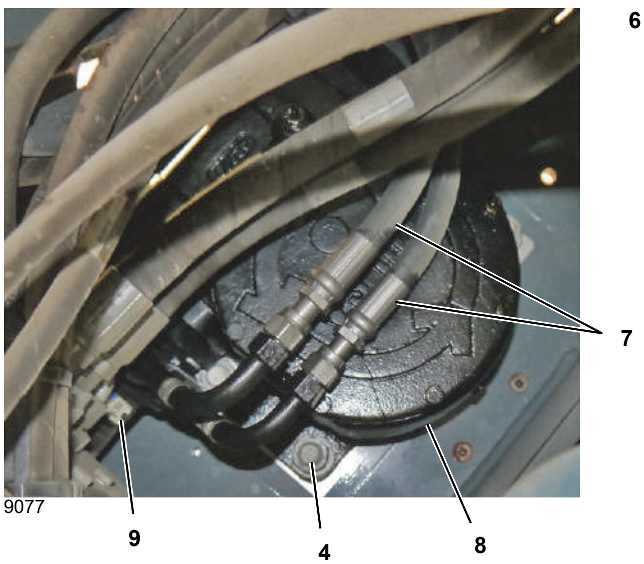
26. Check the oil level in the hydraulic tank. Fill if necessary.

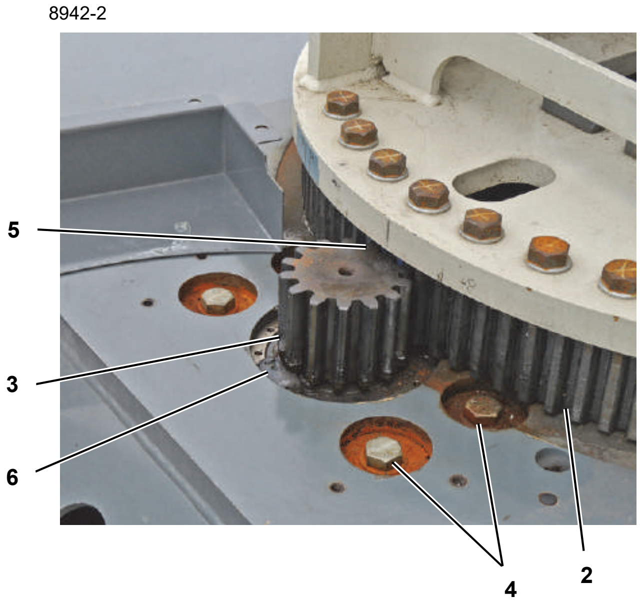
27. Start the engine and operate all functions slowly in all directions to fill the lines with hydraulic oil and to bleed air from the system. Check for leaks and repair if necessary.

28. Check the oil level in the hydraulic tank. Fill if necessary.



View From Under Carrier





Item	Description
1	Swing Pinion Cover
2	Swing Gear
3	Swing Pinion
4	Swing Gearbox Mounting Bolts with Nuts and Washers (qty 4)
5	High Point of Swing Gear
6	Eccentric Ring
7	Hydraulic Hose (qty 2)
8	Swing Gearbox
9	Swing Motor

FIGURE 11-22

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SWING GEARBOX AND PINION

Swing Gearbox Maintenance

The swing gearbox has a worm gear set which rotates on taper roller bearings. The gears and bearings are lubricated by the grease in the gearbox. Gaskets inhibit external leakage from the gearbox. Keep the gearbox filled with grease. See Add Grease to the Swing Gearbox topic in Section 5 of this Service Manual.

Swing Gear/Pinion Maintenance

Lubricate the swing pinion teeth and gear teeth with open gear lubricant (Ceplattyn 300 Spray) at regular intervals. See Lubricate the Swing Gear and Pinion topic Section 5 of this Service Manual.

Swing Gear and Pinion Backlash

See Figure 11-22 for the following procedures.

Checking Backlash

Check the backlash between the swing gear (2) and the swing pinion (3) every six months or after 1500 hours of operation, whichever occurs first.

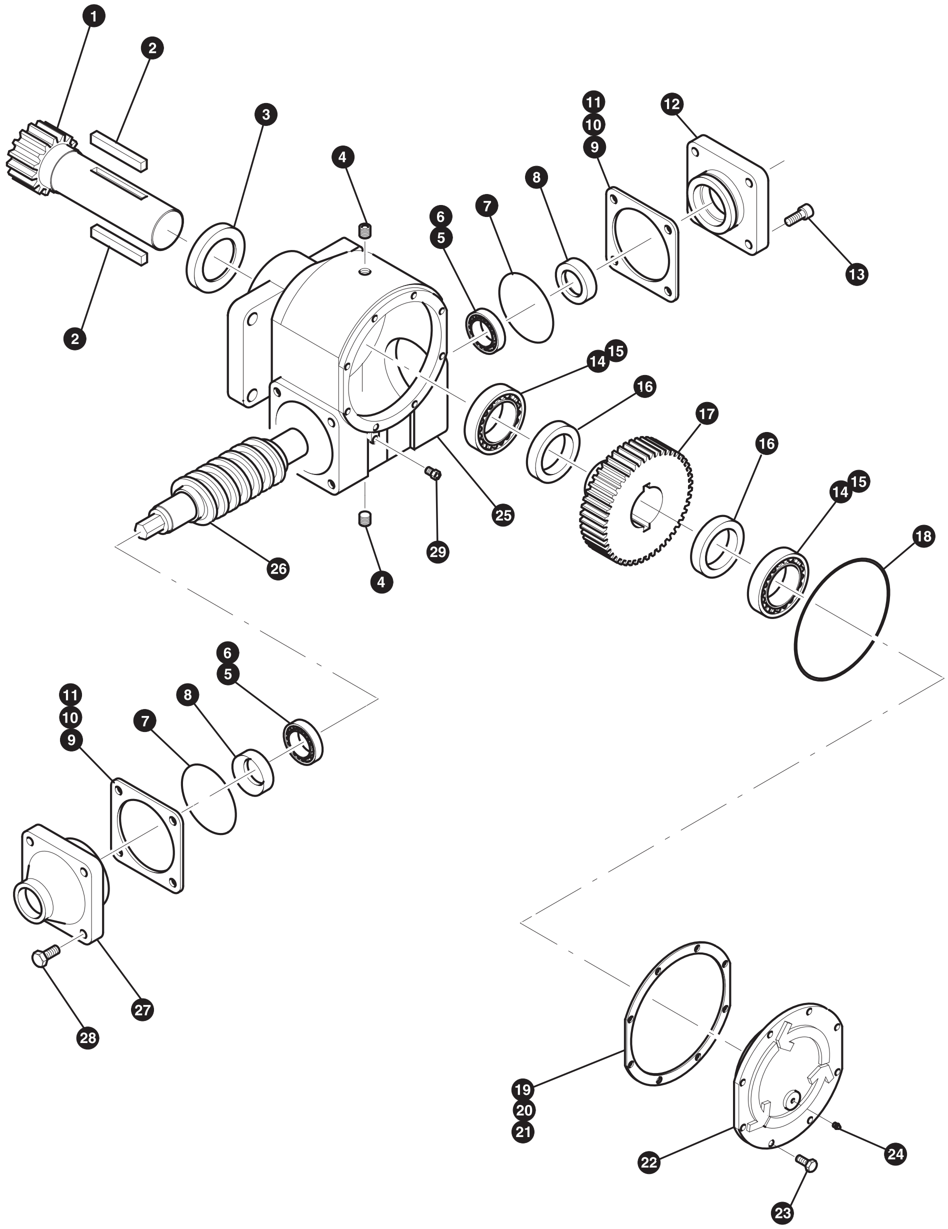
1. Remove the swing pinion cover (1).
2. Start the engine and rotate the mast until the high spot (5) on the swing gear (2) is engaged with the swing pinion (3).

   The high spot of the swing gear is marked with blue lines on the gear teeth, a white dot, or punch marks.
3. The swing pinion (3) must be in full contact with the swing gear (2) (no clearance). If not, adjust the backlash.

Adjusting Backlash

NOTE: Be sure the swing gear and pinion are aligned at the high spot (5) of the swing gear.

1. Slightly loosen the four swing gearbox mounting bolts (4).
2. Using a spanner wrench, rotate the eccentric ring (6) so the swing pinion (3) is in complete contact with the swing gear (2).
3. Tighten the four swing gearbox bolts (4) to 202±5 ft-lb.
4. Install the swing pinion cover.



Item	Description
1	Pinion Shaft
2	Key (2)
3	Oil Seal
4	Pipe Plug (2)
5	Bearing Cup (2)
6	Bearing Cone (2)
7	O-Ring (2)
8	Seal (2)
9	Shim (2)
10	Shim (2)
11	Shim (2)
12	End Motor Cap
13	Socket Head cap screw
14	Bearing Cup (2)
15	Bearing Cone (2)
16	Spacer (2)
17	Worm Gear
18	O-Ring
19	Shim
20	Shim
21	Shim
22	Cover
23	Cap Screw (8)
24	Grease Fitting
25	Housing
26	Worm
27	End Cap
28	Cap Screw (4)
29	Breather

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FIGURE 11-23

Swing Gearbox Repair

Removal

See Figure 11-22 for the following procedure.

1. Position the crane on a firm level surface, extend the outriggers, and block the carrier to provide access to the swing drive under the carrier.
2. Fully retract and lower the boom to horizontal.
3. Secure the boom in position to ***prevent the mast from rotating***.
4. Park the crane and stop the engine.
5. Remove the swing pinion cover (1) to access the four swing gearbox mounting bolts (4).
6. Be prepared to catch the oil leakage when the hydraulic hoses (6) are disconnected from the swing motor (9).
7. Tag the hydraulic hoses (7) for proper installation and disconnect them.
8. Cap the fittings and plug the hoses to prevent contamination.
9. From under the carrier, support for the swing gearbox (8). With motor, it weighs approximately 45 kg (99 lb).
10. Remove the four mounting bolts (4) that fasten the swing gearbox to the carrier.
11. Remove the swing gearbox and the eccentric ring from under the crane.

Disassembly

See Figure 11-23 for the following procedure.

1. Clean the outside of the gearbox before disassembly.
2. Mark the position of the motor on the gearbox and remove the motor.
3. Loosen bolts (23) from cover (22). Remove the cover from the gear housing (25).
4. Clean as much grease out of the housing as possible. Properly dispose of the grease.

NOTE: Tie the shim sets together to prevent any shim from being lost.

5. Remove shims (19) through (21) from the gear case. Be careful not to damage or lose any of the shims.
6. Remove O-ring (18) and cover (22).
7. Remove socket head cap screws (13). Remove end motor cap (12).
8. If shims (9) though (11) are located between cover (12) and housing (25) remove the shims. Be sure not to damage or lose any of the shims.
9. Remove and discard O-ring (7) and seal (8).
10. Remove cap screws (28) and remove end cap (27).
11. If shims (9) through (11) are located between cover (27) and housing (25) remove the shims. Be sure not to damage or lose any of the shims.
12. Remove and discard O-ring (7) from end cap (27).
13. Using a suitable puller, remove bearing cup (5) from end cap (27). Remove and discard seal (8).
14. Using a suitable puller, remove bearing cone (15) from pinion shaft (1). Remove spacer (16).
15. Using a suitable puller, remove worm gear (17) from pinion shaft (1). Remove spacer (16).
16. Using a suitable puller, remove bearing cone (15) from pinion shaft (1).
17. Remove pinion shaft (1) and worm (26) from housing (25).
18. Remove wiper seal (3) from housing (25).
19. Using a suitable puller, remove bearing cup (14) from housing (25).
20. Using a suitable puller, remove bearing cup (14) from cover (22).

Inspection

Clean all parts. Make sure the breather (29, Figure 11-23) is clean. Make a careful inspection of all parts, including gears, shafts and bearings.

Replace all seals and gaskets.

Assembly

See Figure 11-23 for the following procedure.

1. If removed, install a new bearing cup (14) into housing (25).
2. Install new wiper (3) into housing (25).
3. Install pinion shaft (1) into housing (25) through seal (3). Be careful not to damage the seal.

NOTE: Before installing any bearing cone, pack the bearing with a Lithium base, E.P. No. 2 bearing grease.

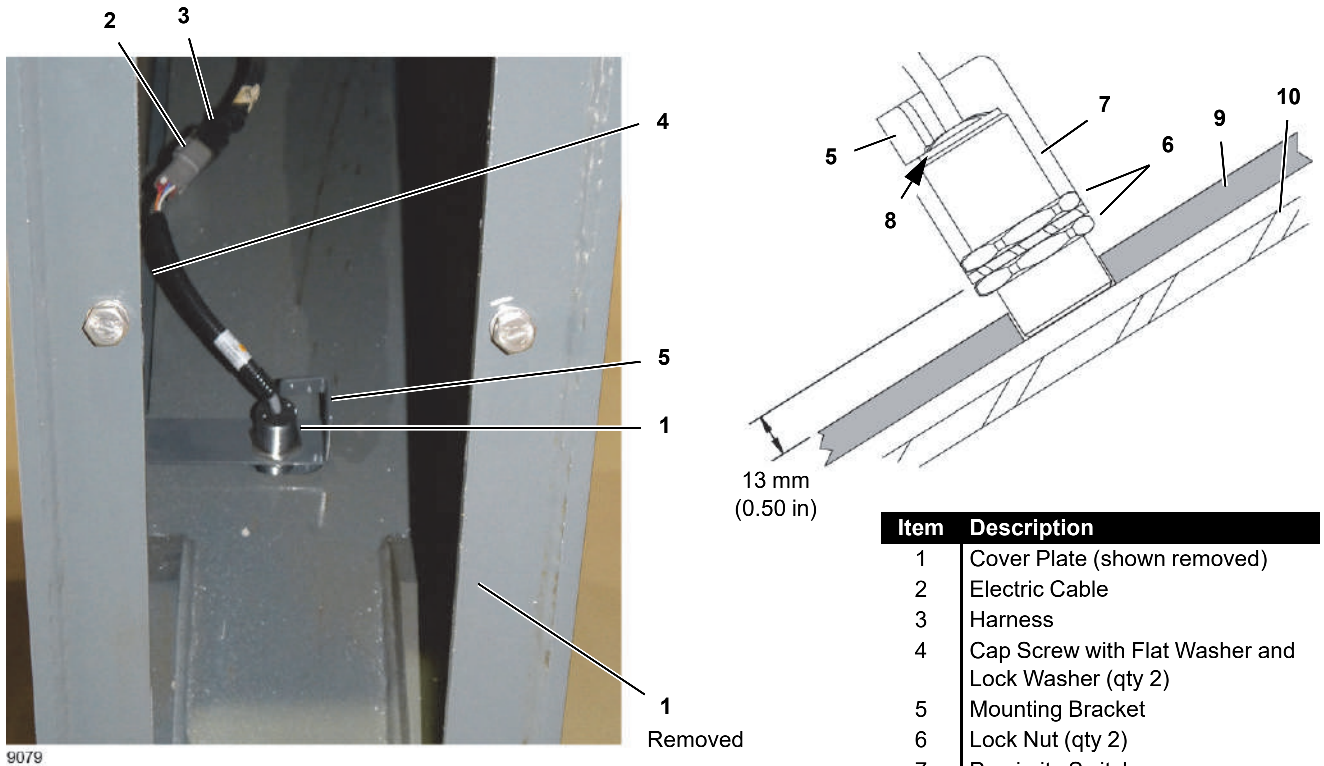
4. Pack both bearing cones (6) with grease and install onto worm (26).
5. Insert worm (26) into housing (25).
6. Pack first bearing cone (15) with grease and install onto pinion shaft (1). Install first spacer (16).
7. Using two keys (2), install worm gear (17) onto pinion shaft (1).

8. Install second spacer (16) and second bearing cone (15) onto pinion shaft (1). Be sure bearing cones are packed with grease before assembly.
9. Install seal (8) into end cap (12). Install bearing cup (5). Install O-ring (7). Lubricate the seal and O-ring with grease before assembly.
10. Install seal (8) into motor cap (27). Install O-ring (7). Lubricate seal and O-ring with grease before assembly.
11. Insert the end of worm (25) into end motor cap (12). Fasten end motor cap (12) to housing (25) with socket head cap screws (13).
12. Align the gear teeth of worm (25) with the teeth of worm gear (17).
13. If the original bearing cups and cones were installed in the end caps and onto the worm, the existing shims (9) through (11) may be installed between housing (25) and end cap (27). Install the shims and end cap (27). Attach end cap (27) with cap screws (28).
    If new bearings were installed, proper bearing pre-load must be determined before final installation of the end cap (27).
    a. Install end cap (27) without shims installed.
    b. Using a dial indicator, measure the amount of axial movement of the worm. Proper axial movement must be between -0.025 to +0.05 mm (-0.001 to + 0.002 in). Determine the amount of shims required to acquire the proper axial movement. Then, install the shims between housing (25) and end cap (27). Fasten with cap screws (28).
14. If the original bearings were installed on pinion shaft (1), then the existing shims (19) through (21) may be installed between cover (22) and housing (25). Install shims and fasten cover (22) with cap screws (23).

    If new bearings were installed, proper bearing pre-load must be determined before final installation of the cover.
    a. Install the cover without shims.
    b. Using a dial indicator, measure the amount of axial movement of the pinion shaft. Proper axial movement must be between -0.076 to -0.127 mm (-0.003 to -0.005 in). Determine the amount of shims required to acquire the proper axial movement. Then, install the shims between housing (25) and cover (22). Fasten with cap screws (23).
15. Fill the housing with a Lithium base E.P. No. 2 bearing grease through the grease fitting on the cover. See Section 5 of this Service Manual.
16. Install the motor in the proper position on the gearbox.

Installation

1. Install the gearbox in reverse order of removal.
2. Align the swing pinion with the swing gear following the instructions under the topic Swing Gear and Pinion Backlash on page 11-46.



Item	Description
1	Cover Plate (shown removed)
2	Electric Cable
3	Harness
4	Cap Screw with Flat Washer and Lock Washer (qty 2)
5	Mounting Bracket
6	Lock Nut (qty 2)
7	Proximity Switch
8	Tab
9	Outrigger Box Top Plate
10	Outrigger Beam

FIGURE 11-24

OUTRIGGER MONITORING SYSTEM

An Outrigger Monitoring System (OMS) proximity switch is mounted outside each outrigger box as shown in Figure 11-24. The proximity switches activate the green outrigger monitoring light in the cab when the outrigger beams are fully extended.

Proximity Switch Removal

1. Chock the tires so the crane cannot roll.
2. Park the crane and stop the engine.
3. Remove the desired cover plate (1).
4. Disconnect the electric cable (2) from the harness (3).
5. Remove the cap screws (4) connecting the mounting bracket (5) to the outrigger box.
6. Remove the lock nuts (6) and the proximity switch (7) from the mounting bracket (5).

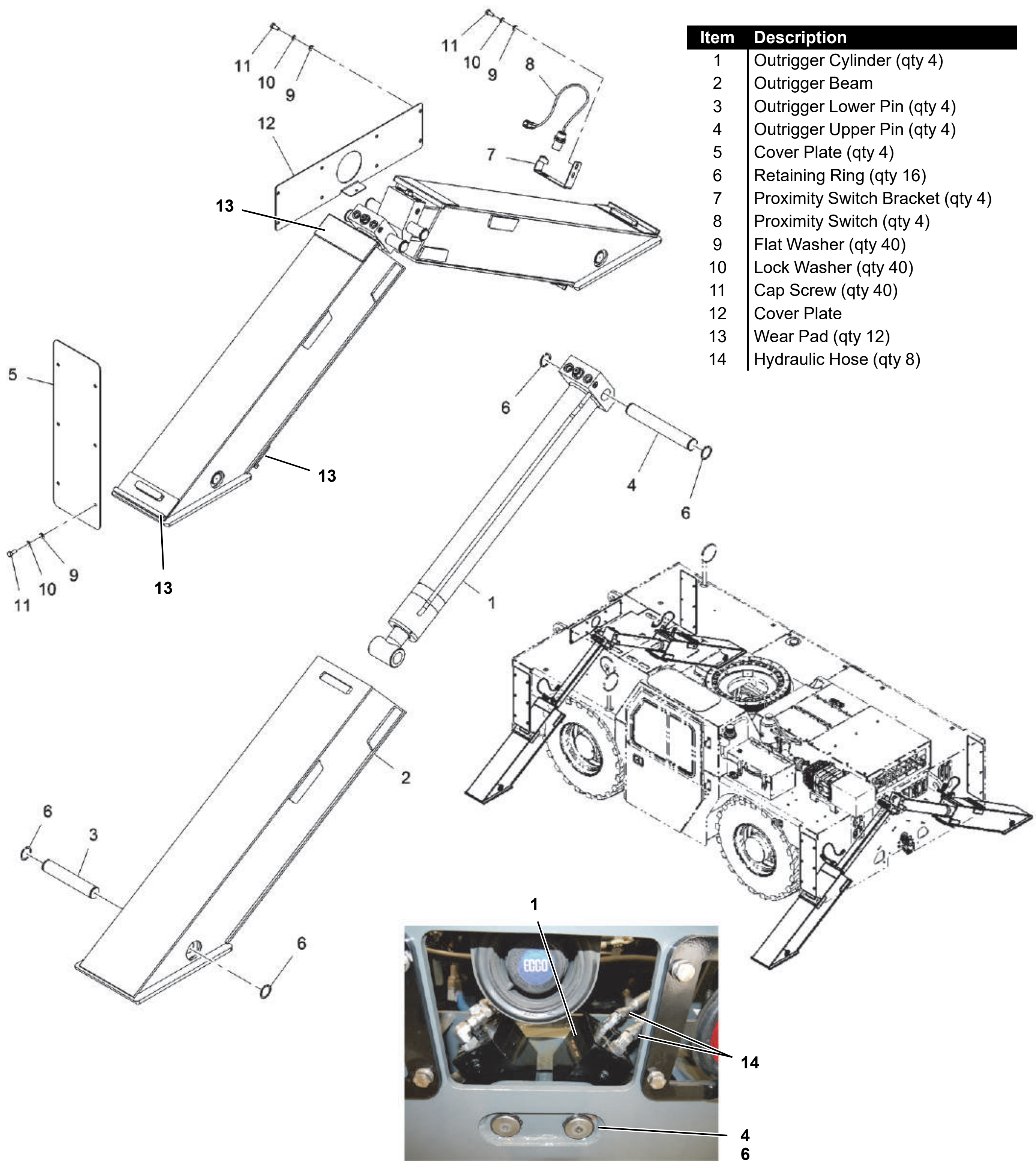
Proximity Switch Installation

1. Loosely fasten the proximity switch (7) to the mounting bracket (5) with the lock nuts (6).
2. Adjust the position of the proximity switch (7) so it is against the tab (8) of the mounting bracket. Then securely tighten the lock nuts (6).
3. Loosely fasten the mounting bracket (5) to the outrigger box with the capscrews (4), flat washers, and lock washers.
4. Set the distance between the mounting bracket (5) and the outrigger box top plate (9) to 13 mm (0.50 in).

   The face of the proximity switch will be just inside the bottom edge of the outrigger box top plate (9).
5. Securely tighten the cap screws (4).
6. Start the engine and check for proper operation of the OMS.

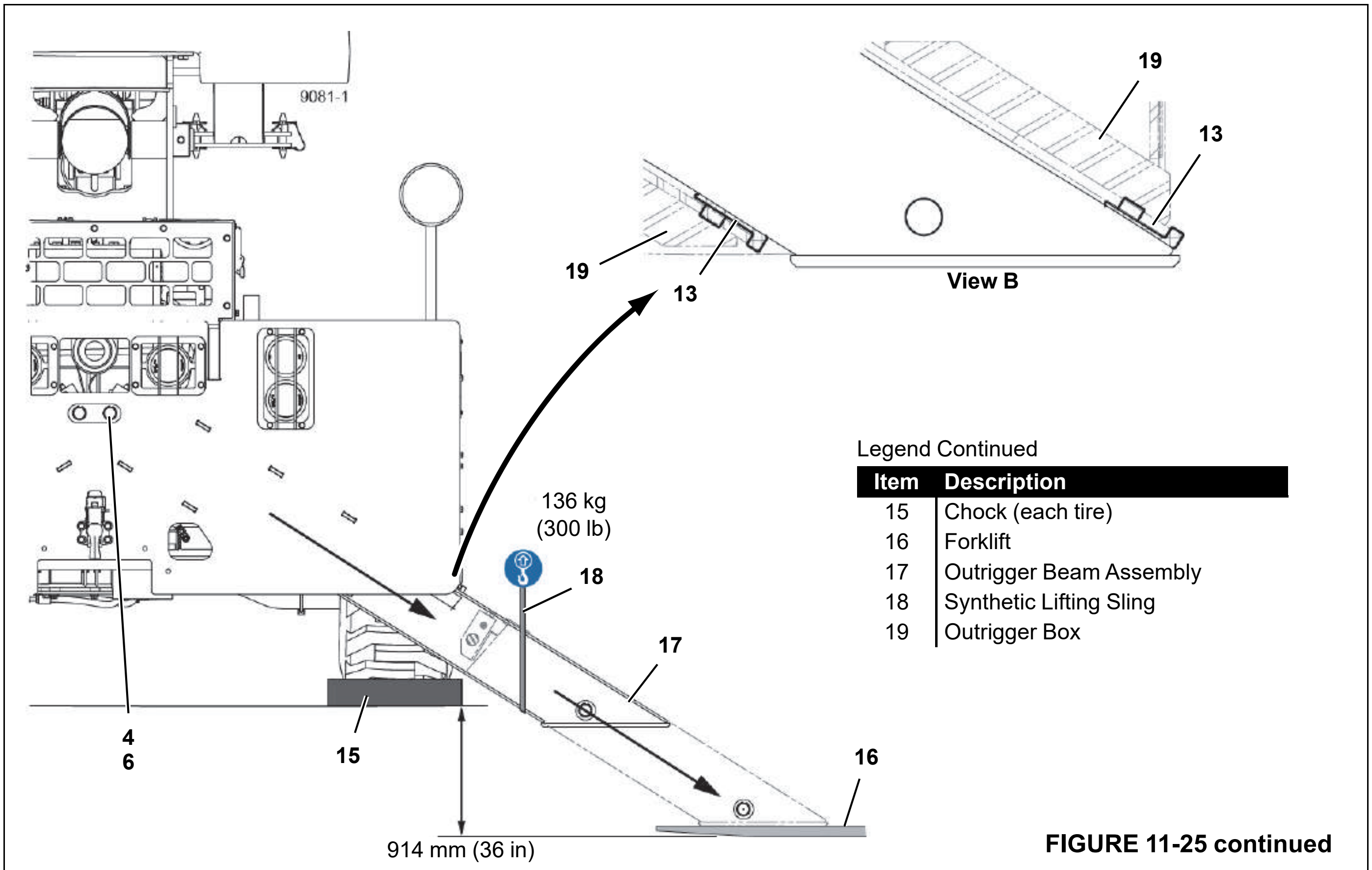
   The green outrigger monitoring light in the cab should come on when the outriggers are fully extended.
7. Reinstall the cover plate (1).

Item	Description
1	Outrigger Cylinder (qty 4)
2	Outrigger Beam
3	Outrigger Lower Pin (qty 4)
4	Outrigger Upper Pin (qty 4)
5	Cover Plate (qty 4)
6	Retaining Ring (qty 16)
7	Proximity Switch Bracket (qty 4)
8	Proximity Switch (qty 4)
9	Flat Washer (qty 40)
10	Lock Washer (qty 40)
11	Cap Screw (qty 40)
12	Cover Plate
13	Wear Pad (qty 12)
14	Hydraulic Hose (qty 8)



View A
Rear shown. Front similar.)

FIGURE 11-25



Legend Continued

Item	Description
15	Chock (each tire)
16	Forklift
17	Outrigger Beam Assembly
18	Synthetic Lifting Sling
19	Outrigger Box

FIGURE 11-25 continued

OUTRIGGERS

See Figure 11-25 for the following procedures.

The following owner furnished lifting equipment is required for outrigger removal and installation:

- An assist crane or overhead hoist capable of handling 136 kg (300 lb)
- A forklift truck or other type portable jack
- Synthetic lifting sling

Outrigger Removal

1. Full retract and lower the boom.
2. Position the crane on a firm level surface along side a ledge (or pit) that is at least 914 mm (36 in) deep.
3. Chock the tires so the crane cannot roll.
4. Park the crane and stop the engine.
5. Position the forks from a forklift (16) under the shoe of the outrigger beam (17).
6. For the front outrigger boxes only, remove cover plate (12).
7. Be prepared to catch the oil leakage when the hydraulic hoses (14, View A) are disconnected.
8. Tag the hydraulic hoses (14) for proper installation and disconnect them.
9. Cap the fittings and plug the hoses to prevent contamination.
10. Remove the snap ring (6, View A) and drive the pin (4) out (toward inside of carrier) with a brass drift pin. An assistant will have to catch the pins from under the carrier during this step.
11. Slowly lower the outrigger beam assembly (17) with the forklift until the outrigger beam is about 152 mm (6 in) from disengaging the outrigger box (19).
12. Using a chocker hitch, attach a synthetic lifting sling to the outrigger beam and to the hook of the assist crane.
13. Lower the outrigger beam the remainder of the way out of the outrigger box.
14. Place the outrigger beam assembly in the desired storage/work area.

Disassembly

1. Remove retaining ring (6, Figure 11-25) from either side of lower pin (3). Drive the lower pin out using a brass drift pin.
2. Pull the outrigger cylinder (1) out of the outrigger beam (2). The cylinder weighs 45 kg (100 lb).
3. Service or replace the outrigger cylinder.

Assembly

1. Completely clean the outrigger beam and cylinder. Use steam or a suitable solvent.
2. Install the outrigger cylinder (1, Figure 11-25) in the outrigger beam (2).
3. Make sure the cylinder is oriented as shown in Figure 11-25.
4. Align the mounting holes and install lower pin (3) with the retaining rings (6).

Installation

1. Using a chocker hitch, attach a synthetic lifting sling (18) to the outrigger beam assembly (17, Figure 11-25) and to the hook of the assist crane.
2. Lift the outrigger beam assembly into position at the end of the outrigger box (19).
3. Assemble a wear pad (13) to the outer top plate of the outrigger beam. Use multi-purpose grease to hold the wear pad in position.
4. Assemble two wear pads (13, View B) to the outrigger box (19). Use multi-purpose grease to hold the wear pads in position.
5. Lubricate the wear pads with multi-purpose grease.
6. Using the assist crane and a forklift (16), guide the outrigger beam assembly (17) into the outrigger box (19).
7. Use care not to dislodge the wear pads (13).
8. Once the outrigger beam assembly is engaged with the outrigger box, disconnect the lifting sling (18).
9. Using the forklift, lift the outrigger beam assembly into the outrigger box until the pin hole in the outrigger cylinder (1, View A) can be aligned with the pin hole in the carrier.
10. Align the pin holes and install the upper pin (4) with retaining rings (6). An assistant will have to install the inboard retaining ring from under the carrier.
11. Remove the forklift.
12. Remove the caps and plugs from the hydraulic fittings and hoses and thoroughly clean the hydraulic connections.
13. Connect and properly tighten the hydraulic hoses (14, View A) to the hydraulic fittings.
14. Check the oil level in the hydraulic tank. Fill if necessary.
15. Start the engine and operate the outrigger beam up and down to fill the outrigger cylinder and the hydraulic lines with hydraulic oil and to bleed air from the system. Check for leaks and repair if necessary.
16. Check the oil level in the hydraulic tank. Fill if necessary.

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SECTION 12
SCHEMATICS/WIRING DIAGRAMS

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