CD25

Service Manual

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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Shady Grove, PA 17256-0021 T
717 597 8121 F 717 593 5999
www.manitowoc.com

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 -

CD25

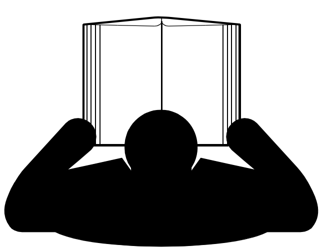
Crane Model Number

This Manual is Divided into the following Sections:

NOTICE

The crane serial number is the only method your distributor or the factory 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 distributor or the factory.



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. Grove 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

This manual contains information on maintenance, service and repair of the Model CD25 cranes. Major components and systems are included, except service on the engine. This information will be found in the engine manufacturer's service manual.

DIRECTIONAL REFERENCE

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

IDENTIFICATION DECAL

When assistance is required for parts and service, be sure to include the model number and serial number of the crane in the correspondence. Location of serial number decal is shown in Figure 1-1.

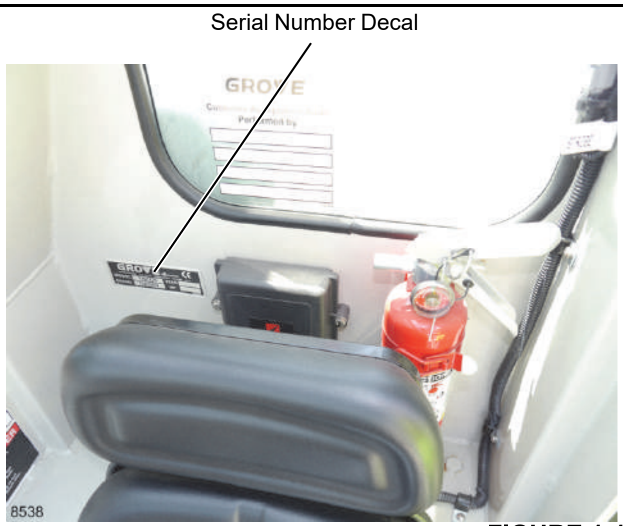

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FIGURE 1-1

SPECIFICATIONS

Engine	
Make and model	Cummins QSB4.5-130diesel
Horsepower	130 hp @ 2500 rpm
Torque	525 Nm (457 lb-ft) @ 1500 rpm
Low idle speed	800 rpm
Intermediate Speed Control (ISC) Idle Speed	1200 rpm - Coolant Temperature is less than 71° C (160° F)
Maximum engine speed (full load)	2500 rpm
Transmission	
Type	4 Speed Powershift
Tires	
Size	Standard: Bias 17.5 X 25
Air Pressure	17.5“Tires 758 kPa (110 psi)
Wheel nut torque	499 Nm (368 lb-ft)
Electrical System	
Voltage	12 VDC negative ground
Batteries	Two - Low maintenance
Cold starting amps @ 0 degrees	820 amp
Battery rating	150 amp/hr
Alternator	12 volts/130 amps
Wire Rope	
Size	15.9 mm (5/8”) 6 x 19 Bright EEIPS-IWRC
Length	114.3 m (375’ 0”)
Weight	
Crane	Open Cab: 20963 kg (46,214 lb) Closed Cab: 21073 kg (46,457 lb)
Travel Speeds	
Two-wheel steer:	
1st gear	4.66 km/hr (2.9 mph)
2nd gear	10.45 km/hr (6.5 mph)
3rd gear	22.99 km/hr (14.3 mph)
4th gear	31.35 km/hr (19.5 mph)
Operating Dimensions	
Two-wheel steer:	
Outside turning radius (center line of outside tires)	7.32 m (24’ 0”)
Four-wheel steer:	
Outside turning radius (center line of outside tires)	4.04 m (13’ 3”)

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Boom angle:	
Maximum	80°
Minimum	0°

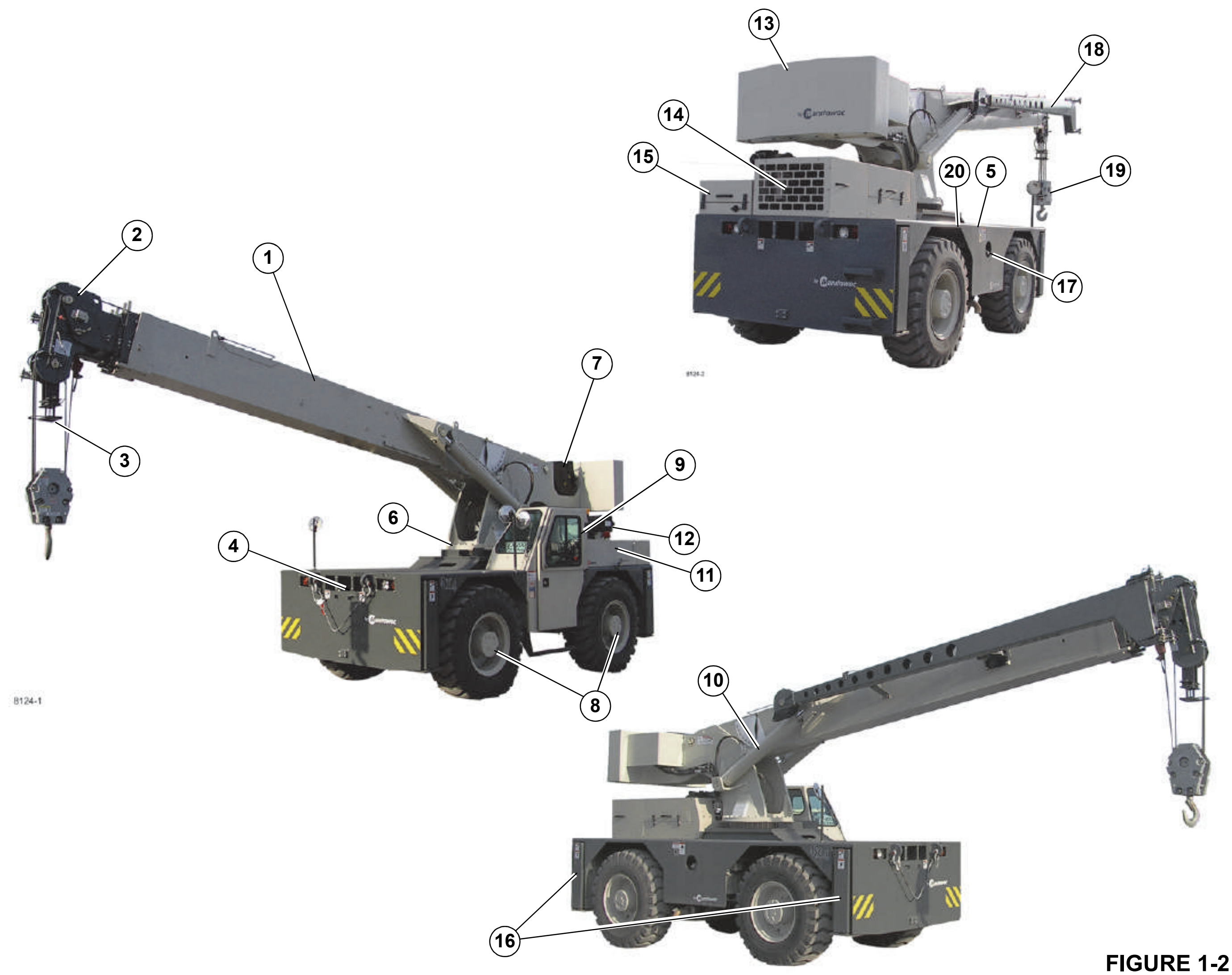


FIGURE 1-2

Item	Description	Item	Description
1	Boom, Four Section	13	Counterweight
2	Pivot Head	14	Engine Compartment
3	Anti Two-Block Device	15	Batteries
4	Winch	16	Outriggers
5	Hydraulic Valve Location (Below Deck)	17	Fuel Tank
6	Mast w/ Swing Gear	18	Folding Boom Extension
7	Hoist	19	Hook Block
8	Drive/Steer Axles	20	Storage Compartments
9	Cab		
10	Lift Cylinder (2)		
11	Hydraulic Tank		
12	Air Cleaner		

GENERAL SERVICE INFORMATION

Appropriate service methods and proper repair procedures are essential for safe, reliable operation of the crane and safety of the individual doing the work. This Service Manual provides general directions for accomplishing service and repair with effective techniques. Following them will assure reliability.

There are many variations in procedures, techniques, tools and parts for servicing machines as well as work skills. This manual cannot possibly anticipate all such variations and provide advice or cautions for each one. Accordingly, anyone who intends to depart from the instructions in this manual must first consider personal safety and the machine's integrity.

CLEANING INSTRUCTIONS

Complete Assemblies

Before removal or disassembly, clean the outside of the component as necessary. Steam can be used if all openings are closed to prevent water from entering the component.

Parts with Machined Surfaces

Gears, bearings, shafts, or other parts which have machined surfaces can be cleaned with a solvent that is not flammable. DO NOT clean these parts in hot solution tanks or with warm water and alkaline solutions (for example; hydroxide, othosilicates and phosphates).

WARNING

Burn Hazard!

To prevent injury from burns, always use a solvent that is not flammable for cleaning component parts. DO NOT use gasoline or other flammable substances.

Bearings

See *Cleaning* for bearing cleaning instructions.

Rough Parts

Housings and case parts can be cleaned in hot solution tanks with a mild alkali if these parts do not have machined surfaces. Keep the parts in the solution long enough to be thoroughly cleaned and heated. Flush the parts thoroughly after cleaning to remove all residue of the alkali solution.

Rubber Parts

Use brake fluid to clean rubber parts. To inhibit damage to the part, do not use mineral base solvents (for example; acetone or paint thinner).

NOTE: Use brake fluid to clean rubber parts. Acetone, paint thinner or other mineral base solvents must not be used on rubber parts. Mineral base solvents will cause damage and possible failure of the part.

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.

WARNING

Possible Eye Injury Hazard!

When using compressed air use only low air pressure nozzles and safety glasses; keep air stream from direction of face. Injury to eyes could occur.

To Prevent Corrosion

Apply a light weight oil to those parts which normally use lubrication and are assembled immediately. If the parts will be put into storage for any length of time, apply a rust preventative lubricant and put a protective paper on the parts.

O-RING, SEAL AND ELASTIC NUT REPLACEMENT

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

HOSES AND TUBES

> ⚠ **DANGER**
>
> **High Pressure/Temperature Hazard!**
>
> Exercise extreme care around pressurized hydraulic hoses or tubes. DO NOT work on a hydraulic system while it is in operation or until all pressure is released.
>
> Hydraulic oil is hot, it can cause severe burns.
>
> Pressurized hydraulic oil can cause death or serious injury.
>
> Stay clear of all hydraulic oil leaks. Relieve system pressure and use a piece of cardboard or paper to check for leaks. Do not use your hands.
>
> Fluid injected into skin must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene will result.

Inspection

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

Tighten all connections to recommended torque.

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

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

Replace hoses if any of the following is evident Figure 1-3:

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

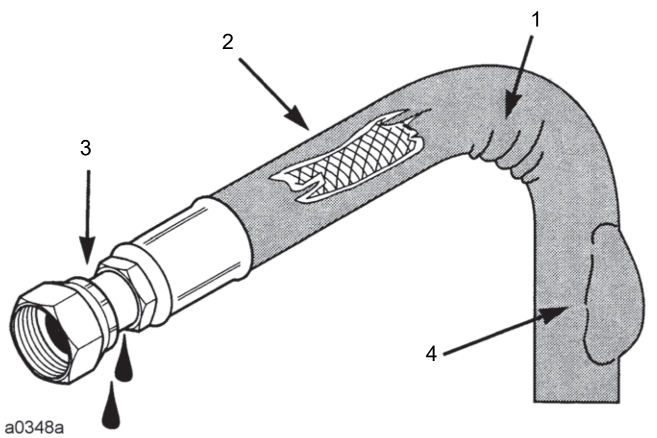


FIGURE 1-3

Installation

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

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

BEARINGS

Removal

1. Bearings should never be removed unless absolutely necessary. Always use the appropriate puller to reduce the risk of bearing or related component damage.
2. When bearings or bushings are removed, check that the bearing is free from discoloration, nicks, scuffing, and signs of overheating. If in doubt, replace the bearing or bushing.

Cleaning

Bearings acceptable for service should be cleaned in a suitable solvent and immersed in clean lubricating oil until needed.

Installation

1. Be sure bearings are installed with care during servicing, maintenance and repair.
2. Whenever possible, always install the bearing on the rotating part first.
3. Use proper tools or a press when installing a bearing or bushing.
4. In the absence of the proper tools or press, when installing press fit bearings and bushings, heat the bearing and/or the casing in hot oil to assist in the installation.

HYDRAULIC FITTINGS

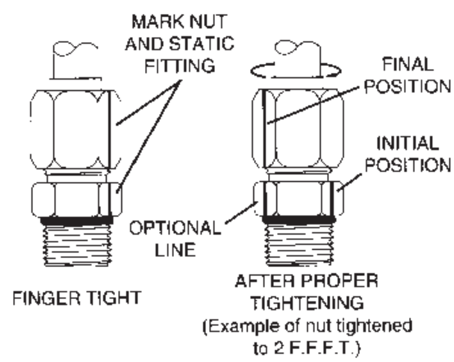
Flats from Finger Tight (F.F.F.T.) Method

Industrial product support 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.

This method will also reduce the chance of a leaky connection which is normally caused by combinations of fittings with different types of plating. This method is particularly useful when the type of plating on the 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



a0027 **FIGURE 1-4**

5. Tighten the joint by the number of flats as specified in Table 1-1 and 1-2 for size and type of fitting.
6. Optionally 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 1-4).

37° Flared Steel Fitting: Tube or Hose to Fitting

Follow the F.F.F.T. method, described above.

Table 1-1: Tube and Swivel Nut/Hose Fittings

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

T-2-5

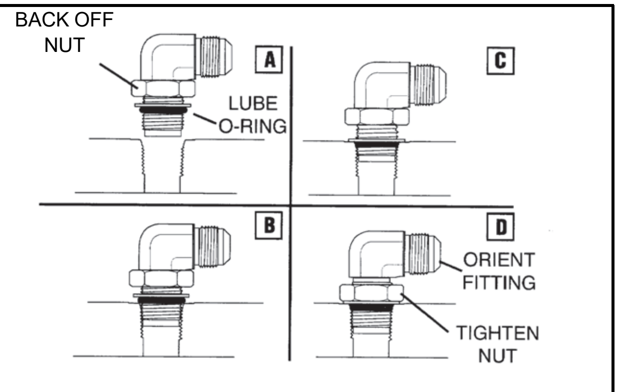
Adjustable Straight Thread O-ring Fittings

Refer to Figure 1-5 and Table 1-2 for the following procedure.

Table 1-2: Adjustable Straight Thread O-ring Fittings

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

T-2-6



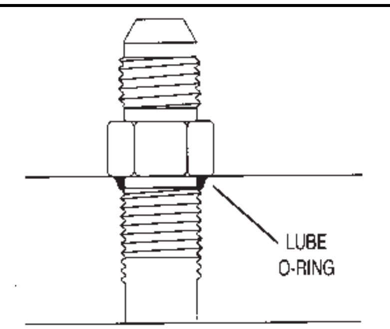
a0030 Adjustable Fitting to Port **FIGURE 1-5**

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

Nonadjustable Straight Thread O-ring Fitting: Fitting to Port

Refer to Table 1-3 for the following procedure.

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 1-6).



a0032 Non-Adjustable Fitting to Port **FIGURE 1-6**

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

Table 1-3: Straight Thread Fittings

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

T-2-7

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.

FASTENERS

Loctite®

CAUTION

Possible Eye and Skin 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 #243) and primer (Locquic® Primer T 7471).

Primer Application

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

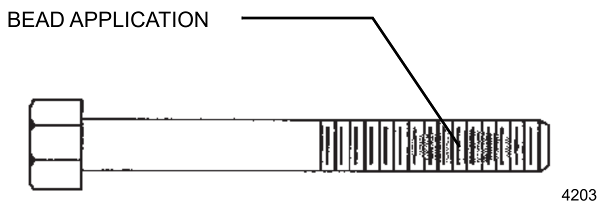


FIGURE 1-7

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (Figure 1-3).
2. In a blind hole application, 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, bonding will occur within five (5) minutes if primed prior to engagement. Fixtures 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 thread locking adhesive.

Fasteners and Torque Values

Use bolts of the correct length. A bolt which is too long may bottom out 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 Industrial crane product support for reference when performing maintenance (see Figure 1-8).

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.

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

Grade 8 or higher fasteners should be replaced after removal.

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:

1. 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.
2. 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.

3. 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.

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.

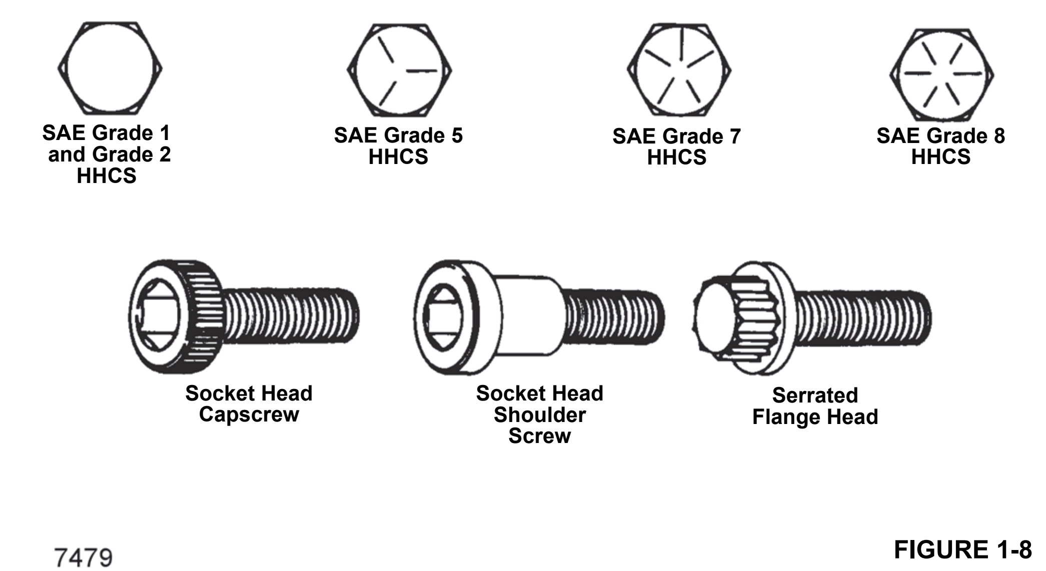


FIGURE 1-8

Table 1-4Inch 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

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Table 1-5 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 1-6 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 1-7 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

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Table 1-8 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 1-9 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 1-10 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 1-11 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
M24X3	12.9	1306	1256	1206
M27X3	10.9	1591	1530	1469

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Table 1-12 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 1-13 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

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Table 1-14 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

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Table 1-15 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 1-16: Weld Stud Torque Values

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

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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 drop block or hook and ball are lowered to the ground.	Inhibits serious injury and/or death.
Radiator Cap	Always remove the radiator cap only when the engine cooling system is cool. Turn the radiator cap slowly to first stop to relieve pressure.	Escaping coolant will burn.
Supports	Make sure safe and stable supports are installed before removing any component or structural item.	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 overinflate the tires.	Over-inflation can cause tires to burst and could result in injury.

ENVIRONMENTAL PROTECTION

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

Potentially harmful waste used in Grove 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.

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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

Electrical Hazard!

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

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

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

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

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

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

To Find:

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

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

1. Current always flows from (+) positive to (-) negative, or from the point of highest voltage.
2. Because the system used on this machine is a negative ground system, current that leaves the supply (battery) returns to the supply (battery).
3. In series circuit arrangements, the voltage is completely used in the circuit when the current is flowing. In parallel circuit arrangements, the voltage is constant.
4. When the voltage is constant, resistance controls the rate of current (amps) in the circuit. Refer to Ohm's Law.

Comparing Electrical System to a Hydraulic System

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

Table 3-1: Comparing Electrical System and Hydraulic System

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

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 3-2.

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.

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.

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.

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

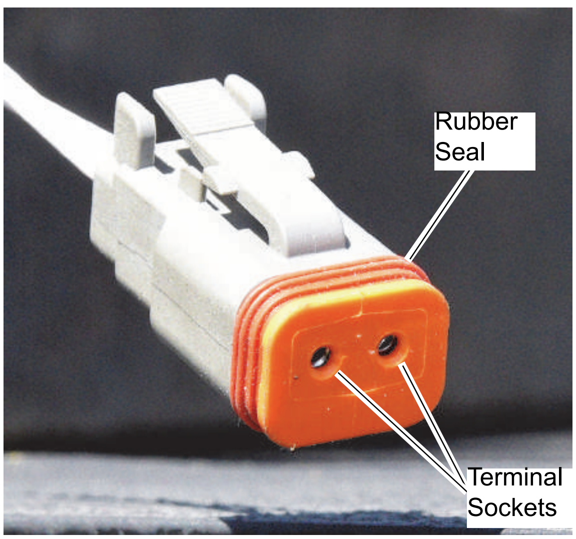
Do not apply dielectric grease to the following connections:

- 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.
8. Secure the connector when complete.

MAIN ELECTRICAL SYSTEM

General

The electrical system used on this machine is a 12 volt, direct current (DC) system with a (-) negative ground. The power is supplied by two 12 volt batteries.

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

Wire Harnesses

Four wire harnesses connect the electrical system components:

- Instrument Panel Wire Harness
- Main Frame Wire Harness
- Engine Wire Harness
- Outrigger Wire Harness

Fuses and Relays

Main Fuse/Relay Panel

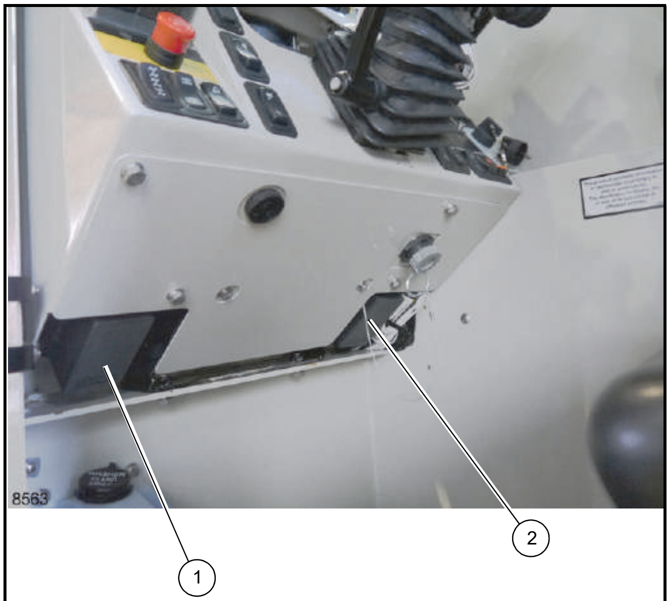


FIGURE 3-2

The main fuse/relay panel (1, Figure 3-2 and Figure 3-3) is located below the left side of the dash. Refer to Figure 3-3 for identification of the relays and TABLE 3-1 for identification of the fuses.

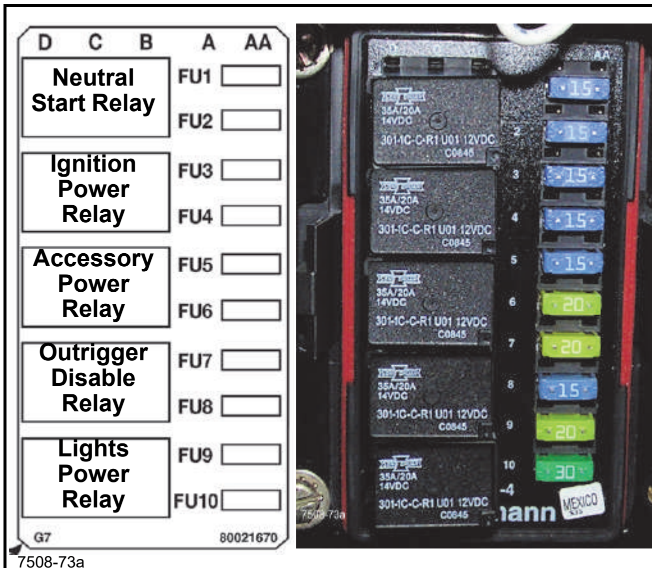


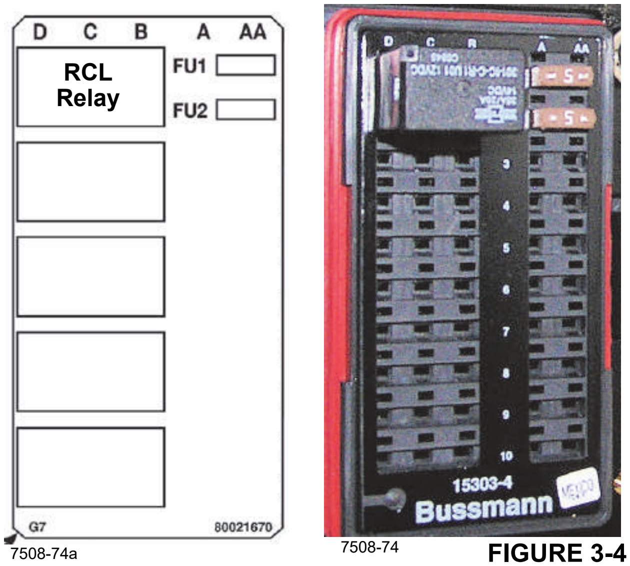
FIGURE 3-3

TABLE 3-1: Main Fuse/Relay Panel, Fuse Identification

Fuse	Rating	Function
FU1	15 amp	A/C, Heater/Defroster Fans, Strobe Light, 4-in-1 Gauge
FU2	15 amp	Windshield Wipers
FU3	15 amp	Cold Start Switch, Horn Switch
FU4	15 amp	Winch Control Switch, Outrigger Disable Relay
FU5	15 amp	Brake Light Pressure Switch, Oil Pressure Switch
FU6	20 amp	LSI Relay, LSI LI/LSI RCL/Hirsch, Wylie Power Connector
FU7	20 amp	Drum Rotation Indicator Driver Board, Drum Rotation Indicator, Indicator Lamp Panel, Hoist Speed Switch, Turn Signal/Emergency Flasher, Axle Lockout, Axle Lockout Proximity Switch
FU8	15 amp	2WD/4WD Switch, Parking Brake Switch
FU9	20 amp	Front-Wheel Drive Steering Proximity Switch, Rear Steering Proximity Switch, Two-Wheel Steer Solenoid, All-Wheel Drive ‘B’ Solenoid, Crab Steer Solenoid, All-Wheel Drive ‘D’ Solenoid, Third-Wrap Indicator Limit Switch
FU10	30 amp	Head and Tail Lights, Work Lights

RCL Fuse/Relay Panel

The RCL fuse/relay panel (2, Figure 3-2 and Figure 3-4) is located below the right side of the dash. Refer to Figure 3-4 for identification of the relay and TABLE 3-2 for identification of the fuses.



7508-74a 7508-74 FIGURE 3-4

TABLE 3-2: LSI Fuse/Relay Panel, Fuse Identification

Fuse	Rating	Function
FU1	5 amp	RCL Power
FU2	5 amp	Seat Switch

Battery Compartment Fuse/Relay Panel

There are five fuses in the battery compartment. Refer to TABLE 3-3 for identification of the fuses. The relay is the starter lockout relay.

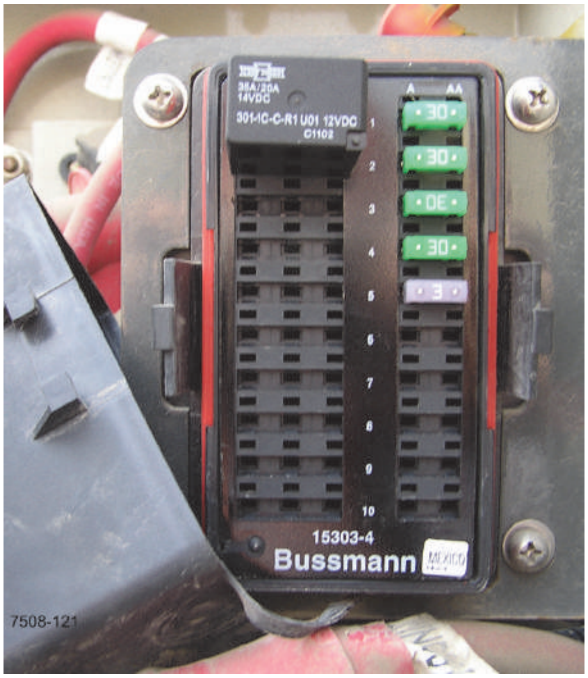


FIGURE 3-5

TABLE 3-3: Engine Compartment, Fuse Identification

Fuse	Rating	Function
1	30 amp	Ignition Power Relay
2		Light Power Relay
3		Accessory Power Relay
4		Engine Control Module
5	3 amp	Starter Lockout Relay

CHARGING SYSTEM

The purpose of the charging system is to keep a full charge on the batteries. The charging circuit includes the alternator, voltage regulator, warning light, batteries, 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.

Alternator Replacement

Removal

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. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the alternator.
7. Using a 1/2 in drive bar/ratchet, turn the tensioner, below the alternator, clockwise to remove tension from the belt. Slip the belt off of the alternator pulley, then let the tensioner return to its normal position.
8. Remove the alternator mounting capscrews. Remove the alternator.

Installation

1. Inspect the belt. Verify it has no cracks or other damage. Replace damaged belt as needed.
2. Install the alternator using the mounting bolts and washers. Torque bolts; refer to *Fasteners and Torque Values*, page 1-8 for the proper torque value.
3. Install the belt on all engine pulleys except the alternator pulley for now.
4. Turn the tensioner clockwise. Slip the belt onto the alternator pulley, then carefully return the tensioner to its normal position so it puts tension on the belt. Make sure the belt is centered on the tensioner.
5. Check belt tension at the belt’s longest span (longest distance between pulleys). At the center point of the longest span, push in on the belt with your thumb. Verify you can deflect the belt no more than 3/8 to 1/2 in (10 to 13 mm) with your thumb. (Or, using a belt tension gauge, verify there is 60 to 130 lb (267 to 578 N) of tension on the belt in the middle of its longest span.) Replace belt if it is too loose (overstretched).
6. Verify tensioner bolt is torqued to 32 lb-ft (43 Nm).
7. Connect the electrical leads to the terminals as tagged during removal.
8. Close the engine compartment.
9. Reconnect the ground cables to the battery.
10. Install the ECM power fuse.
11. Turn the battery disconnect switch to the ON position.

Check

1. Run engine. Verify reading of voltmeter on front console is 12 volts or greater. Make repairs as needed.
2. Continue troubleshooting charging system as needed if replacement of alternator did not correct problem in charging system.

Starter Replacement

Removal

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. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the starter.
7. Remove the bolts holding the starter to the mounting pad. Remove the starter.

Installation

1. Place the starter on its mounting pad. Secure the starter with the bolts. Torque the bolts to 32 lb-ft (43 Nm).
2. Connect the electrical leads to the terminals as tagged during removal.
3. Connect the batteries.
4. Install the ECM power fuse.
5. Turn the battery disconnect switch to the ON position.

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6. Close the engine compartment.

Check

1. Try to start the engine. Verify the starter starts the engine.

Start engine again, and listen for starter noises. Verify there is no abnormal noise indicating the starter's gear is meshing properly with the flywheel, that the starter's gear hasn't remained engaged to the flywheel after the ignition switch is in the ignition (run) position, or some other problem. Install starter properly as needed.

Batteries

The batteries are maintenance-free, lead-acid type batteries. The batteries have 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.
4. Store power.

Voltmeter

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

Special Precautions

- 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.
- An alternator is not the same as a generator. Never try to change the polarity of the alternator. The diodes keep the correct polarity.
- 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.
- Never operate the alternator on an open circuit or disconnect the batteries when the alternator is operating. A high voltage condition will occur and cause damage to the diodes.
- When a booster battery is used, make sure the battery is connected correctly (positive terminal to positive terminal; negative terminal to negative terminal).
- Never use a battery charger as a booster for battery output.
- Heat can cause damage to the diodes. Keep all sources of heat away from the alternator.

Battery Maintenance and Charging

Batteries

Maintenance-free batteries are used on this machine. A limited amount of maintenance is required on the batteries. See *Preventive Maintenance, page 5-9*.

Charging the Batteries

CAUTION

Burning hazard!

Do not smoke or allow sparks or open flame near batteries, they can explode.

When working with batteries always wear protective clothing, gloves and eye protection. Batteries contain corrosive liquids that can burn skin and eyes and destroy clothing.

Remove rings, watches or other jewelry before working with batteries. A battery can produce a short-circuit current high enough to weld a ring, or the like, to metal causing severe burns

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 prevent 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.

NOTE: *Keep both batteries fully charged. Charging one of the batteries and leaving the other at low charge can cause damage to the fully charged battery. A weak battery in the system puts an overload on the electrical system.*

Battery Replacement

Removal

CAUTION

To avoid possible engine fault codes and undesirable operation, ensure the keyswitch has been off 2 minutes before disconnecting batteries.

Disconnect batteries if machine will be inactive for over 24 hours.

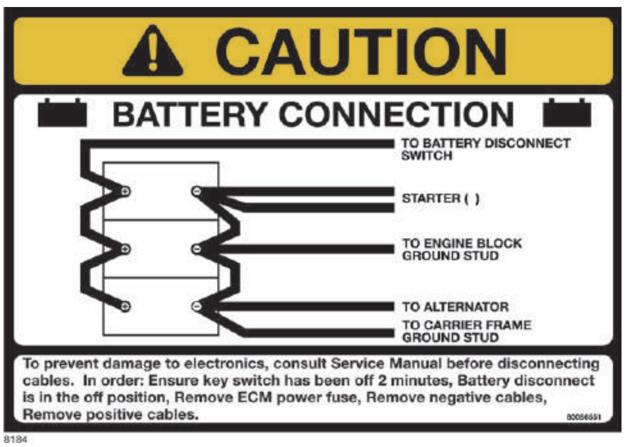

FIGURE 3-6

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.
6. Tag and disconnect leads from the battery terminals starting with the positive terminals.
7. Remove the nuts and washers from the bracket hold down rods. Remove the hold down bracket.
8. Remove the batteries.

Installation

1. Place the batteries in the battery box.
2. Install the hold down bracket so it can hold down the batteries. Secure the bracket (and batteries) to the bracket hold down rods with nuts and washers.
3. Connect leads to the battery terminals starting with the positive terminals.
4. Close the battery box cover.
5. Install the ECM power fuse.
6. Turn the battery disconnect switch to ON.
7. Verify replacement batteries work by starting crane's engine and operating various crane components.

Relay Panel Component Replacement

Accessory Relay

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. Tag and disconnect the electrical leads from the suspect relay.
4. Remove the hardware securing the suspect relay to the relay panel assembly. Remove suspect relay.
5. Install replacement relay on relay panel and secure it with attaching hardware.
6. Connect the electrical leads to the relay as tagged during removal.
7. Position the cover on the panel and secure with the attaching hardware.
8. Connect the batteries.
9. Turn the battery disconnect switch to the ON position.
10. Verify proper installation by operating all components involved with the replacement relay verifying they all work.

Buzzer Replacement

1. Remove the hardware securing the panel cover and remove the cover.
2. Tag and disconnect the electrical leads from the buzzer.
3. Remove the buzzer.
4. Install replacement buzzer.
5. Connect the electrical leads to the buzzer as tagged during removal.
6. Position the console front cover on the console and secure with the attaching hardware.

Verify proper operation by positioning the ignition switch to RUN (1). Buzzer should sound when engine is not running.

STARTING CIRCUIT

The starting circuit includes the batteries, starter motor and solenoid, starter relay, neutral start relay, starter lock-out relay, and the ignition switch.

General Inspections

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

1. Check that the parking brake is engaged.
2. Check battery condition. Charge or replace the batteries as necessary. Clean battery posts and cable connectors.
3. Inspect wiring for worn insulation or other damage. Replace bad wiring. Inspect all connections at the starter motor, starter solenoid, starter relay, neutral start relay, starter lock-out 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, remove the starter and perform a bench test.
5. If the starter passes the bench test, troubleshoot the electrical system.

INSTRUMENT AND LIGHT CIRCUITS

General

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

Light Bulbs

Table 3-1
Light Bulbs

Location	Part No.	Trade No.
Head Lights	--	4411 Sealed
Work Lights	--	4411 Sealed
Boom Work Lights	--	4411 Sealed

Gauge Cluster

The following gauges are part of the gauge cluster: fuel, voltmeter, hour meter, engine RPM, engine temp, DEF gauge & engine fault code display.The gauges are 12 volt components. Power is available to the gauges through a 15 amp fuse when the ignition switch is in the ON position.

Fuel Gauge

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

Engine Oil Pressure Gauge

This gauge connects to a sending unit in the engine lubrication system. The sending unit causes a variable resistance which gives a corresponding indication on the gauge, indicating engine oil pressure.

Engine Temperature Gauge

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

Voltmeter

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

Normally, when the engine is stopped (ignition switch in the ON position) or when the engine is running at low idle, the voltmeter will indicate 11-14 volts. When the engine is running above low idle, the voltmeter will normally indicate 14-16 volts. More than 16 volts indicates an overcharging condition, Table 3-2.

3

Hour Meter

The hour meter works off engine RPM, only when the engine is running.

Table 3-2: Voltage Level Conditions

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

WIRE HARNESSES

Refer to *Schematics/Wiring Diagrams, page 12-1* and Parts Book for specific information on all wire harnesses.

Engine Wire Harness

The engine wire harnesses supply electrical current from the batteries to the charging circuit, starting circuit, and senders attached to the engine. It also supplies the current to the main frame wire harness.

Main Frame Wire Harness

The main frame wire harness supplies electrical current to operate the electrical components attached to the main frame. It also connects to the instrument panel, engine wire harnesses and the transmission.

Instrument Panel Wire Harness

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

Cab Wire Harness

The cab harness supplies power to the strobe light, dome light, seat switch, and heater/AC unit. It connects to the main frame harness.

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Heater

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

See the electrical wiring diagrams in *Schematics/Wiring Diagrams, page 12-1*. Power is available through a 15 amp fuse to the heater/defroster switch in the instrument panel when the ignition switch is in the ON position. The switch is a three position switch (HI, LO and OFF).

TROUBLESHOOTING

Finding a problem in the electrical system is not difficult if you know basic electricity and understand the arrangement of the electrical system. Use the wiring diagrams in *Schematics/Wiring Diagrams, page 12-1* as your guide.

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

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

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

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

Problem	Possible Cause	Solution
Alternator does not charge.	**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. Fault in voltage regulator.	**4.** Replace voltage regulator.
	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.
	8. Alternator fuse blown.	**8.** Replace 250 amp fuse.
High charging rate (batteries 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 voltage regulator.	**4.** Replace voltage regulator.
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 battery.
	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 voltage regulator.	**7.** Replace the voltage regulator.
	8. Low engine speed.	**8.** Run engine at higher speed.

Problem	Possible Cause	Solution
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 keyway, 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.** Open circuit, dirty or loose connections.	**1.** Clean and tighten connections at batteries and starter. Check wiring and connections between ignition switch and starter solenoid.
	2. Bad starter relay	**2.** Replace starter relay.
	3. Bad ignition switch.	**3.** Replace switch.
	4. Worn starter motor, bad starter solenoid, or internal problem in engine.	**4.** Repair or replace starter, replace solenoid, or see engine manual.
	5. Dead battery(s).	**5.** Recharge or replace battery(s).
	6. Parking brake not engaged.	**6.** Engage parking brake.
	7. Bad neutral start relay.	**7.** Replace relay.
	8. Bad starter lock-out relay.	**8.** Replace relay.
	9. Transmission shifter not sending neutral signal.	**9.** Replace shifter switch.
	10. Park brake switch not sending neutral signal.	**10.** Replace park brake switch.

SECTION 4
HYDRAULIC SYSTEM

SECTION CONTENTS

4

TECHNICAL DATA

NOTE: Schematics are located at the back of this manual.

Hydraulic Pressures:

Main System Pressure (Pump Compensator) . . . . 3835 ± 50 psi (26441 ± 345 kPa)

Pump Margin Pressure . . . . 350 ± 25 psi (2413 ± 17 kPa)

Priority Flow Load Sense . . . . 2500 ± 50 psi (17237 ± 345 kPa)

Swing Pressure . . . . 2000 ± 100 psi (13 790 ± 690 kPa)

Accumulator Cutout
- High Charge . . . . 2000 +100/-0 psi (13 790 + 690/-0 kPa)
- Low Charge . . . . 1600 ± 100 psi (11031 ± 690 kPa)

Outrigger Circuit Pressure . . . . 2100 ± 50 psi (14480 ± 345 kPa)

Telescope Extend Pressure . . . . 2800 ± 150 psi (19305 ± 1034 kPa)

Telescope Retract Pressure . . . . 2950 ± 150 psi (20340 ± 1034 kPa)

Pilot Supply Pressure . . . . 400 ± 50 psi (2758 ± 345 kPa)

Load Sense Relief Valve . . . . 3500 + 50 psi (24132 + 345 kPa)

Under the Deck Winch (Optional) . . . . 2500 ± 50 psi (17237 ± 345 kPa)

Lift Cylinder Holding Valves . . . . Not adjustable

Telescope Cylinder Holding Valve . . . . Not adjustable

Outrigger Holding Valves . . . . Not adjustable

Hoist Holding Valve . . . . Not adjustable

Rated Pump Output at 2500 RPM:

Main Pump. . . . . 49 gpm (185 L/min)

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 pump, 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 pump. 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 kilopascals (kPa). There are four general types of pressure.

1. **High Pressure**, which is normally the result of an external load on the system.
2. **Low Pressure**, normally the result of the internal resistance of the components in the system.
3. **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.
4. **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:

1. The swing motor
2. The boom cylinders
3. The front and rear outrigger cylinders
4. The 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.

WARNING

Burn or Injury Hazard!

Never use your hands to check for hydraulic leaks.

Hydraulic oil can be very hot and can cut through skin. Burns and/or serious injury, gangrene or death may result.

If cut by hydraulic oil seek medical attention immediately.

Troubleshooting Aids

1. **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 in *Schematics/Wiring Diagrams, page 12-1*.
2. **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 (L/min). Normally, the flow meter is used to check the output of the pump. The flow meter can also be used to find the location of leakage or restriction in the system. Instructions for installation of the flow meter and the use of the flow meter are normally included with the flow meter.
3. **Pressure Gauge** - an instrument for measurement of the pressure in the system. This indication is normally given in pounds per square inch (psi) or kiloPascals (kPa). On this machine, 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.

1. Check with the operator. Learn if there was a loss of power (machine did not move the load) or a loss of speed (slow cycle time).
2. Learn if the problem is common to all circuits or is found in one or two circuits.
3. 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:

1. 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.
2. 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: relief valve, hydraulic swivel, etc.
3. 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 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 inhibit damage to the pump and other components.

TROUBLESHOOTING GUIDES

General Hydraulic System Troubleshooting

Table 4-1

Symptom	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. See SECTION 5.
	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.
Slow operating speeds (All functions)	Low engine rpm.	Increase engine rpm.
	Air leak in pump inlet line.	Tighten pump inlet line. Replace O-ring 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.	Check and adjust relief valve setting. See page 4-17.
	Leakage in hydraulic swivel.	Replace seals on swivel shaft.
	Control valve not fully actuated.	Check spool travel.
	Improper pump pressure.	Check and adjust pump pressure settings. See page 4-20.
	Faulty pump.	Overhaul or replace pump.

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Symptom	Possible Cause	Remedy
No movement when system is first started.	Low oil level.	Check and add oil.
	Air or restriction in inlet line to pump.	Check and tighten inlet line. Clear restriction.
	Cold oil or wrong weight of oil.	Use correct oil, follow manual 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 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. See SECTION 5.
	Oil too light.	Use correct oil.
	Low oil level.	Check and add oil.
	Dirty oil.	Change oil and filters. See SECTION 5.
Foam in hydraulic 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 pump shaft.	Replace shaft seal.
Difficult to engage valve spools	Restriction in pilot lines.	Check and correct.
	Dirt or foreign material between valve 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.

Lift Circuit Troubleshooting

Table 4-2

Symptom	Possible Cause	Remedy
Lift cylinder does not extend or retract	Control valve not actuated.	Check hoses to control valve. Also, see "Difficult to Engage Valve Spools", page 4-5.
	Not enough oil from pump to operate the cylinder.	See "Loss of Movement During Operation", page 4-5.
	Bad leak in hydraulic swivel.	Replace seals.
	Load sense relief valve held open by dirt on valve seat.	Disassembly 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.
	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.

Telescope (Crowd) Circuit Troubleshooting

Table 4-3

Symptom	Possible Cause	Remedy
Cylinder will not extend the boom under load	Restriction in boom sections.	Clean and apply lubricant to boom slides. See *Lubrication, page 5-3*.
	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 control valve.	Check and correct.
	Malfunction in the holding valve.	Replace the holding valve. DO NOT ADJUST.
	Faulty controller.	Repair or replace.
Boom slow at extending	Restriction in boom sections.	Clean and lubricate boom slides. See *Lubrication, page 5-3*.
Boom constantly getting out-of-sequence	Chain stretch or broken.	Adjust or replace chain.

Outrigger Circuit Troubleshooting

Table 4-4

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

Hoist Circuit Troubleshooting

Table 4-5

Problem	Possible Cause	Remedy
Hoist will not lift maximum (rated) load, considerable reduction in line speed.	Faulty load sense relief valve.	Check and adjust the relief valve setting. See page 4-17.
	Dirt in load sense relief valve, keeping the valve off the valve seat.	Remove and clean the relief valve. See page 4-47.
	Not enough oil from the pump.	Check hoses and lines for restrictions to or from pump.
	Improper pump pressure.	Check and adjust pressures. See page 4-20.
	Malfunction or damage to hoist components.	Check and overhaul the hoist, if necessary.
	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 brake valve cartridge.	Replace the brake valve cartridge.
Motor will not hold the load when the control lever is in NEUTRAL— load drops rapidly.	Overload condition.	Decrease the load.
	Brake not holding.	Repair or replace the brake. See *Brake Holding Valve, page 4-29*.
	Faulty brake valve cartridge.	Replace the brake valve cartridge.
Hoist drum does not move.	Restriction in brake valve cartridge.	Clean or replace the brake valve cartridge.
	Brake not releasing.	Check condition of the brake line. Repair as necessary. Check condition of brake. Repair as necessary.
Hook block lowers, but will not raise.	Malfunction in anti-double blocking electrical system.	Check and correct.
	Restriction in hoses to control valve.	

Swing Circuit Troubleshooting

Table 4-6

Symptom	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.
	Faulty pump.	Overhaul or replace the pump.
	Leakage in hydraulic swivel.	Replace seals in the swivel.
	Swing relief valve malfunction.	Check swing relief pressure. See page 4-22.
	Dirt or restriction in swing relief.	Clean the relief valve.
Difficult or slow swing	Restriction in pilot control lines.	Check and repair.
	Friction or restriction in mast bearing.	See *Mast Bearing, page 11-42*.
	Faulty swing motor or gearbox.	Repair or replace.

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HYDRAULIC SYSTEM

General 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 Grove 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 *Recommended Lubricants , page 7-4*.

Draining and Flushing

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

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

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

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

5. Disconnect the return line from the lift cylinder and raise the boom to maximum elevation.

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

CAUTION

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

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

CAUTION

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

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

Removing Air From the Hydraulic System

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

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

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

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CAUTION

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

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

CAUTION

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

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

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

System Description

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

The hydraulic system includes a variable displacement axial piston pump and pressure compensated sections of the main control valve. The four section main control valve is used in the hydraulic system. See *Four Section Main Control Valve, page 4-18*.

The variable displacement axial piston pump has an attached pressure compensator. This compensator senses the output pressure at the pump vs. the load sense signal from the control valve. The compensator regulates the flow to the control valve until flow requirements, as defined by the margin pressure requirements of the pressure compensator, are met.

When the metering notches of the control valve spool are open a small amount, very little is needed to satisfy the margin pressure requirement. Stroking the valve spool further causes the load sense control to increase the pump stroke until the margin pressure is once again attained. Conversely, reducing the control valve stroke will cause the control to de-stroke the pump to meet the new flow requirements.

For information on the steering system, see Section 10.

For information on the outrigger system, see page 4-33.

For information on the brake system, see Section 9.

Description of Operation

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.

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

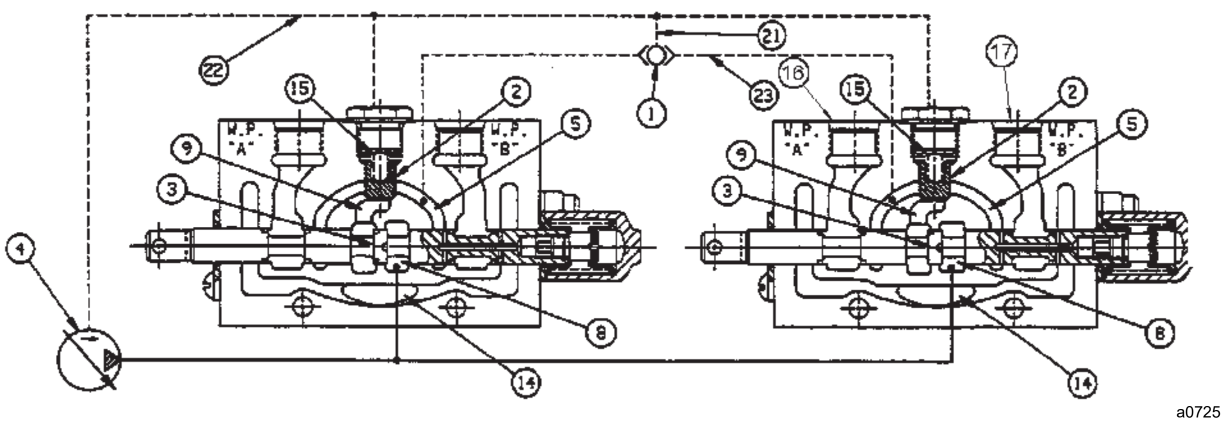
After the spool is activated the work port load pressure is transmitted to the bridge (5). The load sense shuttle (1), in turn, transmits the highest work port pressure to the load sense port of the pump (4) and all compensators (2) within the valve assembly. Pump (4) responds to the load sense signal with load sense pressure plus pump margin or differential pressure. It is this margin or differential pressure that overcomes the compensators (2) and permits flow to bridge (5) and work port A (16) or B (17). This system establishes a constant pressure differential across a variable orifice spool (3). At full stroke of spool (3) the maximum orifice can be determined, thus creating spool flow ranges (i.e. 76, 114, 151 Lpm [20, 30, 40 gpm]) at a predetermined pressure differential at spool (3). It is the working combination of the components that sets up the flow dividing principle.

Inlet Section

The inlet section (Figure 4-2) is connected to the pressure side of the variable displacement load sense pump by a hydraulic hose. There is no relief valve installed in the inlet section.

Working Valve Sections

There are four working sections (Figure 4-2) of the main control valve that receive hydraulic oil from the variable displacement load sense pump. These sections control the hoist, lift, swing and telescope functions. They are closed-center sections, blocking any return of oil back to tank until the valve spool is actuated to operate a function. Flow is then directed through the return core (14, Figure 4-1) to the outlet port of the inlet/outlet section and then to tank.



Item	Description	Item	Description
1	Load Sense Shuttle	14	Return Core (To Tank/Outlet)
2	Compensator	15	Bias Spring
3	Spool	16	Work Port A
4	Pump	17	Work Port B
5	Work Port Feeder Core (Bridge)	21	Section Load Sense Line
8	Pump Supply (From Inlet Port)	22	Load Sense & Compensator Signal Line
9	Pump Supply After Spool to Compensator	23	Load Sense Shuttle Signal Line From Work Port Feeder Core (Bridge)

FIGURE 4-1

Load-Sensing Valve Section

The load-sensing valve section (Figure 4-2) has a load sense relief valve installed in its housing. The load sense relief valve is a direct-acting design. It limits the pressure sent to the variable displacement load sensing pump. Using the load sense relief valve to limit system pressure versus a main relief valve, maintains flow to any function operating below the load sense relief valve setting.

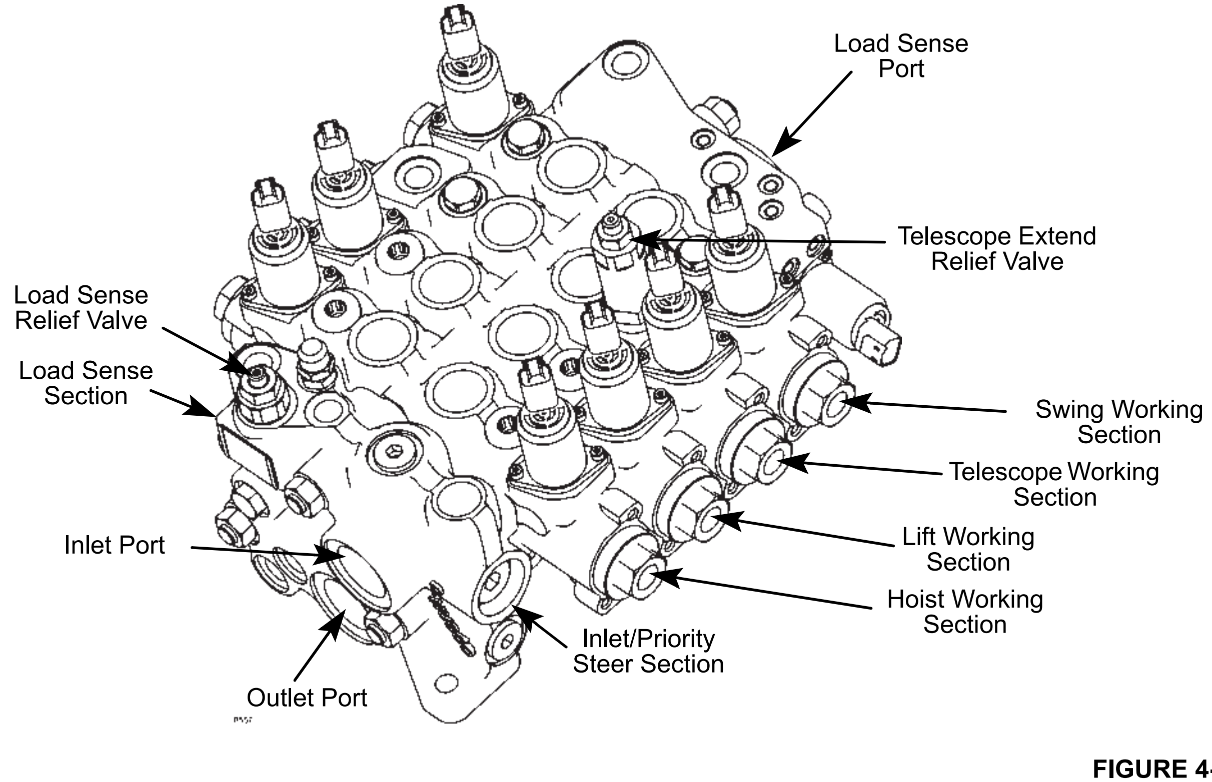

Load Sense
Port
Telescope Extend
Relief Valve
Load Sense
Relief Valve
Load Sense
Section
Swing Working
Section
Telescope Working
Section
Lift Working
Section
Inlet Port
Hoist Working
Section
Inlet/Priority
Steer Section
Outlet Port
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FIGURE 4-2

SUCTION, RETURN AND PUMP PRESSURE CIRCUITS

General

The suction, return and pump pressure circuits (Figure 4-3 through Figure 4-5) include the pump, filter, and hoses. The pump (Figure 4-3) is a variable displacement axial piston pressure compensated pump. This pump moves hydraulic oil to the inlet section of the three section main control valve. Here the oil is available to operate the lift, telescope, and hoist functions. Hydraulic oil is also available from this pump to operate the pilot control system. Hydraulic oil returns to the hydraulic oil tank through the return filter.

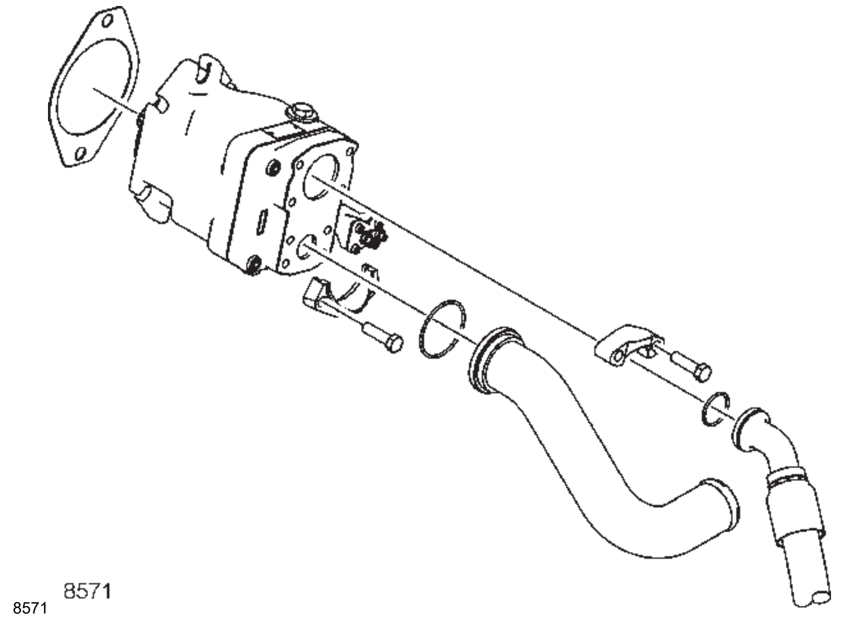

FIGURE 4-3

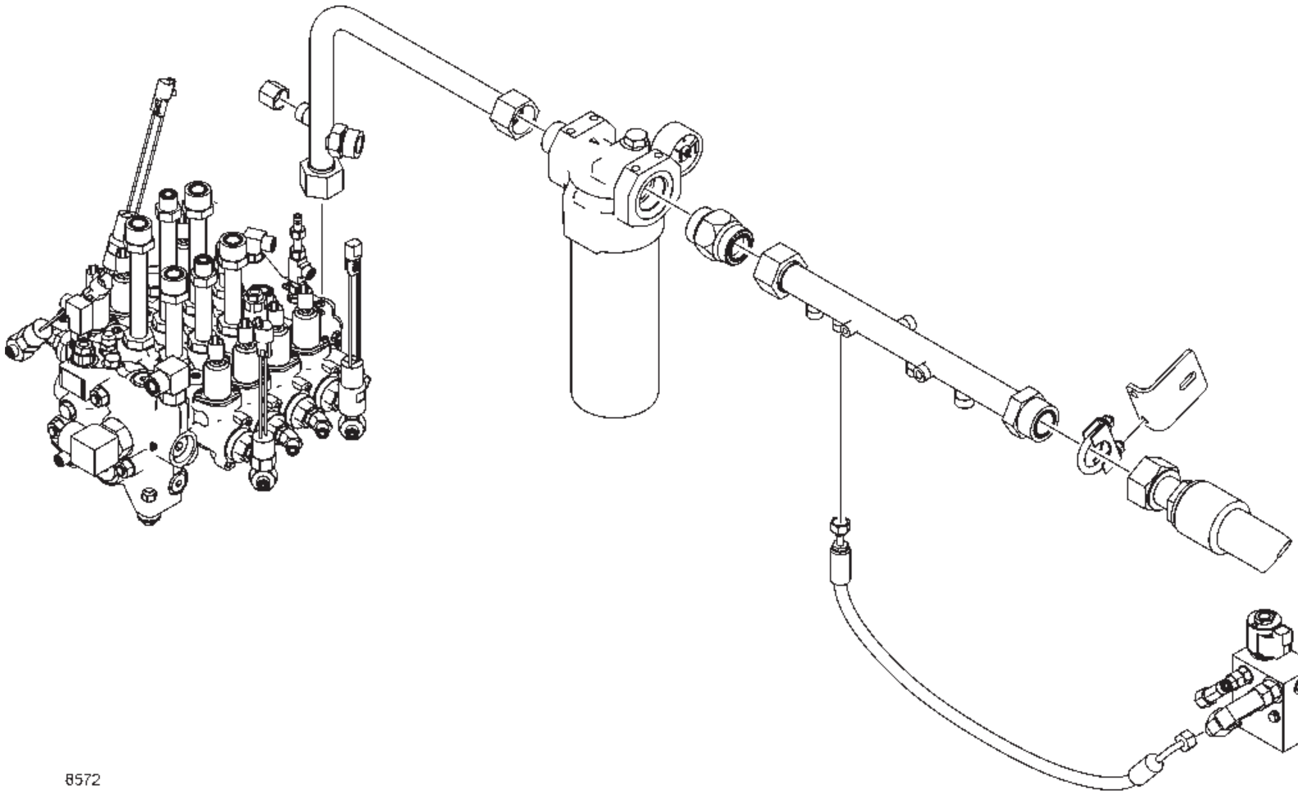

FIGURE 4-4

Hydraulic Pump

Description

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

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

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

Pressure Regulation

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

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

When the system pressure falls below the compensator spring setting, spring force returns the spool back to the normal position, which drains the control piston (2, Figure 4-5) to the pump case drain. This causes the pump to de-stroke, reducing the fluid flow to the level required.

Item	Description
1	Housing
2	Piston
3	Shoe
4	Port Plate
5	Drive Shaft
6	Swash Plate
7	Shaft Seal
8	Compensator Control
9	Valve Plate

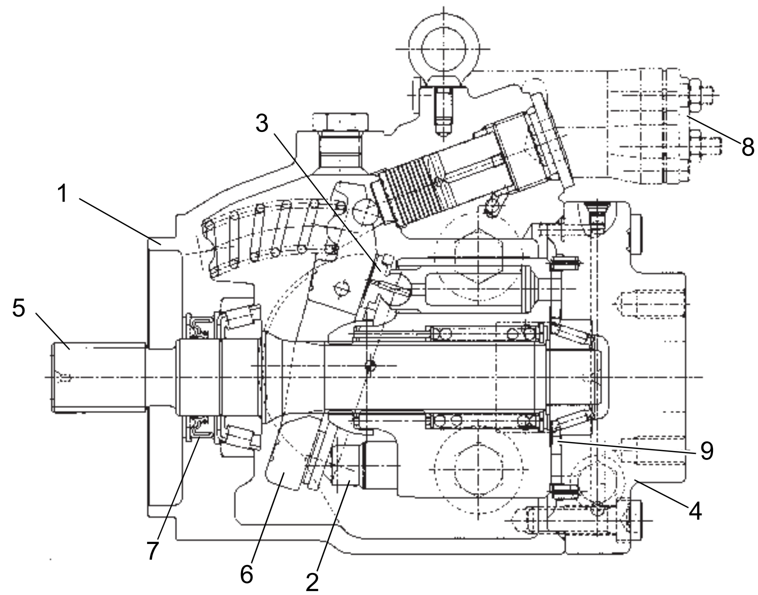

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FIGURE 4-5

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Test - Pump Output

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

Hydraulic Swivel

General

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

The hydraulic swivel has seven passages. Grooves and ports in the inner shaft align with ports in the outer housing. Seals between the grooves of the shaft inhibit leakage between the passages. The seals fit tightly against the housing. The housing rotates with the mast and the shaft is stationary.

Functions

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

Port No. 1

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

Port No. 2

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

Port No. 3

Hydraulic oil under pressure flows though this port when the boom sections are being extended. When retracting the boom sections, low pressure oil flows through this port back to tank.

Port No. 4

Hydraulic oil under pressure flows through this port when the boom sections are being retracted. When extending the boom sections, low pressure hydraulic oil flows through this port back to tank.

Port No. 5

Hydraulic oil under pressure flows through this port when the boom is being raised. When lowering the boom, low pressure hydraulic fluid flows through this port back to tank.

Port No. 6

Hydraulic oil under pressure flows through this port when the boom is being lowered. When raising the boom, low pressure hydraulic oil returns through this port back to tank.

Port No. 7

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

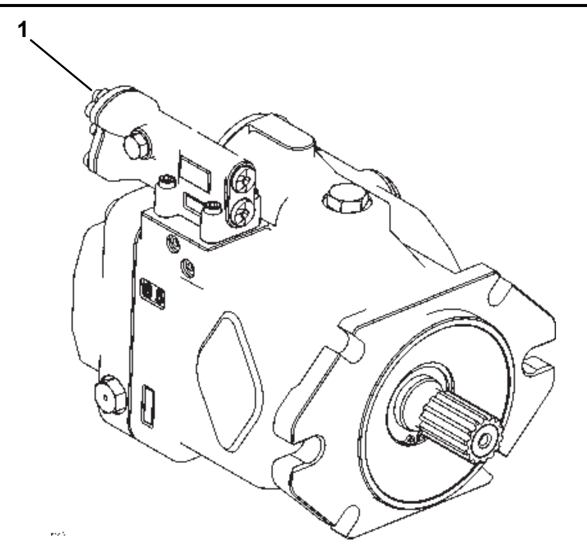
Troubleshooting

Leakage between the passages of the hydraulic swivel 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 hydraulic oil will always follow the path of least resistance.

System Pressure Relief Valves

The hydraulic system does not use a relief valve to regulate system pressure. System pressure is regulated by a pressure compensating valve (Figure 4-6) located on the hydraulic pump.

The purpose of the pressure compensator is to stroke and de-stroke the hydraulic pump, supplying only the amount of hydraulic oil that is required to operate the hydraulic functions. It also acts similar to a relief valve by protecting the hydraulic components. It de-strokes the pump when the setting of the compensator valve is reached, thus preventing an overload condition in the circuit, by cutting back on the amount of oil furnished in the circuit.



8559 **FIGURE 4-6**

Load Sense Relief Valve

The load sense relief valve (Figure 4-7) is a direct-acting design. It limits the pressure sent to the variable displacement load sensing pump. Using the load sense relief valve to limit system pressure versus a main relief valve, maintains flow to any function operating below the load sense relief valve setting.

Four Section Main Control Valve

Technical Data

Spool type . . . . . . 3-position, sliding, double action, cylinder

Spool actuation . . . . .Pilot pressure

Port Relief Valve. . . . . .See Figure 4-7

Load Sensing Relief Valve. . . . . See Figure 4-7

Port pressurized:

- Spool in . . . . .A-Port
- Spool out . . . . .B-Port

Valve Identification

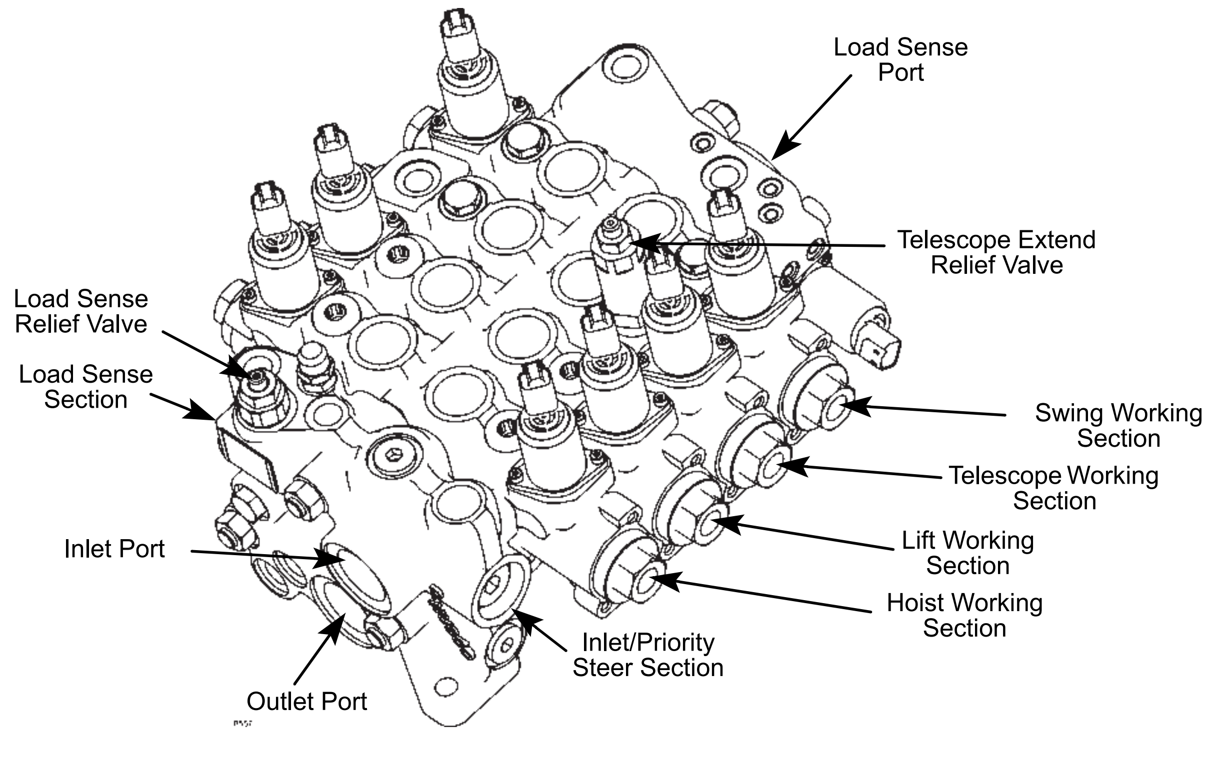


FIGURE 4-7

Valve Description

The valve assembly is mounted under the deck, opposite the operator's cab. The control valve is a multi-section, 3-position directional control valve equipped with spring centering spools.

The valve assembly includes four post-pressure compensated working sections, one inlet/outlet section and one load-sensing section with a load-sensing relief valve. Two of the post-pressure compensated working sections are motor spool sections (telescope and hoist functions), and one is a combination motor and cylinder spool section (lift function), see Figure 4-7. The parallel valve section (swing) is a cylinder spool section.

A **motor spool** section allows oil to return to the hydraulic tank when the valve spool is in the centered or neutral position. A **cylinder spool** section blocks the oil from returning to the hydraulic tank when the valve spool is in the centered or neutral position.

The valve section for boom lift function has a combination motor and cylinder spool valve section. This spool blocks oil from returning through the B port back to tank, but allows oil to return to tank through the A port when the spool is in the centered or neutral position.

Post-Pressure Compensated Valve Section Description

The post-pressure compensated valve section relies on post main spool compensation using a flow divider principle which is based on the pump load-sense differential, or margin pressure. This means that as long as some pump margin exists in the system, even if it's lower than normal, the specified flow relationships between the functions will be maintained. Should the margin drop to zero or essentially zero, the issue will be irrelevant, since this means the pump cannot produce enough flow to build any load pressure, and therefore the system will not be operating.

The most important benefit of this principle is that in multifunction operation, when total demand exceeds pump output capacity, all functions can still be operated, but will "slow down" proportionally.

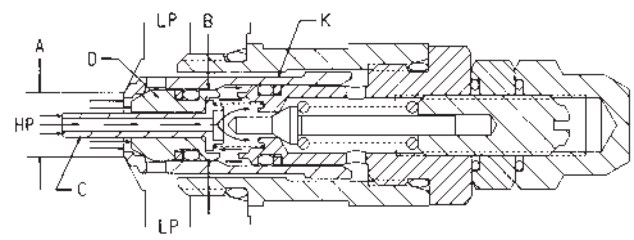
Load-Sensing and Port Relief Valves

The load-sensing relief valve is located in the load-sensing section of the valve assembly. The purpose of the load-sensing relief valve is to limit the amount of pressure being sent back to the pressure compensator on the pump and to control any pressure surges or spikes caused by a sudden load change on the system.

The port relief valves are located in the telescope section of the control valve. The purpose of the port relief valves is to control maximum pressure in the telescope hydraulic circuit to protect the boom extend and retract cables.

Since pressure applied to any point in the circuit is applied equally through the circuit, a pressure surge at a motor or cylinder is transmitted back to the pump.

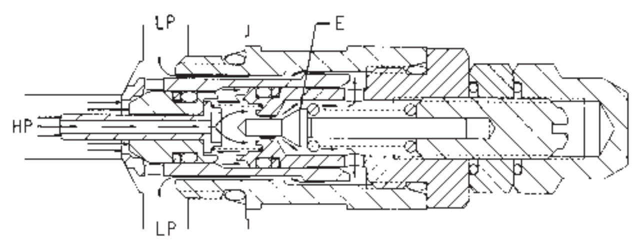
The port relief valves are in communication between the high pressure port "HP" (Figure 4-8) and the low pressure area "LP". Oil is admitted through the hole in poppet "C" and because of a differential area between diameters "A" and "B", relief valve poppet "D" and check valve poppet "K" are tightly sealed.



a0967

FIGURE 4-8

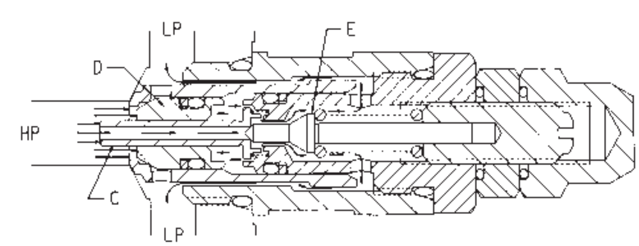
The oil pressure in the high pressure port "HP" (Figure 4-9) has reached the setting of the pilot poppet spring force and unseats pilot poppet "E" and oil flows around the poppet, through the cross drilled holes and to the low pressure area "LP".



a0968

FIGURE 4-9

The loss of oil behind poppet "C" (Figure 4-10) affected by the opening of pilot poppet "E" causes poppet "C" to move back and seat against pilot poppet "E". This shuts off the oil flow to the area behind relief valve poppet "D" and causes a low pressure area internally.



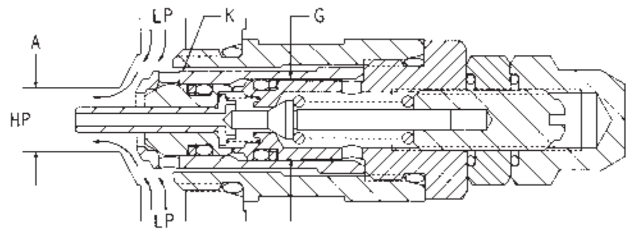
a0969

FIGURE 4-10

The imbalance of pressure on the inside as compared to that of the high pressure port "HP" forces the relief valve poppet "D" (Figure 4-11) to open and relieve the oil directly to the low

4

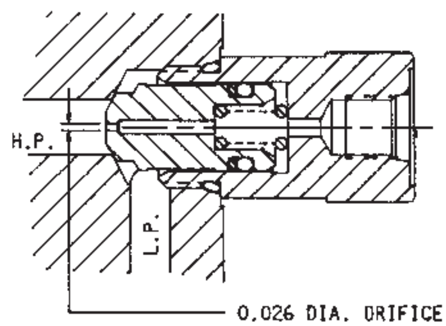
pressure chamber “LP” in the valve. Oil then flows back to the hydraulic oil tank.



a0971 FIGURE 4-11

Anti-Void Check Valve

The ventable anti-void check valve (Figure 4-12) opens when the low pressure passage pressure exceeds the high pressure passage pressure or when vent port is opened to tank.

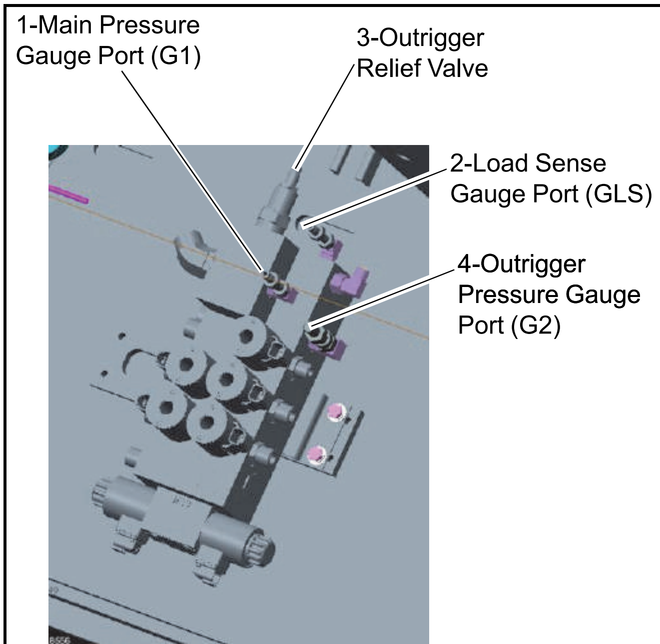


a0956 FIGURE 4-12

Checking and Adjusting Hydraulic Pressure Settings

Check all pressures with hydraulic fluid at 49°C (120°F)—check hydraulic fluid temperature at the bottom of the hydraulic tank.

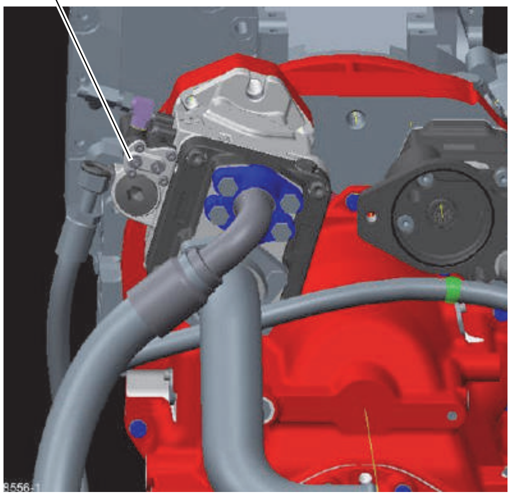
Required pressure gauge (1) three dial gauge 0-5000 PSI (0-345 bar). (1) Parker Diagnostic Quick Disconnect p/n PD240.



8556 Front Outrigger Manifold FIGURE 4-13

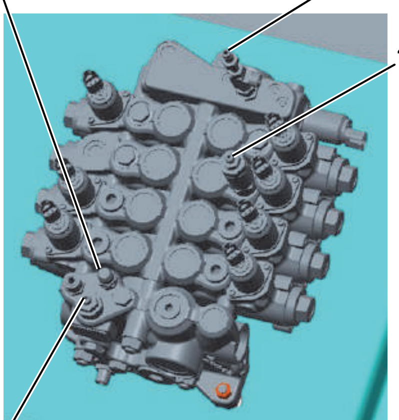
Procedure for Checking/Setting Pump Margin (Stand-by) Pressure

1. With the engine shut off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at the G1 port (1, Figure 4-13).
2. Start engine and read the pressure gauge while at engine idle. A reading of 450 ± 25 psi (31 ± 1.7 bar) should be observed.
3. If pressure reading is correct, shut off the engine, and disconnect the pressure gauge.
4. If pressure is incorrect, loosen the pump margin (stand-by) set screw from the pump compensator valve (Figure 4-14).
5. Adjust the margin pressure setting by turning the pump margin adjusting screw (Figure 4-14) until 450 ± 25 psi (31 ± 1.7 bar) pressure is obtained on the gauge; clockwise increases pressure, counterclockwise reduces the pressure.
6. Tighten the margin set screw.
7. Shut off the engine and disconnect the pressure gauge.



Variable Displacement Piston Pump

8556-1 **FIGURE 4-14**



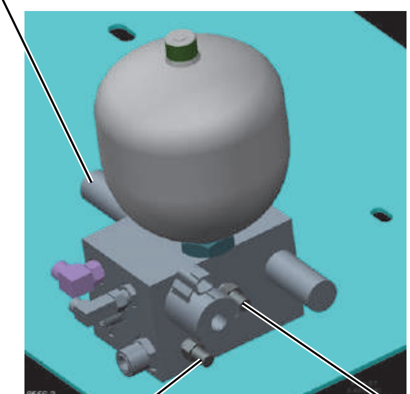
Control Valve

8556-2 **FIGURE 4-15**

Procedure for Checking/Setting Load Sense Relief Valve Pressure

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

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at the load sense test port GLS (2, Figure 4-13) located on front outrigger manifold.
2. Start Engine; ensure the boom is all the way down. Activate the boom down function at full engine RPM, gauge should read 3500 ± 50 (241 ± 3.5 bar), if the pressure needs to be adjusted adjust the load sense relief setting by turning the relief valve adjusting screw (1, Figure 4-15) until 3500 ± 50 psi (241 ± 3.5 bar) pressure is obtained on the pressure gauge; clockwise increases pressure, counterclockwise reduces the pressure.
3. Tighten the jam nut on the load sense relief valve.
4. Shut the engine off and disconnect the pressure gauge.



Brake/Steering Manifold

8556-3 **FIGURE 4-16**

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

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at the G1 gauge port (1, Figure 4-16) located on the brake/ steering manifold.
2. With the park brake on start the engine. Set crane up on a level surface with outrigger jacks fully extended.
3. With the engine at full RPM turn steering wheel all the way to one side until the steer cylinder bottoms out while another person adjusts the priority flow load sense relief setting by turning the Priority Flow Load Sense relief valve adjusting screw (2, Figure 4-15) until 2500 ± 50 psi (172 ± 3.5 bar) is obtained on the pressure gauge; clockwise increases pressure, counterclockwise reduces the pressure.
4. Shut down the engine and remove the pressure gauge.
5. With engine off, repeatedly depress brake pedal several times to relieve pressure and install pressure check

diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at the G2 port (3, Figure 4-16) located on brake/steering manifold.

6. Start engine and allow brake system to fully charge. With the engine at idle, repeatedly depress the service brake pedal on the cab floor until the gauge pressure reads approximately 1700 psi (117 bar). Once you have found the pressure, push the brake pedal again to recharge. Watch the gauge and verify the low charging limit to be 1600 ± 100 psi (110 ± 7 bar) (when it starts to recharge). Then watch gauge as valve is charging it should cut out at 2000 +100/-0 psi (138 +7/-0 bar) if not adjust at UP10 piloted unloading valve (2, Figure 4-16); clockwise increases pressure, counterclockwise reduces pressure. (Note: If charge valve does not cut out check load sense relief valve pressure per Procedure for Checking/Setting Priority Flow Load Sense Relief and Accumulator Relief).
7. Shut down the engine, repeatedly depress brake pedal several times to relieve pressure and remove the pressure gauge.

Procedure for Checking/Setting Outrigger Circuit Pressure

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto front outrigger pressure gauge at the G2 port (4, Figure 4-13).
2. Start and accelerate the engine to maximum RPM and actuate the outrigger enable switch to the extend position while another person observes the pressure gauge. The pressure should be 2100 ± 50 psi (145 ± 3.5 bar).
3. If the pressure reading is incorrect. Loosen the jam nut on the outrigger relief valve (3, Figure 4-13) at the front of the machine on the front outrigger housing weldment.
4. Adjust the outrigger circuit pressure by turning the adjustment screw until 2100 ± 50 psi (145 ± 3.5 bar) is obtained on the pressure gauge; clockwise increases pressure, counterclockwise reduces the pressure.
5. Tighten the jam nut against the relief valve body.
6. Shut down the engine and remove the pressure gauge.

Procedure for checking Supply Pilot Pressure

1. Testing System Pressure
   a. With the engine shutdown and the parking brake set, install pressure diagnostic quick disconnect (Parker PD240) with gauge onto pilot supply test port (3, Figure 4-15) of the control valve.
   b. Start the engine and actuate the crane power switch and read the pressure indicated on the pressure gauge. The gauge should read 400 ± 50 psi (28 ± 3.5 bar). If the pressure setting is correct shutdown the engine and remove the pressure gauge. If the pressure setting is incorrect, verify the supply current to the crane power solenoid. This pressure is not adjustable.
2. Shut down the engine and remove the pressure gauge.

Procedure for Checking Tele Extend/Retract Pressures

NOTE: Set crane up on a level surface with outriggers fully extended.

1. With engine shutdown install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto load sense test port at the GLS port (2, Figure 4-13) located on the front outrigger manifold.
2. Start the engine, with the engine at full RPM engage the Tele Extend function until boom is fully extended and hold, pressure should be 2800 ± 150 psi (193 ± 10 bar).
3. If the pressure is incorrect, adjust the extend work port relief valve setting by turning the adjustment screw, see 4, Figure 4-15, on the main valve until 2800 ± 150 psi (193 ± 10 bar) is obtained on the pressure gauge: Clockwise increases pressure, counterclockwise reduces the pressure.
4. With pressure check diagnostic quick disconnect still on GLS port (2, Figure 4-13) located on the front outrigger manifold.
5. With the engine at full RPM pull the Tele Retract function till boom is fully retracted and hold, pressure should be 2950 ± 150 psi (203 ± 10 bar).This pressure is nonadjustable.
6. Shut down the engine and remove the pressure gauge.

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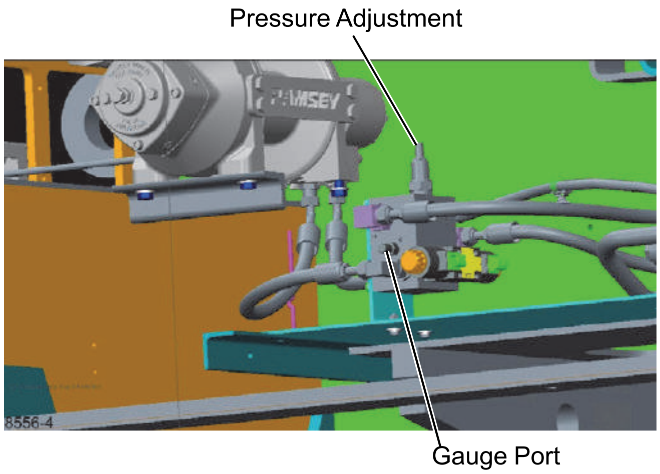
Procedure for Checking Swing Pressure

WARNING

Crushing Hazard!

It is necessary to climb under the crane to disconnect the hoses from the swing motor. Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane. Serious injury or death may result from being crushed by the wheels.

1. With the engine shut off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test port at the GLS port (2, Figure 4-13), disconnect the swing brake hydraulic hose from the swing motor. Cap the hydraulic adapter and plug the hydraulic hose.
2. Start engine and accelerate the engine to full RPM.
3. Watching the pressure gauge, actuate the swing left until the swing relief valve opens. The valve should open at 2000 ± 100 psi (138 ± 6.9 bar). This pressure is not adjustable
4. Watching the pressure gauge, actuate the swing right until the swing relief valve opens. The valve should open at 2000 ± 100 psi (138 ± 6.9 bar). This pressure is not adjustable
5. Shut down the engine and remove pressure gauge, reconnect the swing brake hose.



8556-4 **Under Deck Winch** **FIGURE 4-17**

Procedure for Checking Under the Deck Winch (Optional)

1. With the engine shut off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at the gauge port (Figure 4-17), disconnect both the hydraulic hoses from the under the deck winch motor. Cap the hydraulic adapters and plug the hydraulic hoses.
2. Start engine and accelerate the engine to full RPM.
3. Watching the pressure gauge, actuate the under the deck winch until the winch relief valve opens. The valve should open at 2500 ± 50 psi (172 ± 3.5 bar).
4. Adjust the under the deck winch circuit pressure by turning the adjustment screw until 2500 ± 50 psi (172 ± 3.5 bar) is obtained on the pressure gauge: clockwise increases pressure, counterclockwise reduces the pressure.
5. Shut down the engine and remove pressure gauge, reconnect the hoses.

LIFT CIRCUIT

General

The lift hydraulic circuit (Figure 4-18 and Figure 4-19) includes two lift cylinders, two holding or counterbalance valves, ports 5 and 6 in the hydraulic swivel, an anti-two block cutout solenoid valve in the manifold, a working section of the three-spool control valve, a remote controller, and the hydraulic lines.

Oil Flow

Raising the Boom

NOTE: Always use the hydraulic and electrical schematics in *Schematics/Wiring Diagrams, page 12-1* when troubleshooting or repairing a crane.

Actuating the lift control in the operator's cab to raise the boom causes pilot pressure to push the valve spool OUT, connecting the pump supply to the control valve section. Oil leaves the control valve and passes through Port 5 of the hydraulic swivel and enters the base end of the lift cylinders through the counterbalance valves. The oil flows freely through the counterbalance valves and into the base end of the cylinders. The cylinder rods extend, pushing oil ahead of the piston out the rod end ports. The oil returns through Port 6 of the hydraulic swivel to the control valve. The oil is routed to the outlet port of the control valve assembly and returns through the in-line return filter to the hydraulic oil tank.

Lowering the Boom

Actuating the lift control in the operator's cab to lower the boom causes pilot pressure to push the valve spool IN, sending oil through Port A, causing the cylinder to retract. The counterbalance valve lets the cylinder retract only if there is enough pressure available to the rod port of the cylinder. See Counterbalance Valve.

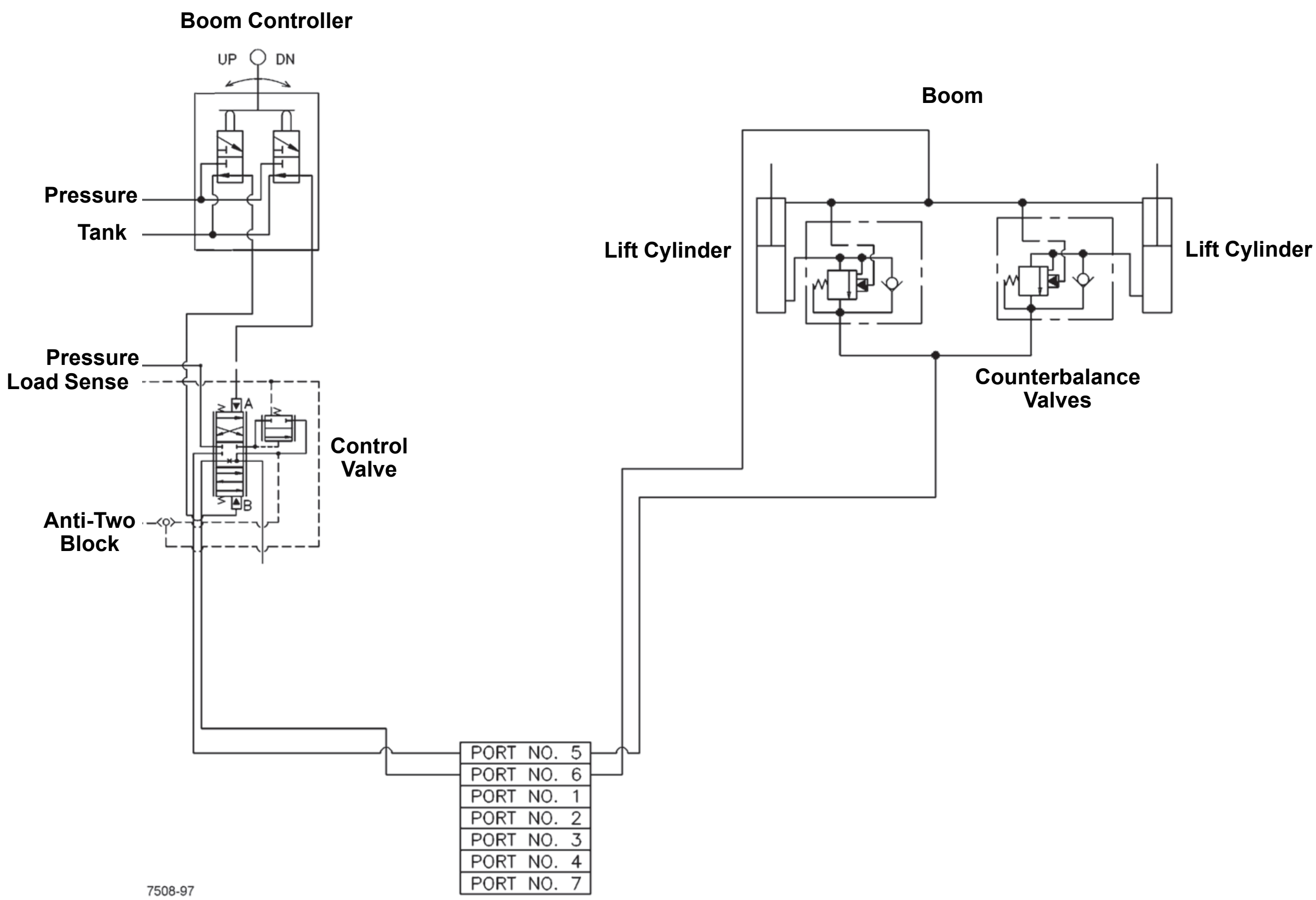


FIGURE 4-18

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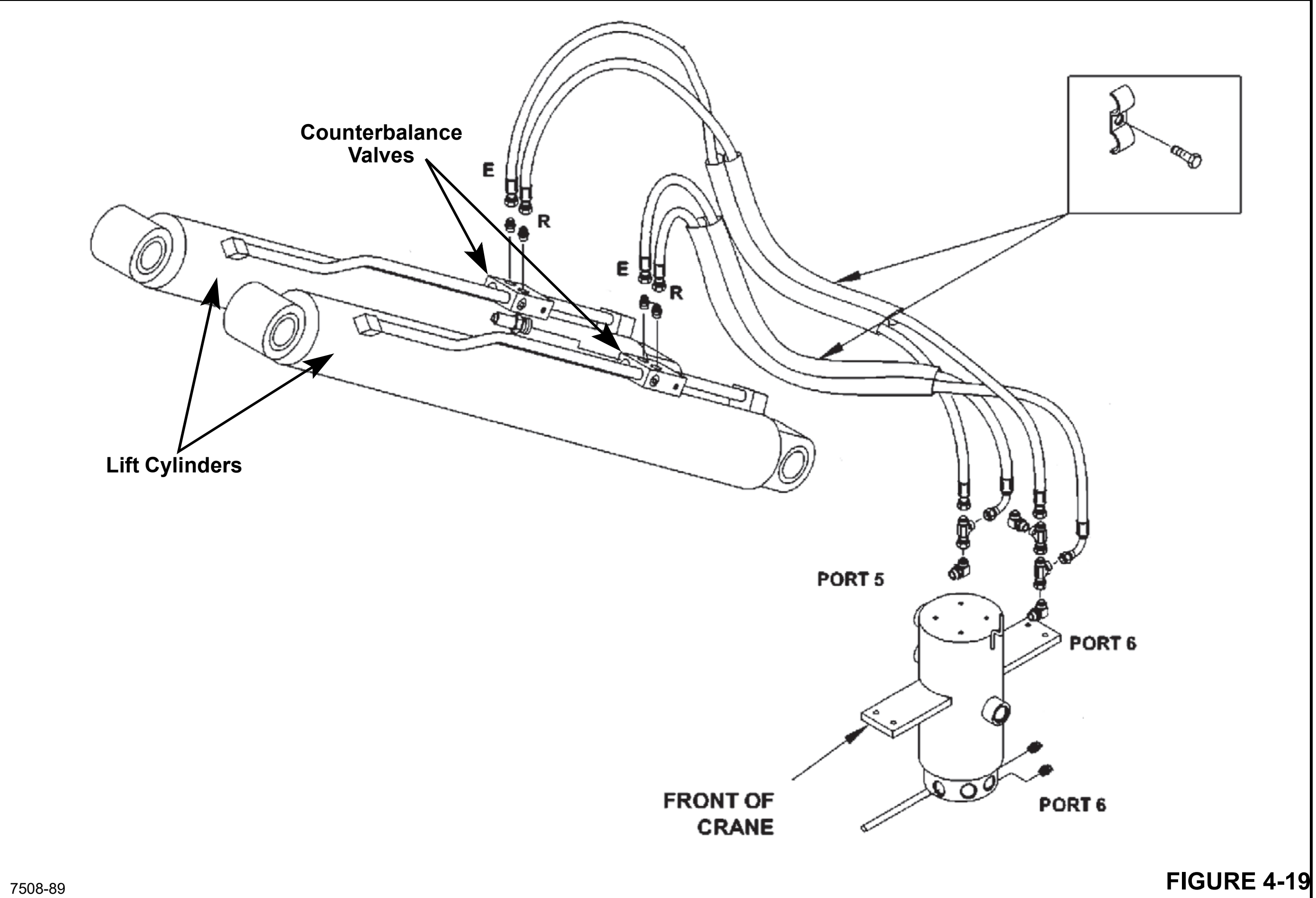

FIGURE 4-19

Counterbalance Valve

The counterbalance valve in the lift circuit has three functions:

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

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

Engine speed is important for proper lowering of the boom. At low engine speed, normally there is not enough oil from the pump to keep the cylinder filled. As a result, the boom will lower in an irregular movement.

NOTE: Do not adjust the counterbalance valve setting. The valve is adjusted at the factory. If the valve is suspected of being faulty, replace the valve.

Lift Cylinder Leakage Test

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

1. Remove the suspected cylinder from the machine. See Hydraulic Cylinders in this section
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, rebuild or replace the cylinder.

TELESCOPE CIRCUIT

General

The telescope circuit (Figure 4-20 through Figure 4-21) includes a telescope cylinder, a holding valve, ports 3 and 4 of the hydraulic swivel, a port relief valve in the telescope section of the main control valve, an anti-double block cutout solenoid in the manifold, a working valve section of the main control valve, a solenoid valve, hose track, a remote controller, and the hydraulic lines.

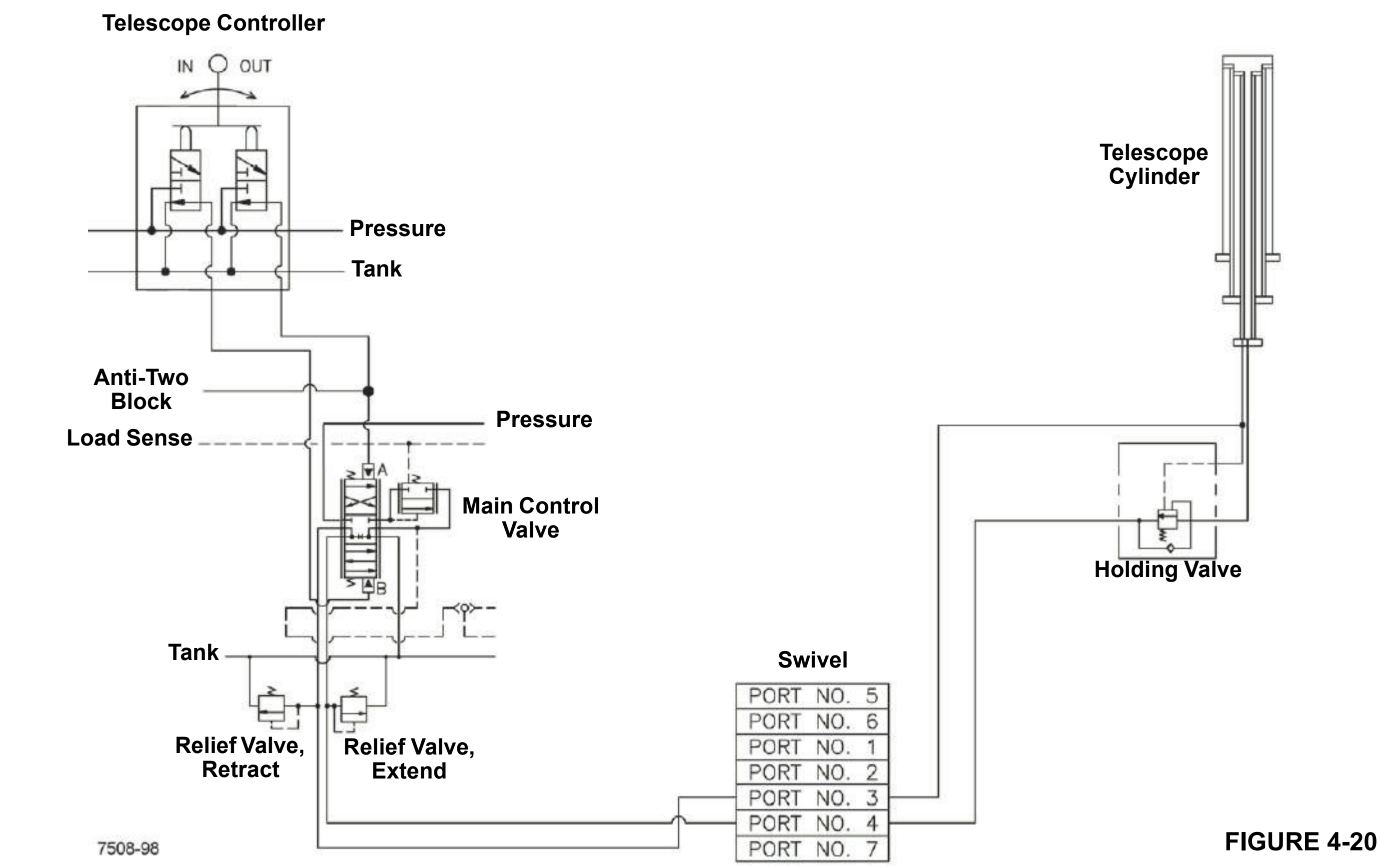

FIGURE 4-20

Oil Flow

Refer to Figure 4-20 for the following explanations.

Boom Extend

Actuating the telescope lever to extend the boom:

- routes oil under pressure to pilot port A of the control valve
- engaging the valve spool connecting the supply from the pump through the port relief valve
- routing the oil to port 4 of the swivel and to the holding valve
- the pressure opens the holding valve
- oil enters the telescope cylinder, extending the boom
- oil returns through swivel port 3 then the control valve and is routed to the outlet port of the valve and returns to the hydraulic tank through the in-line return filter.

Boom Retract

Actuating the telescope lever to retract the boom:

- routes oil under pressure to pilot port B of the control valve
- engaging the valve spool connecting the supply from the pump through the port relief valve
- routing the oil to port 3 of the swivel and to the telescope cylinder
- the pressurized oil retracts the cylinder and opens the holding valve
- oil flows through the holding valve, returning through port 4 of the swivel
- oil is routed to the outlet port of the valve and returns to the hydraulic tank through the in-line return filter.

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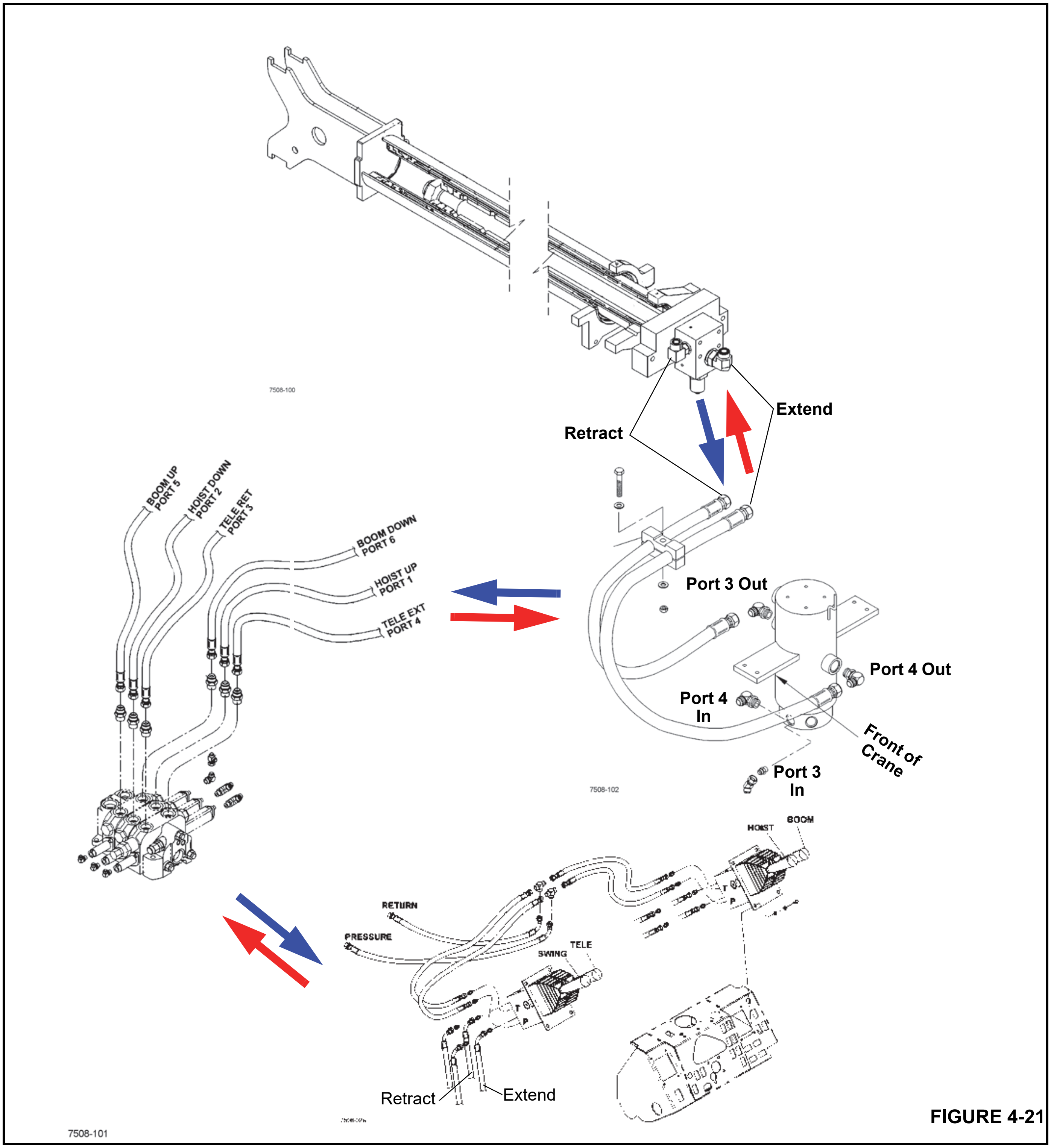

7508-100
Retract
Extend
BOOM UP PORT 5
HOIST DOWN PORT 2
TELE RET PORT 3
BOOM DOWN PORT 6
HOIST UP PORT 1
TELE EXT PORT 4
Port 3 Out
Port 4 Out
Port 4 In
Front of Crane
Port 3 In
7508-102
HOIST
BOOM
RETURN
PRESSURE
SWING
TELE
Retract
Extend
7508-101

FIGURE 4-21

Holding Valve

The holding valve used in the telescope circuit has three functions:

- Inhibit cavitation of the cylinder,
- Give full control of the lowering of the boom,
- 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 the hydraulic lines, the holding valve will hold the boom in position.

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

NOTE: Do not adjust the holding valve setting. The valve is adjusted at the factory. If the valve is suspected of being faulty, replace the valve.

Port Relief Valve

The port relief valves installed in the telescope circuit are used to protect the telescope mechanism (cables, sheaves, etc.) from damage caused by high oil pressure in the telescope extend and retract circuits.

The valves are installed in the telescope section of the main control valve.

Hydraulic Swivel

Refer to *Hydraulic Swivel, page 4-17*.

HOIST CIRCUIT

Refer to Figure 4-22 for the following explanations.

General

The hoist circuit (Figure 4-22 and 4-23) includes a motor, a hydraulic brake, a brake holding valve, ports 1, 2 and 7 of the hydraulic swivel, an anti-double block solenoid valve, a working valve section of the main control valve, and the hydraulic lines.

Oil Flow

Hoist Up

Actuating the hoist lever to raise the load:

- routes oil under pressure to pilot port A of the control valve
- engaging the valve spool connecting the supply from the pump through the port relief valve
- routing the oil through port 1 of the swivel and to the hoist assembly—consisting of the motor, brake, holding valve and high speed solenoid and mechanism.
- the pressure causes the motor to turn and begins releasing the brake, pushing the control lever farther increases the hoist speed and fully releases the brake, as the hoist is slowed the brake is applied.

  When the hoist high speed switch is ON the high speed valve routes oil to the actuator which allows the hoist to rotate faster.
- Oil flows through swivel port 2 and the main control valve returning to the hydraulic tank through the in-line return filter.

Hoist Down

Actuating the hoist lever to lower the load:

- routes oil under pressure to pilot port B of the control valve
- engaging the valve spool connecting the supply from the pump through the port relief valve
- routing the oil to port 2 of the swivel and to the hoist assembly
- the pressure causes the motor to turn and begins releasing the brake, pushing the control lever farther increases the hoist speed and fully releases the brake, as the hoist is slowed the brake is applied.

  When the hoist high speed switch is ON the high speed valve routes oil to the actuator which allows the hoist to rotate faster.
- Oil flows through swivel port 1 and the main control valve returning to the hydraulic tank through the in-line return filter.

Drain Line

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

Brake Holding Valve

The holding valve used in the hoist circuit has three functions:

- Inhibit cavitation of the motor,
- Give full control of the lowering of the load,
- 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 retract faster than the pump can fill 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 a constant flow to the motor. Also, if there is a failure of the pump or the hydraulic lines, the holding valve will hold the hoist in position.

NOTE: Do not adjust the holding valve setting. The valve is adjusted at the factory. If the valve is suspected of being faulty, replace the valve.

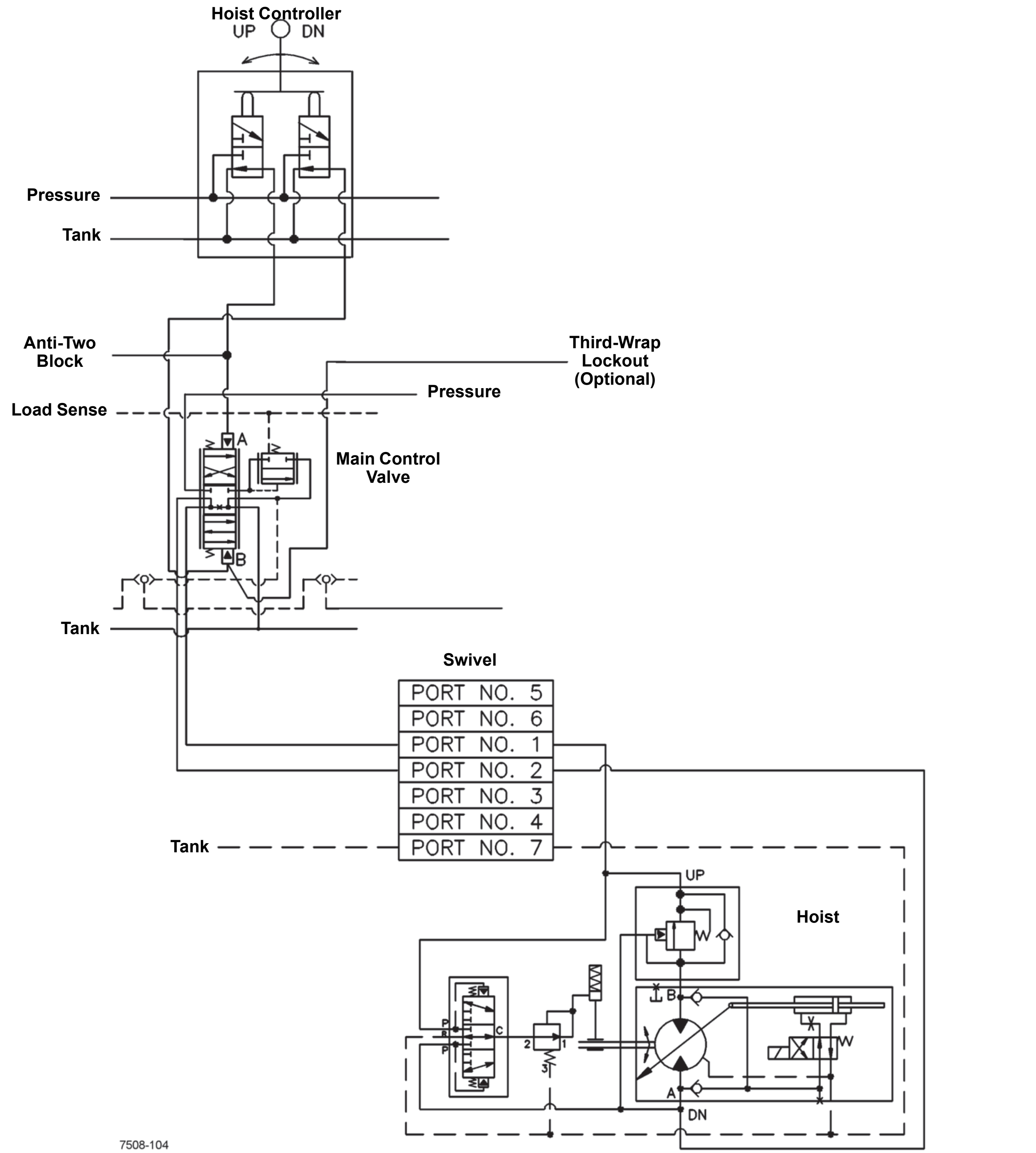

FIGURE 4-22

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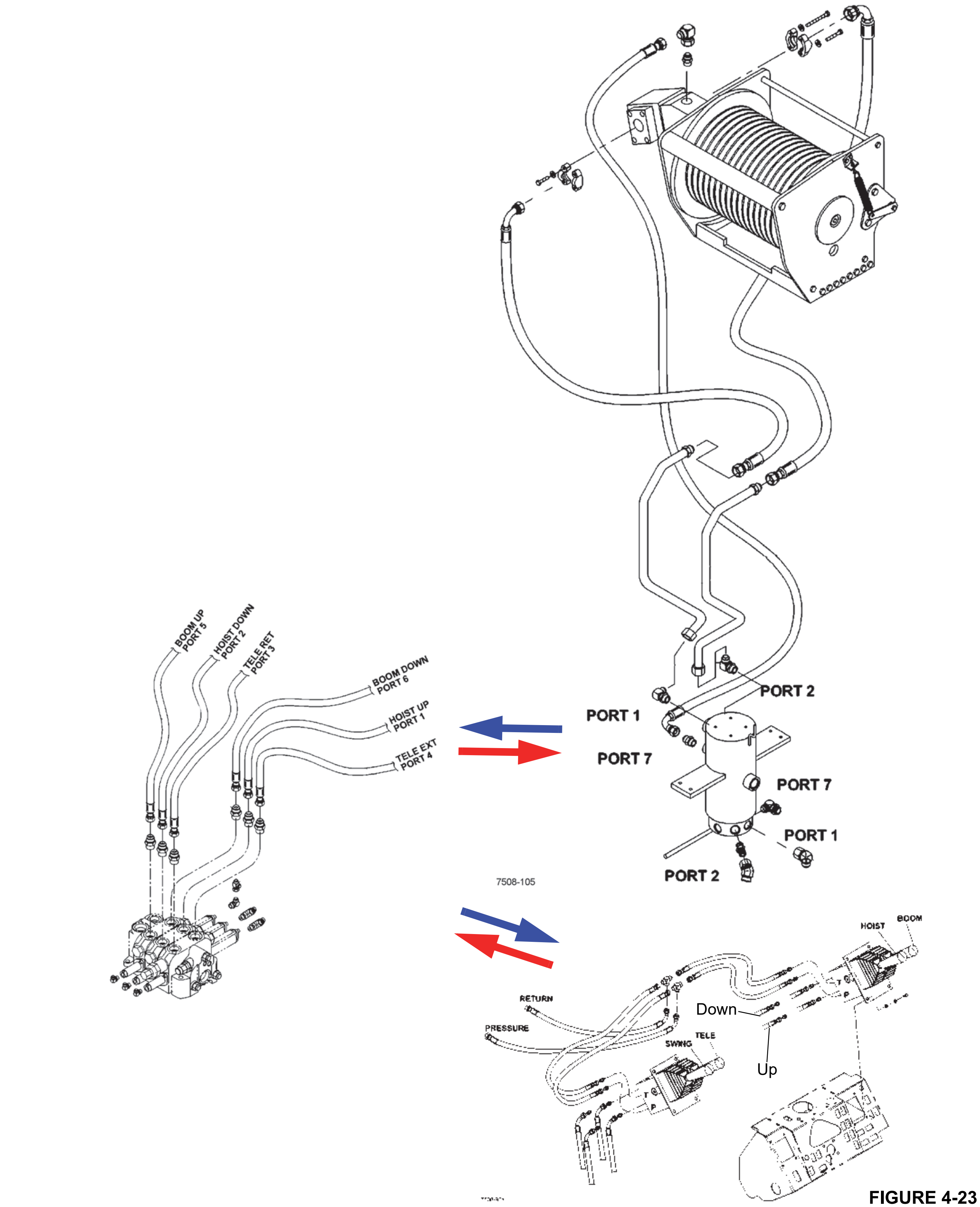

BOOM UP
PORT 5
HOIST DOWN
PORT 2
TELE RET
PORT 3
BOOM DOWN
PORT 6
HOIST UP
PORT 1
TELE EXT
PORT 4
PORT 1
PORT 7
PORT 2
PORT 7
PORT 1
PORT 2
7508-105
HOIST
BOOM
RETURN
PRESSURE
Down
TELE
SWING
Up

FIGURE 4-23

SWING CIRCUIT

General

The swing circuit (Figure 4-24) includes a swing motor, a main control valve, controller, and the hydraulic lines.

Oil Flow

In the neutral position, hydraulic oil is held in the circuit and the motor is prevented from turning. The swing motor is protected by a relief valve in the inlet section of the main control valve.

Swing Right

Actuating the swing lever to rotate the mast/boom right:

- routes oil under pressure to pilot port A of the control valve, sending oil from work port A to the swing motor
- the motor rotates clockwise (counter-clockwise looking down on the pinion gear from the deck), causing the mast and boom to rotate right
- oil from the downstream side of the motor returns to work port B of the control valve. From there the oil is routed to the outlet port of the valve and through the in-line return filter to the hydraulic tank.

Swing Left

Actuating the swing lever to rotate the mast/boom left:

- routes oil under pressure to pilot port B of the control valve, sending oil from work port B to the swing motor
- the motor rotates counter-clockwise (clockwise looking down on the pinion gear from the deck), causing the mast and boom to rotate left
- oil from the downstream side of the motor returns to work port A of the control valve. From there the oil is routed to the outlet port of the valve and through the in-line return filter to the hydraulic tank.

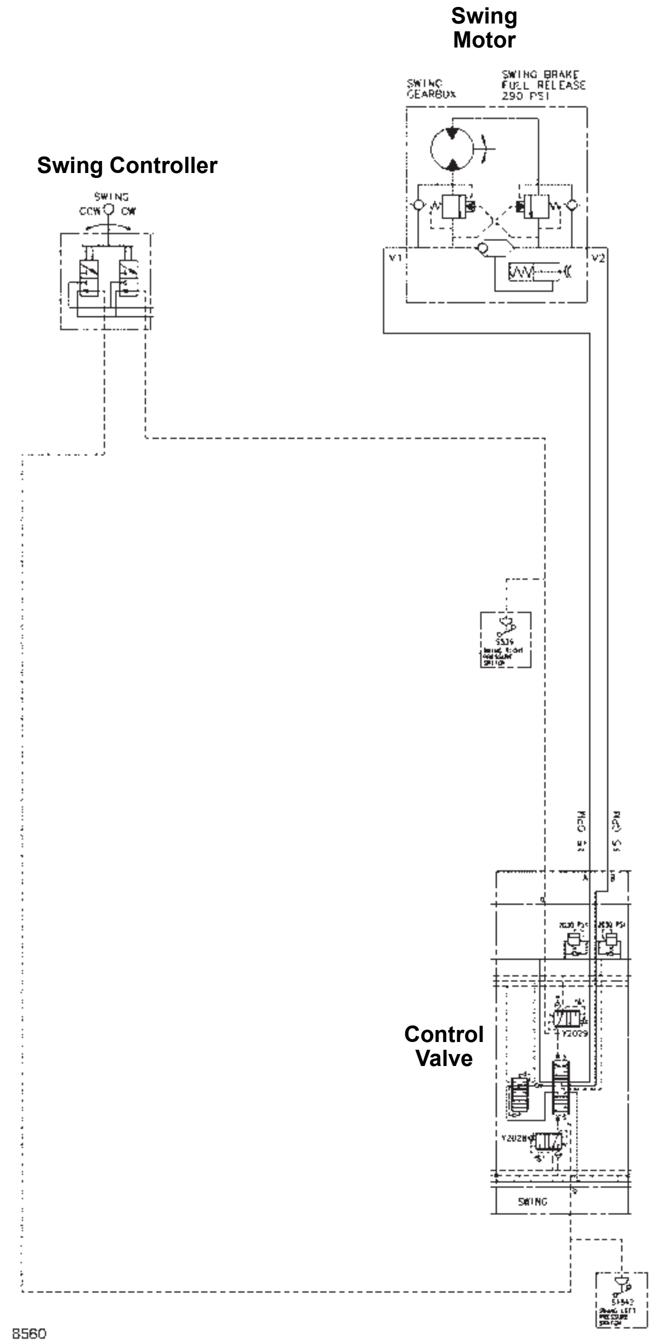
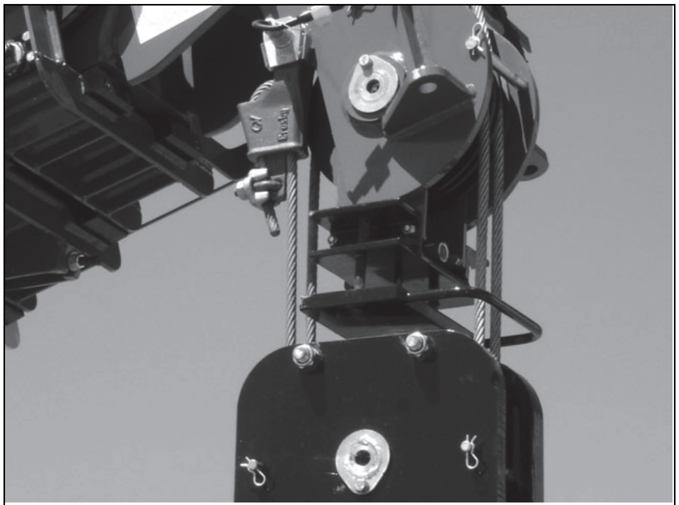


FIGURE 4-24

ANTI-DOUBLE BLOCK SYSTEM

General

The anti-double block circuit protects the hoist, telescope and lift circuits from damage in the event that the hoist block comes in contact with the boom head causing a double blocking situation. The anti-double block system includes an anti-double block mechanism Figure 4-25 at the end of the boom head, a valve block with three normally closed solenoids, and a check valve in the main control valve sections for lift, telescope and hoist functions.



p1873 **FIGURE 4-25**

System Function

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

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

When the hoist block comes in contact with the anti-double blocking bracket at the end of the boom head, the bracket raises and actuates a switch. This switch, when actuated, closes an electrical signal to the three solenoid valves opening them. With the solenoid valves open, oil supply to the check valve is reduced. The check valve spring alone is not enough to hold the check valve closed, therefore, the check valve opens. With the check valve open, hydraulic oil which would normally flow to the lift cylinder, telescopic cylinder or hoist motor through port A of the valve section is returned through the check valve to the outlet of the control valve, or through the open solenoid valve, back to tank.

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

4

OUTRIGGER AND AXLE LOCK OUT CIRCUITS

Outrigger Circuit

The independently controlled outrigger hydraulic system Figure 4-26 and Figure 4-27 includes a front and rear valve manifold, four horizontal outrigger cylinders and four vertical outrigger cylinders with holding valves.

Axle Oscillation Circuit

The axle oscillation hydraulic circuit Figure 4-26 includes the same components used in the outrigger circuits. In addition, it also includes the fifth solenoid valve of the rear outrigger control manifold and two oscillation lock out cylinders.

Oil Flow

Oil from the pump flows to the rear outrigger control manifold and then the front outrigger control manifold. Both valves are located in the distribution manifold. Depending upon which outrigger function or axle lockout function is activated (solenoid valve energized), the oil flows through outrigger valve section to the outrigger or axle lockout cylinders. The cylinder extends or retracts and pushes oil ahead of the piston through one of the ports of the cylinder. The oil returns through the outrigger control valve back to tank through the return filter.

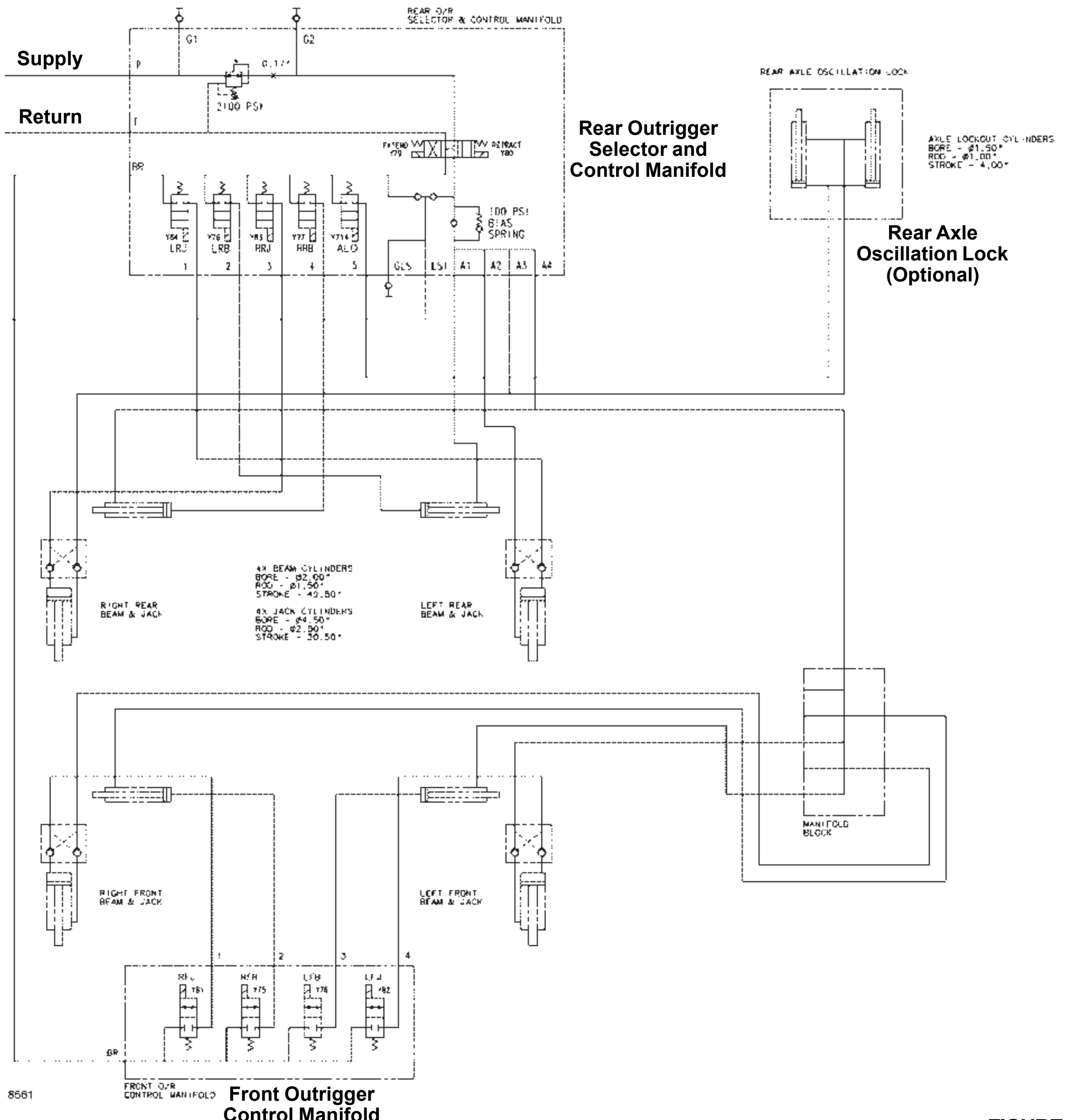


FIGURE 4-26

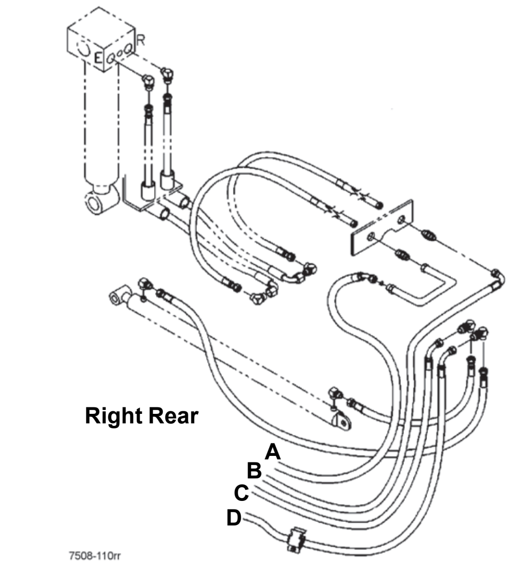
Outrigger Control Valves

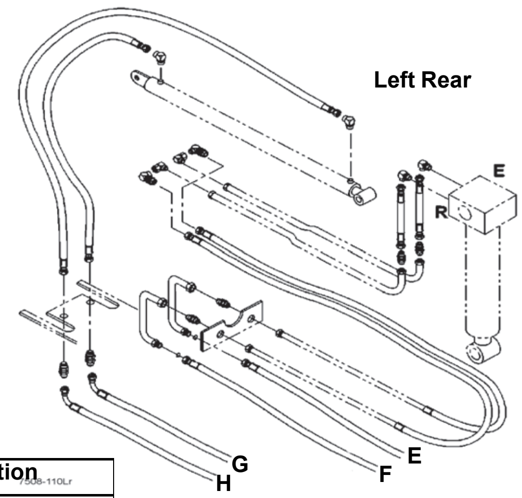
Outrigger Control Manifolds

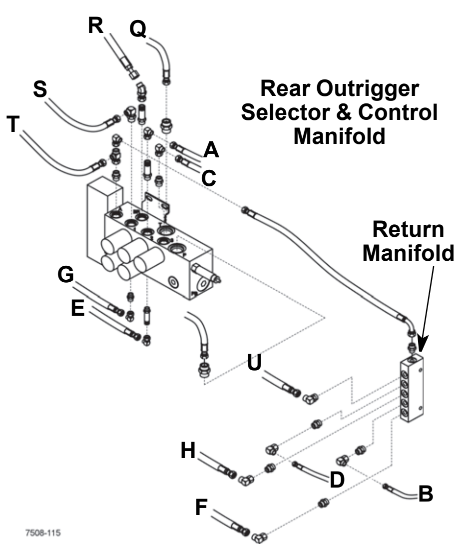
The rear control manifold consists of a relief valve, a directional control valve, and five solenoid valves: one each for the rear outrigger beam and jack cylinders and one for the axle oscillation lockout cylinders. The front control manifold consists of four solenoid valves, one each for the front outrigger beam and jack cylinders

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

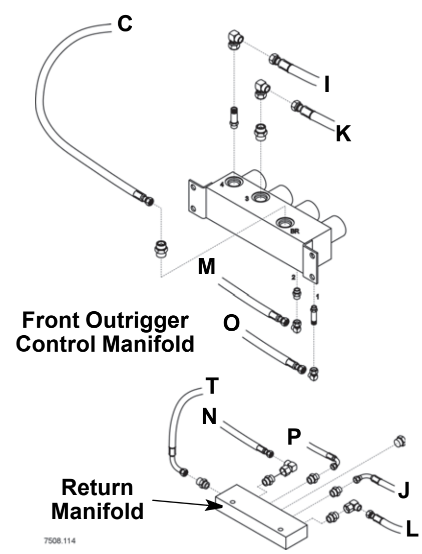
A relief valve set at 17 230 ± 345 kPa (2500 ± 50 psi) installed in the inlet of the manifold, protects the outrigger circuits from high pressure buildup.

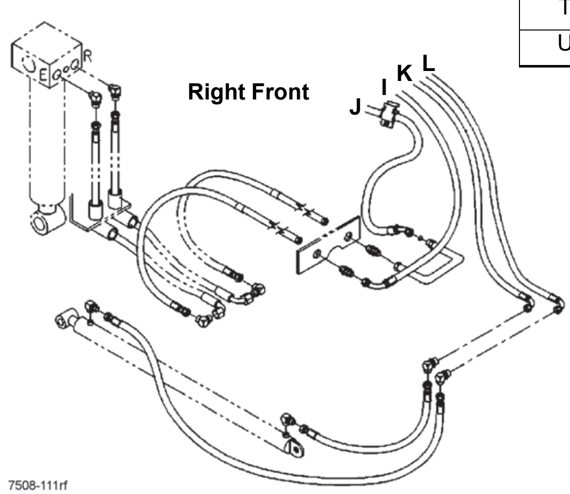






Item	Description
A	Right Rear Down
B	Right Rear Up
C	Right Rear Out
D	Right Rear In
E	Left Rear Down
F	Left Rear Up
G	Left Rear Out
H	Left Rear In
I	Right Front Down
J	Right Front Up
K	Right Front Out
L	Right Front In
M	Left Front Down
N	Left Front Up
O	Left Front Out
P	Left Front In
Q	To Filter
R	Port BR Control Manifolds
S	To Axle Lock
T	Front Outrigger Return
U	To Axle Unlock





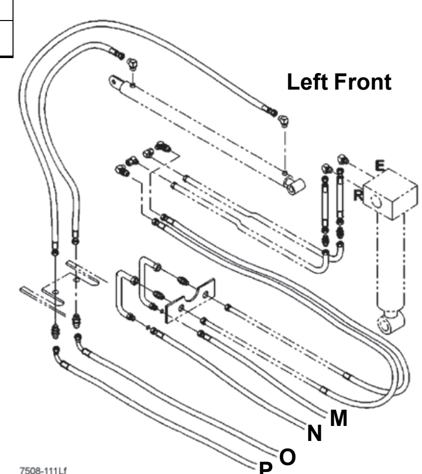


FIGURE 4-27

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Load Holding Valves

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

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

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

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

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

Vertical Outrigger Cylinder Leakage Check

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

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

HYDRAULIC PUMP REPAIR

Removal

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

Disassembly and Repair

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

Installation

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

4

DO NOT OPERATE ANY HYDRAULIC FUNCTION AT THIS TIME.

2. Let the pump run for about 60 seconds to release any air that might be in the hydraulic system. Check the suction hose connections for loose clamps, fittings, etc.
3. Adjust the pump to deliver system pressures. Follow the instruction under *Checking and Adjusting Hydraulic Pressure Settings, page 4-20*.
4. Check the level of hydraulic oil in the hydraulic oil tank. If low, add only pre-filtered hydraulic oil.

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

MAIN CONTROL VALVE

General

The main control valve is designed with very close tolerances between the spools and the valve bores. Dirt, chips or sludge can cause these surfaces and seals to wear and result in internal leakage, sticking spools or both. A thorough cleaning of the valve and replacement of seals will generally remedy a leaking problem. Extreme care must be taken to prevent nicks or scratches in machined surfaces. All spools must be installed in their original bores. If a spool or valve bore is damaged, the entire valve section must be replaced.

Removal

1. Shut off the engine. Before disconnecting the main control valve, let the system bleed down for approximately 10 minutes after shutting off the engine.

NOTE: The swing circuits and lift down circuit will retain hydraulic pressure for approximately 10 minutes after the engine is shut down. Do not disconnect the lines from the valve sections until the pressure has bled down. Even then, crack each circuit slowly to release any pressure that might still be in the circuit.

2. Thoroughly clean the outside of the valve and surrounding tube lines.
3. Mark for assembly, disconnect and plug all lines and hoses attached to the valve assembly. Cap all the valve ports.
4. Loosen and remove the two capscrews and lockwashers securing the valve to the mounting plate. Remove the valve and take it to a clean work area.

Main Control Valve

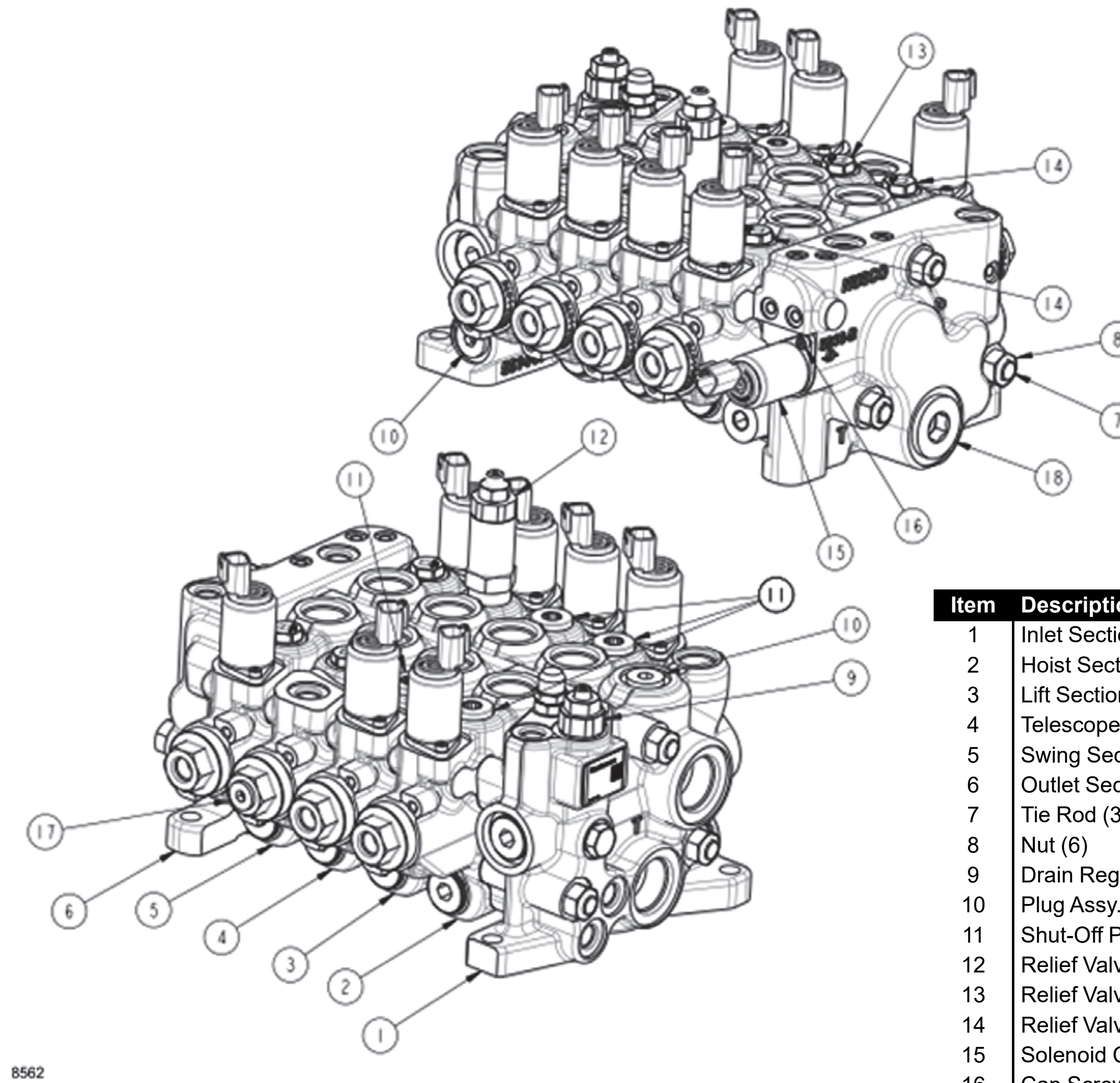
Disassembly

Complete Valve Assembly

1. Place the valve assembly on the work bench and remove all hydraulic fittings.
2. Position the valve with the outlet section (**6**, Figure 4-29) facing up.
3. Remove the three nuts **8** from the tie rods **7** at the outlet section **1**.
4. Slowly, lift the outlet section from the tie rods.

NOTE: Be careful when separating the valve sections. The working sections have spring loaded check valve assemblies. The spring could fly out of the valve section when the section is removed.

5. Slowly, lift the four working valve sections **2**, **3**, **4**, and **5** from the tie rods.
6. Remove the tie rods **7** from inlet section **1**.
7. Remove and discard O-rings from the valve sections.



Item	Description
1	Inlet Section
2	Hoist Section
3	Lift Section
4	Telescope Section
5	Swing Section
6	Outlet Section
7	Tie Rod (3)
8	Nut (6)
9	Drain Regulator Assy.
10	Plug Assy.
11	Shut-Off Plug Assy.
12	Relief Valve Assy.
13	Relief Valve Assy,
14	Relief Valve Assy, (2)
15	Solenoid Cartridge Valve
16	Cap Screw (2)
17	Plug Assy.
18	Plug Assy.

FIGURE 4-28

Inlet Section

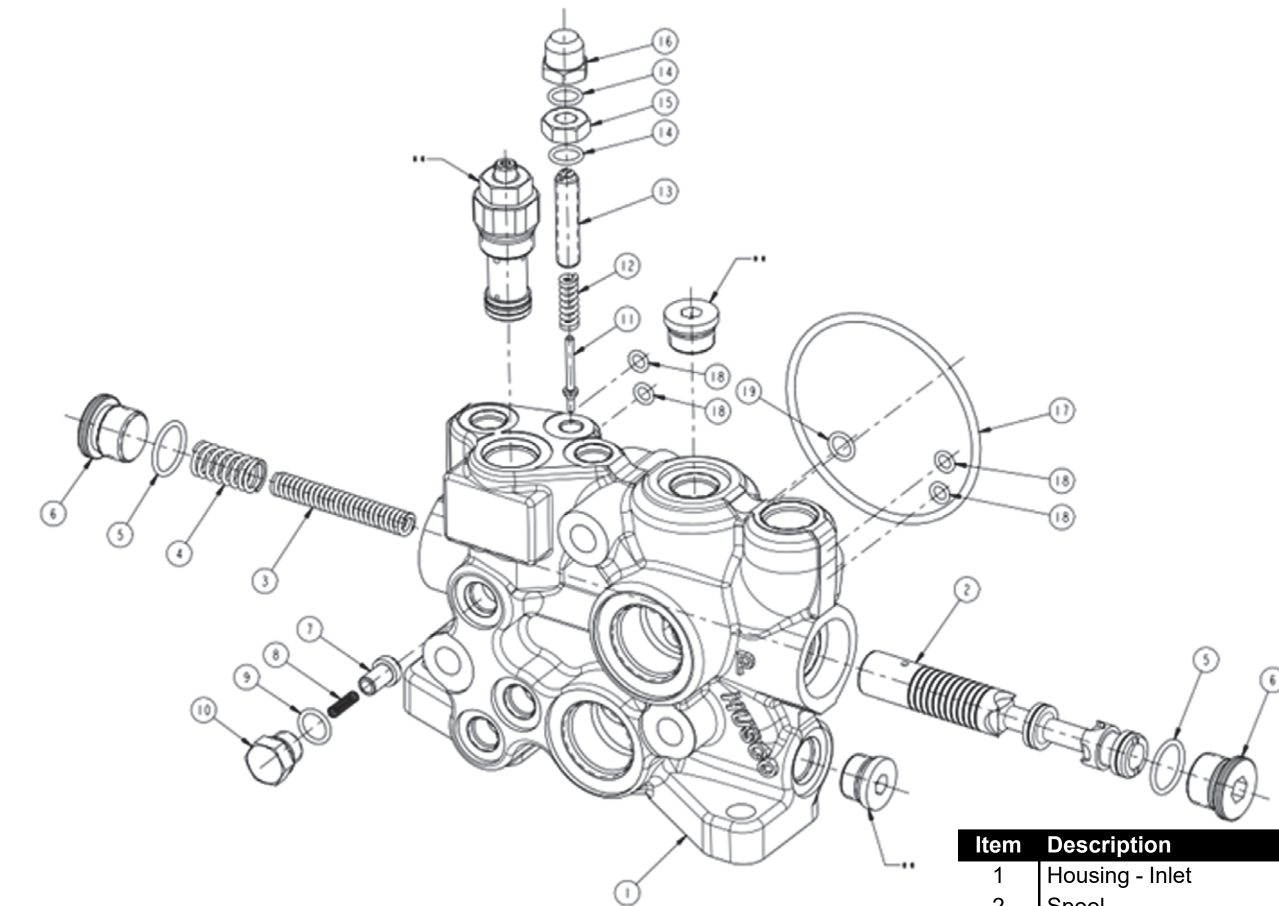
1. Remove plug (**6**, Figure 4-29) and springs **4** and **3**.
2. Remove plug **6** and spool **2**.
3. Remove plug **10,** poppet **7** and spring **8**.
4. Remove relief valve.
5. Remove nuts **15** and **16**, adjusting screw, **13,** spring **12**.and poppet **11**.
6. Remove other plugs and O-rings, as necessary.

Assembly

Inlet Section

1. Install poppet **11**, spring **12** and screw **13** and secure with nuts **15** and **16**.
2. Install relief valve.
3. Install poppet **7**, spring **8** and plug **10**.

4. Install spool **2** and plug **6**.
5. Install springs **3** and **4** and plug **6**.
6. Install other plugs and new O-rings, as necessary.



Item	Description
1	Housing - Inlet
2	Spool
3	Spring
4	Spring
5	O-Ring
6	Plug Assy.
7	Poppet-C.V.
8	Spring
9	O-Ring
10	Plug Assy.
11	Poppet-R.V.
12	Spring
13	Screw-Adjust
14	O-Ring
15	Nut-Special
16	Nut-Special
17	O-Ring
18	O-Ring
19	O-Ring

FIGURE 4-29

Hoist Section

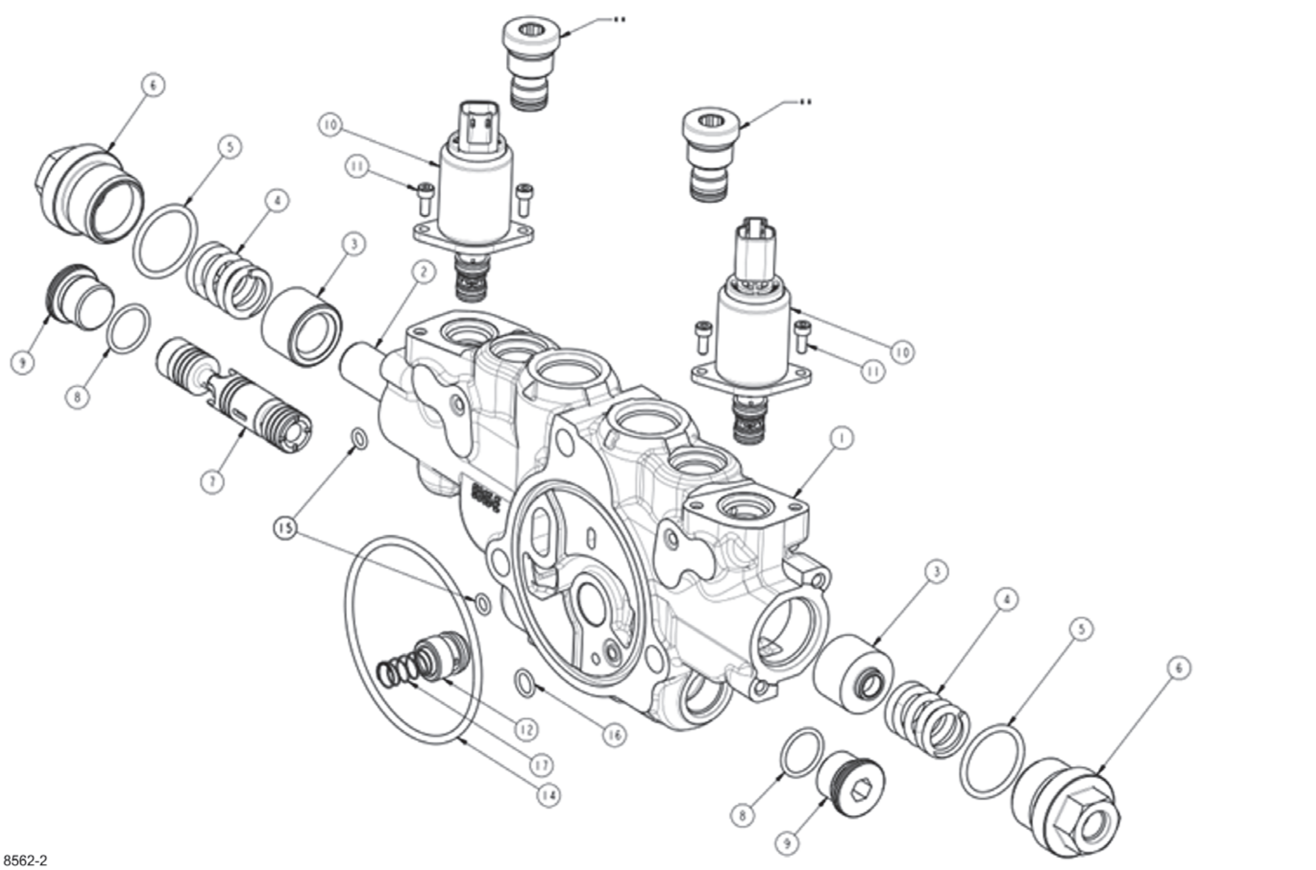
Disassembly

1. Remove screws (**11**, Figure 4-30) and valves **10**.
2. Remove plugs **6**, springs **4** and spring seats **3**.

3. Remove plugs **9** and spool-compensator **7**.
4. Remove other plugs and O-rings, as necessary.

Assembly

1. Install spool-compensator **7** and plugs **9**.
2. Install spring seats **3**, springs **4**, and plugs **6**.
3. Install valves **10** and secure with screws **11**.
4. Install, and hold in place with petroleum jelly, poppet **12** and spring **17**.
5. Install O-rings and other plugs, as necessary.



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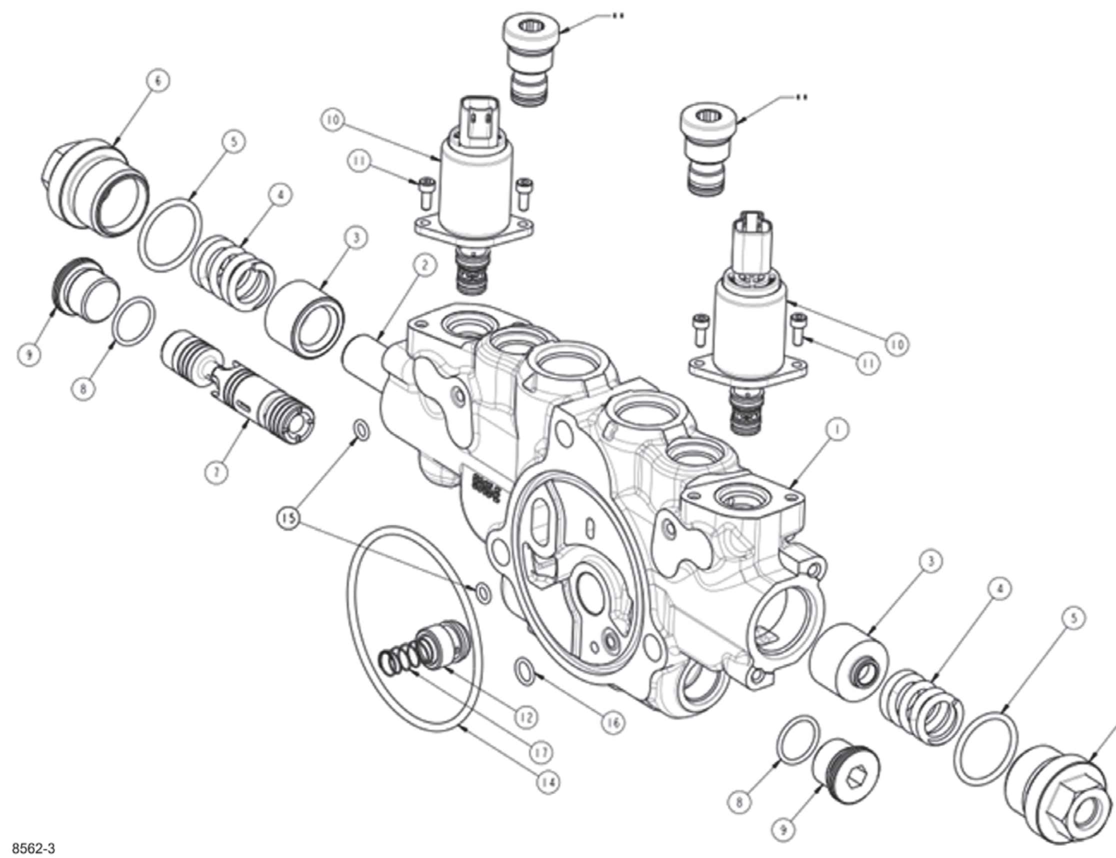
Item	Description
1	Housing - Spool (Hoist)
2	Spool
3	Spring Seat
4	Spring
5	O-Ring
6	Plug Assy.
7	Spool-Compensator
8	O-Ring
9	Plug Assy.
10	Solenoid-Cartridge Valve
11	Cap Screw
12	Poppet-C.V.
13	Spring
14	O-Ring
15	O-Ring
16	O-Ring
17	Spring

FIGURE 4-30

Lift Section

Disassembly

1. Remove screws (**11**, Figure 4-31) and valves **10**.
2. Remove plugs **6**, springs **4** and spring seats **3**.
3. Remove plugs **9** and spool-compensator **7**.
4. Remove other plugs and O-rings, as necessary.



Item	Description
1	Housing - Spool (Lift)
2	Spool
3	Spring Seat
4	Spring
5	O-Ring
6	Plug Assy.
7	Spool-Compensator
8	O-Ring
9	Plug Assy.
10	Solenoid-Cartridge Valve
11	Cap Screw
12	Poppet-C.V.
13	Spring
14	O-Ring
15	O-Ring
16	O-Ring
17	Spring

FIGURE 4-31

Assembly

1. Install spool-compensator **7** and plugs **9**.
2. Install spring seats **3**, springs **4**, and plugs **6**.

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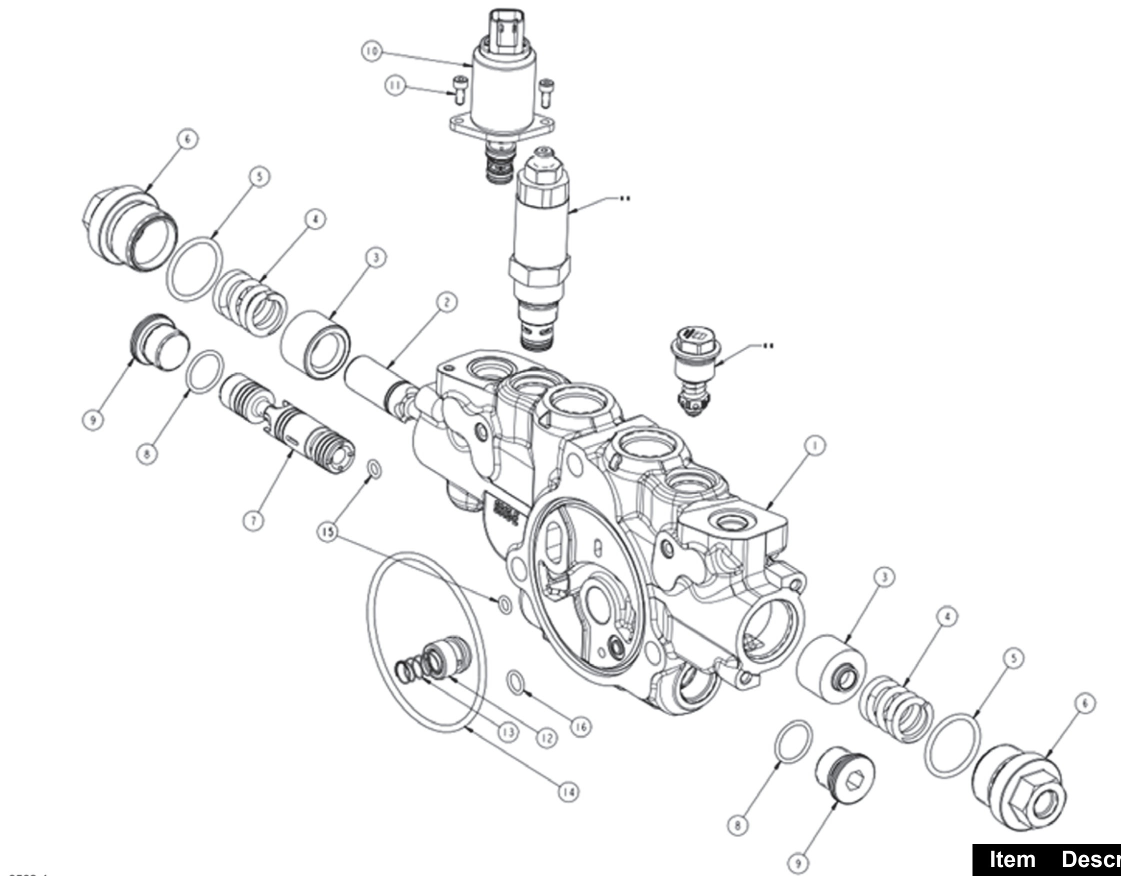
3. Install valves **10** and secure with screws **11**.
4. Install, and hold in place with petroleum jelly, poppet **12** and spring **17**.
5. Install O-rings and other plugs, as necessary.

Telescope Section

Disassembly

1. Remove screws (**11**, Figure 4-32) and valves **10**.
2. Remove plugs **6**, springs **4** and spring seats **3**.
3. Remove plugs **9** and spool-compensator **7**.
4. Remove relief valve.
5. Remove other plugs and O-rings, as necessary.



Item	Description
1	Housing - Spool (Telescope)
2	Spool
3	Spring Seat
4	Spring
5	O-Ring
6	Plug Assy.
7	Spool-Compensator
8	O-Ring
9	Plug Assy.
10	Solenoid-Cartridge Valve
11	Cap Screw
12	Poppet-C.V.
13	Spring
14	O-Ring
15	O-Ring
16	O-Ring
17	Spring

FIGURE 4-32

Assembly

1. Install spool-compensator **7** and plugs **9**.
2. Install spring seats **3**, springs **4**, and plugs **6**.
3. Install valves **10** and secure with screws **11**.
4. Install, and hold in place with petroleum jelly, poppet **12** and spring **17**.
5. Install relief valve.
6. Install O-rings and other plugs, as necessary.

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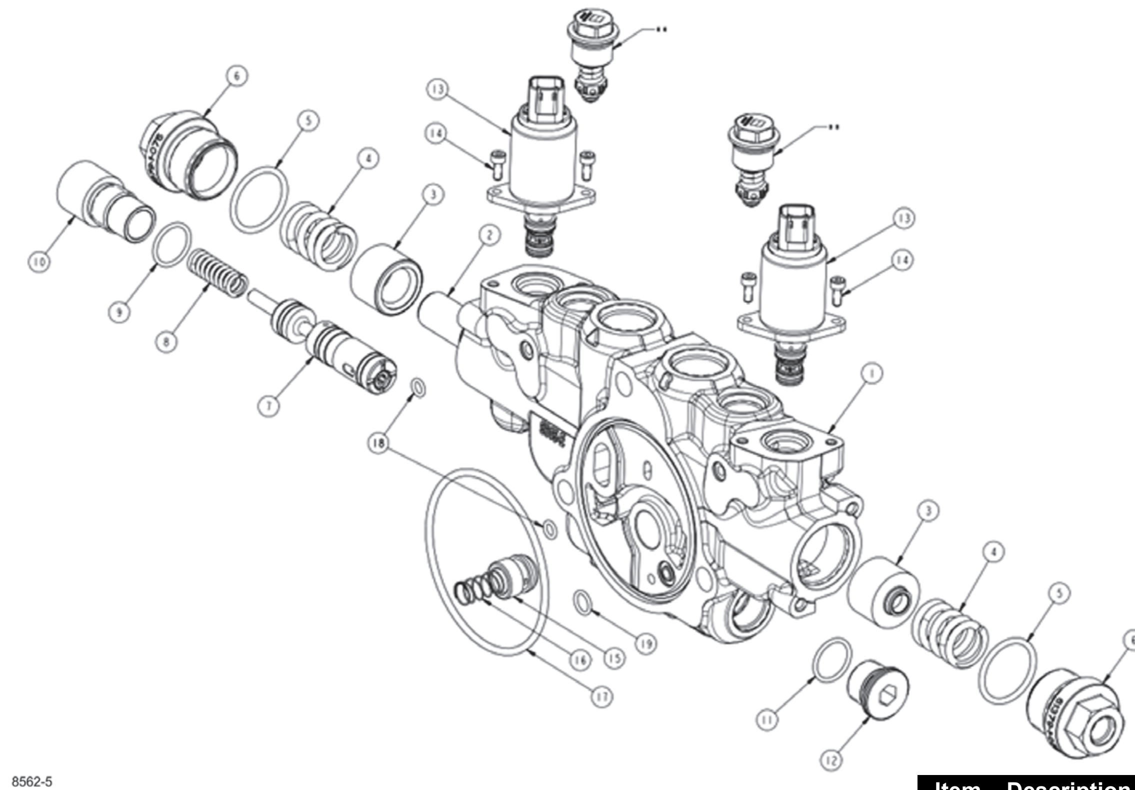
Swing Section

Disassembly

1. Remove screws (**14**, Figure 4-33) and valves **13**.
2. Remove plugs **6**, springs **4**, spring seats **3**, and spool **2.**
3. Remove plug **10**, spring **8** and spool assembly.-compensator **7**.
4. Remove other plugs and O-rings, as necessary.



Item	Description
1	Housing - Spool (Swing)
2	Spool
3	Spring Seat
4	Spring
5	O-Ring
6	Plug Assy.
7	Spool Assy.-Compensator
8	Spring
9	O-Ring
10	Plug Assy.
11	O-Ring
12	Plug Assy.
13	Solenoid-Cartridge Valve
14	Cap Screw
15	Poppet-C.V.
16	Spring
17	O-Ring
18	O-Ring
19	O-Ring

FIGURE 4-33

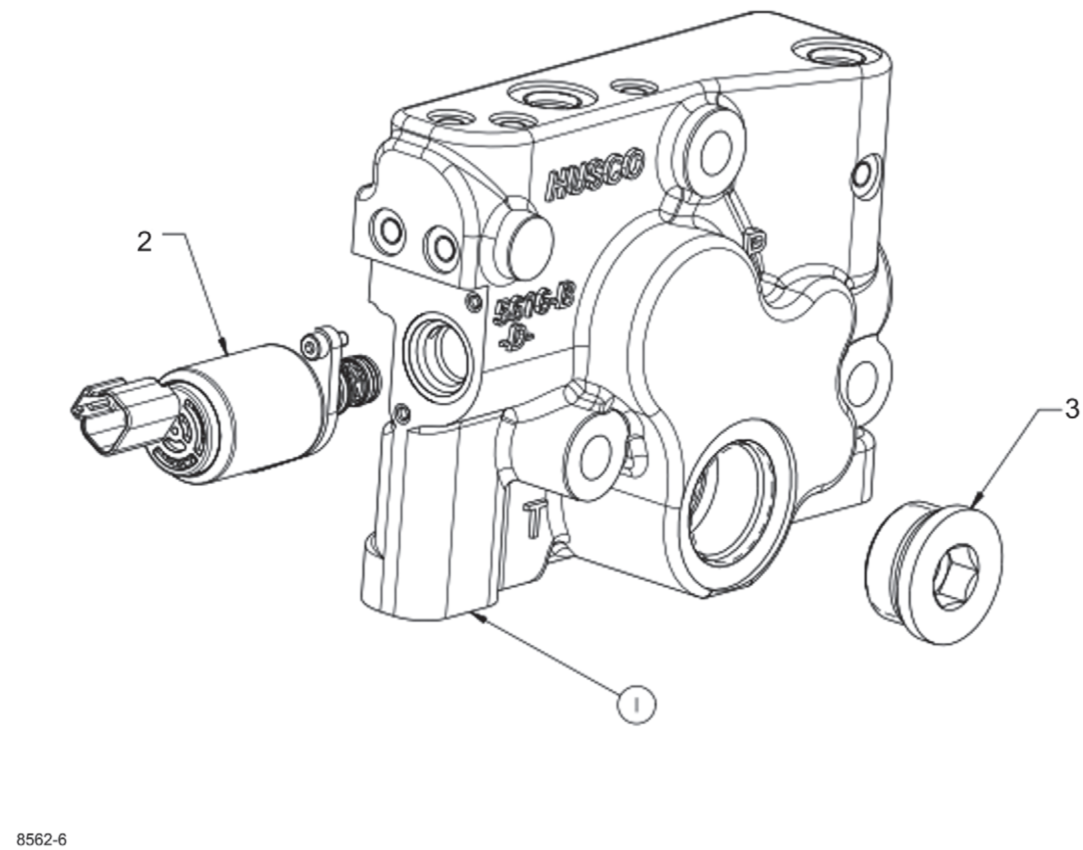
Assembly

1. Install spool-compensator **7**, spring **8** and plug **10**.
2. Install spool **2**, spring seats **3**, springs **4**, and plugs **6**.
3. Install valves **13** and secure with screws **14.**
4. Install, and hold in place with petroleum jelly, poppet **15** and spring **16**.
5. Install O-rings and other plugs, as necessary.

Outlet Section

Disassembly

1. Remove screws and valve (**2**, Figure 4-34).
2. Remove plug **3**.



Item	Description
1	Housing - Outlet Section
2	Solenoid-Cartridge Valve
3	Plug Assy.

FIGURE 4-34

Assembly

1. Install plug **3**.
2. Install valve **2** and secure with screws.

Complete Valve Assembly

1. Lay the valve components on a clean, flat work surface.
2. Assemble nuts (**7** and **9**, Figure 4-29) to one end of each tie rod **6** and **8**. Insert the tie rods through the stud holes in the inlet valve section **10**. Lay the inlet section on the work bench with the studs facing up.

3. Place O-ring **25** in position on the face of the inlet section.
4. Place the first spool valve section **2** (Lift), O-ring side up over the studs onto inlet section **1**. Place O-ring **25** in position on the face of the valve section. Install the load check poppet **28** and spring **27** into the load check cavity. Be sure the nose of the check poppet is facing down.
5. Install the second spool valve section **3** (Telescope). Position O-ring **25** on the valve section.
6. Repeat step 5 for the third and fourth spool valve section (**5** - Hoist).
7. Position outlet valve section **1** on the last working valve section and hand tighten stud nuts **7** and **9**.

1. Install the tie rods **7** into the inlet section.
2. Carefully, install the four working sections **2**, **3**, **4**, and **5**, onto the inlet section inserting the valves, springs and O-rings.
3. Install the outlet section and secure with the nuts **8** on the tie rods **7**.
4. Install the hydraulic fittings.

Main Relief and Port Relief Valves

The cartridge-type relief valves are typically of the pilot poppet type with external adjustment. Any malfunction is usually the result of foreign matter lodging between the piston (see Figure 4-35), the relief valve poppet and the check valve.

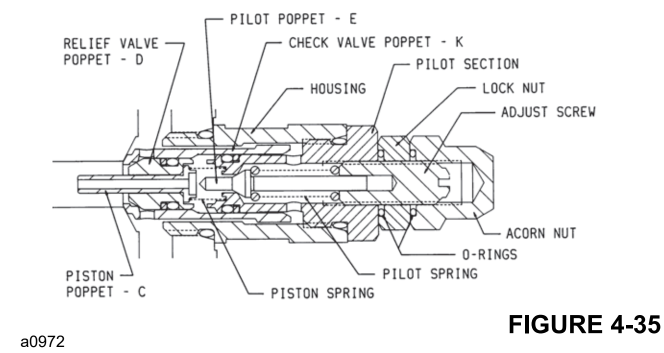


FIGURE 4-35

To perform service, clean the surrounding area and remove the complete relief valve cartridge. Examine the seat in the main relief housing and if grooves and ridges are evident, the valve must be replaced.

The design of the pilot poppet and its seal provides positive seating and very seldom requires any maintenance. Therefore, the pilot section can be removed from the cartridge housing without disturbing the pressure setting. With it will come the check valve poppet and other internal parts. These are easily disassembled and should be examined for foreign material. All seats and seating surfaces should be smooth and free of nicks, scratches or grooves. Examine O-rings and backup washers for any damage and replace if necessary. All moving parts should slide freely, with oil seal friction being present.

After inspecting and cleaning, immerse all parts in hydraulic oil and reassemble. Since the pressure setting was not disturbed, the relief valve can be tested for proper function under actual working conditions.

Relief Valve Troubleshooting

Table 4-7

Problem	Probable Cause	Remedy
Can't get pressure	Poppet D, E, or K stuck open or contamination under seat. (Figure 4-35).	Check for foreign matter between poppets D, E, or K and their mating parts. Parts must slide freely.
Erratic Pressure	Pilot poppet seat damaged. Poppet C sticking in D. (Figure 4-35)	Replace the relief valve. Clean and remove surface marks for free movement.
Pressure setting not correct	Normal wear. Lock nut & adjusting screw loose.	Adjust pressure.
Leaks	Damaged seats. Worn O-ring. Parts sticking due to contamination.	Replace relief valve. Replace relief valve. Replace relief valve.

Anti-Void Troubleshooting

Trouble resulting in a malfunctioning anti-void valve can usually be traced back to foreign matter plugging the sensing hole or preventing free movement of the poppet. Also, check seat for scratches, nicks or other marks.

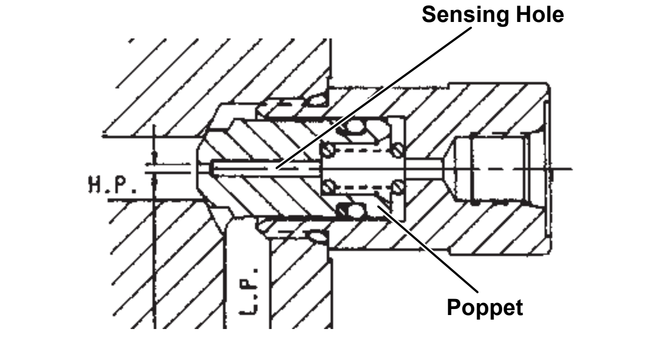


FIGURE 4-36

If operating difficulties indicate that the pilot poppet is leaking or sticking, remove internal parts of the pilot section, and follow the same procedure as above. After assembly, adjust the relief valve pressure per instructions in this section.

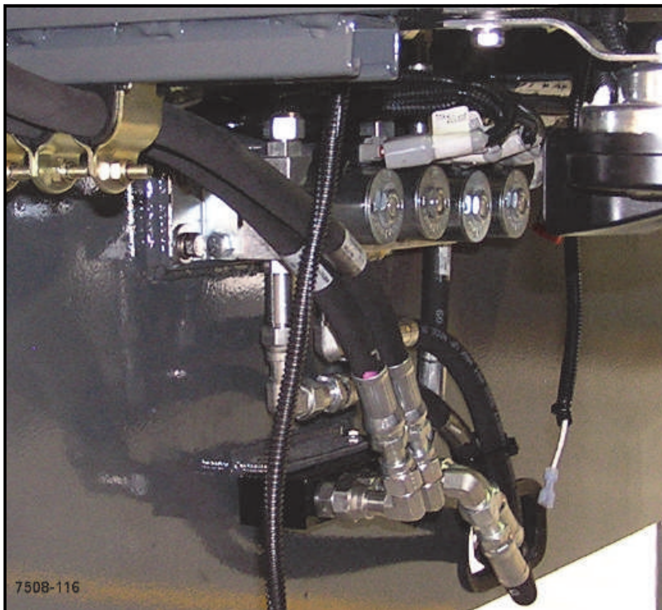
If the relief valve still does not function properly, replace the relief valve.

Installation

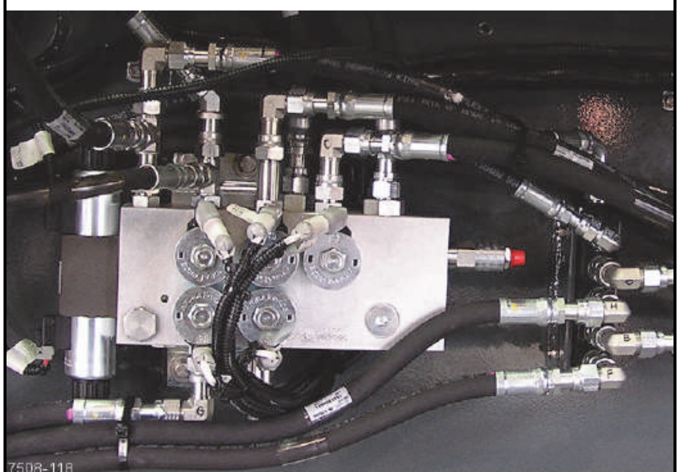
1. Install fittings into valve
2. Position the valve assembly on the mounting plate and secure with two capscrews and lockwashers.
3. Connect all hoses to the control valve.
4. Start the engine and release the air in the hydraulic lines by operating each hydraulic function several times in both directions.
5. Check for leaks and fill the reservoir, if required.

Outrigger Control Valves

The outrigger control valves are on separate valve blocks; front and rear, (Figure 4-37). The valve blocks are mounted between and below the frame rails on the inside of the front and rear outrigger boxes.



Front Outrigger Control Valve



Rear Outrigger Control Valve

FIGURE 4-37

Removal

1. Stop the engine and engage the parking brake. Place chocks under the wheels.
2. Disconnect the negative battery cable from the battery.
3. Access the valves from under the vehicle.
4. Individual valves and/or their solenoids can be removed from the manifold block without removing the complete manifold assembly.
   a. Disconnect the electrical leads from the valve solenoid.

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b. To remove just the solenoid: Remove the retaining nut on the top of the valve and slide the solenoid off the valve.

c. To remove an individual valve: Unscrew the valve from the manifold or if removing the selector valve on the end of the manifold remove the retaining screws.

5. If the complete valve assembly must be removed, tag all hydraulic lines for correct re-assembly. Clean the valve and connecting lines. Disconnect the hydraulic lines from the valve ports. Plug the hose ends and cap the valve ports to keep dirt out of the hydraulic system.

6. Remove the manifold mounting screws and remove the manifold.

Installation

1. If the complete valve assembly is being installed, put the valve assembly in position and secure it with the capscrews, washers and nuts. Connect the hydraulic lines to the manifold block and connect the wire leads to the solenoids.

2. If an individual valve is being installed, screw the valve into manifold or if it is the selector valve secure it with the mounting screws. Connect the wire leads.

3. Connect the battery cable to the battery.

4. Start the engine and check outriggers for correct operation. Check for leaks and add hydraulic oil to the hydraulic tank, if necessary.

Swing Motor

Removal

1. Shut off the engine, set the parking brake and place chock blocks at each wheel. Before disconnecting any lines or hoses from the swing motor, let the system bleed down for approximately 10 minutes after shutting off the engine. Even then, disconnect the hose or line slowly to release any pressure that still might be in the circuit.

NOTE: The swing motor can only be reached from under the machine. Shut off the engine, set the parking brake and remove the ignition key. Block all tires.

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

3. Remove the two mounting socket head capscrews and lockwashers from the swing motor. Remove the swing motor and gasket. Discard the gasket.

Disassembly

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

1. Place the motor in a vice and clamp across the edges of the flange (Figure 4-38) 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.

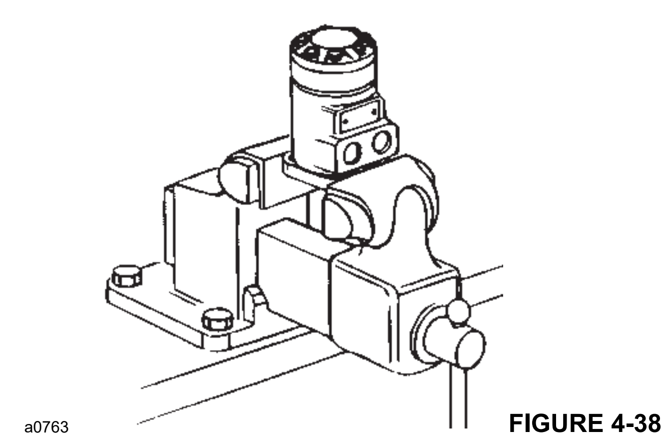


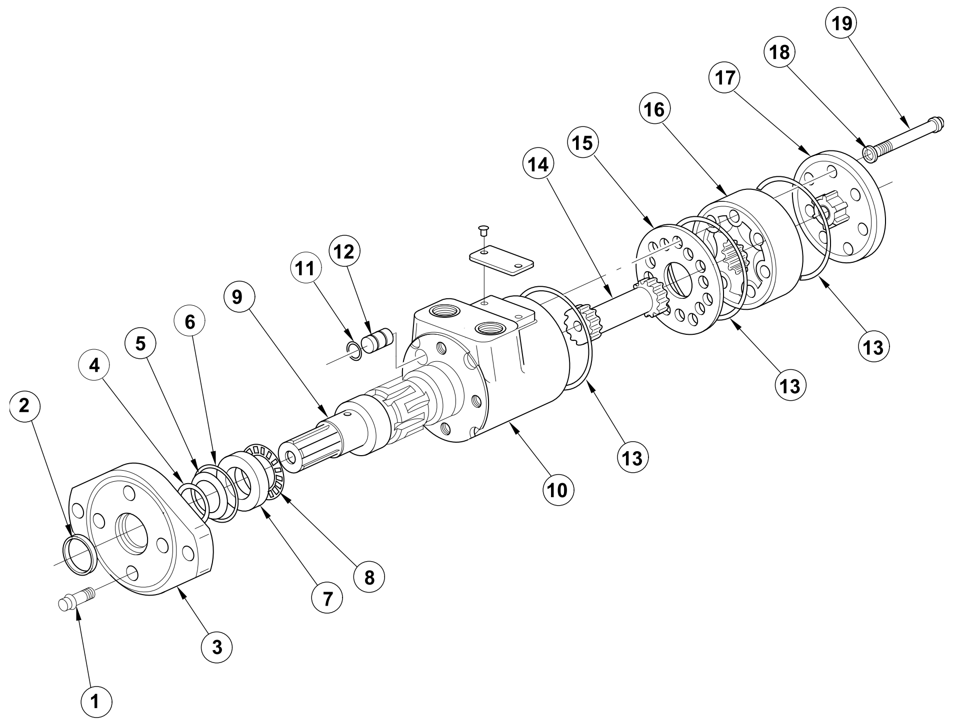
FIGURE 4-38

2. Remove seven capscrews (**19**, Figure 4-39) and seal washers **18**.

3. Remove end cap **17**. Remove and discard seal **13** from the end cap.

4. Remove gerotor **16**. Remove and discard seal **13** from the gerotor.

5. Remove drive shaft **14**.



Item	Description
1	Screw (4)
2	Exclusion Seal
3	Mounting Flange
4	Backup Ring*
5	Shaft Pressure Seal *
6	Seal*
7	Bearing Race
8	Thrust Needle Bearing
9	Output Shaft
10	Housing
11	O-ring
12	Plug
13	Seal (3)*
14	Drive Shaft
15	Spacer Plate
16	Gerotor Set
17	End Cap
18	Seal Washer (7)*
19	Screw (7)

* Included In Seal Kit

FIGURE 4-39

6. Remove spacer plate **15**.
7. Remove seal **13** from housing **10**.
8. Remove output shaft **9** from housing **10**.
9. Remove needle thrust bearing **8** from shaft or housing.
10. Reposition the motor in the vice. Clamp across ports as shown in Figure 4-40. DO NOT clamp on housing. Excessive clamping pressure on side of housing causes distortion.

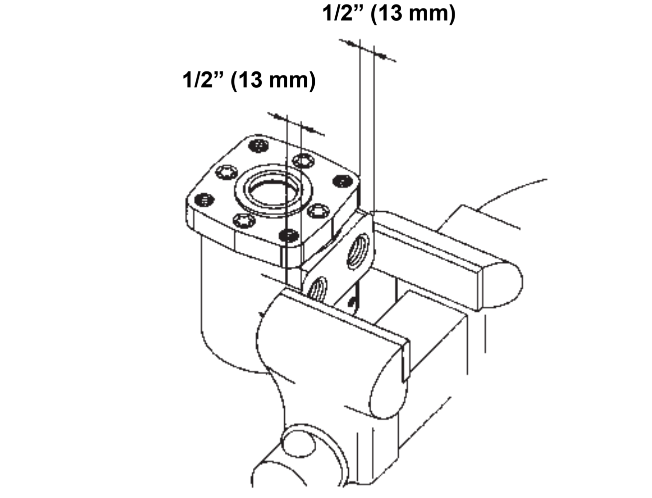


FIGURE 4-40

11. 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. See Figure 4-41. **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.

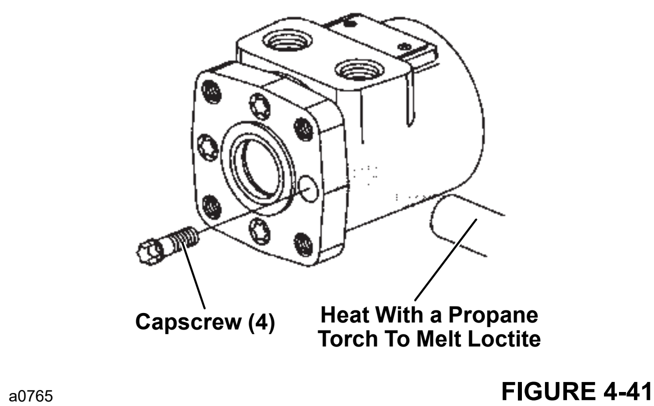


FIGURE 4-41

12. Carefully remove flange (**3**, Figure 4-39) from housing **10**.
13. Exclusion seal **2**, backup ring **4**, pressure seal **5** and seal **6** will come off with flange **3**. Use the seal removal tool shown in exclusion and pressure seals.

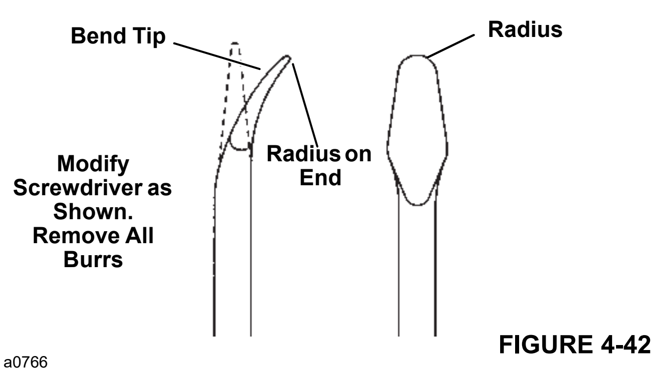


FIGURE 4-42

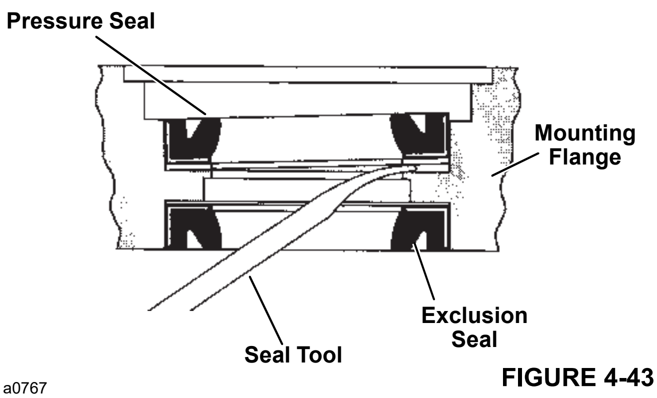


FIGURE 4-43

14. A metal plug (**12**, Figure 4-39), 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 inch) hex key through the port opening and push it out.

Inspection/Cleaning

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

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

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

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

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

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

Assembly

Shaft End

1. If plug (**12**, Figure 4-39) 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 (Figure 4-44) and install the shaft into housing (**10**, Figure 4-39).

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

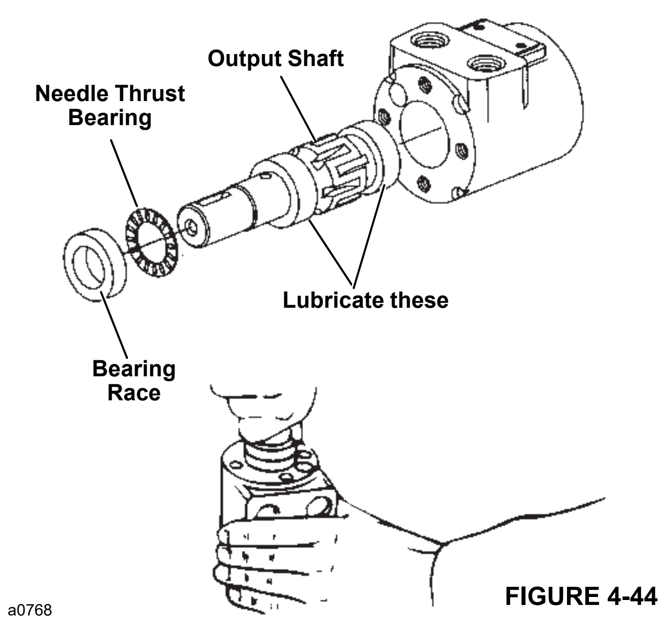


FIGURE 4-44

3. Install needle thrust bearing **8**, then bearing race **7** on shaft **9**. Pull shaft partially out of housing. Push all three parts in housing **10** together (See Figure 4-44). The bearing race must rotate freely when in position.
4. 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.
5. Install exclusion seal (**2**, Figure 4-39) in flange **3** with the lips of the seal facing out (see Figure 4-45). Carefully press the exclusion seal in place.
6. Install shaft pressure seal **5** in flange **3** with lips of seal face up using a suitable driver. See Figure 4-45. Carefully press the pressure seal in place.

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

7. Install O-ring (**6**, Figure 4-39) 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.

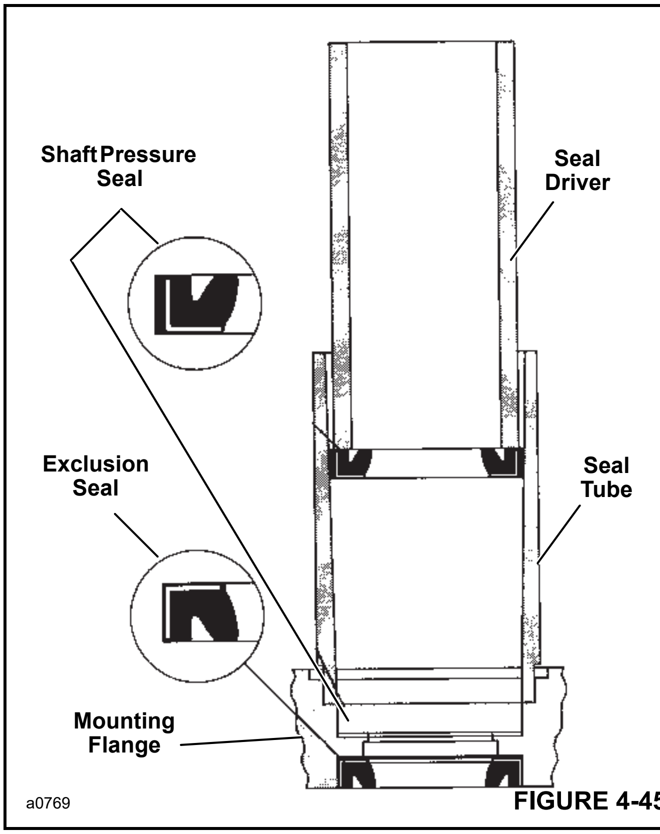


FIGURE 4-45

9. Apply 3 or 4 drops of Loctite sealant at the top of the threads for each of the four holes in the housing (see Figure 4-46). 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.

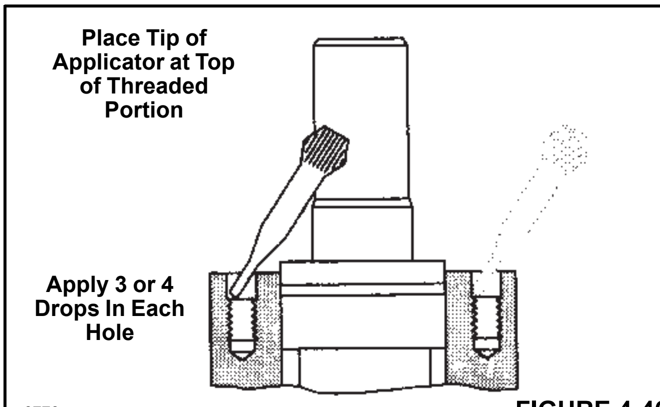


FIGURE 4-46

10. Before installing the flange and seal assembly over shaft (**9**, Figure 4-39), place a protective sleeve or bullet over the shaft. Then lubricate the space between exclusion

seal **2** and pressure seal **5**, as well as the lips of both seals (see Figure 4-47).

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

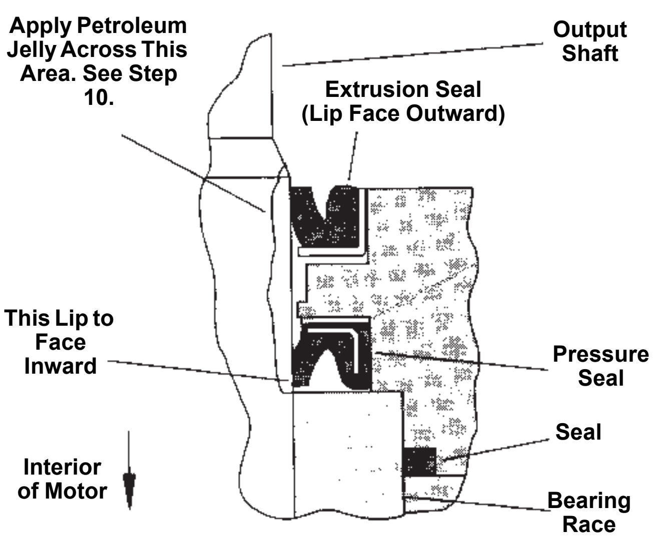


FIGURE 4-47

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

Gerotor End

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

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

13. Pour approximately 30 ml (1 ounce) of clean hydraulic oil in the output shaft cavity.

14. Install O-ring (**13**, Figure 4-39) in the housing groove. Avoid twisting the seal.

Timing Procedure

15. Install drive shaft (**14**, Figure 4-39). Use a felt tip pen to mark one drive tooth. Align this mark with the timing dot on the output shaft (Figure 4-48).

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

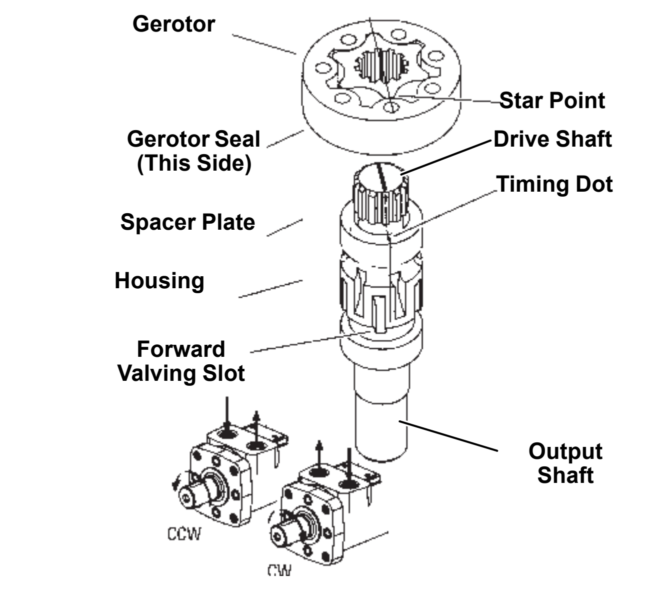


FIGURE 4-48

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 4-48).

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 seal **13** in end cap **17**. Carefully place the end cap on gerotor **16**.

20. 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 27-29 Nm (235-250 lb-in) in the sequence shown in Figure 4-49.

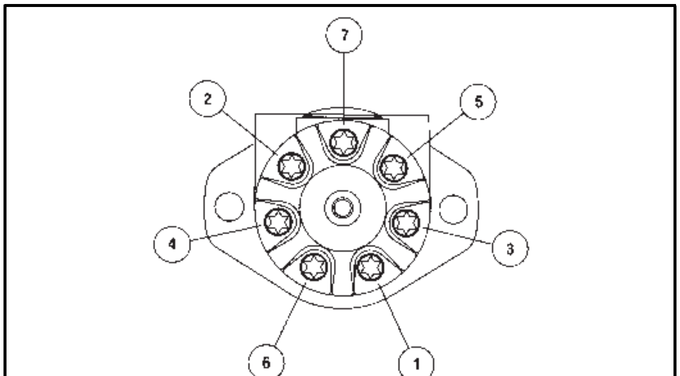


FIGURE 4-49

Installation

1. Place a new gasket on the face of the swing motor mounting flange.

2. Align the splines of the swing motor shaft with the splines of the worm gear shaft of the swing gear box. Install the swing motor to the gearbox with two socket head capscrews and lockwashers.

3. Connect the hydraulic lines and fittings to the swing motor.

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

Hoist Motor

Removal

1. Shut off the engine, set the parking brake.

2. Before disconnecting the hydraulic lines, clean the port area of the hoist motor thoroughly. Disconnect the hydraulic lines from the hoist motor. Put caps and plugs on the hoses and ports to keep dirt out.

3. Loosen and remove the two capscrews and lockwashers securing the motor to the hoist. Remove the hoist motor and gasket. Discard the gasket.

4. Remove the adapter flanges, spacer block and line mount body (Figure 4-50) from the pump. Discard all O-rings.

Disassembly

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

Installation

1. Install the line mount body (Figure 4-50), spacer and adapter flanges to the hoist motor. Be sure to use new O-ring seals.

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

NOTE: To prevent cavitation and damage to the motor due to lack of lubricating hydraulic oil, DO NOT start the motor without first being filled with hydraulic oil.

3. Fill the hoist motor through the case drain hole (Figure 4-50) to the bottom of the fill plug with clean hydraulic oil.

4. Connect all the hydraulic hoses and fittings to the motor.

5. Start the engine and slowly run the boom hoist through several cycles to remove any air in the system. Check for hydraulic leaks.

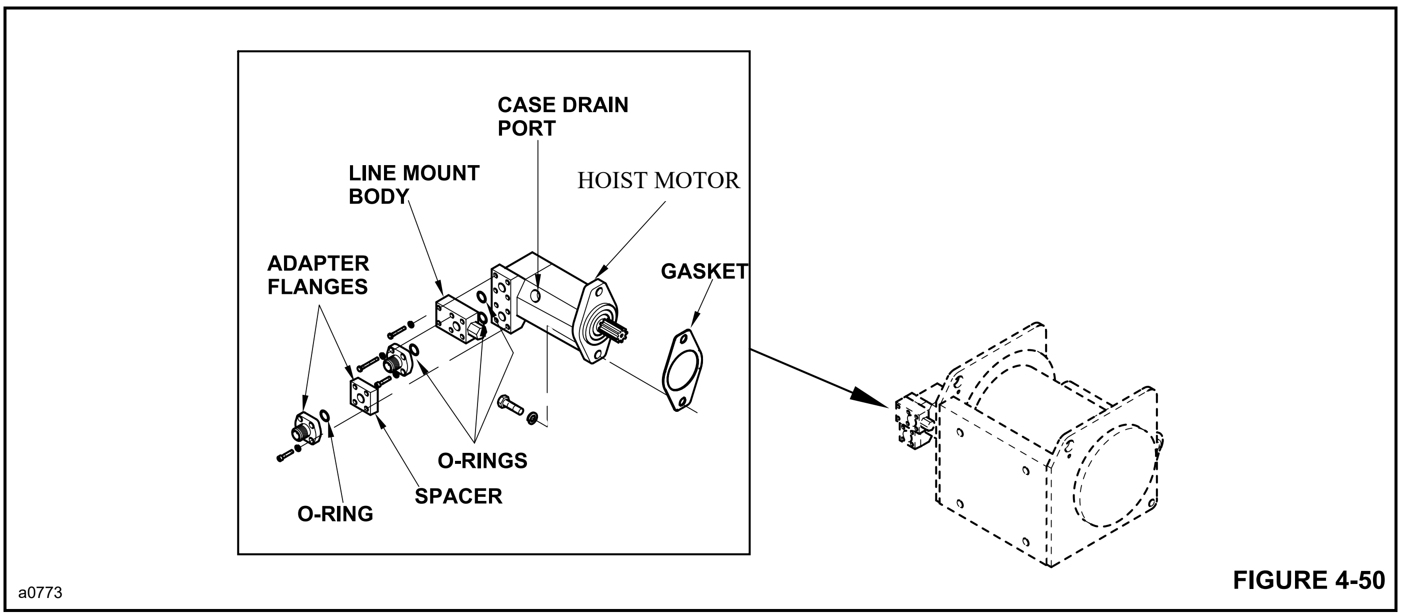


FIGURE 4-50

Hydraulic Swivel

Removal

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

1. Stop the engine and engage the parking brake. Before disconnecting any lines or hoses from the hydraulic swivel, let the system bleed down for approximately 10 minutes after shutting off the engine.

NOTE: The hydraulic circuits will retain hydraulic pressure for approximately 10 minutes after the engine is shut down. Do not disconnect the lines from the swivel until the pressure has bled down. Even then, crack each circuit slowly to release any pressure that might still be in the circuit.

2. Put tags on the hydraulic lines with the number of the hydraulic port to which the line connects.
3. Disconnect the hydraulic lines from the upper and lower swivel ports. Be prepared to collect the hydraulic oil in the lines. Put caps or plugs on the fittings and hydraulic lines.
4. Remove the torque arm from the bottom of the swivel.
5. Remove the three bolts and lockwashers securing the swivel to the mast.
6. Remove the hydraulic swivel.

Disassembly

1. Remove the retaining ring (**9**, Figure 4-51). Remove the retainer **8**, O-ring **5** and thrust washer **6**. Discard the thrust washer and the O-ring.
2. Carefully pull the swivel stem **4** from swivel housing **7**. If the swivel can not be pulled from the housing, hit the bottom of the swivel shaft with a soft hammer.
3. Remove the other O-ring **5** and thrust washer **6**.
4. Remove and discard seals **10**, seals **11**, wear ring **12** and O-rings **13**.

Inspection

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

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

Assembly

1. Lubricate all seals in the seal kit.
2. Place the swivel stem (**4**, Figure 4-51) on the work bench in the vertical position.
3. Walk the top seal **6** down the swivel stem one flow groove at a time until it reaches the swivel stem top. Carefully work the seal until it slips into the seal groove at the swivel stem top.
4. Slip one seal **11** over the bottom of the spool and walk the seal up the swivel one flow groove at a time until it reaches the top seal groove.
5. A seal assembly tool must now be fabricated from a piece of 19 mm (3/4 inch) wide fiberglass packing tape approximately 457 mm (18 inches) long. Fold the tape in half with glue sides together (Figure 4-52). No glue can be exposed on the tape.
6. See Figure 4-52 and insert the piece of packaging tape around the seal ring to form a puller. Place the seal ring into the seal groove over the O-ring. The seal ring will not fit entirely in the groove.
7. Using the tape, stretch the seal ring just enough to work the seal ring over the edge of the flow groove and into the seal groove. See Figure 4-52. Slowly slide the tape along the seal until the entire seal is installed in the seal groove. Be careful not to damage the inside convex edges of the seal ring. If any seal material is removed during this procedure, replace the seal with another.

Item	Description
1	O-ring Plug (2)
2	Plug
3	Plug (4)
4	Swivel Stem
5	O-ring (2)*
6	Thrust Washer (2)*
7	Swivel Housing
8	Retainer
9	Retainer Ring
10	End Seal (2)
11	Piston Seal Assembly (8)*
12	Wear Ring*
13	O-ring*

* Included in Seal Kit

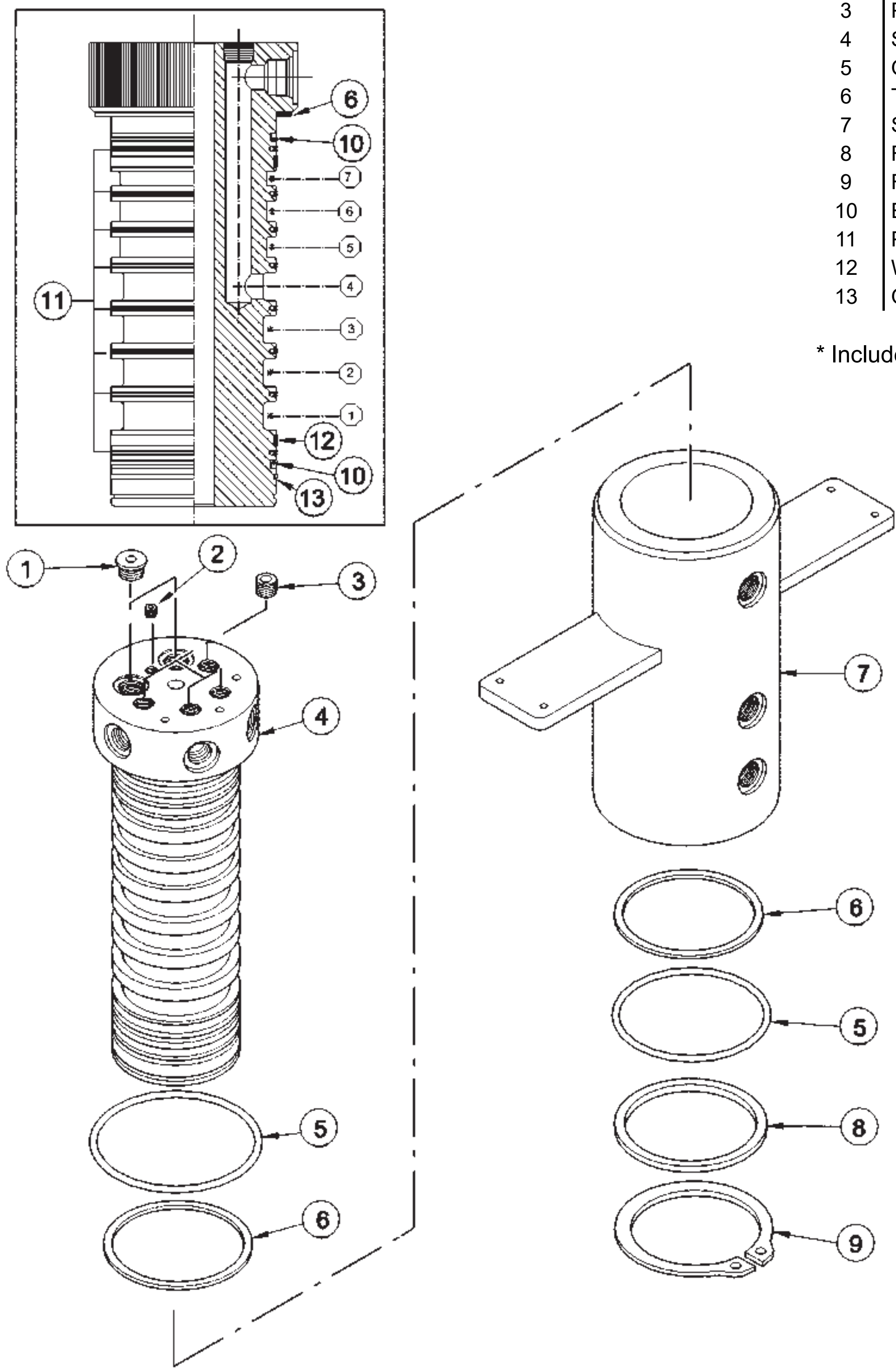


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FIGURE 4-51

NOTE: Do not stretch the seal too far. The seal will not return to its original shape. If the seal diameter is too large, damage to the seal will occur when the spool is installed into the housing.

8. Slowly pull the tape from the seal ring, being careful not to damage the seal.

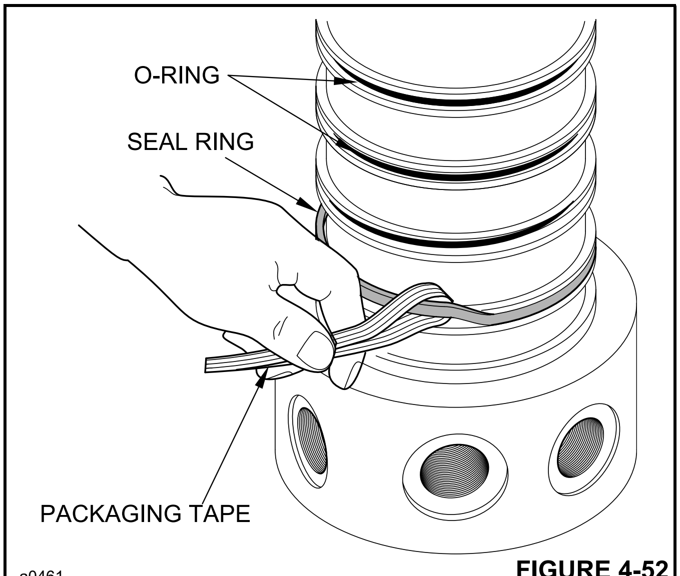


FIGURE 4-52

9. Repeat steps 4 through 8 for the remaining seal grooves.

10. Install wear ring **12**, end seal **10** and O-ring **13** on bottom of swivel stem **4**.

11. Install the top thrust washer (**6**, Figure 4-51) to stem **4**.

12. Place the swivel housing **5** on the work bench with bottom of the housing down. Lubricate the lower 1/4 of the bore of the swivel housing with hydraulic oil.

13. Insert the assembled stem into the housing and then push the stem into the housing bore until it is seated.

14. Install thrust washer **6**, O-ring **5** and retainer **8**.

15. Install retainer ring **9**.

Test

Pressure test the hydraulic swivel at 24 132 kPa (3500 psi). Test each port individually for approximately 1 minute while rotating the swivel stem 360°. No leakage past the seals is permitted.

If internal bypass should occur, rotate the swivel stem and then back pressure the port that the oil was leaking into. If bypass persists, disassemble the swivel and examine for damaged seals. If external leakage occurs, disassemble the swivel, identify the defective component, and replace.

Installation

1. Put the hydraulic swivel in place on the machine. Fasten the hydraulic swivel to the brackets in the mast using three bolts and lockwashers.

2. Install the swivel torque arm to the bottom of the hydraulic swivel using three bolts and lockwashers.

3. Connect the hydraulic lines to the lower ports of the hydraulic swivel.

4. Fill the lower hydraulic system by adding recommended hydraulic oil through the upper ports of the hydraulic swivel.

5. Connect the hydraulic lines to the upper ports.

6. Start the engine and move the hydraulic oil through the swivel by actuating all functions. Visually, check for leaks.

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

Hydraulic Cylinders

Removal

NOTE: The following removal instructions are general and should be modified to suit the cylinder being removed. Crowd cylinder and outrigger cylinder removal instructions will be found in Section 11. Steering cylinder removal instructions can be found in Section 10.

1. Put a support under the component to which the cylinder is fastened. Make sure the component will not fall after the cylinder is removed.

2. Stop the engine. If the lift cylinder is being removed, before disconnecting any lines or hoses from the cylinder, let the system bleed down for approximately 10 minutes. Even then slowly disconnect any line or hose to allow any pressure still in the circuit to release.

3. Disconnect the hydraulic lines from the cylinder. Put caps on the hydraulic lines and plugs on the cylinder ports to keep dirt out of the system.

4. Connect a hoist to lift the weight of the cylinder.

5. Remove the cylinder mounting pins. Remove the cylinder.

Disassembly

NOTE: The following procedures gives general instructions for repair of the hydraulic cylinders. See illustrations for relation of the component parts. Steering cylinder repair instructions can be found in *Steering System, page 10-1*.

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 cylinder rod and piston straight out of the cylinder tube. If the cylinder and piston are hard to remove, install the head gland back into the cylinder and apply shop air to the base port to push the piston out to the head gland.
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 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 and dry.

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.

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. Be sure O-ring is installed between the piston and the rod. Fasten the piston to the rod with locking nut and tighten to the specified torque. On pistons with internal threads, apply Loctite coarse to the threads and screw piston onto cylinder rod and torque in place.
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 move the piston past the threads in the bore of the cylinder tube.
6. Slide the head gland into the cylinder tube and tighten to the 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. Test to pressure in both directions as directed in steps 2 through 5.

Table 4-8

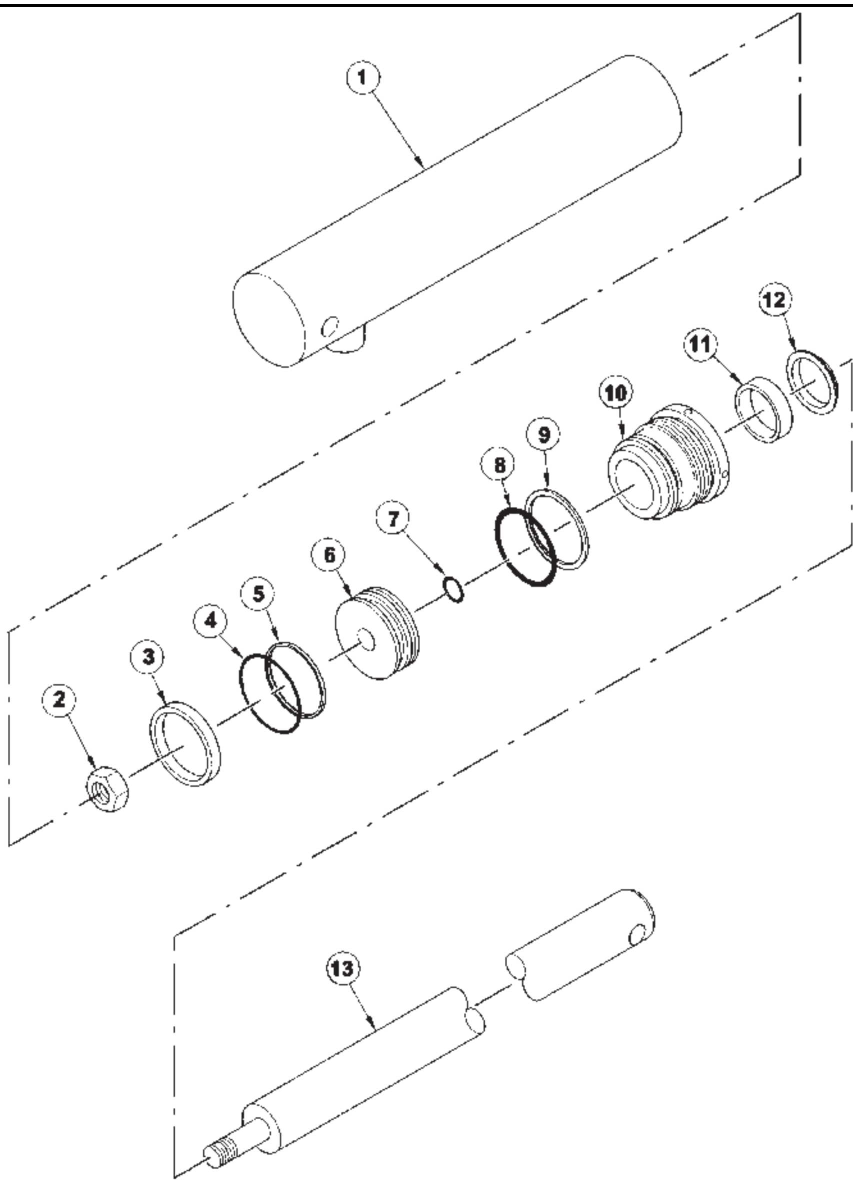
Cylinder	Test Pressure
Lift	34474 kPa (5000 psi)
Telescope	34474 kPa (5000 psi)
Horizontal Outrigger	24131 kPa (3500 psi)
Vertical Outrigger	24131 kPa (3500 psi)

2. Move the cylinder rod through two complete strokes at 5510 kPa (800 psi) to remove air from the cylinder. Look for external leaks. If the pressure difference between cylinder ports is more than 689 kPa (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 5510 kPa (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 (Table 4-8) to the rod port. Hold this pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No internal or external leakage is permitted.
5. Fully extend the cylinder rod. Keep the rod port open. Apply test pressure (Table 4-8) to the base port. Hold this pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No internal or external leakage is permitted.

6. Retract rod and put plugs in the cylinder ports to keep out dirt during installation.

Installation

1. Install the cylinder on the machine using the correct mounting hardware.
2. Connect the hydraulic lines.
3. Lubricate the cylinder pivot grease fittings with recommended grease.
4. Check hydraulic oil level in the hydraulic oil reservoir. Add oil if necessary.



Item	Description
1	Cylinder Tube
2	Nut
3	Wear Ring*
4	O-ring*
5	Piston Seal*
6	Piston
7	O-ring*
8	O-ring*
9	Back-Up Ring*
10	Head
11	Rod Seal*
12	Wiper*
13	Rod

* Included In Seal Kit

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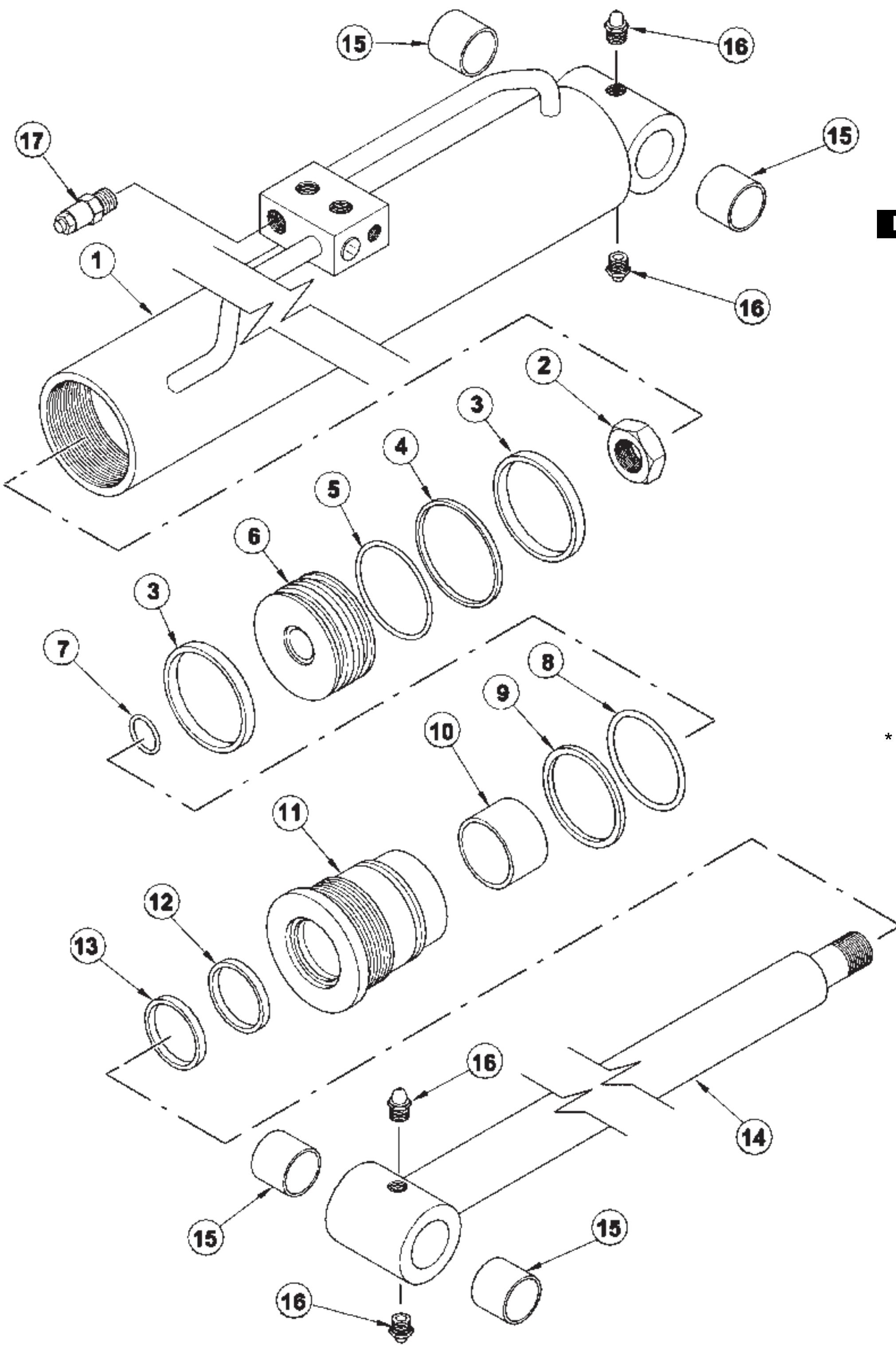
Rear Axle Lockout Cylinder

FIGURE 4-53



Item	Description
1	Cylinder Tube
2	Nut
3	Wear Ring (2)*
4	Seal*
5	Loader*
6	Piston
7	O-ring*
8	O-ring*
9	Back-Up Ring*
10	Wiper Ring*
11	Gland
12	Seal*
13	Wiper*
14	Rod
15	Bushing (4)
16	Grease Fitting (4)
17	Counterbalance Valve

* Included In Seal Kit

Lift Cylinder

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FIGURE 4-54

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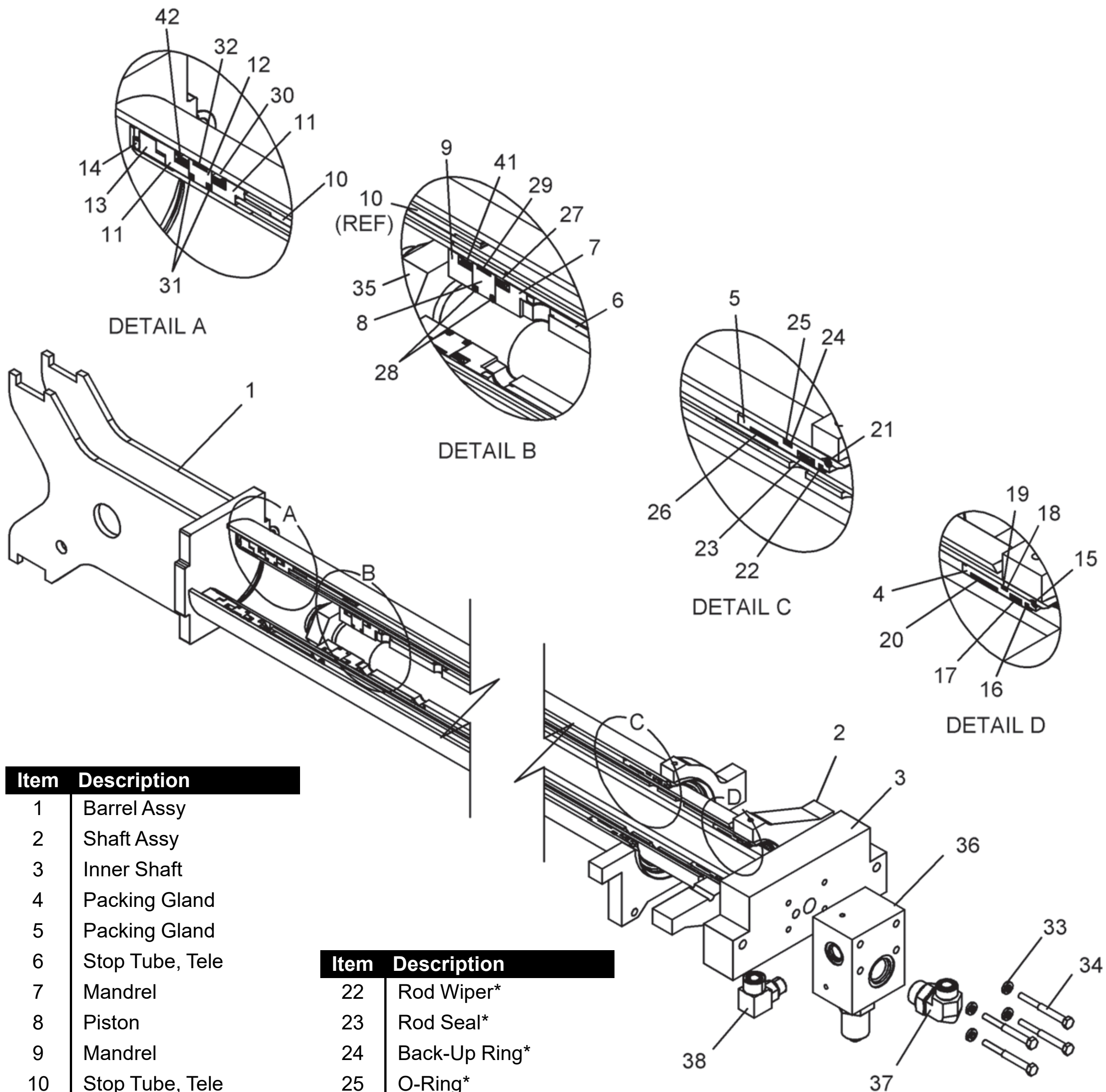

Item	Description
1	Barrel Assy
2	Shaft Assy
3	Inner Shaft
4	Packing Gland
5	Packing Gland
6	Stop Tube, Tele
7	Mandrel
8	Piston
9	Mandrel
10	Stop Tube, Tele
11	Mandrel (2)
12	Piston
13	Round Nut
14	Set Screw
15	Retaining Ring
16	Rod Wiper*
17	Rod Seal*
18	Back-up Ring*
19	O-Ring*
20	Wear Ring*
21	Retaining Ring

Item	Description
22	Rod Wiper*
23	Rod Seal*
24	Back-Up Ring*
25	O-Ring*
26	Wear Ring*
27	Piston Seal*
28	O-Ring*
29	Wear Ring*
30	Piston Seal*
31	O-Ring*
32	Wear Ring*
33	Lock Washer 3/8" (4)
34	Cap Screw, 3/8" (4)
35	Locknut
36	Holding Valve Assy

Item	Description
37	90° Elbow Assy
38	90° Elbow Assy
41	Piston Seal*
42	Piston Seal*

* Included In Seal Kit

Telescope Cylinder

FIGURE 4-55

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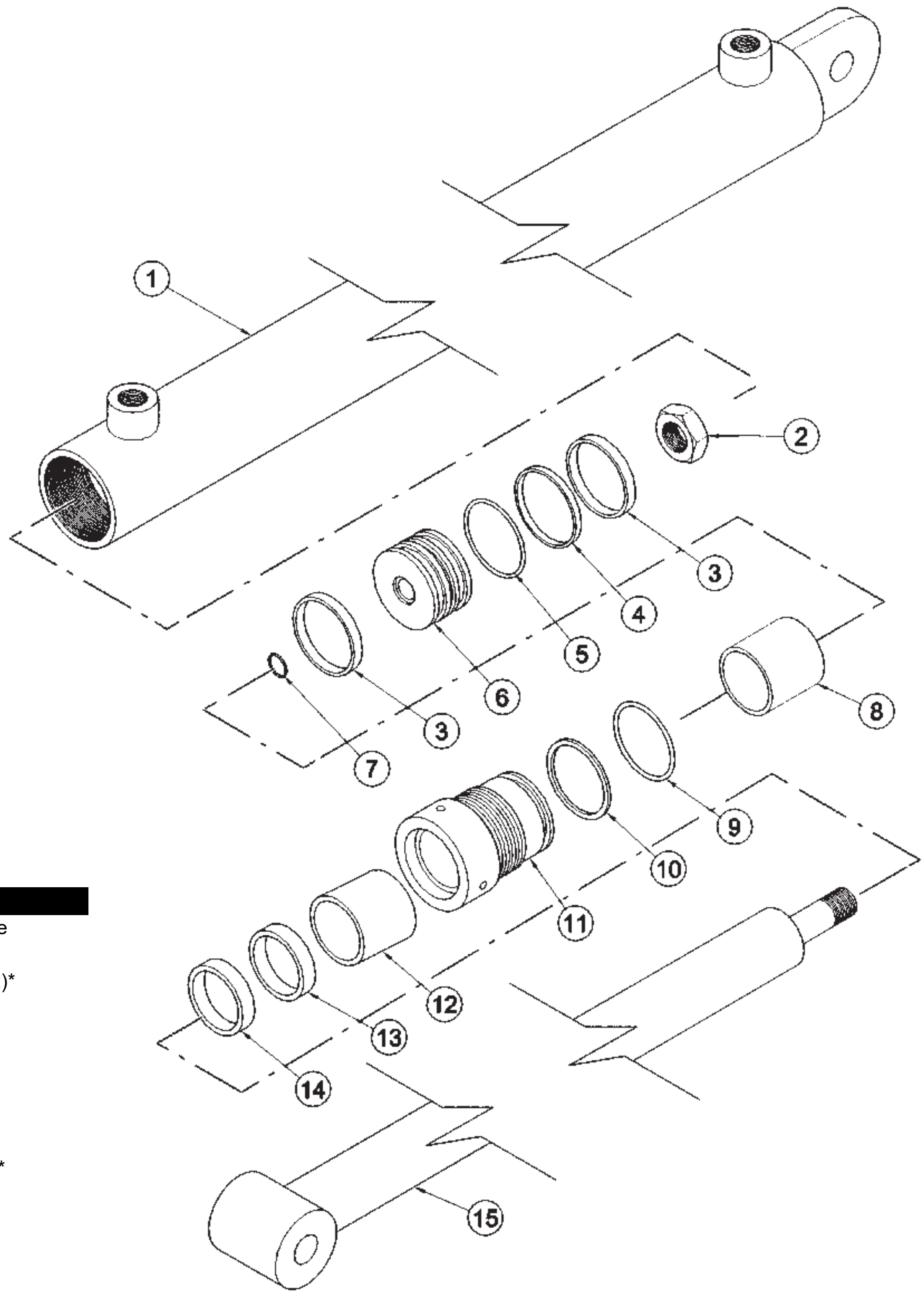


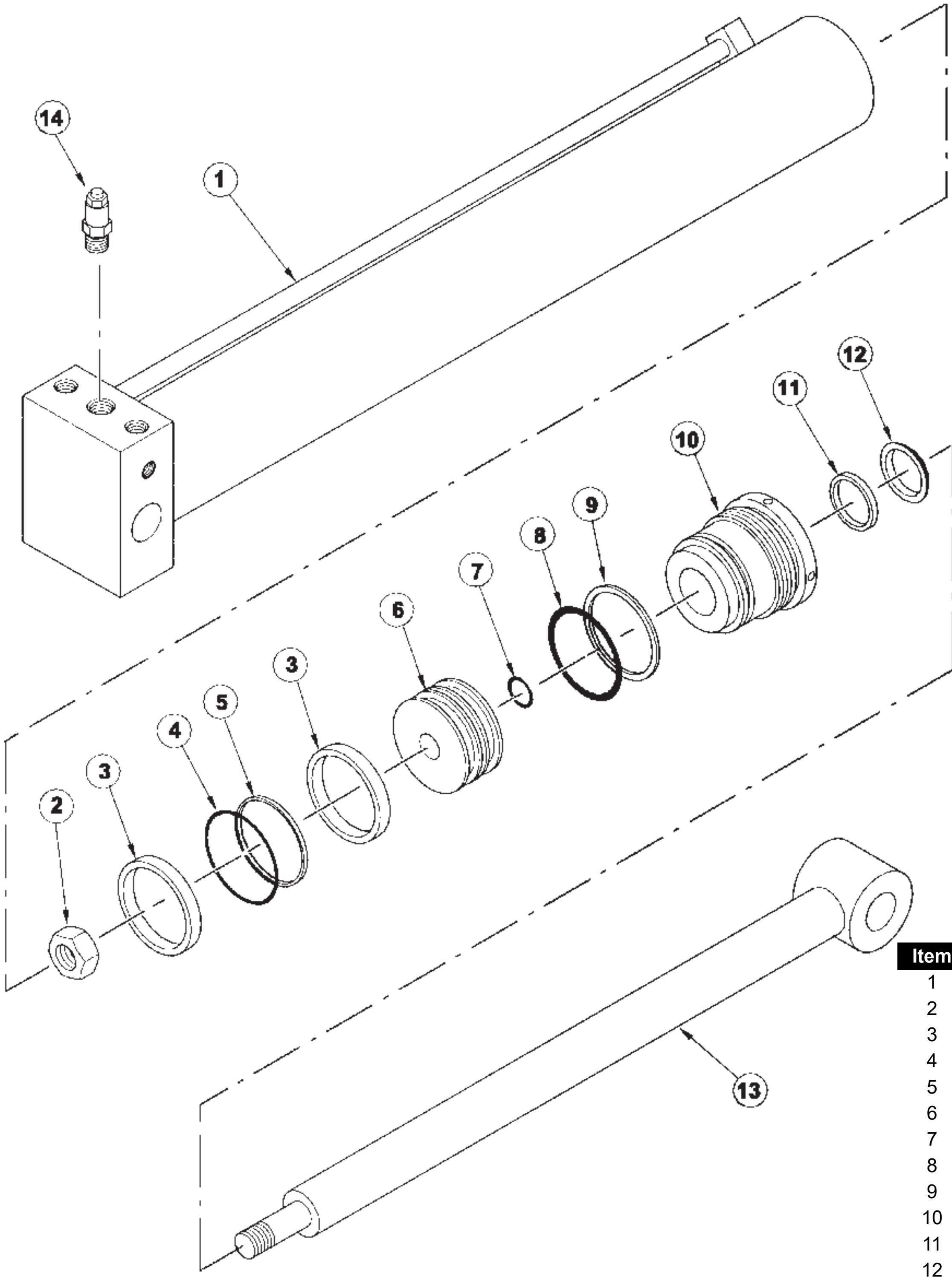
Item	Description
1	Cylinder Tube
2	Nut
3	Wear Ring (2)*
4	Poly Ring*
5	O-ring*
6	Piston
7	O-ring*
8	Spacer
9	O-ring*
10	Backup Ring*
11	Head
12	Wear Ring*
13	U-Cup*
14	Rod Wiper*
15	Rod

* Included In Seal Kit

a4144

Horizontal Outrigger Cylinder

FIGURE 4-56



Item	Description
1	Cylinder Tube
2	Nut
3	Wear Ring (2)
4	O-ring
5	Piston Seal*
6	Piston
7	O-ring*
8	O-ring*
9	Back-Up Ring*
10	Gland
11	Rod Seal*
12	Wiper*
13	Rod*
14	Counterbalance Valve

* Included In Seal Kit

Vertical Outrigger Cylinder

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FIGURE 4-57

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SECTION 5
PREVENTATIVE MAINTENANCE

SECTION CONTENTS

5

INTRODUCTION

WARNING

Explosion, Burn and Personal Injury Hazard!

Do not use gasoline or other flammable fluids to clean component parts. Fire or explosion may occur causing 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 inhibit 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 machine. Decrease these intervals if the machine 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 applications, plus a regulation for construction applications in forest covered, brush covered, or grass covered lands.

WIRE ROPE

General

The following information is a compendium of information 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).

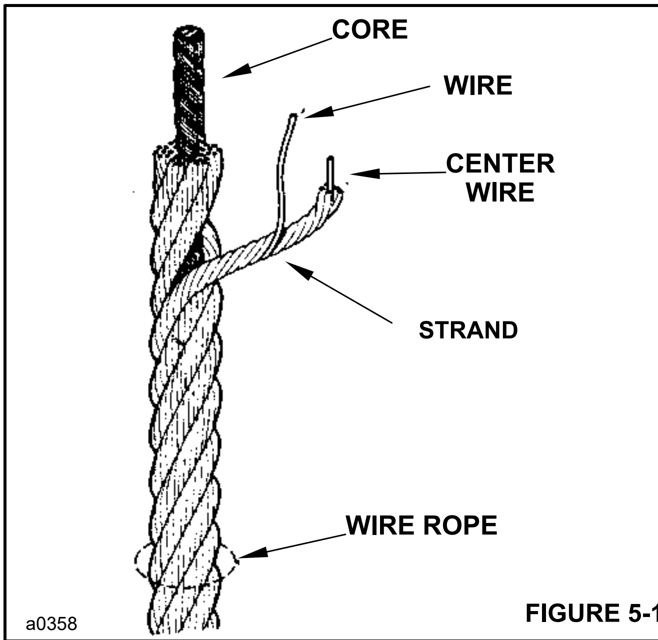


FIGURE 5-1

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 rope's life expectancy. Examples of this type of loading are listed below.

- High velocity movement e.g.; hoisting or swinging of a load followed by abrupt stops.
- Suspending loads while traveling over irregular surfaces such as railroad tracks, potholes, and rough terrain.
- 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:

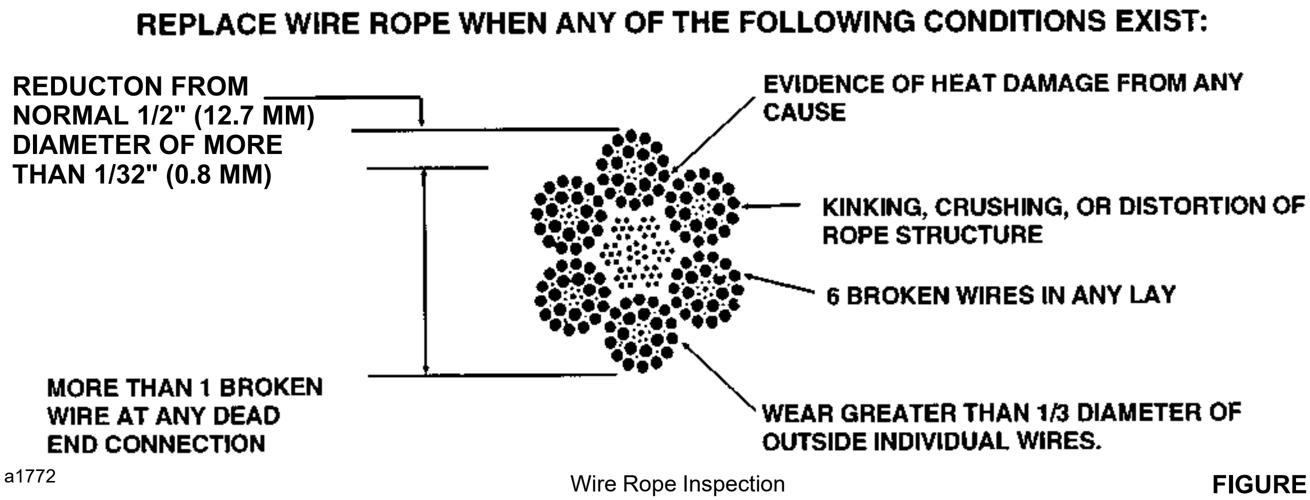
- It should be free from acids and alkalis.
- It should have sufficient adhesive strength to remain on the ropes.
- It should be of a viscosity capable of penetrating the interstices between wires and strands.
- It should not be soluble in the medium surrounding it under the actual operating conditions (i.e. 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

Inspect entire length of wire rope for any conditions listed in Figure 5-2. 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.



Wire Rope Inspection **FIGURE 5-2**

- Always lock out equipment power when removing or installing wire rope assemblies.
- Always use safety glasses for eye protection.
- Wear protective clothing, gloves, and safety shoes as appropriate.
- Use supports and clamps to prevent uncontrolled movement of wire rope, parts, and equipment.
- When replacing fixed length cable assemblies (e.g. 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.
- Replace an entire wire rope assembly. Do not attempt to rework damaged wire rope or wire rope ends.
- Never electroplate wire rope assemblies.
- 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.
- 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.
- On systems equipped with two or more wire rope assemblies operating as a matched set, they shall be replaced as an entire set.
- Do not paint or coat wire ropes with any substance except approved lubricants.
- Measure the rope's diameter across crowns (1) of the strands when determining if rope has become damaged (Figure 5-3).

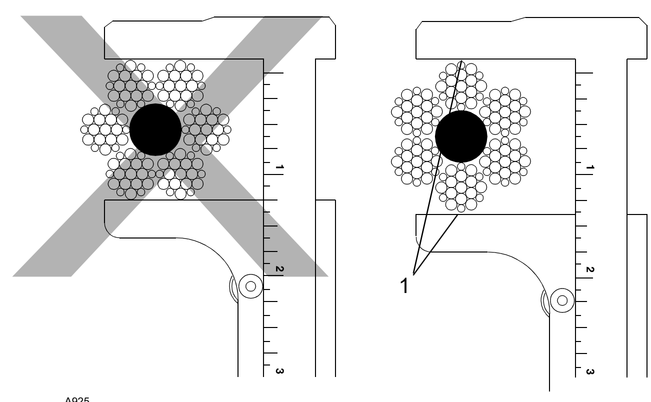


FIGURE 5-3

- When checking for broken wires (5) (Figure 5-4) relax the rope, move it off "pick-up points", and flex it as much as possible. Defect in the rope is spoke of in relations to "Lay Length" (2) which is the distance measured along rope in which one strand (3) makes one complete revolution around core (4).

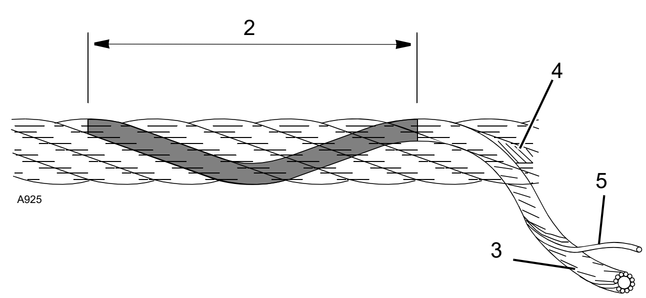


FIGURE 5-4

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 machine to machine 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 Product Support.

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, Bird caging, Reduction of diameter, etc.
- General corrosion.
- Broken or cut strands.
- Number, distribution and type of broken wires.
- Evidence of core failure.
- End fitting wear/abrasion.
- Pay particular attention to areas of the rope where wear and other damage is likely to occur:
- Pick-up Points: Sections of wire rope that are repeatedly stressed during each lift, such as those sections in contact with sheaves.
- End Attachments: The point where a fitting is attached to the wire rope or the point where the wire rope is attached to the drum.
- Abuse Points: The point where the wire rope is subjected to abnormal scuffing and scraping.

Periodic Inspection

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

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

Wire Rope Inspection—Boom Extension and Retraction Cables

Periodic Inspection

If the boom has not been disassembled and inspected in the last five years or 3,000 hours of use, the boom is to be completely torn down to allow a thorough inspection of the extend and retract cables, sheaves, and pins.

he inspection shall cover the entire length of the extension and retraction cables of a disassembled boom prior to reassembly.

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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.

NOTE: Extending and/or retracting the boom may be required to access visual inspection holes.

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

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

Wire rope replacement should be determined by the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies and as recommended by 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:

- Kinking, crushing, bird caging, 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 percent.
- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
- 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 5-5), 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.

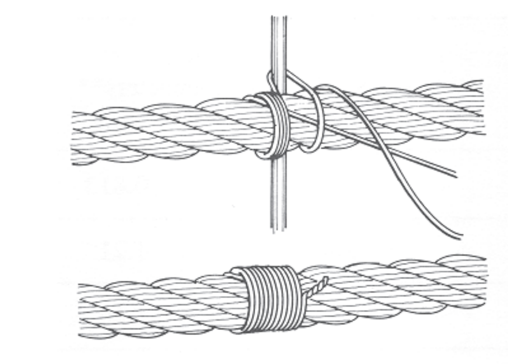
FIGURE 5-5

Method 2

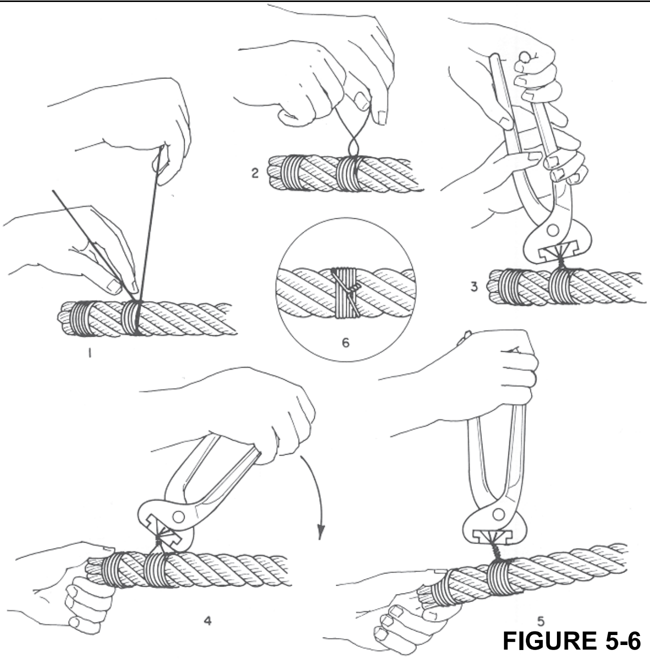

FIGURE 5-6

Wind a length of soft annealed wire (Figure 5-6) 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 5-7) should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).

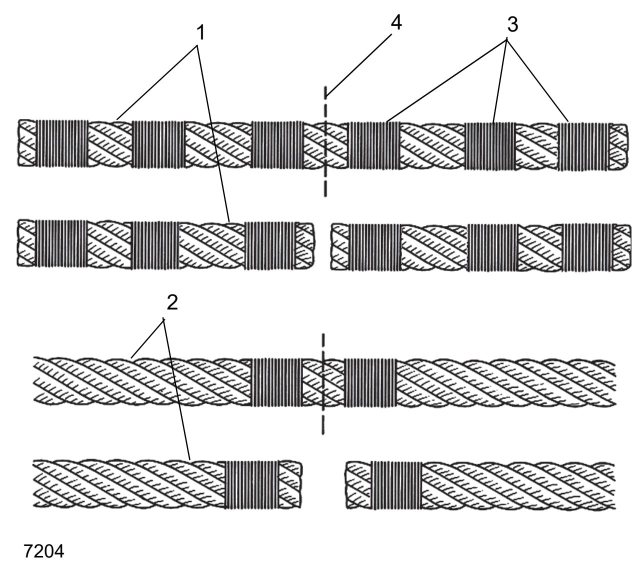

FIGURE 5-7

LUBRICANTS

It is not the policy of Industrial crane product support to publish lists of approved lubricants or guarantee lubricant performance. The responsibly for the quality rests completely with the distributor or manufacturer of the lubricant.

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

MAINTENANCE RECORDS

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

SPECIAL MAINTENANCE

Delivery Inspection

Item	Action
Fuel Tank	Fill with correct fuel. Fill if level is low.
Engine	Check oil in crankcase. Fill if level is low. Remove water from fuel filters.
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 lubricant level. Fill if level is low.
Tires	Check tires for correct air pressure.
Wire Rope Cable Clamps and Connections	Check for loose or missing parts.
Anti-Double Block System	Check that the system is working properly.
Controls	Check that all controls are working properly.

After First 50 Hours of Operation (New Cranes)

Item	Action
Engine	Change the engine oil and filter.
Transmission	Change the transmission oil filter.
Swing Gearbox	Check and tighten mounting bolts.
Hoist Gearbox	Check and tighten mounting bolts.
Swing Gear Pinion and Swing Gear	Lubricate.
Grease Fittings	Apply grease to all grease fittings.
Boom Wear Pads	Lubricate.
Wheel Mounting Nuts	Check Torque.

After First 100 Hours of Operation (New Cranes)

Item	Action
Hoist Gearbox	Change lubricant.

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.

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PREVENTIVE MAINTENANCE

Maintenance Schedule and Checklist

CAUTION

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

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

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

Service/Check	Interval						
	Daily Before Operation	50 Hours (Weekly)	100 Hours (Two Weeks)	250 Hours (Monthly)	500 Hours (Three Months)	1000 Hours (Six Months)	2000 Hours (Yearly)
Inspect the Anti-Double Blocking System	X						
Inspect the Wire Rope	X						
Inspect the Reeving, Clamps, and Connectors	X						
Inspect the Lifting Hook	X						
Inspect Safety Belt	X						
Inspect Safety Decals	X						
Check Parking Brake	X						
Check Backup Alarm	X						
Check Horn	X						
Check Beacon Lights	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/ Water Separator	X						

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Service/Check	Interval						
	Daily Before Operation	50 Hours (Weekly)	100 Hours (Two Weeks)	250 Hours (Monthly)	500 Hours (Three Months)	1000 Hours (Six Months)	2000 Hours (Yearly)
Check Air Cleaner Restriction Indicator	X						
Check Hydraulic Oil Level	X						
Inspect Wire Rope and Sheaves		X					
Apply Grease to All Lubrication Fittings		X					
Lubricate the Boom Wear Pads		X					
Lubricate the Internal Cable Sheaves		X					
Check Hoist Gearbox Lubrication Level		X					
Clean Air Cleaner Vacuator Valve		X					
Cylinder Rods Surface Protection		X					
Inspect the Engine Fan Belts			X				
Check Wheel Nut Torque			X				
Lubricate the Swing Gear and Pinion				X			
Lubricate the Wire Rope				X			
Inspect All Hydraulic Hoses				X			
Replace the Engine Crankcase Oil[1]				X			
Replace the Engine Oil Filter[1]				X			
Clean Radiator Fins and Core				X			
Clean Battery and Connections				X			
Torque Critical Fasteners				X			
Check Axle Wheel Hub Lubricant Level (4 places)					X		
Check Axle Housing Lubricant Level (2 places)					X		
Check Swing Gearbox Lubricant Level					X		
Lubricate the Outrigger Slides					X		
Replace Fuel Filter/Water Separator Elements					X		
Replace the In-line Fuel Filter					X		
Replace Transmission Oil Filter					X		
Inspect the Parking Brake Pads					X		
Inspect Tires for Damage					X		
Add Rust Inhibitor to Engine Cooling System					X		
Replace the Air Cleaner Element[1]					X		

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Service/Check	Interval						
	Daily Before Operation	50 Hours (Weekly)	100 Hours (Two Weeks)	250 Hours (Monthly)	500 Hours (Three Months)	1000 Hours (Six Months)	2000 Hours (Yearly)
Check Swing Gear to Pinion Backlash						X	
Replace the Transmission Oil						X	
Replace the Axle Wheel Hub Lubricant (4 places)						X	
Replace the Axle Housing Lubricant (2 places)						X	
Replace the Hoist Gearbox Lubricant						X	
Replace the Swing Gearbox Lubricant						X	
Replace the Hydraulic Oil						X	
Replace the Hydraulic Oil Filter						X	
Replace the Engine Coolant							X
Inspect the Crane Structure and Booms for Damage							X
Test the Rated Capacity Limiter Option							X

1 Under extremely dusty conditions, the engine oil and filter, as well as the air cleaner element, may require replacement more frequently.

5

LUBRICANT SYMBOLS

Lube Symbol	Description	Specification
EP-MPG	EP-MPG- Multipurpose Grease	A6-829-003477
AFC	AFC- Anti-freeze/coolant	A6-829-101130
HYDO	Hydraulic Oil	A6-829-006444
EO-15w-40	EO-15w-40- Engine Oil	A6-829-104182
ASC	Anti-Seize Compound	A6-829-003689
EP-OGL	Open Gear Lube Ceplattyn 300 Spray	A6-829-102971
AGMA EP-4	AGMA EP-4 Gear Lubricant	A6-829-100213

LUBRICATION POINTS

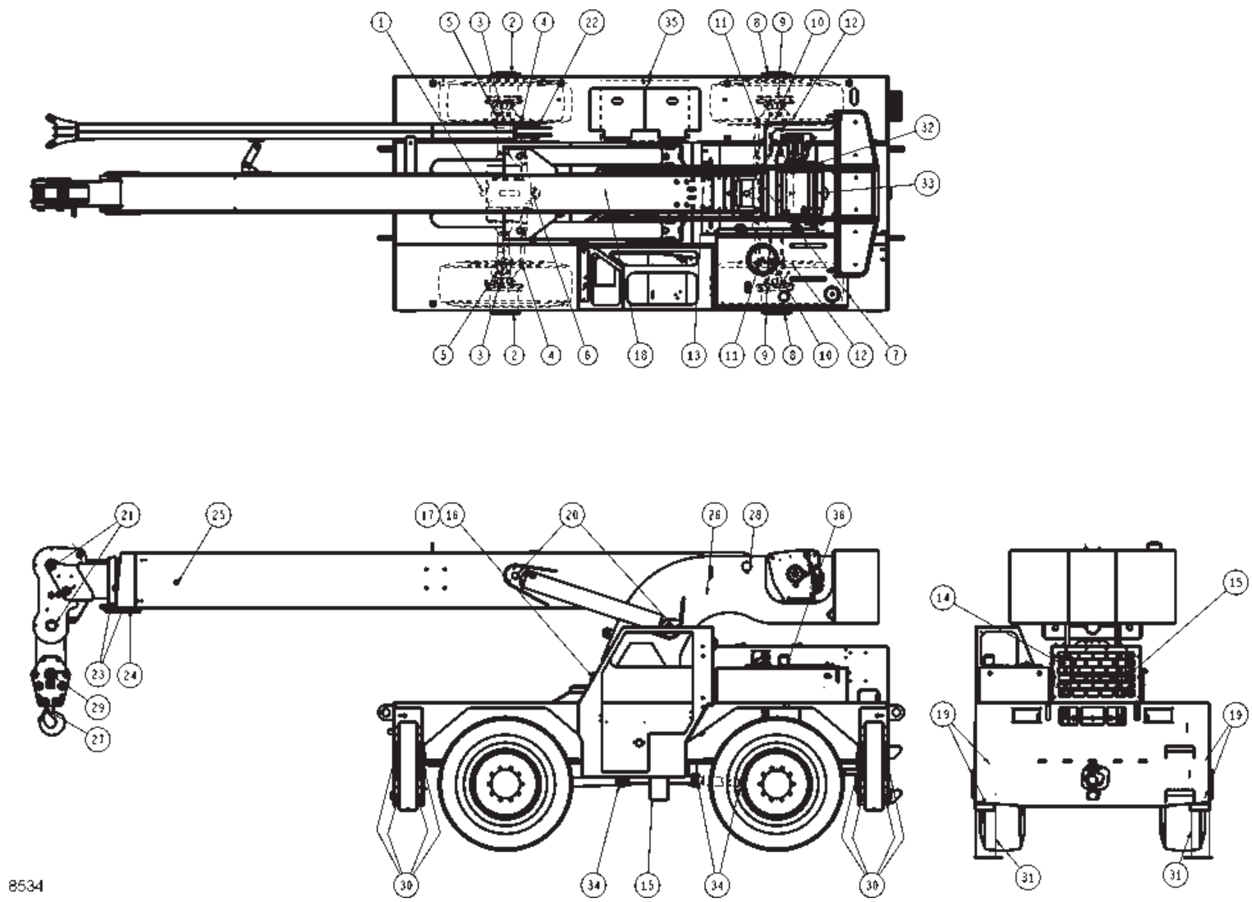

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FIGURE 5-8

No	Location Name	Capacity	Symbol	Instruction
Front Drive/steer Axle				
1	Differential	4.8 Gal (18.0 Liters)	HYDO	
2	Planetary Hub Gears	2.1 Qts (2.0 Liters)	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	4.8 Gal (18.0 Liters)	HYDO	
8	Planetary Hub Gears	2.1 Qts (2.0 Liters)	HYDO	

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No	Location Name	Capacity	Symbol	Instruction
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	8.6-11.6 Qts (8.1-11.0 L)	EO-15W-40	See Note 2
14	Engine Coolant	4.3 Gal (22.7 L)	AFC	See Notes 1 & 7
15	Transmission	6.0 Gal (22.7 L)	HYDO	
Turntable				
16	T/T Gear Box		AGMA EP-4	
17	T/T Gear & Pinion		EP-OGL	
18	T/T Bearing		EP-MPG	
Cylinders				
19	Outrigger Cylinder		ASC	
20	Lift Cylinder		EP-MPG	
Boom				
21	Boom Nose Sheaves		EP-MPG	
22	Jib Boom Sheave		EP-MPG	
23	Boom Sections		EP-MPG	See Note 6
24	Tele Cylinder Wear Pads		EP-MPG	
25	Boom Extension Sheave		EP-MPG	
26	Boom Ret Sheave		EP-MPG	
27	Hook Block Swivel Bearing		EP-MPG	
28	Boom Pivot Shaft		EP-MPG	
29	Hook Block Sheaves		EP-MPG	
Outriggers				
30	Slide Box		EP-MPG	See Note 4
31	Jack Tube		EP-MPG	See Note 5
Hoist				
32	Hoist Winch	11.0 Pts (5.4 Liters)	AGMA EP-4	
33	Cable Follower		EP-MPG	
Misc.				
34	Driveline Joints		EP-MPG	
35	Fuel Tank	50.0 Gal (189.0 Liters)		
35	Hydraulic, Oil Tank	55.3 Gal (209.3 Liters)	HYDO	See Notes 2 & 3

5

Notes:

1. A mixture of 50% AFC and 50% water is required for all standard units.
2. Final fluid levels shall be adjusted by use of dip sticks, markings or filler plugs.
3. The hydraulic oil shall be filtered through a 10-micron (absolute) filter.
4. Both sides.
5. All sides.
6. Lubricate all surfaces in contact with wear pads.
7. Engine coolant capacity listed is the combined capacity for coolant in the engine and radiator.

BEARING GREASE LUBRICATION POINTS

Apply grease to the following fittings after every 50 hours of operation. Use a Lithium Base, E.P. No.2 bearing grease or equivalent. Apply enough grease to remove the old grease.

Booms and Main Frame

Location	Qty
Mast Bearing (See Figure 5-9)	2
Swing Gearbox Bearing (See Figure 5-10)	1
Boom Head Sheaves and Pivot (See Figure 5-11)	2
Lift Cylinder (2) Pivots (See Figure 5-12)	4

Drive Train

Location	Qty
Steering Knuckles - Front and Rear Axles (See Figure 5-13)	8
Steering Cylinder Pivot Ends - Front and Rear Axles (See Figure 5-14)	4
Drive Shaft - Front Axle (See Figure 5-15) No routine lubrication is required. Lubricate only after major axle overhaul.	2
Drive Shaft - Rear Axle (See Figure 5-16) No routine lubrication is required. Lubricate only after major axle overhaul.	2
Axle Pivot - Front and Rear Axles (See Figure 5-17)	4

Optional Equipment and Accessories

Location	Qty
Drop Block (See Figure 5-18)	1
Jib Boom Head Sheave (See Figure 5-19)	1
Jib Boom Deflector Sheave (See Figure 5-20)	1

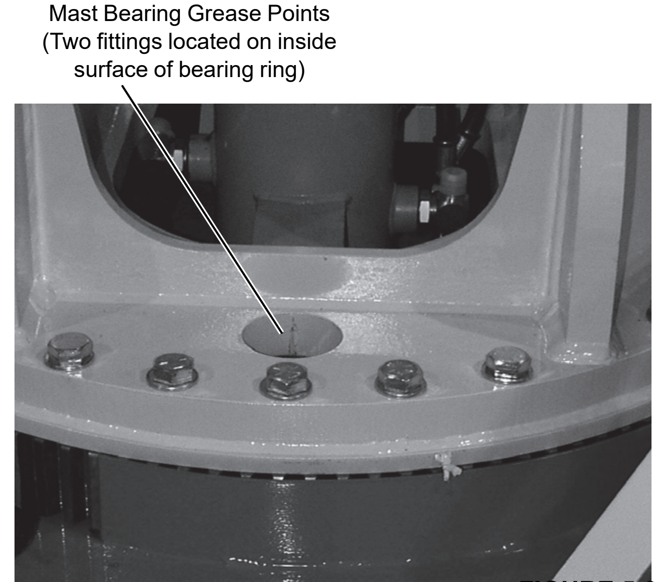

FIGURE 5-9

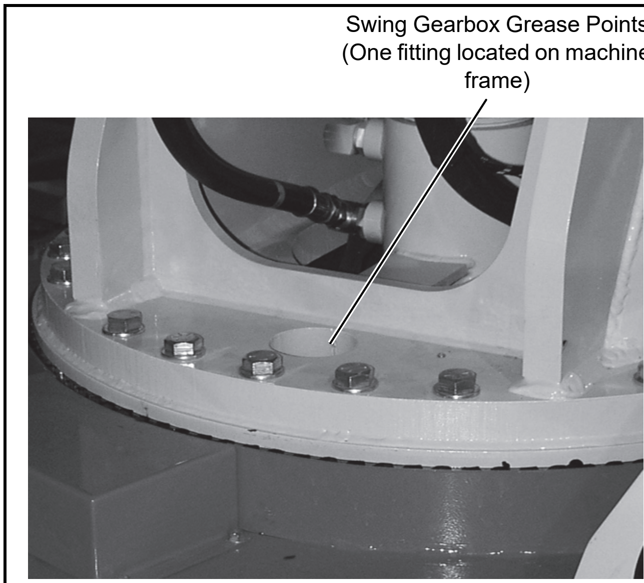

FIGURE 5-10

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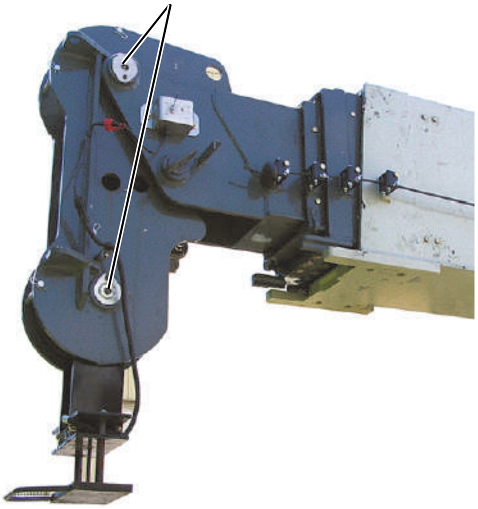

FIGURE 5-11

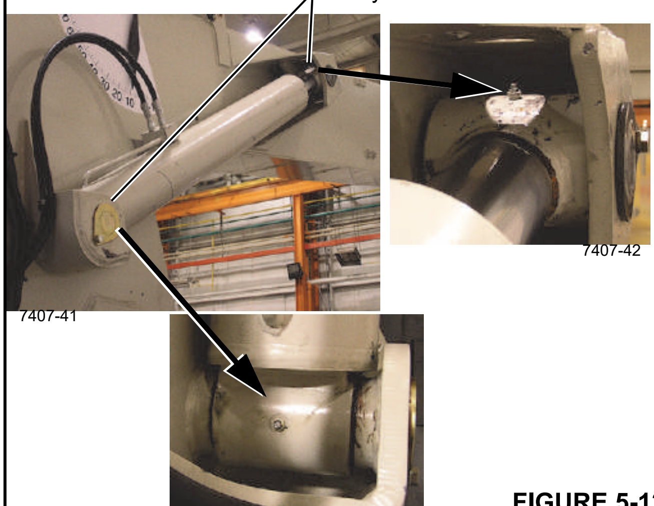

FIGURE 5-12

FIGURE 5-13

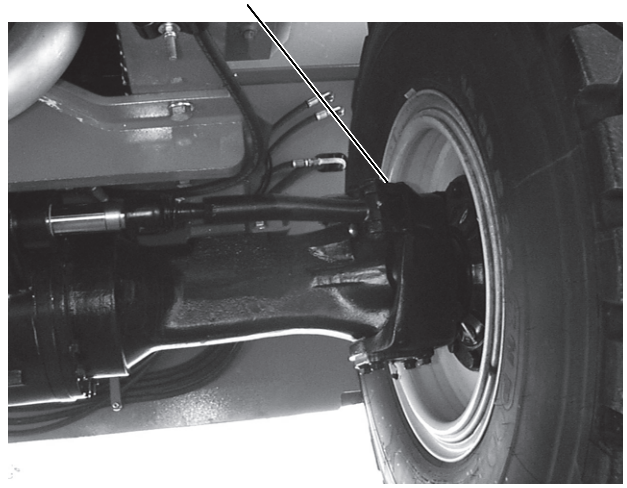

FIGURE 5-14

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Front Axle Drive Shaft Grease Points - Three Lube Fittings

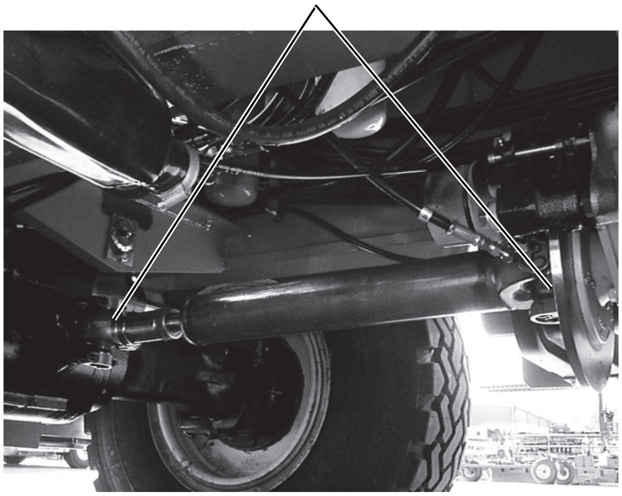

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FIGURE 5-15

Rear Axle Drive Shaft Grease Points - Three Lube Fittings

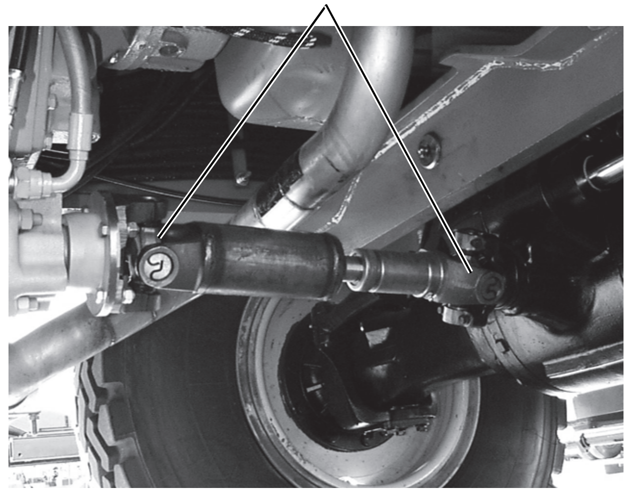

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FIGURE 5-16

Axle Pivot Grease Points - Front and Rear Axles

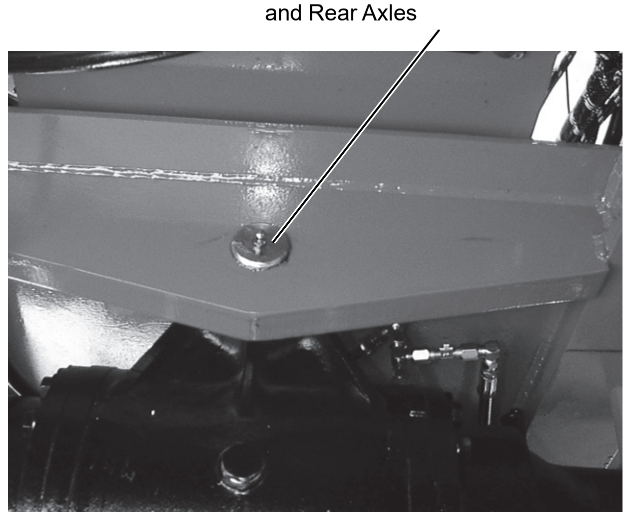

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FIGURE 5-17

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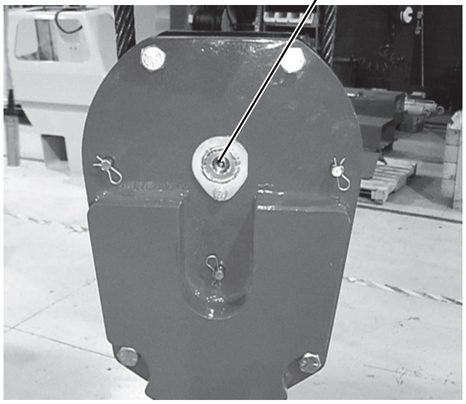

FIGURE 5-18

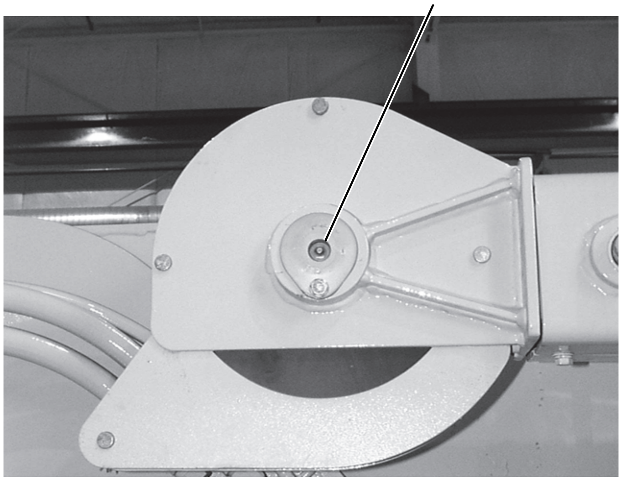

FIGURE 5-19

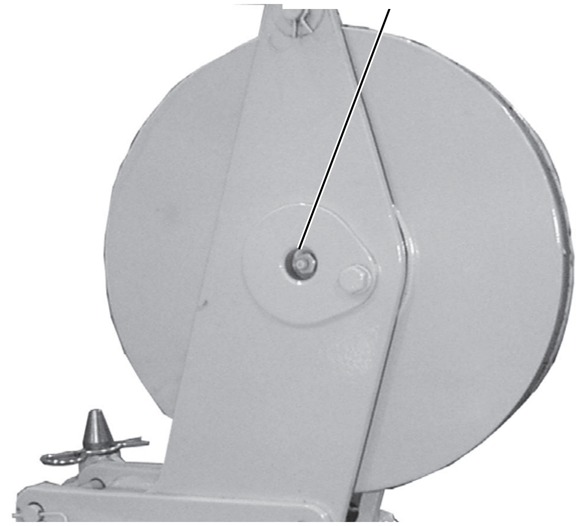

FIGURE 5-20

DAILY WALK-AROUND INSPECTION

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

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

Inspections

Check 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 touches 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 should stop.

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

Inspect the Wire Rope

Each day before beginning operation, visually inspect the wire rope for damage. See *50 Hours of Operation (Weekly)*, page 5-22 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 changed out for 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.

DANGER

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 is found. Only after correcting the problem should the crane be put back in service.

Inspect the Lifting Hook

DANGER

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:

- Safety belt
- Safety decals
- Parking brake
- Backup alarms
- Horn
- Beacon lights.

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

Check Controls Operation

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

Component/System Checks

Check Fuel Level

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

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

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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.

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

w0033

Checking the Engine Crankcase Oil Level

1. Level the crane, engage the parking brake, rotate the boom to the side and shut off the engine.
2. Lift the engine compartment cover.
3. Remove the engine oil dipstick and check the oil level. Oil should be present 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 only when the oil is at normal operating temperature (82° to 93°C [180° to 200°F])
2. Level the crane, engage the parking brake and let the engine run at idle speed.
3. Remove the transmission dipstick (Figure 5-21) and check the oil level. Oil should be at the FULL mark on the dipstick.
4. Install the dipstick.
5. If the oil is low, add recommended oil to bring the level up to the full mark on the dipstick.
6. Shut off the engine.

Transmission Level Dipstick

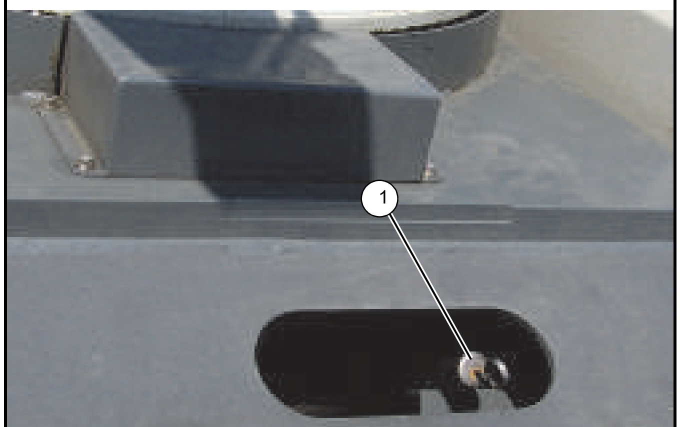

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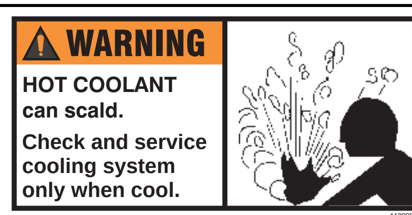
FIGURE 5-21

Check the Engine Coolant Level



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Never remove the radiator cap while the cooling system is hot. Check coolant level only when the coolant temperature is cold. The system is under pressure and the coolant can cause severe burns or eye injury. Wear protective clothing and safety glasses. Always turn the cap slowly to the first stop and allow the pressure to escape before removing the cap completely.

1. Level the crane, engage the parking brake and shut off the engine.
2. Check that the coolant is visible in the sight glass of the overflow reservoir. If coolant is low, add a 50/50 mixture

of glycol antifreeze and water, do not add only water as this could cause rust to form in the radiator and engine.

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

Drain Water from Engine Fuel Filter/Water Separator

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

Check the Hydraulic Oil Level

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

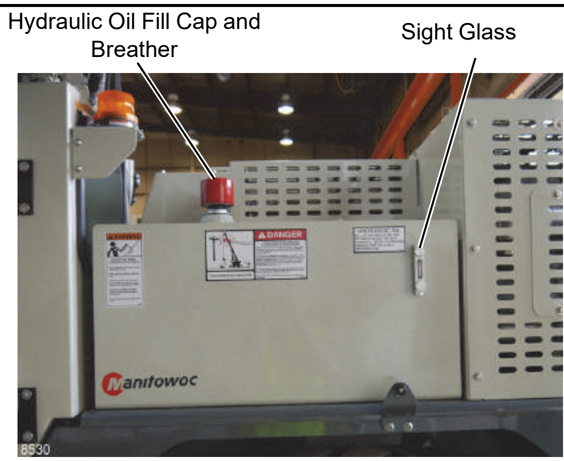

FIGURE 5-22

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1. Be sure the boom is fully retracted and lowered and the outriggers are retracted and up.
2. With the crane on level ground, engage the parking brake and shut off the engine.
3. Visually check the oil level in the sight glass (Figure 5-22). The hydraulic oil should be visible in the sight gauge on the side of the tank. If low, fill the tank with pre-filtered recommended hydraulic oil.

NOTE: The pump used on this crane requires clean hydraulic oil for proper operation. **Contaminated oil can cause damage to the pump.** Before adding any hydraulic oil to the hydraulic system, be sure the oil has been filtered through a 10-micron (absolute), or less, filter.

Check the Tire Pressure

Check the air pressure in the crane's four tires. Correct pressure is 758 kPa (110 psi).

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

Check the Air Cleaner Restriction Indicator

The air cleaner is equipped with a filter restriction indicator (Figure 5-23). The air cleaner element needs replacing if the indicator's colored piston has popped out and is visible when the engine is running at high idle.

To check the visual indicator the engine must be running, but the transmission must be in neutral and the parking brake must be applied.

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

FIGURE 5-23

Remove the Element

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

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

Inspecting the Element

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

Installing the Element

1. Install the safety element in the housing and slide it all the way in.
2. Install the element in the housing and slide it all the way in.
3. Make sure the gasket is seating evenly. If the gasket is not seating evenly for a perfect seal, you won't have protection. Recheck to see if the sealing surface in the housing is clean, or if the element is not the right model number. It may be too short for the housing.
4. Install the air cleaner housing cover with the vacuator valve facing down. Install and tighten the cover clamp.
5. Reset the air cleaner restriction indicator by pushing in the reset button (Figure 5-24).

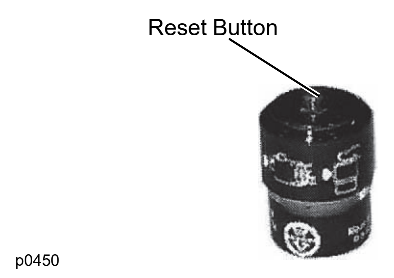

FIGURE 5-24

5

50 HOURS OF OPERATION (WEEKLY)

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

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

Grease Fittings

Lubricate all points indicated under the heading Lubrication Points.

Lubricate the Boom Slides

1. Lower the boom and then extend it to its maximum out position.
2. Engage the parking brake and shut off the engine.
3. Clean the old lubricant from the booms.
4. Apply bronze anti-seize, or equivalent, to the boom sliding surfaces on the boom sections. Only use a small amount of lubricant for best results.
5. Align the boom access holes to gain access to the chain roller bracket and slide pad at the end of the boom telescope cylinder.
6. Apply bronze anti-seize, or equivalent, to the inner boom surface in front of and behind the slide block. Only use a small amount of lubricant for best results. Extend and retract the booms to distribute the lubricant along the slide path.

Check the Hoist Gearbox and Brake Lubricant Levels

1. Lower the boom to its lowest position.
2. Engage the parking brake and shut off the engine.

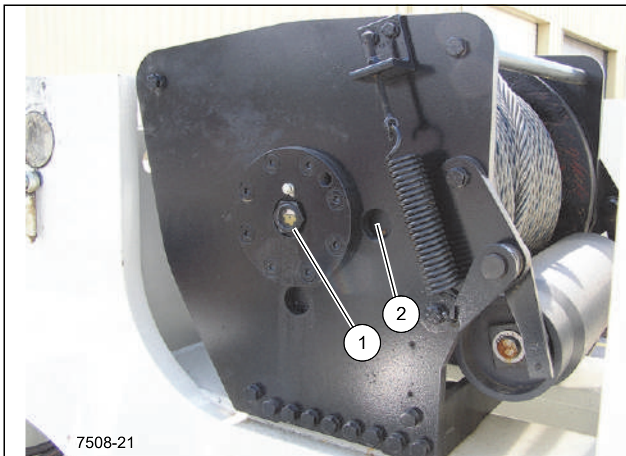

FIGURE 5-25

3. Check the lubricant level. Oil should be visible in the sight glass (1, Figure 5-25).
4. Add the recommended lubrication cited in *Lubrication Points*, page 5-12 if necessary.
   a. Clean around the fill plug (2) and remove the fill plug.
   b. Check the lubricant level. Oil should level with the bottom of the fill plug hole and visible in the sight glass.

DANGER

Do not use EP type gear lube in the brake section of this hoist. EP gear lube may prevent the clutch from locking up, causing the load to fall which could result in property damage, personal injury or death.

5. If necessary, add recommended fluid through the fill plug hole to fill the brake until oil is visible in the sight glass.
6. Clean around the area of the brake breather. Remove the breather and clean it.
7. Reinstall the breather.

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Clean the Air Cleaner Vacuator Valve

Remove the dirt accumulated in the vacuator valve Figure 5-26 by squeezing the bottom of the valve until all dirt and debris is removed. If the vacuator valve is missing or damaged, replace it.

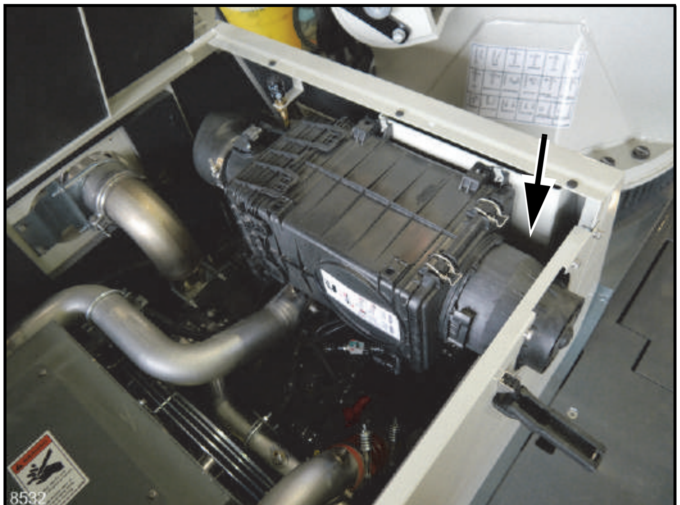


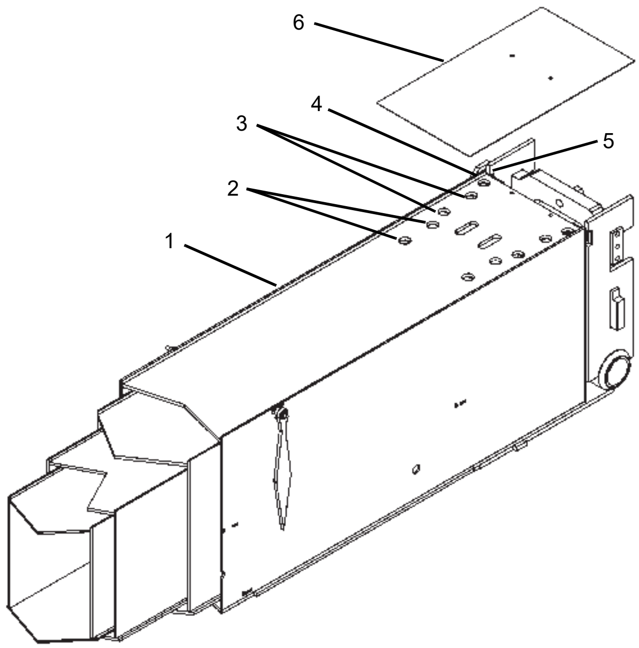
FIGURE 5-26

Surface Protection for Cylinder Rods

Steel cylinder rods include a thin layer of chrome plating on their surfaces to protect them from corroding. However, chrome plating inherently has cracks in its structure which can allow moisture to corrode the underlying steel. At typical ambient temperatures, hydraulic oil is too thick to penetrate these cracks. Normal machine operating temperatures will allow hydraulic oil to warm sufficiently to penetrate these cracks and if machines are operated daily, protect the rods. Machines that are stored, transported, or used in a corrosive environment (high moisture, rain, snow, or coastline conditions) need to have the exposed rods protected more frequently by applying a protectant. Unless the machine is operated daily, exposed rod surfaces will corrode. Some cylinders will have rods exposed even when completely retracted. Assume all cylinders have exposed rods, as corrosion on the end of the rod can ruin the cylinder.

It is recommended that all exposed cylinder rods be protected using Boeshield® T-9 Premium Metal Protectant. Product Support has Boeshield T-9 Premium Metal Protectant available in 12 oz. cans that can be ordered through the Parts Department.

NOTE: Cylinder operation and inclement weather will remove the Boeshield protectant. Inspect machines once a week and reapply Boeshield to unprotected rods.



Item	Description
1	1st Boom Section
2	Access Holes for 4th Section Wear Pad
3	Access Holes for 3rd Section Wear Pad
4	Access Holes for 2nd Section Wear Pad
5	2nd Section Wear Pad
6	Access Plate

FIGURE 5-27

Inner Boom Wear Pad Lubrication

DANGER

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

Refer to Figure 5-27.

1. Fully extend and set the outriggers.
2. With the boom fully retracted, remove the access plate (6) located on the top rear of the 1st section.
3. Apply grease to the wear pads on the top of the 2nd section through the access holes (4) in the 1st section (1) with a grease gun.
4. Extend the boom to line up the access holes on the 2nd section with the wear pads on the 3rd section. Apply grease to the 3rd section wear pads (3) with a grease gun.
5. Extend the boom to line up the access holes on the 3rd section with the wear pads on the 4th section. Apply grease to the 4th section wear pads (2) with a grease gun.
6. Raise the boom to at least 75°.
7. Extend the boom about 1/3 and retract to spread the grease.
8. Repeat steps 3 - 6. Extend the boom about 2/3 and retract to spread the grease.
9. Repeat steps 3 - 5. Fully extend and retract the boom to spread the grease.

Side and Bottom Boom Wear Pad Lubrication

1. Fully extend and set the outriggers.

NOTE: A fully extended boom at horizontal needs to have an assist from a crane or forklift to retract. Lift the front of the boom enough to relieve pressure on the bottom wear pads. This should be sufficient for the boom to retract.

2. Lower the boom to horizontal.
3. Fully extend the boom and apply grease to the side and bottom of the 2nd, 3rd, and 4th sections with a brush.
4. Extend and retract the boom several times until the grease is evenly spread.
5. Repeat steps 3 and 4 as necessary to ensure the boom is fully lubricated.

Internal Cable Sheave Lubrication

DANGER

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

A grease gun adapter is required to lubricate the internal sheaves. The required needle grease gun fitting is:

- A 6.35 mm (0.25 in) diameter nozzle grease gun tip (P/N 955045). Contact Product Support to obtain this tip.

Lubrication of the extend and retract sheaves is as follows:

1. Extend the boom until the grease access holes on the side of the 2^{nd} and 3^{rd} sections are lined up.
2. Lubricate the pin for the extend cable sheaves until a small amount of grease extrudes from the pin. From in front of the boom, look back through the sheave case at the pin to determine the amount of grease.
3. This position also aligns the access holes in the rear of the 1^{st} and 2^{nd} sections for lubrication.
4. Lubricate the pins for the retract sheaves until a small amount of grease extrudes from the sheave pins. From in back of the boom, look up through the hoist mount at the pins to determine the amount of grease.

100 HOURS OF OPERATION (TWO WEEKS)

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

w0021

Belts that are too loose see excessive vibration and increased wear. Belts that are too tight produce 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 or intersecting cracks should be replaced. See Figure 5-28.

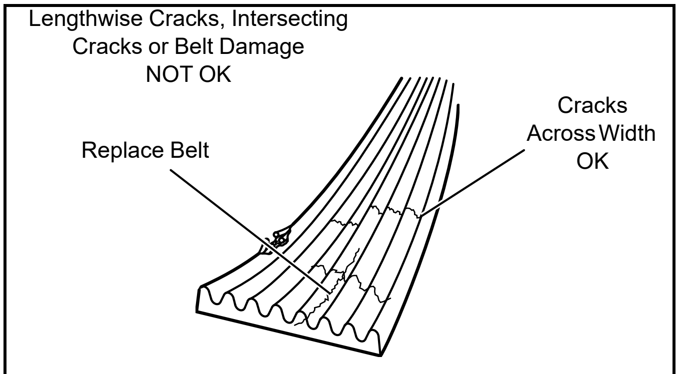


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FIGURE 5-28

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 the Wheel Nut Torque

Check the torque on each wheel nut in a crisscross pattern. Wheel nut torque is 499 Nm (368 lb-ft).

250 HOURS OF OPERATION (MONTHLY)

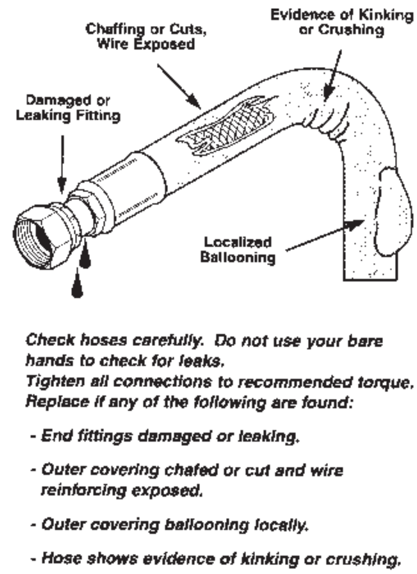
NOTE: You must read and understand the warnings and basic safety rules, found in *Section 2, Safety Practices*, before performing any operation or maintenance procedures.

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

Inspect the Hydraulic Hoses

w0017

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.



a0591

Clean the Batteries and Cables

w0019

1. Open the battery compartment cover to gain access to the batteries (1, Figure 5-29).
2. Tighten all battery hardware to keep the batteries securely in place.
3. Disconnect the battery cables.
4. Sprinkle the top of the batteries with baking soda. Apply water to wash the baking soda from the batteries. Be careful not get any of the solution into the batteries.
5. Clean the battery posts and cable ends with a battery brush.

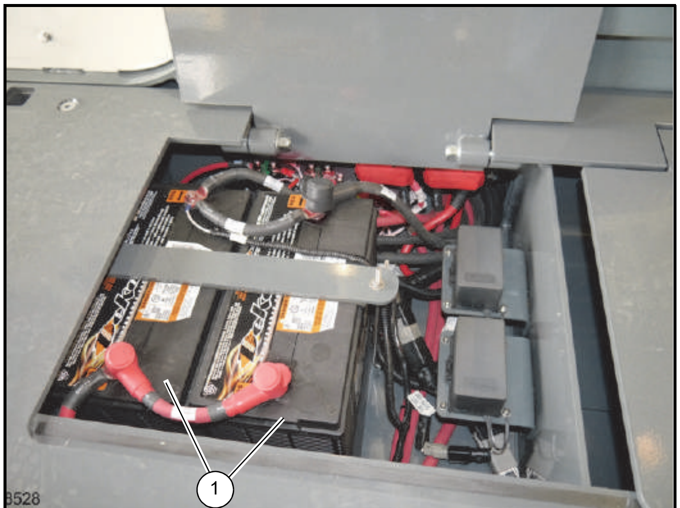


FIGURE 5-29

6. Coat the battery posts with petroleum jelly and reinstall the battery cables.

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. Be sure the wire rope is clean and dry before applying the lubricant.
3. Apply a good grade spray wire rope lubricant to the entire length of the wire rope. If a wire rope lubricant is not available, a light weight engine oil may be used. Preheated oil (15.6° to 37.8°C [60° to 100°F]) can be used to provide better penetration of the oil into the wire rope. Use brush or cloth to apply the oil.

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

Lubricate the Swing Gear and Pinion

1. Engage the parking brake and shut off the engine.
2. Remove the guard covering the swing pinion.
3. Using a brush, apply open gear lube to the pinion and swing gear teeth (1, Figure 5-30).

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

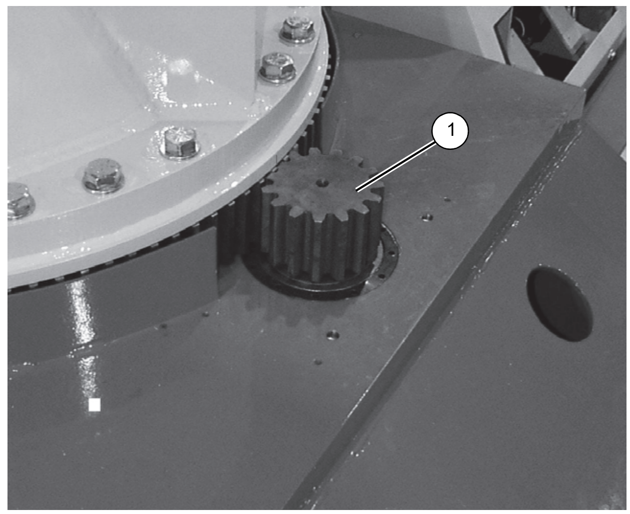


FIGURE 5-30

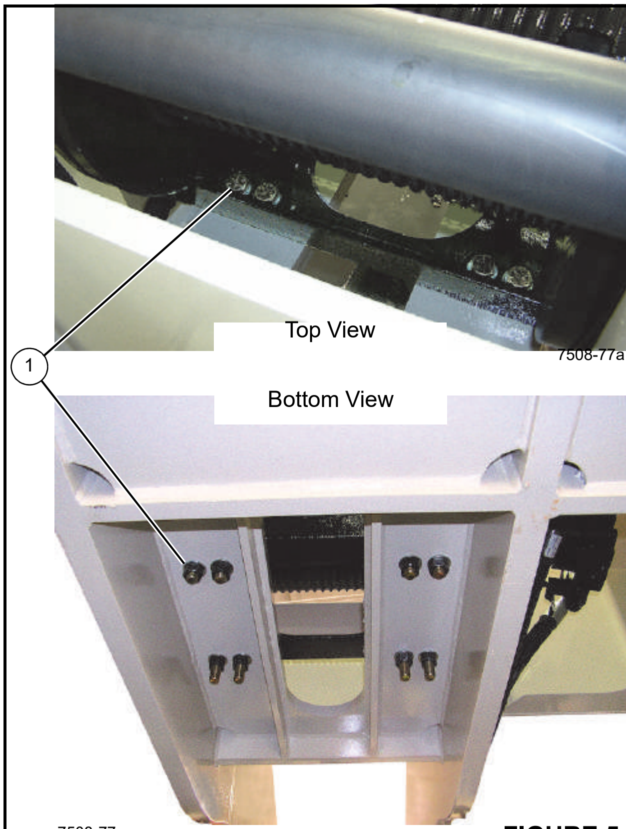
4. Start the engine and rotate the mast until a non-lubricated portion of the swing gear is exposed. Keep hands away from rotating pinion and gear.
5. Shut off the engine.
6. Using a brush, apply open gear lube to the swing gear teeth.
7. Repeat steps 4, 5 and 6 until the complete swing gear is lubricated.
8. Install the guard over the exposed pinion and swing gear.

Torque Critical Bolts

NOTE: Maintain correct torque on all bolts. Failure to do so may result in severe damage to the machine and/or personal injury.

Hoist Gearbox Mounting Bolts

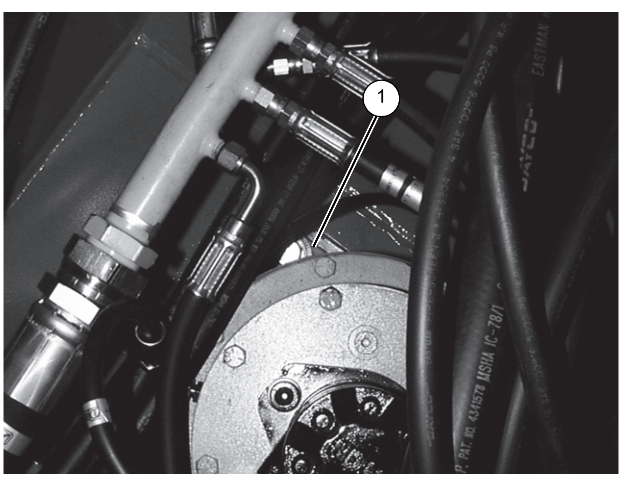
Torque the eight (8) 3/4” mounting bolts (1, Figure 5-31) to 272 Nm (200 lb-ft).



7508-77 FIGURE 5-31

Swing Gearbox Mounting Bolts

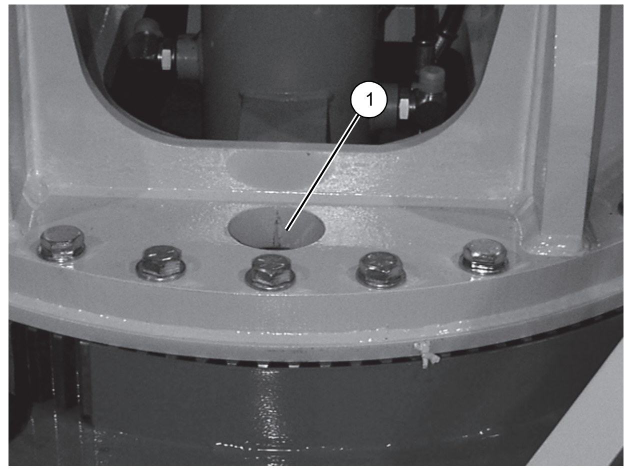
Torque the 5/8” gearbox mounting bolts (1, Figure 5-32) to 232 Nm (171 lb-ft). If bolts are loose check the gear backlash.



p0504 FIGURE 5-32

Swing Bearing to Frame Mounting Bolts

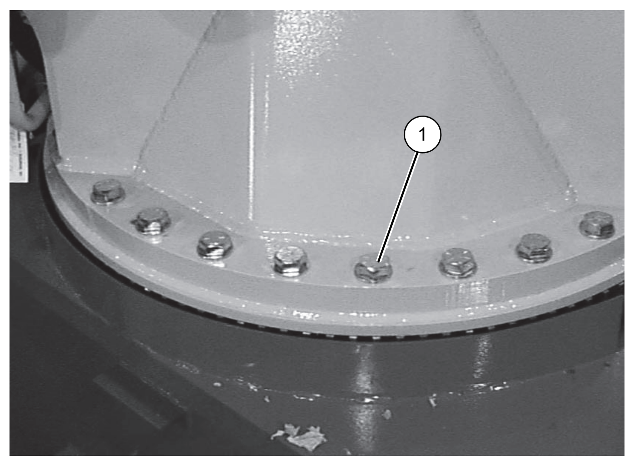
Torque the thirty (30) 7/8” bearing mounting bolts to 619 Nm (455 lb-ft). To gain access to the bolts, rotate the mast until a bolt is visible in both access holes in the mast mounting plate (1, Figure 5-33). Tighten the bolts exposed in each hole, then rotate the mast until different bolts are exposed and tighten them. Rotate the mast through a complete cycle, tightening all bolts.



p0501 FIGURE 5-33

Mast to Swing Bearing Mounting Bolts

Tighten the twenty six (26) 7/8” mast mounting bolts (1, Figure 5-34) to 619 Nm (455 lb-ft). Tighten each bolt in a crisscross pattern.



p0503 FIGURE 5-34

Replace the Crankcase Oil

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

NOTE: It is necessary to climb under the crane to replace the engine crankcase oil. 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.

1. Review the engine manual furnished with the crane on how to change the engine crankcase oil and for oil specifications.
2. 11 l (11.6 qt) of oil is required for an oil change.

Replace the Engine Oil Filter

NOTE: It is necessary to climb under the crane to 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.

1. Drain the crankcase oil from the engine (See Changing the Crankcase Oil above).
2. Turn the filter counterclockwise to loosen. Remove and discard the old filter.
3. Clean the filter mounting surface on the engine.
4. 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.
5. Fill the engine with recommended oil. See the engine manual furnished with the crane. Operate the engine for two to three minutes to fill the filter body. Stop the engine and check the oil level using the dipstick, add oil if necessary. Check the filter for leaks.

Clean the Radiator

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

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

500 HOURS OF OPERATION (THREE MONTHS)

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

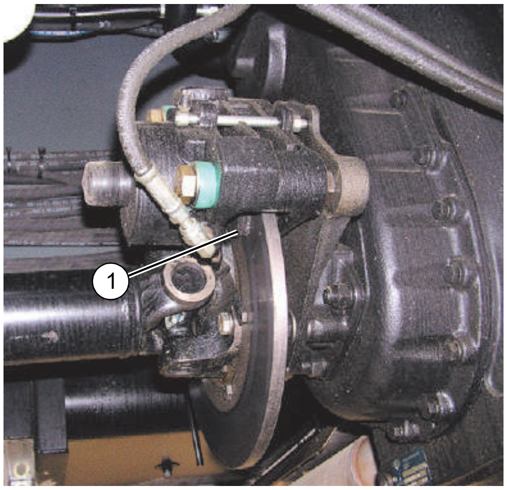
For additional engine maintenance guidelines, see the engine manual furnished with this crane.

Inspect the Tires

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

Inspect the 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.



7407-26

FIGURE 5-35

Inspect the thickness of the brake pads, Figure 5-35. Replace the brake pads if they are 7.1 mm (0.28 in) thick or less.

Replace Fuel Filter/Water Separator

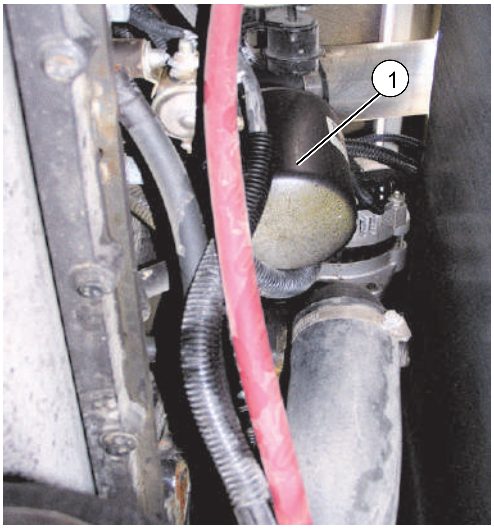
See the engine operator's manual furnished with the crane and follow the recommended replacement procedures.

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 manual furnished with the crane.

Replace the Secondary Fuel Element

It is necessary to climb under the crane to replace the secondary fuel element (1, Figure 5-36). Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.

5



7407-27 FIGURE 5-36

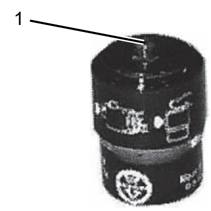
Replace Air Cleaner Element

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

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

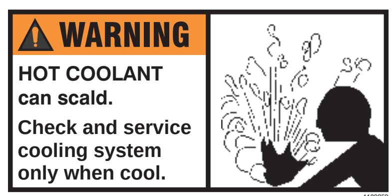
NOTE: The secondary element must be replaced after two primary element replacements.

7. Install the new element in the housing and slide it all the way in.
8. Make sure the gasket is seating evenly. If the gasket isn't seating evenly for a perfect seal, you won't have protection. Recheck to see if the sealing surface in the housing is clean, or if the element is not the right model number. If may be too short for the housing.
9. Install the air cleaner housing cover with the vacuator valve facing down. Install the cover clamp
10. Reset the air cleaner restriction indicator by pushing in the reset button 1, (Figure 5-37).



p0450 FIGURE 5-37

Add Rust Inhibitor to Engine Cooling System



w0020

For maximum protection of the engine cooling system, add a corrosive inhibitor to the radiator. When the engine is cold, remove the radiator cap and pour the inhibitor in the radiator reservoir.

Lubricate the Outrigger Slides

1. Extend and lower the outriggers.
2. Clean the slide beams, top and bottom, with a suitable solvent.
3. Apply Mobil EP grease, or equivalent, to the areas shown in Figure 5-38. Do not over lubricate by applying to the complete outside of sliding beam. Extend and retract the beams several times to spread the grease.

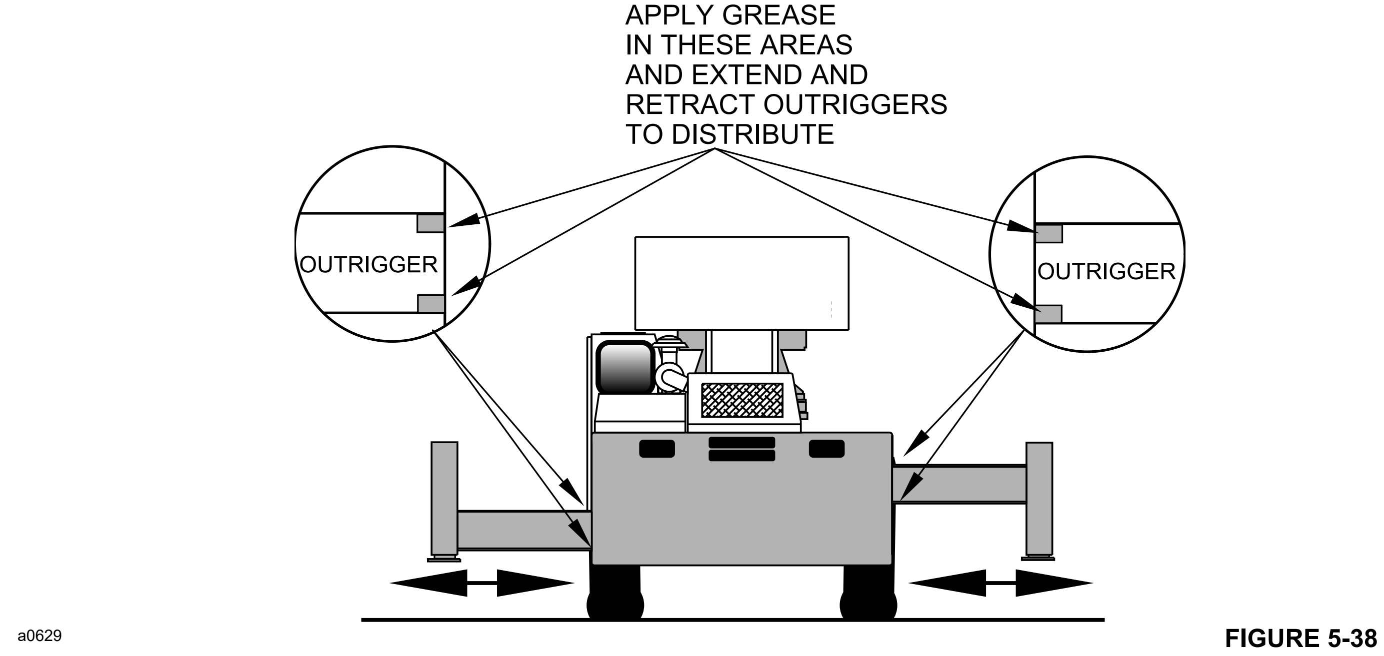


FIGURE 5-38

Check the Axle Housing Lubricant Level

It is necessary to climb under the crane to check the axle housing lubricant. Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.

1. Clean around the axle housing fill/check plug (1, Figure 5-39) and remove the plug.
2. Check the lubricant level, which should be even with the bottom of the fill/check hole.

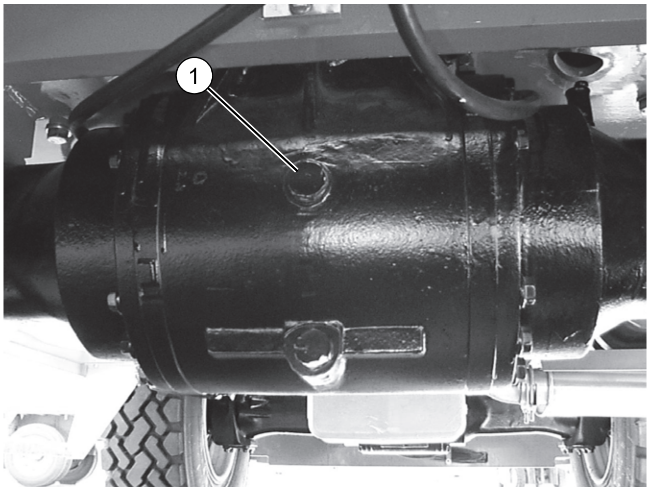


FIGURE 5-39

3. If necessary, add Mobil Fluid 424, or equivalent, to fill the housings until the oil is level with the bottom of the fill/check hole.

Check the Wheel Hub Lubricant Level

1. Position the fill/check plug so it is horizontal with the ground, at the 3 o’clock position (1, Figure 5-40).
2. Clean around the plug and then remove it.
3. Check the lubricant level, which should be even with the bottom of the hole.
4. If necessary, add Mobil Fluid 424, or equivalent, to fill the hub to the bottom of the check plug hole.

Fill/Check Plug - Wheel Hub

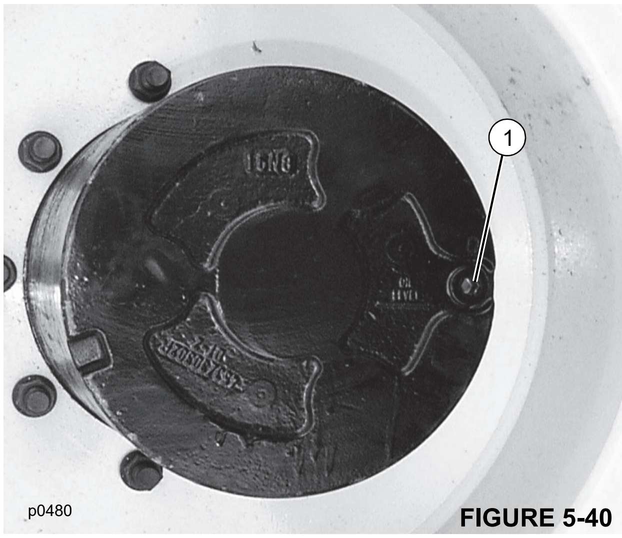


FIGURE 5-40

5. Repeat Steps 1 through 4 for the other wheel hubs.

Check Swing Gearbox Lubricant Level

It is necessary to climb under the crane to check the swing gearbox lubricant level. Be sure engine is shut off, the ignition key is removed and chock blocks are in place before climbing under the crane.

1. Clean around the swing gear box check plug (1, Figure 5-41) and remove the plug.
2. Check the lubricant level, which should be even with the bottom of the check hole.
3. If necessary, add the lubricant cited in *Lubricants*, page 5-7 through the fill port to fill the housing until the oil is level with the bottom of the check hole. Install both plugs
4. Apply a Lithium Base E.P. No. 2 bearing grease to the grease fitting (2, Figure 5-41) on the gear box.

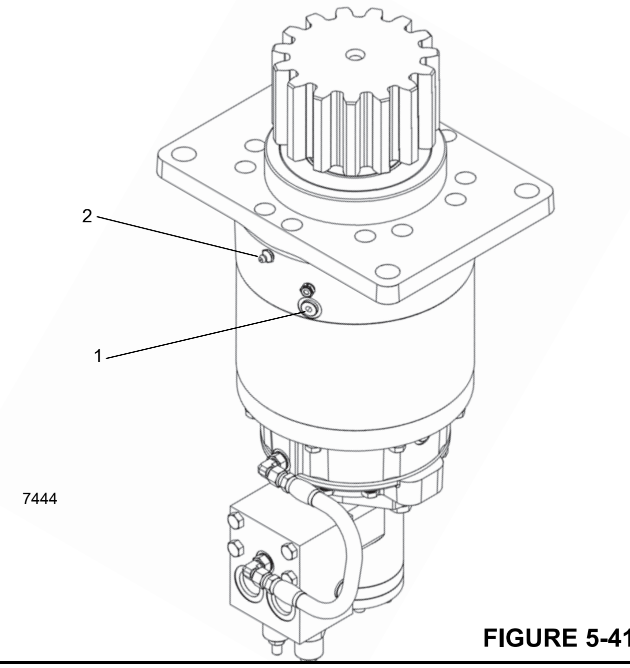


FIGURE 5-41

1000 HOURS OF OPERATION (SIX MONTHS)

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

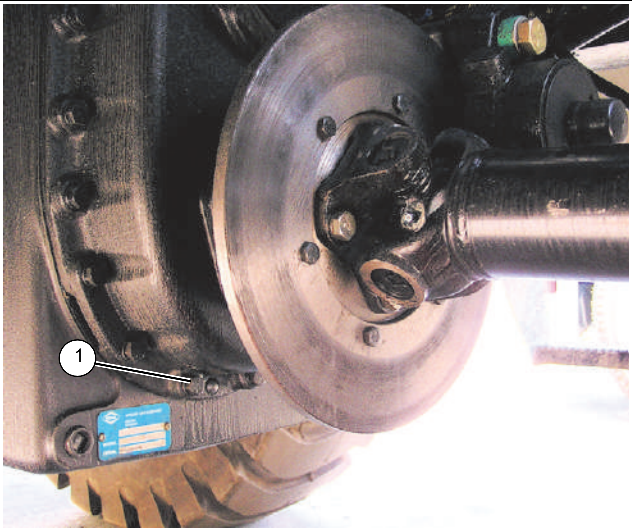
For additional engine maintenance guidelines, see the engine manual furnished with this crane.

Replacing the Transmission Oil and Filter

1. Engage the parking brake and start the engine. Allow the transmission oil to obtain normal working temperature (82.2° to 93.3°C [180° to 200°F]).
2. Shut off the engine. Remove the ignition key.

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

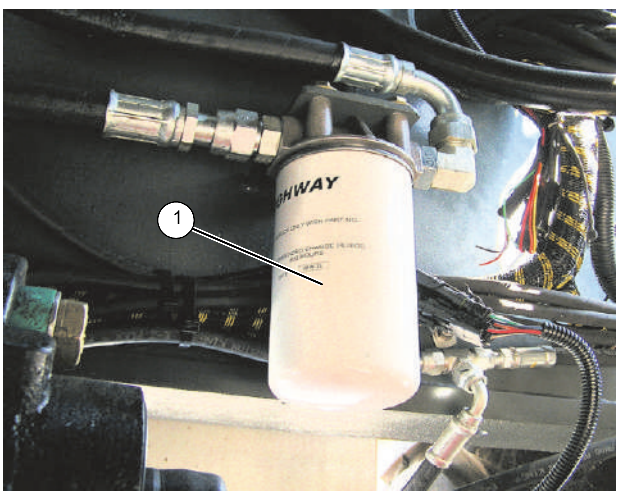
3. Place suitable container under the transmission drain plug (1, Figure 5-42).



7407-29

FIGURE 5-42

4. Remove the plug (1, Figure 5-42). Drain the transmission into the container. Re-install the drain plug.
5. Remove the transmission oil filter (1, Figure 5-43) by unscrewing it from the filter housing. Properly discard the filter.



7407-28

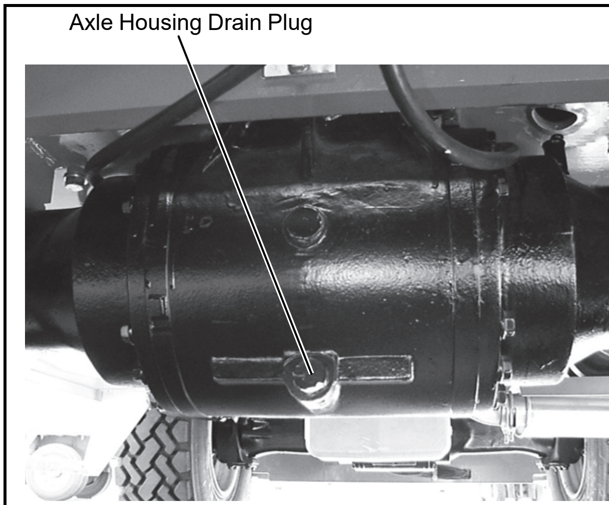
FIGURE 5-43

6. Coat the seal of the new filter with clean transmission oil.
7. Screw on the transmission filter (1, Figure 5-43) until it touches the filter head. Then, turn the filter another 1/2 to 3/4 of a turn to seat the seal.
8. Refill the transmission with recommended fluid to LOW mark on the dipstick.
9. Start the engine and let it run at idle speed to prime the torque converter and fill all lines.
10. With the engine running at idle speed, check the transmission oil level and fill to the LOW mark on the dipstick.
11. When the transmission is at normal operating temperature (82° to 93°C [180° to 200°F]), make a final check of the oil level. Add oil to the FULL mark on the dipstick.

Replace the Axle Housing Lubricant

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

1. Place a container under the differential drain plug (Figure 5-44). Remove the drain plug and drain the fluid into the container. Install the drain plug.



p0479

FIGURE 5-44

2. Clean around the check/fill plug in the axle housing (Figure 5-45). Remove the plug.

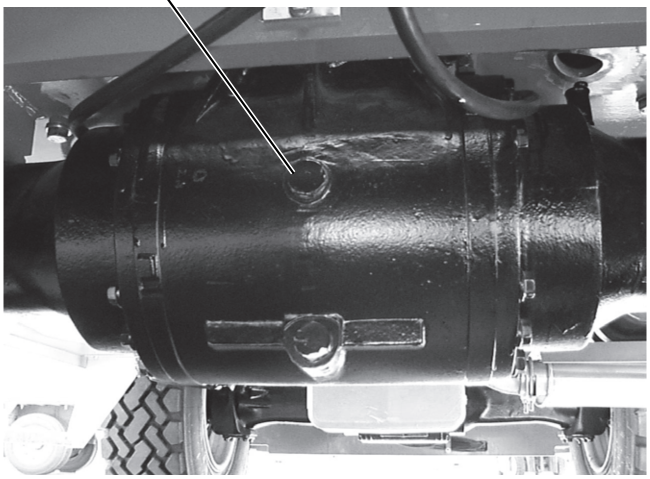


FIGURE 5-45

3. Remove and clean the axle breather (Figure 5-46) with a suitable solvent. Install the breather.

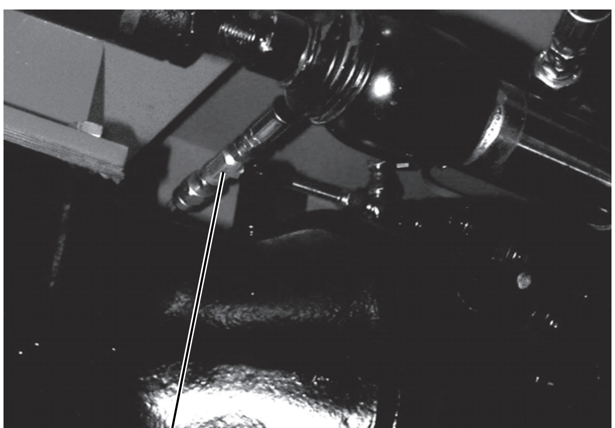


FIGURE 5-46

4. Fill the axle housing with approximately 18 l (4.8 gal) of Mobil Fluid 424 through the check/fill plug hole. Fill until the oil reaches the bottom of the fill hole.
5. Install the check/fill plug. Repeat procedure for the other axle

Replace the Axle Wheel Hub Lubricant

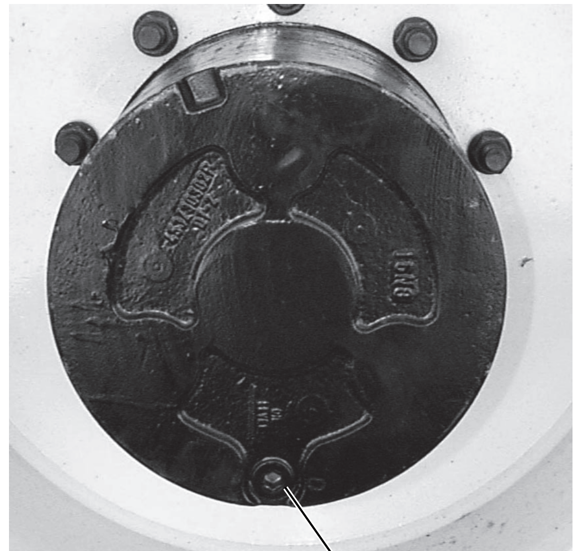


FIGURE 5-47

1. Drive the crane until one of the front axle wheel hub drain plugs is located at the bottom of the wheel hub (Figure 5-47).
2. Clean around the drain plug and then remove it. Drain the wheel hub oil into a suitable container.
3. Drive the crane until the drain hole is horizontal (Figure 5-48).

FIGURE 5-48

4. Fill the wheel hub with approximately 2.0 l (2.1 qt) of Mobil Fluid 424 through the exposed hole until the oil reaches the bottom of the hole.
5. Install the plug.

6. Repeat the above procedure for the other three wheel hubs.

Replace the Hoist Gearbox and Brake Lubricant

Hoist Assembly

1. Fully lower the boom assembly, engage the parking brake, but leave the engine running.
2. Rotate hoist drum until the drain plug is visible through the lower hole in the side mounting bracket (Figure 5-49).

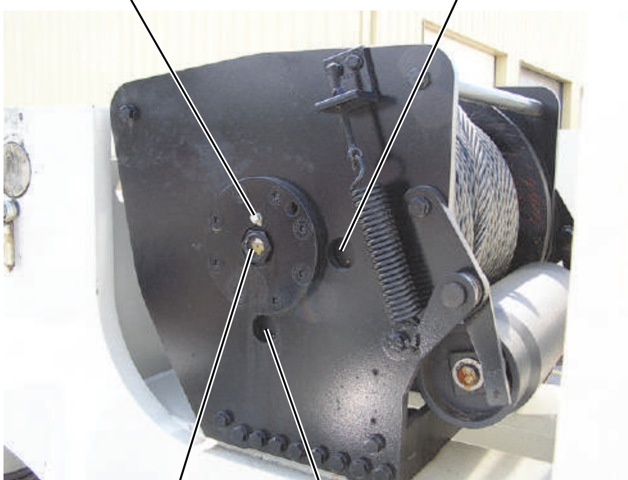


FIGURE 5-49

3. Clean around the gearbox breather Figure 5-49 and the fill/check plug. Remove the gearbox breather and clean it in a suitable solvent, after which reinstall into the gear box.
4. Remove the fill/check plug.
5. Place a suitable container under the drain plug.
6. Remove the drain plug and allow the oil to drain into the container. Examine the oil for signs of metal particles. If found, the gear box may require disassembly and repair.
7. Install the drain plug.
8. Fill the gearbox through the fill hole until the fluid is even with the bottom of the fill hole. Fill with the lubricant cited in *Lubricants*, page 5-7.
9. Install the fill/check plug.

Replace Swing Gearbox Lubricant

1. Clean around the swing gear box drain, check and fill plugs (Figure 5-50).
2. Remove the fill, check and drain plugs and catch draining lubricant in a suitable container. Properly dispose of the lubricant.
3. Install the drain plug.
4. Fill the swing gearbox with the lubricant cited in *Lubricants*, page 5-7 until the oil reaches the bottom of the check plug hole.
5. Install the check plug.
6. Clean the fill plug/vent in a suitable solvent and then install the plug.
7. Apply a Lithium Base E.P. No. 2 bearing grease to the grease fitting on the gear box.

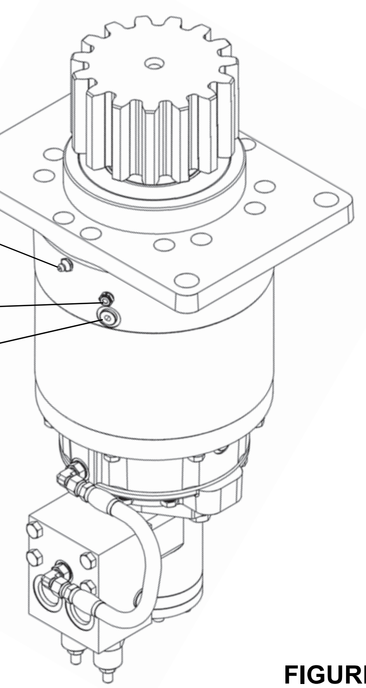


FIGURE 5-50

Replace the Hydraulic Oil

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

For operating in cold climates, Mobilfluid 424 may be substituted with Mobil DTE 10M Series, or equivalent. Specific series selection should be based on an operating viscosity range (at operating temperature) to 80 to 170 SUS (Saybolt Universal Seconds) when referring to tank temperature. It may be necessary to use a pre-heater and longer warming period at low operating speed to heat the oil to operating temperature.

NOTE: The pump used on this crane requires clean hydraulic oil for proper operation. Contaminated oil can cause damage to the pump. Before adding any hydraulic oil to the hydraulic system, be sure the oil has been filtered through a 10-micron (absolute), or less, filter.

To change the hydraulic oil:

1. Fully retract and lower the booms.
2. Retract all outriggers.
3. Operate the hydraulic system until the hydraulic oil is warm.

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

4. Level the crane, engage the parking brake, shut off the engine and remove the ignition key.
5. Place a suitable container under the hydraulic tank drain port (Figure 5-51).
6. Remove the drain plug (1, Figure 5-51) and drain the oil into the container.

7407-38 **FIGURE 5-51**

7. Disconnect the suction hose (2, Figure 5-51) from the hydraulic tank. Drain the hydraulic oil into the container. Remove the suction strainer from the hydraulic tank and clean it in a suitable solvent.
8. Remove the fill strainer from the fill tube and clean it in a suitable solvent.
9. Clean the inside of the hydraulic tank and remove any sediment.
10. Install the fill strainer, suction strainer, suction hose, return hose and drain plug to the hydraulic tank.
11. Replace the hydraulic oil filter. See Replacing the Hydraulic Oil Filter, below.
12. Fill the hydraulic tank with Mobil Fluid 424 hydraulic oil to the bottom of fill strainer.
13. After the tank is filled, start the engine and operate each function until all the cylinders and lines are filled.
14. Fully retract and lower the boom and retract the outriggers. Check the hydraulic oil level. Oil must be visible in the sight gauge on the side of the tank. Add hydraulic oil if necessary.

Replace the Hydraulic Oil Filter

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

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

8192-7 **FIGURE 5-52**

2. Remove the filter:
   a. Using a filter wrench, turn the filter counterclockwise to loosen and remove the filter. Properly discard the removed filter.
   b. Clean the mounting surface on the filter head.
3. Install the filter:
   a. Apply a small amount of clean hydraulic oil to the gasket of the new hydraulic filter. Install the filter. Install the filter to the filter head by turning it clockwise until the filter gasket makes contact. Then, tighten the filter 1/2 to 3/4 turn to achieve a tight seal.

b. Start the engine and check for leaks around the filter.

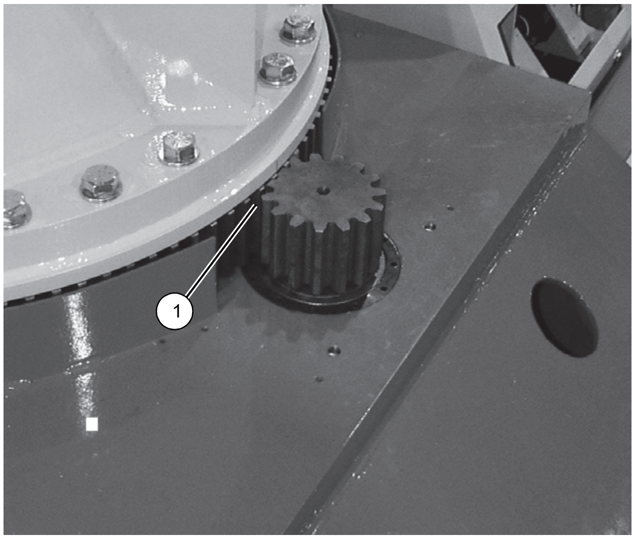
Check the Swing Gear/Pinion Backlash

1. Remove the cover to expose the swing pinion and ring gear.
2. 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 edge of the mast base plate (Figure 5-53).

w0022

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

3. Using a feeler gauge, check the backlash between the gear and pinion (1, Figure 5-53). There should be no clearance between the swing gear tooth and the pinion tooth. If there is any clearance, adjust the backlash. See the *Service Manual*.



p0500

FIGURE 5-53

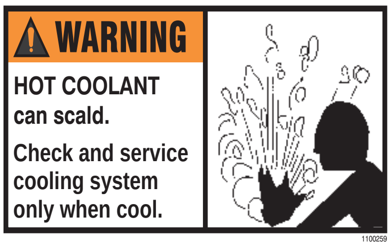
5

2000 HOURS OF OPERATION (YEARLY)

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



w0020

1. Rotate the boom to the side. Open the engine compartment cover.
2. **BE SURE THE ENGINE IS COOL** and follow the cooling system draining and filling procedures in the Engine Operation and Maintenance Manual furnished with the crane.
3. After the coolant is replaced, close the engine compartment cover.

Inspect the Crane Structure and Booms for Damage

Thoroughly inspect the crane structure and booms for the following:

- Inspect for loose mounting hardware. Tighten any loose hardware.
- Inspect for cracked or broken welds. Do not operate the crane if a critical weld is cracked or broken, until the weld is repaired.
- Inspect for missing or unreadable warning decals. Replace if necessary.
- Inspect for excessive rust or corrosion on crane structure and booms. Paint any areas with excessive rust or corrosion.
- Inspect for missing items. Replace if necessary.
- Inspect the crane for any damage that might prevent safe operation of the crane. Repair any damage.

Test the Rated Capacity Limiter (RCL) (Optional)

See the RCL manual furnished with this crane and test the device according to instructions in the manual.

MISCELLANEOUS MAINTENANCE

Batteries/Charging System

NOTE: Lead-acid batteries produce flammable and explosive gases. To avoid personal injury, when checking, testing or charging batteries:

- **DO NOT** use smoking materials near batteries.
- Keep arcs, sparks and flames away from batteries.
- Provide ventilation and wear safety glasses.
- Never check battery charge by placing a metal object across the posts. The sparks could explode battery gases and cause injury or death. Use a voltmeter or hydrometer.

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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 by a qualified service technician.

When the voltmeter on the instrument panel indicates a low battery charge, attach a battery charger and increase the battery charge.

Charging the Battery

Under normal conditions, the engine's alternator will have no problem keeping a charge on the battery. The only condition in which the battery may cause a problem is when it has been completely discharged for a long period of time. Under this condition the alternator may not be able to recharge the battery and a battery charger will be required for charging the battery.

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

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DO NOT charge a frozen battery; it may explode and cause injury. Let the battery warm up before attaching a charger.

Charging rates between 3 to 50 amperes are satisfactory if no excessive gassing or spewing of electrolyte occurs or the battery does not feel excessively warm (over 52°C [125°F]). If spewing or gassing occurs or temperatures exceed 52°C (125°F), the charging rate must be reduced or temporarily stopped to permit cooling.

Replacing the Battery

NOTE: The fluid in electric storage batteries contains sulfuric acid, which is a **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 below.

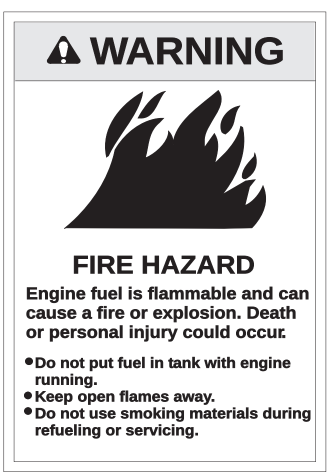
Battery Electrolyte First Aid

- **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



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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.

Fuses and Relays

Fuse Block 1 Fuse/Relay Panel

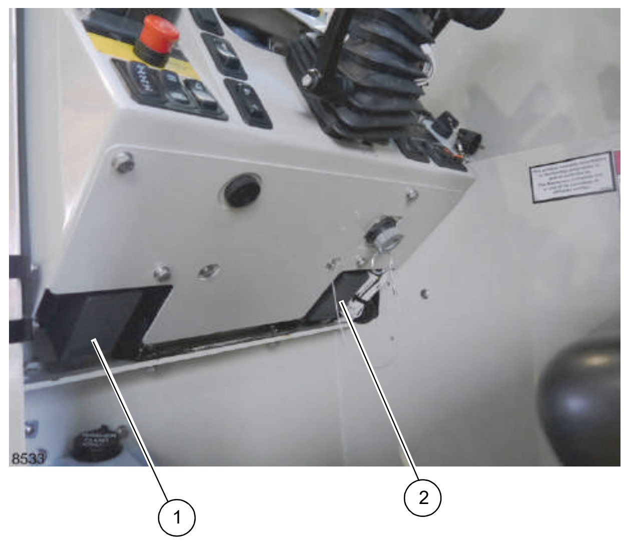

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FIGURE 5-54

Fuse block 1 fuse/relay panel (1, Figure 5-54 and Figure 5-55) is located below the left side of the dash. Refer to Figure 5-55 for identification of the relays and fuses.

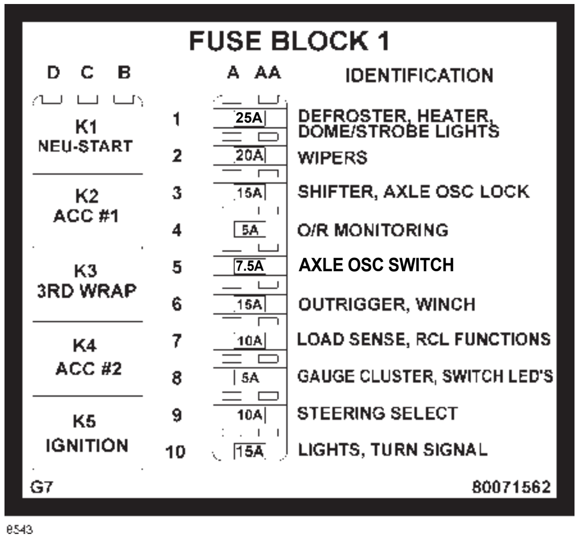

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FIGURE 5-55

Fuse Block 2 Fuse/Relay Panel

Fuse block 2 fuse/relay panel (2, Figure 5-54 and Figure 5-56) is located below the right side of the dash. Refer to Figure 5-56 for identification of the relay and fuses.

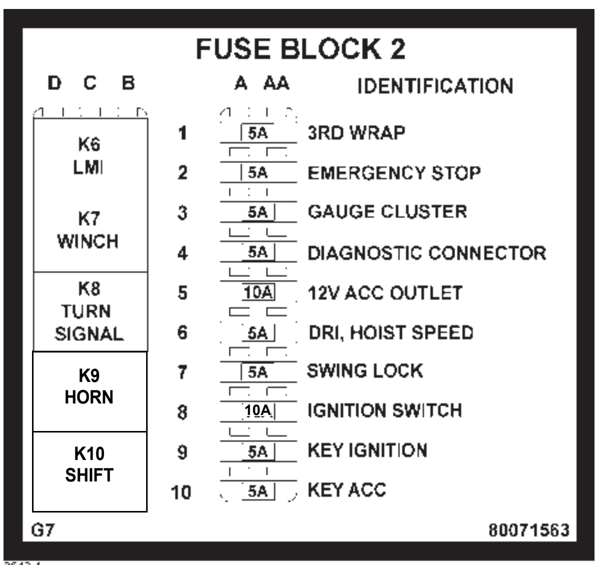

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FIGURE 5-56

Battery Compartment Fuse/Relay Panels

There are two fuse panels in the battery compartment, fuse block 3 (1, Figure 5-57) and fuse block 4 (2). Refer to TABLE 5-1 and TABLE 5-2 for identification of the fuses.

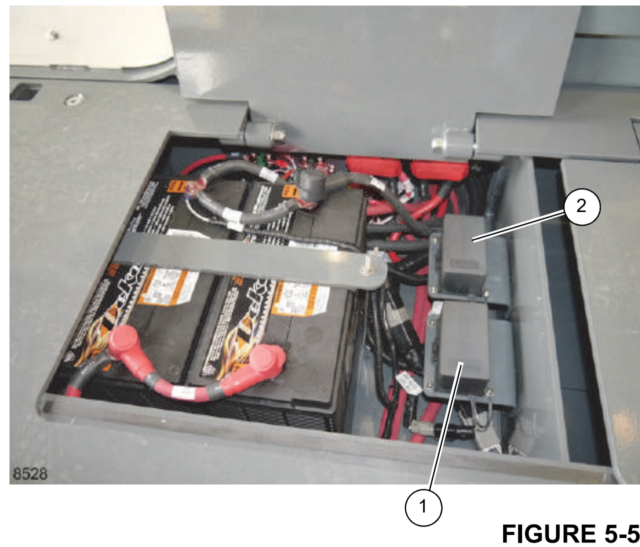

FIGURE 5-57

TABLE 5-1: Fuse Block 3

Fuse	Function	Size
F1	Fuse Block (FB) #1-F10 FB #2-F3	20
F2	FB #1-F1 FB#1-F2 FB#2-F6	30
F3	ECM B+	30
F4	FB #1-F7 FB#1-F8 FB#1-F9 FB#2-F1 FB#2-F4 FB#2-F8	30
F5	FB#1-F3 FB#1-F4 FB#1-F5 FB#1-F6 FB#1-F7	30
F6	Module Power	7.5
F7	Diode	-
F8	Unloader Solenoid	5
F9	Diode	-

TABLE 5-2: Fuse Block 4

Fuse	Function	Size
F1	DEF Pressure Line DEF Return Line DEF Suction Line	15
F2	DEF Line Relay Coil	5
F3	DEF Supply Module Relay Coil DEF Module +	15
F4	Aftertreatment Sensors	10
F5	Aftertreatment Sensor Relay Coil High Exhaust Temp Relay Coil High Exhaust Temp Light	5
F6	Spare	5
F7	Diode	-
F8	Diode	-
F9	Diode	-

Diesel Exhaust Fluid (DEF) Tank

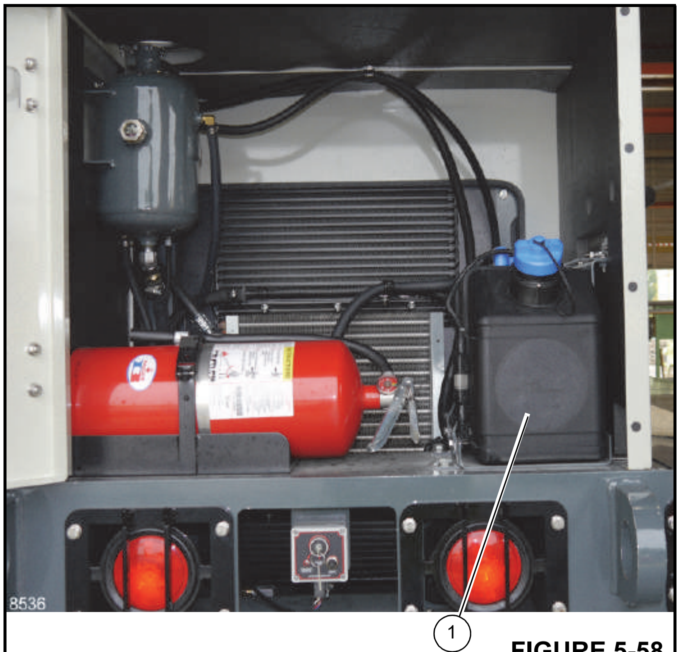

FIGURE 5-58

This engine uses a Selective Catalytic Reduction (SCR) system. SCR is a technology that uses a urea based DEF and a catalytic converter to significantly reduce oxides of nitrogen (NOx) emissions.

The DEF tank (1, Figure 5-58) incorporates a fluid level sending unit and a heating element to keep the DEF from freezing.

When the indicator in the dash illuminates

CARWELL® RUST INHIBITOR

Description

Industrial cranes are manufactured to the highest quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, Industrial cranes are dedicated to help prevent premature corrosion of its cranes.

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

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

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

After applied, the 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 can be removed using standard steam-cleaning techniques.

This treatment works in various ways:

- It eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface;
- The film creates a barrier to repel further moisture from coming into contact with the metal;
- It penetrates crevices.

In addition to this factory-applied treatment, Industrial 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 Industrial cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in 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;
- 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.

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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

Equipment Damage Hazard!

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, sealed bearings, 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 strong 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

Structural Damage Hazard!

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 Industrial paint 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 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.

Carwell 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 primered 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: Unit must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged onto the crane.
- Use of pressure paint pots to apply the treatment to the unit 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 5-59.

- The underside of the crane should 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 ends and fittings, swivel, pumps, axles, drivelines, transmission, slew ring gear fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose ends and fittings, wire rope, hoist rollers, tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring gear fasteners and all bare metal surfaces.
- Boom applications areas are; pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, downhaul weight pins/ hook block pins and fasteners.
- All hardware, clips, pins, and hose connections not painted should have treatment applied.

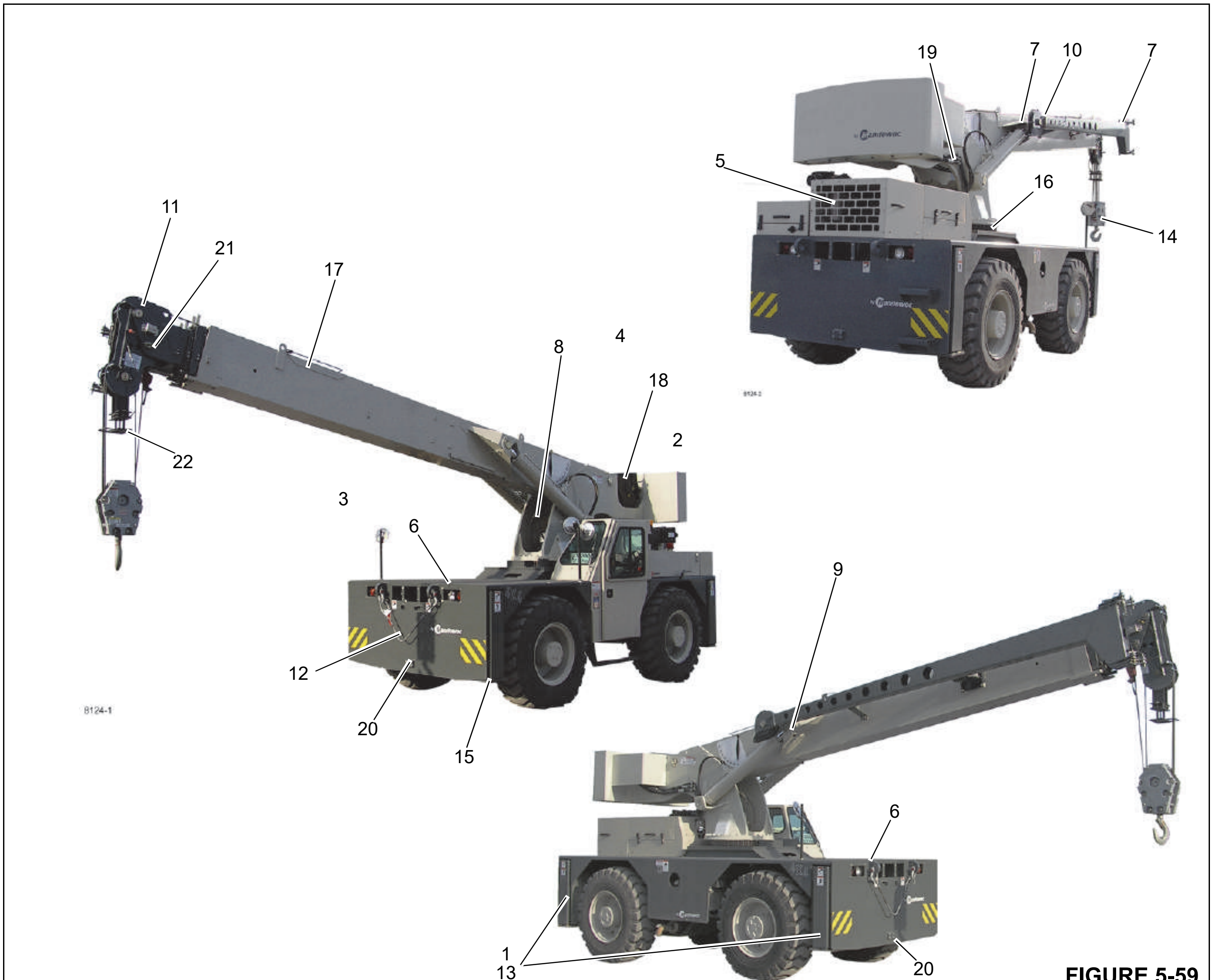

FIGURE 5-59

Item	Description
1	O/R Hose Connections
2	Hoist Tension Springs
3	Mirror Mounting Hardware
4	Hoist Hose Connections
5	Powertrain Hardware (Inside Compartment)
6	Valve Banks (Inside Front & Rear Compartments)
7	Boom Extension Pins, Clips
8	Hose Connections inside turntable
9	Lift Cylinder Pivot Shafts
10	Boom Extension Hanger Hardware
11	Boom Nose Pins, Clips
12	Hook block Tiedown Cable
13	O/R Beam Wear Pad Adjustment Hardware
14	Hook Block\Downhaul Weight
15	Entire underside of unit
16	Turntable Bearing Fasteners
17	All Hardware, Clips, Pins, Hose Connections not painted, O/R Pins, Clips
18	Wire Rope
19	Hose Connections
20	Tow Hooks
21	Boom Nose Pivot and Adjustment Pins
22	Anti-Two Block Mechanism

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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.

The crane uses a Cummins QSB4.5 diesel engine.

ENGINE PERFORMANCE

Engine performance is very important to the operation of the crane. The engine is the drive for the hydraulic pump, which supplies power to operate the work functions of the crane. For maximum power the engine must be kept in good working condition.

ENGINE RPM

To check the engine speed, follow the instructions in the engine operator’s manual. Maximum and minimum speeds are controlled by a governor installed on the engine. The throttle gives variable control of the engine speed within the limits set by the governor.

GOVERNOR

The governor is preset at the factory and is very unlikely that it should ever have to be adjusted.

ENGINE CRANKCASE SYSTEM

The engine crankcase system must be well lubricated to prevent 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

CJ-4/SL For high-speed, four-stroke engines designed to meet EPA Tier 4 exhaust emission standards. CJ-4 oils are formulated to sustain engine durability where exhaust gas recirculation (EGR) is used and are intended for use with diesel fuels ranging in sulfur content up to 0.5% weight.

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

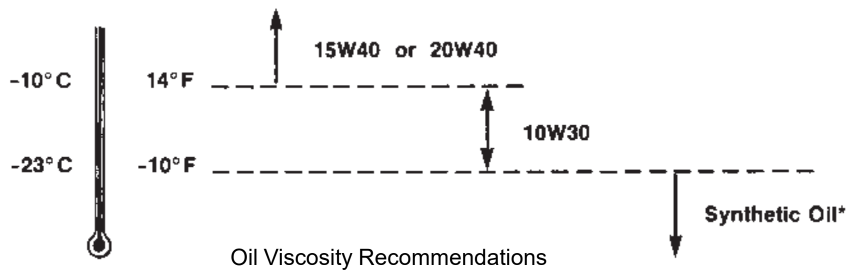
Do not use “break-in” lubricating oils in new or rebuilt engines. Only use lubricating oils specified for normal engine operation.

Cummins Oil Registration List

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

Oil Viscosity Recommendations

The use of a multi-grade lubricating oil improves oil consumption control and improves engine cranking in cold temperatures while maintaining lubrication at high operating temperatures. A multi-grade 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.



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

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) 3.1 mm (0.16 inch) 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.

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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.

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

Radiator Cap

The cooling system is designed to use a radiator cap to prevent the boiling of lubricant. The radiator cap is set to open at 103 kPa (15 psi). An incorrect radiator cap can result in a great loss of coolant and the engine running hot.

Thermostat

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

ENGINE ELECTRICAL SYSTEM

The engine electrical system, the charging and starting circuits, as well as the sending units, are described in *Electric System, Section 3*.

ENGINE FUEL SYSTEM

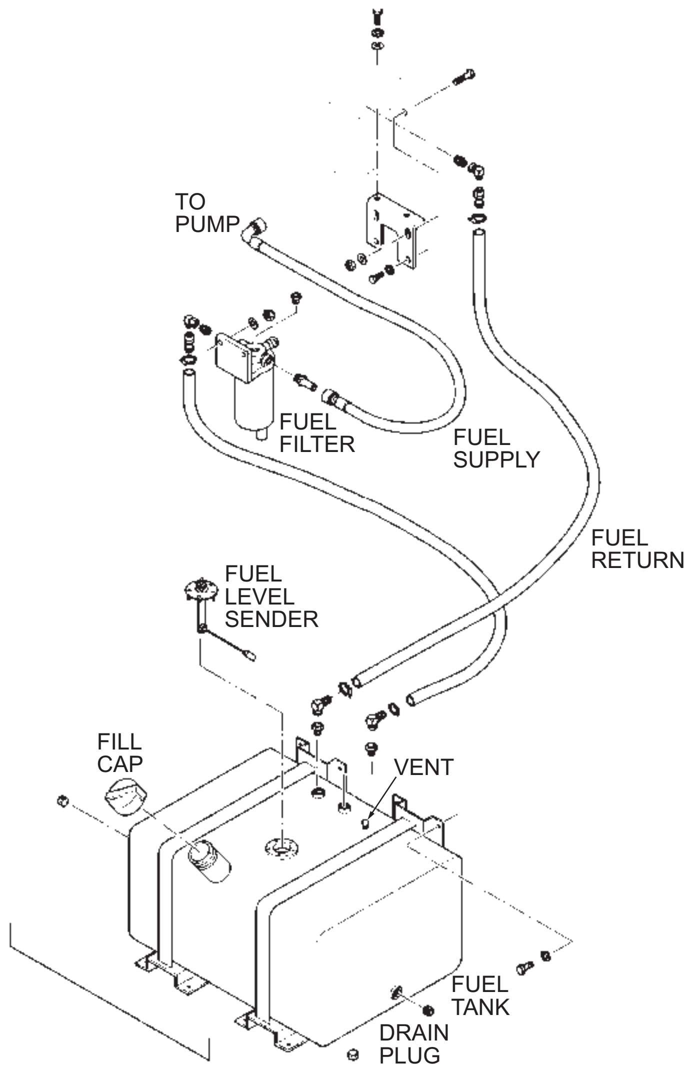
The engine fuel system is a closed-loop fuel system which includes a fuel tank, an engine fuel filter, an engine fuel pump and the fuel lines.

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

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

Fuel Tank

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



Fuel System **FIGURE 6-2**

Fuel Level Sender and Gauge

The fuel level sender and gauge are described in *Gauge Cluster*, page 3-9.

Fuel Pump

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

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

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

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

Fuel Filter

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

Fuel Injection Pump

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

Fuel Injectors

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

QSB Engine Electronic Controlled Fuel System Units

Refer to the Engine Manual Furnished with this crane for a description of the Electronic Controlled Fuel System.

Types of Fuel to Use

Fuel represents the major portion of the crane's operating costs. Therefore, it is important to use it efficiently. Don't let cost tempt you to use an inferior diesel fuel. The savings are a false economy when you consider the damage poor fuel can do to your crane's engine.

WARNING

Do not mix gasoline or alcohol with diesel fuel. This mixture can cause an explosion.

NOTE: Use only diesel fuel designed for diesel engines. Some heating fuels contain harmful chemicals which can seriously affect engine efficiency and performance.

Due to precise tolerances of diesel fuel injection systems, it is extremely important that the fuel be kept clean and free of dirt and water. Dirt or water in the system can cause severe damage to both the injection pump and the injection nozzles.

Use either a Grade No. 1 or a Grade No. 2 diesel fuel as defined by ASTM Designation D-975 for diesel engines. In European countries, use ISO 1585 commercial diesel fuel. Find expected air temperature at time of start up on the thermostatic scale (Figure 6-3). Correct diesel fuel grade (A, B) is shown next to the scale.

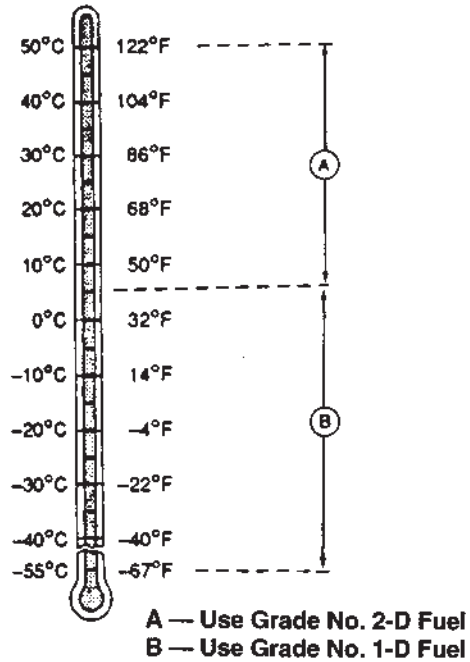


FIGURE 6-3

NOTE: If engine is operating at temperatures of -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 ultra 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.

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 the air filter at the intervals given in *Preventative Maintenance*, page 5-1. 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.*

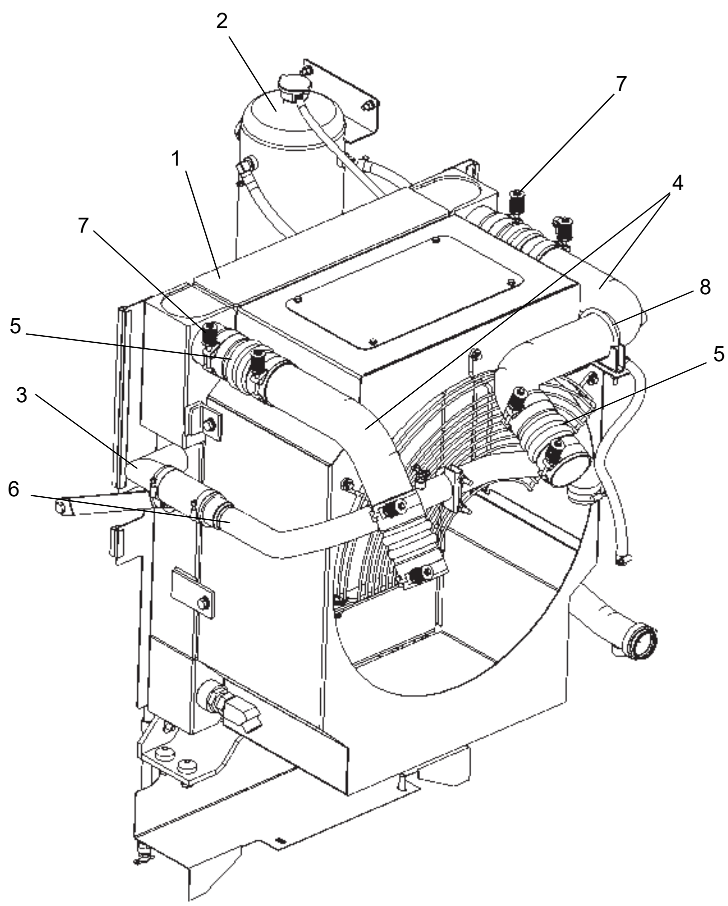
6

Charge-Air Cooler System

The charge-air cooler (CAC) Figure 6-4 is used to cool engine air after it has passed through a turbocharger, but before it enters the engine. The charge-air cooler provides better horsepower, increased fuel efficiency, and reduces engine emissions.

The CAC system consists of the ducting to and from the charge-air cooler and a hydraulically driven fan. The charge-air cooler system must be air-tight in order to work efficiently.

The ducting consists of metal tubing, hose clamps and bellows. The recommended installation torque of the spring loaded T-bolt clamps is 6.8-8.5 Nm (60-75 lb-in). Do not compress the spring completely, the bellows and/or clamp may be damaged from thermal expansion of the CAC tube.



Tier 4 Charge-Air Cooler Assembly **FIGURE 6-4**

Item	Description
1	Charge-air Cooler Assembly
2	Radiator Surge Tank
3	Radiator Assembly
4	Tubes
5	Bellows
6	Tube
7	T-Bolt Clamp
8	Muffler Clamp

Maintenance

Check the hose clamps for proper torque.

Inspect the bellows for cracks or holes.

Clean the charge-air cooler, removing any dirt or debris.

Verify the fan is operating correctly and there are no hydraulic leaks.

ENGINE EXHAUST SYSTEM

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

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FIGURE 6-5

Exhaust system components get very hot and can cause severe burns.

Annoying rattles and noise vibrations in the exhaust system are usually caused by misalignment of parts. When aligning the system, leave all bolts and nuts loose until all parts are properly aligned, then tighten working from top to bottom.

When installing exhaust parts, make sure there is sufficient clearances between the hot exhaust parts and parts that would be adversely affected by heat.

When installing an exhaust system, allow for expansion when the system is hot.

Periodic maintenance of the exhaust system is not required, however, it is advisable to check the condition of the system when performing other maintenance on the crane.

Check the complete exhaust system for broken, damaged, missing or mispositioned parts, open seams, holes, loose connections and other deterioration which could cause exhaust fumes to seep into the operator’s compartment. Any damaged areas must be corrected.

Exhaust System Assembly

The Tier 4 exhaust system (Figure 6-6) is made of a diesel oxidation catalyst (DOC), decomposition reactor tube, a selective catalytic reduction (SCR) unit and various tubes, elbows and clamps.

Removal

NOTE: The down pipe insulation is an emissions component and must be replaced if removed for service or if damaged.

The exhaust aftertreatment components are bolted to a single weldment that can be removed by a properly rated lifting device. The subassembly weighs approximately 300 lb (136 kg).

CAUTION

Burn Hazard!

Do not touch muffler or exhaust parts until they are at ambient temperature. Severe burning may result.

1. Remove the sheet metal guard to gain access to the exhaust system.
2. Tag and disconnect electrical and DEF connections.
3. Remove clamp to free exhaust tailpipe from the SCR.
4. Remove the mounting bands to free the SCR.
5. Loosen the V-band clamps to remove the elbows and decomposition reactor tube.
6. Remove mounting bands to free DOC from the mounting bracket.
7. Loosen the V-band clamps to remove the exhaust tube and flex hose.
8. If necessary loosen the V-band clamp and remove the exhaust tube from the turbocharger.
9. Inspect the parts of the exhaust system and repair or replace if damaged or missing.

6

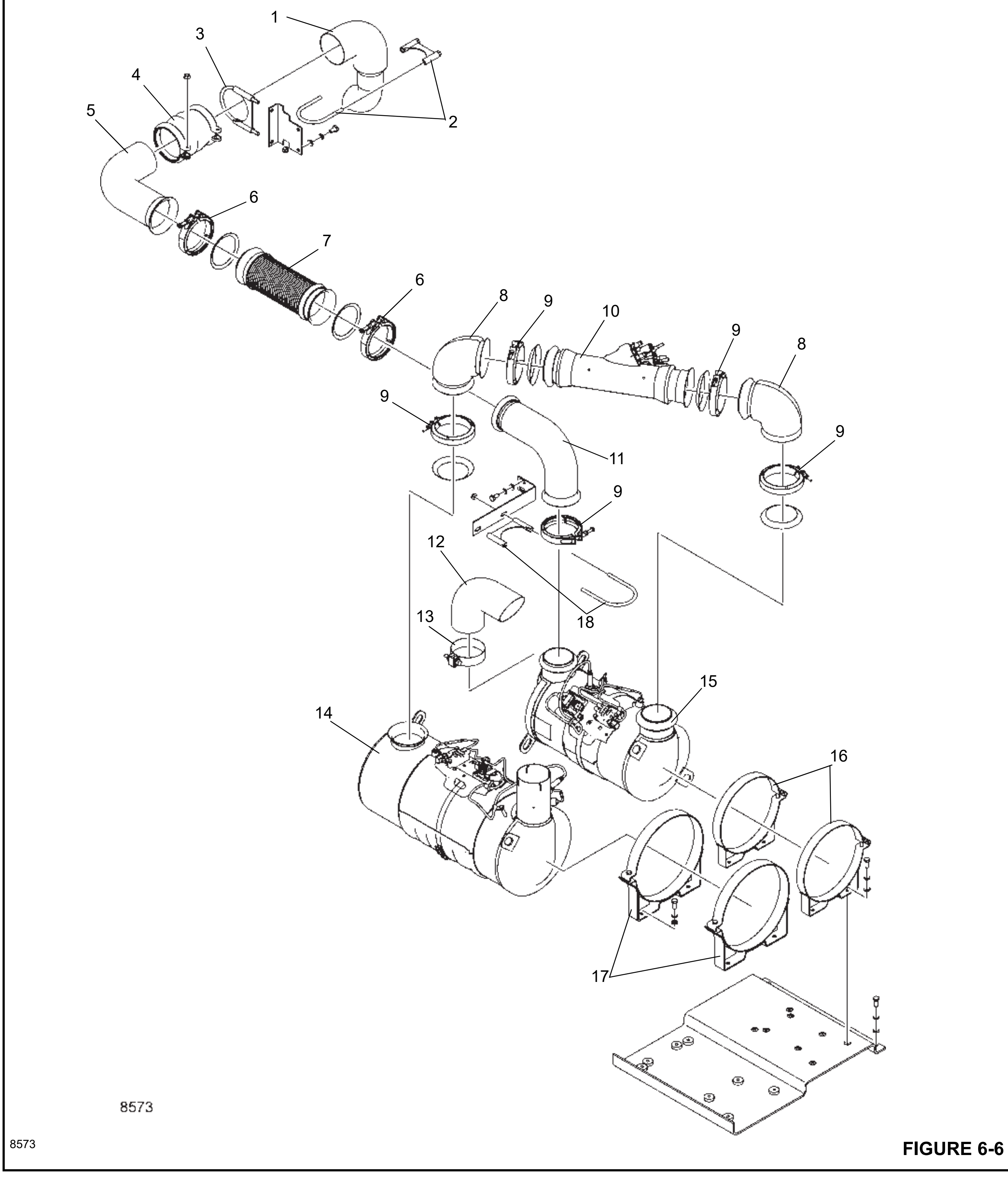

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FIGURE 6-6

Item	Description
1	Turbo Exhaust Tube
2	Muffler Clamp
3	Muffler Clamp
4	Bellows
5	Elbow
6	V-Band Clamp
7	Flex Tube
8	Elbow
9	V-Band Clamp
10	Decomposition Reactor Tube
11	Elbow
12	Tail Pipe
13	Clamp
14	Selective Catalytic Reduction (SCR) Unit
15	Diesel Oxidation Catalyst (DOC) Unit
16	Mounting Band
17	Mounting Band
18	Muffler Clamp

Installation

1. Install the exhaust tube on the turbocharger with the V-band clamp.
2. Attach the flex hose to the exhaust tube with the V-band clamp.
3. Attach the exhaust tube to the flex hose with the V-band clamp.
4. Secure the DOC to the mounting bracket.
5. Attach the exhaust tube to the DOC with the V-band clamp.
6. Install the elbow to the DOC with a V-band clamp.
7. Install the decomposition reactor tube to the elbow with a V-band clamp.
8. Install the elbow to the decomposition reactor tube with a V-band clamp.
9. Secure the SCR to the mounting bracket and connect to the elbow with a V-band clamp.
10. Install the exhaust tailpipe on the SCR. Secure the exhaust tailpipe to the SCR with clamp.
11. Connect electrical connections and DEF line as tagged during disassembly.
12. Install sheet metal guard.

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 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.

6

Table 6-2: Engine Troubleshooting Chart

Problem	Probable Cause	Action
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 hose 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 machine can fall on you causing sever injury or death. Position the machine on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the machine hydraulics or outriggers to support the machine when working under it.

1. Raise and support the frame far enough to remove the rear axle assembly.
2. Remove the engine cover.
3. Disconnect the ground 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 frame electrical wire harness.
7. Drain the radiator. Disconnect the upper and lower hoses from the radiator.
8. Disconnect the charge air-cooler (CAC) hoses. Put plugs and caps on all openings.
9. Disconnect the transmission cooling lines from the radiator. Put plugs and caps on all lines to keep dirt out of the system.
10. Remove the radiator/CAC assembly.
11. Remove the air cleaner 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 engine. Plug or cap the lines to prevent leakage.
13. Disconnect the drive shaft(s) from the transmission. See *Drive Shafts*, page 8-15.
14. Disconnect the exhaust pipe from the exhaust manifold of the engine.
15. Drain the oil from the hydraulic tank.

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16. Disconnect all hydraulic lines from the hydraulic pumps.
17. Disconnect the engine ground cable from the engine.
18. Remove the rear axle.
    a. Attach chains to the engine support brackets and to a hoist. Use the hoist to support the engine while the rear axle is being removed.
    b. Loosen and remove the wheel lug nuts and remove both rear wheels.
    c. Disconnect and plug the hydraulic hoses at the steering cylinder.
    d. Disconnect and cap and plug the brake hoses from the axle.
    e. Support the axle on a trolley jack.
    f. Remove the front engine mounting hardware.
    g. With the engine and rear axle both supported, remove the eight bolts and flat washers securing the engine/axle mounting bracket to the chassis.
    h. Lower and remove the axle clear of the chassis.
19. Remove the rear engine support mounting bolts, washers, rubber mounts and nuts.
20. Using a trolly jack, raise the transmission so it can be removed out the rear of the chassis.
21. Using the hoist, slowly pull the engine and transmission forward 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.
22. 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.

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 all hydraulic lines to the hydraulic pumps. Fill the hydraulic tank.
6. Connect the engine ground cable to the engine.
7. Connect the exhaust pipe to the turbocharger. If a gasket is used, install a new gasket.
8. Connect the drive shafts to the transmission. See *Drive Shafts*, page 8-15.
9. Connect the fuel lines to the engine.

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.

10. Install the air cleaner and intake hose.
11. Install the CAC/radiator in place on the chassis.
12. Connect the CAC tubes to the engine.
13. Connect the transmission cooling lines to the radiator. Connect the upper and lower radiator hoses.
14. Fill the radiator with recommended coolant.
15. Connect the transmission wire harness to the frame electrical wire harness.
16. Connect the transmission high temperature switch lead to the switch.
17. Connect the engine wire harness to the frame wire harness.
18. Install the engine cover.
19. Connect the battery cables to the battery.
20. Check complete installation to be sure all components are installed and secure.
21. Fill the engine and transmission with recommended oil.
22. Start the engine. Continue to add transmission fluid until transmission cooling lines are full. Add fluid as needed to fill the cooling system.
23. Steer the rear wheels in both directions several times to remove air from the steering circuit.
24. Bleed air from brake lines. Refer to *Service Brake Bleeding*, page 9-4.
25. Stop the engine and check for leaks. Tighten fittings if necessary.

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SECTION 7
TRANSMISSION AND TORQUE CONVERTER

SECTION CONTENTS

TOWING OR PUSHING

Before towing the vehicle, be sure to lift the rear wheels off the ground or disconnect the driveline to avoid damage to the transmission during towing.

If the transmission has 4 wheel drive, disconnect both front and rear drivelines. because of the design of the hydraulic system, the engine cannot be started by pushing or towing.

4-SPEED POWERSHIFT TRANSMISSION

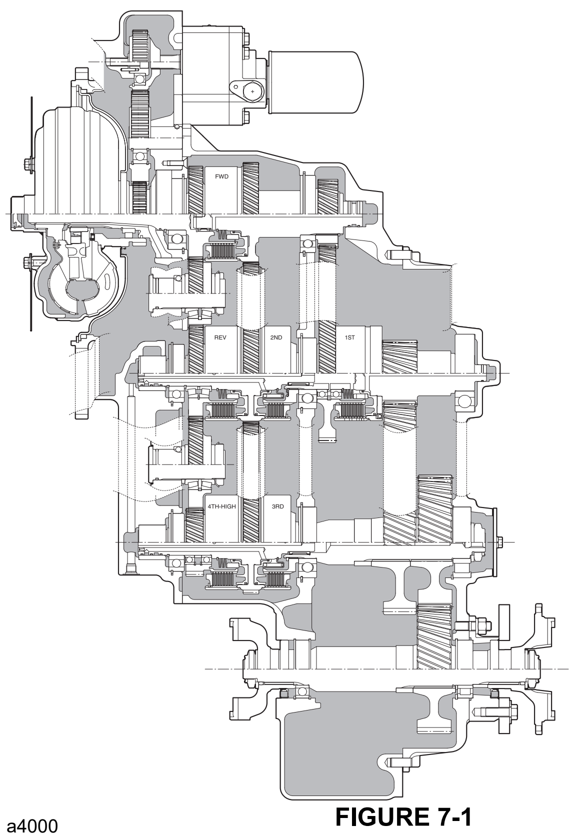

FIGURE 7-1

TECHNICAL SPECIFICATIONS

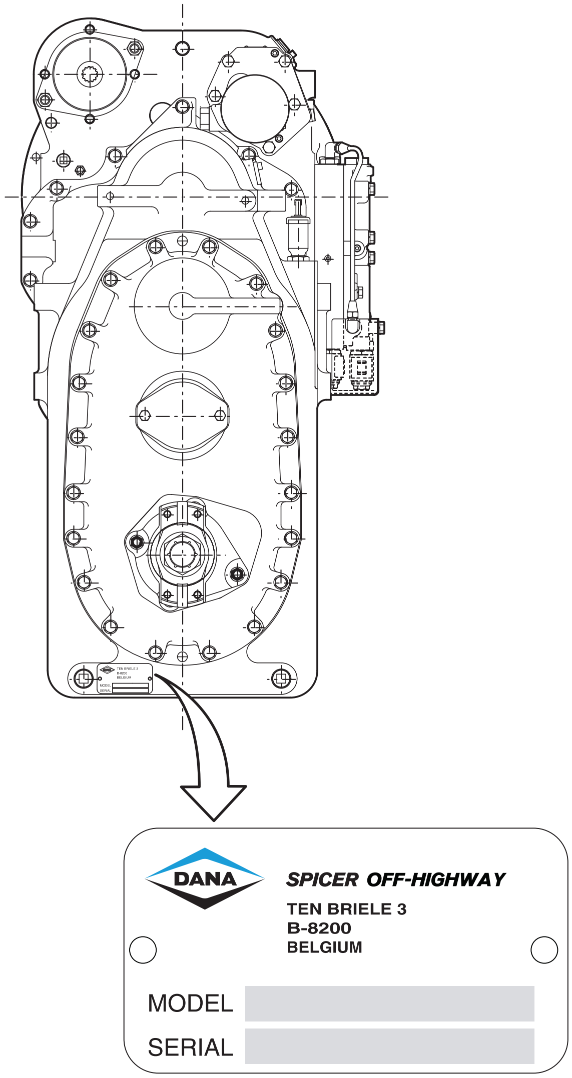

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FIGURE 7-2

T-model

Maximum length: 1081.3 mm (42.57 in)
Maximum width: 584.2 mm (23.00 in)
Maximum height: 1016.3 mm (40.01 in)

Oil capacity

24 L (6.3 gal) without cooler and hydraulic lines. Consult operator's manual on applicable machine for system capacity.

Identification of the Unit

1. Model and type of the unit.
2. Serial number.

Weight, Dimensions, Oil Capacity

Weight (dry): ± 380 kg (836 lb)

Pressure and Temperature Specifications

Normal operating temperature	70 - 120°C (158 - 248°F) measured at temperature check port converter out
Maximum allowed transmission temperature	120°C (248°F)
Transmission regulator pressure (*) - (neutral).	At 600 rpm min. 16.5 bar (240 psi) minimum At 2200 rpm: 19.3 bar (280 psi) maximum
Pump flow (*)	
At 1800 rpm in neutral	54.9 l/min. minimum (14.5 gpm)

(*) All pressures and flows to be measured with oil temperature of 82-93°C (180-200°F)

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Electrical Specifications

Solenoid (forward, reverse, 1st and 2nd)

Coil resistance .... 12V: 9.79 ±0.5
24V: 39.3 ±2

Speed sensor

Type .... magneto resistive sensor

Sensing distance .... 0 - 1.8 mm (0 - 0.07 in)

Sensor signal........ generates a square current with a fixed amplitude changing between 7 and 14 mA.

Hydraulic Cooler and Filter Line Specifications

Minimum .... 19 mm (.75 in) internal diameter for lines and fittings

Operation .... Suitable for operation from ambient to 120°C (248°F) continuous operating temperature

Pressure........ Must withstand 20 bar (290 psi) continuous pressure and with 40 bar (580 psi) intermittent surges

Conform SAE J1019 and SAE J517........ 100RI

MAINTENANCE

Oil Specification

Recommended Lubricants

Caterpillar .... TO-4.
John Deere .... J20 C, D.
Military .... MIL-PRF-2104G.
Allison .... C-4.
Dexron®............................. II Equivalent - See note below.

NOTE: Dexron® II equivalents are acceptable; however they are not compatible with torque converters or transmissions equipped with graphite based friction material clutch plates.

CAUTION

Equipment Damage Hazard!

Dexron® III, engine oil or GL-5 oils are not recommended.

Synthetic lubricants are approved if qualified by one of the above specifications. Oil viscosity guidelines apply, but synthetic multigrades may span more than 10 points. For fire resistant fluid recommendations please contact spicer off-highway products.

Use of unapproved lubricants can damage the transmission.

Preferred Oil Viscosity

It is recommended that the highest viscosity monograde lubricant available be used for the anticipated ambient temperature. Typically this will be a CAT TO-4 qualified lubricant. When large swings in ambient temperature are probable, J20 C, D multigrades are recommended. Multigrade lubricants should be applied at the lower viscosity rating for the prevailing ambient temperature, i.e. a 10W20 should be used where a 10W monograde is used. If a C-4 multigrade is used in stead of J20 lubricant it is recommended that the viscosity span no more than 10 points, i.e. 10W20.

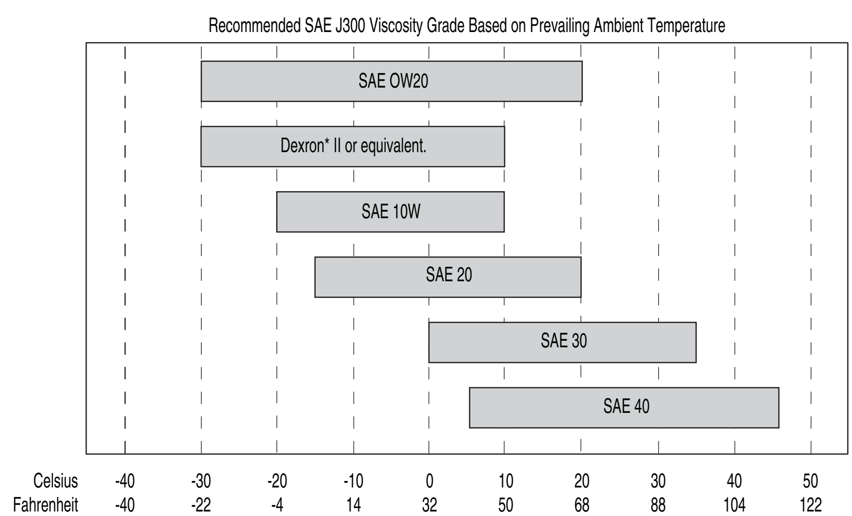

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FIGURE 7-3

Sump Preheaters

Preheat the transmission fluid to the minimum temperature for the oil viscosity used before engine start up.

Normal Oil Change Interval

Drain and refill system every 1000 hours for average environmental and duty cycle conditions. Severe or sustained high operating temperature or very dusty atmospheric conditions will result in accelerated deterioration or contamination. Judgement must be used to determine the required change intervals for extreme conditions.

Extended Oil Change Interval

Extended oil service life may result when using synthetic fluids. Appropriate change intervals should be determined for each transmission by measuring oil oxidation and wear metals, over time, to determine a baseline.Wear metal analysis can provide useful information but a transmission should not be removed from service based solely on this analysis.

Filters

Service oil filter elements every 500 hours under normal environmental and duty cycle conditions.

Maintenance Intervals

Daily

Check oil level daily with engine running at idle (600 rpm) and oil at 82 - 93°C (180-200°F). Maintain oil level at full mark.

Normal Drain Period

Normal drain period and oil filter element change are for average environment and duty cycle condition.

Severe or sustained high operating temperature or very dusty atmospheric conditions will cause accelerated deterioration and contamination.

For extreme conditions judgement must be used to determine the required change intervals.

Every 500 Hours

Change oil filter element.

Every 1000 Hours

Drain and refill system as follows (Drain with oil at 65 - 93°C (150 - 200°F)):

1. Drain transmission.
2. Remove and discard filter. Install new filter.
3. Refill transmission to FULL mark.
4. Run engine at 500 - 600 rpm to prime convertor and lines.
5. Recheck level with engine running at 500 - 600 rpm and add oil to bring level to LOW mark. When oil temperature is hot 82.2 - 93.3°C (180- 200°F) make final oil level check and adjust if necessary to bring oil level to FULL mark.

NOTE: It is recommended that oil filter be changed after 100 hours of operation on new, rebuilt or repaired unit.

Servicing Machine After Components 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 element.
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.

CAUTION

Equipment Damage Hazard!

Do not use flushing compounds for cleaning purposes. Damage to the engine may result.

5. Reassemble all components and use only type oil (See *Recommended Lubricants* page 7-4). Fill the transmission through filler opening until fluid comes up to FULL mark on transmission dipstick.
   - Remove filler plug and fill oil until FULL mark.
   - 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 LOW mark on dipstick.
   - Recheck with hot oil 82.2 - 93.3°C (180 - 200°F).
   - Adjust oil level to FULL mark on dipstick.

6. Recheck all drain plugs, lines, connections, etc., for leaks and tighten where necessary.

REMOVAL

1. Remove the complete power unit. See Engine and Engine System, Section 6.

2. Fasten engine in an engine stand.

3. Use a hoist and chains to support the weight of the transmission.

WARNING

Crushing Hazard!

The transmission is very heavy and could cause personal injury if not supported properly when it is removed.

4. Remove the access cover on the engine flywheel.

5. Through the access hole, remove the eight (8) bolts and lockwashers securing the torque converter drive plate to the engine flywheel. Rotate the flywheel to gain access to each bolt.

6. Remove the eleven (11) bolts and lockwashers securing the transmission to the engine. Remove the nut and lockwasher from the locating stud.

7. Carefully remove the transmission and move to a clean work area.

INSTALLATION

1. Use a hoist and chains to support the weight of the transmission.

2. Position the transmission on the engine flywheel housing, aligning one mounting hole with the locating stud.

3. Install lockwasher and bolt on locating stud.

4. Install eleven (11) lockwashers and bolts securing the transmission to the engine.

5. Through the access hole, align the flywheel and drive plate. Install the eight (8) lockwashers and bolts securing the torque converter drive plate to the engine flywheel.

6. Install the access cover on the engine flywheel.

7. Install the complete power unit. See *Engine and Engine System*, Section 6.

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SECTION 8
AXLES/DRIVE SHAFTS/WHEELS AND TIRES

SECTION CONTENTS

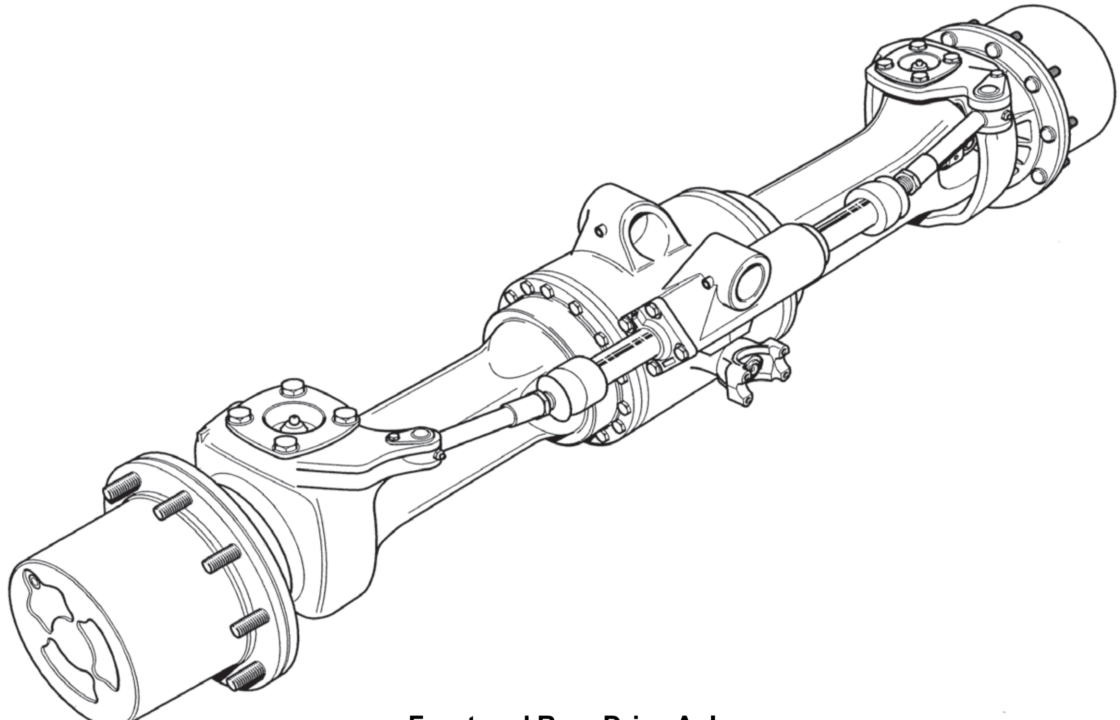
DESCRIPTION

Front Axle and Rear Axle

The front axle and rear axle (Figure 8-1) are the same except for the means of attachment to the crane frame. The axles include a 3 piece spiral bevel input with epicyclic hub reduction. The brakes are on either side of the drive head.

The front axle is a rigid-mounted drive axle attached to the frame by a pin.

The rear axle is pin mounted to a mounting plate which in turn is bolted to the frame. The axle is allowed to pivot 4 degrees in either direction when the axle locks are disengaged. With oscillation locks engaged, the axle is rigid.



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Front and Rear Drive Axle

FIGURE 8-1

8

TECHNICAL DATA

Front and Rear Drive Axle

Type	Spiral bevel input with epicyclic hub reduction
Installation	Pin mount
Number of steering cylinders	Power track rod, integral cylinder
Weight (dry, with no steering cylinders and without wheels)	540 kg (1191 lb) approximate
Hub brakes	5 plate (either side of drive head) positive retraction type.
Input type	1480 half yoke
Oscillation (Both Directions) (Rear Axle only)	4 degrees (Oscillation lockouts not engaged)
Toe-in	0 degrees
Caster angle	0 degrees
Camber angle	1 degrees
King pin inclination	0 degrees
Hub reduction	5.4:1
Overall ratio	24.975:1
Crownwheel and pinion ratio	4.625:1
Number of teeth:	
Crownwheel	37
Pinion	8

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FRONT AND REAR DRIVE AXLE REPAIR

Removal

WARNING

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

Disconnect the battery cables while you are under the machine, to prevent the engine from being started.

1. Loosen the wheel lug nuts then raise and support the machine on axle stands or blocks positioned under the chassis frame. Remove the wheels.
2. Disconnect the drive shaft from the axle by removing the four bolts and lockwashers securing the drive shaft to the axle.
3. Disconnect and plug the hydraulic hoses to the steering cylinder.
4. Disconnect the brake lines from the axle.
5. Support the axle on a trolly jack.
6. Remove the bolt and lockwasher, securing the mounting pin and remove the pin.
7. Remove the axle from the machine.

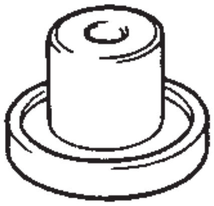
Installation

1. Place the axle on a trolly jack.
2. Position the axle and trolly jack under the machine frame.
3. Align the axle mounting holes with the holes on the machine and install the mounting pin. Secure the mounting pin with a bolt and lockwasher.
4. Apply grease to the grease fittings on both ends of the pin.
5. Connect the brake line or hose to the axle.
6. Connect the hydraulic hoses to the steering cylinder.
7. Connect the front drive shaft to the axle using four bolts and lockwashers.
8. Bleed the air from the service brake system. See *Brake System, page 9-1*.
9. Bleed the air from the steering circuit. See *Steering System, page 10-1*.
10. Install the wheels to the axle. Lower the machine. Torque the lug nuts to 499 Nm (368 lb-ft).

Special Tools

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

The tools illustrated in (Figure 8-2) are available from your Grove Cranes distributor.



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Driver - Crownwheel Bearing and Differential Bearing Cones

a0168

Adapter - Steer/Drive Axle Pinion Bearing Cone

a0169

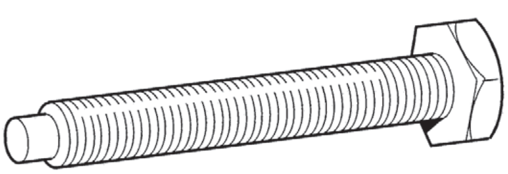
Spacer - Pinion Bearing Pre-load

a0173

17 mm A/F x 3/4 in. square drive

a0179

Impulse Extractor Set for Hub Bearing Seals



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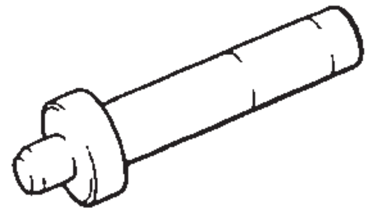
Annulus Removal Tool



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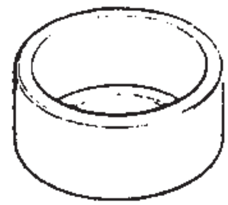
Bearing Pad Driver



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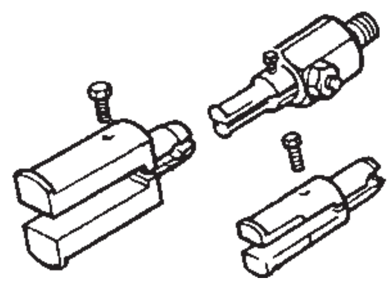
Measuring Cup - Pinion Head Bearing



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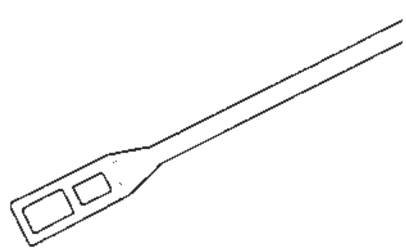
Adapter - Impulse Extractor
Small - 17 to 25 mm
Medium - 25 to 45 mm
Large 45 to 80 mm

a0175

Driver - Pinion Head Bearing Cup



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Drive Coupling Spanner for Axle Yoke Couplings

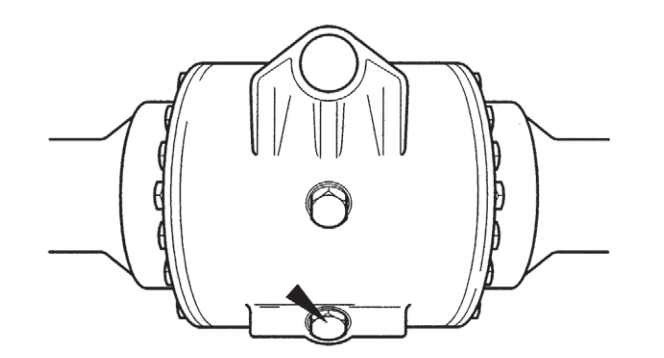
FIGURE 8-2

Drive Head - Disassembly

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

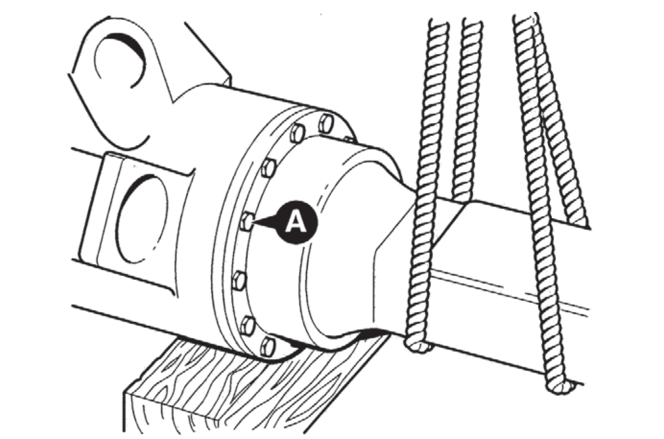
It will be necessary to provide a suitable stand on which to support the axle once it has been removed from the machine.

1. Remove the oil drain plug (Figure 8-3) from the axle housing and drain the oil.



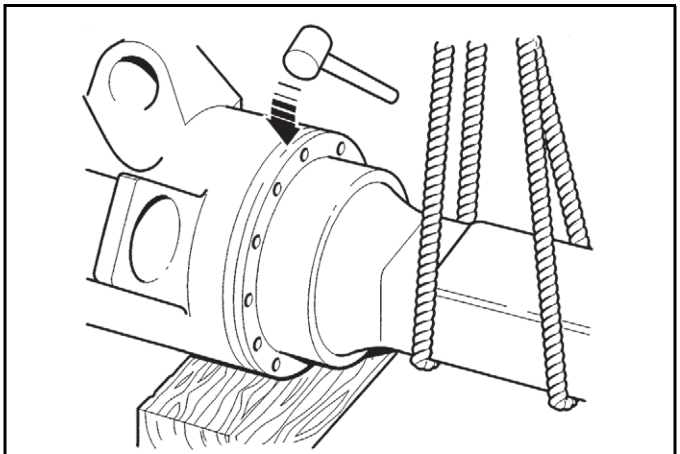
a4070 **FIGURE 8-3**

2. Support the axle arm and remove bolts **A** (Figure 8-4).



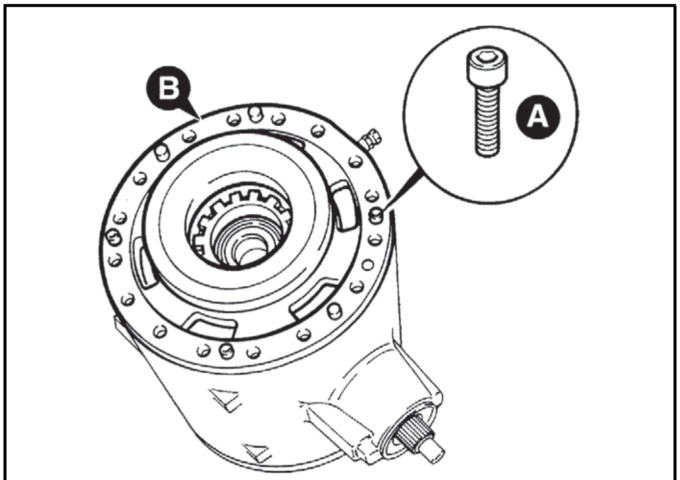
a4071 **FIGURE 8-4**

3. Separate the axle arm from the drive head (Figure 8-5) by tapping the flange with a soft faced hammer. Remove all traces of gasket material from the mating faces.



a4072 **FIGURE 8-5**

4. Position the drive head as shown in Figure 8-6, with the crownwheel at the top. Remove coupling yoke using Annulus Removal Tool and removing stake nuts together. Remove capscrews **A**.
5. Match-mark the brake piston housing **B** and drive head. Pull off the brake piston housing.



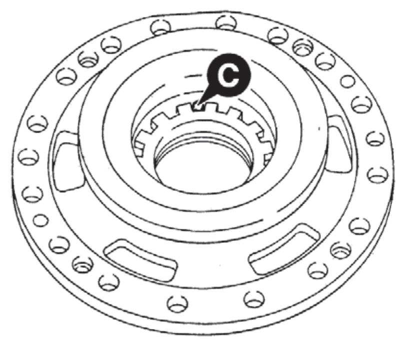
a4073 **FIGURE 8-6**

8

6. Drive out the differential side nut locking pin **C** (Figure 8-7) to allow readjustment on assembly. Remove the other brake piston housing only if damaged, but remove its locking pin **C** regardless (to allow side load adjustment on assembly).

CAUTION

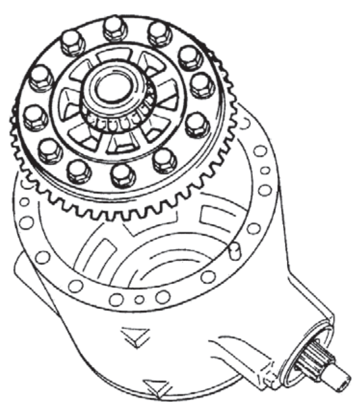
You can be injured by flying metal splinters when driving metal pins in or out. Use a soft faced hammer or drift to remove and fit metal pins. Always wear safety glasses.



a4074 **FIGURE 8-7**

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

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

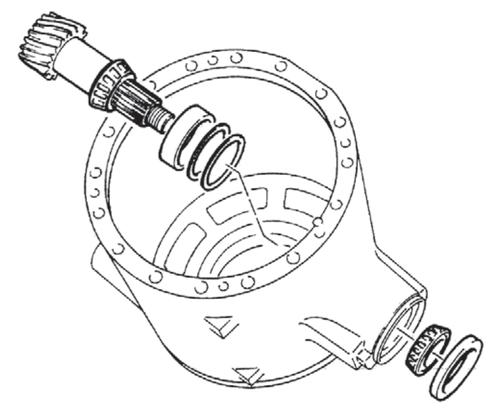


a4075 **FIGURE 8-8**

8. Using a soft faced hammer, hit the pinion end shaft until the pinion is free from its front bearing, then withdraw the pinion (Figure 8-9).

9. Withdraw the pinion seal and outer bearing cone.

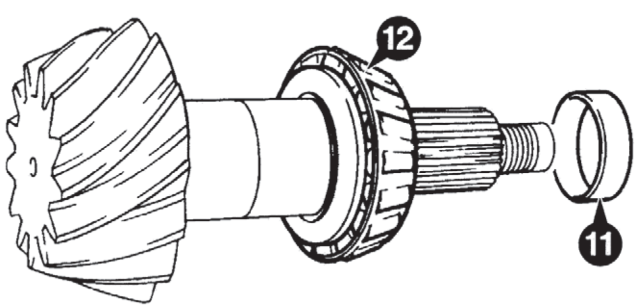
10. If necessary, drive out the pinion inner bearing cup and shims. Discard the shims. Repeat for the outer bearing cup if required. Note that there are no shims for the outer bearing cup.



a4076 **FIGURE 8-9**

11. Remove and discard the pinion collapsible spacer (Figure 8-10)

12. Pull the bearing cone, **12**.



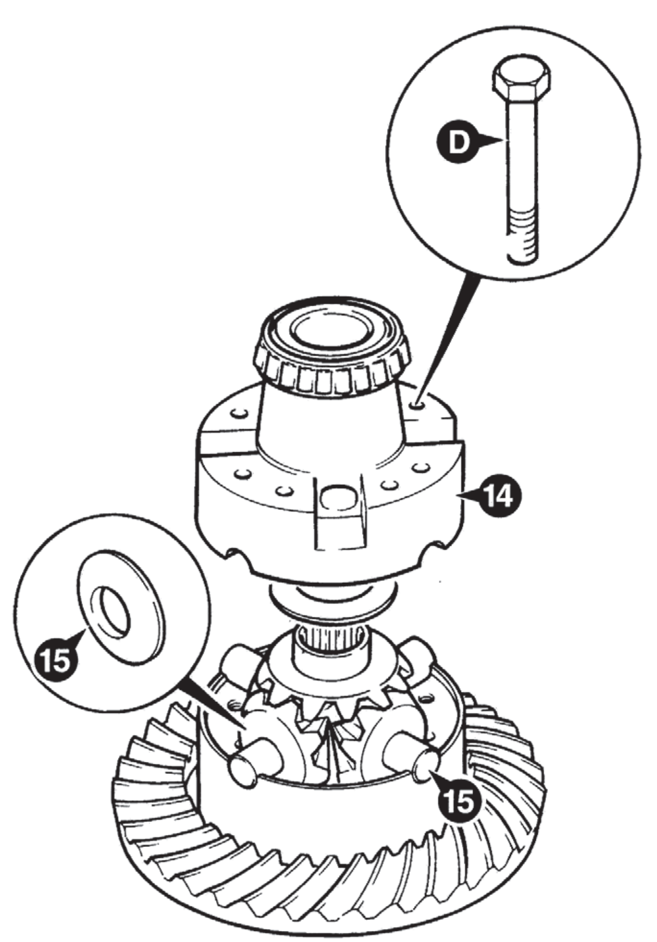
a4077 **FIGURE 8-10**

13. To dismantle the differential assembly, first remove bolts **D** (Figure 8-11).

14. Lift off the top half housing **14**.

15. Remove the differential gears and spherical washers **15**.

If required, remove the crownwheel and discard the Verbus Ripp bolts.



a4078 **FIGURE 8-11**

Drive Head - Assembly

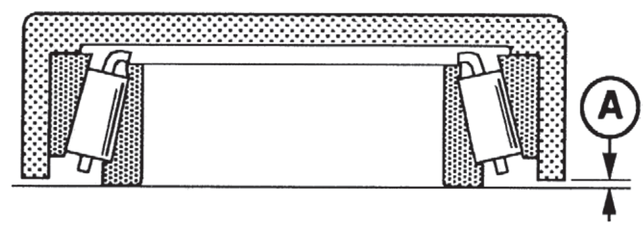
Pinion Depth

Determine the pinion depth setting as follows:

NOTE: See *Crownwheel and Pinion Adjustment* for general guidance on crownwheel and pinion adjustment.

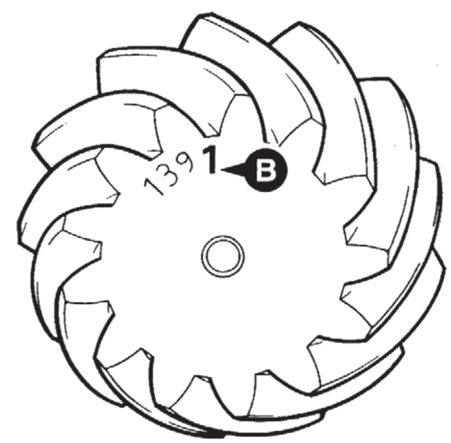
1. Assemble the pinion inner bearing and its cup on a flat surface.

2. Place Measuring Cup (Pinion Head Bearing, Figure 8-2) over the bearing assembly. Measure gap **A** (Figure 8-12). Add tool depth (30.01 mm) to gap **A** to give bearing depth.



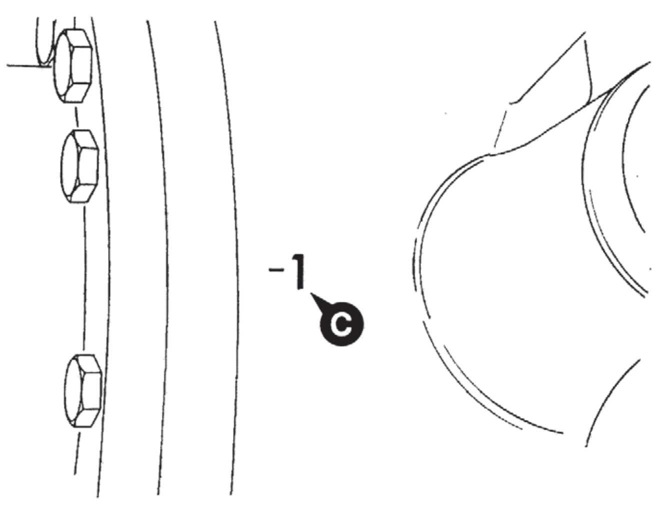
a4079 **FIGURE 8-12**

3. Note the mounting distance **B** (Figure 8-13) etched on the pinion and the deviation **C** (Figure 8-14) on the drive head housing. Both figures are in units of 0.01 mm.



a4080 **FIGURE 8-13**

4. If dimension **B** is positive, add it to the bearing depth. If dimension **B** is negative, subtract it from the bearing depth.



a4081 **FIGURE 8-14**

5. If dimension **C** is positive, subtract it from the total. If dimension **C** is negative, add it to the total.
6. Subtract the result from the standard value of 31.19 mm to give the required shim thickness.

Example (Dimensions in mm)

Dimension **A** 0.25
Add tool 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

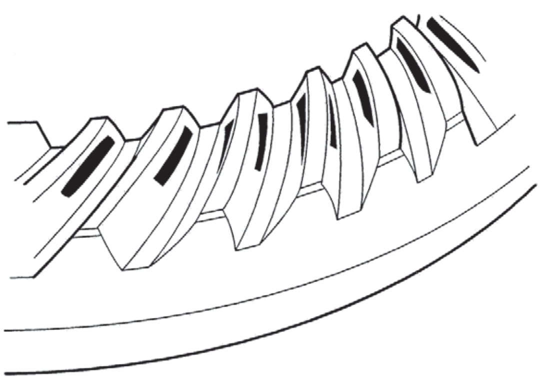
Standard Value 31.19
Less calculated total from above .... - 30.28
SHIM THICKNESS .... = 0.91

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.

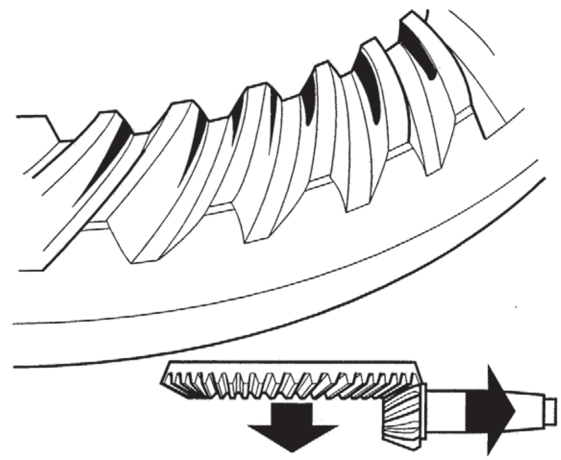
1. Figure 8-15 shows correct tooth marking.



a4082 **FIGURE 8-15**

2. Figure 8-16 shows pinion too deeply in mesh.

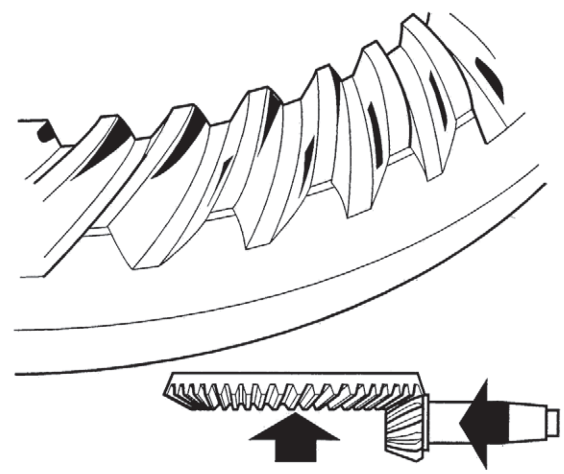
   Decrease the shim thickness between the pinion inner bearing cup and the axle casing. Move the crown wheel towards the pinion to correct the backlash.



a4083 **FIGURE 8-16**

3. Figure 8-17 shows pinion too far out of mesh.

   Increase the shim thickness between the pinion inner bearing cup and the axle casing. Move the crown wheel away from the pinion to correct the backlash.



a4084 **FIGURE 8-17**

NOTE: The crownwheel and pinion are matched and should be renewed as a pair 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 halves or gears.

Verbus Ripp bolts must be replaced throughout assembly.

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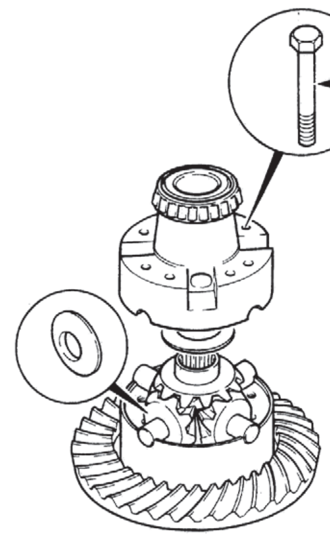
1. If required, fit a new crownwheel (Figure 8-18) to the differential case half, torque the new crownwheel retaining bolts to 166 Nm (122 lb-ft).

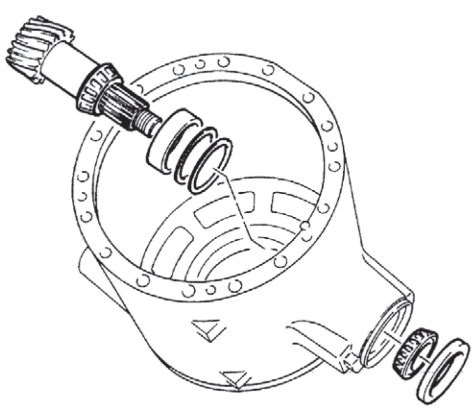
   Assemble the differential gears and their spherical washers into the bottom half housing. Fit the differential bearing cones.

2. Position the top half housing onto the differential, aligning the match mark letters (see Note above). Apply Loctite 243 to the threads of bolts **D**, then fit and torque to 56 Nm (42 lb-ft). Check the gears for free rotation.



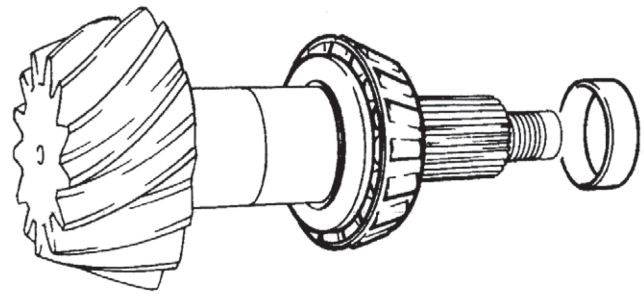
a4085 **FIGURE 8-18**

3. Fit the pinion inner bearing cup (Figure 8-19) together with the required thickness of shims to give correct pinion depth (see *Pinion Depth*). To ensure the cup is fitted square, use a suitable puller assembly. Do not use a hammer. Fit the outer bearing cup.



a4076 **FIGURE 8-19**

4. Fit the pinion inner bearing cone (Figure 8-20) and a new collapsible spacer.

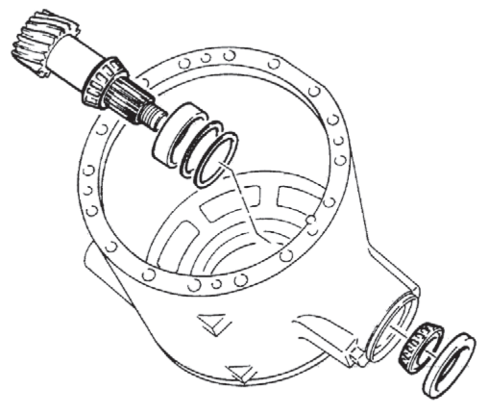


a4086 **FIGURE 8-20**

5. Insert the pinion into its bore (Figure 8-21).

NOTE: Before inserting, ensure that the pinion matches the crownwheel. The code numbers etched on the pinion end face and the crownwheel perimeter should be the same.

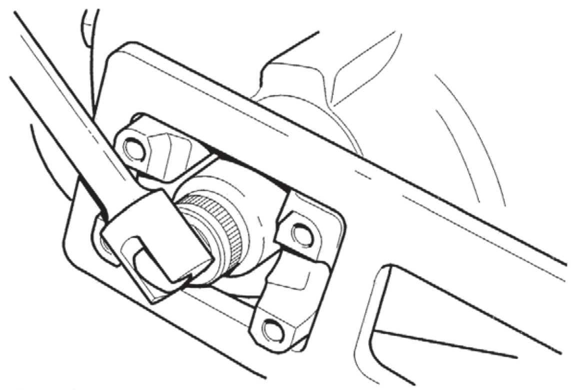
6. Fit the pinion outer bearing cone and the seal. Pack between the lips of the seal with grease before fitting.



a4076 **FIGURE 8-21**

8

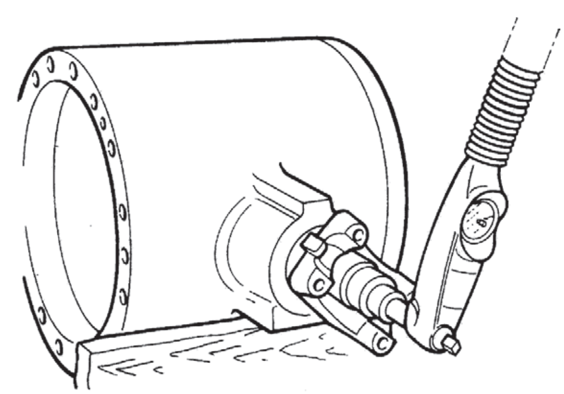
7. Install the drive coupling yoke (Figure 8-22) and secure it with a new combined stake nut and washer. Hold the yoke with Drive Coupling Spanner for Axle Yoke Coupling (Figure 8-2). Tighten the stake nut until end float is almost zero then check seal drag torque is between 0.40 to 1.0 Nm (3.5 to 8.9 lb-in). Continue to tighten the stake nut to achieve the correct rolling torque; see Step 8. If the nut is overtightened, the collapsible spacer must be renewed.



a4087 **FIGURE 8-22**

8. Measure the rolling torque (Figure 8-23) which should be 1.7 to 2.8 Nm (1.3 to 2.1 lb-ft) excluding seal drag. When the torque is correct, stake the nut to the pinion shaft using a square-ended staking tool.

9. If both brake piston housings were removed, fit the one at the opposite end to the crownwheel, using the procedure in Step 8. Then install the crownwheel/ differential assembly into the drive head.

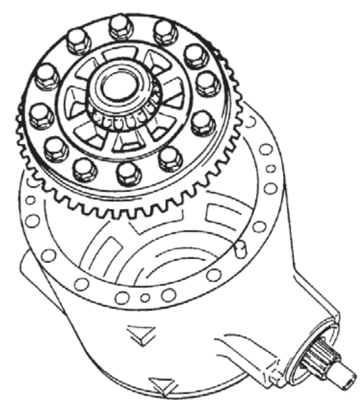


a4088 **FIGURE 8-23**

10. Apply Loctite 275 sealant to the drive head mating face, then fit the brake piston housing (Figure 8-21). Ensure that the match marks made during disassembly are aligned. Fit capscrews **A** (see Note) and torque to 56 Nm (42 lb-ft). (Applies to both piston and housings.)

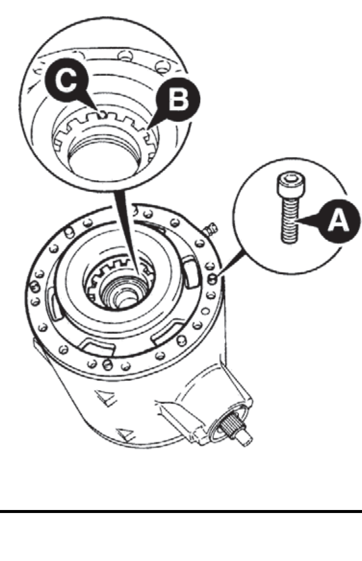
NOTE: When refitting the cap screws, clean the threads with a wire brush and coat the threads with Loctite 243. Fit and torque to the figure quoted above.

New capscrews are encapsulated and do not require cleaning or manually coating with sealant.



a4075 **FIGURE 8-24**

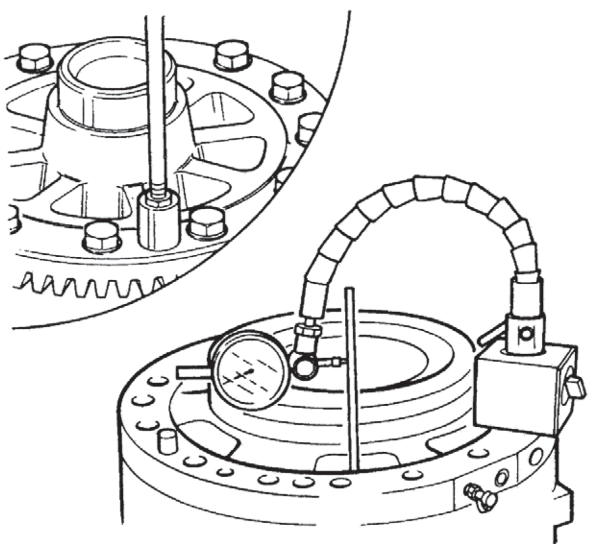
11. Adjust differential side nuts **B** (Figure 8-25) to give a bearing preload of 1.36 to 2.5 Nm (1.0 to 1.84 lb-ft). Measure the preload by taking another pinion rolling torque reading and subtracting the torque figure measured at Step 8. The difference is the bearing preload.



a4089 **FIGURE 8-25**

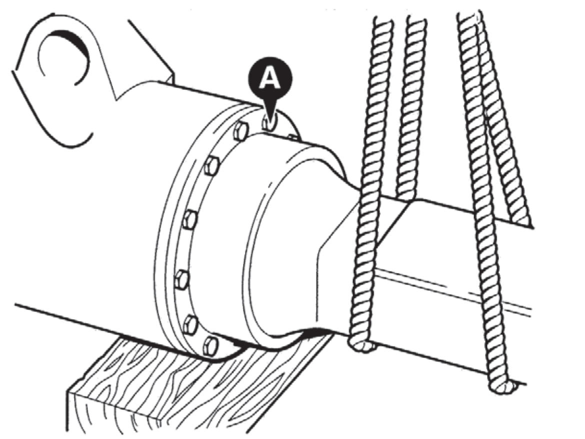
12. Measure the crownwheel backlash (see Note), which should be 0.13 to 0.2 mm (0.005 to 0.008 in). Adjust the differential side nuts by equal amounts when altering backlash. When backlash and preload are both correct, fit the side nut locking pins **C** (see illustration, step 11). Verify crownwheel, pinion and preload are set correctly, see *Crownwheel and Pinion Adjustment*.

NOTE: To measure the backlash, use a magnet drilled and tapped 6 mm to accept a length of threaded 6 mm on one end. Position the magnet in between the crown wheel locking bolts as shown in Figure 8-26.

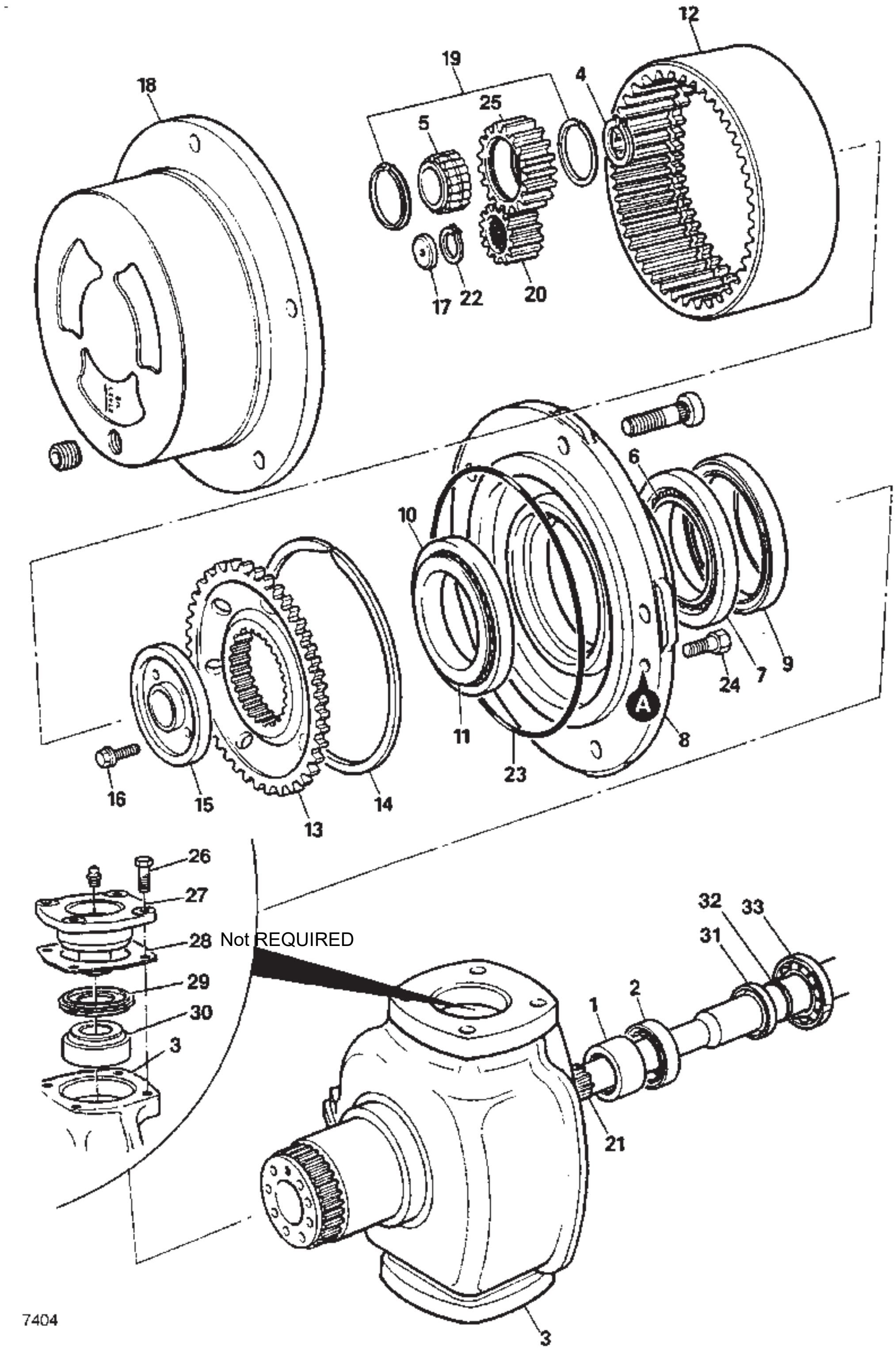


a4090 **FIGURE 8-26**

13. Apply Loctite 275 to the mating face of the drive head. Locate the axle arm onto the drive head (Figure 8-27) with the embossed word 'TOP' on the axle arm uppermost. Fit bolts **A** and torque to 400 Nm (295 lb-ft).



a4091 **FIGURE 8-27**



Item	Description
1.	Bearing
2.	Outer oil seal
3.	Hub Swivel
4.	Circlip
5.	Bearing
6.	Inner bearing
7.	Inner bearing cup
8.	Bearing carrier
9.	Combination Seal
10.	Outer wheel bearing Cup
11.	Outer wheel bearing
12.	Annulus ring
13.	Annulus carrier
14.	Circlip
15.	Retaining Plate
16.	Verbus Ripp bolts
17.	Driveshaft Thrust Pad
18.	Planet gear carrier
19.	Circlip
20.	Sun gear
21.	Half Shaft
22.	Circlip
23.	O-ring)
24.	Screws
25.	Planet gear
26.	Bolt
27.	Trunnion
28.	Shim - Not Required
29.	Trunnion seals
30.	Trunnion Bearing
31.	Inner Seal
32.	Circlip
33.	Bearing
A.	Tapped Hole

a4092

FIGURE 8-28

Axle Hub and Axle Half Shaft Disassembly

1. Drain oil from the axle hub.
2. Remove screws **24** (Figure 8-28).
3. Using a soft-faced mallet, tap the planet gear carrier **18** to 'crack' the joint between the carrier and bearing carrier **8**, then lever the planet gear carrier off the bearing carrier. Remove and discard O-ring **23**.
4. Remove a planet gear **25** only if it is defective. Note that a planet gear can only be replaced as an assembly, which comprises the pinion, the bearing **5** and two 'L' shaped circlips **19**. To remove a planet gear, first remove the external circlip **4**, then pull off the planet gear.
5. The half shaft thrust pad **17** is drilled and tapped M6 for removal purposes. Remove the half shaft thrust pad from planet gear carrier.
6. Remove external circlip **22** and sun gear **20**.
7. Remove Verbus Ripp bolts **16**. These bolts are very tight and care must be taken not to distort the bolt heads. Use as short an extension bar as possible with a six sided socket. Discard the Verbus Ripp bolts after removal.

NOTE: Ensure annulus ring position is marked for reassembly.

8. Using special tool (Annulus Removal Tool, Figure 8-2) as jacking screws, jack the annulus assembly **12**, **13** and **14** off the bearing carrier **8**.

NOTE: Fretting between the hub swivel and annulus carrier mating faces 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 pairs and not individually.

9. Remove internal circlip **14** to separate the annulus ring **12** from the annulus carrier **13**.
10. Pull off the bearing carrier **8** together with the outer wheel bearing cone and cup **11**. Withdraw the inner bearing cup from the inboard side of the carrier.
11. Pull off the inner wheel bearing **6**.

NOTE: Earlier type axles may have an O-ring and wear ring fitted. These parts should be discarded.

12. On later type axles remove and discard combination seal **9**.
13. Disconnect the track rod and steering cylinder from the axle steer knuckles.

    If the track rod is removed completely, identify R.H.and L.H. ends to ensure correct assembly.

NOTE: The top and bottom trunnions are very similar (bottom trunnion not illustrated), the only difference being that shims **28** are fitted to the top trunnion only.

Trunnions may be removed easily and without damage to the shims by pumping grease through the grease nipple.

14. Mark position of top and bottom trunnions **27**, remove bolts **26** and remove trunnions. Withdraw the hub swivel **3**.

NOTE: Note: Shims **28** is not required with this assembly.

15. Remove the top and bottom trunnion seals **29** and bearings **30**.
16. Withdraw half shaft **21** from the axle casing.
17. Pry out half shaft outer oil seal **2**.
18. Remove bearing **1** using the Impulse Extractor tool Figure 8-2.
19. Pry out half shaft inner seal **31**.
20. Remove circlip **32**.
21. Remove bearing **33** using the Impulse Extractor tool Figure 8-2.

NOTE: If there has been a component failure, remove all traces of debris and clean the magnetic drain plug.

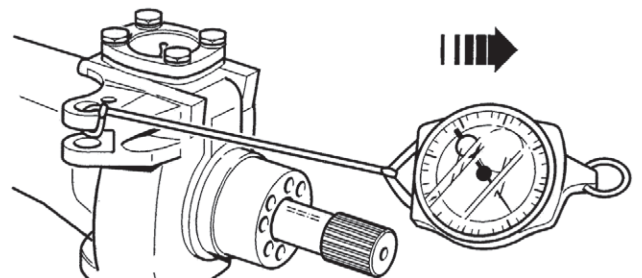
Axle Hub and Axle Half Shaft Assembly

NOTE: The top and bottom trunnions are very similar (bottom trunnion not illustrated), the shims **28** are not required.

1. Tap the half shaft inner bearing **33** into position in the hub swivel half shaft bore, secure with circlip **32**.
2. Fit new oil seal **31**. Pack grease between lips of seal.
3. Fit half shaft **21**, taking care to locate inner end into splines of differential gears.
4. Tap half shaft outer bearing **1** into position in the hub swivel.
5. Fit new oil seal **2**. Pack grease between the lips of the seal.
6. Press new top and bottom trunnion oil seals **29** into position followed by bearings **30**. Grease bearing and oil seal before fitting axle.
7. Locate hub swivel **3** and fit bottom trunnion **27**. Apply Loctite 243 to threads of bottom trunnion bolts **26** and then torque bolts to 56 Nm (42 lb-ft). Fit top trunnion **27** and leave top trunnion bolts **26** finger tight.
8. Attach a spring balance to track rod swivel and note pull required to turn the swivel. Tighten the top trunnion bolts

8

26 to eliminate end float but without bearing pre-load, i.e. no increase in spring balance reading.



a4094 **FIGURE 8-29**

9. Measure gap at top trunnion and subtract 1 mm (0.040 in) to give shim thickness (bearing pre-load). For example:

Gap = 1.55 mm (0.061 in)
<u>minus –</u> <u>1.00 mm (0.040 in)</u>
Shim = 0.55 mm (0.021 in)

NOTE: If the gap measures 1 mm, then no shim is required.

If after fitting shims, the bearing pre-load is unattainable, fit new bearings.

10. Refit top trunnion. Apply Loctite 243 to the top trunnion bolt threads, fit and tighten to 56 Nm (42 Ib-ft).

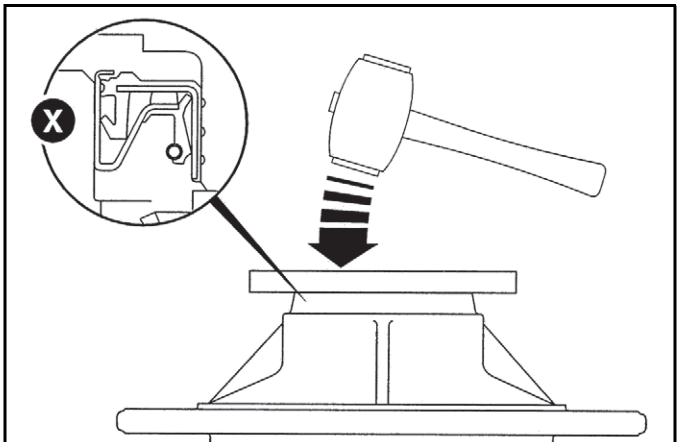
Check spring balance reading which should be 4.5 kg (10 Ib) more than the reading recorded at step 8.

11. Connect the track rod and steering cylinder to the axle steer knuckles. Tighten track rod nut to a minimum torque of 135 Nm (100 Ib-ft), then continue to tighten to next castellation and insert pin.

12. Lightly oil the inner wheel bearing **6** and its cup **7**, then fit them into the bearing carrier **8**.

13. Fit a new combination seal **9** into the bearing carrier.

Do not lubricate before fitting. Using the Oil Seal Insertion tool Figure 8-2 and spacer drive the seal squarely into carrier **19** until flush, as shown at **X**.



a4095 **FIGURE 8-30**

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** into the bearing carrier **8**. Grease the bore of the seal and the surface of the stub.

15. Fit the bearing carrier **8** onto the hub swivel **3**.

16. Lightly oil the bearing race of outer wheel bearing **11**. Fit the bearing onto the axle arm. Rotate the carrier **8** (and therefore the bearings) during fitting.

17. Assemble the annulus ring **12** to the annulus carrier **13**. Secure with circlip **14**.

18. Fit annulus assembly in the same angular position as removal, aligning the marks made during disassembly, using new Verbus Ripp bolts **16**. Do not fully tighten bolts but allow the bearing carrier to rock slightly.

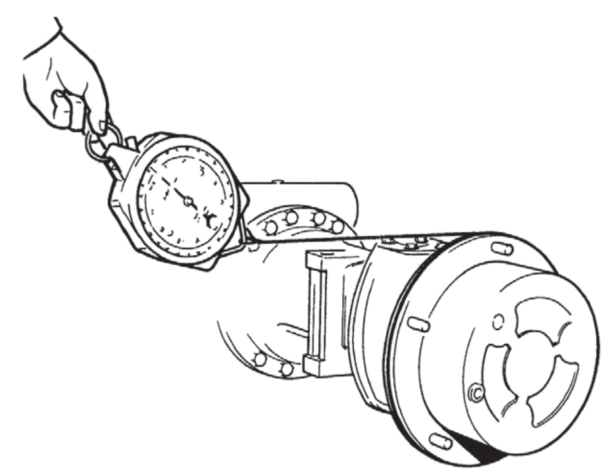
CAUTION

Equipment Damage Hazard!

Verbus Ripp bolts must **NOT** be reused. Damage to the axle assembly may result.

19. Check the seal drag rolling force:

a. Use a spring balance and cord wrapped around the planet carrier flange Figure 8-31. Pull the spring balance so that the hub rotates, do several times to let the seal bed in and record the reading.



a4096 **FIGURE 8-31**

b. Remove the planet gear carrier and tighten new Verbus Ripp bolts **16** to 166 Nm (122 Ib-ft).

c. Repeat step a. and record the reading.

d. To get the rolling force, subtract seal drag rolling force (step a.) from reading obtained at step c., the result should be 14 to 152 N (3 to 34 lb).

If the resulting figure is outside these limits check that seal **9** is fitted correctly and/or replace bearings **6** and **11**.

NOTE: A high rolling force reading may indicate that the oil seal was damaged during fitting.

20. Press the half shaft thrust pad (chamfered side lowermost) into the recess in the planet gear carrier **18**.

21. Fit new planet gears **25** in place of any that were removed (see Disassembly, step 4.). Secure with circlip **5**.

NOTE: The large radius at end of bearing bore fits onto the pin first.

22. Slide sun gear **20** onto the half shaft and secure with circlip **22**. Fit a new O-ring **23**.

Fit planet gear carrier **25** onto bearing carrier **8**, turning it slightly to engage the gear teeth and aligning the two tapped holes **A** Figure 8-28 in the bearing carrier. (The tapped holes are diametrically opposite one another.) Ensure the planet gear carrier butts fully against the bearing carrier.

NOTE: Do not strike the centre of the planet gear carrier **18** when fitting, as this may dislodge the half shaft thrust pad **17**.

23. Fit screws **24** and torque to 56 Nm (41.3 lb-ft).

24. Grease the half shaft u-joint, see *Lubrication Points, page 5-12*.

25. Fill the axle hub with oil, see *Replace the Axle Wheel Hub Lubricant, page 5-34*.

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 **5** (Figure 8-32 and Figure 8-33) stretch with use, therefore these straps must always be replaced with new ones.

Front Axle Drive Shaft

1. Remove bolts, lockwashers and mounting straps **5** (Figure 8-32) from front axle flange.

2. Remove bolts and lockwashers securing yoke flange **1** to transmission.

Rear Axle Drive Shaft

1. Remove bolts, lockwashers and mounting straps **5** **(**Figure 8-33) from transmission.
2. Remove bolts and lockwashers securing yoke flange **1** to transmission.

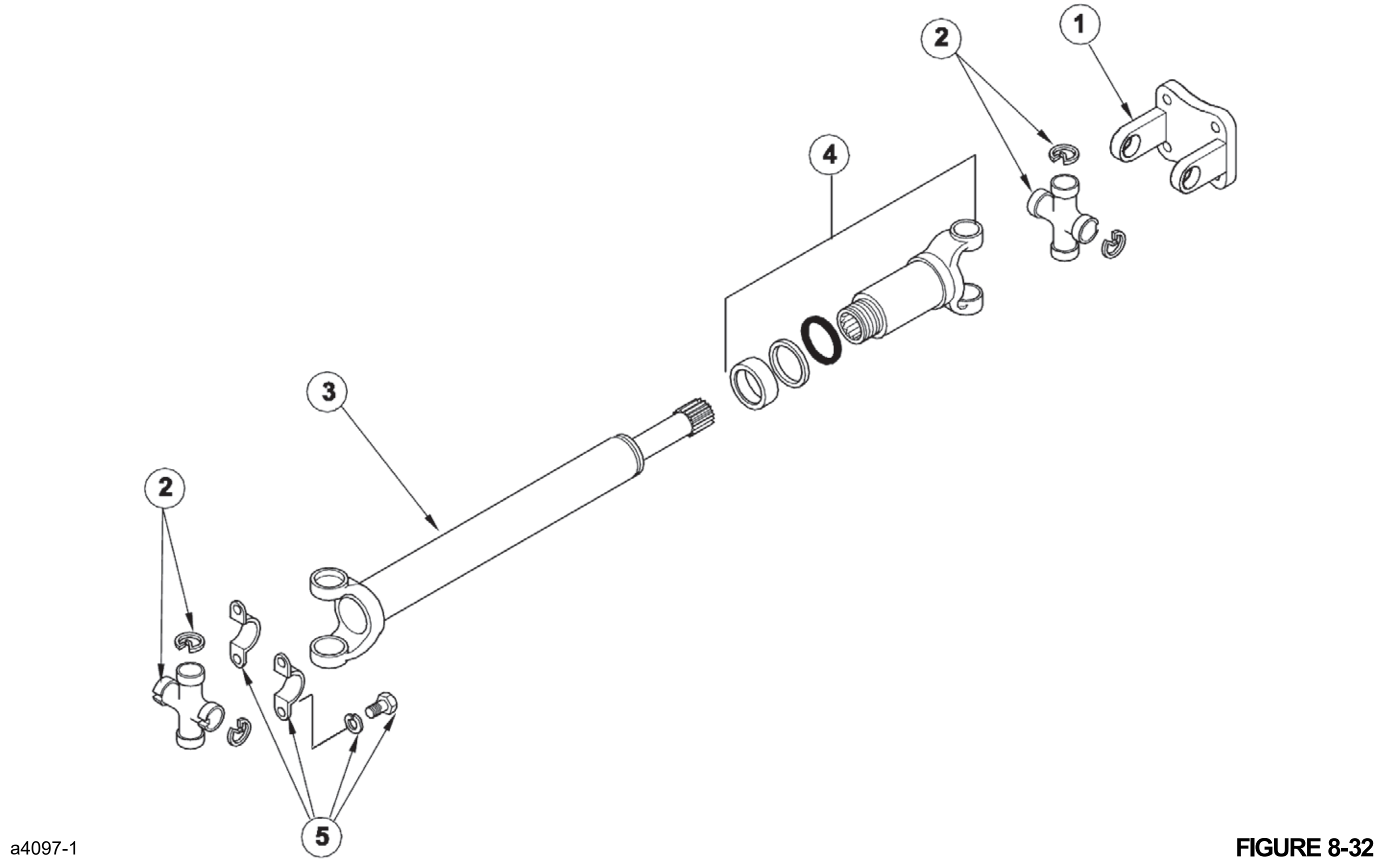


FIGURE 8-32

Disassembly

1. Put the flange yoke **1** (Figure 8-32 and Figure 8-33) 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 **2** 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.

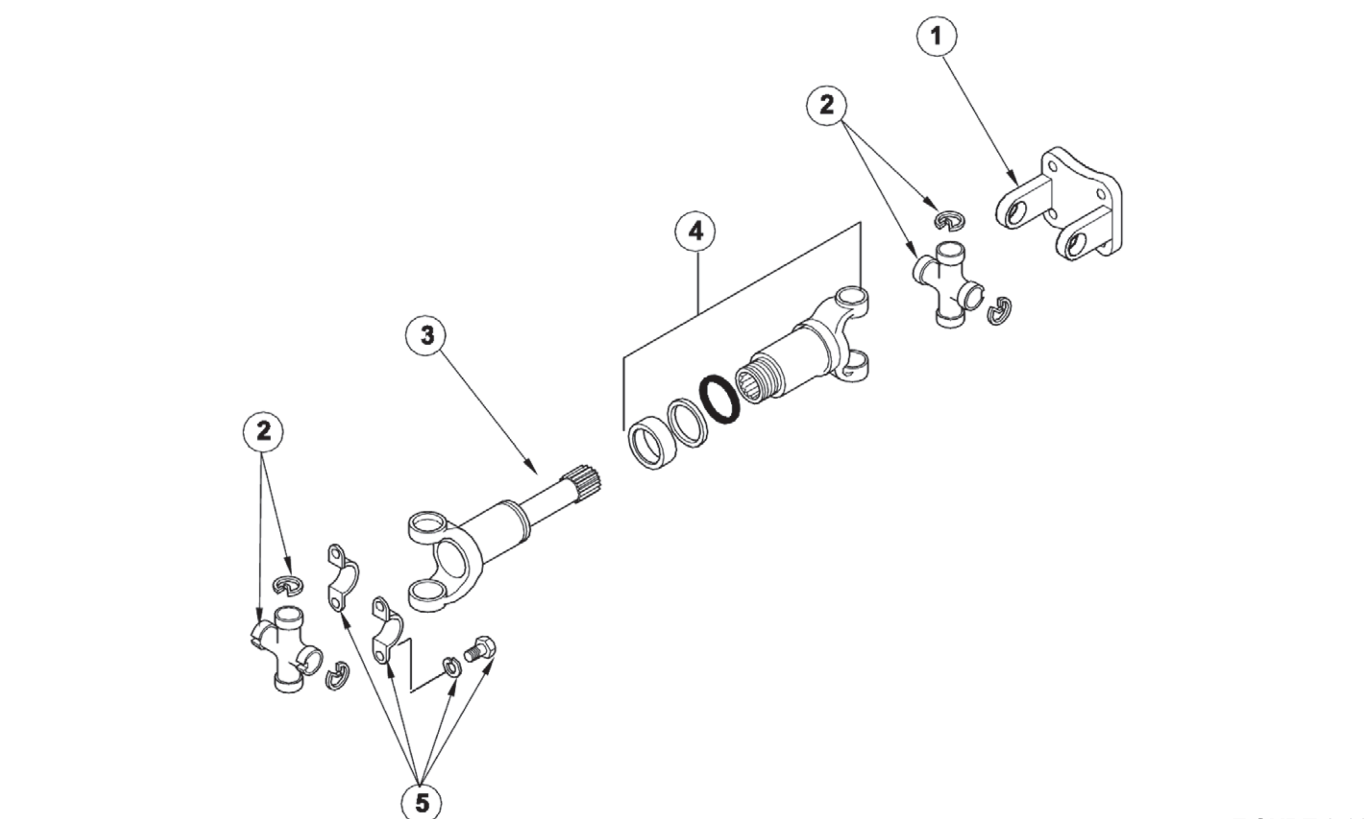


FIGURE 8-33

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

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 8-32 and Figure 8-33). Assemble the dust cap assembly to the sleeve yoke. Slide the sleeve yoke into the slip yoke (**4**). Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.

Installation

Front Axle Drive Shaft

1. Fasten the flange yoke **1** (Figure 8-32) to the transmission four bolts and lockwashers.

NOTE: The drive shaft must have both ends exactly on the same plane as shown in **X** (Figure 8-34). The yokes must not be at right angles as at **Y** or at an intermediate angle as at **Z.**

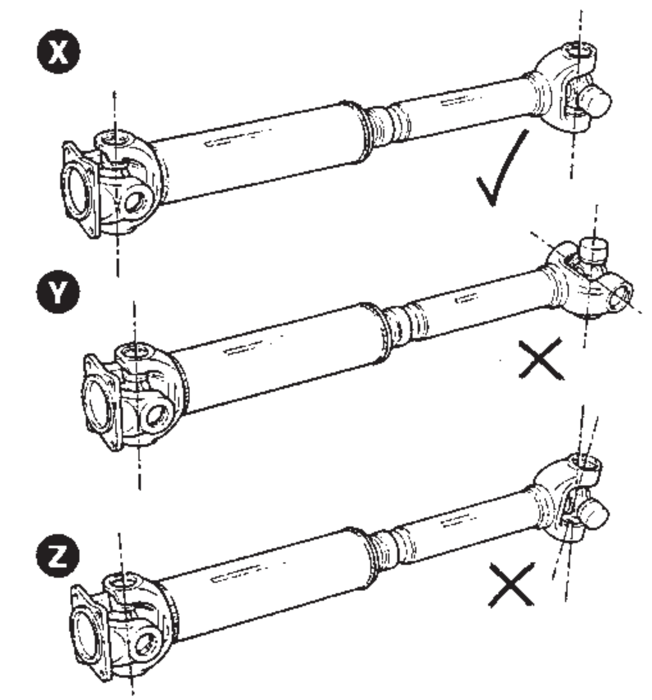


FIGURE 8-34

2. Fasten the other end to the axle using a new strap kit.

NOTE: The retaining straps (**5**) 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.

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.

Rear Axle Drive Shaft

1. Fasten cross **2** (Figure 8-33) to the rear axle yoke using a new strap kit **5**.

NOTE: The retaining straps **5** stretch with use, therefore these straps must always be replaced with new ones.

2. Fasten the flange yoke **1** to the transmission with four bolts and lockwashers.

NOTE: The drive shaft must have both ends exactly on the same plane as shown in **X** (Figure 8-34). 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 exits through the seals. See Lubrication Procedure.

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 of the shaft. Put your finger over the hole (Figure 8-35) 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.

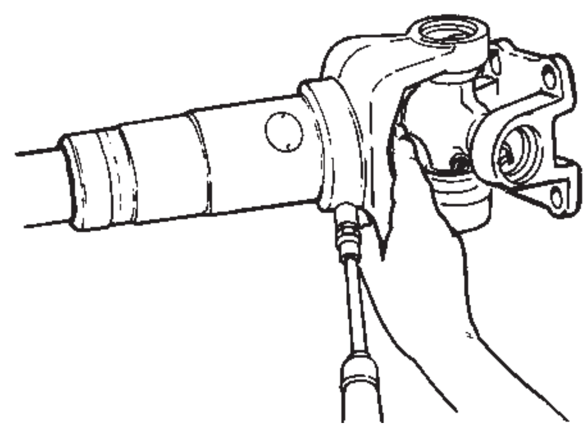


FIGURE 8-35

WHEELS AND TIRES

WARNING

Never try to disassemble the wheel until all air is released from the tire. The retaining ring and rim of the wheel and tire can come off with explosive force and can cause serious injury or death. Be extremely careful when working with them. Always use a tire and rim cage guard when inflating tires.

Tire Inflation

Check the tire pressure daily before operation. Also look for cuts and damage.

Tire Pressures

Tire Size	*Pressure*
17.5 x 25 Bias	758 kPa (110 psi)

Wheel Stud Nuts

The tightening order of the stud nuts is shown in Figure 8-36. Check the tightness of the lug nuts weekly or after every 50 hours of operation, whichever occurs first.

Wheel stud torque is 499 Nm (368 lb-ft).

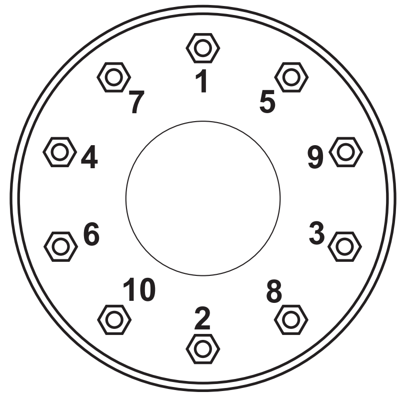


FIGURE 8-36

8

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SECTION 9
BRAKE SYSTEM

SECTION CONTENTS

TECHNICAL DATA

Axle Brakes

Type . . . . . Oil-immersed multi-plate disc

Actuation . . . . . Hydraulic

Location . . . . . Inboard - Drive Head

Friction Plates . . . . . 4 per set

Outside Diameter . . . . . 220 mm (8.66 in)

Inside Diameter . . . . . 180 mm (7.09 in)

Nominal facing area/plate . . . . . 12 616 mm² (19.5 in²)

Hydraulic Piston Diameter . . . . . 216 mm (8.5 in)

Piston Operation . . . . . Standard retraction

Accumulator

Type . . . . . Piston, Hydro-pneumatic

Volume . . . . . 2632 cu. cm (120.63 cu. in)

Nitrogen Recharge Pressure . . . . . 5171 ± 275 kPa (750 ± 40 psi).

Accumulator Charging Valve

Nominal Accumulator Charge Rate . . . . . 10.2 ± 1.9 L/min (2.7 ± 0.5 gpm)

Nominal High Limit . . . . . 13 790 ± 345 kPa (2000 ± 50 psi)

Nominal Low Limit. . . . . 11 376 ± 345 kPa (1650 ± 50 psi)

9

DESCRIPTION

There are two brake systems used on the crane; the service brake system and the parking brake system.

Service Brake System

The service brake system (Figure 9-1) consists of the single section gear pump attached to the piston pump, a relief valve, accumulator charging valve, a low pressure warning switch, an accumulator, a needle valve, a manifold valve, a brake modulating valve, a brake light switch and the front and rear axle service brakes.

Description of Operation

Hydraulic Pump

The pump supplies hydraulic oil flow to the priority flow control valve (Figure 9-1).

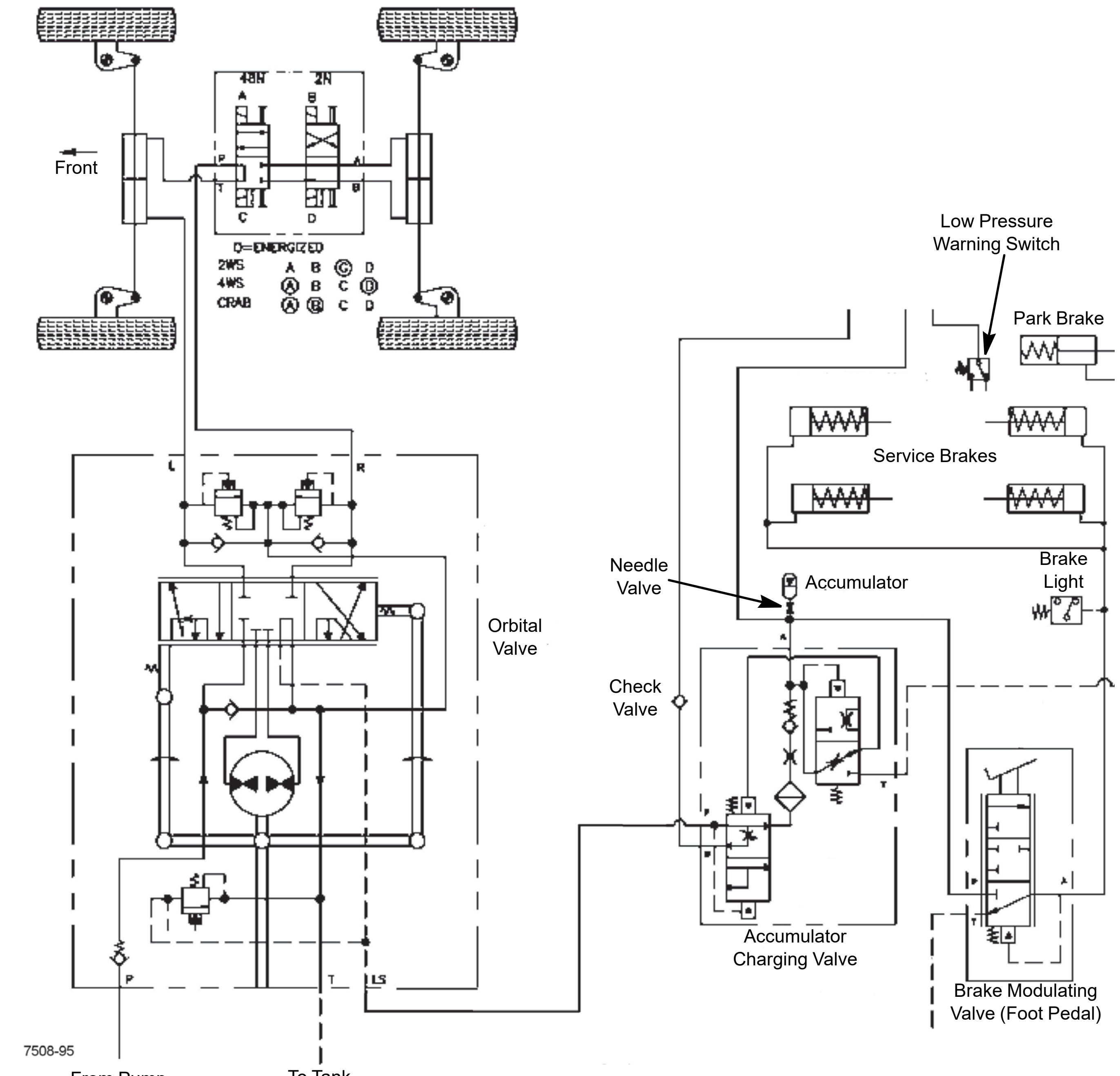


FIGURE 9-1

Accumulator Charging Valve

The accumulator charging valve supplies oil to the accumulator on demand. This is accomplished at a preset rate at a selected pressure; neither of which is adjustable.

The flow to the downstream brake modulating valve will be reduced fractionally for a short time when the accumulator is charging. This does not noticeably affect the operation of these components. Full system pressure is available to the downstream components at all times, providing oil delivery and pressure from the pump and relief valve are not impeded.

The accumulator charging flow rates and upper and lower pressure limits are set at the time of manufacture and are not adjustable.

Low Pressure Warning Switch

The low pressure warning switch illuminates a red light on the dash when the brake pressure goes below 5861 kPa (850 psi). When the red light illuminates, there still is enough pressure for brake application to stop the crane. After which, the brake system must be checked and repaired.

Accumulator

The accumulator is a hydro-pneumatic, piston-type accumulator. This means that the accumulator is charged with nitrogen and stores hydraulic fluid to a pressure of 13 790 kPa (2000 psi) for brake system usage.

NOTE:

Brake Modulating Valve

The brake modulating valve is a closed-center spool design. When the valve is in no-applied position, brake port, (**A**, Figure 9-1) is open to tank port **T**. As the valve is initially actuated, tank port **T** is closed off from brake port **T**. 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 414 kPa (60 psi).

Axle Brakes

The brakes are self-adjusting oil immersed and are located on either side of the drive head. Each brake assembly consists of four friction plates and five counter plates. The brakes are applied when the brake pedal in the operator's compartment is actuated. Brake fluid is forced from the master cylinder through the brake lines to both of the axle brakes. The brake fluid under pressure reacts against the brake pistons, forcing the friction plates against the counter plates, slowing and/or stopping the crane.

Parking Brake System

Description of Operation

The parking brake system consists of two-way switch in the instrument panel, a solenoid valve and a parking brake. The system connects into the service brake system and uses the accumulator for system pressure.

Parking Brake

The parking brake is a disc-type brake (Figure 9-2). The brake disc is attached to the front driveshaft output shaft on the transmission. The brake is attached to a bracket on the transmission. 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.

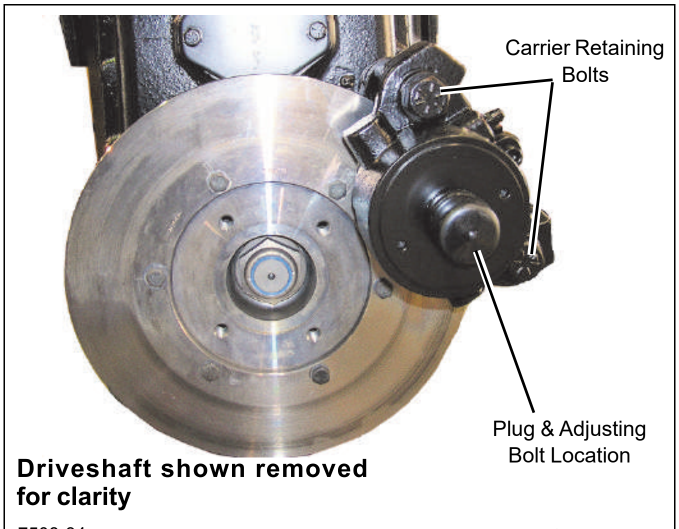


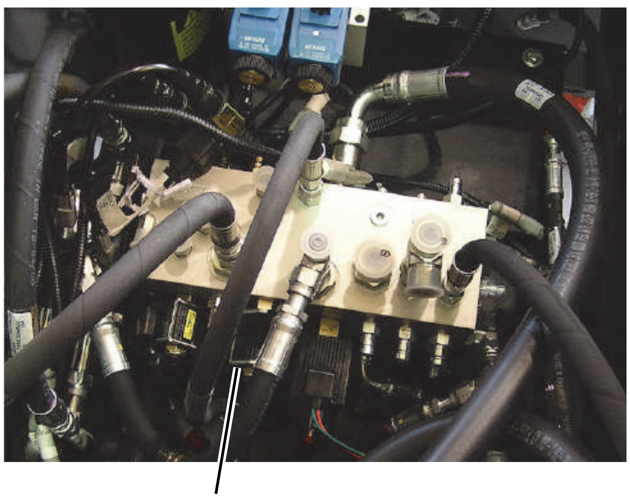
FIGURE 9-2

Parking Brake Solenoid Valve

The parking brake solenoid valve (SV3) on the manifold (Figure 9-3) 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.

Some hoses removed for clarity



7508-66 **FIGURE 9-3**

MAINTENANCE AND ADJUSTMENTS

Service Brake Bleeding

Whenever 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.

1. Engage the parking brake and shut off the engine. Block the rear wheels on both sides.
2. Attach a hose to the right hand bleed screw ensuring that the free end of the hose 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.

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 hose to the bleed fitting on the parking brake (Figure 9-4) and place the other end in a suitable container.
3. Open the bleed fitting, then disengage the parking brake.
4. Observe the fluid exiting the hose. When there is no air or fluid being released, close the bleed fitting with the parking brake still disengaged.
5. Engage the parking brake.
6. Repeat steps 3 through 5 as needed until no air is release from the fluid.

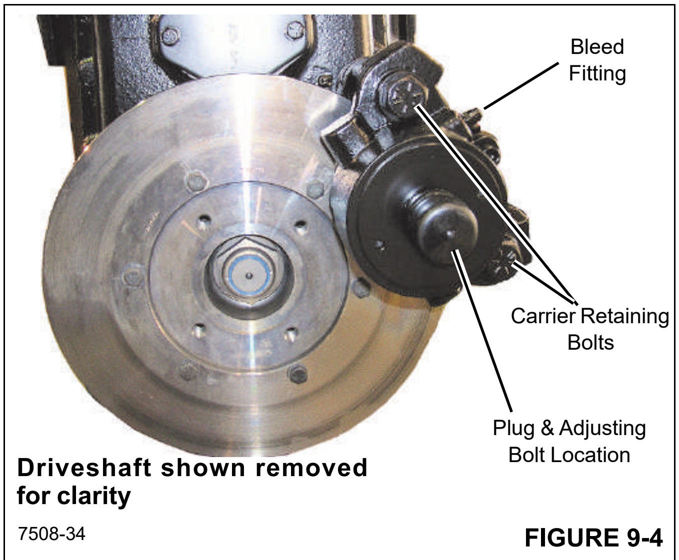


FIGURE 9-4

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.

Adjustment and Rebuild Criteria

1. Check to insure floating parts move freely and that all other parts are mounted securely. Tighten hardware as required.
2. Check actuator linkage to insure that there is adequate freedom of movement for positive brake operation. Adjustment of pad gap is to be accomplished by adjusting the actuating cable or linkage. If adjustment is used up, back off cable or linkage. Unbend tab on anti-rotation clip and loosen screw enough to disengage lever spline. Rotate the lever one tooth, in the direction opposite the actuation direction, and retorque the screw making sure the spline teeth are properly engaged. Bend up a tab that aligns with one of the screw head flats, to prevent screw rotation. Both lever and linkage must be free to return to home position. An external return spring is required.
3. Check disc surface condition. Replace if it is badly warped, pitted, or below minimum recommended thickness. Check for loose mount bolts. Retighten if necessary.
4. Check to insure friction pads are not worn to less than 1.0 mm (0.039 in) thick. Replace worn friction pads. Generally, if the disc is still running true and the pad clearance is still adjustable, no other maintenance is required. To check for wear, measure the distance from the carrier side casting face to disc face. If the distance is less than 1.5 mm (0.060”), replace the friction pads.

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 5171 ± 275 kPa (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.

SERVICE BRAKE REPAIR

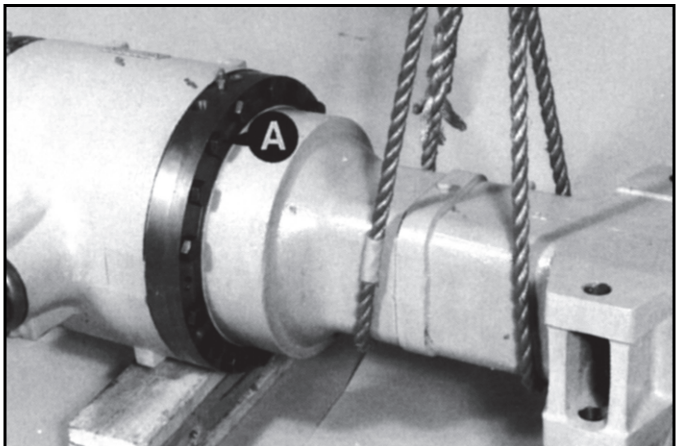
The front and rear axle brakes are the same.

NOTE: It is recommended that the axle be removed from the machine when disassembling the front axle brakes. See *Front and Rear Drive Axle Repair, page 8-3*.

The axle half shaft u-joints should be lubricated at this time, see *Lubrication Points, page 5-12*.

Disassembly

1. Support the axle arm Figure 9-5 and remove bolts **A**.



p0088 **FIGURE 9-5**

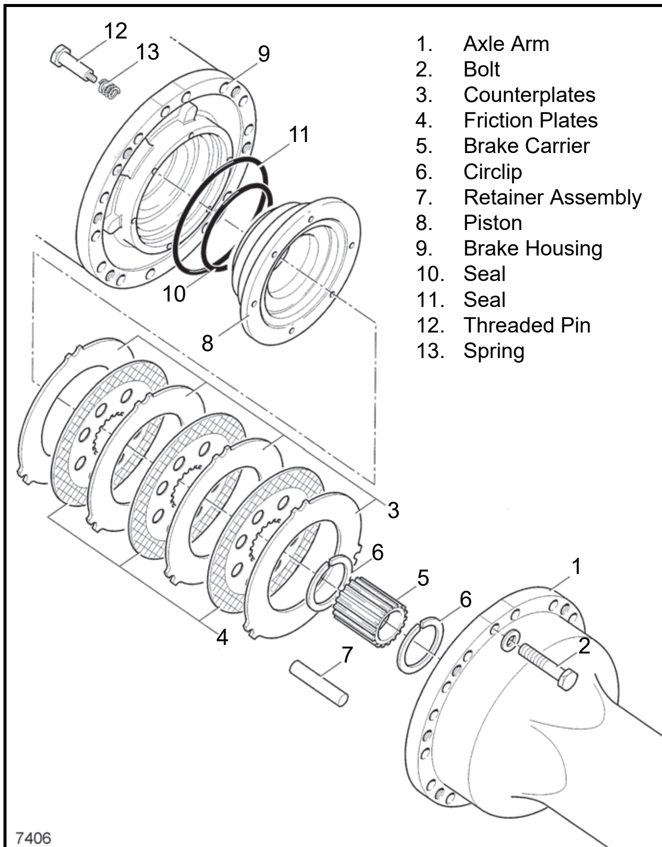
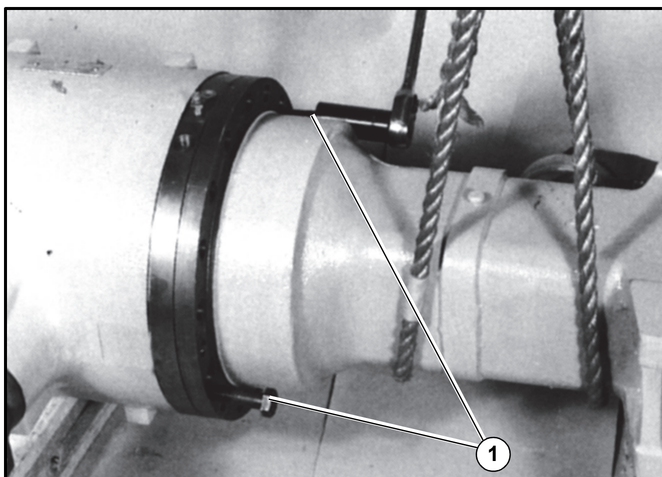


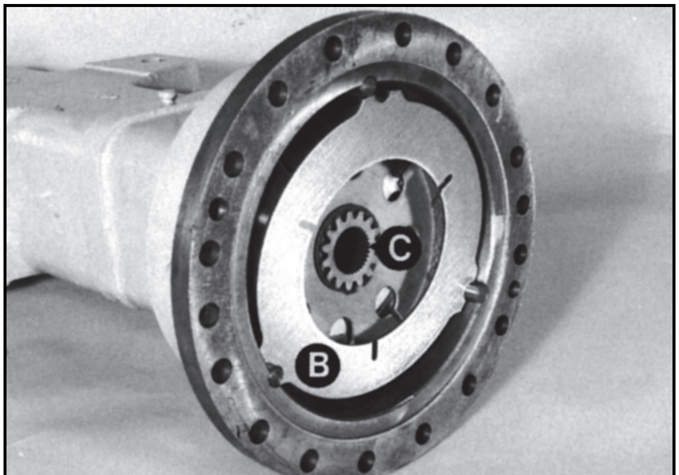
FIGURE 9-6

2. Jack the axle arm off the drive head, using drive head securing bolts (1) Figure 9-7. Remove all traces of gasket from the mating surfaces.



p0089 **FIGURE 9-7**

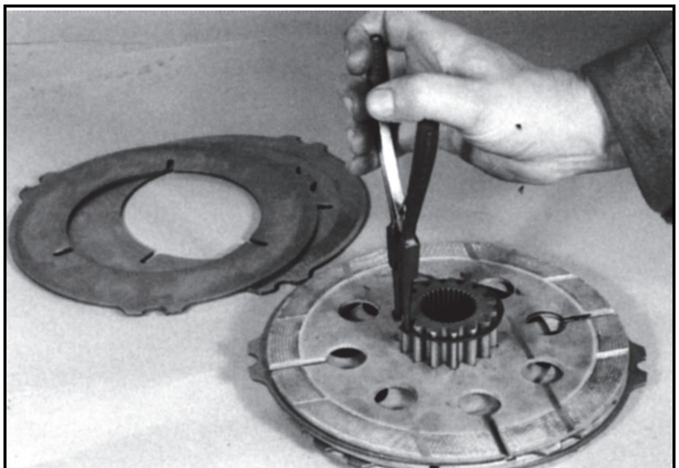
3. There are two counterplates **B** Figure 9-8 one at each end of the brake pack, which are not secured to the plate carrier **C**. If the plates are to be reused, note their position and which direction they are installed then remove the brake pack.



p0090 FIGURE 9-8

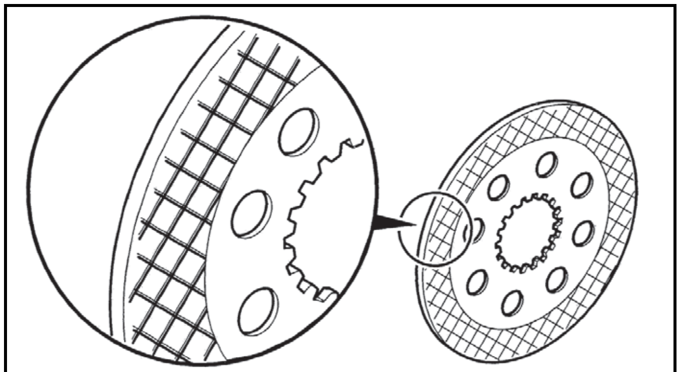
4. Remove the retaining ring Figure 9-9. If the brake pack is to be reused, note the position of the plates before removing them.

NOTE: The planet carrier has an internal chamber at the end which faces away from the drive head.



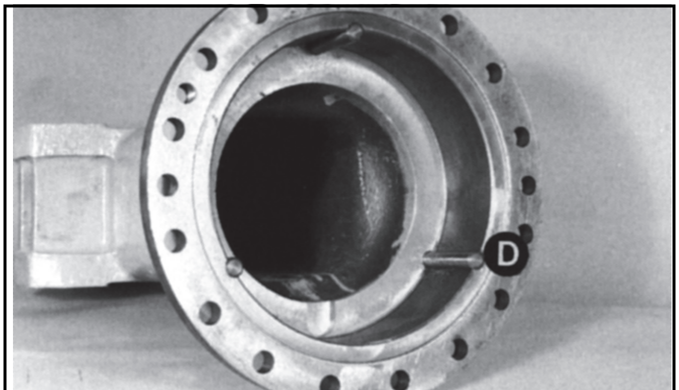
p0091 FIGURE 9-9

5. Wear limit of friction plates is to the depth of the crosshatching Figure 9-10. Check all plates for flatness and damage. (Wear and polishing of the counterplates is normal.) Completely replace the brake pack if worn or damaged. Do not replace individual plates.



a4093 FIGURE 9-10

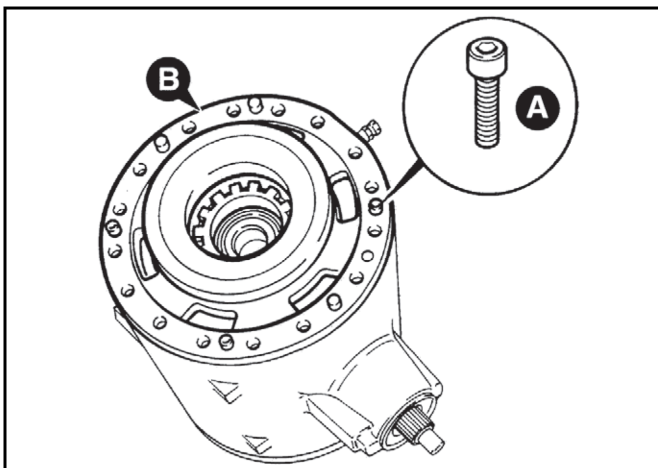
6. Remove the three reaction pins **D** Figure 9-11. Inspect for damage and scoring.



p0092 FIGURE 9-11

7. Position the drive head as shown in Figure 9-12, with the crownwheel at the top. (For coupling removal see *Drive Head - Disassembly, page 8-5*). Remove capscrews **A**.

8. Match-mark the brake piston housing **B** and drive head. Pull off the brake piston housing.

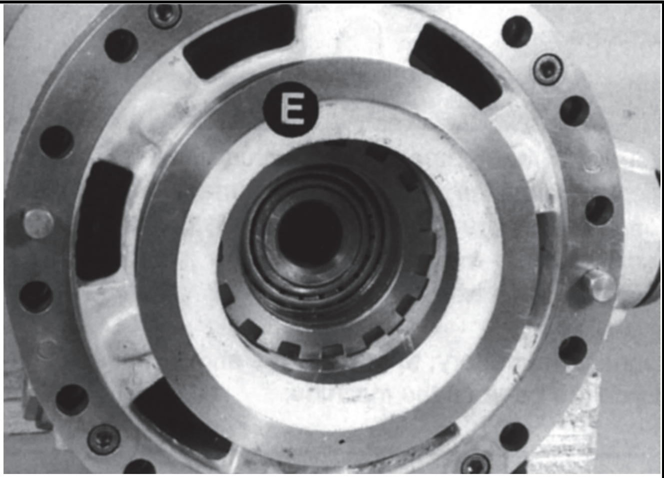


a4073 FIGURE 9-12

9. Remove threaded pins **12** and springs **13** Figure 9-6. Inspect for damage.

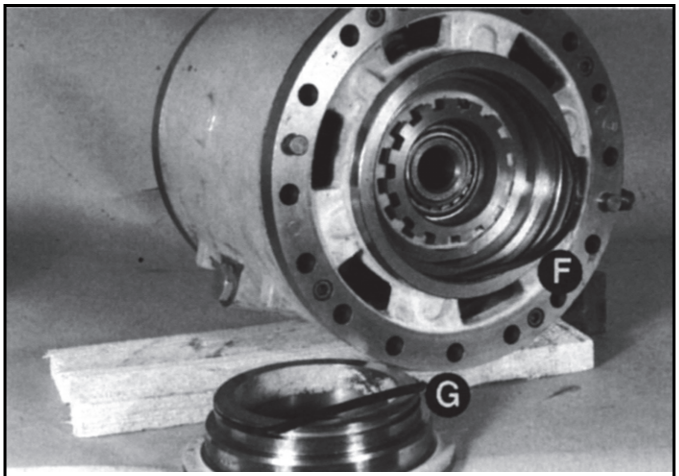
9

10. Carefully remove brake piston **E** Figure 9-13 from its housing, if removal is necessary. A hydraulic hand pump can be used to force the piston out of the housing.

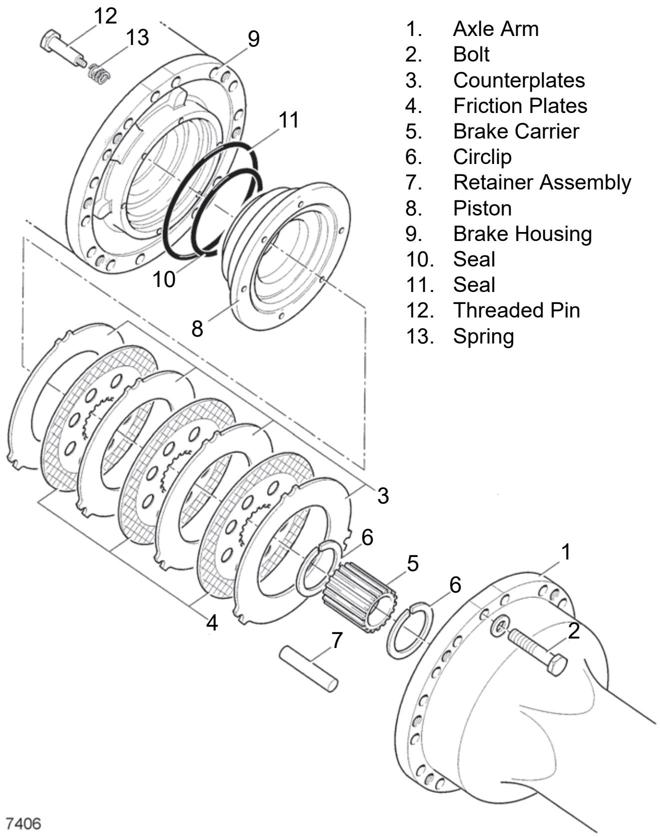


p0093 **FIGURE 9-13**

11. Remove and discard seals **F** and **G** Figure 9-14. Inspect the housing for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.



p0094 **FIGURE 9-14**



1. Axle Arm
2. Bolt
3. Counterplates
4. Friction Plates
5. Brake Carrier
6. Circlip
7. Retainer Assembly
8. Piston
9. Brake Housing
10. Seal
11. Seal
12. Threaded Pin
13. Spring

7406 **FIGURE 9-15**

Assembly

1. Install new seals **F** and **G** Figure 9-14. Make sure they seat squarely in their grooves.

2. Carefully press piston **E** Figure 9-13 all the way into its housing.

3. Place the housing and piston on a firm flat surface, piston downwards. Install springs **13** and threaded pins **12** Figure 9-15.

4. Apply Loctite 275 sealant to the drive head mating face, then fit the brake piston housing. Ensure that the match marks made during dismantling are aligned. Fit capscrews **A** Figure 9-12 (see Note) and torque to 56 Nm (42 lb-ft). (Applies to both piston housings.)

NOTE: When refitting the cap screws, clean the threads with a wire brush and coat the threads with Loctite 243.

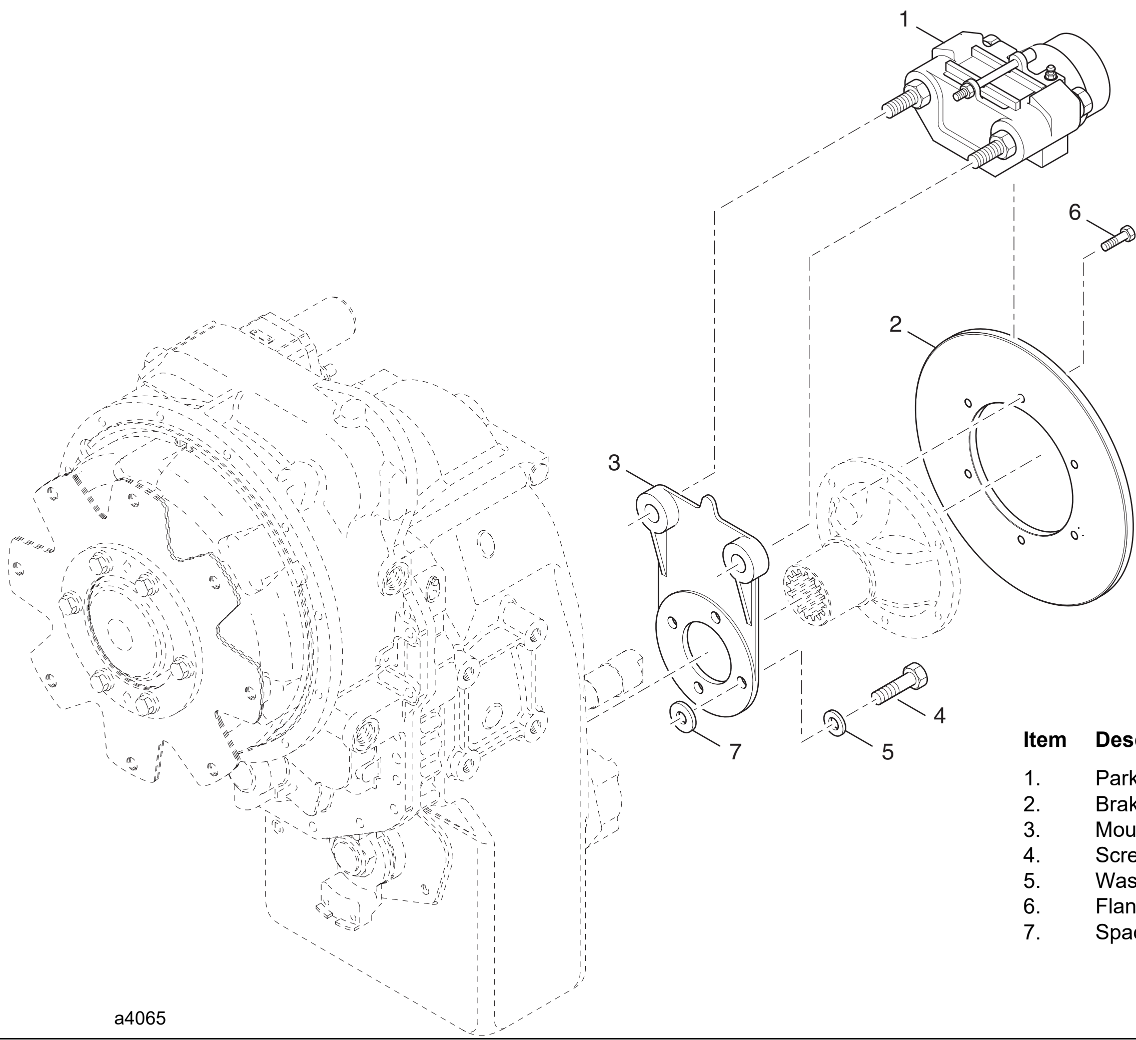
Some new capscrews come pre-coated and do not require cleaning or manually coating with sealant.

5. Assemble the friction plates and counterplates onto the carrier. If the original brake pack is being reused, return the plates to their original positions, refer to step 3., page

9-6. Soak new friction plates in gear oil before assembly. Install retaining ring (Figure 9-9).

6. Locate the three reaction pins **D** (Figure 9-11) into their grooves, securing them with grease. Push the pins fully into their location holes in the housing.
7. Install one counterplate **B** (Figure 9-8) 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 in until fully seated.
8. 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.
9. Install bolts **A** Figure 9-3 and tighten to a torque of 400 Nm (295 lb-ft).
10. Fill the axle with recommended lubricant. See *Replace the Axle Housing Lubricant, page 5-33*.

Install the axle to the crane's frame. Refer to *Axles/Drive Shafts/Wheels and Tires, page 8-1*.



Item	Description
1.	Parking Brake Caliper
2.	Brake Disc
3.	Mounting Assembly
4.	Screw
5.	Washer
6.	Flange Screw
7.	Spacer

FIGURE 9-16

PARKING BRAKE REPAIR

Operation

Ten disc springs **8** (Figure 9-17) are used to hold the park brake in the actuated state. The springs **8** push the pistons **9**, **12** into the lining and carrier assembly **19** which squeezes a driveline mounted disc. The brake is released by fluid entering a SAE 7/16-20 threaded inlet in the side of the torque plate **1** which pushes the pistons back and compresses the springs **8**.

Adjustment and Rebuild Criteria

1. Apply hydraulic pressure to the brake.
2. Remove plug **5** and set running clearance to 0.51 to 0.76 mm (0.020 to 0.030 in) using the adjustment bolt **6**.

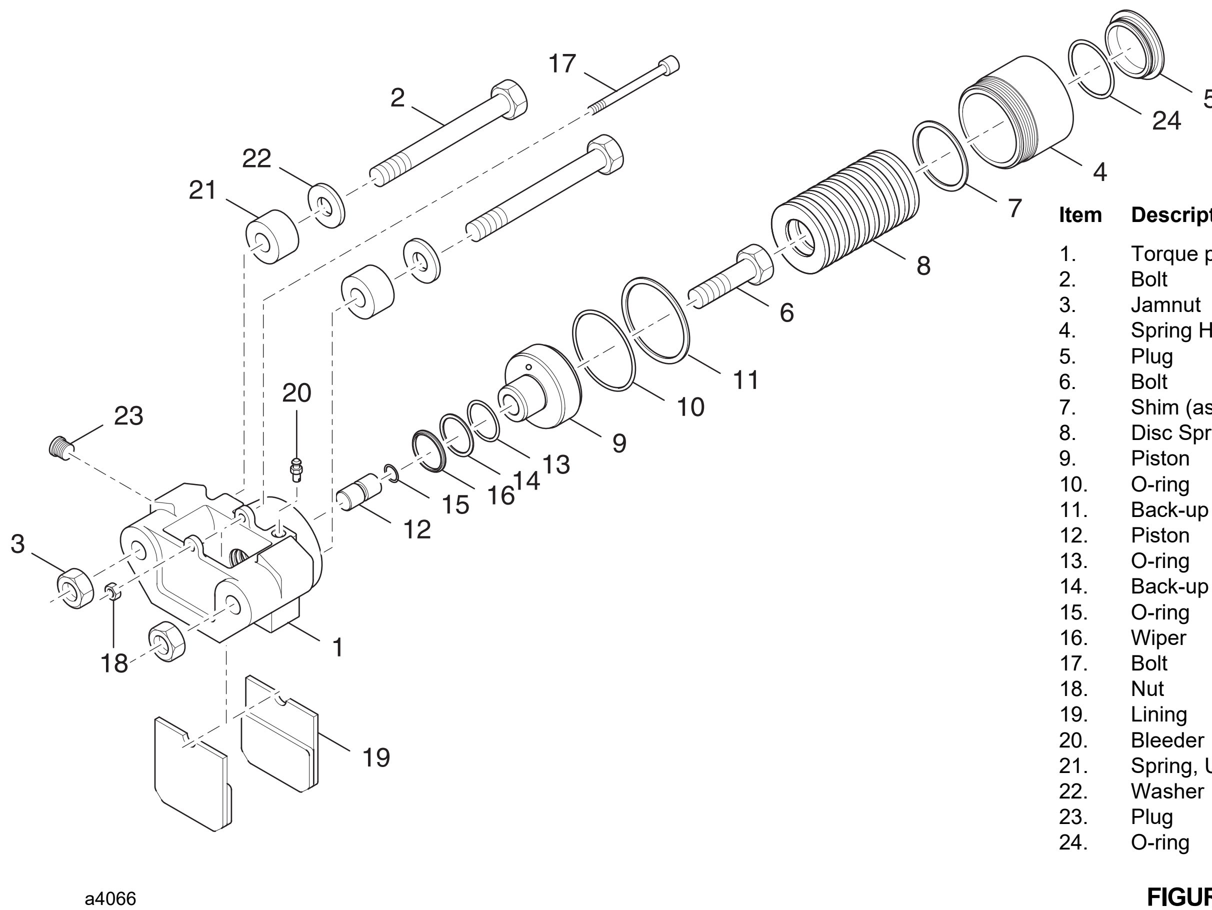
3. Replace plug **5**.
4. Even up running clearance on each side of the disc by adjusting the carrier retaining bolt **17**.

The brake should be rebuilt when one or more of the following criteria are met:

1. Any signs of fluid leakage.
2. Lining thickness less than 0.079 mm (0.031 in).
3. Cracked or chipped linings.

Replacing Friction Pads

1. Apply hydraulic pressure to the brake and remove plug **5** and carrier bolt **17**.
2. With pressure applied, back-off adjustment bolt **6** until piston **12** is flush with piston **9**.
3. Release hydraulic pressure from the brake and remove lining and carrier assemblies **19**.



Item	Description
1.	Torque plate
2.	Bolt
3.	Jamnut
4.	Spring Housing
5.	Plug
6.	Bolt
7.	Shim (as required)
8.	Disc Springs
9.	Piston
10.	O-ring
11.	Back-up Ring
12.	Piston
13.	O-ring
14.	Back-up Ring
15.	O-ring
16.	Wiper
17.	Bolt
18.	Nut
19.	Lining
20.	Bleeder
21.	Spring, Urethane
22.	Washer
23.	Plug
24.	O-ring

FIGURE 9-17

Disassembly

CAUTION

Possible Equipment Damage!

If the park brake is being disassembled while on the vehicle, it is important to follow the directions regarding the removal of the spring housing **4** and the linings **19** very closely.

1. Apply hydraulic pressure to the brake and remove plug **5** and carrier bolt **17**.
2. With pressure applied, back-off adjustment bolt **6** until piston **12** is flush with piston **9**.
3. Release hydraulic pressure from the brake and remove lining and carrier assemblies **19**.
4. Using a press, compress springs **8** to reduce the force on the spring housing **4**.
5. Use a spanner wrench to remove the spring housing **4** (counter-clockwise direction).
6. The springs **8** will be accessible when the spring housing is removed.

NOTE: The spring housing **4** may be removed without compressing the springs **8**, however it is not recommended due to the high torque required.

7. The adjustment bolt **6** threaded part of the way into the hydraulic piston **9** may be used to remove the pistons **9** and **12** if brake is mounted on the vehicle.
8. If brake is not mounted to the vehicle it is easier to press the pistons out from the lining and carrier **19** side of the torque plate **1**.

CAUTION

Possible Equipment Damage!

Do not damage seals **10**, **13**, **15** or back-up rings **11**, **14** or the wiper **16** when removing the pistons **9** and **12.**

9. Piston **12** may be removed from piston **9** by pushing on piston **12** through adjustment bolt hole with a small nut-driver or similar device.

Cleaning and Inspection

1. Clean all metal parts prior to assembly.
2. Blow excess cleaning solution off of all parts and out of all fluid passages.

Assembly

1. Apply a thin coat of fluid (compatible with mineral oil based hydraulic fluid) to seals **10**, **13**, **15**, Back-up rings **11**, **14** and the wiper **16**.
2. Install seal **15** in seal groove on piston **12**.
3. Slide the adjustment piston **12** into the bore located in the hydraulic piston **9** until it hits the bottom of the bore.
4. Install wiper **16**, back-up ring **14**, and seal **13** in the grooves located in the small hole in the torque plate **1**.
5. Install seal **10** and back-up ring **11** in larger grooves in torque plate **1**.
6. Install piston assembly into torque plate **1**.
7. Thread adjustment bolt **6** into the hydraulic piston **9** until the bolt contacts the adjustment piston **12**.
8. Place springs **8** in the torque plate **1**. Springs should be placed in an alternating cupped face to cupped face orientation. The springs on the outside ends of the stack should be oriented cupped face out.
9. If the brake contained a shim **7** when it was disassembled, place the shim **7** so it will be in the bottom of the spring housing **4** when it is installed. (See Figure 9-18) for a graphical representation.

NOTE: Springs are matched and pretested. If new springs are being installed add a shim only if the new springs are shipped with one.

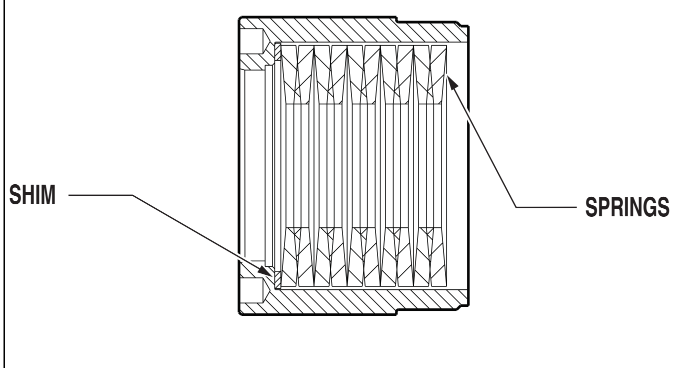


FIGURE 9-18

10. Thread spring housing **4** into torque plate **1** about 3 turns or until it makes contact, with the springs **8**.
11. Using a press, compress springs **8** to reduce the force on the spring housing **4**.
12. Use a spanner wrench to tighten spring-housing until the face bottoms out on the counterbore face in the torque plate **1**. Tighten to 678-814 Nm (500-600 lb-in) torque.
13. Assemble washer **22** and the urethane spring **21** on the mounting bolt **2** then slide mounting bolts through bolt holes in the torque plate **1**.
14. Thread jam nut/sleeve **3** onto mounting bolt. The cylindrical part of the jam nut/sleeve should extend into the torque plate.
15. Install lining and carrier assemblies **19.** Thread lining and carrier adjustment bolt into hex nut **8** located in the slot in the back side of the torque plate **1**.
16. Install the bleeder **20** in the port located on the top side of the torque plate **1**.
17. After brake is mounted and adjusted, snap plug **5** onto spring housing **4**.

Installation

1. Slide brake over disc and into the mounting position.
2. Start mounting bolts **2** into mounting surface far enough to just support the brake.
3. Remove plug **5** and tighten adjustment bolt **6** until linings **19** are clamped to the disc.
4. Tighten mounting bolts **2** until they make contact with the urethane springs **21**, then tighten 1 to 2 flats more.

5. Tighten jam nut/sleeve **3** against mounting surface to torque shown in the Torque Specs table, below.

CAUTION

Possible Equipment Damage!

Brake linings are susceptible to contamination when installing or servicing brakes. Keep all oil and fluids away from the linings. Poor brake performance may result.

6. Attach brake line to inlet port located on the side of the torque plate **1**.
7. Bleed brake system to remove trapped air as follows.

NOTE: Use bleeder hose on bleeder screws (preferably clear tubing) to route fluid away from the brake and linings and into a suitable container.

CAUTION

Eye Injury Hazard!

Brake system uses high pressure, open bleeder screw **20** very slowly when performing bleeding procedure. Always wear eye protection when working with fluids under pressure.

8. Apply pressure to brake and slowly open the bleeder screw **20** observe any air bubbles that flow from the brake.
9. Repeat above paragraph until no air is observed in the fluid from the bleeder screw **20**.

Torque Specs

Part (Item No.)	Thread Size	Dry Torque
Bleeder Screw (20)	7/16 - 20	271-339 Nm (200-250 lb-in)
Jamnut/Sleeve (3)	3/4 - 10	271 Nm (200 lb-in)

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. Shut off the engine and set the parking brake.
3. Shut off the accumulator needle valve.
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**.
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 in Figure 9-19.

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NOTE: Lubricate all rubber components in repair kit with clean hydraulic oil of the same type used in the hydraulic system.

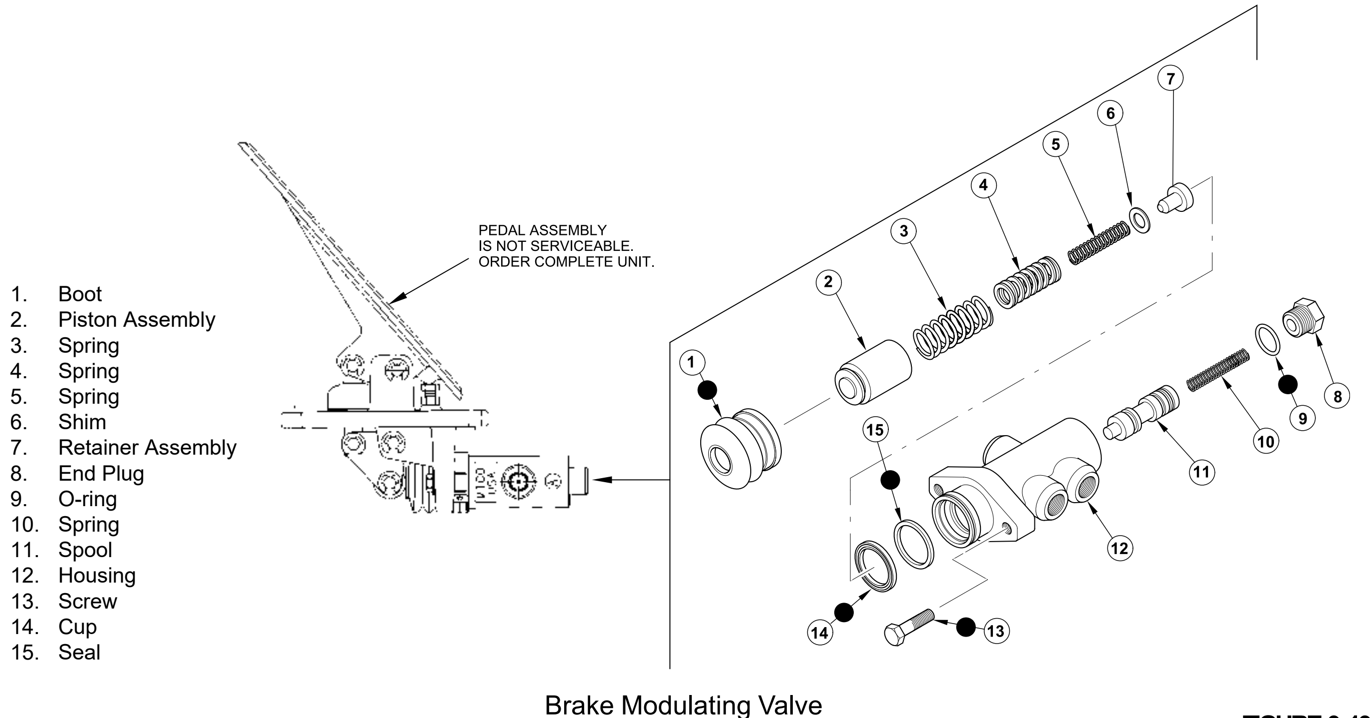
1. Clean all parts before assembling. Use a suitable solvent.
2. Lubricate spool (**11,** Figure 9-19) with clean hydraulic oil and carefully slide into plug end of housing **12**.

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 3792 ± 345 kPa (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 9-4.



Brake Modulating Valve

FIGURE 9-19

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 or 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.

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SECTION 10
STEERING SYSTEM

SECTION CONTENTS

TECHNICAL DATA

Rated pump output . . . . . 37,1 L/min at 2500 rpm (9.8 gpm at 2500 rpm)

Relief valve setting . . . . . 32959 ± 345 kPa at 2500 rpm (3475 ± 50 psi at 2500 rpm)

Steering Proximity Switch Setting. . . . . 3.2 - 5.6 mm (1/8 - 7/32 inch)

DESCRIPTION

General

The main components of the steering system are the pump (Figure 10-1), the priority flow control valve, the load sensing steering orbital, hydraulic tank, one front steering cylinder, one rear steering cylinder and the steering select valve.

When the steering wheel is turned, a pressure demand is sensed by the priority flow control valve through load sensing line between the priority flow control valve and the flow sensing steering orbital.

Oil from the pump is then distributed through the priority flow control valve 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 ceased, full pump flow is then distributed to the outrigger and brake circuits through the priority flow control valve.

Maximum steering system pressure is controlled by a relief valve in the priority flow control valve.

Steering Modes

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

- Two-wheel steering
- Four-wheel steering
- Crab steering

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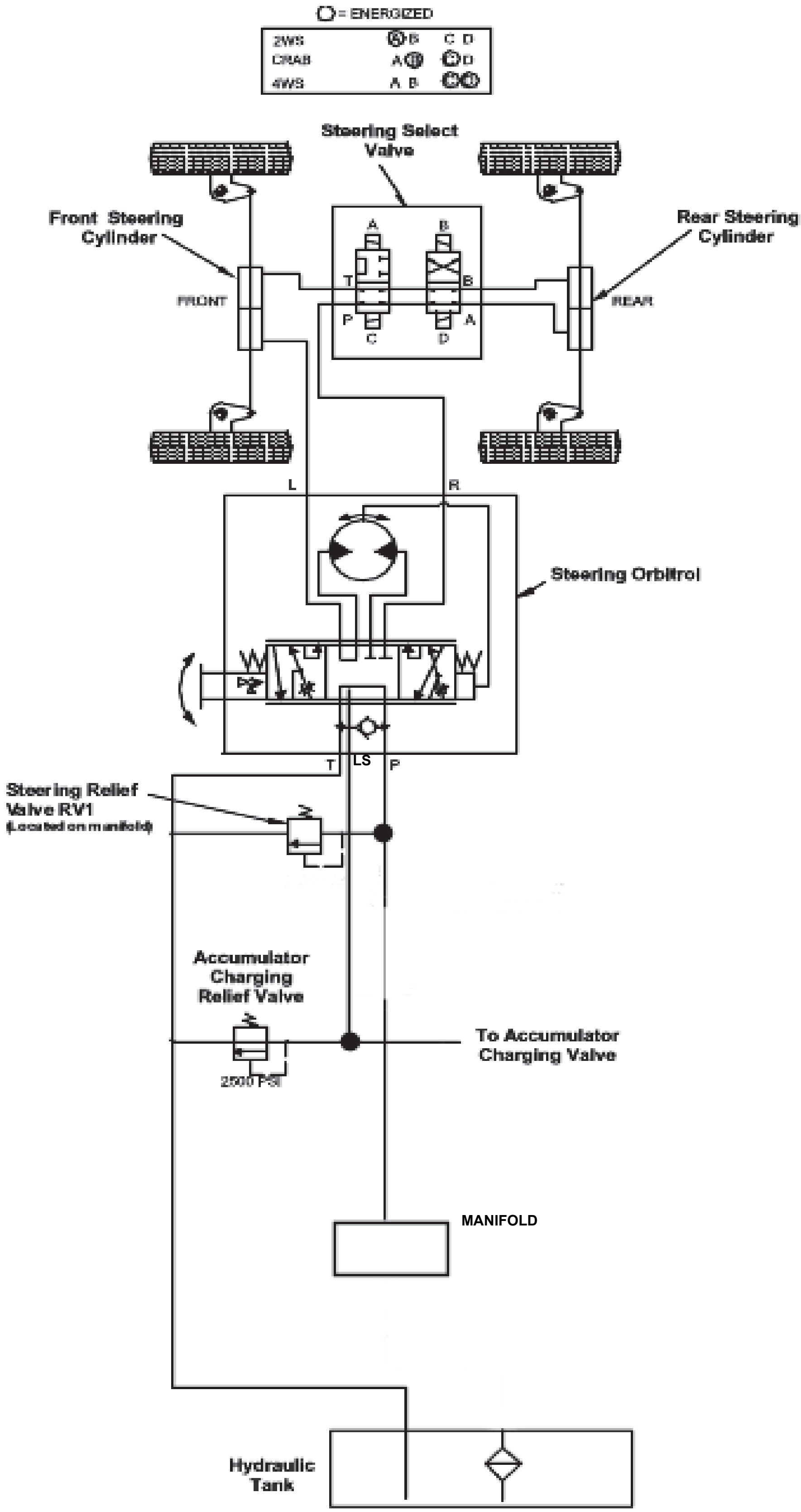


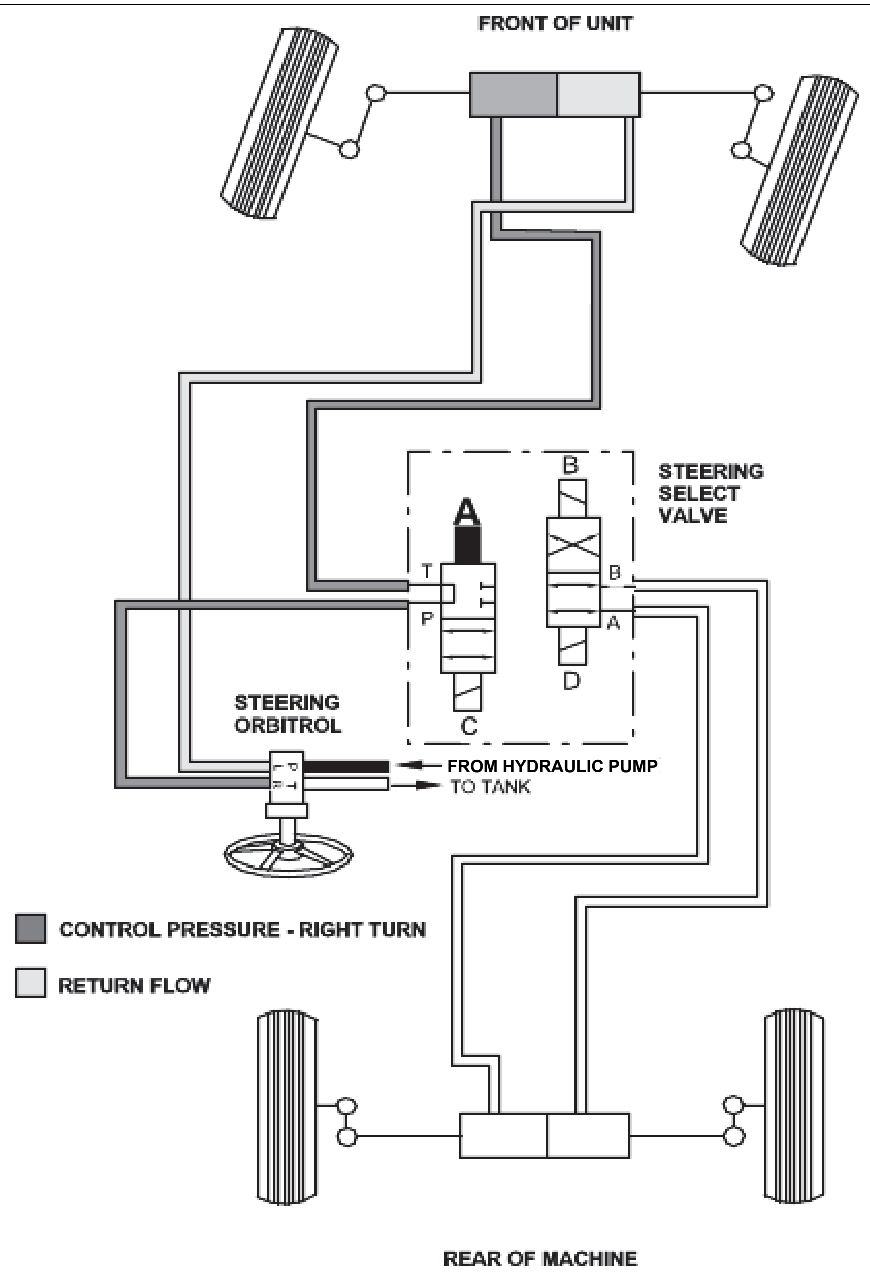
Steering System

FIGURE 10-1

Two-Wheel Steering

During two-wheel steering, the front wheels steer in the same direction that the steering wheel turns. The rear wheels remain in a fixed forward position.

When turning to the right (Figure 10-2), hydraulic oil under pressure from the steering pump flows through the priority flow control valve to the **P** port of the steering orbital in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port **R** of the steering orbital to port **P** of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operators compartment. When the steering select switch is placed in the two-wheel steering mode solenoid **A** is actuated. Oil passes through the porting of the valve block to the base end of the front axle steering cylinder. The piston moves to the left, extending the left cylinder rod and retracting the right cylinder rod, creating a right turn. Return oil from the steering cylinder flows into port **L**, out of port **T** of the steering orbital and back to tank.



Right Turn in 2 Wheel Steer Mode

FIGURE 10-2

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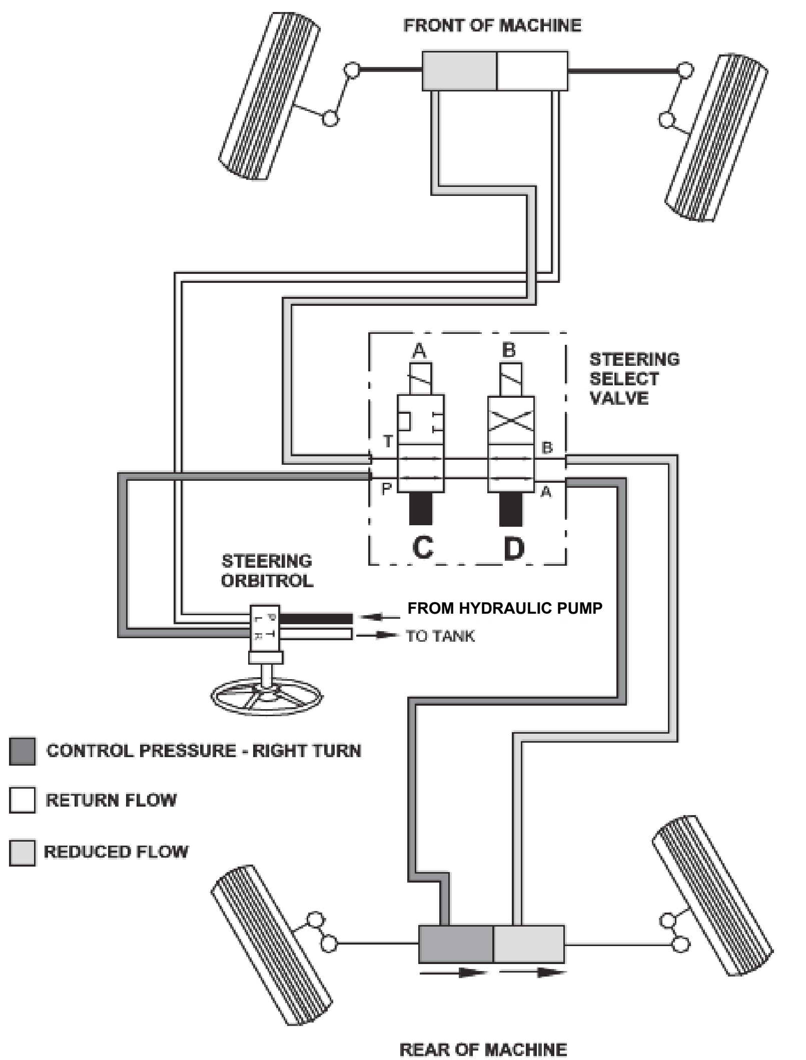
Four-Wheel Steering

During four-wheel steering, the front wheels steer in the direction that the steering wheel is turned, while the rear wheels turn in the opposite direction. This mode provides an extremely short turning radius. It allows the rear wheels to follow the track of the front wheels, which is an advantage in muddy or sandy conditions.

When turning to the right (Figure 10-3), hydraulic oil under pressure from the pump flows through the priority flow control valve to the **P** port of the steering orbital in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port **R** of the steering orbital to port **P** of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operator's compartment. When the steering select switch is placed in the four-wheel steering mode solenoids **C** and **D** are actuated. Oil passes through the porting of the valve block and out port **A** to the rear axle steering cylinder. Oil is directed to the rod end of the left steering cylinder and base end of the right cylinder, causing the rear wheels to turn to the left. Return oil under pressure from the rear steering cylinders flows into port **B** of the steering select valve block and out port **T** to the front steering cylinder. The left rod of the steering cylinder extends and the right rod retracts, turning the front wheels to the right. Return oil from the front steering cylinder flows into port **L** and out of port **T** of the steering orbital and back to tank.



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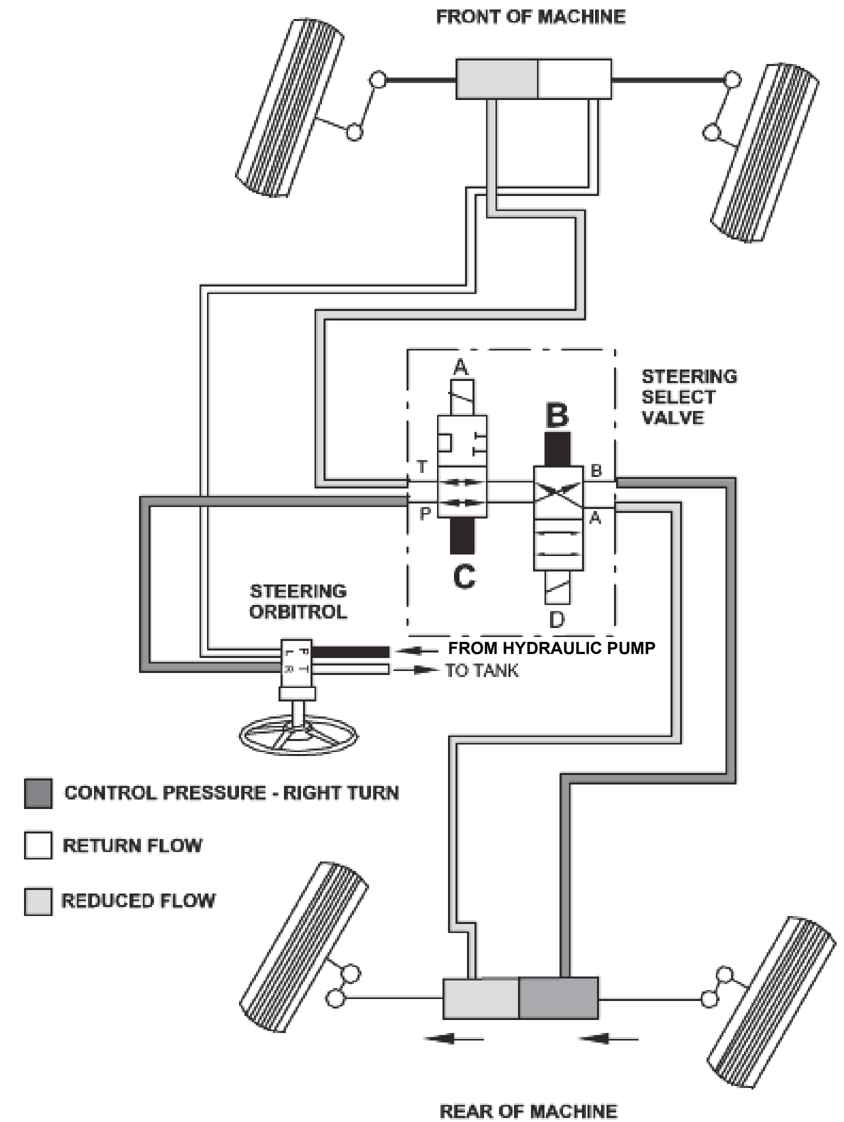
Right Turn in 4 Wheel Steer Mode

FIGURE 10-3

Crab Steering

During crab steering all the wheels steer in the same direction. This mode allows the operator to move the machine sideways. This is especially helpful in tight areas on the job.

When turning sideways to the right (Figure 10-4), hydraulic oil under pressure from the pump flows through the priority flow control valve to the **P** port of the steering orbital in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port **R** of the steering orbital into port **P** of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operator's compartment. When the steering select switch is placed in the crab-steering mode solenoids **B** and **C** are actuated. Oil passes through the porting of the valve block and out port **B** to the rear axle steering cylinders. Oil is directed to the base end of the left steering cylinder and rod end of the right cylinder, causing the rear wheels to turn to the right. Return oil under pressure from the rear steering cylinders flows to port **A** of the steering select valve block and out port **T** to the front steering cylinder. The left rod of the steering cylinder extends and the right rod retracts, turning the front wheels to the right. Return oil from the front steering cylinder into port **L** and out of port **T** of the steering orbital and back to tank.



Right Side Ways in Crab Steer Mode

FIGURE 10-4

RELIEF VALVE PRESSURE CHECK AND ADJUSTMENT

Pressure Check

1. Remove the deck cover over the hydraulic valves by removing four socket head screws.
2. Remove the cap from the quick-disconnect fitting (1, Figure 10-5) located in the P1G port of the manifold. Connect a 20 670 kPa (0-3000 psi) pressure gauge to the quick-disconnect fitting.

Some hoses removed for clarity

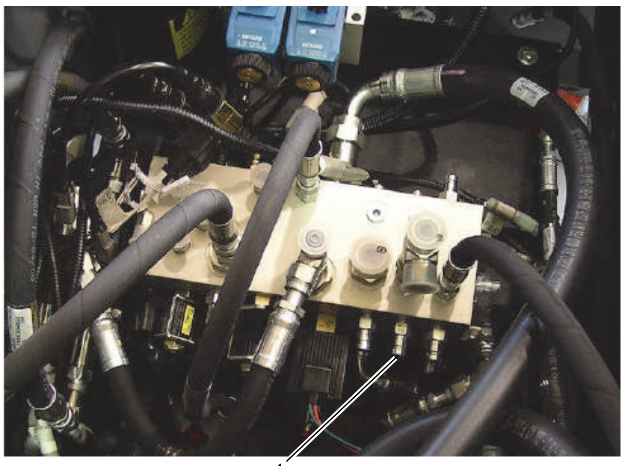


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FIGURE 10-5

3. Start the engine allowing the hydraulic oil to reach operating temperature. Increase the engine speed to full RPM. Turn the steering wheel and put the wheels at the maximum angle. Continue to turn the steering wheel after the wheels are at their maximum angle. Read the pressure gauge and then release the steering wheel.
4. The correct pressure reading is 17 236 ± 345 kPa (2500 ± 50 psi).

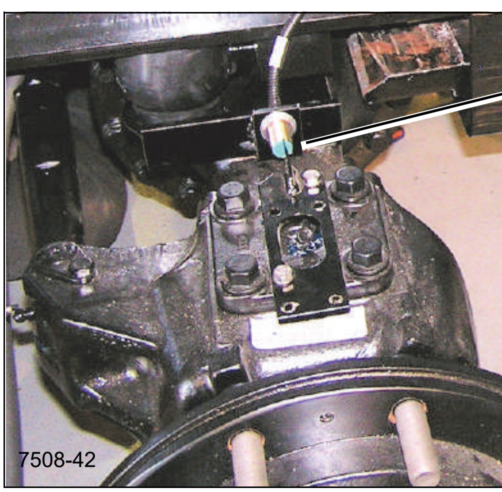


FIGURE 10-6

STEERING PROXIMITY SWITCHES

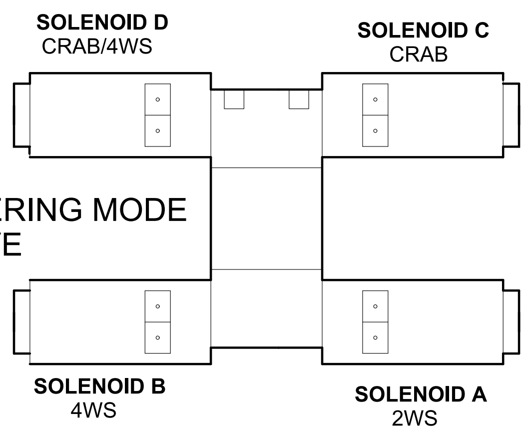
General

The purpose of the steering proximity switches in the steering system is to prevent the changing of steering modes until all wheels are aligned forward. The sensors are positioned on the front and rear axles (Figure 10-6) and are activated when a bracket attached to the steering yoke of the axle, is aligned with the sensor.

Principle of Operation

The steering system electrical circuit includes two sensors (Figure 10-8) one selector switch, one relay box and two solenoid valves. The selector switch is controlled by the operator in the cab to select the steering modes. The relay box, located under the instrument panel, contains relays that control the steering mode solenoid valves.

The system is used to select one of the three steering modes. When the selector switch in the cab is placed in two-wheel steer, four-wheel steer or crab steer, that particular mode of steering is used to steer the crane. The system, however, will not activate unless the front and rear wheels are in or pass over the forward position. For example, when the front wheels are not aligned forward in two wheel steer mode and the crane must be placed in four wheel steer, placing the steering selector switch, located in the cab, to four wheel steer will not place the steering system in four wheel steer mode. Turning the front wheels to forward position or past, activates the proximity switches and energizes the relays in the relay box, which in turn energize the correct solenoid arrangement (Figure 10-7) to put the steering system in four wheel steer.



2WS = Solenoid "A" Energized
Crab = Solenoids "B & C" Energized
4WS = Solenoids "C & D" Energized

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FIGURE 10-7

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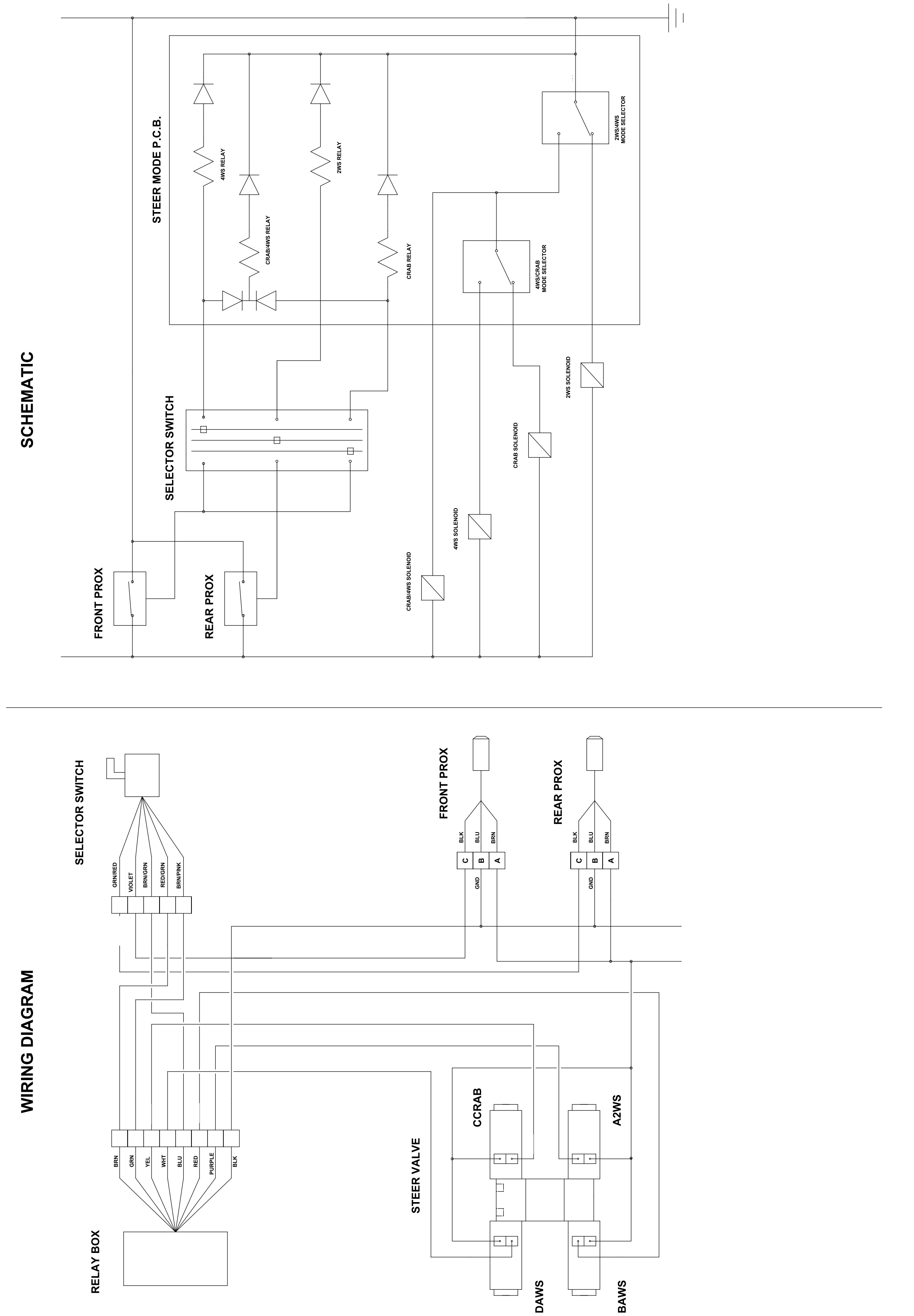

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Steering Wiring Diagram

FIGURE 10-8

Sensor Operation and Spacing Checks

Checking Alignment and Operation

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

Proper Operation Check

1. Using the outriggers, raise the crane. Shut off the engine but leave the ignition key switch in the ON position to energize the steering sensor circuit.
2. Remove the two tires (front and rear) on left side (cab side) of the crane to obtain access to the steering sensors.
3. Using a piece of metal, pass it within 3.2 mm (1/8 inch) to 5.2 mm (7/32 inch) in front of the sensor. A yellow light (Figure 10-9) will illuminate, indicating that the sensor is functioning.

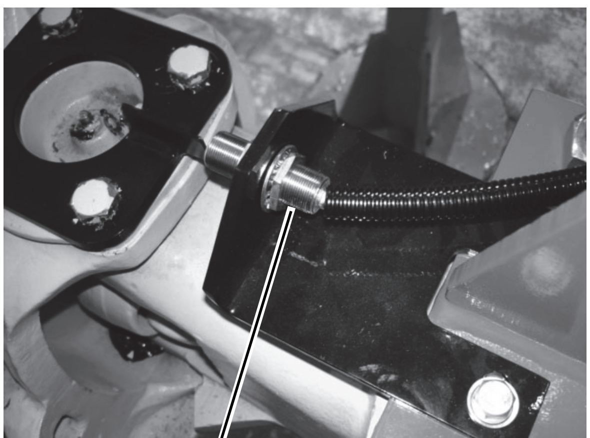
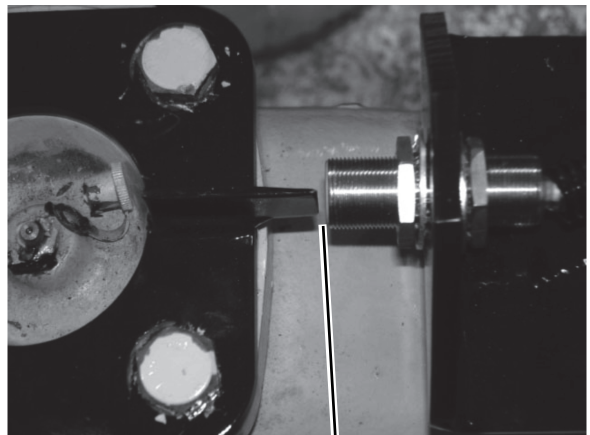


FIGURE 10-9

4. If the sensor is working properly, check the spacing between the sensor and sensor bracket. Adjust if necessary.
5. If the sensor is malfunctioning, replace it and adjust the sensor spacing.

Sensor Spacing Check

1. Align the sensor bracket on the axle steering knuckle with the sensor on the axle (Figure 10-10).



Sensor Spacing **FIGURE 10-10**

2. Measure the distance between the end of the sensor and edge of the sensor bracket. The sensor spacing must be between 3.3 mm (1/8 inch) to 5.6 mm (7/32 inch). If the spacing is incorrect, adjust the spacing with the jam nuts on the sensor. Be sure they are tightened after proper gap is obtained.

Symptom	Probable Cause	Action
Slow steering, hard steering, or loss of power assist.	**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 10-11. Correct if required.
Machine will not turn when the steering wheel is turned.	**1.** Insufficient oil level.	**1.** Check for leaks and fill tank.
	2. Leaks in relevant hoses or component connections.	**2.** Check hoses and connections for leaks.
	3. Air in the hydraulic system.	**3.** Bleed system -bleed the load sense line.
	4. Low pump flow.	**4.** Check pump flow. If required, repair or replace the pump.
	5. Malfunctioning relief valve.	**5.** Replace priority valve.
	6. Worn or damaged parts in the steering orbital.	**6.** Remove, inspect and repair.
	7. Priority valve not operating correctly.	**7.** Check if the priority valve is sticking and repair if necessary. Check the load sense line for leaks or loose connections.
	8. Steering mode valve not operating correctly.	**8.** Check for sticking spools. Clean or replace. Check for faulty solenoids. Replace if necessary.
	9. Mechanical failure.	**9.** Check for damaged axle components, such as cylinders, tie rods, linkages, etc.
	10. Steering column splined shaft not fully engaged in orbital.	**10.** Check shaft engagement.

Symptom	Probable Cause	Action
Steering fails to respond to selected mode. IMPORTANT: The wheels must pass the proximity sensor to actuate relays to change steering mode.	**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 coarse.	**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.
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. Check 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.

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Symptom	Probable Cause	Action
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.

STEERING ORBITAL

Description

General

The steering orbital (Figure 10-12) provides directional control and metering of oil for precise steering control. In the neutral or balance position, when the steering wheel is not turned, the IN port **P** is connected to the OUT port **T** and oil from the pump returns to tank (Figure 10-12). Oil is locked in the lines by the interacting spool and sleeve. Centering springs keep the spool and sleeve in relative position. The spool is coupled to the steering wheel and rotates inside the sleeve when the steering wheel is turned. Corresponding ports in the spool and sleeve align to meter oil from the pump into the steering circuit and also allow return to tank. When the sleeve catches up with the spool, oil flow is blocked to the steering cylinder lines, and the available supply from the pump is returned to tank.

Steering Left

When making a left turn, flow from the pump enters port **P** (Figure 10-12). 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 10-12). The gerotor takes this flow and meters to port **R** (right turn). Return flow from the steering cylinders, enters port **L** and is returned to tank through port **T**.

Emergency Manual Steering

The gerotor (Figure 10-12) 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.

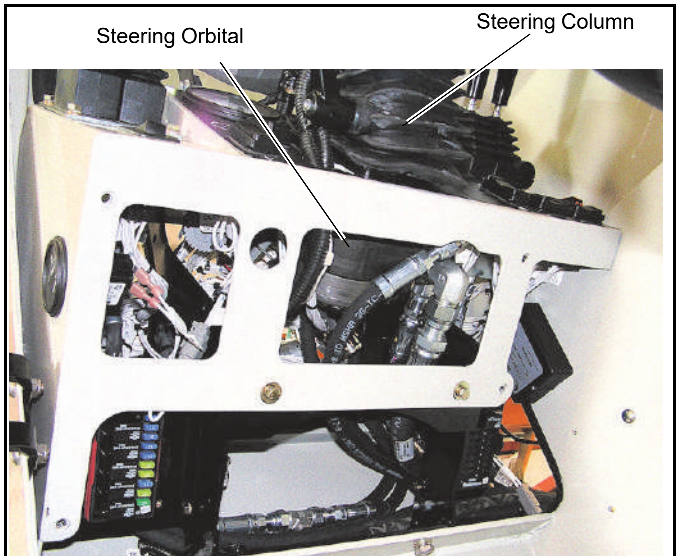
Orbital Repair

Special Tools

A spring installation tool, is required to assemble the orbital.

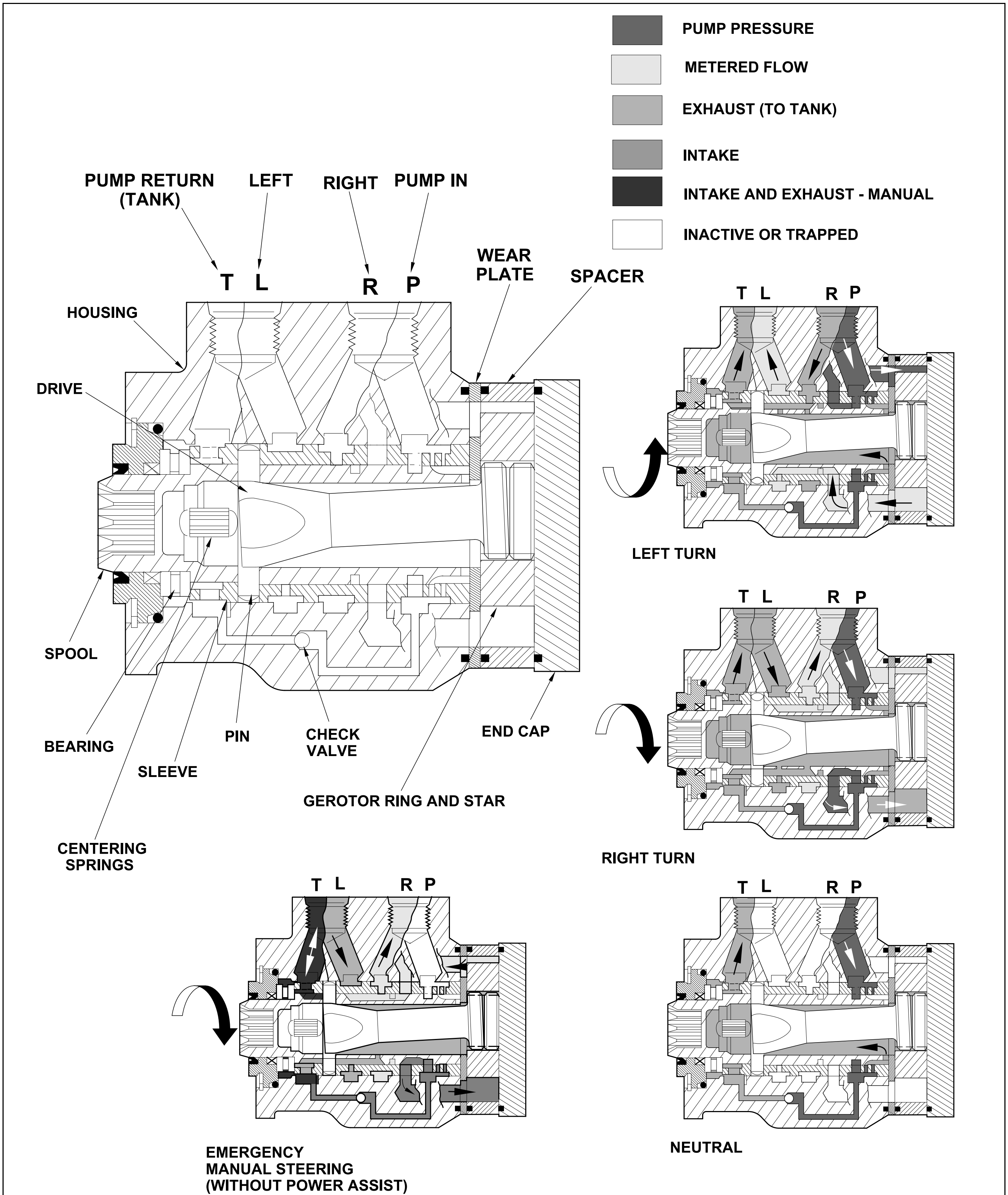
Removal

1. Remove the outside cover plate (Figure 10-11) in front of the operator's compartment.



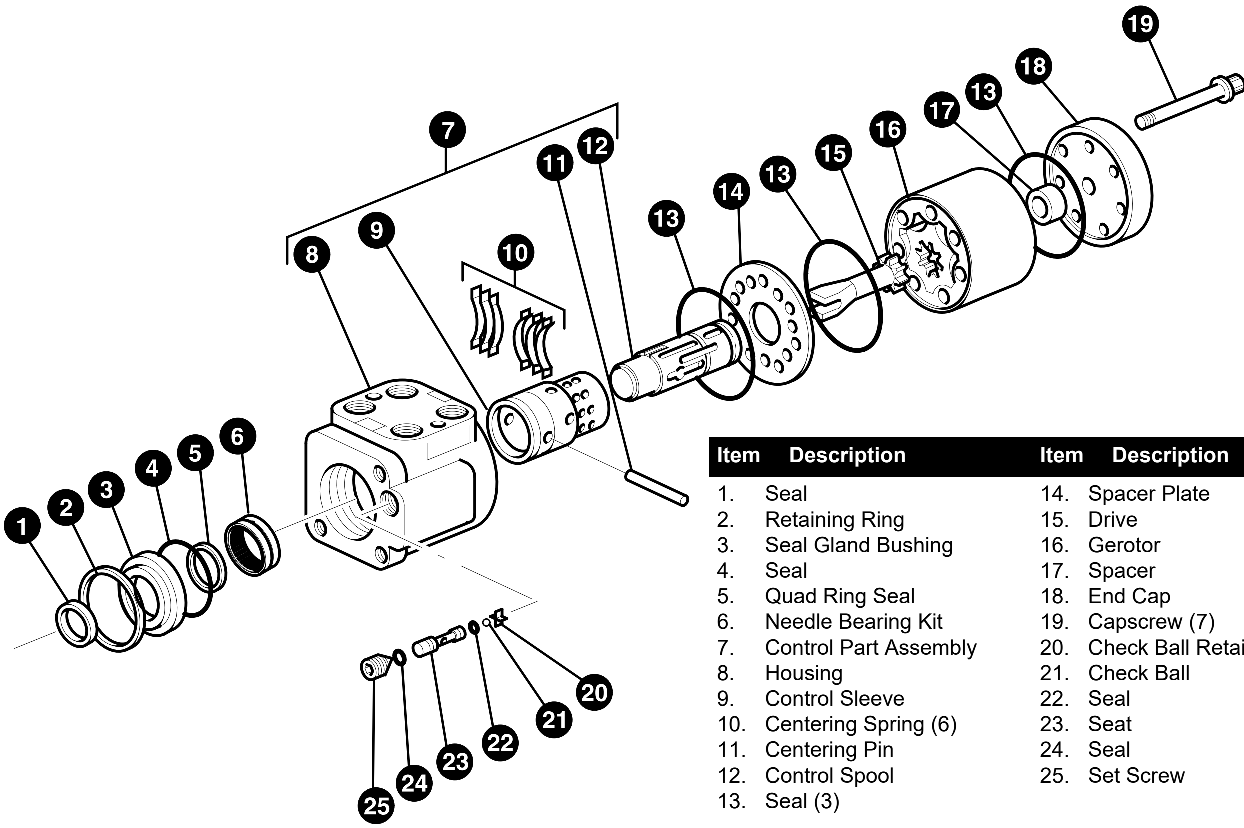
7508-78 FIGURE 10-11

2. Completely clean around the area of the steering orbital.
3. Put tags on the lines to the steering orbital for identification at installation.



Steering Orbital

FIGURE 10-12



Item	Description	Item	Description
1.	Seal	14.	Spacer Plate
2.	Retaining Ring	15.	Drive
3.	Seal Gland Bushing	16.	Gerotor
4.	Seal	17.	Spacer
5.	Quad Ring Seal	18.	End Cap
6.	Needle Bearing Kit	19.	Capscrew (7)
7.	Control Part Assembly	20.	Check Ball Retainer
8.	Housing	21.	Check Ball
9.	Control Sleeve	22.	Seal
10.	Centering Spring (6)	23.	Seat
11.	Centering Pin	24.	Seal
12.	Control Spool	25.	Set Screw
13.	Seal (3)		

a0327

Steering Orbital

FIGURE 10-13

4. Rotate the steering wheel a small amount in each direction several times, then release to get a balance of pressure in the steering circuit. Slowly loosen the hydraulics lines at ports **L** and **R** to release any remaining pressure. Disconnect the hydraulic lines from IN and OUT ports. Put plugs and caps in the ports and hydraulic lines.

5. Remove the four bolts which fasten the steering column and orbital to the mounting bracket. Be sure to hold the steering orbital in position while the last bolt is being removed. Remove the steering 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.

NOTE: Although not all illustrations show the unit in a vice, we recommend that you keep the unit in a vice during disassembly. Follow the clamping procedures explained throughout the instructions.

1. Clamp the unit in a vise, meter end up. Clamp lightly on the edges of the mounting area (Figure 10-14). Use protective material on the vise jaws. Housing distortion could result if the vise jaws are overtightened.

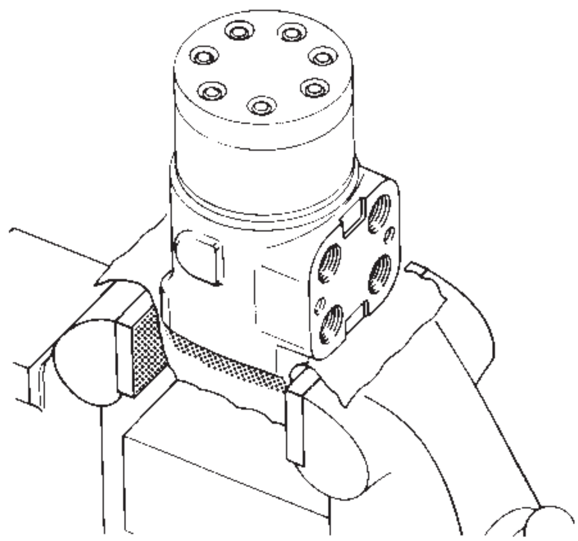


FIGURE 10-14

2. Remove the seven 6 pt. Torx Drive bolts (**19**, Figure 10-13). Remove end cap **18**. Remove seal **13** from the end cap.
3. Remove the gerotor **16**. Remove seal **13** from gerotor **16**. Remove drive spacer(s) **17**.
4. Remove drive **15**. Remove spacer plate **14**. Remove seal **13** from housing **8**.
5. Remove housing **8** from the vise. Place it on a clean soft cloth to protect the surface finish. Use a thin bladed screwdriver (Figure 10-15) to pry retaining ring (**2**, Figure 10-13) from housing **8**.

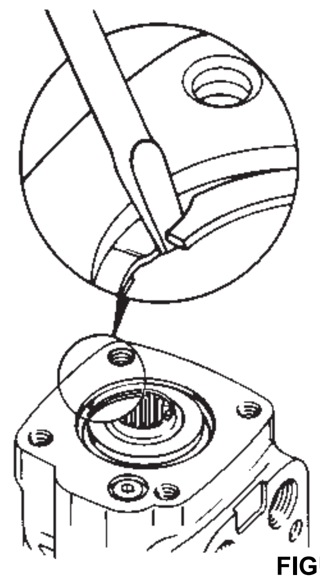


FIGURE 10-15

6. Rotate spool **12** and sleeve **9** until pin **11** is horizontal. Push the spool and sleeve assembly forward with your thumbs just far enough to free gland bushing **3** from the housing. Remove gland bushing **3**.
7. Remove quad seal **5** from gland bushing **3**.
8. Use a thin bladed screwdriver to pry dust seal **1** from gland bushing **3**. Do not damage the gland bushing.
9. Remove needle bearing kit **6**. The kit consists of two bearing races and a needle thrust bearing (Figure 10-16).

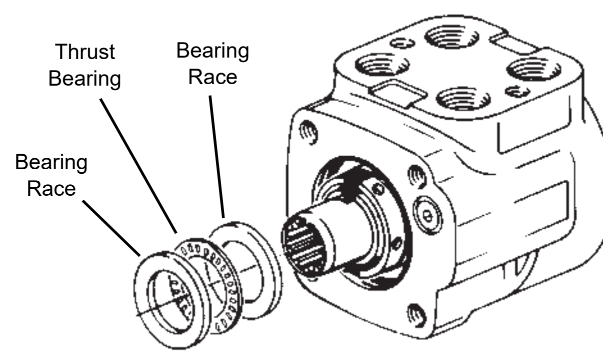
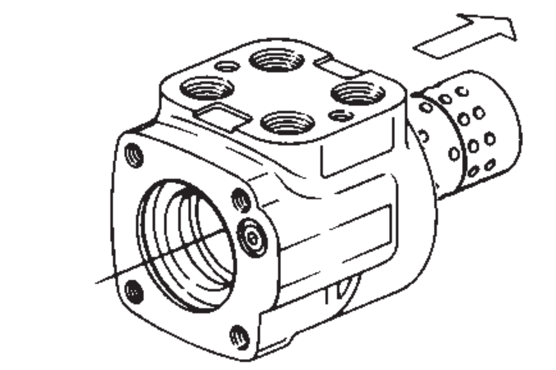


FIGURE 10-16

10. Remove spool and sleeve assembly, **10** through **12**, (Figure 10-13). Remove from rear end of housing (Figure 10-17).



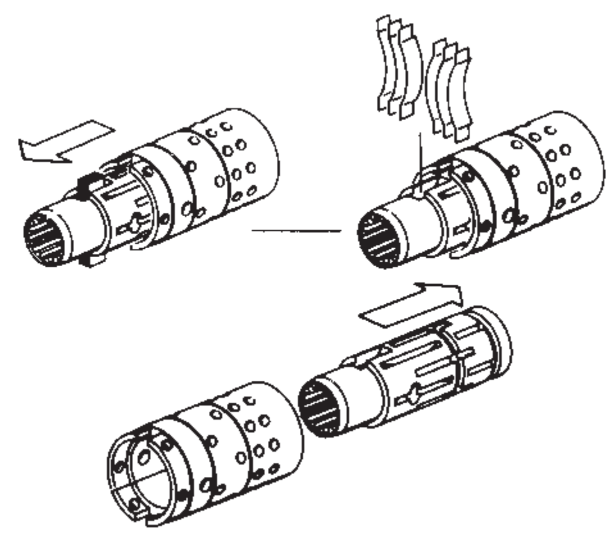
a0335 FIGURE 10-17

NOTE: Do not bind spool and sleeve in the housing. Rotate the spool and sleeve assembly slowly when removing from housing.

11. Push pin (**11**, Figure 10-13) from spool and sleeve assembly.

12. Push spool **12** partially from control end of sleeve **9**. Remove six centering springs **10** from the spool carefully by hand (Figure 10-18).

13. Push spool **12** back through and out of sleeve **9**. Rotate spool slowly when removing from the sleeve (Figure 10-18).



a0331 FIGURE 10-18

14. Remove seal (**4**, Figure 10-12) from housing **8**.

15. Remove set screw **25**.

16. Screw a No. 10-24 machine screw into the end of check ball seat **23**. Then by pulling on the screw with a pliers, lift the seat out of the housing.

17. Remove two seals **22** and **24** from the check ball seat.

18. Tip the housing to remove check ball **21** and check ball retainer **20**.

Inspection

Check all mating surfaces. Replace any parts that have scratches or burrs that could cause leakage or binding. Clean all metal parts in a clean solvent. Blow dry with air. Do not wipe dry with a cloth or paper towel, because lint or other matter can get into the hydraulic system and cause damage. Do not use a coarse grit emery cloth or try to file or grind any parts.

Replace all seals when assembling the unit. Lubricate all seals with clean petroleum jelly before assembling. DO NOT use excessive lubricant on seals for the meter section.

Assembly

1. Use a needle nose pliers to lower check ball retainer (**20**, Figure 10-13) into the check valve hole in housing **8**.

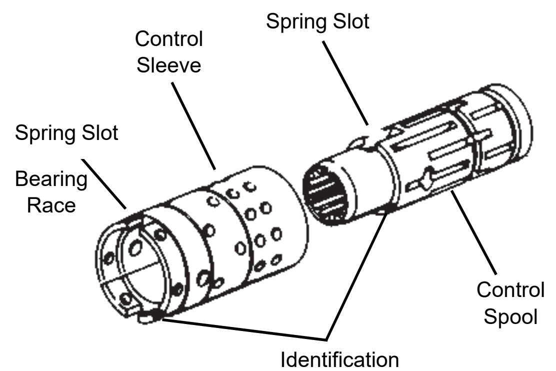
2. Install check ball **21** into housing **8**.

3. Lubricate seals **22** and **24** and install them on check ball seat **23**.

4. Lubricate the check ball seat and seals thoroughly before installing into the housing. When installing the seat do not twist or damage the seals. Install the check ball seat into housing, insert open end first. Push the check ball seat to the shoulder of the hole.

5. Install set screw **25** and tighten to a torque of 11.3 Nm (100 lb-in). To prevent interference, make sure the top of the set screw is slightly below the housing mounting surface.

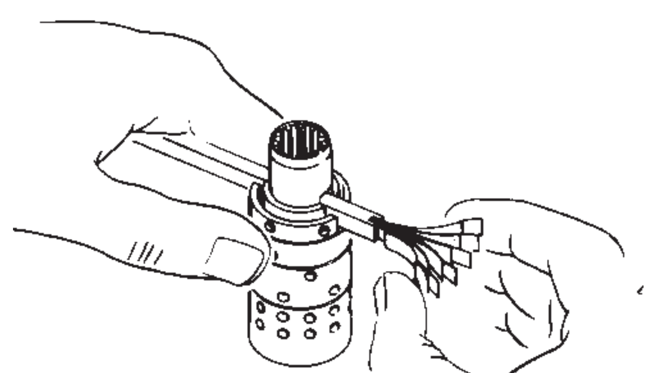
6. Lubricate the spool **12** and sleeve **9**. Install spool **12** and sleeve **9** carefully so that the spring slots (Figure 10-19) line up at the same end. Rotate spool (**12**, Figure 10-13) while sliding the parts together. Some spools and sleeve sets have identification marks, align these marks as shown in (Figure 10-19). Test for free rotation. The spool should rotate smoothly in the sleeve with finger tip force applied at splined end.



a0332 FIGURE 10-19

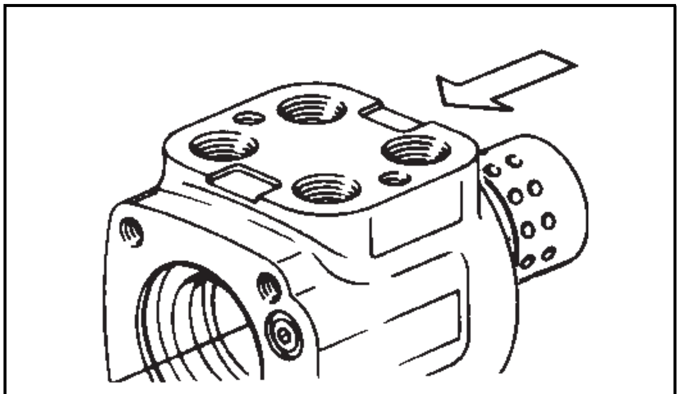
10

7. Bring spring slots of both parts in line and stand parts on end on the work bench (Figure 10-19). Insert special spring installation tool through the spring slots of both parts. Position centering springs (in 2 sets of 3 each) on bench so that the extended edge is down and arched center section is together. In this position, insert one end of the entire spring set (all six) into the spring installation tool (Figure 10-20) with spring notches facing the sleeve.



a0333 FIGURE 10-20

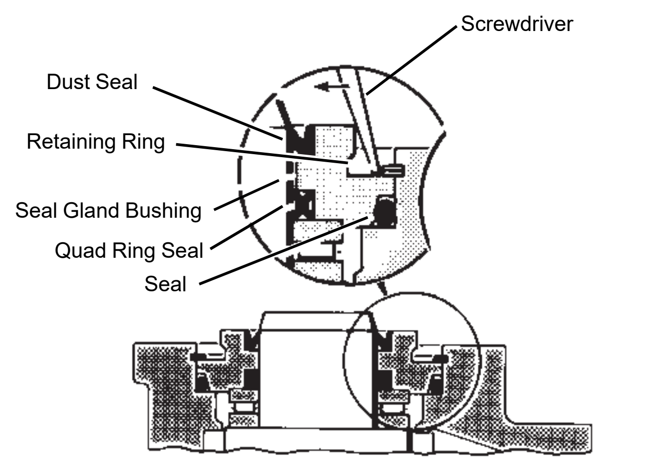
8. Compress the extended end of the centering spring set and push into the spool and sleeve assembly, withdrawing the installation tool at the same time.
9. Center the spring set in the parts so they push down evenly and flush with the outer surface of the sleeve.
10. Insert pin (**11**, Figure 10-13) through the spool and sleeve assembly until the pin becomes flush at both sides of the sleeve.
11. Lubricate the spool and sleeve assembly and position the assembly so that the splined end of the spool enters the meter end of housing (**8**, Figure 10-13). See (Figure 10-21).



a0334 FIGURE 10-21

NOTE: Be extremely careful that the parts do not tilt out of position while inserting. Push parts gently into place with a slight rotation action; keep the pin horizontal. Bring the spool assembly entirely within the housing bore until the parts are flush at the meter end of the housing. Do not pull the spool and meter assembly beyond this point to prevent the cross pin from dropping into the discharge groove of the housing. With the spool assembly in this flush position, check for free rotation within the housing by turning with a light finger tip force at the splined end.

12. Place the housing on a clean, lint free cloth. Install seal (**4**, Figure 10-13) into housing **8**.
13. Install needle bearing kit **6**.
14. Install dust seal **1** into seal gland bushing **3**. Flat or smooth side of the dust seal must face down towards the bushing (Figure 10-22).



a0337 FIGURE 10-22

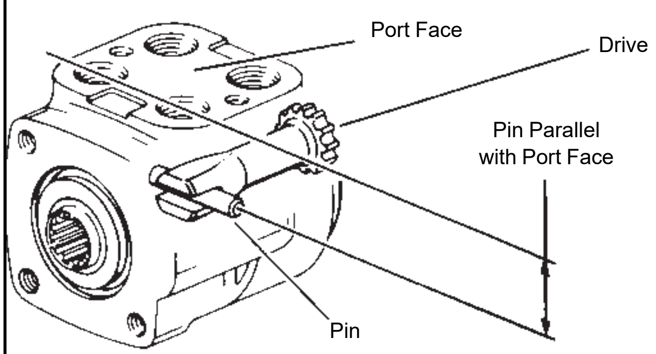
15. Install quad ring seal (**5**, Figure 10-13) into seal gland bushing **3**. Smooth seal in place with your finger. Do not use any seal that falls freely into the pocket of the bushing (Figure 10-22).
16. Install seal gland bushing (**3**, Figure 10-13) over the spool end with a twisting motion. Tap the bushing in place with a rubber hammer. Make sure the bushing is flush against the bearing race.
17. Install retaining ring (**2**, Figure 10-13) in the housing (Figure 10-22). After installing the retainer ring, tap on ring end or pry with a screwdriver around entire circumference of the ring to properly seat the ring in the groove.
18. Clamp housing (**8**, Figure 10-13) in a vise. Clamp lightly on edges of mounting area. Do not over tighten the vise jaws.

NOTE: Check to ensure that the spool and sleeve assembly are flush or slightly below the mounting surface.

NOTE: Clean the upper surface of the housing by wiping with the palm of your hand. Clean each of the flat surfaces of the meter section parts in a similar way when ready for assembly. **DO NOT USE cloth or paper to clean the surfaces.**

19. Install seal **13** into groove in housing **8**. Install spacer plate **14**. Align bolt holes in spacer plate with tapped holes in the housing.

20. Rotate the spool and sleeve assembly until pin **11** is parallel with the port face (Figure 10-23) Install drive (**15**, Figure 10-13), Make sure you engage the drive with pin **11**. To ensure proper alignment, mark the drive as shown in (Figure 10-24), Ref. **B**. Note relationship between the slotted end of the drive to the splined end of the drive when marking.



a0336 **FIGURE 10-23**

21. Install seal (**13**, Figure 10-13) into the gerotor **16**.

22. With seal side of the gerotor toward spacer plate **14**, align star valleys (Figure 10-24) Ref. **A**) on drive (Ref. **B**). Note the parallel relationship of reference lines **A**, **B**, **C** and **D**. Align bolt holes without disengaging the gerotor from the drive.

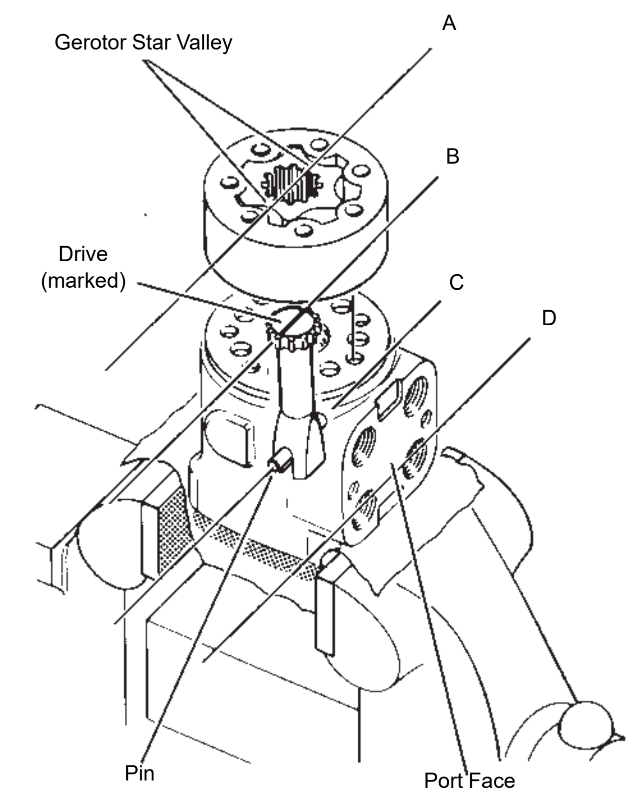
23. Install drive spacer (**17**, Figure 10-13) into the gerotor.

24. Install seal **13** into end cap **18**. Install end cap **18** onto gerotor **16**. Align the bolt holes.

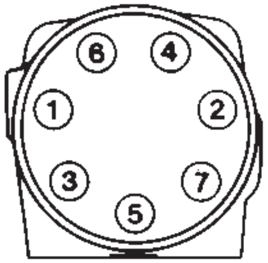
25. Install the seven 6 pt. Torx Drive screws with new seal washers in the end cap. Tighten each screw to 17 Nm (150 lb-in), then tighten each screw in sequence (Figure 10-25) to a torque of 31 Nm (275 lb-in).

Installation

1. Locate the steering orbital and steering column in position on the mounting bracket under the instrument panel. Secure in place with four bolts and numerous flat washers.



a0338 **FIGURE 10-24**



a0339 **FIGURE 10-25**

2. Connect the hydraulic lines to the steering orbital.

3. Check the hydraulic oil level in the reservoir. Fill if necessary.

4. Start the engine and turn the steering wheel in both directions to fill the lines with hydraulic fluid and bleed air from the system. Check for leaks and repair if necessary.

5. Check the hydraulic oil level in the reservoir. Fill if necessary.

6. Install the outside cover to the operator's compartment.

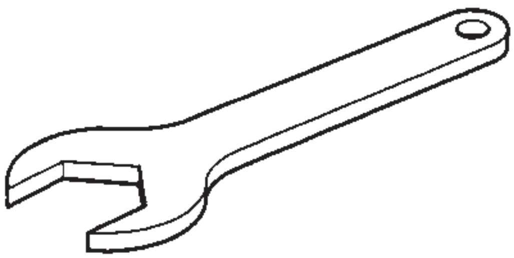
STEERING CYLINDER

Technical Data

Cylinder Bore . . . . .75 mm (2.95 inches)

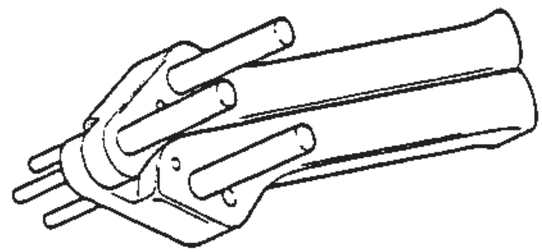
Rod Diameter. . . . . .42 mm (1.65 inches)

Special Tools



Hexagon Spanners for Cylinder Pistons and End Caps

a0340



Gland Seal Fitting Tool

a0341

FIGURE 10-26

Cylinder/Power Track Repair

Removal

WARNING

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

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Raise and support the crane to gain access to the steering cylinder.
2. With the engine not running, turn the steering wheel in both directions to release any pressure in the hydraulic lines to the steering cylinder.
3. Be prepared to collect the oil as you remove the steering lines. Slowly loosen the hydraulic hoses to release any remaining pressure. Install a plug in the hose end and a cap on the cylinder port. Place a tag on the hoses for identification and correct assembly.
4. Remove locking screws (**A,** Figure 10-27) and pivot pins **B**. Swing the track-rod clear of the steering joints.
5. Remove screws **C** and washers **D** (4 of each) from the cylinder mounting flange.
6. Mark the cylinder flange and housing for relocation.
7. Using a soft faced hammer, tap the closed end of the cylinder and carefully withdraw the cylinder and track-rod from the housing.

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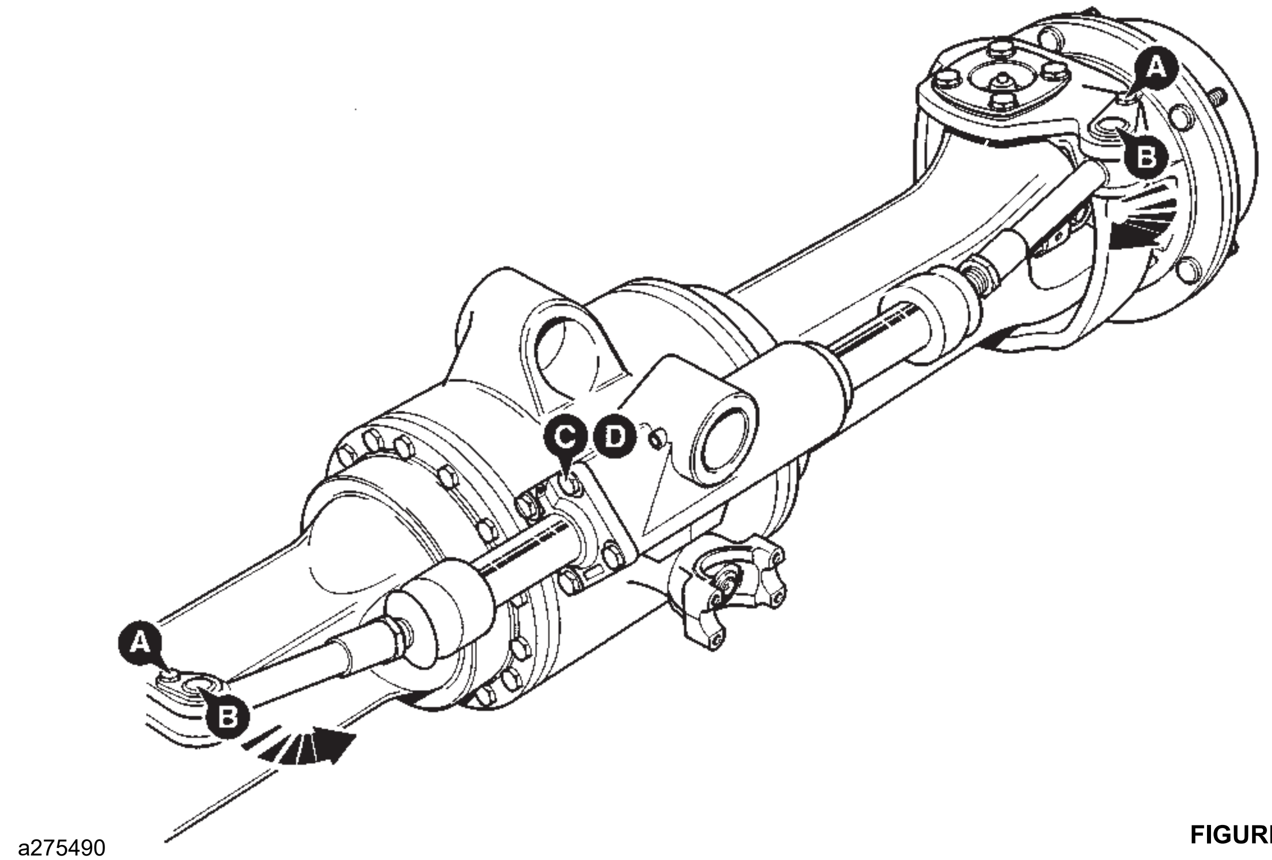
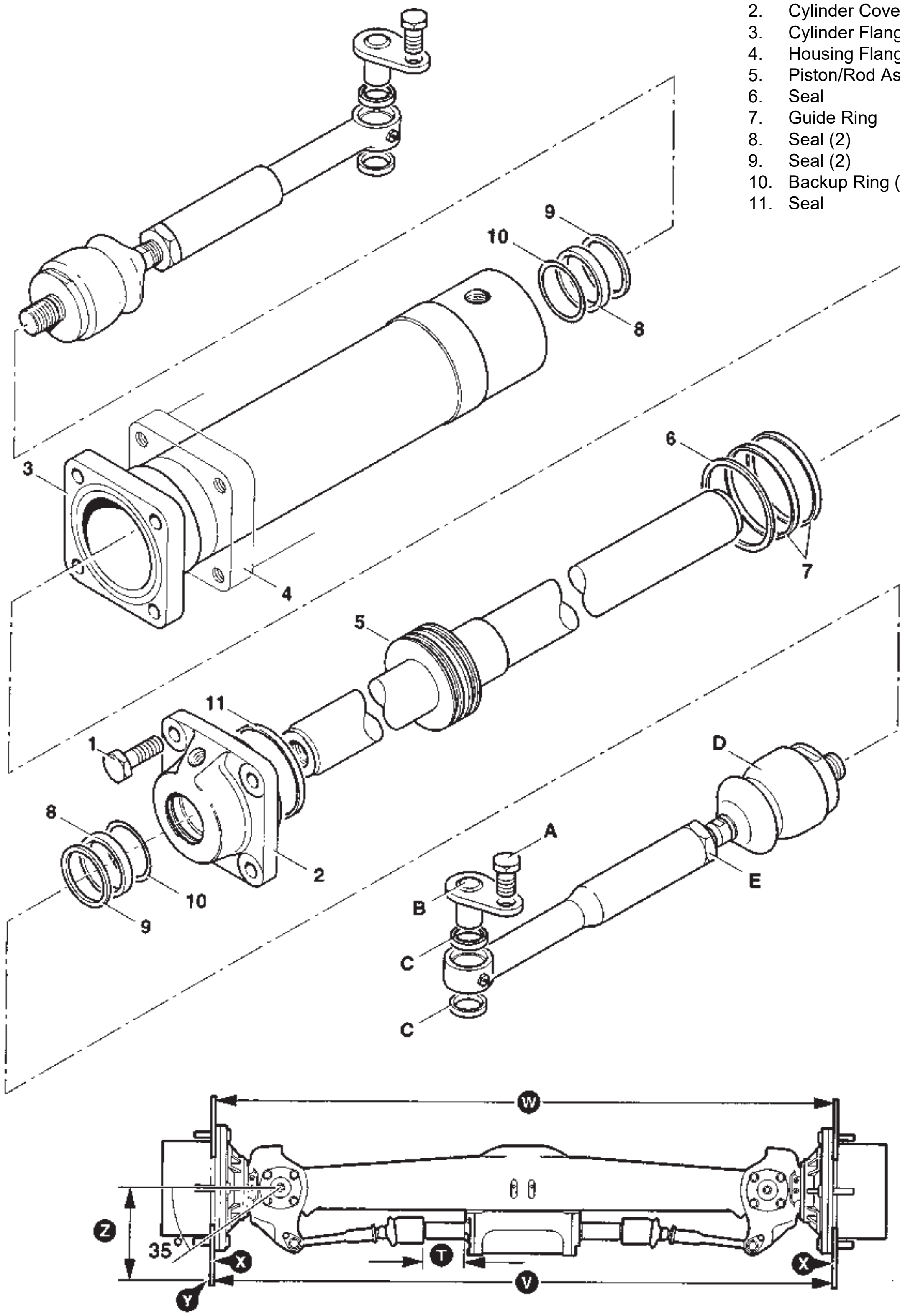


FIGURE 10-27

Item	Description
1.	Screw
2.	Cylinder Cover
3.	Cylinder Flange
4.	Housing Flange
5.	Piston/Rod Assembly
6.	Seal
7.	Guide Ring
8.	Seal (2)
9.	Seal (2)
10.	Backup Ring (2)
11.	Seal



JS07951

FIGURE 10-28

Disassembly

1. Remove setscrew (**A**, Figure 10-28) extract pivot pin **B** and disengage the track rod ends from the steering knuckles.
2. Remove ball joints **D** as follows:

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

   a. Using two suitable open ended spanners located on the flats at (**F** and **G**, Figure 10-29) rotate against each other until one ball joint unscrews.

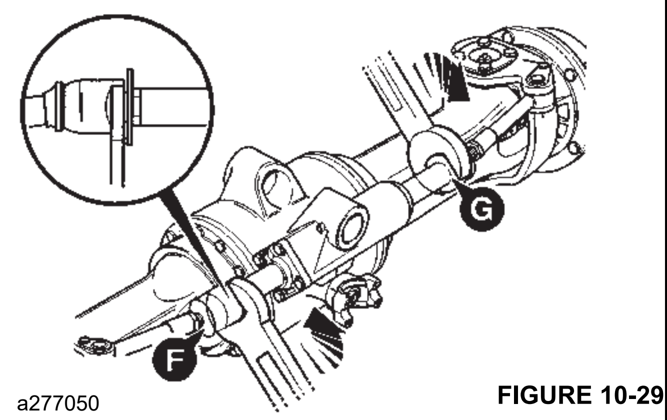


FIGURE 10-29

   b. Unscrew the ball joint until an open ended spanner can be fitted on rod (**5**, Figure 10-30). Screw the ball joint against the spanner to secure the spanner and to prevent damage to the rod.

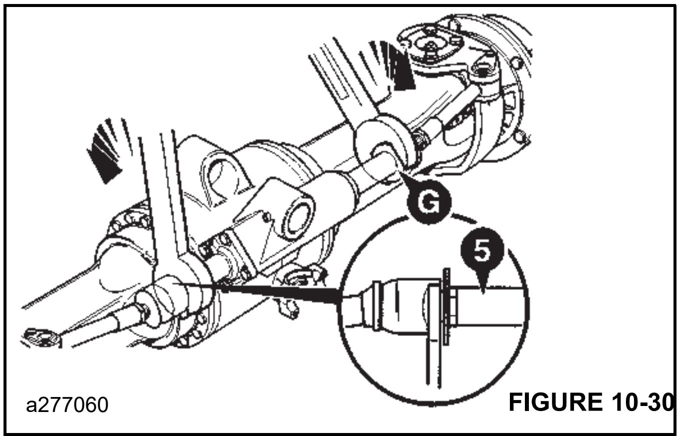


FIGURE 10-30

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

NOTE: Mark cover (**2**, Figure 10-28) and cylinder flange **3** relative to housing flange **3** before removal.

3. Take out four screws **1** and remove the cylinder cover/ piston guide **2**. Remove and discard seals **8** and **9** with back-up washer **10** and seal **11**.
4. Pull piston/rod assembly **5** out of the cylinder. Remove and discard guide rings **7** and seal **6** from the piston.

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

5. Using a soft faced hammer, carefully tap the closed end of cylinder **3** and withdraw the cylinder from its housing **4**. Remove and discard seals **8** and **9** with back-up washer **10**.

Inspection

1. Clean all parts in a suitable solvent. Dry with compressed air. Make sure threads of piston rod, piston, end cap and cylinder are thoroughly cleaned using a wire brush to remove grease, hydraulic oil and Loctite.
2. Inspect cylinder rod for rust, distortion, pitting or damage to the chrome. If there is damage to the cylinder rod, replace it. Do not try to straighten a bent cylinder rod.
3. Inspect inside of the cylinder barrel for grooves, distortion or other damage. Use a light to illuminate the cylinder bore for careful inspection. Replace any cylinder barrel if there is distortion or damage.
4. Inspect the piston for damage to the lands.
5. Inspect rod and barrel bushings for wear or damage.
6. Replace all seals and rings.

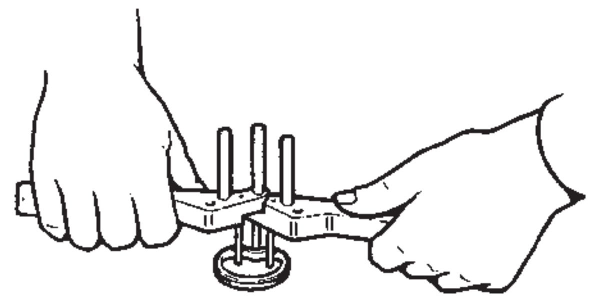
Assembly

1. Install new gland seal (**8**, Figure 10-28) 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.

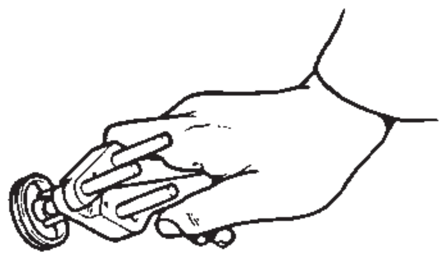
The pins are screwed into threaded holes in the tool body, the spacing of the holes is designed to fit small and large diameter gland seals.

   a. Open the tool (Figure 10-31) 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.



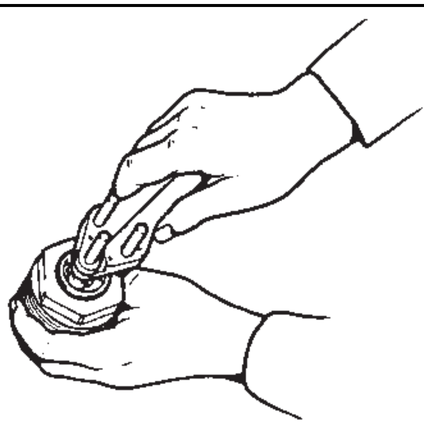
a0343 FIGURE 10-31

b. Close the tool (Figure 10-32). The seal must form a kidney shape.



a0344 FIGURE 10-32

c. Locate the seal in the end cap groove (Figure 10-33). 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 10-33

2. Fit new seal (**6**, Figure 10-28) and guide rings **7** to the piston. Ensure they are seated correctly.
3. Grease piston rod seal **8**, wiper ring **9** and back-up washer **10** and fit them into the grooves in the closed end of cylinder **3**. See step 1 for seal **8** installation. Ensure they are seated correctly.
4. Grease the machined external shoulders on cylinder **3** and insert the closed end into housing **4**. Using a soft faced hammer, carefully tap the flange until the cylinder is fully seated in the housing. Align the flange marking with the housing mark.
5. Apply grease to piston seal **6** and the surfaces of the piston rod. Insert piston/rod assembly **5** into the cylinder, ensuring it is the correct way round, with the piston sleeve towards the closed end of the cylinder, carefully guiding the rod through the seals in the closed end of cylinder **3**.
6. Grease and fit seal **8** (See step 1) wiper ring **9**, back-up washer **10** and cover seal **11** to the cylinder cover/piston guide. Ensure they are seated correctly.
7. Apply Loctite 574 to cylinder flange face **3**. Locate cover/piston guide **2** onto the piston rod and slide into position against cylinder flange **3**, aligning the location mark made during dismantling.
8. Insert four screws **1** and torque them to 166 Nm (122 lb-ft).
9. Coat the first three external threads of track rod end ball joint **D** with Loctite 243 and screw into the end of the steering piston rod. Torque to 400 Nm (295 lb-ft).
10. Grease and fit new web seals **C** to the hub steering knuckle. Ensure the seals are fitted correctly and are fully seated in position.
11. Connect the track rod ends to the hub carrier steering knuckles.

    Coat the surface of pivot pin **B** with anti-seize paste and insert the pin into the hub carrier and fit the setscrew **A**. Apply Loctite 243 to the threads and torque to 56 Nm (41 lb-ft).
12. Center the steering so that the distance **T** measured from the end of the piston guide to the steering ball joint face is 111 mm (4.37 in).
13. Attach a straight edge **X** to both hubs using a wheel mounting nut. Make a mark at position **Y** which corresponds to the distance **Z**, wheel center to rim flange on each straight edge.
14. Measure the distance **V** between the two straight edges. Rotate both hubs through 180 degrees and measure the distance **W**. The two measurements should be the same. If not, carry out step 15.
15. Loosen the locknut **E** on each track rod end. To adjust the tracking, use a spanner to rotate the inner ends of the track rods.

16. Repeat steps 14 and 15 until the two measurements are the same.
17. Check that a steering angle of 35 degrees can be achieved in both directions. If the steering angle is not the same in both directions it is necessary to adjust both track rod ends to compensate while still meeting the requirements of step 14.
18. Finally torque the locknut **E** on each track rod end to 240 to 260 Nm (177 to 192 lb-ft).

Installation

1. Carefully insert the cylinder and track-rod into housing aligning with marks made during removal.
2. Install four screws (**C**, Figure 10-27) and torque to 166 Nm (122 lb-ft).
3. Swing track-rods into steering joints.
4. Apply Anti Seize to pivot pins **B** and install in both steering joints. Install locking screws **A**.
5. Connect the hydraulic hoses to the cylinder.
6. Lubricate the grease fitting 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 bleed the system. See Bleeding Steering System.
9. Check for leaks and repair if necessary.
10. Check the hydraulic oil level and fill if necessary.

Bleeding Steering System

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

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

1. Select 2 Wheel Steer
   a. Turn steering wheel to left, until front wheels are fully locked to the left.
   b. Turn steering wheel to right, until front wheels are fully locked to the right.
2. Select 4 Wheel Steer
   a. Turn steering wheel to left, until front wheels are fully locked to the left.
3. Select 2 Wheel Steer
   a. Turn steering wheel to full right lock.
   b. Turn steering wheel to full left lock.
   c. Turn steering wheel to full right lock.
4. Select 4 Wheel Steer
   a. Turn steering wheel to left, until the front wheels are fully locked to the left.
5. Select 2 Wheel Steer
   a. Turn steering wheel to full right lock.
   b. Turn steering wheel to full left lock.
   c. Turn steering wheel to full right lock.
6. Select 4 Wheel Steer
   a. Turn steering wheel to left, until front wheels are fully locked to the left.
7. Select 2 Wheel Steer
   a. Turn steering wheel to full right lock.
   b. Turn steering wheel to full left lock.
   c. Turn steering wheel to full right lock.
8. Select 4 Wheel Steer
   a. Turn steering wheel to left, until the front and rear wheels are fully locked.

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SECTION 11
STRUCTURALS

SECTION CONTENTS

BOOM

Theory of Operation

Refer to Figure 11-1.

The boom is a four section boom that uses a hydraulic telescope cylinder and internal cables to extend and retract the boom. A lift cylinder located under the boom is used to raise and lower the boom.

The telescope cylinder is a two-stage, double acting type. It is attached to the 1st or base section. The cylinder extends the 2nd and 3rd sections. Extend cables are used to extend the 4th section.

The telescope cylinder retracts the 2nd section. Retract cables are used to retract the 3rd and 4th sections.

The extend cables for the 4th section are attached to the rear of the 2nd section, reeved around sheaves on the front of the telescope cylinder and attached to the rear of the 4th section.

The retract cables for the 4th section are attached to the front of the 2nd section, reeved around sheaves on the rear of the 3rd section, and attached to the rear of the 4th section.

The retract cables for the 3rd section are attached to the front of the base section, reeved around sheaves at the rear of the 2nd section, and attached to the rear of the 3rd section.

A proportioning cable is attached to the rear of the base section, reeved around a sheave at the front of the 2nd section, and attached to the rear of the 3rd section. This cable maintains proper telescope cylinder proportion and equal boom section extension.

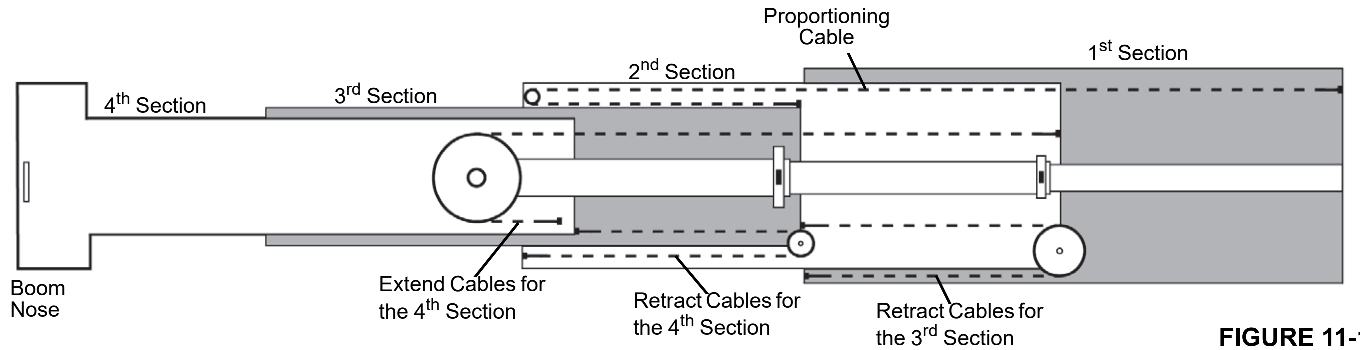
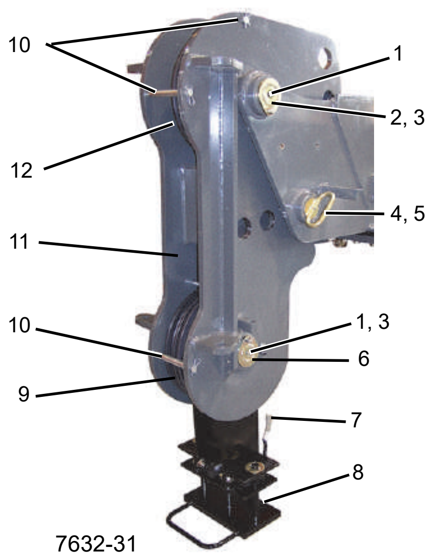


FIGURE 11-1

Boom Nose

Removal

Refer to Figure 11-2.



Item	Component
1	Grease Fitting
2	Upper Pin
3	Capscrew
4	Pivot Locking Pin
5	Lynch Pin
6	Lower Pin
7	A2B Switch Connector

Item	Component
8	A2B Switch Assembly
9	Lower Sheave
10	Cable Retaining Pin
11	Boom Nose
12	Upper Sheave

FIGURE 11-2

WARNING

Crushing Hazard!

Ensure the lifting device is capable of supporting the boom nose.

Serious injury, death or equipment damage may result.

1. Disconnect A2B switch connector from A2B harness.
2. Remove the RCL A2B assembly.
3. Attach a lifting device to the boom nose.
4. Remove lower pin (6), sheave assembly, shims, spacers and bearings.
5. Remove the lynch pin (4) and pivot lock pin (5).
6. Lift the boom nose slightly to remove the weight on the upper pin.
7. Remove the upper pin, side plates, sheave assembly, shims, spacers and bearings.
8. Lift the boom nose off the boom.

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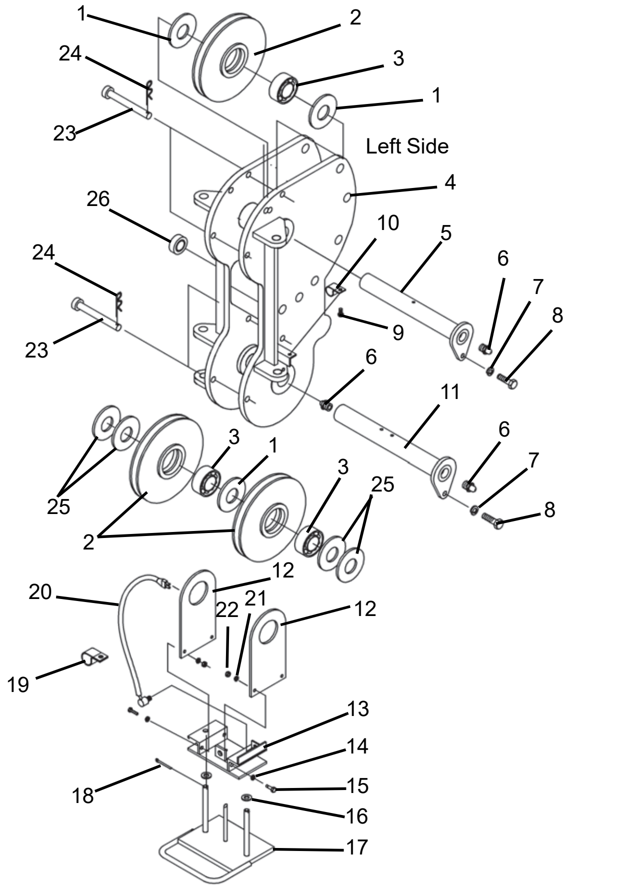
Assembly



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Item	Component
1	Spacer
2	Sheave
3	Bearing
4	Boom Nose
5	Pin
6	Grease Fitting
7	Lockwasher
8	Capscrew
9	Capscrew
10	Clip
11	Pin
12	Plate
13	A2B Assembly

Item	Component
14	Flatwasher
15	Capscrew
16	Flatwasher
17	A2B-Lower
18	Cotter Pin
19	Clamp
20	A2B Switch Assy
21	Flatwasher
22	Nut
23	Retaining Pin
24	Retaining Clip
25	Thrust Washer
26	Collar

FIGURE 11-3

1. Lift the boom nose into position on the boom.
2. Install the upper pin, plates, spacers, bearing, sheave, and grease fitting.
3. Install the boom angle pivot pin and secure with the lynch pin.
4. Install the lower pin, thrust washers, bearings, sheaves, spacers, and grease fitting.
5. Install the cable retaining pins and retaining clips.
6. Install the RCL A2B assembly.
7. Connect the A2B switch to the A2B harness

Boom Removal

The boom is removed from the carrier as one assembly.

The boom, including jib mounted on side, weighs 3456 kg (7,620 lb), use suitable crane/lifting device and associated straps, etc.

⚠ WARNING

Falling 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.

---

1. Extend and set the outriggers, and level the crane.
2. Fully retract the boom.
3. If installed, remove folding extension according to Section 4 of the Operator Manual.
4. Remove the hook block or downhaul weight and retract the wire rope onto the hoist drum.
5. Attach a lifting device and two straps to the boom strong enough to lift the boom. Lift the boom slightly to relieve the weight off the lift cylinder pivot pins.
6. Attach another lifting device to the upper end of one of the lift cylinders.
7. Remove the lift cylinder boom pivot pin retainer and pivot pin from the base section (Figure 11-4).
8. Lower the lift cylinder to a suitable support.
9. Repeat the procedure to remove the boom pivot pin on the other lift cylinder.
10. Tag and disconnect the hydraulic lines from the boom telescope cylinder. Cap all lines and ports.

⚠ DANGER

Crushing Hazard!

Ensure the lifting device is capable of supporting the boom assembly.

Death or serious injury will result.

11. With the lifting device attached to the boom, raise the boom until the weight is removed from the boom pivot pin. Remove the boom pivot pin retainer and pivot pin (Figure 11-4) and lift boom off the turret.
12. Place the boom assembly on a suitable work surface.

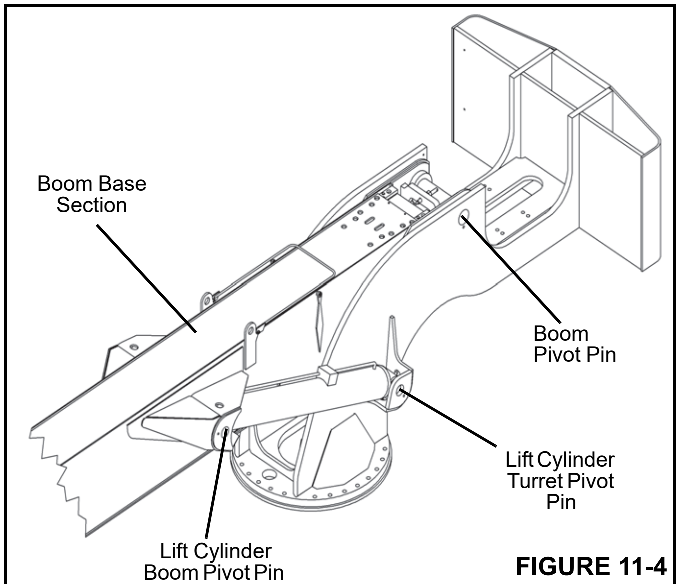


FIGURE 11-4

Lift Cylinder Removal

1. Tag and disconnect the hydraulic lines attached to the lift cylinder. Cap all lines and ports.
2. Attach a lifting device to one lift cylinder.
3. Remove the lift cylinder turret pivot pin retainer and pivot pin.
4. Lift the cylinder off the turret.
5. Repeat the above procedure for the other lift cylinder.

Boom Disassembly

Refer to Figure 11-5

The front of the boom is the sheave case end and the rear of the boom is the hoist mount end. Left and right are viewed from the rear to the front.

The hoist can be removed to facilitate disassembly, but it is not required.

Boom Sections Removal

To remove the 2nd, 3rd and 4th sections from the base section as an assembly, use the following procedure:

1. Loosen tension on proportioning cable (8) and remove cable from rear anchor plate (24).
2. Remove the retainer plates outside rear base section (23).
3. Remove the left and right upper wear pads (18) in the rear between the base and 2nd sections.

NOTE: Leave the lower wear pads in to protect the extend cables during removal of the 2nd, 3rd and 4th boom sections.

4. Remove the two telescope cylinder anchor plates (5) from the rear of the base section.
5. Attach a suitable lifting device to the 2nd, 3rd and 4th section assemblies.
6. Slide the 2nd, 3rd and 4th sections out about 0.7 m (2 ft).
7. Remove and tag the top and side wear pads, shims, and wear plates. Leave the bottom wear pads in.
8. With the boom sections supported, slide the assembly out of the base section until the assembly is two-thirds out of the base section. Relocate the slings on the 2nd, 3rd and 4th boom assembly so that the assembly is balanced as it slides out of the base section.

CAUTION

Equipment Damage Hazard!

Keep the retract cables tensioned slightly by hand as the assembly is pulled out of the base section to prevent damage to the cable assemblies.

9. Remove the inside top wear pad (20).
10. Remove the bottom wear pads from the base section.
11. Raise the 2nd, 3rd and 4th boom assembly inside the base section, remove and tag bottom wear pads.
12. Slide the 2nd, 3rd and 4th assembly out of the base section and place on a suitable work surface.

CAUTION

Equipment Damage Hazard!

Take care not to pinch or crush the retract cables while lifting or supporting assembly.

Disassembly of Boom Sections

Refer to Figure 11-5.

1. Remove adjustment nuts for the 4th section extend cables (9).
2. Remove the cable anchor assembly (9).
3. Remove two cylinder locking retainers (6)
4. Remove and tag the wear pads, shims, and plates (25) on the 2nd section.

NOTE: Keep all parts for each wear pad together for proper reassembly.

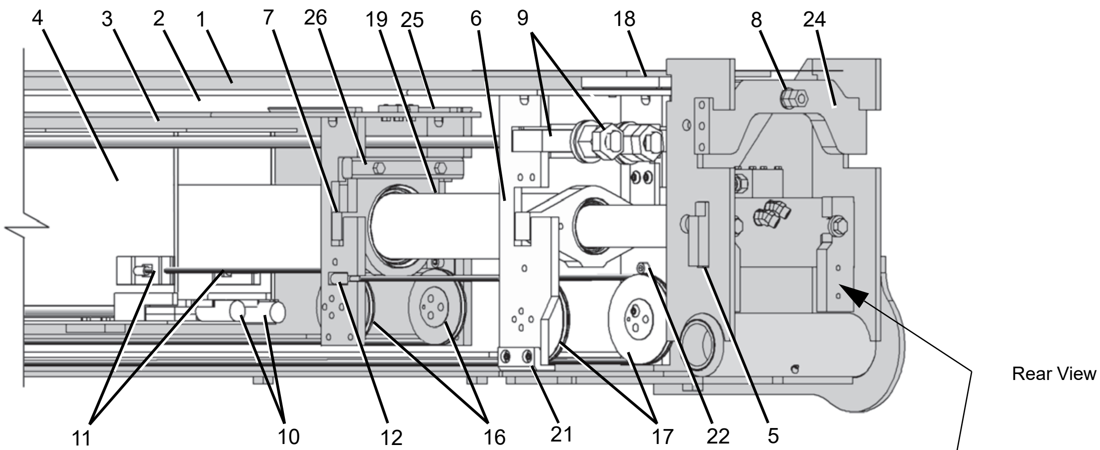
5. Remove the two rear bottom wear pads on the 2nd section (21).

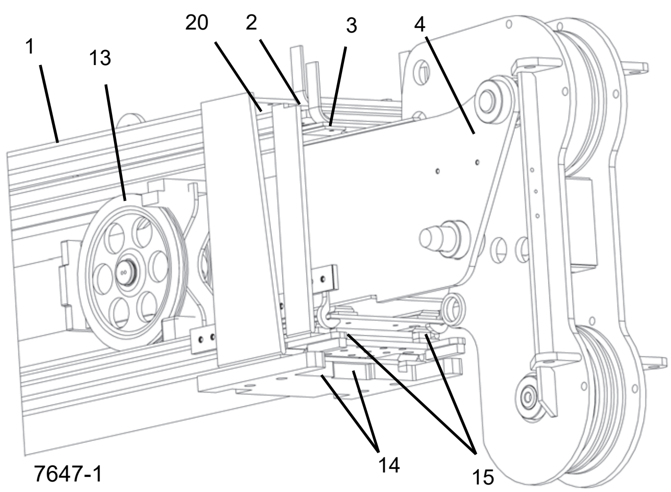
   Removal of these pads allow the retract cables to uncoil off the retract sheaves.
6. Place the retract cable ends in a location to minimize the possibility of damage.
7. Remove the two retract sheave pins and two retract sheaves to the 2nd section.
8. Remove the two upper retract cable keepers (22).
9. Remove the retract cables.
10. Remove the lock bar (26).
11. Remove the capscrews that secure the extend cable anchor to rear of the 4th section (10).
12. Support the telescope cylinder (19) with an appropriate lifting device and pull the telescope cylinder out of the boom to within 3 feet (91 cm) of complete removal from the boom sections.

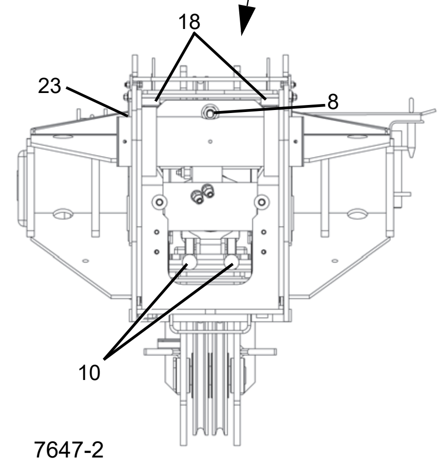
CAUTION

Equipment Damage Hazard!

Keep the extend cables tensioned slightly by hand to minimize the possibility of damage to the cables.







Item	Component
1	1^{st} boom section
2	2^{nd} boom section
3	3^{rd} boom section
4	4^{th} boom section
5	Telescope cylinder anchor plates
6	Telescope cylinder attach point 2^{nd} section.
7	Telescope cylinder attach point 3^{rd} section.
8	Proportioning cable attach point.
9	Rear anchor point 2^{nd} section of 4^{th} section extend cables.
10	Rear anchor point of 4^{th} section for 4^{th} section extend cables.
11	Rear anchor point of 4^{th} boom section for 4^{th} section's retract cables.
12	Rear anchor point of 3^{rd} section for 3^{rd} section retract cables.
13	Extend sheaves at front of telescope cylinder.
14	Front attach point of 1^{st} section for 3rd section retract cables.
15	Front attach point of 2^{nd} section for 4^{th} section retract cables.
16	Retract sheaves at rear of 3^{rd} section for 4^{th} section retract cables.
17	Retract sheaves at rear of 2^{nd} section for 3^{rd} section retract cables.
18	Upper Wear Pad
19	Telescope Cylinder
20	Wear Pad
21	Wear Pad
22	Cable Keeper
23	Retainer Plates
24	Anchor Plates
25	Wear Pad
26	Lock Bar

FIGURE 11-5

13. Reach into the rear of the 4th section and pull the extend cable anchor (10) out from its retaining pocket on the bottom of the 4th section. A slight angle applied to the anchor as it's being pulled to the rear permits easier removal through the 2nd and 3rd sections.

14. Remove the telescope cylinder and cables from the boom. Place cylinder and cables in a safe place to keep them from being damaged.

15. Remove the wear pad, and cable guide from the front top of the 2nd section.

16. Remove the capscrews attaching the bottom cable retainer plate (14) to the 2nd section. Slightly lift the 3rd section and remove the retainer plate.

17. Slide the 3rd section out of the 2nd section. The side pads may need to be removed. Remove and tag the side pads and shims, if required.

18. Remove the cable guide, wear pad, and spacer bar from the front top of the 3rd section.

19. Remove the capscrews attaching the bottom pad plate (15) to the 3rd section. Slightly lift the 4th section and remove the pad plate.

20. Slide the 4th section out of 3rd section. The side pads may need to be removed. Remove and tag the side pads and shims if required.

21. Loosen and remove all remaining wear pads.

Cleaning and Inspection

Thoroughly clean all parts and inspect the following:

- All boom sections for wear, dents, bent or crooked sections, broken welds, or any abnormal conditions. Repair or replace as required.
- Sheaves for excessive groove wear or abnormal rim wear. Replace as required.
- Sheave bearings for excessive wear or damage, replace as necessary. If the bearing diameter is 0.38 mm (0.015 inch) larger than the pin diameter, the bearing must be replaced.
- Clean and inspect all cable assemblies and replace as required. Lubricate all cable assemblies before reinstalling in boom.
- Inspect all sheave pins for wear or damage, replace as necessary.
- Inspect all grease fittings and grease holes in pins to ensure proper grease flow. Clean or replace as required.
- Replace all lubricating plugs in all wear pads.

Boom Assembly

Refer to Figure 11-5.

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

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

NOTE: The boom nose assembly can be installed now or after the boom sections are assembled.

1. Attach the rear wear pads on bottom of the 4th section as per removal tags. Use Loctite 243 on all wear pad mounting capscrews (Figure 11-6).

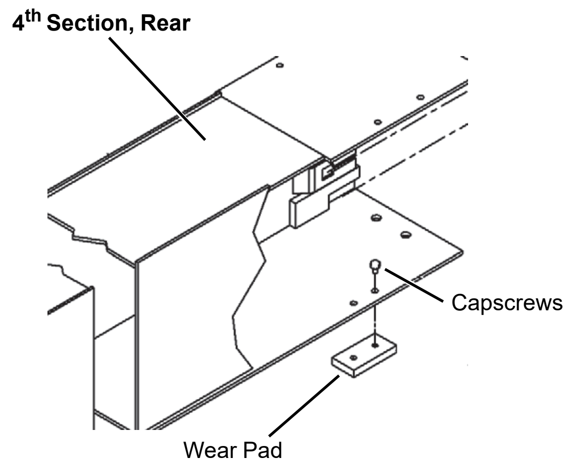


FIGURE 11-6

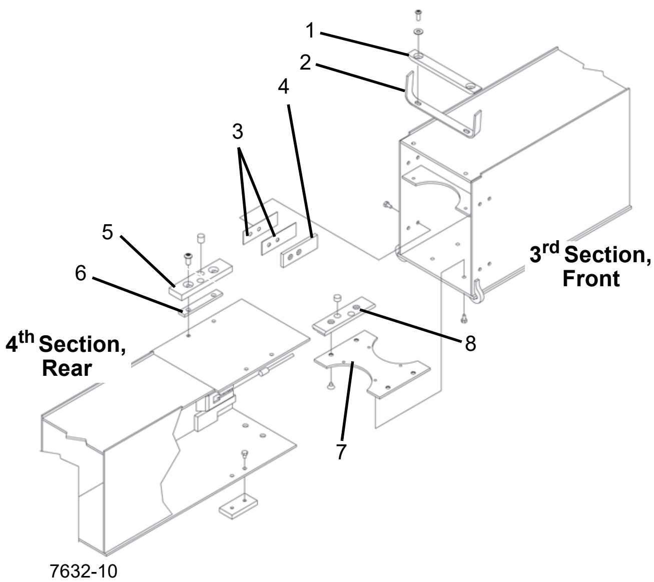
2. Install the 4th section boom into the 3rd section. Slide in until about 1.5 m (5 ft) of the 4th section extends from the 3rd section.

3. Assemble the bottom front wear pads (7) for the 3rd section as per removal tags and attach to the pad plate (8) (Figure 11-7).

4. Using an appropriate lifting device, lift the 4th section to allow for wear pad/pad plate installation in lower front of the 3rd section.

5. Install the wear pad/pad plate assembly and slide the sections together within 30 cm (12 in) of full retraction.

6. Install the cable guide (2) and wear pad (1) to the front top of the 3rd section.



Item	Component
1	Wear Pad
2	Cable Guide
3	Shim
4	Side Wear Pad
5	Top Wear Pad
6	Adjusting Plate
7	Wear Pad
8	Bottom Pad Plate

FIGURE 11-7

7. Install the front side wear pads (4) and shims (3) between the 4th and 3rd sections.

NOTE: For boom reassembly with no new sections, reinstall shims per removal tags. For a new boom section, adjusting the clearance with shims may be necessary.

The boom should slide with a slight amount of resistance and be centered in the other section.

8. Slide the 4th section in until the wear pad mounting pads can be comfortably reached from the rear of the 3rd section.

9. Assemble the top rear wear pads (5) and adjusting plates (6) and install through the rear section of the boom, secure with the capscrews through holes in the top outer boom sections (Figure 11-7).

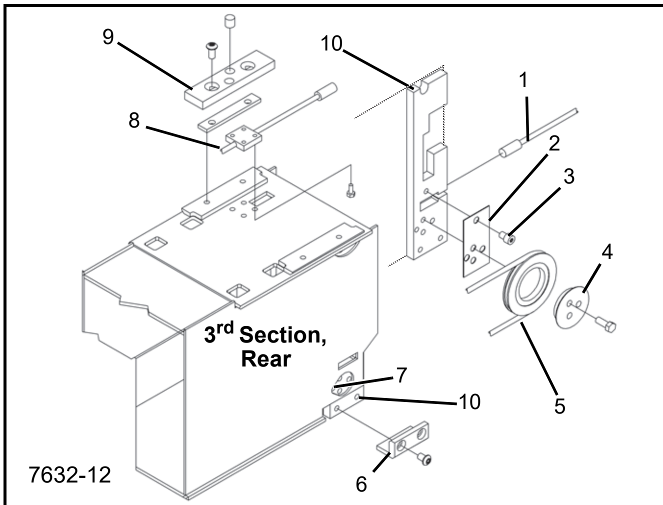
NOTE: The section should slide with a slight amount of resistance and be centered in the other section.

The holes in the wear pads are offset 0.8 mm (0.03 in) and the holes in the adjusting plate are offset 1.5 mm (0.06 in). To adjust the wear pads, pivot the wear pads and plates independently of each other.

10. Slide boom sections completely together.

Extend/Retract Cable installation

1. Uncoil 3rd section retract cable assemblies (1) and insert the button end into the slot in the anchor plate (10) inside the rear of the section. Install the keeper plate (2) over the cable end (Figure 11-8).



Item	Component
1	3rd Section Retract Cable
2	Keeper Plate
3	Retainer
4	Sheave Retainer
5	4th Section Retract Cable
6	Keeper\Wearpad
7	Grease Hole
8	Proportioning Cable
9	Wearpad
10	Anchor Plate

FIGURE 11-8

2. Coat the surfaces of the bearings and keeper plates with grease, and install the cable sheave onto anchor plate. (Figure 11-8).

3. Secure the sheave with the sheave retainer and capscrews.

NOTE: Grease hole must align with hole in keeper plate retainer and the lube hole (4) (Figure 11-9) in the 3rd boom section.

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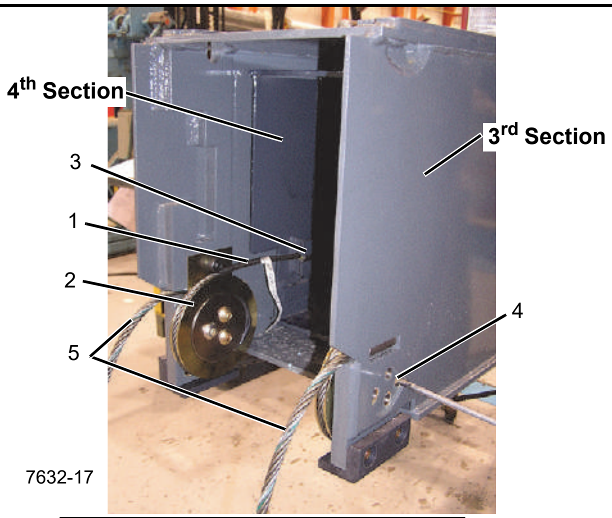


Item	Component
1	4th Section Retract Cable
2	Sheave
3	Anchor, 4th Section
4	Lube Hole
5	3rd Section Retract Cable

FIGURE 11-9

4. Place the uncoiled cable in a safe area to prevent damage.

5. Reeve the 4th section retract cable (1) around the cable sheave (2) (Figure 11-9).

6. Install the 3rd section retract cable button end into the 4th section anchor (3).

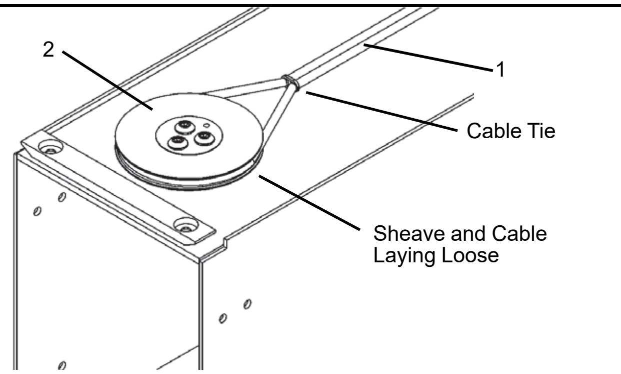
7. Route the cable underneath the 3rd section and temporarily attach to the front of the section.

8. Apply grease to the retract cable sheave through lube hole (4) in the 3rd section. A grease gun adapter (P/N 955045) is required to lubricate the internal sheaves. Contact Product Support to obtain this tip.

9. Install and secure the proportioning cable (8) to the top of the 3rd section (Figure 11-8).

10. Loop the proportioning cable (1) (Figure 11-10) around the cable sheave (2) and place it on top of the 3rd section. Tie the cable together as shown—this assembly is attached to the 2nd section later.

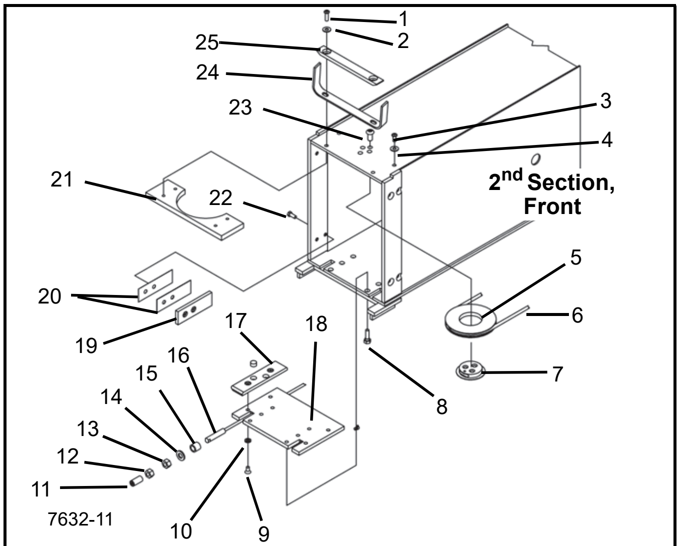
NOTE: The cable/sheave must be towards the front. The threaded end of the cable should be on the left side and button end should be on the right side.



Item	Component
1	Proportioning Cable
2	Sheave

FIGURE 11-10

11. Slide the 4th/3rd section assembly into the 2nd section; routing the 3rd section retract cable through the 2nd section and being careful to not damage the 4th section retract cables under the 3rd section. Leave this assembly hanging out of the 2nd section about 1.5 m (5 ft) (Figure 11-11).



Item	Component
1	Capscrew
2	Washer
3	Capscrew
4	Washer
5	Proportioning Sheave
6	Proportioning Cable
7	Sheave Retainer
8	Capscrew
9	Capscrew
10	Washer
11	Protective Sleeve
12	Jam Nut

Item	Component
13	Adjusting Nut
14	Washer
15	Spacer
16	4th Section Retract Cable
17	Wear Pad
18	Cable Anchor
19	Wear Pad
20	Shim
21	Cable Retainer
22	Capscrew
23	Capscrew
24	Cable Guide
25	Wear Pad

FIGURE 11-11

12. Slightly lift the assembled sections in the 2nd section and install the bottom side wear pads (19) and shim (20) as required (Figure 11-11).

13. Remove the cable tie installed in step 10.

14. Slide the 4th/3rd section assembly into the 2nd section an additional 0.7 m (2 ft).

15. Assemble the 4th section retract cable anchor plate (18) and wear pads (17).

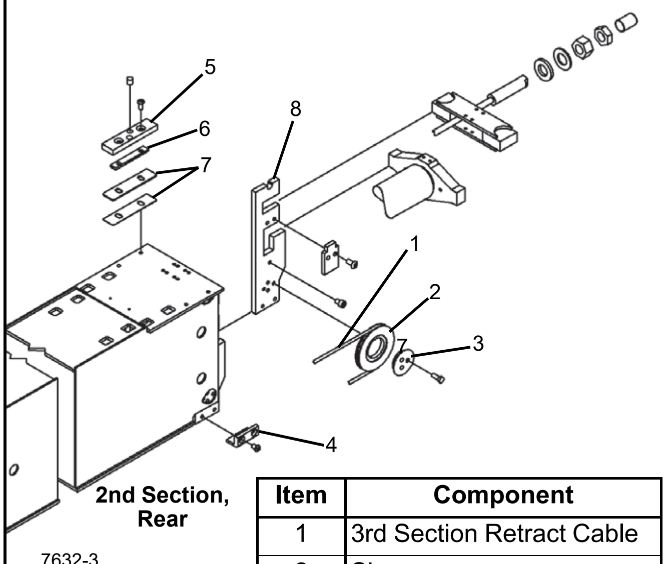
16. With the assembled sections still supported, install the cable anchor/wear pad assembly to the bottom of 2nd section, routing the 4th section retract cables (16) under the cable anchor plate in the slots (Figure 11-11). Secure with capscrews.

17. Lower the assembled section and secure the proportioning cable, sheave and sheave retainer (5, 6 & 7) with capscrews to the inside of the top plate of the 2nd section.

NOTE: Grease hole must align with hole in keeper plate retainer and the lube hole in the 2nd section.

18. Apply grease to the proportional cable sheave through lube hole in the top of 2nd section with a grease gun fitted with the adapter tip (P/N 955045).

19. Install the cable retainer (21), cable guide (24) and wear pad (25) with capscrews and washers to the top plate of the 2nd section.



Item	Component
1	3rd Section Retract Cable
2	Sheave
3	Sheave Retainer
4	Wear Pad
5	Wear Pad
6	Adjusting Plate
7	Shim
8	Anchor Plate

FIGURE 11-12

20. Install the cable sheave (2) onto anchor plate (8) with the sheave retainer (3) (Figure 11-12).

NOTE: Grease hole must align with hole in keeper plate retainer and the lube hole in the boom section.

21. Reeve the 3rd section retract cable (1) around the cable sheave (2).

22. Route the cable underneath the 2nd section and temporarily attach to the front of the section.

23. Apply grease to the retract cable sheave through lube hole.

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Telescope Cylinder Installation

1. Install the sheave wheels on the telescope cylinder. The holes in the end of the pin must be located on the left side, see Figure 11-13.
2. Apply grease to the cable sheave with a grease gun fitted with the adapter tip (P/N 955045).

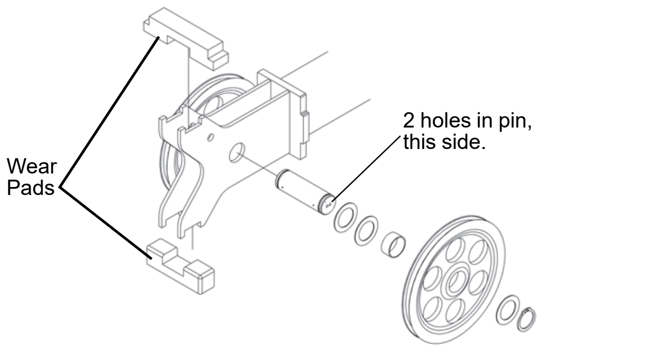


FIGURE 11-13

3. Reeve the retract cables around the telescope cylinder sheaves.
4. Install the wear pads on the telescope cylinder.

NOTE: Ensure the wear pads do not fall off during cylinder installation.

5. Insert the telescope cylinder assembly ½ to ¾ of the way into the 2nd section.
6. Support the telescope cylinder to access the bottom of the 4th section.

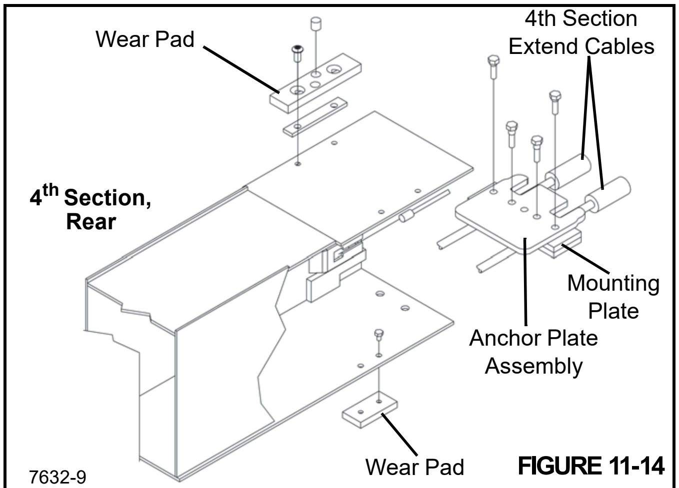


FIGURE 11-14

7. Install the anchor assembly into the base end of the 4th section (Figure 11-14).
8. Insert the telescope cylinder the rest of the way into the boom assembly.
9. Insert cylinder lugs into notches in rear 2nd and 3rd sections (Figure 11-15).

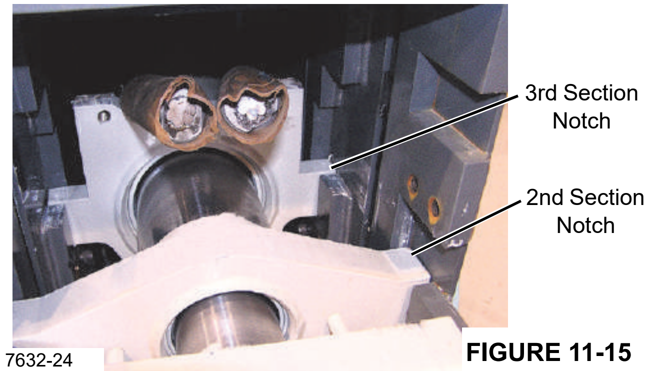
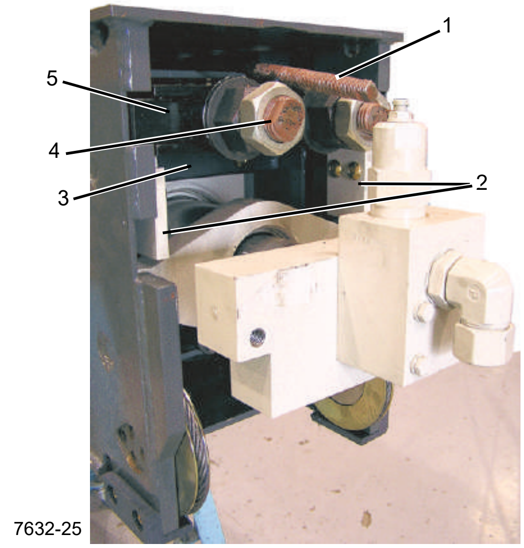


FIGURE 11-15

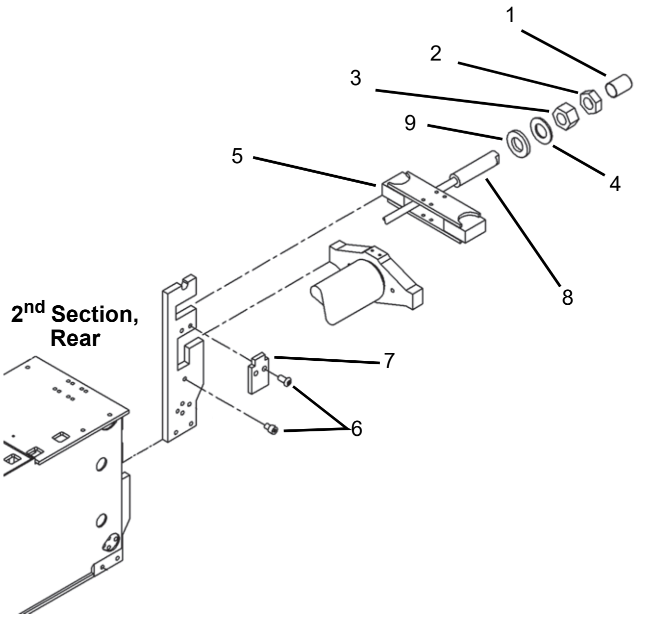
10. Install the cylinder lock bar and retainer plates (Figure 11-16).



Item	Component
1	Proportional Cable
2	Retainer Plate
3	Lock Bar
4	Extend Cable
5	Extend Cable Anchor

FIGURE 11-16

11. Insert the extend cable anchor assembly into the base end of the 2nd section.(Figure 11-17)
12. Install the extend cable through the extend cable anchor assembly.
13. Secure the extend cable with the hardware as shown in Figure 11-17.



Item	Component
1	Cable Protector
2	Jam Nut
3	Hex Nut
4	Flat Washer
5	Anchor Assembly
6	Capscrew
7	Retainer Plate
8	Extend Cable
9	Spacer

FIGURE 11-17

Final Assembly

1. Slide the 2nd, 3rd and 4th section assembly into the base section until 1.8 m (4 to 5 ft) of the assembly remains out.
2. Install the lower wear pads at the front end of the base section along with the 3rd section retract cables (Figure 11-18).
3. Install the side wear pads and shims as required. Secure with capscrews
4. Install the upper wear pad and secure with a flat washer and capscrews.

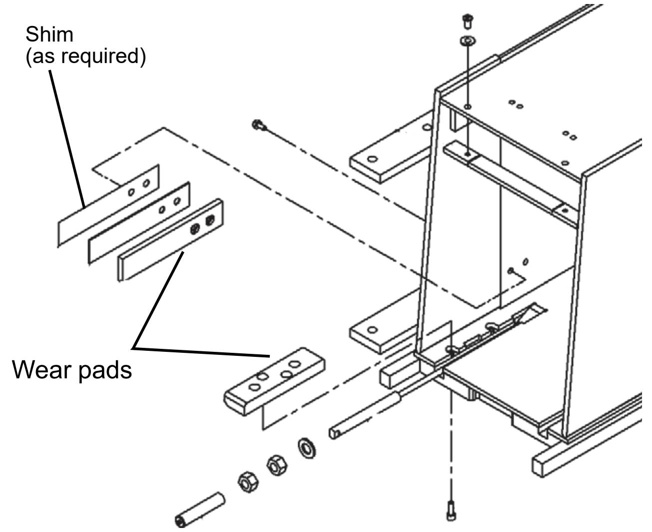


FIGURE 11-18

5. Slide the assembled sections all the way into the base section.

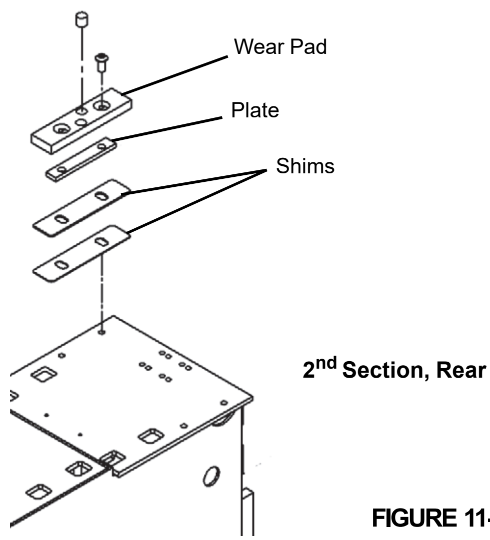


FIGURE 11-19

6. On the base end of the 2nd section, install the upper wear pad and plate (Figure 11-19).

NOTE: The section should slide with a slight amount of resistance and be centered in the other section.

The holes in the wear pads are offset 0.8 mm (0.03 in) and the holes in the adjusting plate are offset 1.5 mm (0.06 in). To adjust the wear pads, pivot the wear pads and plates independently of each other.

7. Install the spacers and capscrews through the telescope cylinder anchor plates.(Figure 11-20)

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8. Insert the proportioning cable thorough anchor plate and install the anchor plate.

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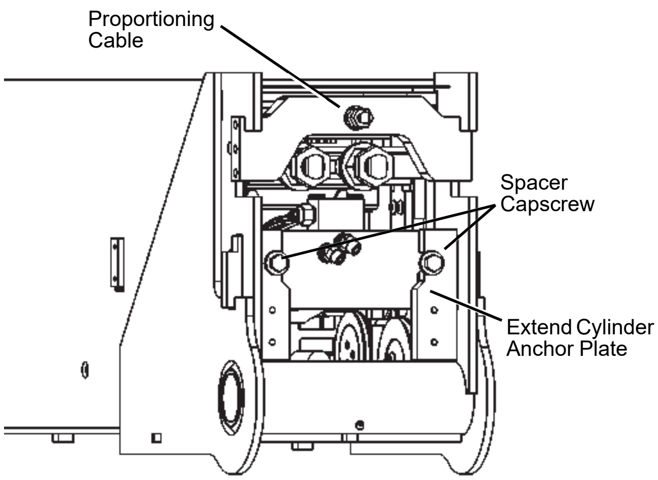


FIGURE 11-20

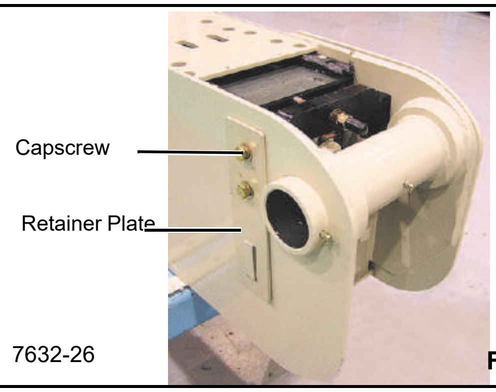


FIGURE 11-21

9. Install the retainer plates and capscrews to secure anchor plate to the outside of the base section (Figure 11-21).

CABLE TENSIONING

A boom assembly is considered properly timed when 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.

Hydraulic extend cylinder construction will dictate which extendable section will be the driver that the other extend sections will need to be adjusted to utilizing cable adjustment.

A single stage cylinder will control first extendable section.

A dual stage cylinder will control second extendable section.

Timing sequence of cables will depend on number of sections and the extend cylinder construction.

Design intent of the cable tensioning is to balance the preload of extend and retract cables for each extendable section. In addition, sequencing of the sections during retraction requires retract cables of every section to be indexed relative to each other.

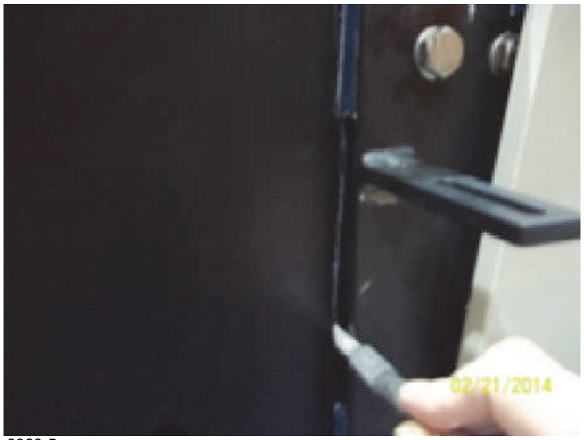
Tensioning Setup Procedure

Tensioning must be done with the boom in the horizontal position.

When tightening/loosening the first (adjustment) nuts on cables, secure cable using the wrench flats at the front of the cable ends to prevent cable twist. Excess twisting of cables can cause premature failure.

Ensure boom is completely assembled and fully retracted.

1. Mark the front of each section with a chalk line as indicated in Figure 12.
2. Extend and retract boom several times to establish working state of cables.
3. Extend boom so scribed lines are exposed by approximately 12 inches.
4. Measure the extension gaps between each boom section and scribed line and note values.
5. Retract boom so that the scribed lines are exposed by approximately 6 inches.
6. Measure the retraction gaps between each boom section and scribed line and note values.
7. Extend and retract the boom a few times and then repeat measuring the extension gaps.
8. Adjust all corresponding cables according to ***Cable Tightening Sequence*** instructions.



8860-5

8860-6

FIGURE 12

Cable Tension Sequence

Four section boom with two stage cylinder.

Cable tensioning to be in the following order:

1. 321 retract cables
2. 123 extend (synchronizing) cables.
3. 234 extend cables
4. 432 retract cables.

4- Section Boom w/ 2 Stage Cylinder Cable Positioning

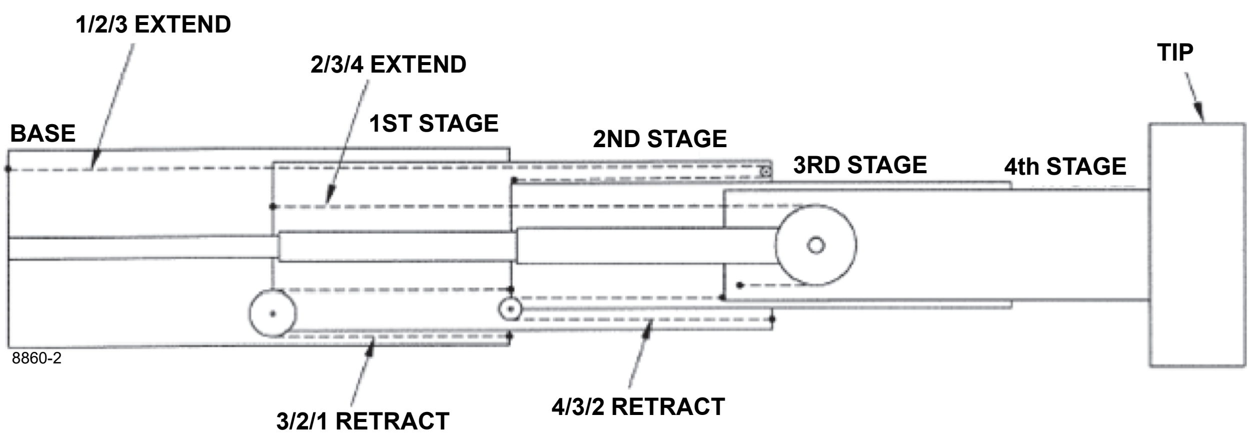


FIGURE 13

Cable Tightening Sequence 4 Section Boom with Two Stage Extend Cylinder

Boom must be in horizontal position when adjusting cable tension (See Figure 13.) Retract boom fully ensuring sections are bottomed out on section stops. Ensure all sections are fully bottomed out and do not spring back.(Reference Tensioning Setup Procedure)

321 and 123 cable balancing

Extension

1. Measure the extension gaps between the first and second section and the second and third section.

If the extension gap between first and second section is less than the extension gap between the second and third section;

2. Tighten **321** retract cable located at the front bottom of the base section the difference in the extension gap measurements.

3. Extend and retract the boom a few times and then repeat measuring the extension gaps.

The second section should have moved out.

4. Tightening until the extension gap between the first and second section and the extension gap between the second and the third are 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.

If the retraction gap is greater between the first and second section than the retraction gap between the second and third section;

2. Tighten the **123** synchronizing cable located at the back of the base section the difference in the retraction gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the retraction gaps.

The third section should have moved out.

4. Tightening until the retraction gap between the first and second section and the retraction gap between the second and the third are 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.

If the extension gap between third and fourth section is less than the extension gap between the second and third section;

2. Tighten the **234** extend cable located at the back top of the second section the difference in the extension gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the extension gaps.

The fourth section should have moved out.

4. 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.

If the retraction gap is greater between the third and fourth section than the retraction gap between the second and third section;

2. Tighten the **432** retract cable located at the front bottom of the second section the difference in the retraction gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the retraction gaps.

The fourth section should have moved in.

4. 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 the all extendable sections should extend and retract equally and bottom out against the stops simultaneously.

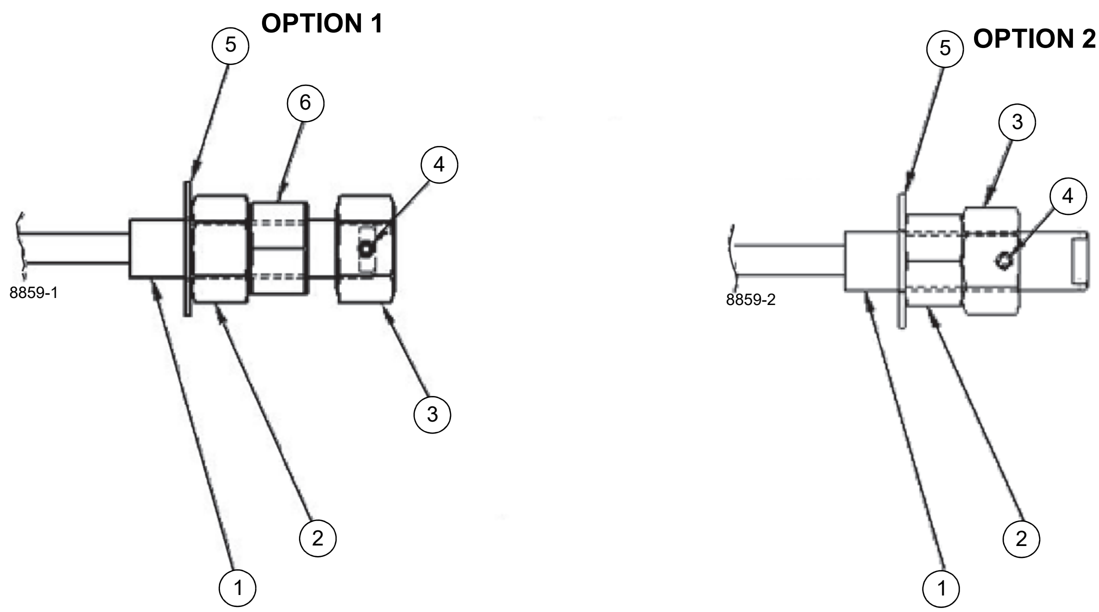


FIGURE 14

Cable Retention

Cable Retention Hardware

Item	Description
1	Threaded Cable End
2	Nut (Adjustment)
3	Nut (Positive Lock)
4	Setscrew
5	Washer
6	Nut (Torqued)

Nut configuration (see Figure 14) will be First Nut (ADJUSTMENT) and Second Nut (TORQUED).

NOTE: (**OPTION 2**) method used ONLY when space constraints prevent **OPTION 1** usage.

When tightening/loosening the first (adjustment) nuts on cables, secure cable using the wrench flats at the front of the cable ends to prevent cable twist.

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.

The second nut should be hand tightened until it comes in contact with the back of the first nut.

Hold the first (adjustment) nut stationary and a torque wrench to tighten the second (torqued) nut against the first (adjustment) nut to the values indicated in TORQUE VALUES for Second Nut:

Third (positive lock) nut installation is to be placed on each of the extend cables. The retract cables do not require the third (positive lock) nut.

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.

Install set screw into Third nut and tighten.

(**OPTION 2**) method used ONLY when space constraints prevent **OPTION 1** usage (see Figure 14).

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TORQUE VALUES for Second Nut:

Inch Series with Coarse Threads (UNC)

Cable end Thread Size	Minimum Nut Strength GRADE	Nut Type	TORQUE ft lbf
1/2-13	SAE 2	Hex Jam (HALF)	12
5/8-11	SAE 2	Hex Jam (HALF)	31
3/4-10	SAE 2	Hex Jam (HALF)	47
7/8-9	SAE 2	Hex Jam (HALF)	63
1-8	SAE 2	Hex Jam (HALF)	199
1 ¼-7	SAE 2	Hex Jam (HALF)	203
1 ½-6	SAE 5	Hex Jam (FULL)	250
1 ¾-5	ASTM B	Hex Jam (FULL)	250

Metric Series with Coarse Threads

Cable end Thread Size	Minimum Nut Property Class	Nut Type	TORQUE Nm
M16x2	5	Hex Jam (THIN)	26
M20x2.5	5	Hex Jam (THIN)	66

BOOM INSTALLATION

WARNING

Falling 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.

1. Extend and set the outriggers.
2. Attach a lifting device to the boom lifting lugs and lift the boom onto the carrier and lower to the boom rest.
3. Line up the boom with the attach point on the turret.
4. Install the boom pivot pin (Figure 11-1).
5. Re-install telescope cylinder hydraulic lines as per removal tags.

DANGER

Crushing Hazard!

Ensure the lifting device is capable of supporting the boom assembly.

Death or serious injury will result.

LIFT CYLINDER INSTALLATION

1. Attach a lifting device to the lift cylinder.
2. Raise the lift cylinder to the carrier deck under the boom.
3. Line up the lift cylinder with the attach point on the turret and install the pivot pin (Figure 11-4).
4. Raise the rod end of the lift cylinder to the attach point under the boom and install the pivot pin.

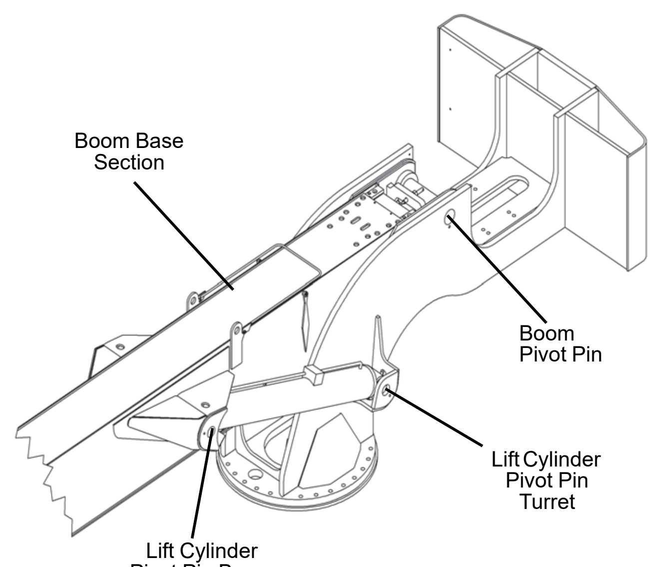


FIGURE 11-1

WIRE ROPE, SHEAVE AND HOIST BLOCKS

Inspecting Wire Rope

Inspect the wire rope in accordance with *Wire Rope, page 5-2*.

Inspection of Sheaves

Inspect all sheaves for wear and proper alignment.

For maximum life of the wire rope, the sheave grooves must be smooth and must be a little larger than the diameter of the wire rope.

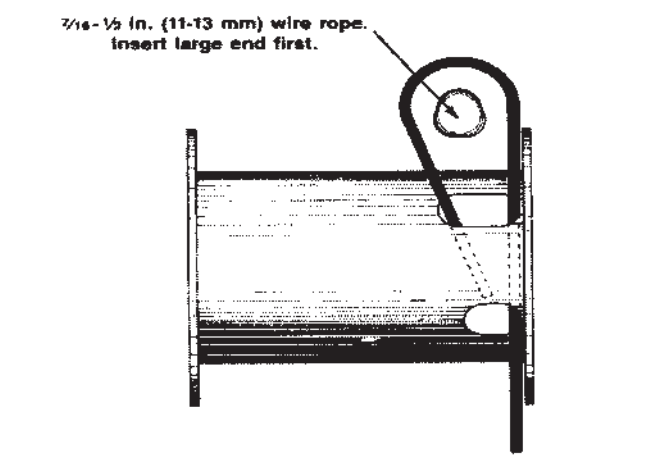
As wear in the sheaves increases, the groove for the wire rope gets smaller, NOT larger. Tracks in the sheaves are caused by the wire rope, yet the wire rope will continue to engage the tracks (example; a chain engaging a sprocket). A twist in the wire rope or a small change of lay will prevent the wire rope from engaging the track in the sheave. The result will be a rapid wear on the wire rope.

Wire Rope Installation

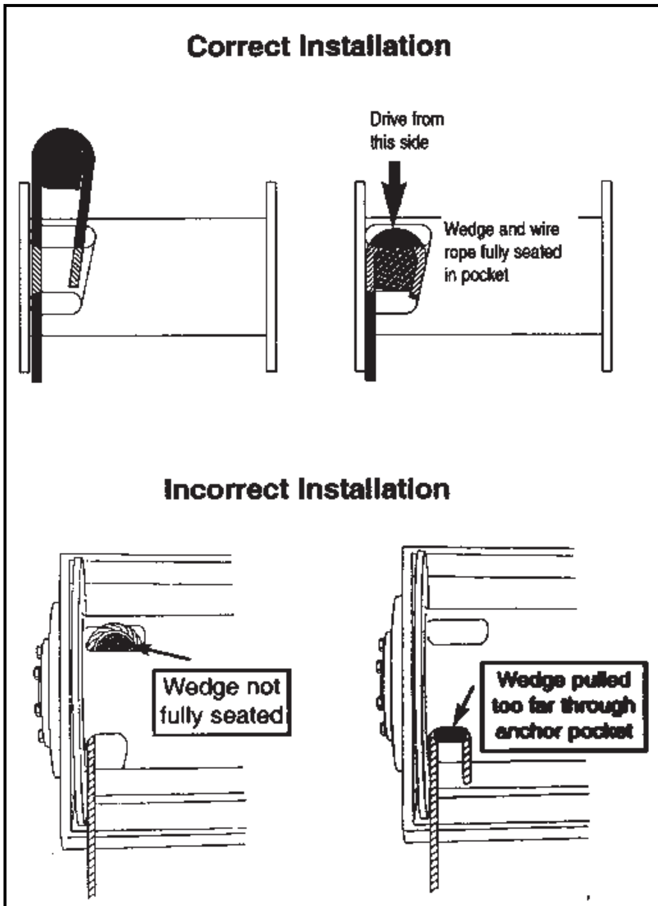
Anchoring Wire Rope

Take the free end of the wire rope and insert it through the small opening on the anchor pocket. Loop the wire rope and push the free end about 3/4 of the way through the pocket. Install the wedge, then pull the slack out of the wire rope. The wedge will slip into the pocket and secure the wire rope into the drum. The anchor is designed to fit several different sizes of wire rope. Make sure the anchor is installed large end first. See Figure 11-2.

Refer to Figure 11-3 and verify that the wedge is installed correctly.



a2274 FIGURE 11-2



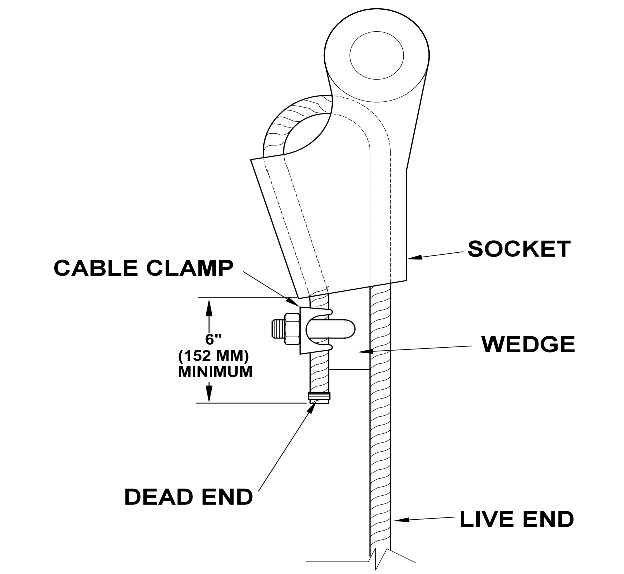
a2275 FIGURE 11-3

Installation of Socket and Wedge

Always connect the socket so that the load is pulled on the same line as the socket (See Figure 11-3).

When installing the wedge, hit the wedge several times with a SOFT hammer to make sure the wedge is fully engaged with the socket. Be sure not to damage the wire rope. Install cable clamp on the loose end of the wire rope as shown in Figure 11-4.

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

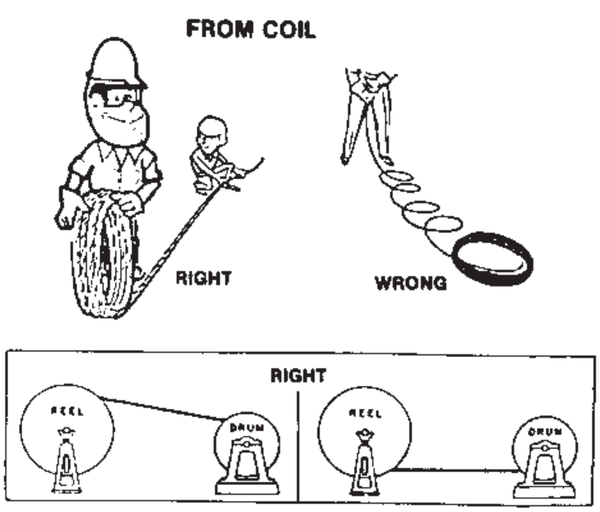


X = A MINIMUM OF 6 ROPE DIAMETERS, BUT NOT LESS THAN 152 MM (6 INCHES).

a0069 **FIGURE 11-4**

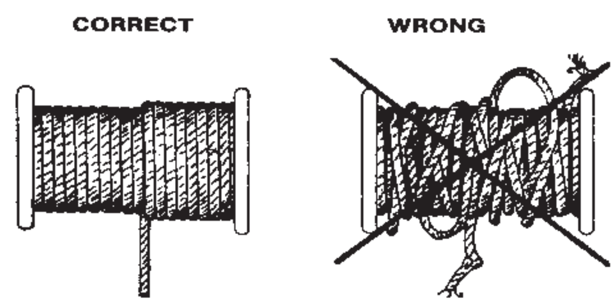
Installation of a New Wire Rope

The wire rope is given a natural bend or winding from coil. If the wire rope is on a reel, unwind the wire rope from the real as shown in Figure 11-5. Use care to prevent reverse bend in the wire rope.



a0473 Wire Rope Installation **FIGURE 11-5**

1. Make sure that the equipment (hoist, sheaves, etc.) are in good condition.
2. Unwind enough rope from the reel to connect the wire rope to the hoist drum. Use care to prevent twists or sharp bends.
3. Operate the hoist slowly to move the wire rope directly from the reel to the hoist. Make sure the wire rope winds correctly on the drum. Loose windings will increase wear on the wire rope and cause bad performance.



a0474 Correct Winding of Wire Rope **FIGURE 11-6**

4. After installation, operate the hoist with a minimum load until you see the wire rope is moving easily over the sheaves and 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.

HOIST

Theory of Operation

Description of Hoist (**Figure 11-7**)

The hoist has five basic component parts:

1. Hoist base.
2. Hoist tension roller subassembly.
3. Hydraulic motor subassembly.
4. Brake cylinder and motor support.
5. Drum assembly.

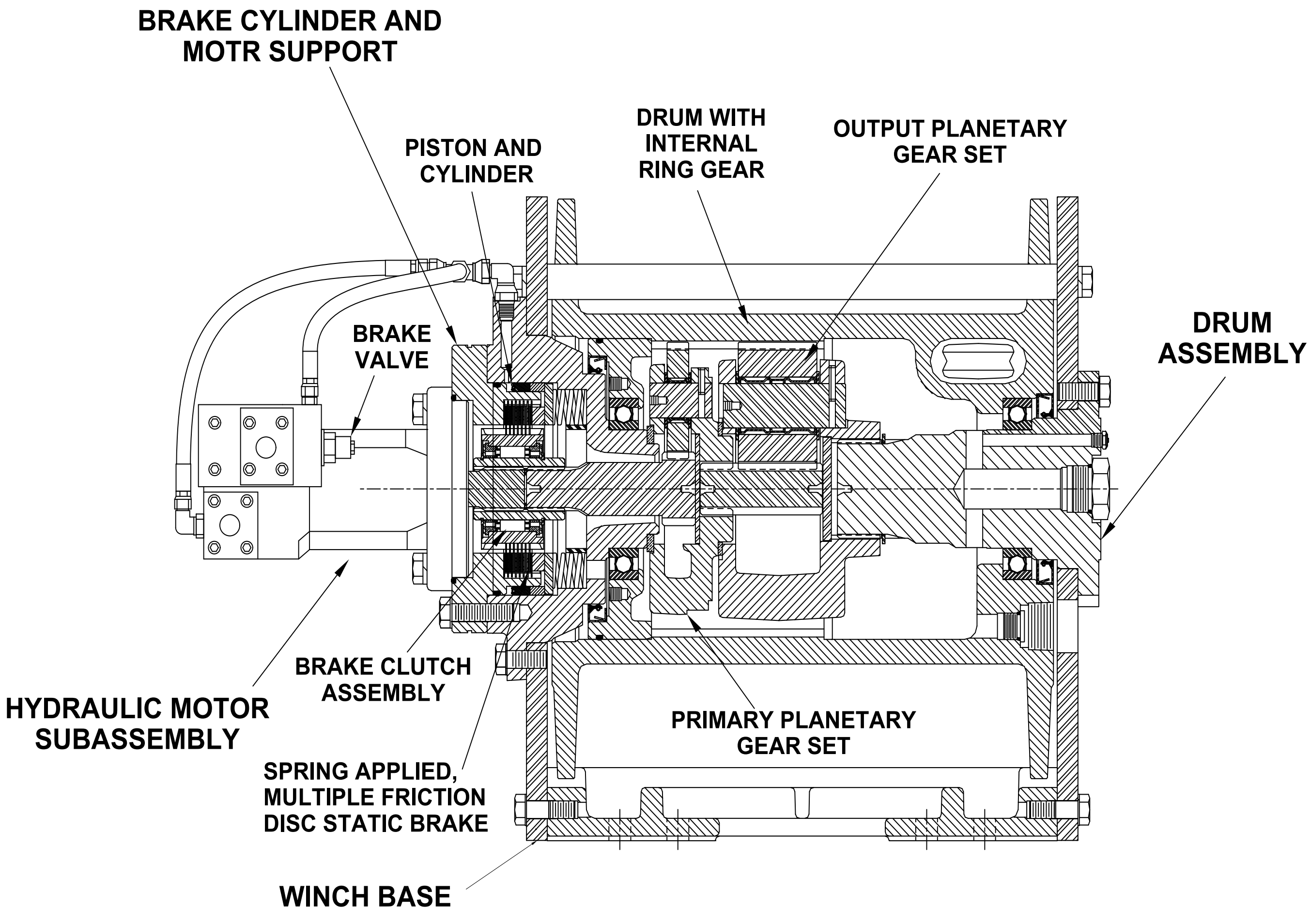
The drum assembly consists of three assemblies:

1. Drum with internal ring gear.
2. Output planetary gear set.
3. Primary planetary gear set.

The hydraulic motor is bolted to the motor support which in turn is bolted to the brake cylinder and the base. The motor end of the drum, rotating on a ball bearing, is supported by the brake cylinder.The other end of the drum rotates on a ball bearing on the support bolted to the base. The ring gear for both planetary sets is machined into the drum's inside surface.

Hoist Operation

The hydraulic motor drives the sun gear of the primary planetary gear set through the spline inner race of the brake clutch. When driven by the sun gear, the primary planet gears walk around the ring gear in the drum and drive the planetary carrier.



Hoist Cut-Away View

FIGURE 11-7

The primary planet carrier drives the output planet sun gear, which in turn drives the planet gears.The output planet carrier is splined to the bearing support and cannot rotate. Therefore, as the output planet gears are driven by the sun gear, they will drive the ring gear/drum.

Dual Brake System Description

The dual brake system consists of dynamic brake system and a static brake system.

The dynamic brake system has two operating components:

1. Brake valve assembly.
2. Hydraulic motor.

The brake valve is a counterbalance valve which contains a check valve to allow free flow of oil to the motor in the hoisting direction, and a pilot operated, spring loaded spool valve that blocks the flow of oil out of the motor when the control valve is placed in neutral.

When the main control valve is placed in hoisting position, oil, under pressure, from the pump is sent through the main control valve to the counterbalance valve; opening the check valve. Oil flows through the check valve to the motor, rotating in the hoisting direction. See Figure 11-8.

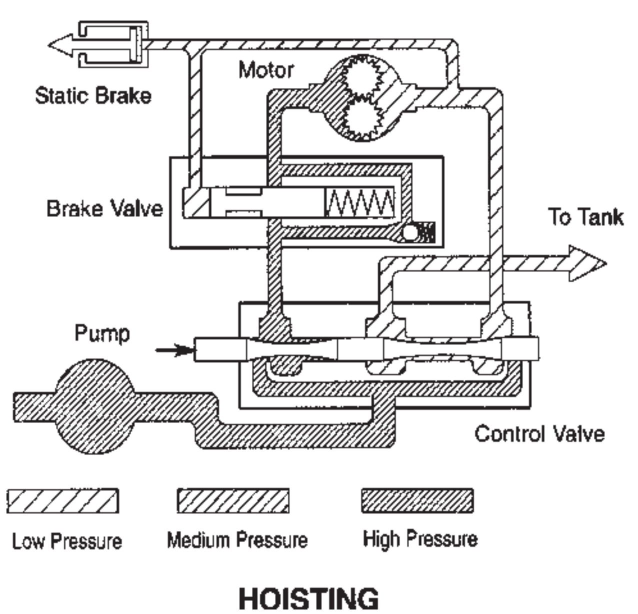


FIGURE 11-8

When the control valve is placed in the lowering position, the spring loaded, pilot operated spool valve remains closed (Figure 11-9) until sufficient pilot pressure is applied to the end of the spool valve to shift it against spring pressure; opening a flow passage (Figure 11-10). After the pilot operated spool valve cracks open, the pilot pressure becomes flow-dependent and modulates the spool opening which controls the lowering speed.

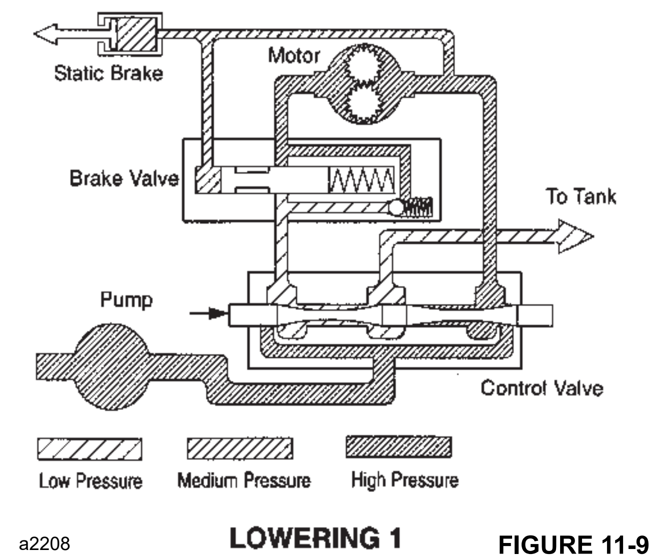


FIGURE 11-9

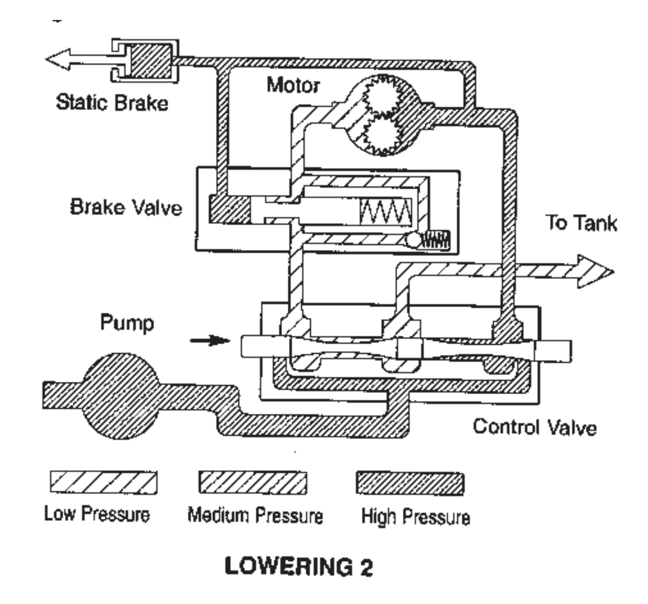


FIGURE 11-10

The static brake system has three operating components (see Figure 11-7):

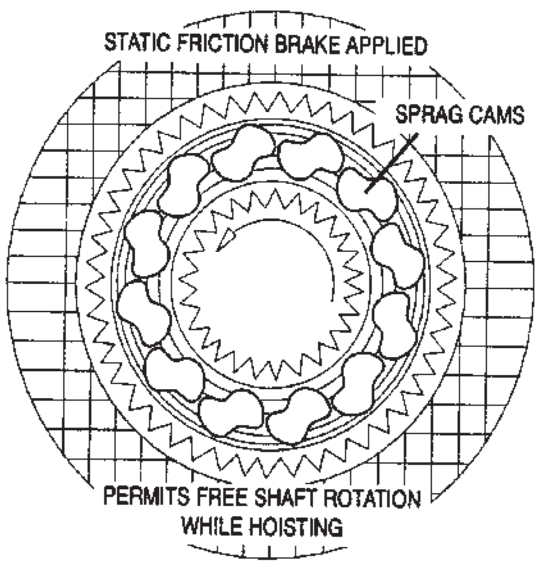
1. Spring applied, multiple friction disc static brake.
2. Brake clutch assembly.
3. Hydraulic piston and cylinder.

The static brake is released by the brake valve pilot pressure at a pressure lower than that required to open the pilot operated spool valve.This sequence assures that dynamic braking takes place in the brake valve and that little, if any, heat is absorbed by the friction brake.

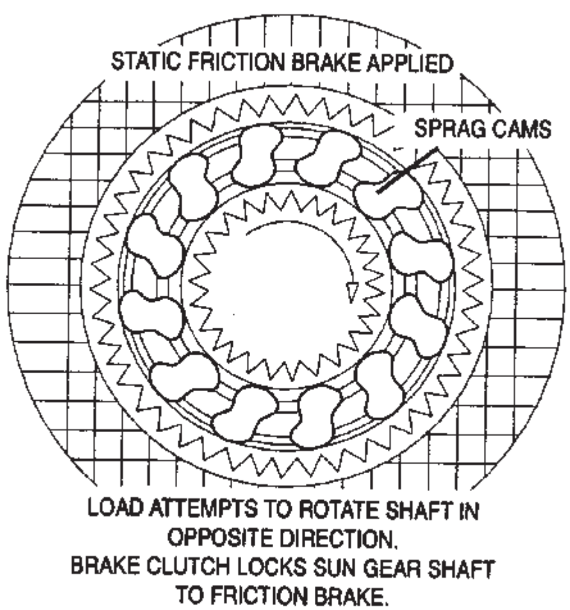
The friction brake is a load holding brake only, and has nothing to do with dynamic braking or rate of descent of a load.

The brake clutch is splined to the primary sun gearshaft between the motor and the primary sun gear. It will allow this shaft to turn freely in the direction to raise a load and lock up to force the brake discs to turn with the shaft in the direction to lower a load. See Figure 11-11 and 11-12.

The hydraulic cylinder, when pressurized will release the spring pressure on the brake disc, allowing the brake discs to turn freely.



a2209 **FIGURE 11-11**



a2210 **FIGURE 11-12**

Dual Brake System - Operation

When hoisting a load, the brake clutch, which connects the motor shaft to the primary sun gear, allows free rotation. The sprag cams lay over and permit the inner race to turn free of the outer race (Figure 11-11). The friction brake remains fully engaged. The hoist, in raising a load, is not affected by any braking action. See Figure 11-7.

When the lifting operation is stopped, the load attempts to turn the primary sun gear in the opposite direction. The reverse input causes the sprag cams to instantly roll forward and firmly lock the shaft to the fully engaged friction brake (Figure 11-12).

When the hoist is powered in reverse, to lower the load, the motor cannot rotate until sufficient pilot pressure is present to open the brake valve. See Figure 11-9 and 11-10. The friction brake within the hoist will completely release at a pressure lower than that required to open the brake valve. The extent to which the brake valve opens will determine the amount of oil that can flow through it, and the speed at which the load will be lowered. Increasing the flow of oil to the hoist motor will cause the pressure to rise and the opening in the brake valve to enlarge, speeding up the decent of the load. Decreasing this flow causes the pressure to lower and the opening in the brake valve to decrease, thus slowing the descent of the load.

When the main control valve is shifted to neutral, the pressure will drop and the brake valve will close, stopping the load. The friction brake will engage and hold the load after the brake valve closes.

When lowering a load very slowly for precise positioning, no oil flow actually occurs through the hoist motor. The pressure will build up to a point when the brake will release sufficiently to allow the load to rotate the motor through its own internal leakage. This feature results in a very slow speed and extremely accurate positioning.

The friction brake receives very little wear in the lowering position. All of the heat generated by the lowering and stopping of the load is absorbed by the hydraulic oil where it can be readily dissipated.

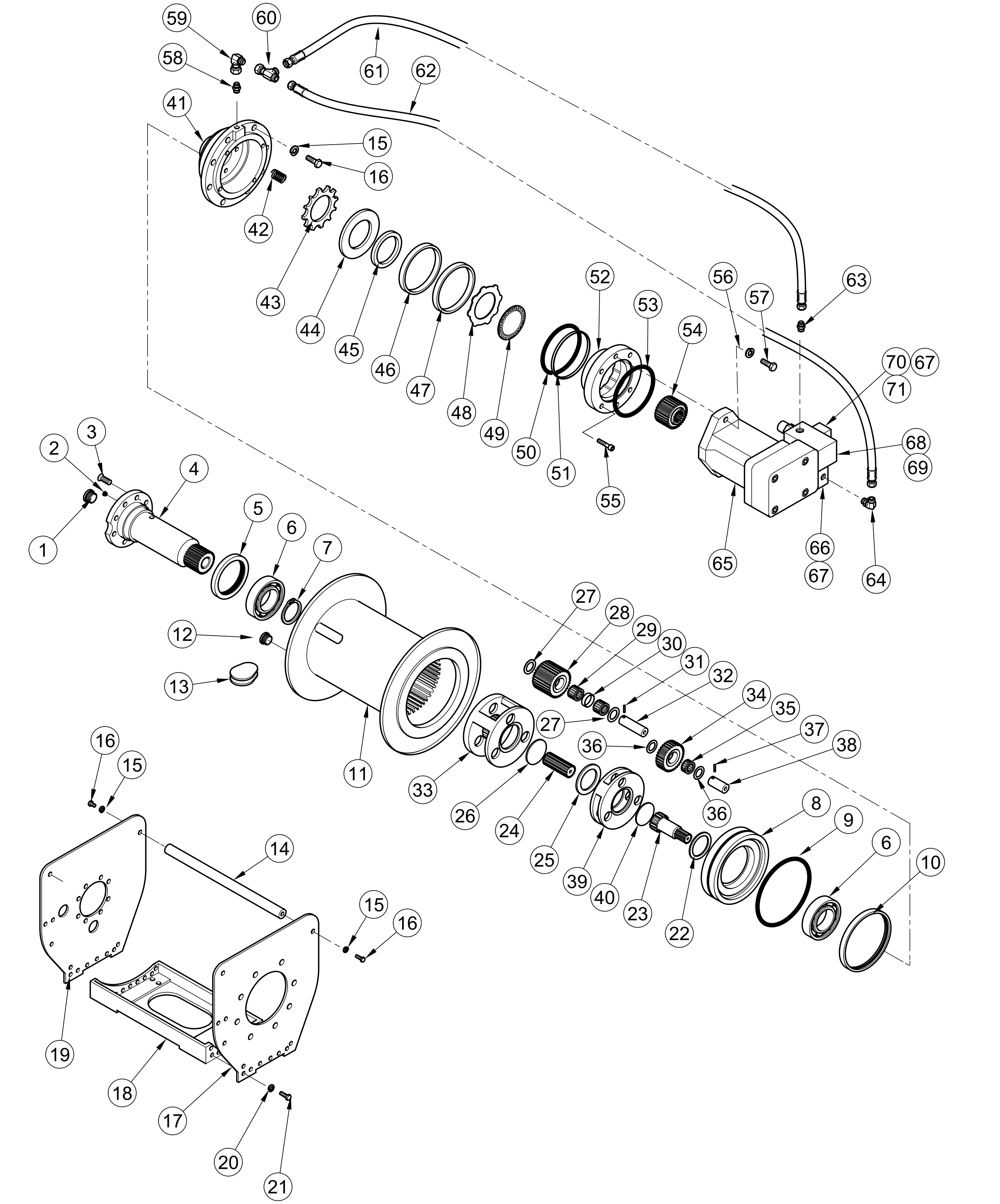
Repair

Removal

1. Remove the wire rope from the hoist drum.

NOTE: Be sure hydraulic pressure is relieved in the hoist circuit before disconnecting any hydraulic lines.

2. Disconnect hydraulic hoses from the hoist motor and motor drain ports.
3. Securely fasten an overhead hoist to the hoist assembly. Remove the hoist mounting hardware and then remove the hoist.



Hoist Exploded View

FIGURE 11-13

Item	Description	Item	Description	Item	Description	Item	Description
1.	Sight gauge	20.	Lockwasher (16)	38.	Primary planet gear shaft	57.	Capscrew (2)
2.	Relief valve	21.	Capscrew (16)			58.	Fitting
3.	Capscrew (8)	22.	Thrust washer	39.	Primary planet carrier	59.	Elbow
4.	Bearing support	23.	Primary sun gear	40.	Primary spacer	60.	Tee
5.	*Seal	24.	Output sun gear	41.	Brake cylinder	61.	Hose assembly
6.	Ball bearing	25.	Thrust washer	42.	Spring (12)	62.	Hose assembly
7.	Retaining ring	26.	Output spacer	43.	Spring spacer	63.	Fitting
8.	Drum closure	27.	Thrust washer (6)	44.	Pressure plate	64.	Elbow
9.	*O-Ring	28.	Planet gear (3)	45.	Spacer	65.	Hydraulic motor
10.	*Seal	29.	Roller bearing (6)	46.	Backup piston ring	66.	Manifold
11.	Drum	30.	Output spacer	47.	*Seal 48 - Brake disc (8)	67.	Capscrew (6)
12.	Plug	31.	Spirol pin (3)	49.	Friction disc (7)	68.	Brake valve block
13.	Cable wedge	32.	Planet gear shaft	50.	O-Ring	69.	Capscrew (2)
14.	Spacer bar	33.	Planet carrier	51.	Backup ring	70.	Manifold
15.	Lockwasher (12)	34.	Planet primary gear	52.	Motor support	71.	Capscrew (2)
16.	Capscrew (12)	35.	Roller bearing (3)	53.	*O-Ring		
17.	Motor side plate	36.	Bearing race (6)	54.	Clutch assembly	* Seal Kit	
18.	Base	37.	Spirol pin (3)	55.	Capscrew (4)		
19.	Support side plate			56.	Lockwasher (2)		

Service Precautions

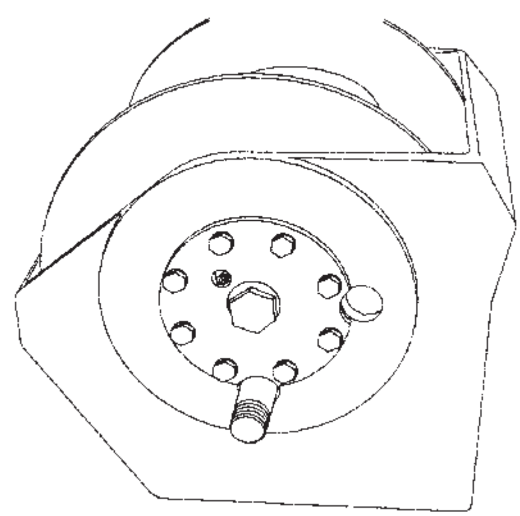
- Before any part is removed from the hoist, all service instructions should be read and understood.
- Work in a clean dust free area as cleanliness is of the utmost importance when servicing hydraulic equipment.
- Inspect all replacement parts, prior to installation, to detect any damage which might have occurred in shipment.
- Use only Grove replacement parts for optimum results. Never reuse expendable parts such as oil seals and O-rings.
- Inspect all machined surfaces for excessive wear or damage before assembling the hoist.
- Lubricate all O-rings and seals with gear oil prior to installation.
- Use a sealing compound on the outside surface of oil seals and a light coat of thread sealing compound on pipe threads. Avoid getting thread compound inside parts or passages which conduct oil.
- Thoroughly clean all parts in a good grade of nonflammable safety solvent. Wear protective clothing as required.

Hoist Assembly

Disassembly

NOTE: Some illustrations may not depict the exact hoist you are disassembling, but the disassembly procedure is the same. Use Figure 11-13 as a reference.

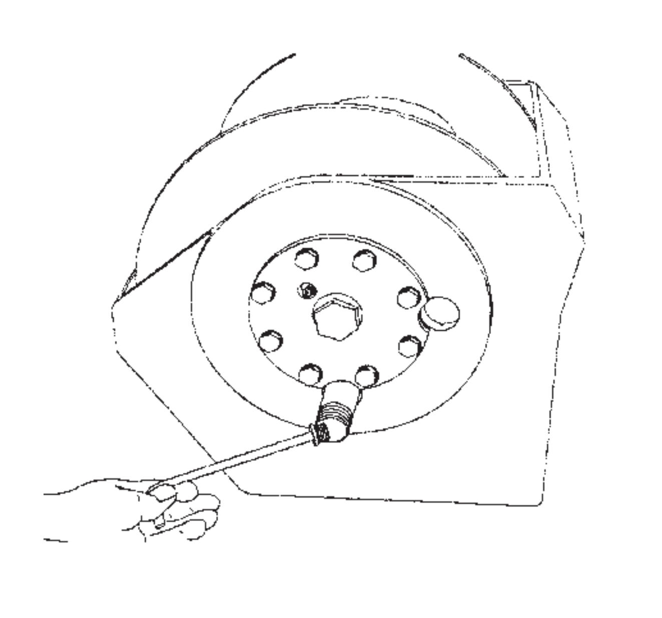
1. Align the drain hole in the drum with a hole in the support side plate before removing the hoses and mounting bolts. After the hoist is removed from its mounting, thoroughly clean the outside surfaces. To drain the oil, install a short piece of 1 inch threaded pipe in the larger threads of the drain hole (Figure 11-14). If necessary, insert a bar in the wedge socket anchor pocket and manually rotate the drum in the direction to hoist a load until the drain holes align.



a2211

FIGURE 11-14

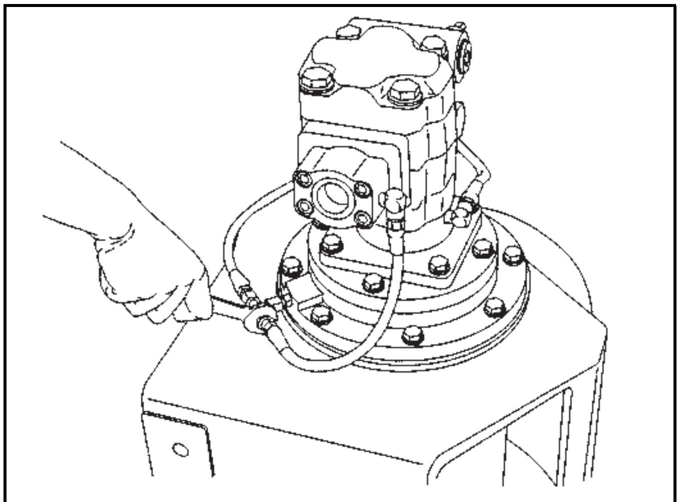
2. Use a 5/16 inch Allen wrench to remove the drain plug through the pipe (Figure 11-15).



a2212 FIGURE 11-15

NOTE: It is not necessary to remove the hoist tension roller subassembly to disassemble the hoist. But if it becomes necessary, see *Hoist Tension Roller Subassembly Service, page 11-39* for disassembly procedures.

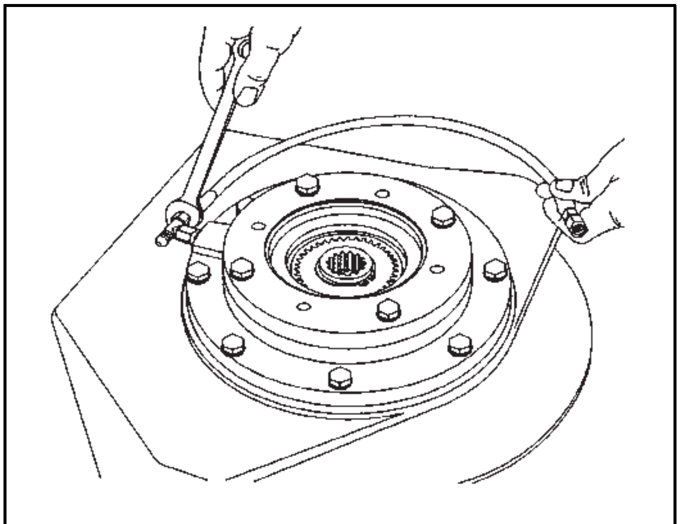
3. Begin disassembly by removing the oil level plug and standing the hoist on the bearing support end. Tag and remove the hydraulic hoses that connect the brake valve and manifold to the brake cylinder (Figure 11-16).



a2213 FIGURE 11-16

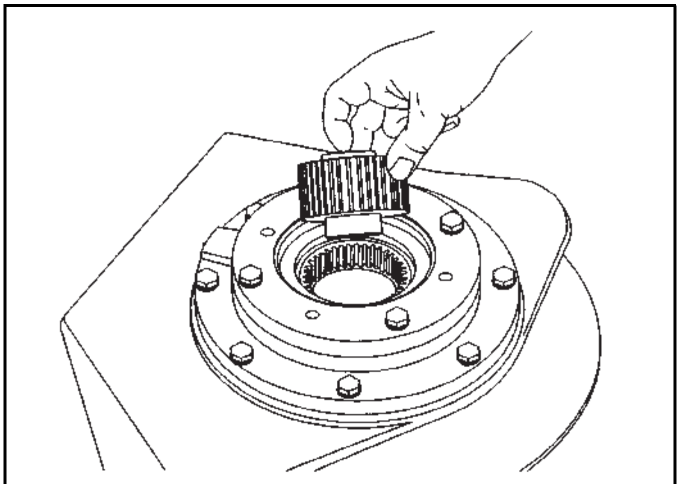
4. Remove the capscrews securing the motor, and lift the motor off the hoist. Remove and discard the O-ring installed on the pilot of the motor.

5. Tag and remove the hoses and fittings from the brake cylinder release port (Figure 11-17).



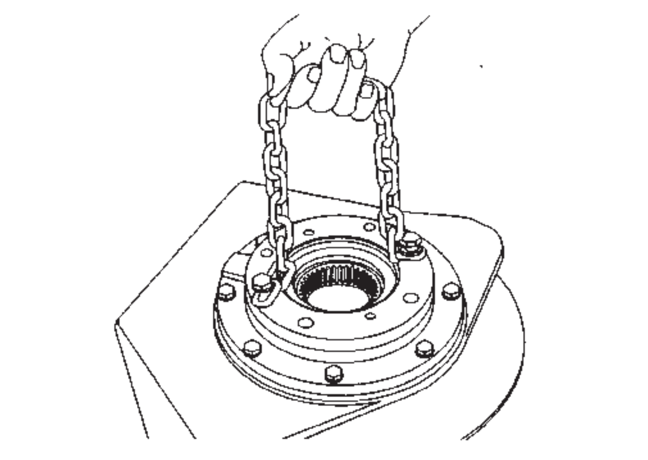
a2214 FIGURE 11-17

6. Remove the brake clutch (Figure 11-18) assembly from the motor support. Refer to *Brake Clutch Service, page 11-36* for additional information.



a2215 FIGURE 11-18

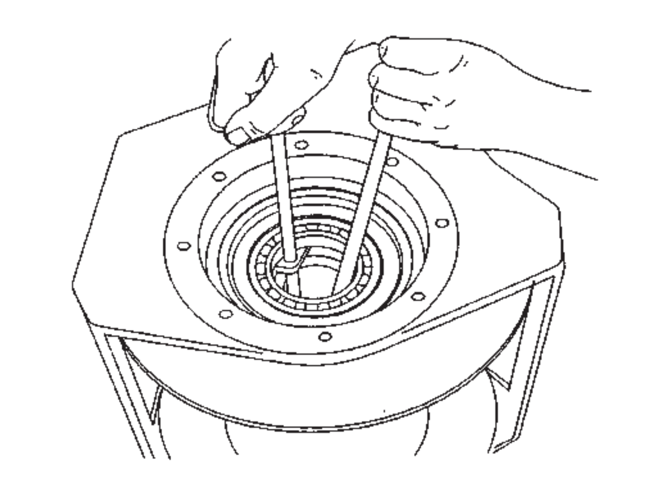
7. Remove the motor support capscrews and install two (2) capscrews and a short piece of chain (Figure 11-19) into the motor mounting bolt holes. Using the chain as a handle, lift the motor support out of the brake cylinder being careful to avoid damaging the sealing surfaces. Remove and discard the O-ring and backup ring from the motor support. Refer to *Motor Support-Brake Cylinder Service, page 11-33* for additional information.



a2216 FIGURE 11-19

8. Remove the brake cylinder capscrews and install two (2) capscrews and a short piece of chain into the motor support mounting bolt holes. Using the chain as a handle, lift the brake cylinder out of the drum and base, being careful to avoid damaging the sealing or bearing surfaces. Refer to *Motor Support-Brake Cylinder Service, page 11-33* for additional information.

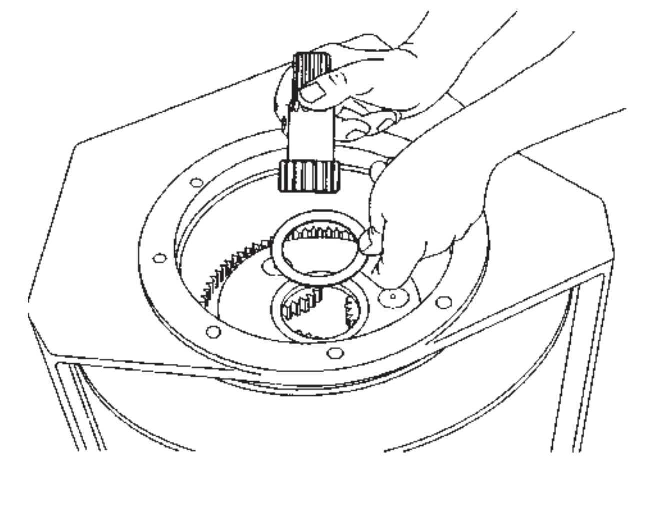
9. Using two heel type pry bars (Figure 11-20) placed between the primary planet carrier and the drum closure, pry upward to remove the drum closure. Remove and discard the O-ring from the outside of the drum closure.



a2217 FIGURE 11-20

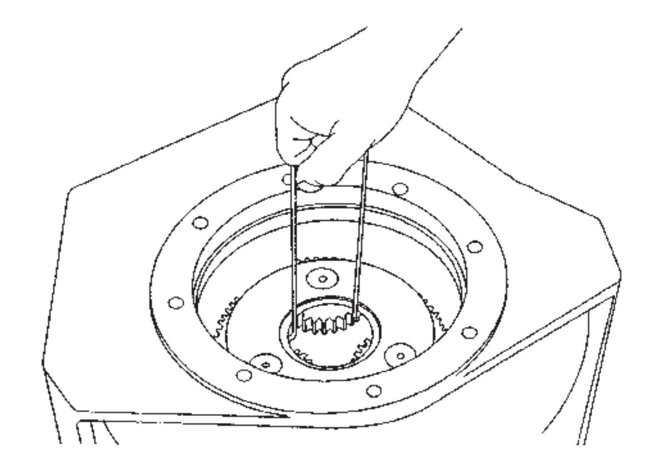
10. Remove the seal and bearing from inside of closure.

11. Remove the primary sun gear and thrust washer (Figure 11-21) from the primary planet carrier.



a2218 FIGURE 11-21

12. Remove the primary planet carrier from the drum (Figure 11-22). Refer to *Planet Carrier Service, page 11-31* for additional information.



a2219 FIGURE 11-22

13. Remove the output sun gear and thrust washer (Figure 11-23) from the output planet carrier.

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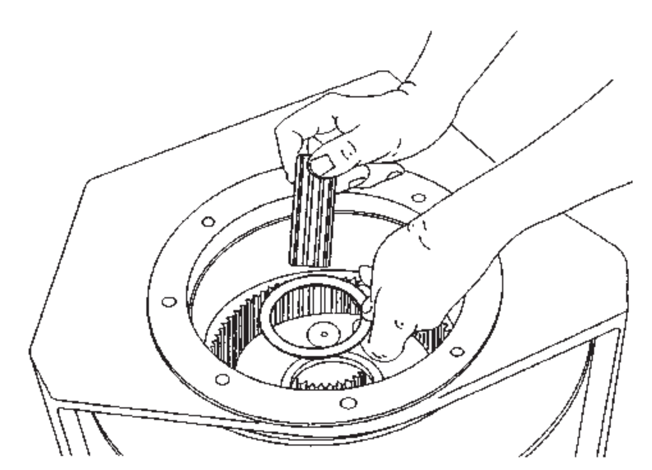


FIGURE 11-23

14. Remove the output planet carrier (Figure 11-24) from the drum. Refer to *Planet Carrier Service, page 11-31* for additional information.

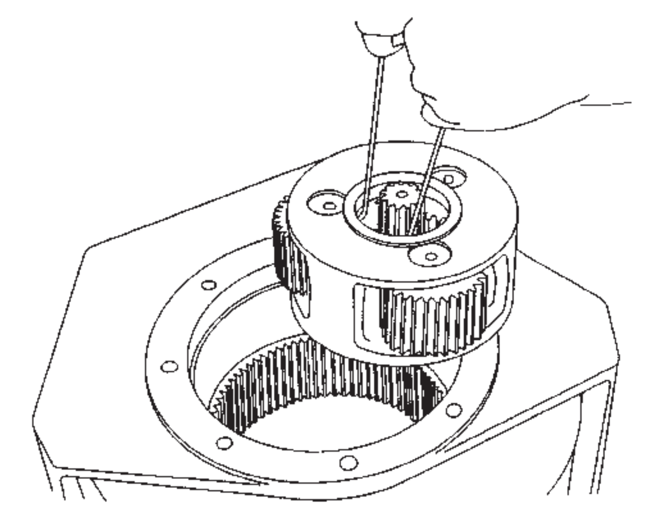


FIGURE 11-24

15. Stand hoist on motor end with bearing support up. Then remove eight (8) bearing support capscrews and bearing support being careful to avoid damaging the sealing or bearing surfaces.

16. Slide drum cut of base onto a work bench and remove seal and bearing from support end.

17. Thoroughly clean and inspect drum and base. Check ring gear (machined into inside surface of drum) teeth for nicks, spalling or excessive wear. Replace if wear is greater than 0.4 mm (0.015 in) when compared to unworn area of teeth.

Assembly

NOTE: Hoists with a three piece fabricated base use special shoulder capscrews to fasten the side plates to the base plate. DO NOT use standard capscrews in their place.

1. Place hoist base on side with bearing supported up (Figure 11-25).

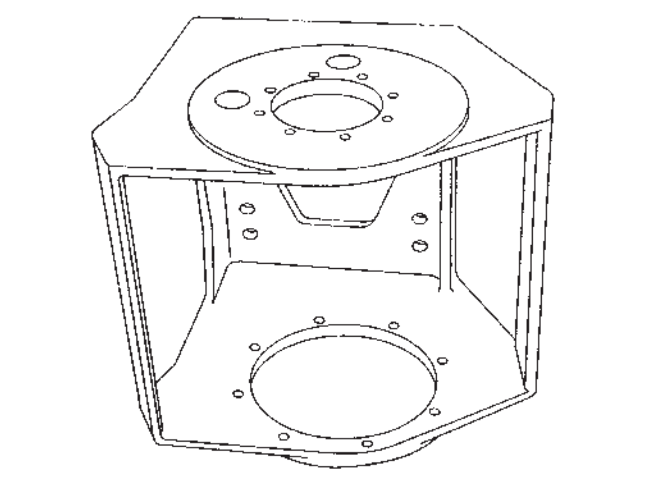


FIGURE 11-25

2. Install a new bearing in the drum if replacement is necessary. Apply a non-hardening sealant on the outside diameter of the new seal. Install the spring side of the seal next to the bearing, then press into the drum, using a flat plate to avoid distortion. Be sure the drain plug is installed correctly.

3. Install the snap ring on the bearing support (Figure 11-26).

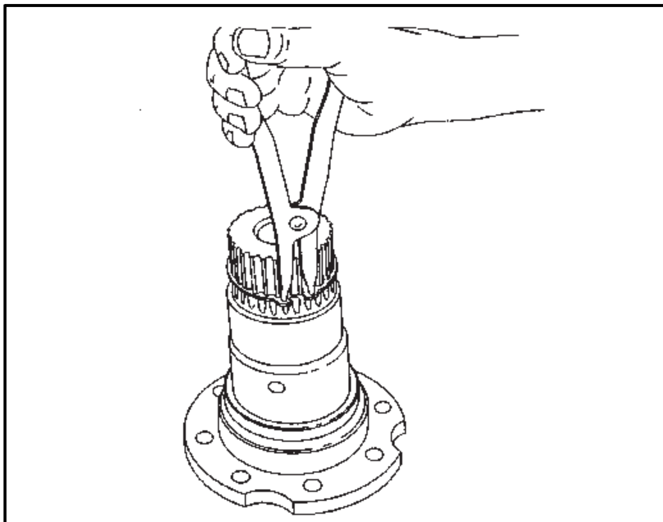
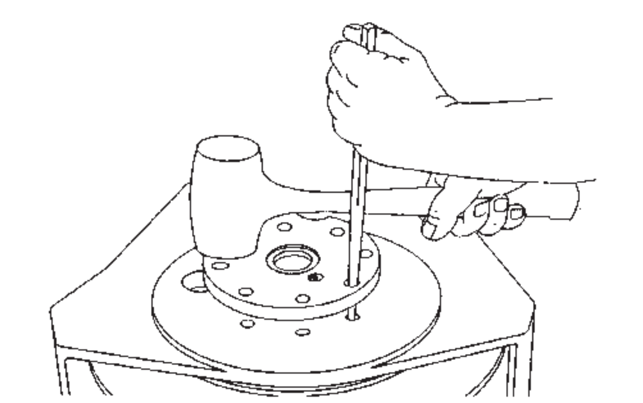


FIGURE 11-26

NOTE: Make certain the snap ring is installed on the bearing support. This snap ring will keep the output planet carrier correctly positioned in the hoist. Gear train damage may occur if this snap ring is omitted.

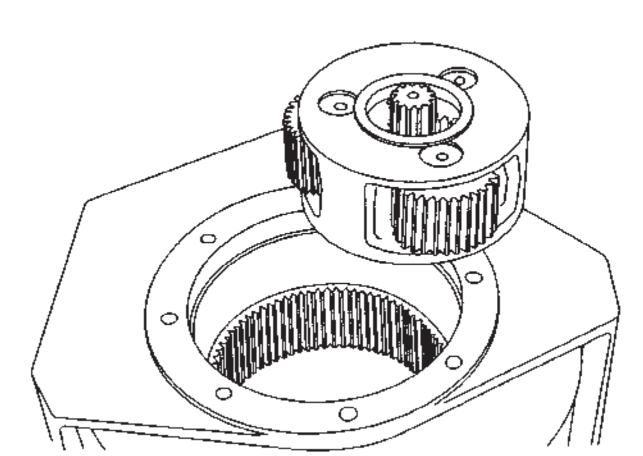
4. Center the drum in the opening of the base (Figure 11-27). Lubricate the bearing support with petroleum jelly or gear oil and install in base and drum.

NOTE: Be sure the vent plug is located above the horizontal center line for the intended application. Oil leakage may occur if vent is positioned incorrectly.



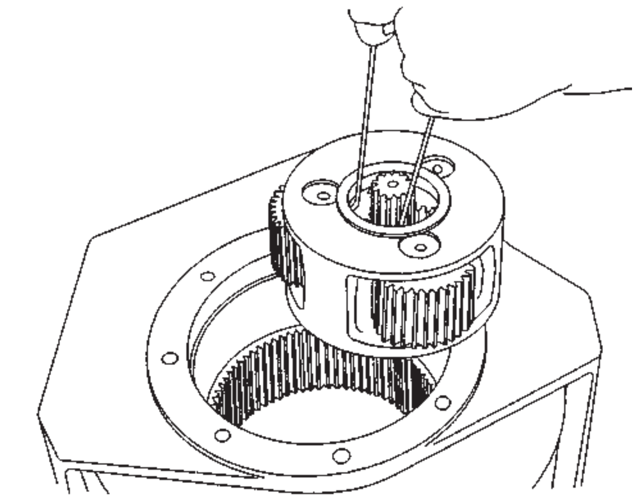
a2224 **FIGURE 11-27**

5. Install and tighten the bearing support capscrews to the recommended torque.
6. Stand hoist on bearing support end. Install the output sun gear and thrust washer into output planet carrier (Figure 11-28).



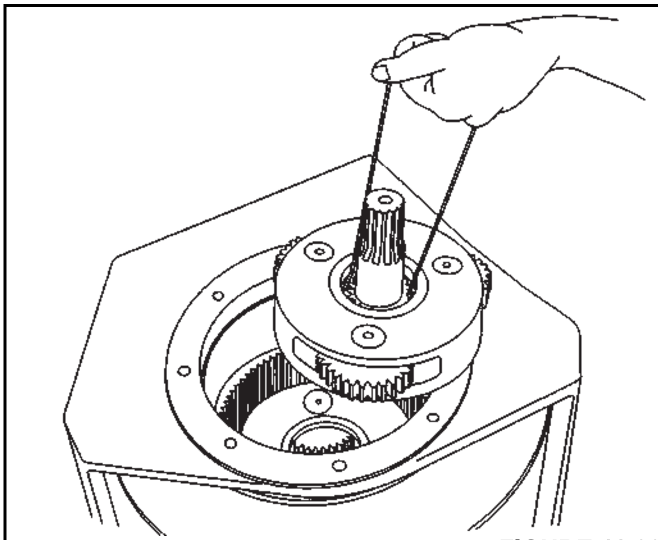
a2225 **FIGURE 11-28**

7. Install the output planet carrier (Figure 11-29) into the drum while meshing the planet gears with the ring gear and the planet housing with the bearing support.



a2226 **FIGURE 11-29**

8. Install the primary sun gear and thrust washer into the primary planet carrier.
9. Install the primary planet carrier (Figure 11-30), meshing the planet gears with the ring gear and the planet housing with the output sungear.



a2227 **FIGURE 11-30**

10. Install a new bearing (Figure 11-31) in the drum closure as required. Use sealant on the outside surface of the oil seal. Install with spring side of the seal toward bearing, using a flat plate to avoid distortion.

Install a new O-ring (Figure 11-31) in the groove on the O.D. of the drum closure.

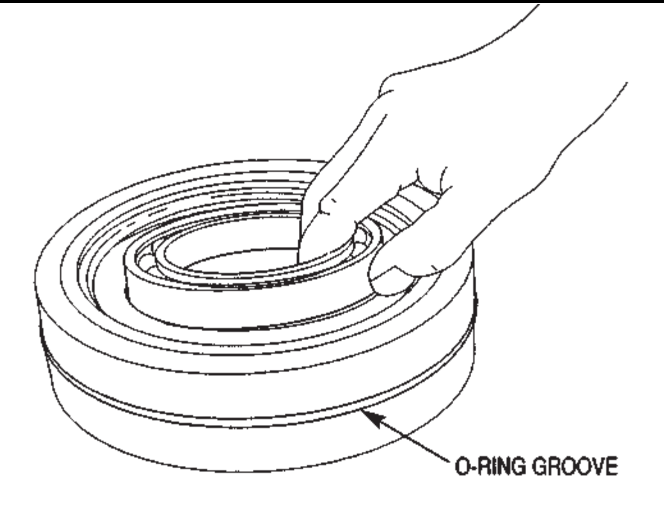


FIGURE 11-31

11. Lubricate the O-ring and drum opening with petroleum jelly or gear oil and install the drum closure (Figure 11-32) into the drum.

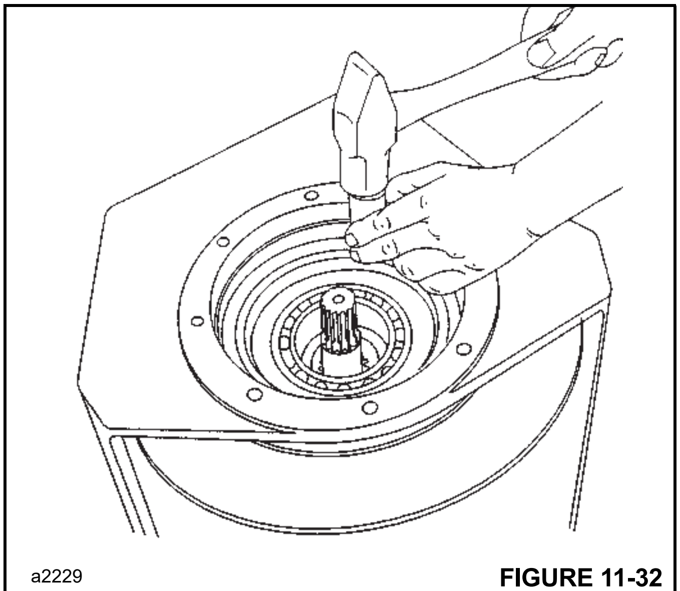


FIGURE 11-32

12. Lubricate the pilot, oil seal and bearing surfaces of the brake cylinder and carefully install brake cylinder into base and drum. Locate the brake release port toward the lower rear corner of the base. Install and tighten brake cylinder capscrews to recommended torque.

13. Install the brake clutch assembly (Figure 11-33) with the short end of the inner race toward motor.

When installed correctly, the inner race should turn freely in the opposite direction the drum turns to pull wire rope in. An easy way to check the rotation is to hold the outer race in one hand, and rotate the inner race.

If the clutch free wheels in the wrong direction, disassemble the clutch and reverse the inner race. Refer to *Brake Clutch Service, page 11-36* for additional information.

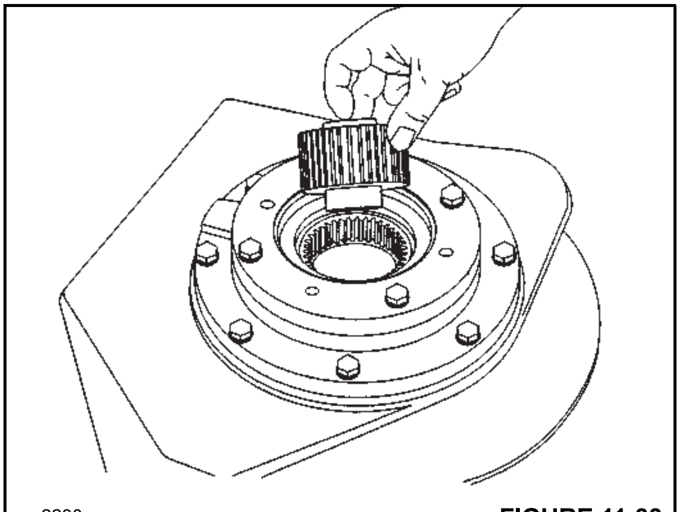
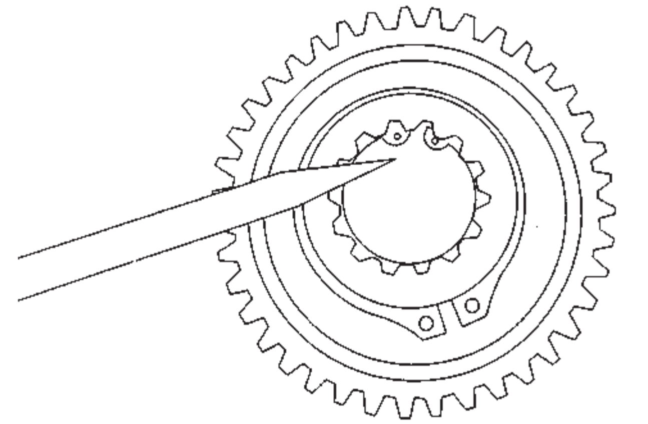


FIGURE 11-33

WARNING

Load Control Hazard!

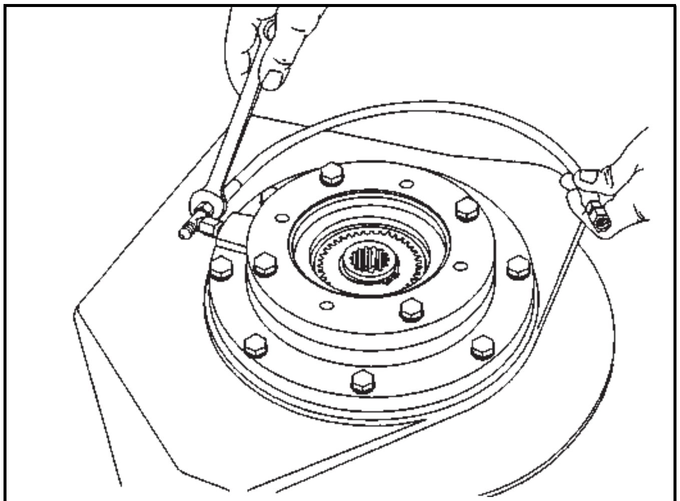
Be certain the snap ring (Figure 11-34) is seated in the groove in the splined bore of the inner race. This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted, causing loss of control of the load.



a2231 FIGURE 11-34

14. If the brake discs are misaligned: preventing the installation of the clutch, then with a hand pump, apply 5171-6895 kPa (750-1000 psi) to the brake release port. The brake discs will move freely with the brake released, permitting alignment of the discs, brake clutch and input sun gear.

15. Install the hoses and fittings to the brake cylinder release port (Figure 11-35).

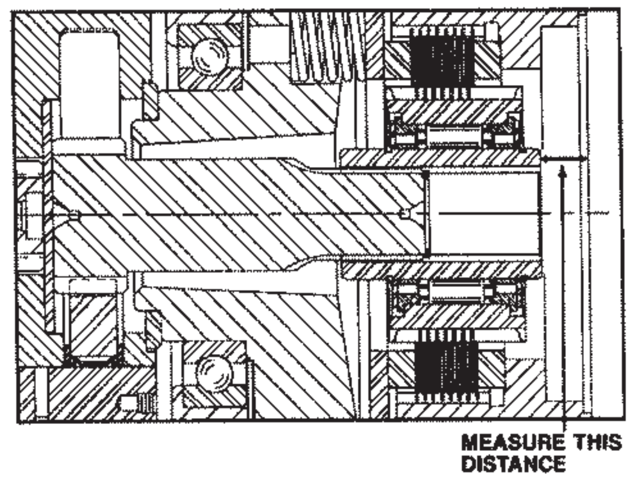


a2232 FIGURE 11-35

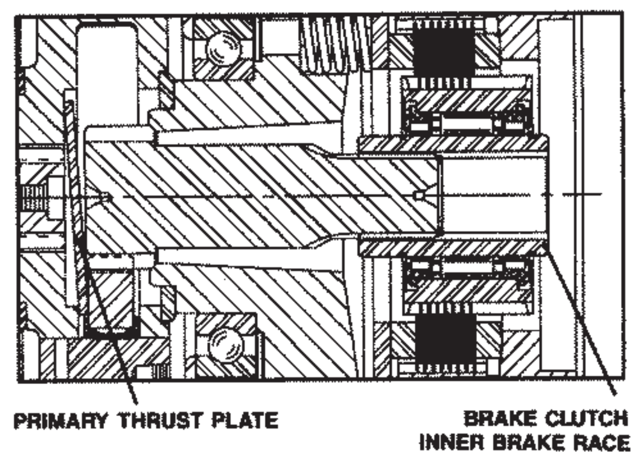
16. Install a new O-ring on the motor pilot then lubricate with petroleum jelly or gear oil.

NOTE: Care must be taken to assure the primary thrust plate remains properly located in its counter bore when the motor is installed for the first time, or is being reinstalled on the hoist. It is possible for the primary thrust plate to drop out of its counter bore and become wedged between the planet gears and the planet carrier. If the hoist is operated with the primary thrust plate wedged between primary gears and the planet carrier, or with a thrust washer out of position, severe damage to internal hoist components could result.

17. Measure the distance from the motor mounting surface to the inner brake race (Figure 11-36). With all components properly installed, this distance should be 17.5 mm (11/16 in) to 19.1 mm (3/4 in). If this distance is less than 14.3 mm (9/16 in), the primary spacer may be positioned as shown in Figure 11-37 and should be checked.



a2233 FIGURE 11-36

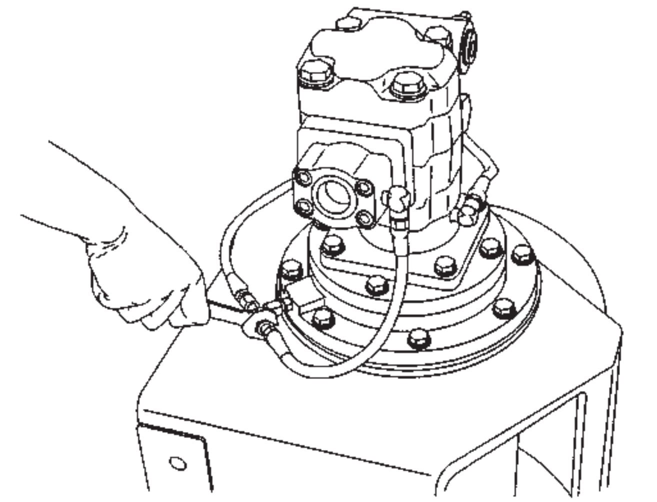


a2233 FIGURE 11-37

The primary thrust plate is shown wedged between the planet gears and the planet carrier. Note that the primary sun gear and the entire brake clutch assembly have moved to the right (toward the hydraulic motor).

18. Engage the motor shaft with the brake clutch inner race and lower motor into place. Tighten capscrews to recommended torque.

19. Install the hoses that connect the manifold and brake valve to the brake cylinder (Figure 11-38).



a2235 **FIGURE 11-38**

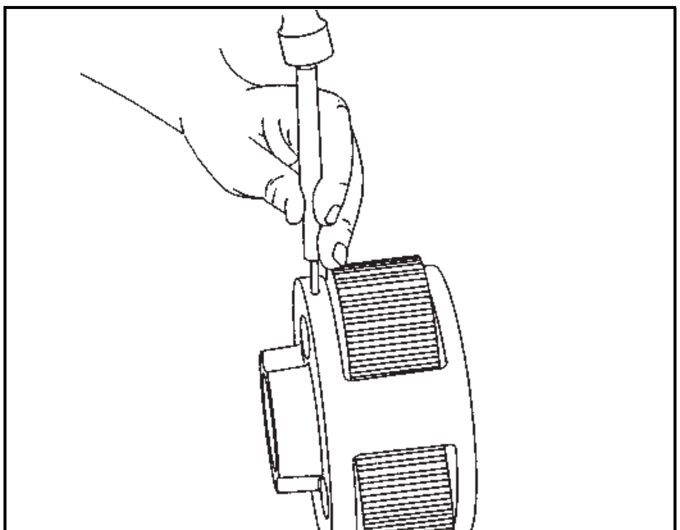
20. After the hoist assembly is complete, check all capscrews and fittings to make certain they have been tightened correctly.

21. Refill the hoist with the recommended oil listed in *Lubricants, page 5-7*, and install the oil level plug.

Planet Carrier Service

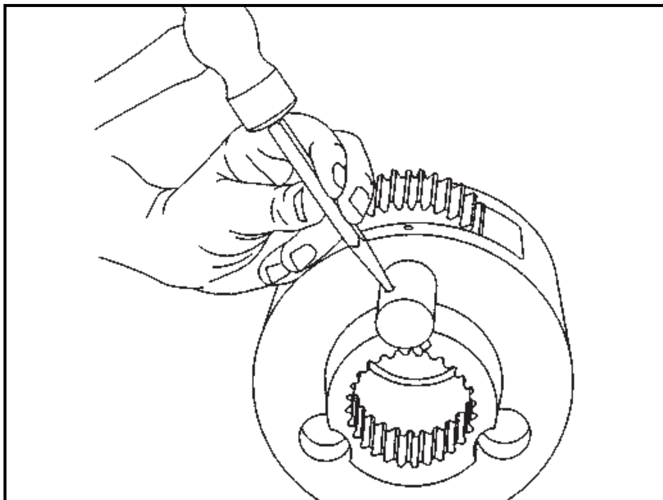
Planet Carrier Service Disassembly

1. Remove the planet gears by driving the roll pins into the center of the planet shafts (Figure 11-39).



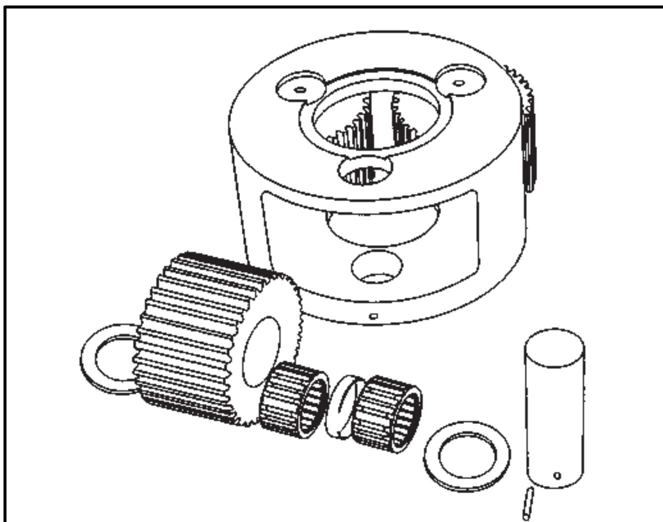
a2236 **FIGURE 11-39**

2. Use a punch (Figure 11-40) to drive the roll pins from the planet shafts. Do not reuse the roll pins.



a2237 **FIGURE 11-40**

3. Now you can remove the planet shafts, bearings, spacer, thrust washers and gears. Thoroughly clean all parts and inspect for damage and wear. The bearing rollers should not exhibit any irregularities. If the rollers show any sign of spalling, corrosion, discoloration, material displacement or abnormal wear, the bearing should be replaced. Likewise, the cage should be inspected for unusual wear or deformation, particularly the cage bars. If there is any damage that will impair the cage's ability to separate, retain and guide the rollers properly, the bearing should be replaced. The thrust washer contact areas should be free from any surface irregularities that may cause abrasions or friction. The gears and shafts should be inspected for abnormal wear or pitting. Replace if necessary.



a2238 **FIGURE 11-41**

Assembly

1. Place the output planet carrier on workbench with splined coupling side down. Install output thrust plate in center of carrier (Figure 11-42).

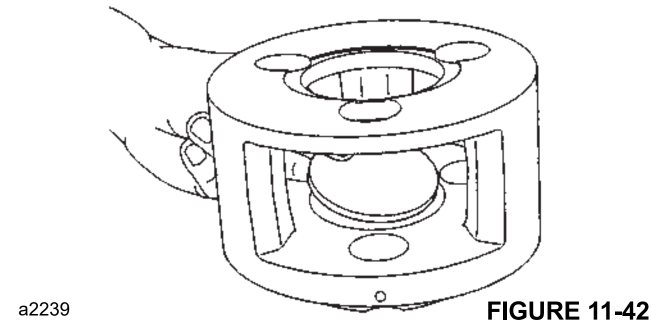


FIGURE 11-42

2. Insert two (2) bearings and a bearing spacer into a gear with the spacer between the bearings. Place a thrust washer on each side of the gear and position in a carrier opening. Slide the shaft through the carrier, thrust washer, bearing gear subassembly and remaining thrust washer (Figure 11-43).

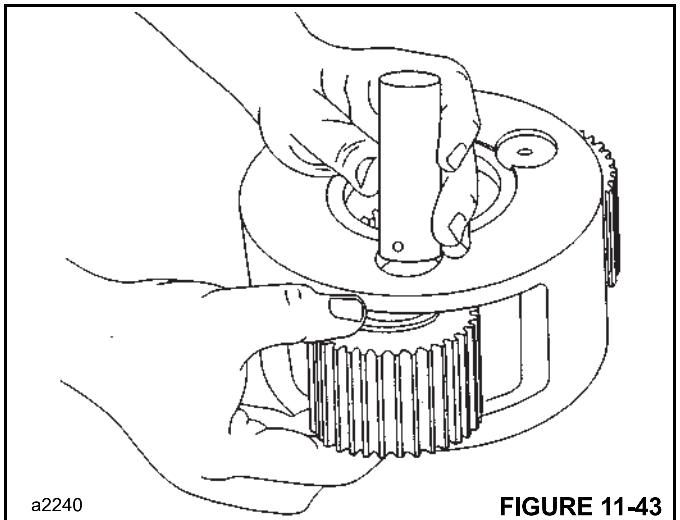


FIGURE 11-43

3. Carefully align the pin hole in the carrier with the hole in the planet gear shaft (Figure 11-44) and drive the roll pin into place. Always use NEW roll pins. When properly positioned, 50% of the roll pin will engage the planet gear shaft and 50% will remain in the planet carrier.

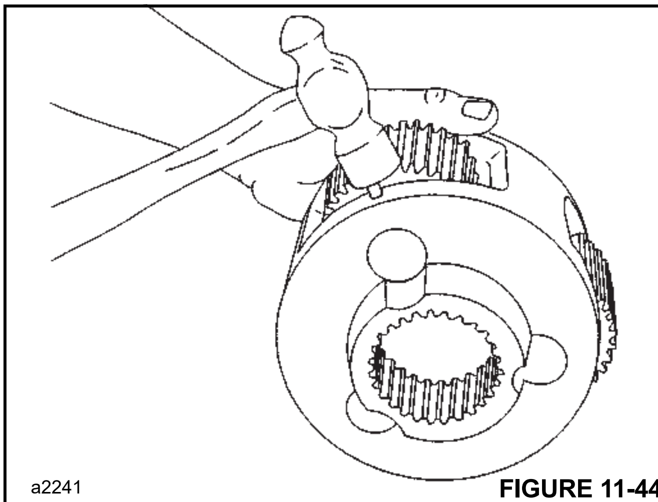


FIGURE 11-44

4. Note that the roll pin is slightly recessed in the carrier when properly installed. With a center punch (Figure 11-45); stake the carrier next to the pin hole as shown. This will distort the hole so the pin will not back out. Repeat these steps for each of the three planet gears.

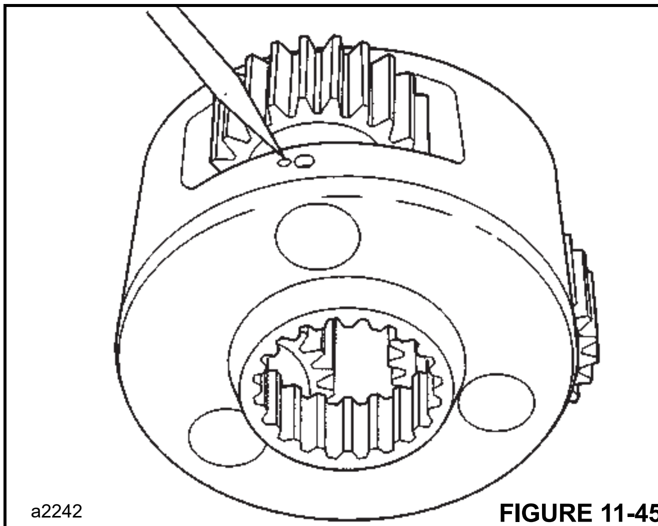


FIGURE 11-45

Primary Planet Carrier

To service the primary planet carrier, the steps are the same as for the output carrier except there is only one bearing for each gear and no bearing spacer.

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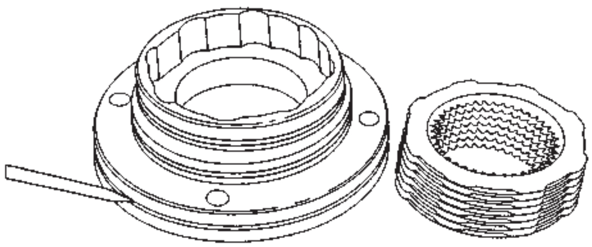
Motor Support-Brake Cylinder Service

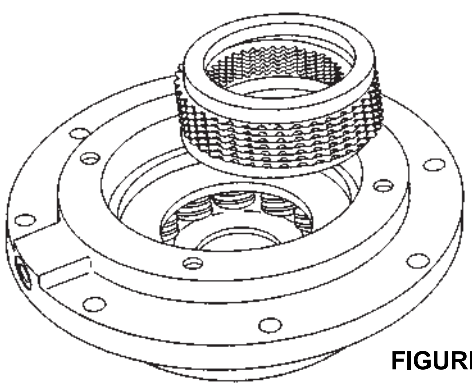
NOTE: Some of the illustrations show spined brake discs. This brake uses a lobed steel brake separator and motor support as shown in Figure 11-46.



a2243 **FIGURE 11-46**

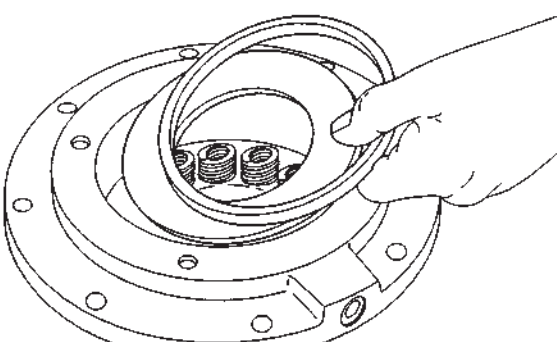
Disassembly

1. Remove spacers, friction brake discs and steel brake discs (Figure 11-47).



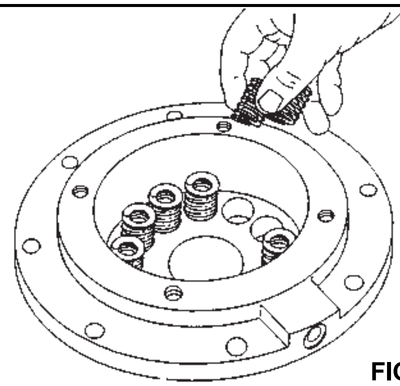
a2244 **FIGURE 11-47**

2. Remove the piston backup ring and pressure plate (Figure 11-48).



a2245 **FIGURE 11-48**

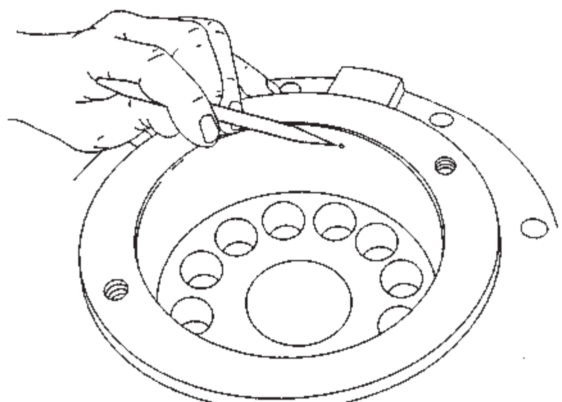
3. Remove brake springs (Figure 11-49) and the spring spacer.



a2246 **FIGURE 11-49**

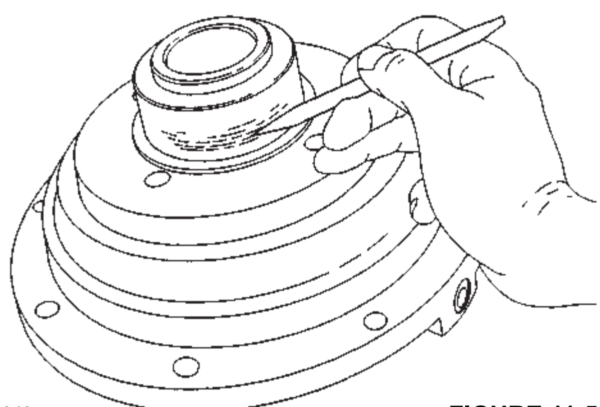
Clean and Inspect

1. Thoroughly clean and inspect all parts at this time. Check brake piston sealing surfaces on the brake cylinder and motor support. Be sure brake release port is free of contamination (Figure 11-50).



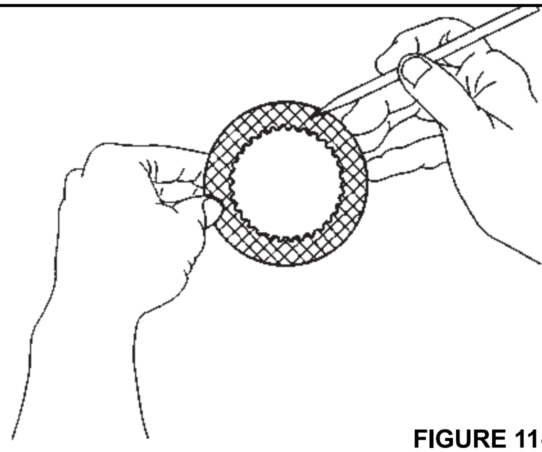
a2247 **FIGURE 11-50**

2. Check oil seal and bearing surfaces on the brake cylinder for damage and wear (Figure 11-51).



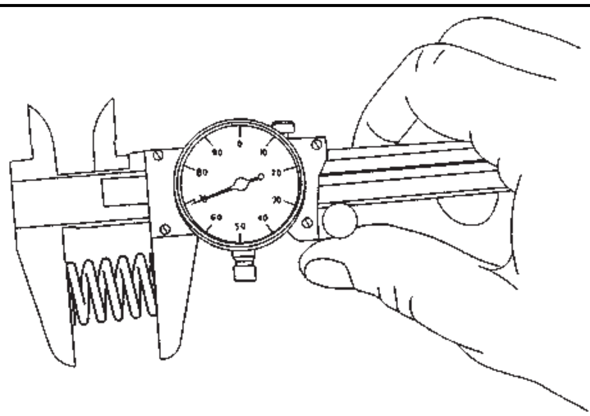
a2248 **FIGURE 11-51**

3. Place friction plate disc on a flat surface and check for distortion with a straight edge. Friction material should appear even across the entire surface with the groove pattern visible. Replace the friction disc if the splines are worn to a point, disc is distorted, friction material is worn unevenly, or the groove pattern is worn away.



a2249 FIGURE 11-52

4. Place the steel brake disc on a flat surface and check for distortion with a straight edge.Check surface for signs of material transfer or heat. Replace the steel disc if the splines are worn to a point, disc is distorted, or if it is heat discolored.
5. Check the brake spring free length (Figure 11-53). Minimum free length is 30.2 mm (1-3/16 in). Check springs for any sign of cracking or failure. If a brake spring must be replaced, then all brake springs must be replaced.

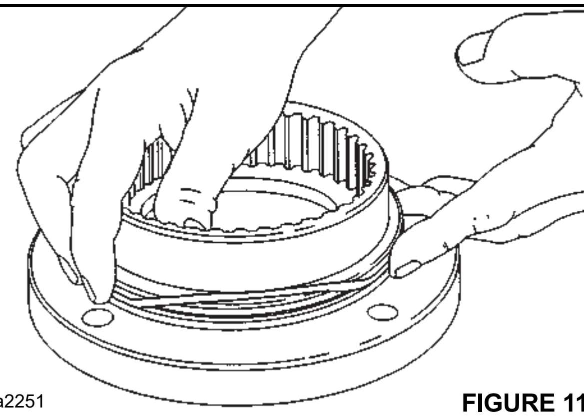


a2250 FIGURE 11-53

NOTE: Failure to replace brake springs as a set may result in uneven brake application pressure and repeated brake spring failure.

Assembly

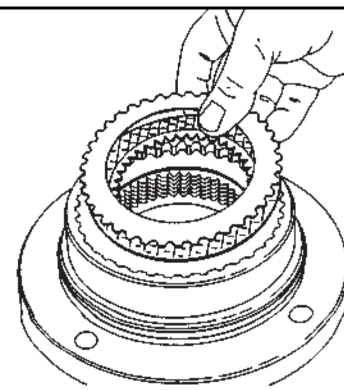
1. Begin assembly by placing the motor support on the workbench with motor mounting surface down. Install new O-ring and brake-spring (Figure 11-54).



a2251 FIGURE 11-54

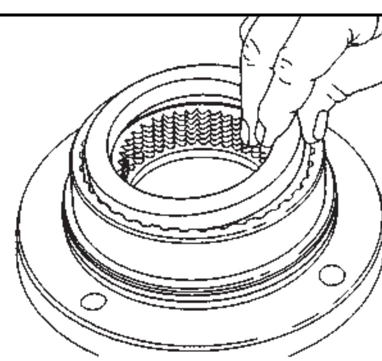
2. Insert first, a steel brake disc followed by a friction disc. Then, alternate steel friction discs until seven (7) friction and eight (8) steel discs have been installed (Figure 11-55). Finish with a steel brake disc on top.

NOTE: It is good practice to pre-lubricate the discs in light motor oil prior to assembly.



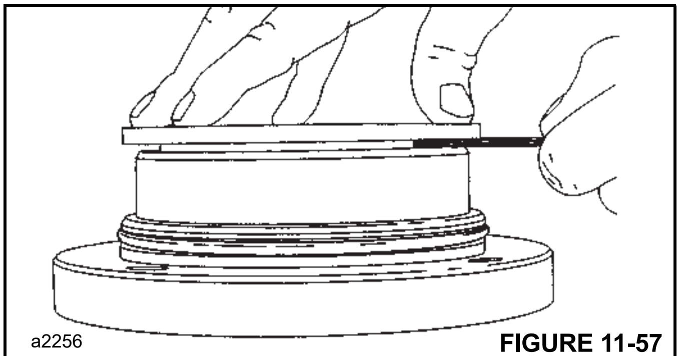
a2254 FIGURE 11-55

3. Install the brake spacer on top of the last steel brake disc (Figure 11-56).



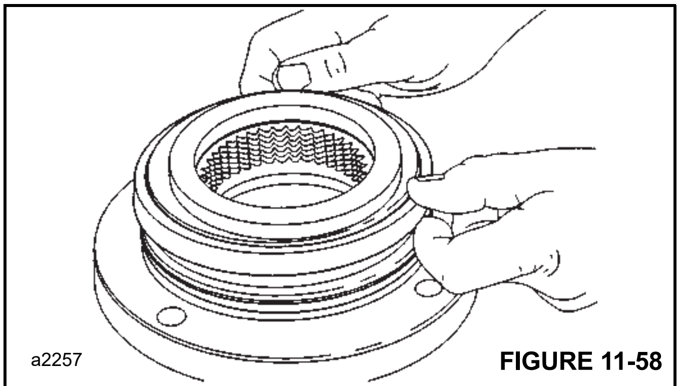
a2255 FIGURE 11-56

4. To check brake stack height, place a pressure plate on top of brake spacer. Hold pressure plate down firmly by hand and measure the clearance in three places between the motor support and the pressure plate (Figure 11-57). Average gap must measure between 4 mm (0.153 in) maximum and 2 mm (0.078 in) minimum. If the gap exceeds the maximum limit, there are too many brake discs in the stack-up, or the brake discs are distorted. If the gap is less than the minimum, there are too few discs in the stack-up, or the discs are worn out. If the stack-up height is correct, remove pressure plate and continue with assembly.



a2256 **FIGURE 11-57**

5. Lubricate the brake piston seal and motor support sealing surface with petroleum jelly or hydraulic oil. Insert a new piston seal to the motor support with the lip seal down (Figure 11-58).

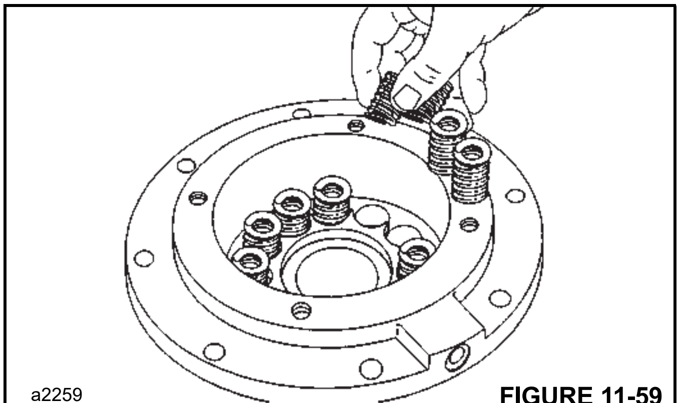


a2257 **FIGURE 11-58**

6. Install the spring spacer and then the brake springs (Figure 11-59).

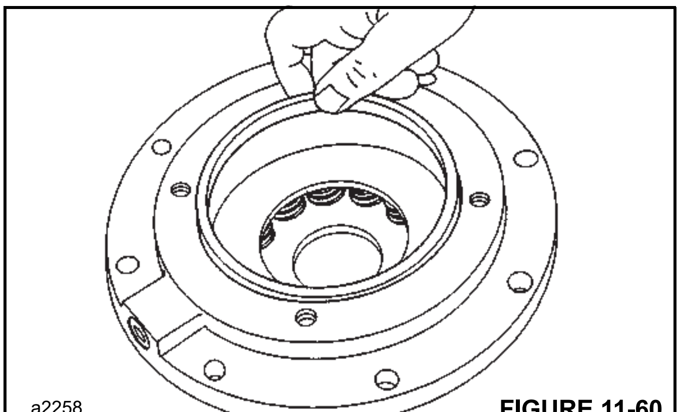
WARNING

Always use the molded spring spacer with the brake cylinder. The brake springs must be properly positioned by the spring spacer. Failure to install the spring spacer may allow the springs to contact each other and become damaged. This could result in loss of load control, property damage, injury or death.



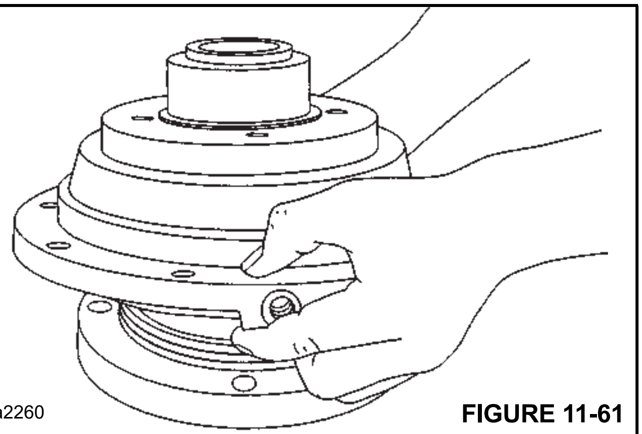
a2259 **FIGURE 11-59**

7. Install the pressure plate into the brake cylinder followed by the piston backup ring (Figure 11-60). The close fitting piston backup ring may be depressed slightly to one side to lodge the backup ring in the brake cylinder bore. Temporarily hold the pressure plate and springs in place while lowering the brake cylinder over the motor support.



a2258 **FIGURE 11-60**

8. Apply petroleum jelly to the entire sealing surface of the brake cylinder and to the piston seal. Install the brake cylinder over the motor support (Figure 11-61) being careful to avoid damaging the piston seal or motor support O-ring. A press may be necessary to avoid cocking the brake cylinder during installation.

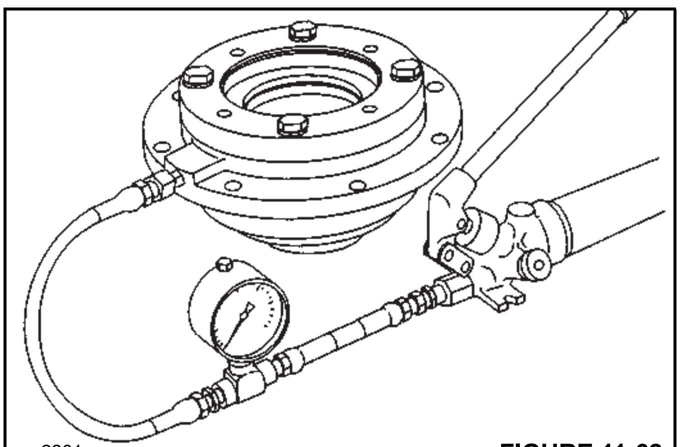


a2260 FIGURE 11-61

9. Install the motor support capscrews and tighten evenly to recommended torque.

Brake Cylinder Pressure Test

1. Install the -4 J.I.C fitting in the brake release port. Connect a hand pump with a 0 - 38.00 bar (0 - 2000 psi) pressure gauge and shut-off valve to this fitting (Figure 11-62).



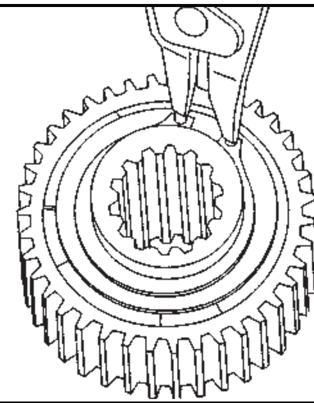
a2261 FIGURE 11-62

2. WHILE PRESSURE IS APPLIED AND THE BRAKE RELEASED, install the brake clutch assembly in the brake pack, short end of the inner race toward the motor. Turn the clutch back and forth as you align the outer race splines with the brake disc splines.
3. Release the pressure on the cylinder, and then remove the brake clutch assembly. The brake cylinder assembly is now complete and ready to install in the hoist.

Brake Clutch Service

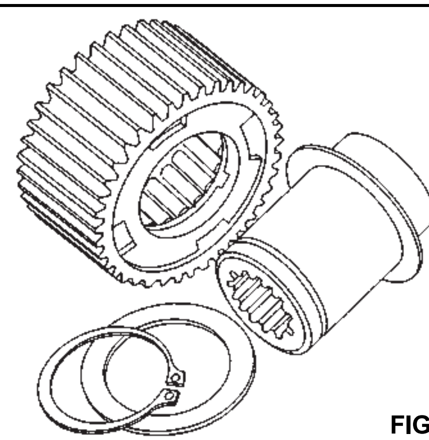
Disassembly

1. Remove the snap ring and sprag bushing retainer from one end only (Figure 11-63).



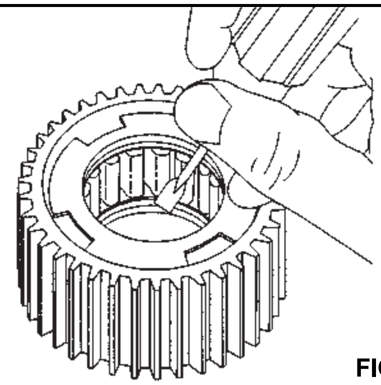
a2262 FIGURE 11-63

2. Pull the inner race out (Figure 11-64). Examine the race for scoring, wear, or indentations cause by the sprag cams.



a2263 FIGURE 11-64

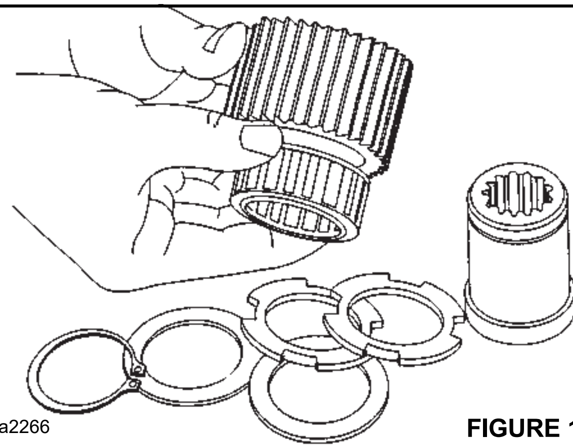
3. Use a screwdriver and mallet to remove the sprag bushing from one end of the outer race (Figure 11-65). There are four cutouts in the bushing for this purpose. Be careful not to damage the bushing inside surface. If the bushing's inside surface is damaged, or shows wear, replace it.


a2264 **FIGURE 11-65**

4. Next, slide the sprag clutch out. Inspect the sprag clutch closely for abnormal wear, cracks, pitting, or corrosion. Check small clips for breakage or bright spots which are signs of excessive wear. Unless the outer race or remaining sprag bushing is damaged or shows signs of excessive wear, there is no need for further disassembly. If disassembly is necessary, remove the bushing according to the procedure covered in step 3. All brake clutch assembly parts should be thoroughly cleaned and inspected before assembly.

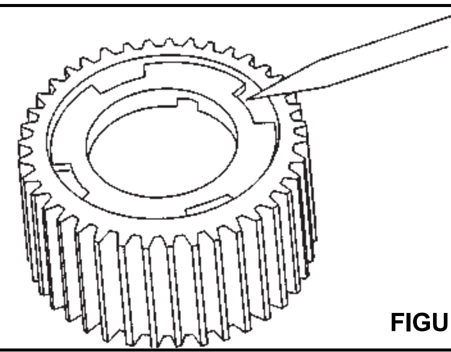
WARNING

The polished surfaces of the races and sprag cams must be perfectly smooth to ensure positive engagement of the clutch.The slightest defect may reduce brake clutch effectiveness, which may lead to loss of load control and result in property damage, personal injury, or death. It is recommended to replace the entire brake clutch assembly if any component is defective.

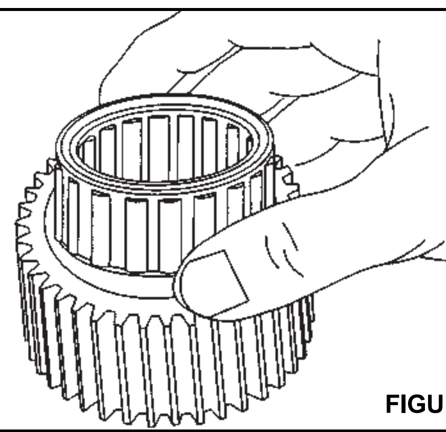

a2266 **FIGURE 11-66**

Assembly

1. Press a sprag bushing into the outer race, using a suitable press. A flat plate of approximately the same diameter as the bushing flange outside diameter should be placed between the press and bushing. This will protect the bushing from damage. Be certain the bushing flange is against the shoulder in the outer race (Figure 11-67).

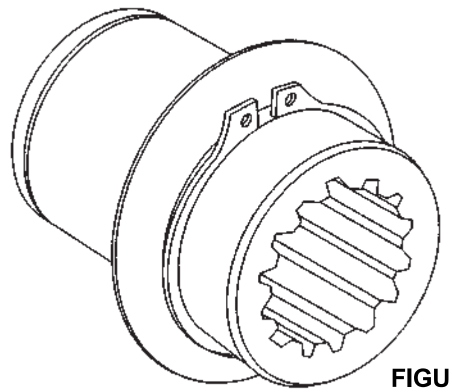

a2267 **FIGURE 11-67**

2. Turn the assembly over and install the sprag clutch in the bore of the outer race (Figure 11-68).

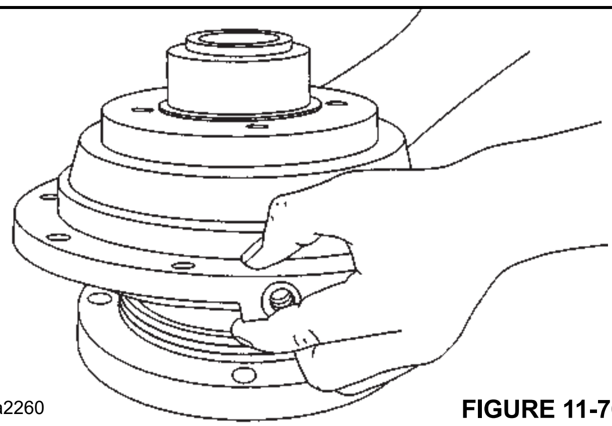

a2265 **FIGURE 11-68**

3. Press the remaining bushing against the race. Again, make sure the bushing is against the shoulder.

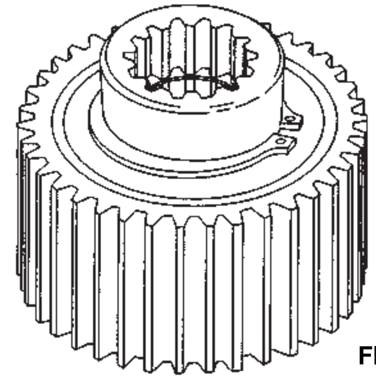
4. Next, install a sprag bushing retainer, then a snap ring on the inner race (Figure 11-69). Be sure the snap ring is seated in the snap ring groove.


a2268 **FIGURE 11-69**

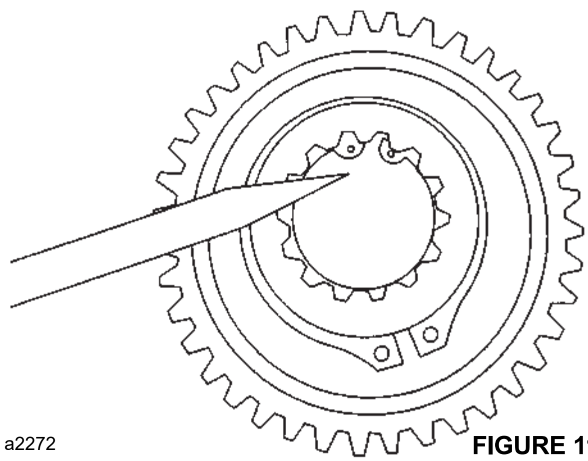
5. Slide the inner race through the bushings and sprag clutch. The race will have to be rotated in the freewheeling direction to start it through the sprag clutch. If the inner race will not go through the bushings, the bushings have probably been damaged and should be replaced.


a2260 **FIGURE 11-70**

6. Turn the assembly over with the snap ring down. Install the second retainer and snap ring (Figure 11-71). Make sure the snap ring is properly seated in the groove.


a2271 **FIGURE 11-71**

7. Figure 11-72 shows a completed clutch assembly.


a2272 **FIGURE 11-72**

WARNING

Load Control Hazard!

Be certain the snap ring (Figure 11-34) is seated in the groove in the splined bore of the inner race. This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted, causing loss of control of the load.

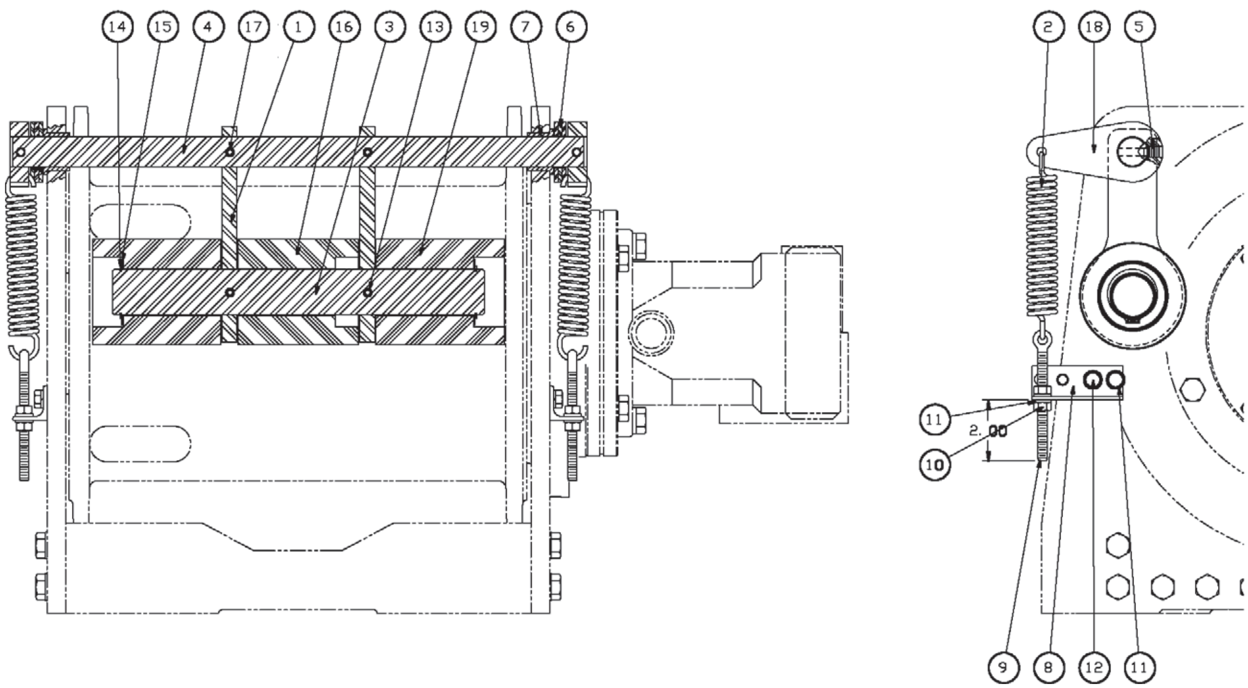
Hoist Tension Roller Subassembly Service

Disassembly

Use Figure 11-73 as a guide in disassembling the tension roller assembly.

Assembly

1. When assembling the tension roller assembly use washers **6** (Figure 11-73) to center the roller assembly between the drum flanges.
2. Tighten each eyebolt **9** to the dimension shown in Figure 11-73.
3. Apply grease to shaft and I.D. of rollers. Rollers must turn freely.



a2270

Hoist Tension Roller Subassembly Cut-Away View

FIGURE 11-73

Item	Description	Item	Description
1.	Tension roller arm	11.	Lockwasher (8)
2.	Tension spring (2)	12.	Capscrew (4)
3.	Tension roller shaft	13.	Roll pin (2)
4.	Tension arm shaft	14.	Snap ring (2)
5.	Set screw (2)	15.	Thrust race (2)
6.	Washer (6)	16.	Roller
7.	Roller bushing (2)	17.	Roll pin (2)
8.	Spring anchor (2)	18.	Lever arm (2)
9.	Roller rod end (2)	19.	Roller (2)
10.	Nut (4)		

Troubleshooting

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Trouble	Possible Cause	Remedy
A - The hoist will not lower the load or not lower the load smoothly.	**1.** The friction brake may not be releasing as a result of a defective brake cylinder seal. **NOTE:** If the brake cylinder seal is defective leaking will occur from the hoist vent plug.	**1.** Check brake cylinder seal as follows: **a.** Disconnect the swivel tee from the brake release port. Connect a hand pump with an accurate 0-13 790 kPa (0-2000 psi) pressure gauge and shut-off valve to fitting in the brake release port. **b.** Apply 6895 kPa (1000 psi) to the brake. Close the shutoff valve and let stand for five (5) minutes. **c.** If there is any loss of pressure in five (5) minutes, the brake cylinder should be disassembled for inspection of sealing surfaces and replacement of the seals. Refer to *Motor Support-Brake Cylinder Service, page 11-33*.
	2. Friction brake will not release as a result of damaged brake disc.	**2.** Disassemble the brake to inspect brake discs. Check stack-up height as described in *Motor Support-Brake Cylinder Service, page 11-33*.
B - Oil leaks from vent plug.	**1.** Same as A2.	**1.** Same as A2.
	2. Motor seal may be defective as a result of high system back pressure.	**2.** System back pressure must not exceed 3448 kPa (500 psi). Inspect hydraulic system for a restriction in the return line from the main control valve to the hydraulic tank. Oil analysis may indicate contamination has worn the motor shaft and seal. Install a new motor seal.

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Trouble	Possible Cause	Remedy
C - The brake will not hold a load with the control lever in neutral.	**1.** Excessive system back pressure acting on the brake release port. **2.** Friction brake will not hold due to worn or damaged brake discs. **3.** Brake clutch is slipping.	**1.** Same as Remedy 2 of possible cause B2. **2.** Same as Remedy 3 of Possible Cause A2. **3.** Improper planetary gear oil may cause the brake clutch to slip. Drain old gear oil and flush hoist with a suitable solvent. Thoroughly drain the solvent and refill hoist with recommended planetary oil. See *Preventative Maintenance, page 5-1*.
D - The hoist runs hot.	**1.** Excessively worn or damaged internal hoist parts.	**1.** Disassemble hoist to inspect/ replace worn parts.
E - Hoist chatters while raising rated load.	**1.** Hydraulic oil flow to motor may be too low. **2.** Hoist control being operated too quickly.	**1.** Hydraulic pump not operating efficiently. **2.** Conduct operator training as required.
F - The wire rope does not spool smoothly on the drum.	**1.** Improper wire rope being used. **2.** The hoist may have been overloaded, causing permanent set in the wire rope.	**1.** Use only wire rope as specified by Product Support. **2.** Replace wire rope.

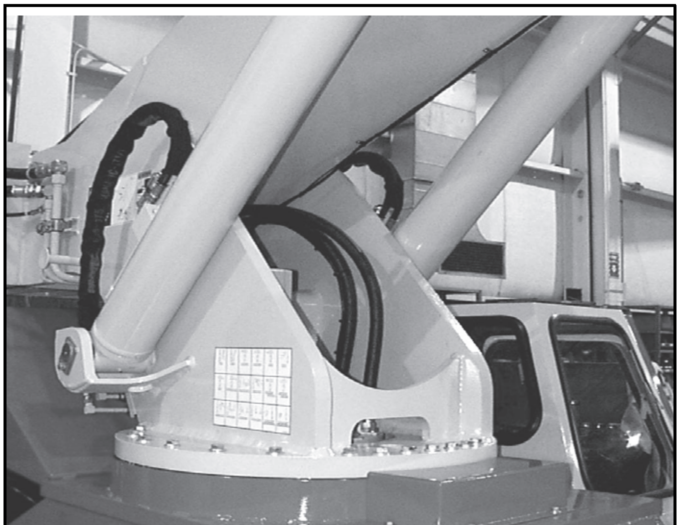
BEARING, MAST AND RELATED PARTS

General

The mast is fastened to the main frame of the crane through a bearing. The inner race of the bearing is fastened to the frame and the outer race of the bearing is fastened to the mast. See Figure 11-74.

The rotation of the mast is done by a gearbox which is mounted below the frame deck. A hydraulic motor connected to the gearbox provides power for rotation of the mast.

The bearing is filled with grease through two grease fittings on the inner race of the bearing. A hole in the mast plate allows access to the inner race and the grease fittings.



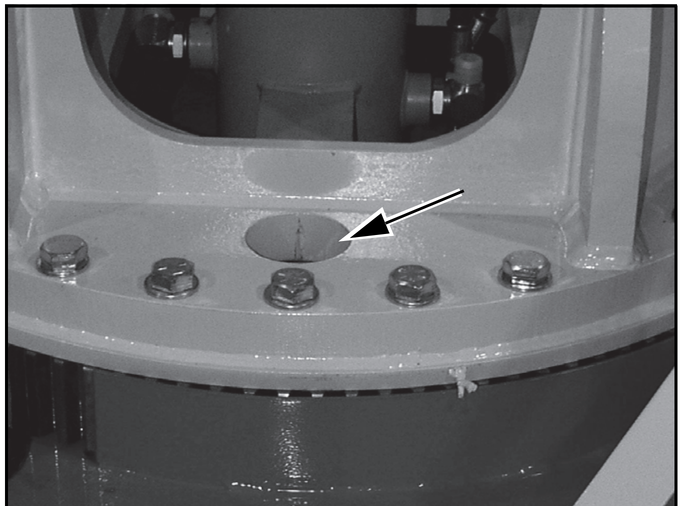
p0219 Swing Mechanism **FIGURE 11-74**

Mast Bearing

The bearing is a ball thrust bearing. The inner race rotates inside the outer race on a row of steel balls.

Apply grease weekly or every 50 hours of operation, whichever occurs first. Use a Lithium based, E.P. No. 2 bearing grease, or equivalent.

There are two grease fittings to grease the bearing and they are directly across from each other. Rotate the mast until the access hole (Figure 11-75) aligns with the grease fitting. Apply grease to the bearing. Rotate the mast through several rotations and then repeat the procedure with the other grease fitting. The excess grease will extrude out of the bearing seal.



p0501 Mast Bearing Grease Points (Two fittings located on inside surface of bearing ring) **FIGURE 11-75**

Mast Bearing Bolts

Very high stress is put on the mast bolts during crane operation. It is important that these bolts be checked at regular intervals.

Check the torque on the bolts after the first week or 50 hours of operation, whichever occurs first, and then every month or 250 hours of operation, whichever occurs first. Make a record of any loose bolt. If any bolt does not hold to correct torque after the second check, remove and replace the bolt. A loose bolt indicates possible failure of the bolt.

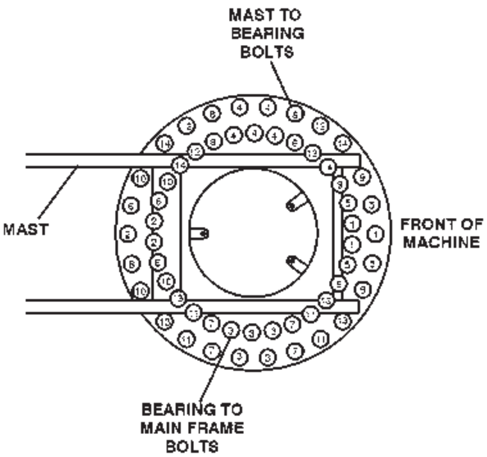
The correct torque on each bolt should be 619 Nm (455 lb-ft).

Use the torque sequence shown in Figure 11-76 when checking the torque on the bolts.

NOTE: Use only special Grade 8 bolts for replacement of the mast bolts. Order the bolts from your Grove Cranes distributor, see your parts manual.

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

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



8903 Swing Mechanism **FIGURE 11-76**

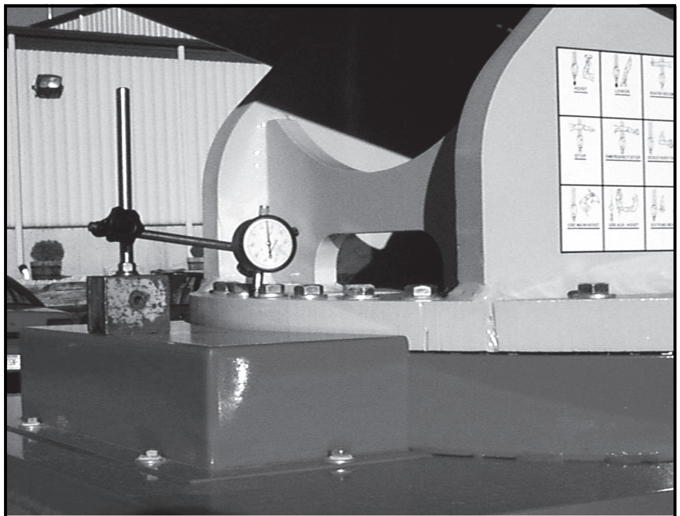
Inspection for Bearing Wear

The mast bearing has moving internal parts that are prone to wear if not maintained properly. As the bearing wears, there will be free-play or movement in the bearing. Some of the symptoms of mast bearing wear are:

- **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 11-77.
3. Set the dial indicator to zero.



p0222 **FIGURE 11-77**

4. Raise the boom to its full raised position and record the amount of movement on the dial indicator.
5. Lower the boom and then rotate it 180°. Repeat steps 2 through 4.
6. Average the two readings. The maximum allowable movement is 1.52 mm (0.060 in). The mast bearing must be replaced if the movement is greater than the stated measurement.

Replacing the Mast Bearing

Removal

1. Refer to *Boom Removal, page 11-3* and remove the boom from the mast.
2. Remove swivel torque arm **29** (Figure 11-79) from the bottom of the hydraulic swivel **31**.
3. Attach tags to the hydraulic hoses and lines with the swivel port number to which they connect.
4. Disconnect the hydraulic lines from the lower swivel ports. Put caps or plugs on the fittings and hydraulic lines.
5. Using an overhead crane, remove the three counterweights **3** and **4** from the mast.
6. Refer to procedures in this section and remove the hoist assembly.
7. Connect an overhead crane to the mast capable of handling the weight of the mast. Remove the 26 bolts **12** and flat washers **13**, which fasten the mast to the mast bearing.
8. Remove the mast and place it on blocks.

9. Remove the 30 bolts **15** and flat washers **13** and remove the mast bearing **14** from the frame.

Installation

1. Using a suitable solvent, clean the holes in the bearing plate on the main frame. Remove the residue with compressed air. Clean all dirt from the bearing plate.

2. Locate the mast bearing **14** (Figure 11-79) in place on the bearing plate.

3. Install bolts **15** and structural washers **13** to fasten the mast bearing to the bearing plate.

4. Figure 11-76 shows order of tightening the bolts. Each bolt must first be tightened to a torque of 619 Nm (455 lb-ft) and then loosened slightly. After which, each bolt must again be torqued to 619 Nm (455 lb-ft).

NOTE: For ease of lubrication when turntable mast is removed, apply grease to grease fittings located on the bearing before mounting the turntable mast to the bearing. Reference "Mast Bearing" on page 11-42 for lubrication procedure.

5. Make sure the top surface of the mast bearing and the bottom surface of the mast base are clean.

6. With a hoist, raise and lower the mast into position over the mast bearing. Install bolts **12** (Figure 11-79) and washers **13**.

7. Figure 11-76 shows the order for tightening the bolts. Each bolt must first be tightened to a torque of 619 Nm (455 lb-ft), and then loosened slightly. After which, each bolt must again be tightened to a torque of 619 Nm (455 lb-ft).

8. Install swivel torque arm **29** (Figure 11-79) to hydraulic swivel **31**.

9. Connect the hydraulic lines to the hydraulic swivel.

10. Install counterweights **3** and **4** into the mast.

11. Install the hoist assembly to the mast.

12. Install the boom assembly.

Swing Gearbox and Pinion

Maintenance

Gearbox

Oil in the gearbox lubricates the gears, bearings, and swing brake. Gaskets inhibit external leakage from the gearbox. Keep the gearbox filled with oil. The output pinion bearings are lubricated with grease. Add grease through the grease fitting. For more information about checking and replacing swing gearbox lubricants, see "Check Swing Gearbox Lubricant Level" on page 5-32 and "Replace Swing Gearbox Lubricant" on page 5-35.

Swing Gear and Pinion Gear

The swing pinion and swing gear must be lubricated at regular intervals. For more information, see "Lubricate the Swing Gear and Pinion" on page 5-27.

Adjustment

Checking Backlash

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

1. Remove the swing gear pinion cover.

NOTE: The high point may be punch-marked on the edge of the slew ring or marked with blue paint.

2. Start the engine and rotate the mast until the high point on the swing gear is engaged with the pinion (Figure 11-78).

3. 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.

Backlash Adjustment

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

1. Slightly loosen the four bolts securing the gearbox (Figure 11-78).

2. With a spanner wrench or screwdriver, turn the eccentric ring to move the pinion until it contacts the swing gear tooth and engages the swing gear snugly (zero backlash).

3. Tighten the four bolts to appropriate torque.

4. Install the swing pinion cover.

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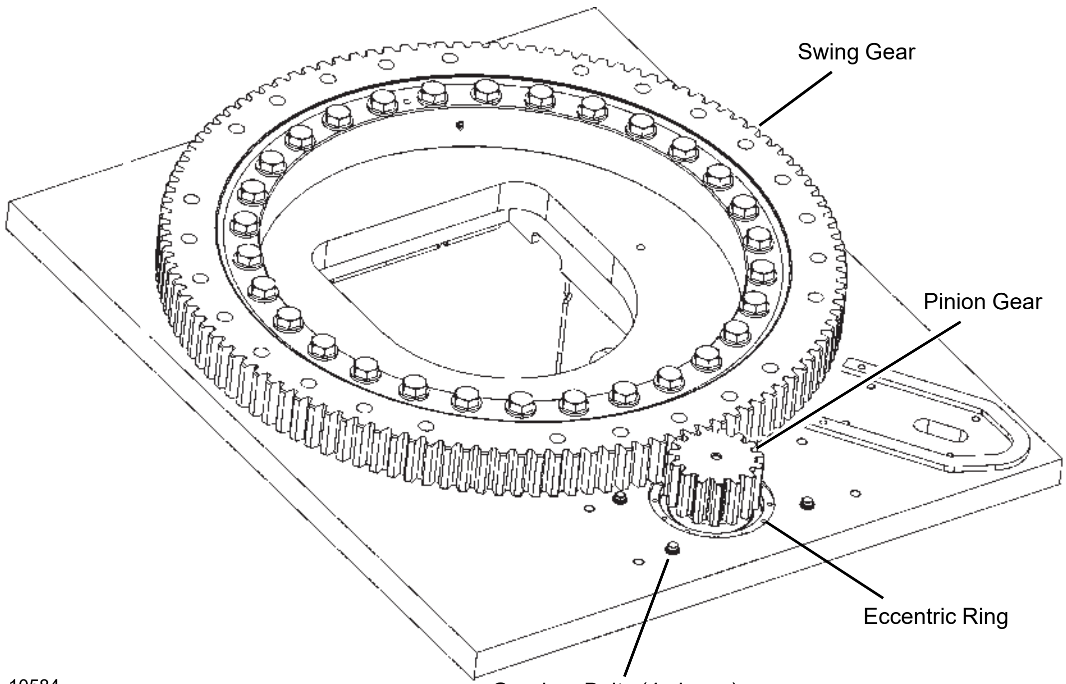
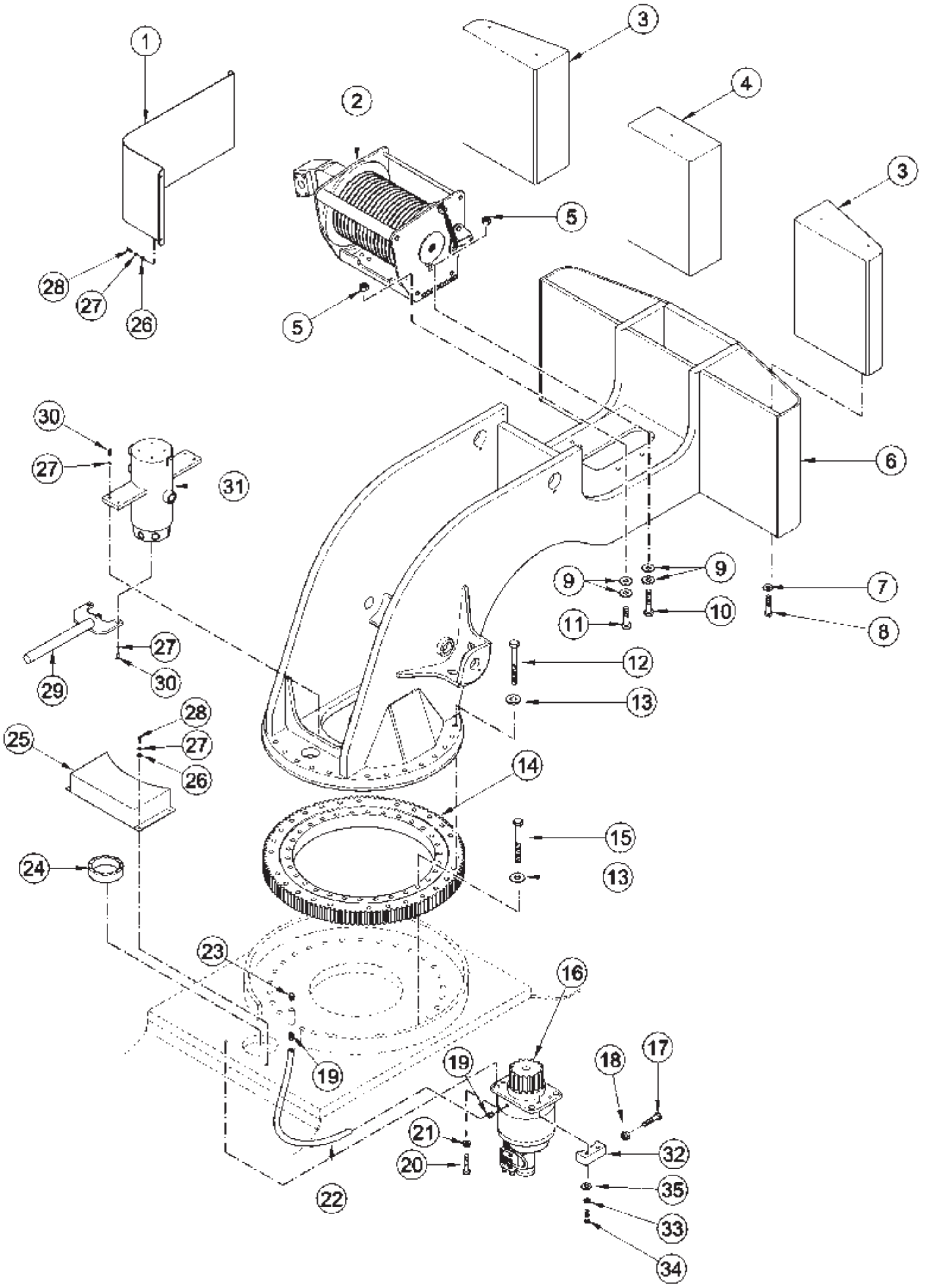


Swing Gear
Pinion Gear
Eccentric Ring
Gearbox Bolts (4 places)
10584

FIGURE 11-78



Item	Description
1.	Hoist motor cover
2.	Hoist assembly
3.	Side counterweight (2)
4.	Center counterweight
5.	Nut (8)
6.	Mast
7.	Washer (6)
8.	Hex bolt (6)
9.	Washer (16)
10.	Hex bolt (4)
11.	Hex bolt (4)
12.	Hex bolt (26)
13.	Washer (56)
14.	Mast bearing
15.	Hex bolt (30)
16.	Swing gearbox
17.	Hex bolt (2)
18.	Nut (2)
19.	Connector (2)
20.	Hex bolt (4)
21.	Washer (4)
22.	Tubing
23.	Grease fitting
24.	Eccentric ring
25.	Swing pinion cover
26.	Washer (8)
27.	Lockwasher (8)
28.	Hex bolt (4)
29.	Swivel torque arm
30.	Hex bolt (7)
31.	Hydraulic swivel
32.	Chock (2)
33.	Lockwasher(4)
34.	Hex bolt (4)
35.	Washer (4)

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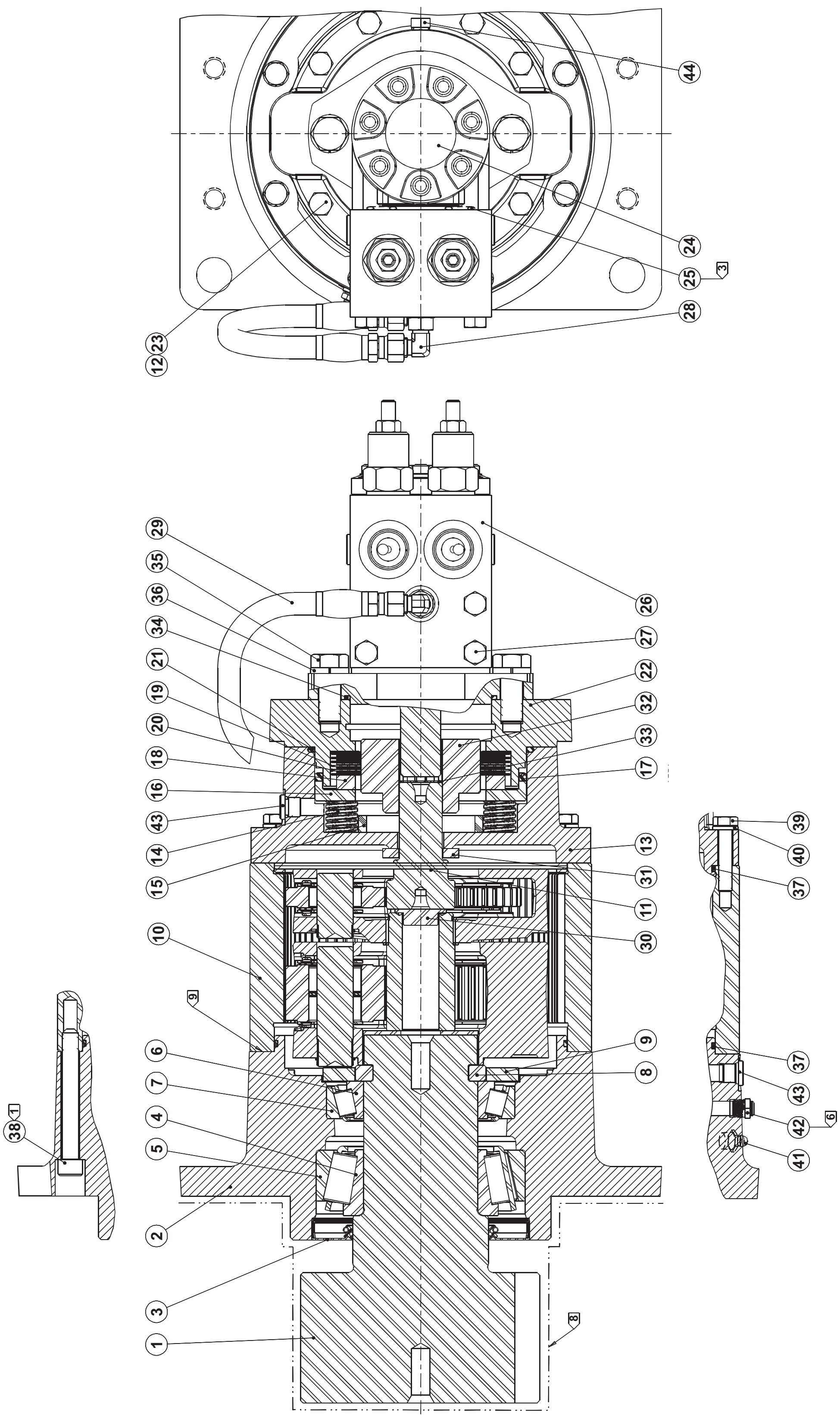
Mast Assembly

FIGURE 11-79



Item	Description
1.	Output pinion
2.	Bearing carrier
3.	Lip seal
4.	Bearing
5.	Bearing
6.	Bearing cone
7.	Bearing cup
8.	Split ring
9.	Split ring retainer
10.	Ring gear
11.	Primary sun gear
12.	Lockwasher (8)
13.	Brake housing
14.	Spring (4)
15.	Spring locator
16.	Spring plate
17.	U-cup seal
18.	Brake plate spacer
19.	Friction disc (5)
20.	Brake disc (7)
21.	O-ring
22.	Motor adapter
23.	Capscrew (8)
24.	Hydraulic motor
25.	O-ring (2)
26.	Brake valve
27.	Capscrew (4)
28.	Elbow fitting (2)
29.	Hose assembly
30.	Thrust plug
31.	Thrust washer
32.	Brake coupling
33.	Snap ring
34.	O-ring
35.	Capscrew (2)
36.	Lockwasher (2)
37.	O-ring (2)
38.	Capscrew (12)
39.	Capscrew (8)
40.	Lockwasher (8)
41.	Grease fitting
42.	Relief valve
43.	Plug (2)
44.	Plug (2)

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Hoist Tension Roller Subassembly Cut-Away View

FIGURE 11-80

Swing Gearbox Repair

Removal

1. Use a hoist and blocks to hold the boom in position and prevent the mast from rotating.
2. Tag and disconnect the hydraulic hoses from the swing gearbox. Plug the hoses and cap the hydraulic fittings.
3. Provide support for the gearbox and remove the four bolts which fasten the gearbox to the frame. Remove the gear box and eccentric ring from beneath the machine.

Disassembly

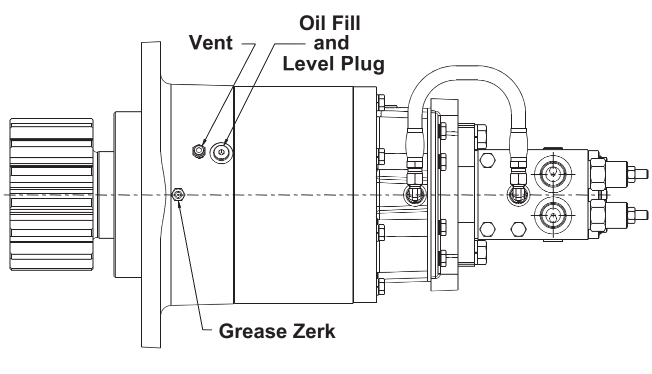

FIGURE 11-81

1. Drain the oil and clean the outside surfaces of the gearbox. Set the gearbox with the input/motor side up on a work bench and use wood blocks under the flange of the bearing carrier **2** (Figure 11-80) to stabilize it on the workbench.

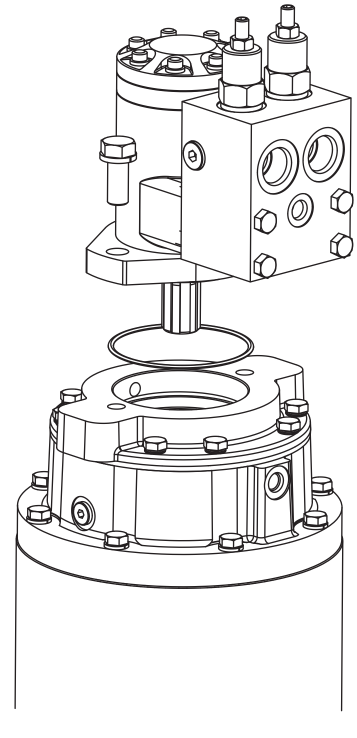

FIGURE 11-82

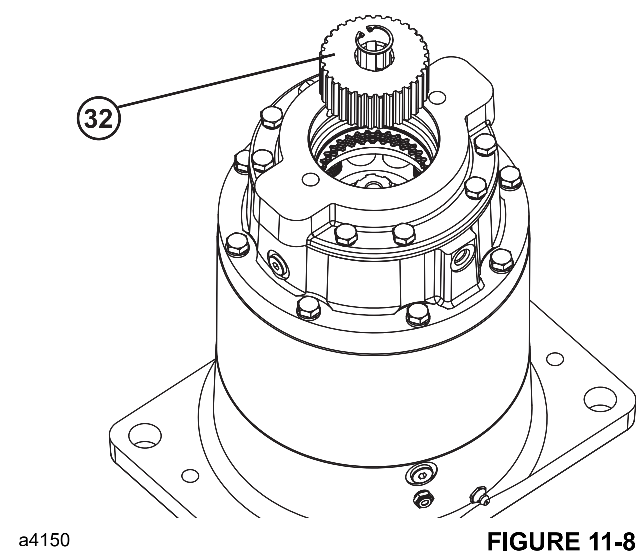

FIGURE 11-83

2. Disconnect the brake release hose at the gearbox. Unbolt and remove the hydraulic motor from the gearbox. Remove the brake hub **32** and remove and discard the motor pilot O-ring.

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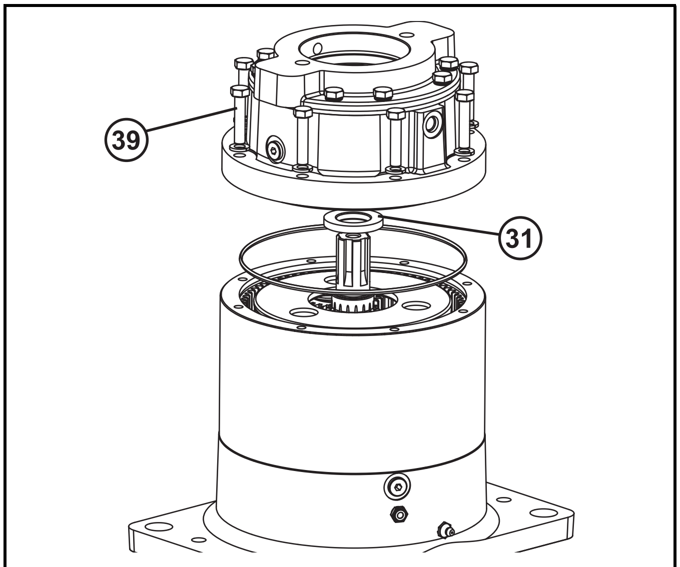

FIGURE 11-84

3. Remove the complete brake cylinder assembly by removing the eight metric bolts **39** and lifting the brake cylinder off of the ring gear. See *Brake Cylinder Service, page 11-52* for procedure to disassemble the brake cylinder assembly.

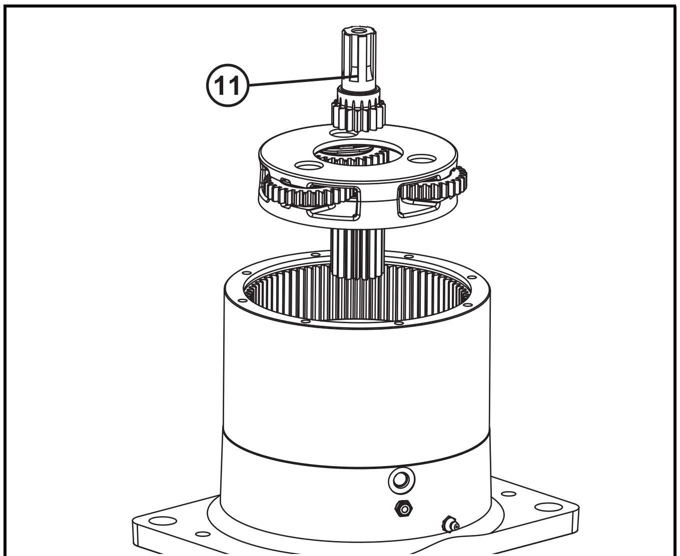

FIGURE 11-85

4. Remove the primary sun gear **11** and the thrust washer **31**.

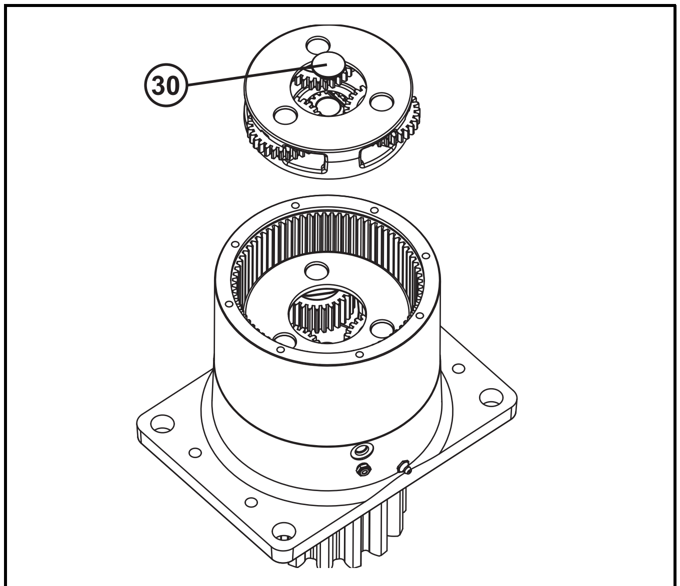

FIGURE 11-86

5. Remove the primary planet carrier assembly and thrust plug **30**.

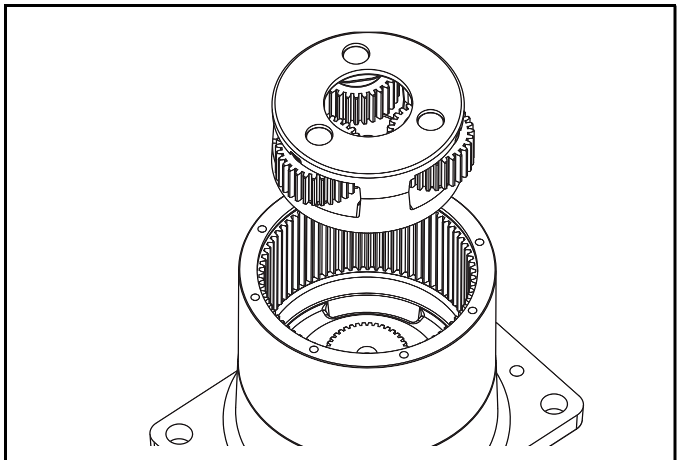

FIGURE 11-87

6. Remove the secondary planet carrier assembly.

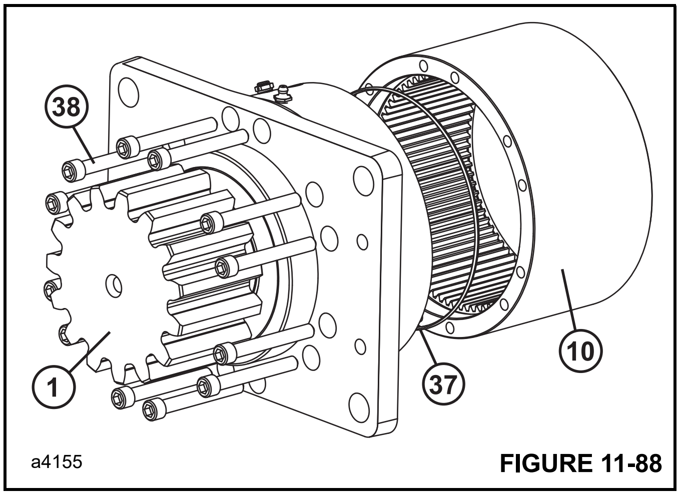

FIGURE 11-88

7. If the output pinion **1** will be removed, remove the ring gear **10** from the bearing carrier by removing the metric socket head capscrews **38** and discard the ring gear O-rings **37**.

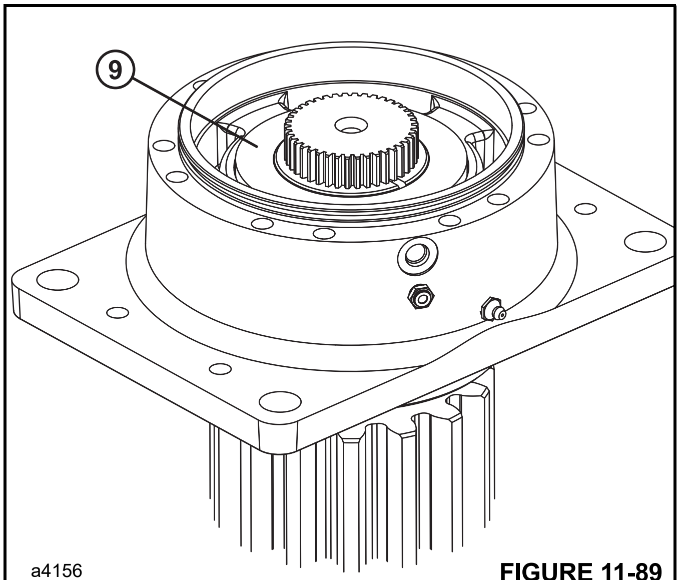

FIGURE 11-89

8. Remove the split ring retainer **9**.

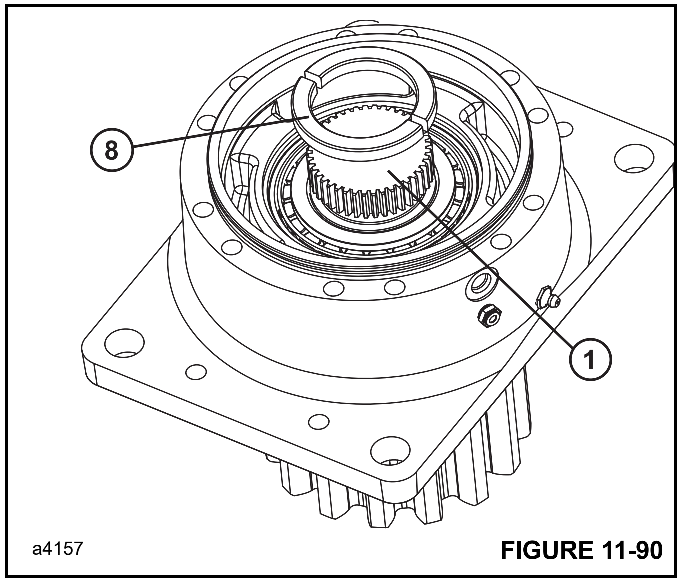

FIGURE 11-90

9. Take care not to damage the ground surface of the split ring halves. Use a hammer and punch to remove the split ring halves **8** from the output pinion **1**.

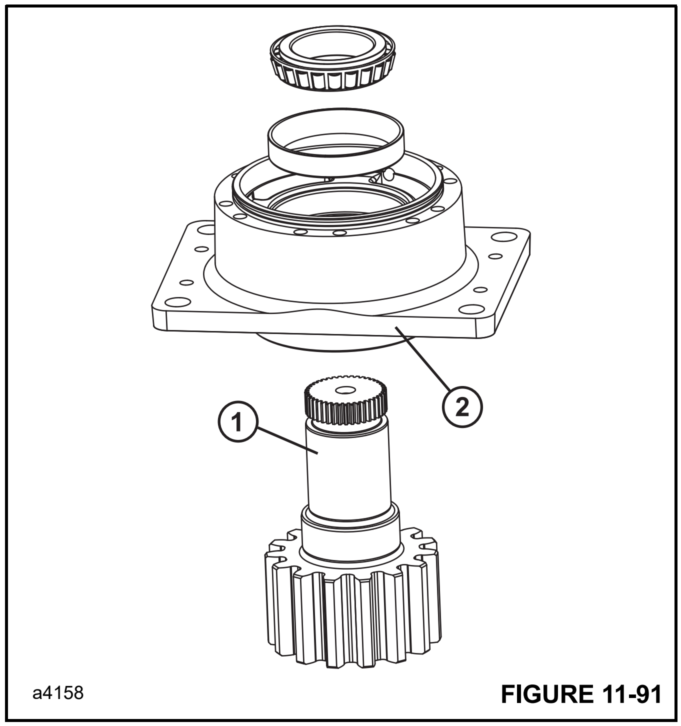

FIGURE 11-91

10. Remove output pinion from bearing carrier **2**.

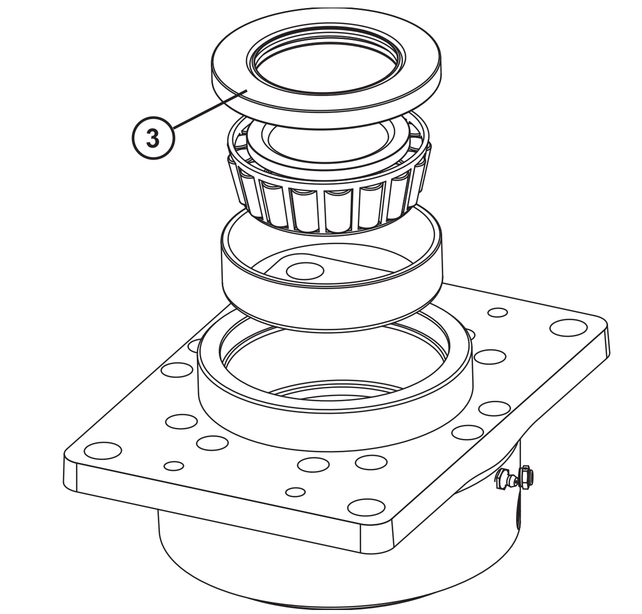

FIGURE 11-92

11. Remove the output pinion seal **3**.

12. Wash and inspect the bearings, planet carriers, and ring gear.

Assembly

1. Verify that the bearing cups **5** and **7** are installed in the bearing carrier **2**. Pack the tapered roller bearings **4** and **5** with grease.

2. Place the bearing carrier **2** on a workbench with the output pinion side facing up. Set bearing cone **4** in bearing cup **6**.

3. Lubricate the outside diameter of lip seal **3** with Loctite Aviation Gasket Sealant or equivalent and install lip seal in bearing carrier.

4. Lubricate output pinion bearing and seal surfaces with grease and install output pinion in bearing carrier taking care not to damage the lip seal.

5. Position bearing carrier on the workbench with the pinion down and place wood blocks under bearing carrier to stabilize unit. Install bearing cone **6** over pinion and in bearing housing. Install split rings **8** in pinion shaft and then install split ring retainer **9**.

6. Install O-ring **37** into bearing carrier groove and lubricate lightly. Ensure the mating horizontal surfaces on bearing carrier **2** and ring gear **10** are clean and free of any lubricants.

7. Position ring gear onto bearing carrier. Apply Loctite 243 to capscrews **38** and torque to 81 ± 7 N•m (60 ± 5 lb-ft).

8. Install output planet carrier assembly into ring gear and lower onto the output pinion ensuring that the carrier splines engage with the pinion.

9. Install the primary planet carrier assembly into the ring gear. The output sun gear is retained on the primary planet carrier and engages with the output carrier assembly planet gears.

10. Install the thrust plug **30** and then the primary sun gear **11** into the primary planet carrier assembly. Install the thrust washer **31** onto the primary sun gear **11**.

11. Install O-ring **37** into groove on brake housing **13** and lubricate lightly.

12. Slowly lower the brake cylinder assembly onto ring gear and verify proper alignment. Install lockwashers **40** and capscrews **39** and torque to specified value.

13. Install internal snap ring **33** in brake hub **32**. Install brake hub in brake cylinder and ensure the internal snap ring is seated on the input sun gear **11**. If the friction brake plate splines are not aligned, the brake cylinder must be pressurized to install the brake hub.

14. Install the hydraulic motor **24** in the brake cylinder assembly aligning the motor splines with the inner race of the brake hub **32**. Install hydraulic motor lockwashers **36** and capscrews **35** and torque to specified value.

15. Install O-rings **25** in brake valve **26** and bolt the brake valve to the hydraulic motor using capscrews **27**. Torque to specified value.

16. Connect brake release hose **29** to fittings on the hydraulic motor and brake valve.

17. Operate the unit at no load while monitoring the gearbox for abnormal noises and oil leaks. Correct any abnormal condition before returning the gearbox to service.

Installation

1. Install the gearbox in reverse order of removal.

2. Align the pinion gear with the swing gear following the instructions.

Brake Cylinder Service

Disassembly

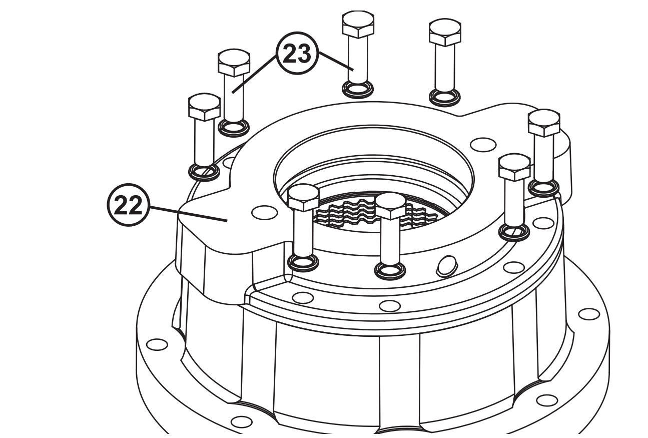

FIGURE 11-93

1. The force of the brake springs is applied to the motor adapter **22**, so loosen the metric capscrews **23** one turn at a time, alternating across the gearbox, until the spring force is released. Remove the motor adapter and discard O-ring **21**.

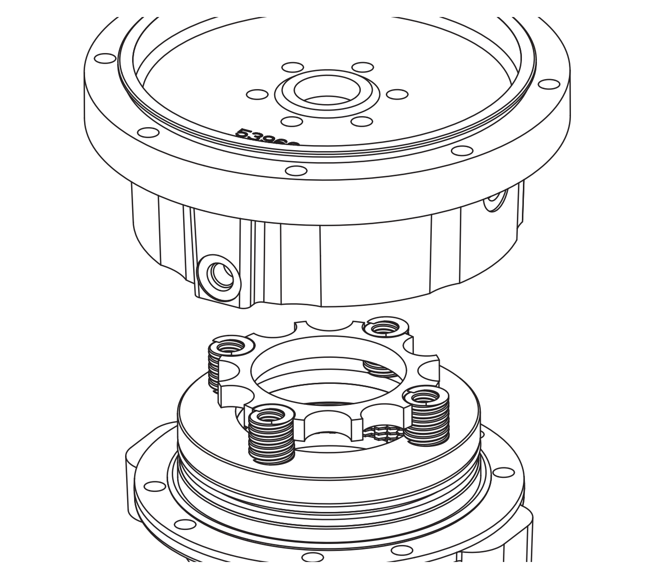

FIGURE 11-94

2. Continue disassembly removing spacer **18**, friction discs **19**, brake discs **20**, U-cup seal **17**, pressure plate **16**, springs **14**, and spring locator **15**.

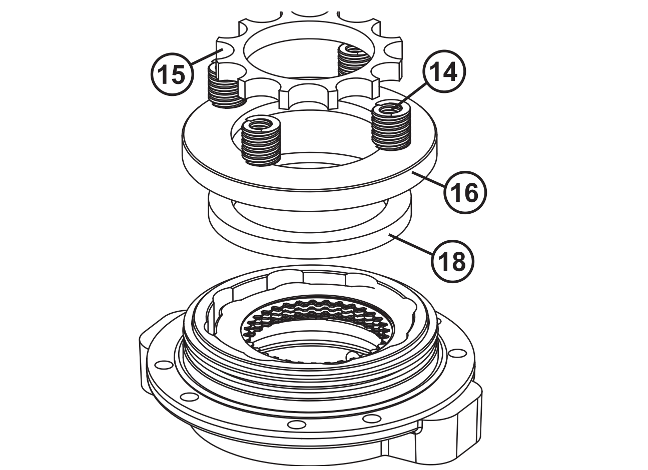

FIGURE 11-95

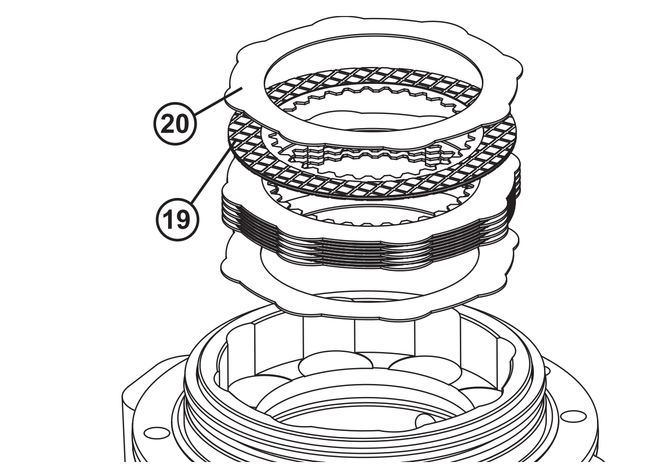

FIGURE 11-96

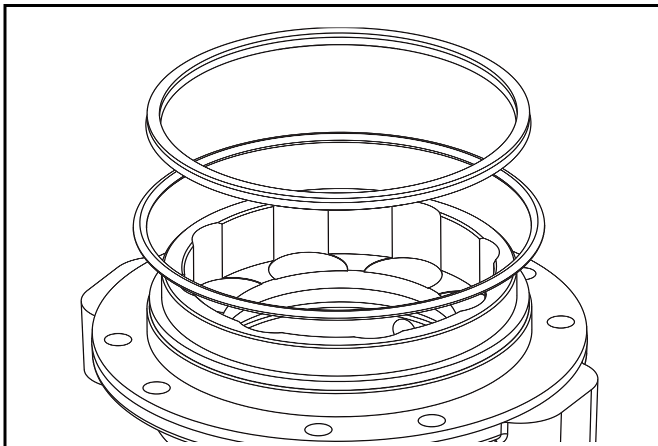

FIGURE 11-97

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Clean and Inspect

1. Thoroughly clean and inspect all parts. Check brake piston sealing surfaces for wear on the brake cylinder and motor support. Ensure the brake release port is free of contamination.
2. Place friction disc on a flat surface and check for distortion with a straight edge. Friction material should appear even across the entire surface with the groove pattern visible. Replace friction disc if splines are worn to a point, disc is distorted, friction material is worn unevenly, or groove pattern is worn away.
3. Place steel brake disc on a flat surface and check for distortion with a straight edge. Inspect surface for signs of material transfer or discoloration due to heat damage. Replace disc if discolored, distorted, or if material is deformed on the outer edges at point of contact with the brake housing.
4. Inspect brake springs for any signs of cracking or distortion. If a brake spring is defective, ALL brake springs must be replaced.

CAUTION

Failure to replace springs as a set may result in uneven brake application force and repeated brake spring failure.

Assembly

CAUTION

The number of steel discs, friction discs, and brake springs is listed on the material list. SD40 gearboxes are used in several applications with different brake requirements, so it is critical to reference the unit's material list for this information.

---

1. Begin assembly by placing the motor adapter on a workbench with the motor mounting surface down. Install a new O-ring **21**.
2. Refer to the gearbox material list for the number of steel discs and friction discs needed. Lubricate the friction discs with the gearbox oil. The brake stack will alternate steel and friction discs ending with steel disc on one end and a friction disc on the opposite end. Any additional steel discs are the first discs put into the motor adapter. The brake stack is then installed in the motor adapter beginning with a friction disc and alternating until the final steel disc is installed. Place the spacer **18** on top of the top steel disc.
3. Lubricate the brake piston u-cup seal **17** and the motor adapter sealing surface with petroleum jelly or hydraulic oil. Install the brake piston seal onto the motor support with the seal lip down.
4. Place the brake housing **13** on the workbench and place the spring locator in the housing. Refer to the unit material list for the required number of springs **14**. Space the required number of springs evenly around the outside diameter of the spring locator.
5. Install the spring pressure plate **16** on top of the springs in the brake housing. The close fitting spring pressure plate may be depressed at a slight angle to lodge it into the brake housing which will hold the parts in place while the brake housing is lowered onto the motor adapter.
6. Apply petroleum jelly, grease, or hydraulic oil to the mating surfaces of the O-ring and seal on the motor adapter. Install the brake housing over the motor adapter carefully to avoid damaging the seal and O-ring.
7. Install motor adapter capscrews and tighten each bolt one turn at a time in a crossing pattern to keep motor adapter level as springs are compressed. Torque to specified value.

Pressure Test

1. Connect a hydraulic hand pump with an accurate gauge and shut-off valve to the brake release port of the brake cylinder. Apply 34.47 bar (500 psi) to the brake. Close the shut-off valve and let stand for five (5) minutes. If there is any loss of pressure in five (5) minutes, the brake cylinder should be disassembled for inspection of the sealing surfaces and O-rings. (See the following step before releasing brake pressure.)
2. WHILE PRESSURE IS APPLIED AND THE BRAKE IS RELEASED, install the brake hub assembly. Rotate the clutch back and forth to align the outer race splines with the brake disc splines. Release the pressure on the brake cylinder and remove the brake hub and hand pump. The brake assembly is now complete and ready to be assembled with the main ring gear.

Planet Assembly Service

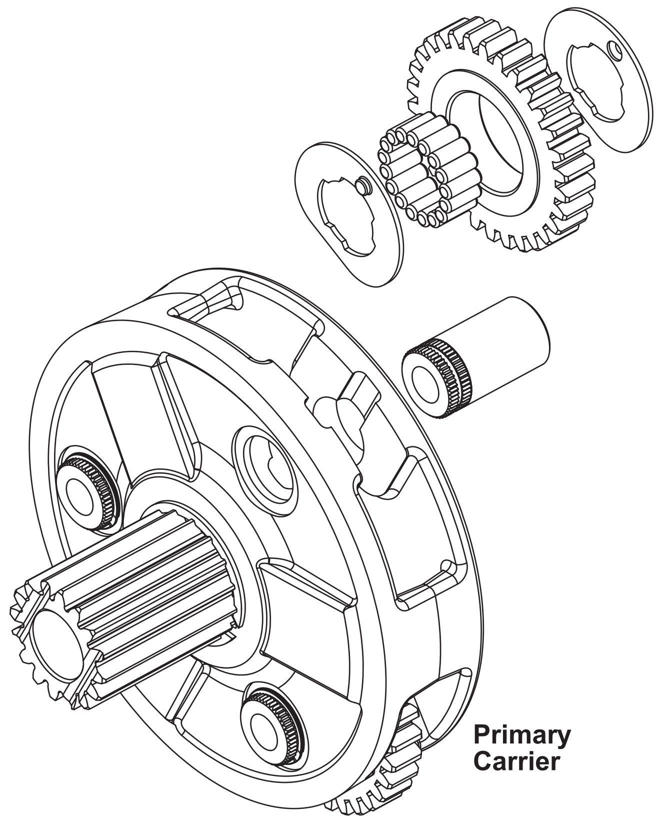

FIGURE 11-98

NOTE: The primary planet carrier assembly has one row of loose roller bearings under the planet gears, while the output carrier has two rows of loose rollers under each gear.

The planet carrier assemblies should not be disassembled unless damage is suspected.

Disassembly

1. Remove the retaining ring from the knurled end of the planet shaft. Support the planet carrier assembly and press out each planet pin by applying force at the knurled end. Place a container under the press to catch any rollers that might come out with the planet pin.
2. Slide the planet gear and its bearings out of the carrier, being careful not to drop all the loose rollers.
3. Remove the rollers from the planet gear.

NOTE: The output planet assembly has two rows of loose rollers separated by a spacer.

4. Remove the two thrust washers from the planet carrier.
5. Repeat steps 1 through 4 for each of the remaining planet gears.
6. Thoroughly clean all parts and inspect for damage and wear. The bearing rollers should be examined for any signs of spalling, corrosion, discoloration, material displacement or abnormal wear. Gears should be inspected for abnormal wear or pitting and replaced as necessary. Inspect machined surfaces and bearing bores for signs of damage or excessive wear.

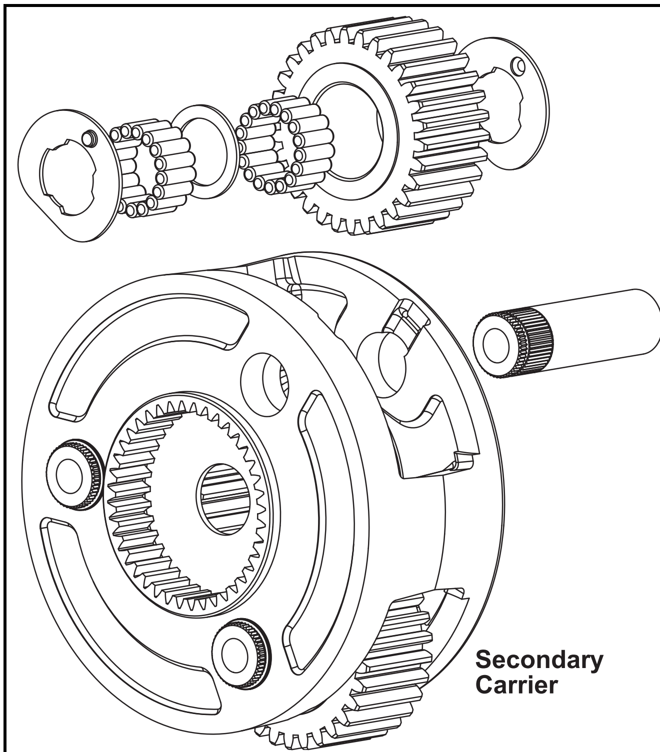

FIGURE 11-99

Assembly

1. Liberally coat the bore of a planet gear with general purpose oil soluble grease.
2. Set a thrust washer on a clean flat work surface. Set a planet gear on its side centered over the thrust washer so the bearing rollers can be installed and the assembly slid off into the planet carrier.
3. Install a row of rollers around the bottom of the planet gear bore. Coat the rollers with a small amount of grease if necessary to hold them in place.

Step 4 applies only to the output planet assemblies.

4. Install a bearing spacer on top of the rollers and put another row of rollers on top of the spacer.
5. Put the other thrust washer on top of the planet gear and slide the completed planet gear and bearing assembly into place in the planet carrier aligning the thrust washer knubs with the planet carrier slots. Align the roller bearings with one of the planet gear shaft holes.

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6. Install a planet gear shaft through the planet carrier and bearings. Use a press to push the knurled surface through the carrier until the retaining ring groove is visible.
7. Install the retaining ring on the planet pin.
8. Repeat steps 1 through 7 for the remaining planet gears.

OUTRIGGERS

Removal

1. Engage the parking brake and put blocks under the wheels to prevent machine movement.

NOTE: If outrigger proximity switches are installed, disconnect them before removing the outriggers.

2. Stop the engine. With the ignition switch in the ON position, actuate the outrigger controls in both directions to release pressure in the hydraulic circuits. Turn the ignition switch to the OFF position.
3. Tag and disconnect the four hydraulic hoses at the rear of the outrigger horizontal beam **1, 2** (Figure 11-100).
4. Remove snap rings **14** and pin **13** securing the barrel end on the horizontal outrigger cylinder **5** to the frame mounting lug.
5. Using a hoist and sling, slide the outrigger assembly from the frame.

Disassembly

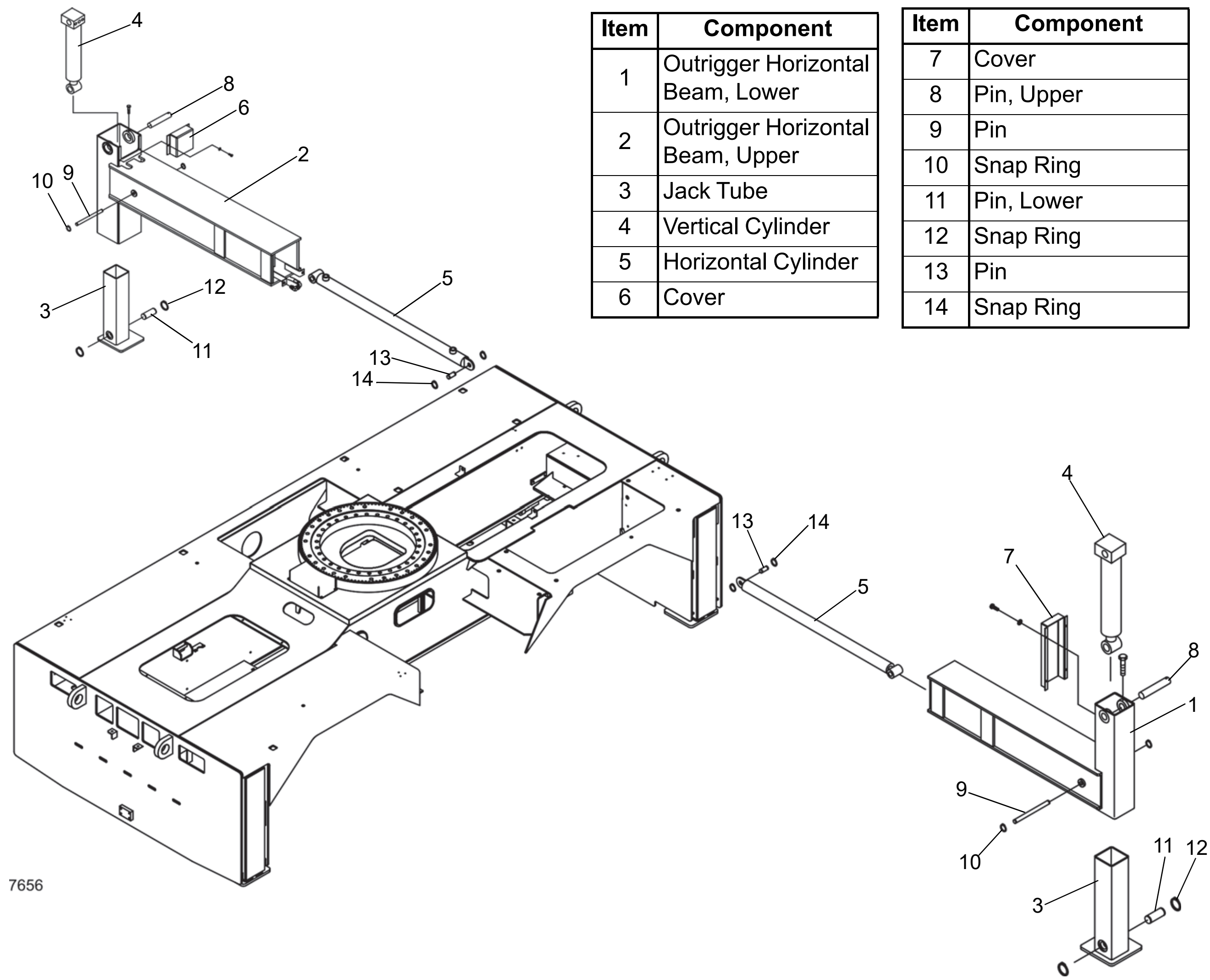
1. Place the outrigger assembly on proper supports.
2. Remove snap rings **10** (Figure 11-100) and pin **9** securing the rod end on the horizontal outrigger cylinder **5** to the outrigger horizontal beam.
3. Slide the cylinder **5** from the beam. Tag and disconnect the hydraulic hoses from the cylinder. Cap and/or plug all openings.
4. Tag and disconnect the hydraulic hoses from the vertical outrigger cylinder **4**.
5. With the pad of the sliding jack weldment **3** touching the ground or supported, remove the snap rings **12** and pin **13** securing the rod end of the vertical outrigger cylinder **4** to the weldment **3**.
6. Attach a sling and hoist to the vertical outrigger cylinder **4** and remove the two capscrews and pin **8** securing the cylinder to the horizontal beam **1, 2**. Lift the cylinder from the beam.
7. Using a sling and hoist, raise the beam so the sliding jack weldment **3** can be removed from the beam.
8. As necessary, tag, disconnect and remove hydraulic hoses, tubes and fittings from the outrigger horizontal beam.

Assembly

1. If removed, install and connect the hydraulic hoses, tubes and fittings in the outrigger horizontal beam **5** (Figure 11-100) as tagged during disassembly.
2. Lubricate the inside of the outrigger horizontal beam box and the outside of the sliding jack weldment **3** with “STP Oil Treatment, “LUBAID NF”, or bronze anti-seize compound.
3. Using a sling and hoist, raise the outrigger horizontal beam **1, 2** and insert the sliding jack weldment **3** into the end of the beam.
4. Using a sling and hoist, insert the vertical outrigger cylinder **4** (rod end first) into the sliding jack weldment **3**.
5. Attach the rod end of the cylinder to the weldment using pin **11** and two snap rings **12**.
6. With the sling and hoist still attached to the cylinder, raise the cylinder and align the holes in the cylinder barrel with the holes in the beam box. Install pin **8** and secure the pin with two capscrews.
7. Connect the hydraulic hoses to the vertical outrigger cylinder **4** as tagged during disassembly.
8. Connect the hydraulic hoses to the outrigger horizontal cylinder **5** as tagged during disassembly. Slide the cylinder **5** into the beam **1, 2**.
9. Secure the rod end of the horizontal outrigger cylinder **5** to the outrigger horizontal beam with pin **9** and snap rings **10**.

Installation

1. Lubricate the inside of the main frame and the outside of the outrigger horizontal beam box with “STP Oil Treatment, “LUBAID NF”, or bronze anti-seize compound.
2. Using a sling and hoist, slide the assembly into the main frame.
3. Secure the barrel end on the horizontal outrigger cylinder **5** to the frame mounting lug using pin **11** and snap rings **12**.
4. Connect the four hydraulic hoses at the rear of the outrigger horizontal beam **5** as tagged during removal.
5. Operate the outriggers and check for correct installation. Stop the engine. Check for leakage at all hose connections.



Item	Component
1	Outrigger Horizontal Beam, Lower
2	Outrigger Horizontal Beam, Upper
3	Jack Tube
4	Vertical Cylinder
5	Horizontal Cylinder
6	Cover

Item	Component
7	Cover
8	Pin, Upper
9	Pin
10	Snap Ring
11	Pin, Lower
12	Snap Ring
13	Pin
14	Snap Ring

FIGURE 11-100

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

The Outrigger Monitoring System (OMS) proximity switches (if equipped) are mounted outside the outrigger housing tubes. The proximity switches identify whether an outrigger beam is at the fully extended position or at any position less than fully extended.

Removal

1. Disconnect switch cable (1) from harness.
2. Remove switch mounting bracket (2).
3. Remove jam nuts (3) and thread switch (4) out of the mounting bracket.

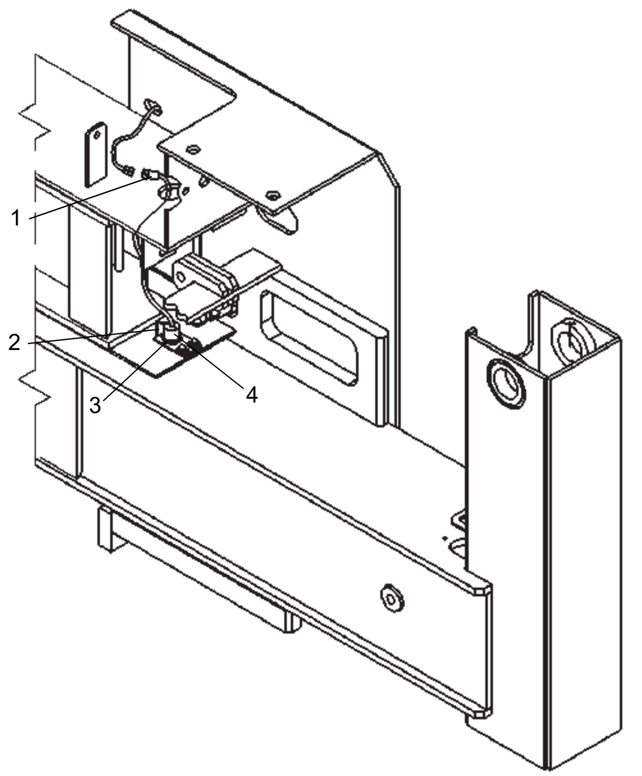


FIGURE 11-101

Installation

1. Feed cable through the mounting bracket and jam nuts.
2. Thread switch through mounting bracket.
3. Thread nuts on switch.
4. Thread switch up until it touches tab of mounting bracket and LED is pointed away from the bracket.
5. Tighten jam nuts against mounting bracket.
6. Install bracket with switch onto outrigger mounting plate.
7. Adjust bracket and/or switch to have 3 to 10 mm (0.12 to 0.38 in) gap between end of switch and outrigger beam.
8. Connect switch cable to wire harness.

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SECTION 12
SCHEMATICS/WIRING DIAGRAMS

Included in this Section

- Electrical Schematic
- Hydraulic Schematic

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ALPHABETICAL INDEX