SERVICE MANUAL

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

CD3340B/YB4411

Crane Model Number

Crane Serial Number

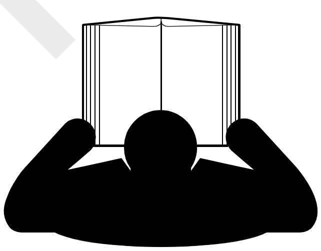
This Manual is Divided into the following Sections:

SECTION 1	**INTRODUCTION**
SECTION 2	**SAFETY PRACTICES**
SECTION 3	**ELECTRIC SYSTEM**
SECTION 4	**HYDRAULIC SYSTEM**
SECTION 5	**MAINTENANCE**
SECTION 6	**ENGINE AND ENGINE SYSTEMS**
SECTION 7	**TRANSMISSION AND TORQUE CONVERTER**
SECTION 8	**AXLES/DRIVE SHAFTS/WHEELS AND TIRES**
SECTION 9	**BRAKE SYSTEM**
SECTION 10	**STEERING SYSTEM**
SECTION 11	**STRUCTURAL**
SECTION 12	**SCHEMATICS/WIRING DIAGRAMS**

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

Published 05/07/2015 CTRL# 569-00

CALIFORNIA
PROPOSITION 65 WARNING

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

CALIFORNIA
PROPOSITION 65 WARNING

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

The original language of this publication is English.

TOC

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SECTION 1
INTRODUCTION

SECTION CONTENTS

GENERAL

This manual contains information on maintenance, service and repair of the YardBoss (YB) 4411 Crane. Major components and systems are included, except service on the engine. This information will be found in the engine manufacturers 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 PLATE

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 plate is shown below.

p0294

S/N Location

FIGURE 1-1

SPECIFICATIONS

Table 1-1
Engine

Diesel Engine	
Make and Model	Cummins QSB3.3 Tier 4i diesel
Type of Aspiration	Turbocharged
Horsepower	100 hp @ 2600 rpm
Low Idle Speed	800 rpm
Maximum Engine Speed	2860 rpm
Boom	
Construction	Telescopic, welded box sections
Number of Sections	Three section, full proportional
Reach	4.22 m (13 ft-10 in) to 10.1 m (32 ft-10 in)
Mast Rotation — 360°	
Mast Bearing (Diameter)	860.6 mm (33.884 in)
Swing Drive Mechanism	Hydraulic motor driven gearbox
Swing Speed	2 rpm
Electrical	
Type	12 volts, direct current
Alternator	120 amps
Battery	90 amp/hr
Fuel Tank	
Capacity	64 L (17 gal)
Hydraulic System	
Pump	Variable displacement piston pump
Main Control Valves	Four-section, pressure compensated, pilot actuated
Swing Motor	Single section, gerotor-type
Hoist Motor	Fixed displacement, axial piston
Hydraulic Filters	One 10-micron filter in line from valves One 30-mesh suction filter inside hydraulic tank
Hydraulic Cylinders	Double-acting cylinders for lift, telescope, steering and outriggers
Hydraulic Tank	130.6 l (34.5 gal) capacity, steel construction with internal baffles
Wire Rope	
Wire Rope (Main Hoist)	
Diameter	14.3 mm (9/16 in)
Type	6 x 9 Bright EEIPS-IWRC
Length:	36.58 m (120 ft)

Wire Rope (Optional Below Deck Winch)	
Diameter	8 mm (5/16 in)
Length	30.5 m (100 ft)
Torque Converter	
Model	Borg Warner
Type	Hydraulic
Transmission	
Type	International Transmissions Limited
Model	PS-750
Type	Powershift
Travel Speed	
First	7.14 km/h (4.6 mph)
Second	13.0 km/h (8.1 mph)
Third	23.0 km/h (14.3 mph)
Fourth	37.7 km/h (23.4 mph)
Front Axle, Drive/Steer	
Type	Carraro
Model	26.18M-164
Ratio	10.66:1

ENGINE OIL SPECIFICATIONS

Oil Performance Recommendations

The use of quality engine lubricating oils combined with appropriate oil and filter change intervals are critical factors in maintaining engine performance and durability.

It is recommended that a high quality SAE 15W-40 heavy duty engine oil which meets the American Petroleum Institute (API) performance classification CE/SG.

NOTE: CF-4, CH-4, CI-4, or CJ-4 engine oils can be used in areas where CE oil is not available, but the oil change interval must be reduced to one half the interval given in the maintenance schedule.

A sulfated ash limit of 1.0 mass percent is suggested for optimum valve and piston deposit and oil consumption control. The sulfated ash must not exceed 1.85 mass percent.

Oil Viscosity Recommendations

The use of multi-viscosity lubricating oil has been found to improve oil consumption control and improve engine cranking in cold temperatures while maintaining lubrication at high operating temperatures.

While 15W-40 oil is recommended for most climates, refer to the viscosity recommendations for extreme climates (Figure 1-2).

NOTE: Limited use of low viscosity oils, such as 10W-30 may be used for easier starting and providing sufficient oil flow at ambient temperatures below -5°C (23°F). However, continuous use of low viscosity oils can decrease engine life due to wear.

New Engine Break-In Oils

Do not use special “break-in” lubricating oils for new or rebuilt engines. Use the same type of oil during the “break-in” as that which is used in normal operation.

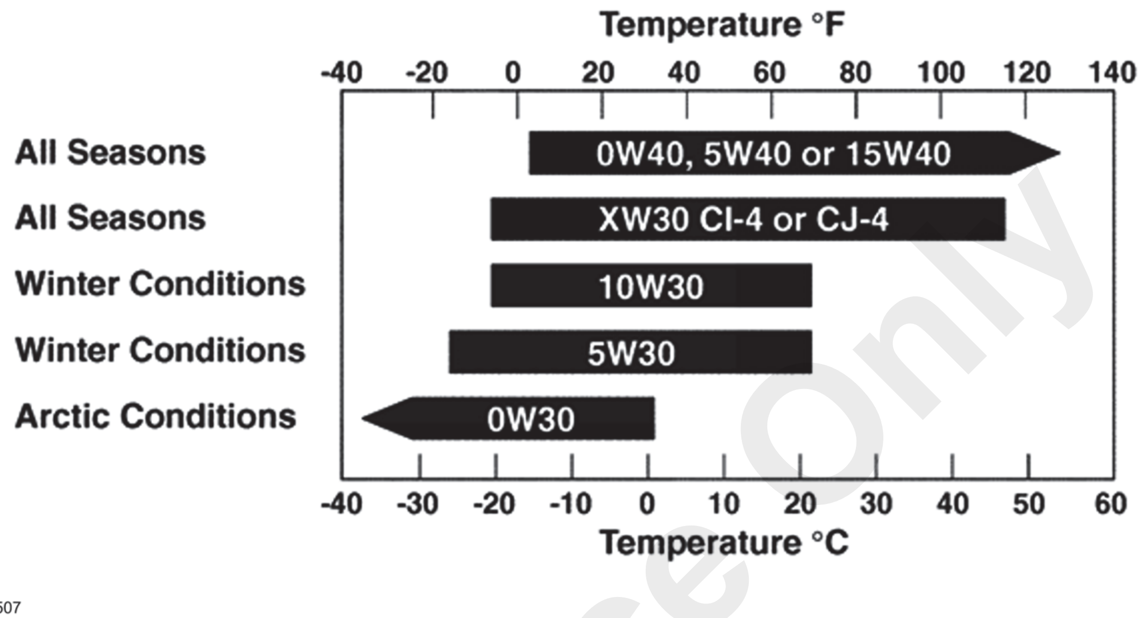
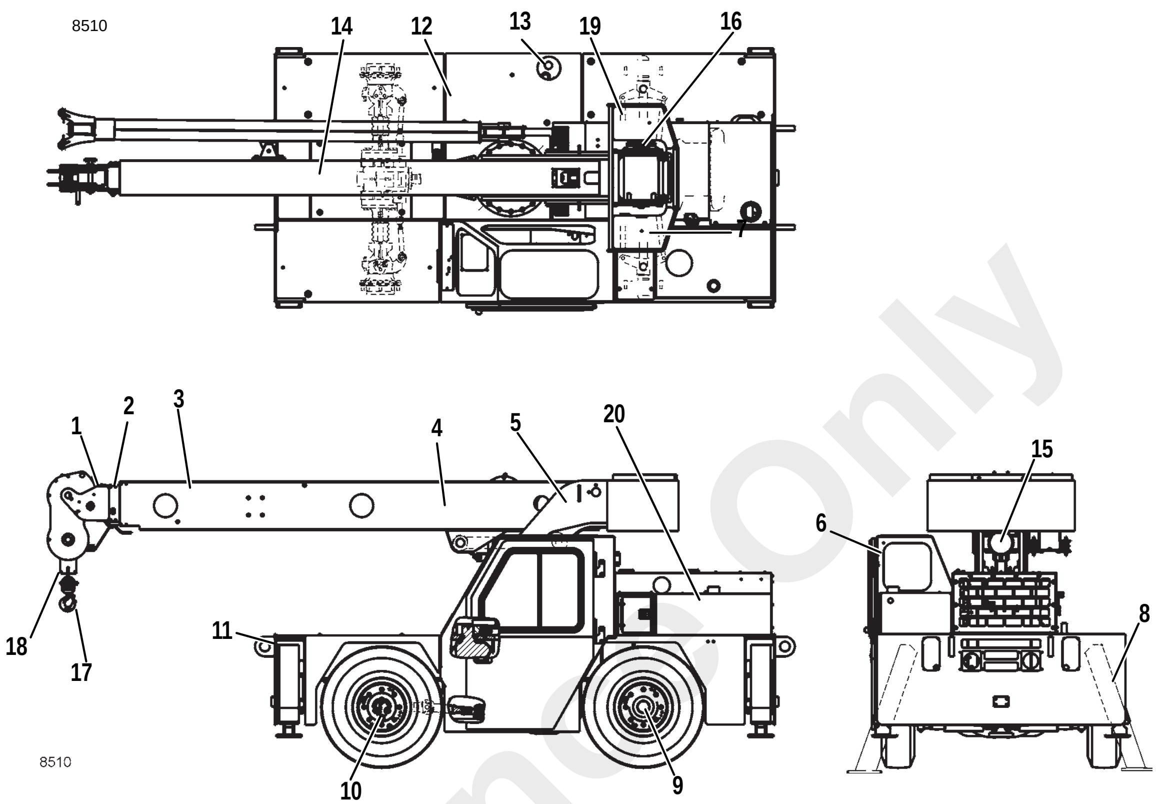


FIGURE 1-2

DIESEL FUEL

The Cummins Diesel Engine operates most efficiently with No. 2 diesel fuel in temperatures above 0°C (32°F). When operating in temperatures below 0°C (32°F), use No. 1 diesel fuel, or a blend of No. 1 and No. 2 diesel fuels, most commonly known as "Winterized" No. 2 diesel. Use ASTM No. 2 diesel fuel with a minimum Cetane number of 40. No. 2 diesel fuel gives the best economy and performance under most operating conditions. Fuels with Cetane numbers higher than 40 may be needed in high altitudes or extremely low ambient temperatures to prevent misfires and excessive smoke.

NOMENCLATURE



Item	Description	Item	Description
1	Inner Boom (3rd. Section)	11	Recessed Mounted Winch Location (Optional)
2	Intermediate Boom (2nd. Section)	12	Hydraulic Valve Location
3	Main Boom (1st. Section)	13	Right Side - Fuel Tank Location
4	Telescope Cylinder Location	14	Swing Gearbox and Motor Location
5	Mast	15	Lift Cylinder
6	Operator's Compartment	16	Hoist Gearbox, Motor and Brake
7	Engine Compartment	17	Drop Block
8	Outrigger	18	Double-Blocking Cutout Switch
9	Steering Axle	19	Counterweight
10	Drive/Steer Axle	20	Hydraulic Tank

FIGURE 1-3

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).

CAUTION

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 bearing cleaning instructions in this section.

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.

CAUTION

When using compressed air use only low air pressure and 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 with 10W30 oil or petroleum jelly before installation. Replace **all** used elastic locknuts with new parts.

HOSES AND TUBES

Inspection

1. If the hose end connections are damaged, always replace hoses and tubes. 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.
2. Be sure hoses are in good condition. If in doubt, replace them.
3. Replace hoses if any of the following occur:

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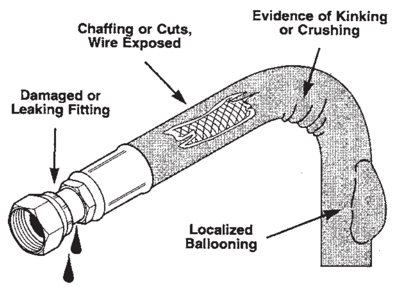

Check hoses carefully. Do not use your bare hands to check for leaks. See "Fluid Penetration". Tighten all connections to recommended torque. Replace if any of the following are found:

- End fittings damaged or leaking.

- Outer covering chafed or cut and wire reinforcing exposed.

- Outer covering ballooning locally.

- Hose shows evidence of kinking or crushing.

FIGURE 1-4

Installation

1. When installing a new hose, loosely connect each end and make sure the hose takes up the designed position before tightening the connection. Clamps should be tightened sufficiently to hold the hose without crushing and to inhibit chafing.
2. If a hose is replaced on a moving part, be sure it does not foul by moving the part through its complete range of movement.
3. Be sure any hose which has been installed is not kinked or twisted.
4. Free moving, unsupported hoses must never touch 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 recommended 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 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 to eliminate the possibility of injury.

FATIGUE OF WELDED STRUCTURES

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

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

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

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

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

LOCTITE®

> **⚠ CAUTION**
> **Skin and/or Eye Hazard!**
> Loctite® type adhesives contain chemicals that may be harmful if misused. Read and follow the instructions on the container.

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

Application of Medium Strength Loctite

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

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

NOTE: Ensure the threaded surface, both male and female, is clean of contaminants and free of dirt and oil.

Adhesive/Sealant Application

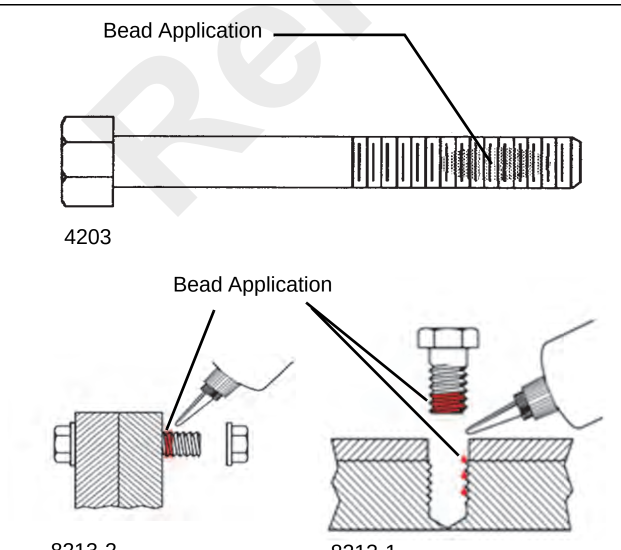

FIGURE 1-5

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 1-5).
2. In a blind hole application, a bead of several drops of adhesive should be applied into the bottom of the hole to be hydraulically forced up during engagement.
3. After application and engagement of mated threads, fixturing will occur within five (5) minutes. Time required to achieve full strength is 24 hours.

FASTENERS AND TORQUE VALUES

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

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

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

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

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

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

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

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

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

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

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

Torque Wrenches

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

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

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

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

- Torque wrenches must be those specified and forces must be applied at the handle grip. The use of handle extensions will change applied torque to the bolt.
- All handles must be parallel to the step wrench during final tightening. Multiplier reaction bars may be misaligned no more than 30 degrees without causing serious error in torque.
- Multiplier bar handles must be propped or supported within the outer 1/4 of the handle length, or serious under or over tightening will occur.

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

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

Torque Values

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

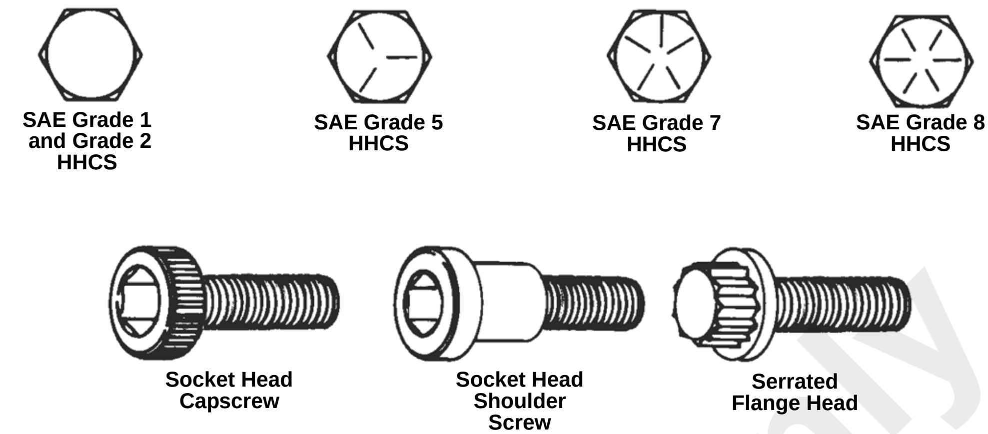

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FIGURE 1-6

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

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

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

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

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

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

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

Bolt Diameter - Metric

Torque Values (Nm)

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

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

Bolt Diameter - Metric

Torque Values (Nm, Maximum/Minimum)

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

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

Bolt Diameter - Metric

Torque Values (Nm)

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

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

Bolt Diameter - Metric

Torque Values (Nm, Maximum/Minimum)

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

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

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

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

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

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

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

Weld Studs

Unless otherwise specified the following grade 2 torque values (± 10%) apply.

Table 1-10: 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

T-2-4

O-RING FACE SEAL (ORFS) HYDRAULIC FITTINGS

ORFS fittings are used on the hydraulic system throughout carrier.

ORFS (O-Ring Face Seal) fittings have a straight thread and a flat face with an O-ring groove machined in the flat face. Sealing takes place by compressing the O-ring onto the flat face of the female connector.

Fittings with O-rings offer advantages over metal-to-metal fittings. Under or overtightening any fitting can allow leakage, but all-metal fittings are more susceptible to leakage because they must be tightened to a higher and narrower torque range. This makes it easier to strip threads or crack or distort fitting components, which prevents proper sealing.

Leaks can result from vibration, thermal cycling and from loads being supported by the connection (i.e. using the fitting in the connection to support mechanical loads).

Recommended O-Ring Face Seal Fitting (ORFS) Assembly Instructions

1. If installing new fittings, inspect for possible contamination or damage from shipping or handling. Confirm face seal O-ring is properly installed.
2. Lubricate the threads and the O-ring with your systems hydraulic fluid or a light lubricant.
3. Align mating face seal flange against O-ring and finger tighten face seal flange nut.
4. Torque flange nut to the value shown in the table below.

Alternate Assembly Method

1. If torque method not possible, follow steps 1-3 above, then proceed to the steps below.
2. Lightly wrench tighten the nut until there is firm resistance.
3. Place a wrench on wrench pad next to nut as near the 6 o’clock position as possible.

4. Place second wrench on nut as near the 3 o'clock position as possible.
5. Turn nut clockwise to no less than the 4 o'clock position, but no more than the 6 o'clock position. Required rotation generally decreases as size increases.

Fitting Size	Dash Size	Thread Size	Torque ft-lbs
ORFS 4	-04	9/16-20	10-12
ORFS 6	-06	11/16-16	18-20
ORFS 8	-08	13/16-16	32-35

Fitting Size	Dash Size	Thread Size	Torque ft-lbs
ORFS 10	-10	1-14	45-50
ORFS 12	-12	1 3/16-12	65-70
ORFS 16	-16	1 7/16-12	92-100
ORFS 20	-20	1 7/8-12	125-140
ORFS 24	-24	2-12	150-165

TORQUE VALUES: The minimum torque values listed are to provide a benchmark that give optimum results for leak free connections. Actual torque values should be based on individual application.

HYDRAULIC FITTING F.F.F.T. METHOD (FLATS FROM FINGER TIGHT)

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

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

Follow these steps when tightening all fitting connections:

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Align tube or hose to the mating fitting and check to see that the flare seats properly on the nose of the fitting.
3. Finger tighten the nut onto the fitting. If necessary, a wrench should be used to seat the nut snugly against the fitting. This is considered the FINGER TIGHT condition.
4. Using a permanent-type ink marker, make a mark on one of the flats of the nut and continue it onto the hex of the static fitting or port (Figure 1-7.)
5. Tighten the joint by the number of flats (F.F.F.T.) as specified in Table 1-11 and Table 1-12 for size and type of fitting.
6. (Optional for future tightening of the same connection.) Extend the line from the nut at its new location onto the hex of the static fitting or port (Figure 1-7).

a0027

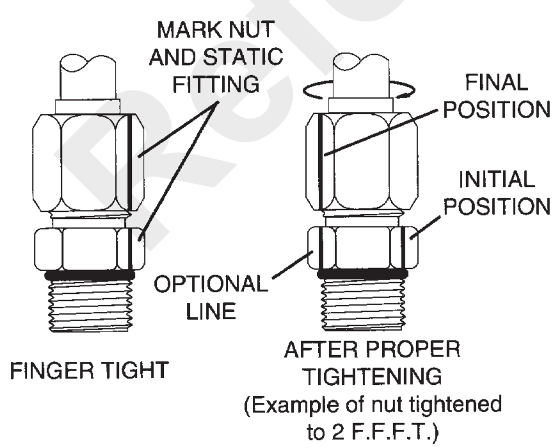


FIGURE 1-7

37°Flared Steel Fitting - Tube or Hose to Fitting (Table 1-11)

See Hydraulic Fitting F.F.F.T. Method in this section.

a0028

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

Table 1-11

Adjustable Straight Thread O-ring Fitting - Fitting to Port (Table 1-6)

a0029

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

Table 1-12

1. Inspect both mating parts for burrs, nicks, scratches, or foreign particles.
2. Lubricate O-ring with a light coat of clean oil (Figure 1-8 A).
3. Back off locknut as far as possible (Figure 1-8 A).
4. Screw fitting into port by hand until the backup washer contacts face of port and is pushed all the way towards the locknut (Figure 1-8 B & C).
5. To orientate the fitting, unscrew the fitting the required amount, but not more than one full turn (Figure 1-8 D).

6. Hold the fitting in the desired position and tighten the nut (Figure 1-8 D) following the F.F.F.T. method, see Hydraulic Fitting F.F.F.T. Method starting with step 4.

a0030

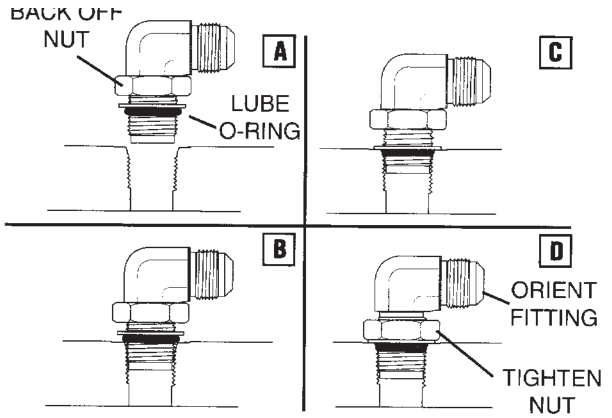


FIGURE 1-8

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

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Lubricate O-ring with clean oil (Figure 1-9).
3. Turn fitting until finger tight.
4. Using the assembly torque method, tighten to given torque for size from Table 1-13.

a0031

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

Table 1-13

a0032

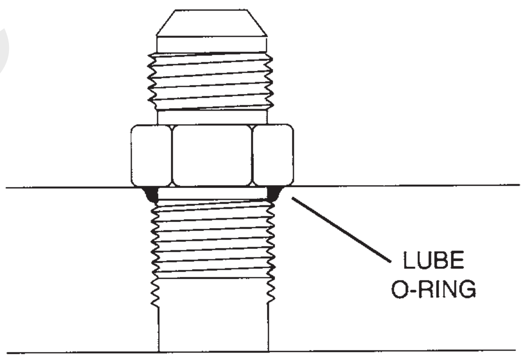


FIGURE 1-9

SECTION 2
SAFETY PRACTICES

SECTION CONTENTS

GENERAL

Some of the SERVICE work involves the need to drive the Crane. The operators 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 symbol means **Attention! Become Alert! Your Safety is involved!** The symbol is used with the following signal words to attract your attention to safety messages found on the decals and throughout this manual. The message that follows the symbol contains important information about **Safety**. To avoid injury and possible death, ***carefully read the message!*** Be sure to fully understand the causes of possible injury or death.

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

The signal word DANGER denotes that an extremely hazardous situation exists on or near the machine which would result in high probability of death or irreparable injury if proper precautions are not taken.

WARNING

The signal word WARNING denotes a hazard exists on or near the machine which could result in injury or death if proper precautions are not taken.

CAUTION

The signal word CAUTION denotes a reminder of safety practices or directs attention to unsafe practices on or near the machine which could result in personal injury if the proper precautions are not taken.

CAUTION

The signal word CAUTION without the safety alert symbol denotes a hazard that will cause property damage if the proper precautions are not taken.

NOTE: 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 machine 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

.

Table 2-1
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 clothes 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.	Fumes, dust and paint spray are unpleasant and harmful.
Hearing Protection	Use ear protection if noise is excessive.	A loud noise may damage your hearing. The greater the exposure, the worse the damage.
Hand Protection	Use protective cream before work and clean hands thoroughly after.	Prevents irritation and skin contamination.
Foot Protection	Wear protective footwear with reinforced toe caps and oil-resistant soles.	Protects feet from falling objects and to avoid slipping.
Lifting	Make sure you are capable of lifting the object. If in doubt, get help.	Avoids injury through incorrect handling of components.

Table 2-2
Equipment Considerations

	What to Do	Why
Operators Cab	Before using the crane, be sure the operators cab is secure.	Inhibits operator injury from parts of operators 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. Never stand under a suspended load.	Prevents serious injury or death due to falling objects. 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. Look around before using an air hose.	Prevents serious injury to operator and/or bystanders. Bystanders may get grit into their eyes, ears or skin.
Hand Tools	Never use the wrong tool for the job. Always use the recommended tool. Always keep tools clean and in good working condition.	Many cuts, abrasions and injuries are caused by defective or wrong tools. These tools will reduce work, labor and cost.

Table 2-3
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. <u>Make sure you know the location of the First Aid Box.</u>	What appears at first trivial could become painful and injurious. Results in quick application of aid procedures.
Cleanliness	Plug all hose ends and connections. Clean exterior of all parts before repairing.	Ensures optimum performance. Dirt and abrasive dust can reduce the efficiency and working life of a component and lead to costly replacement.

Table 2-4
Operatiional Considerations

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

Table 2-4
Operatiional Considerations

	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.

Final Word

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

SECTION 3
ELECTRIC SYSTEM

SECTION CONTENTS

GENERAL

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

CAUTION

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

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

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

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

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

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

To Find:

EMF (Voltage) - Multiply CURRENT (amps) by RESISTANCE (Ohms)

RESISTANCE (Ohms) - Divide EMF (voltage) by CURRENT (amps)

CURRENT (Amps) - Divide EMF (voltage) by RESISTANCE (Ohms).

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

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

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

Comparing Electrical System to a Hydraulic System

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

Table 3-1
Comparing Electrical System and Hydraulic System

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

Magnetism

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

MAIN ELECTRICAL SYSTEM

General

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

An alternator supplies the necessary current (amps) for system operation, and charging of the battery, when the engine is running. A voltage regulator on the alternator controls the voltage in the charging system. A voltmeter is installed in the instrument panel in the cab for monitoring the battery charge.

Wire Harnesses

Seven wire harnesses connect the electrical system components:

1. Dash Wire Harness
2. Outrigger Wire Harness (Cab)
3. Outrigger Wire Harness (Circuit Board to Cab)
4. Outrigger Wire Harness (Circuit Board to Outrigger Valve)
5. Main Frame Wire Harness
6. Transmission Wire Harness
7. Engine Wire Harness

Fuse and Relay Replacement

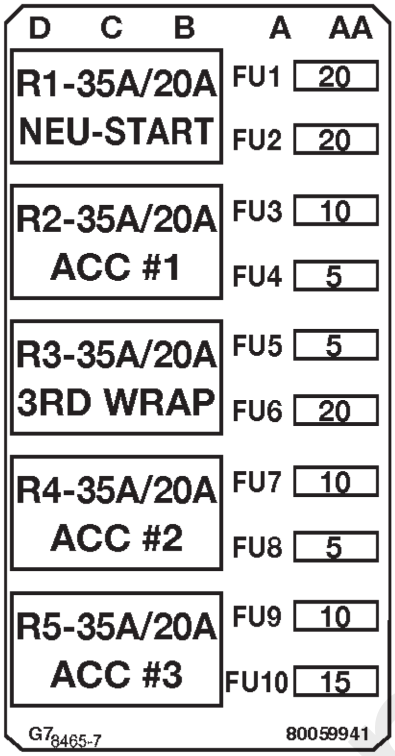
The fuses and relays are located on fuse blocks under the control panel (Figure 3-1, 3-2 and 3-3) and in the electrical compartment behind the cab (Figure 3-4 and 3-5).

The following figures show the fuse location, rating and circuit functions.

8465-5 Fuse Box 1

8465-6 Fuse Box 2

FIGURE 3-1



8465-7

FUSE BOX #1
CIRCUIT IDENTIFICATION

FU1 – 20 AMP – 60 – DEFROSTER, HEATER, DOME/STROBE LIGHTS

FU2 – 20 AMP – 68 – WIPERS, WASHER, SWING LOCK

FU3 – 10 AMP – 718 – SHIFTER, TCU, TRANS OIL COOLER, BACK UP ALARM

FU4 – 5 AMP – 2274 – O/R MONITORING

FU5 – 5 AMP – 849 – PARK BRAKE, BRAKE LIGHT SWITCH

FU6 – 20 AMP – 46 – OUTRIGGERS, WINCH

FU7 – 10 AMP – 71 – LMI, CRANE FUNCTIONS

FU8 – 5 AMP – 221 – GUAGE CLUSTER, SWITCH LED'S

FU9 – 10 AMP – 980 – STEERING SELECT

FU10 – 15 AMP – 11 – HEAD & TAIL LTS, WORKLIGHTS, TURN SIGNALS/4 WAYS

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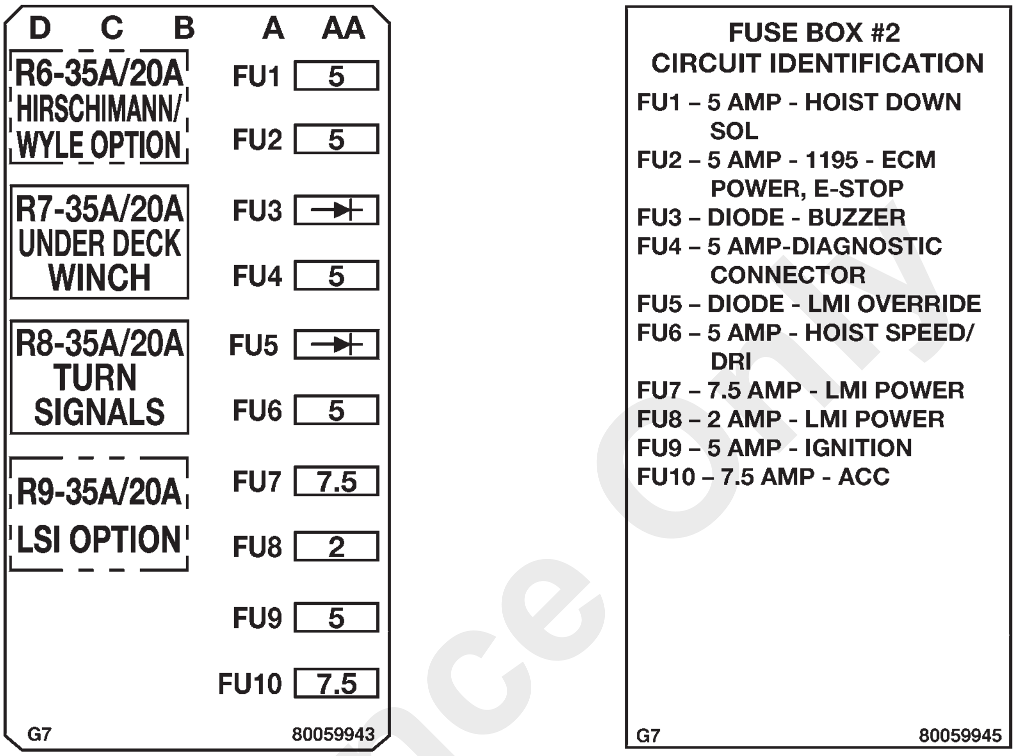
8465-8

FIGURE 3-2



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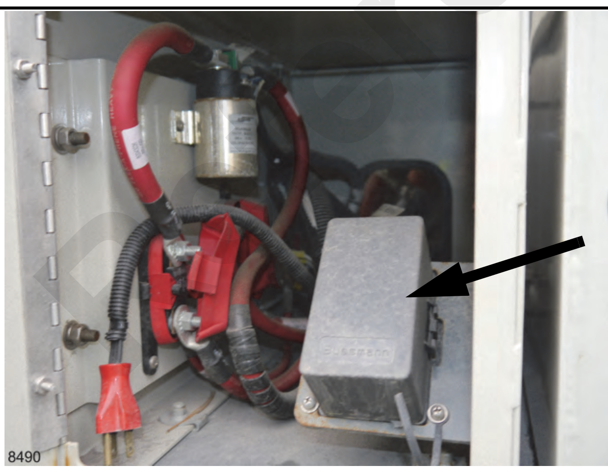
8465-10

8465-10

FIGURE 3-3



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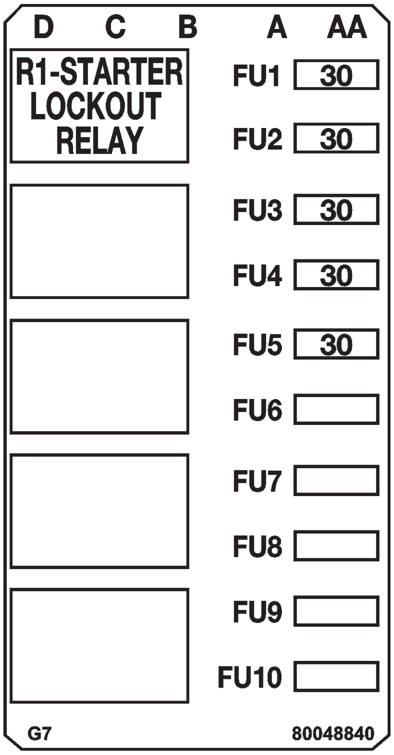
8490

Fuse Box 3

FIGURE 3-4



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8465-11

FUSE CIRCUIT IDENTIFICATION

FU1 30 AMP - IGN SW, ACC #2 RELAY
FU2 30 AMP - ACC #1 RELAY
FU3 30 AMP - ENGINE ECM POWER
FU4 30 AMP - HEAD/WORK LIGHTS, GAGE CLUSTER
FU5 30 AMP - ACC #3 RELAY
FU6 OPT - T3 ENGINE START RELAY
FU7 SPARE
FU8 SPARE
FU9 SPARE
FU10 SPARE
R1 STARTER LOCKOUT RELAY

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8465-12

8465-12

FIGURE 3-5

CHARGING SYSTEM

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

Battery

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

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

Voltmeter

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

Resistor

The resistor is used to reduce the voltage on the field connection (D+) at the alternator. When the alternator is working, the field does not require full system voltage, therefore the resistor reduces the voltage to approximately 9 volts DC.

Special Precautions

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

Battery Maintenance and Charging

Battery

A maintenance-free battery is used on this machine. A limited amount of maintenance is required on the battery. See Preventive Maintenance.

Charging the Battery

WARNING

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

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

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

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

Battery Replacement

Removal

1. Remove the negative battery cables.
2. Remove the positive battery cables.
3. Tag and disconnect leads from the battery terminals starting with the positive terminals.
4. Remove the nuts and washers from the bracket hold down rods. Remove the hold down bracket.
5. Remove the battery.

Installation

1. Place the battery in the battery box.
2. Install the hold down bracket so it can hold down the battery. Secure the bracket (and battery) to the bracket hold down rods with nuts and washers.
3. Connect leads to the battery terminals starting with the positive terminals.
4. Verify replacement battery works by starting crane's engine and operating various crane components.

STARTING CIRCUIT

The starting circuit includes the battery, starter motor and solenoid, starter relay, neutral start relay, fuel shut-off valve, travel select switch, and the ignition switch.

General Inspections

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

1. Check battery condition. Charge or replace the battery as necessary. Clean battery posts and cable connectors.
2. 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 and wire harness plugs. Clean and tighten all connections and replace any bad wiring.
3. If the starter still does not operate after correcting the circuit, perform the Starting Circuit Check.

Starting Circuit Check

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

CAUTION

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

1. Place the ignition switch in the OFF position and place the travel select lever in neutral.
2. See the electrical schematic at the end of this manual. Momentarily connect a jumper cable to the “B” and “S” terminals on the starter solenoid.
   a. If the starter operates, the starter and solenoid are good. The problem is somewhere between the solenoid and the ignition switch. Go to step 3.
   b. If the starter does not operate, connect the jumper cable to the “B” and “M” terminals on the starter solenoid. If the starter operates correctly, the problem is in the starter solenoid. Replace the solenoid. If the starter still does not operate, the starter is bad and must be repaired or replaced.
3. Check the voltage at the “BAT” terminal of the ignition switch. If no voltage is indicated, there are wrong connections or damage to the wiring between the starter and the ignition switch. If voltage is indicated, go to step 4.
4. Turn the ignition switch to the START position and check voltage at the start terminal. Go to step 5 if voltage is indicated. If no voltage is indicated, replace the ignition switch.
5. Have someone hold the key switch in the START position, check for voltage at wires 21 and 21A on the neutral start relay located under the instrument panel. Make sure the travel select lever is in the NEUTRAL position.

   If voltage is indicated at the relay wire 21A, go to step 6. If there is no voltage at wire 21, check the wire to the ignition switch. If there is voltage at wire 21 and no voltage at wire 21A, replace the relay.
6. Turn the ignition switch to the START position. Connect a jumper wire between wires 21A and “B” on the starter solenoid. If the starter operates, the starter relay is defective and must be replaced. If the starter did not operate, go to step 7.
7. With the ignition switch in the START position, check for voltage at the switch “S” terminal of the starter solenoid. If there is no voltage, the problem is in the wire from the

starter relay to the starter solenoid. Repair or replace the wiring. If voltage is indicated, the problem is in the starter solenoid.

INSTRUMENT AND LIGHT CIRCUITS

General

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

Light Bulbs

Table 3-2
Light Bulbs

Location	Part No.	Trade No.
Panel Lights	71421	T-61
Head Lights	--	4411 Sealed
Tail Lights	--	1157
Turn Signal	--	1156
Work Lights	--	4411 Sealed
Mast Lights	--	4411 Sealed

Gauges and Indicators

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

Fuel Gauge

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

Engine Oil Pressure Indicator

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

Engine Temperature Gauge

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

Voltmeter Display

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

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

Hour Meter

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

ECM Display Toggle Switch

FIGURE 3-6

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

Table 3-3: Voltage Level Conditions

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

ACCESSORY CIRCUITS

Anti-Double Blocking System

General

This mechanism inhibits the hook block from being pulled into the boom head during extension of the booms, raising of the booms, and during hoist operation. When the hook block actuates the limit switch on the boom head, oil flow to the telescope cylinder, lift cylinder, and hoist motor is stopped. A horn is activated to give a warning to the operator in all cases. To move the hook block away from the boom head, the operator must lower the hoist block, retract the boom or lower the boom.

Circuit Description

See the wiring diagrams in Schematics/Wiring Diagrams. Power is made available through a 20 amp fuse to the circuit relay under the console in the cab and to the limit switch on the boom head. When the hook block reaches the upper limit, the limit switch closes, energizing the relay. The energized relay activates the three anti-double blocking solenoid valves in the lift, telescope, and hoist circuits.

Electric Swivel

On machines with a load indicator and/or anti-double blocking system, an electrical swivel is installed at the center of the mast rotation. The swivel gives electric current continuity through full rotation of the mast.

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 at the end of this manual for the circuit. 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).

WIRE HARNESSES

Engine Wire Harness

The engine wire harnesses (Figure 3-7) supply electrical current from the battery to the charging circuit, starting circuit, and senders attached to the engine. It also supplies the current to the main frame wire harness.

Transmission Wire Harness

The transmission wire harness (Figure 3-8) supplies electrical current to transmission solenoid valves, speed sensor, and oil pressure sender. It connects to the ECU in the instrument panel.

Main Frame Wire Harness

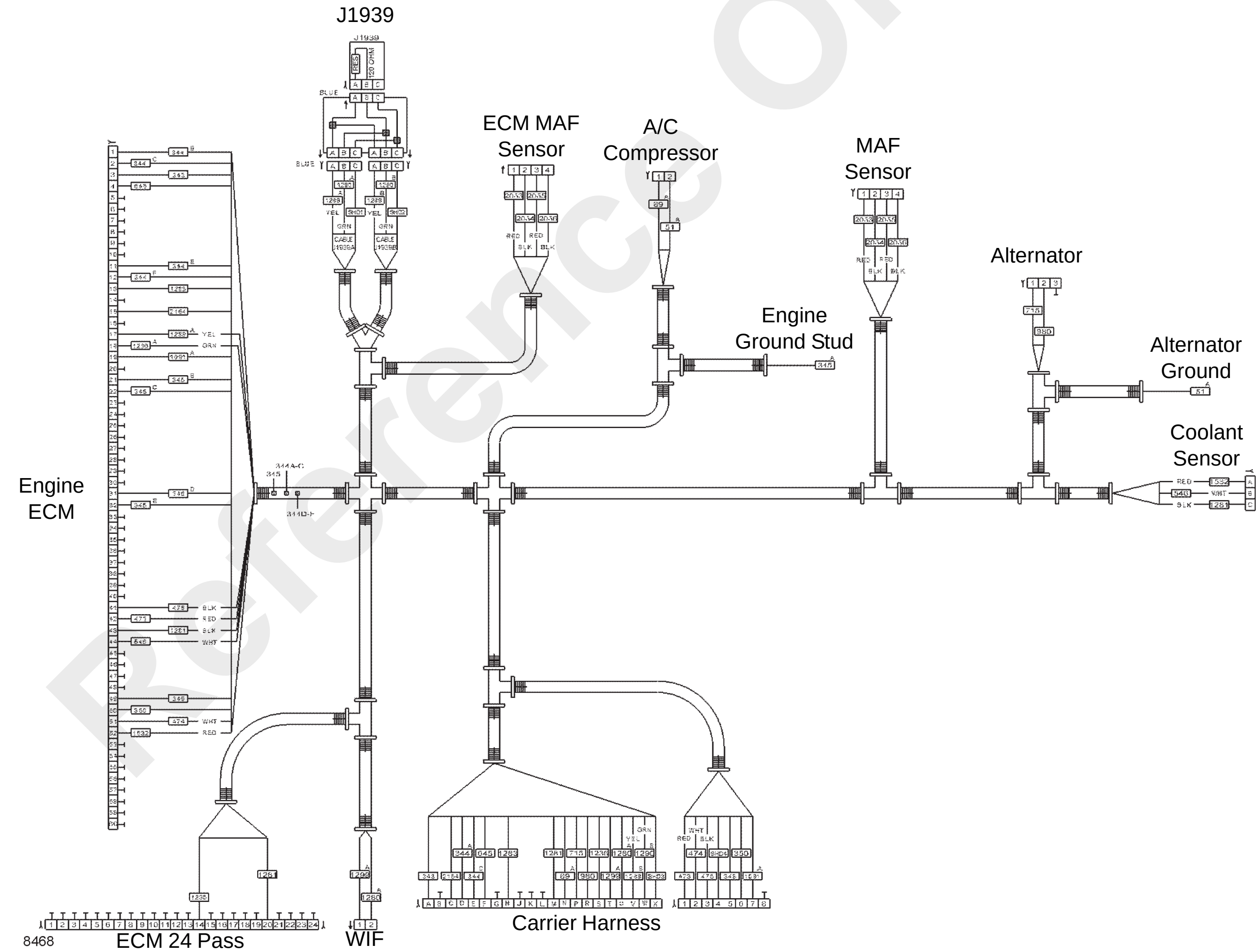
The main frame wire harness (Figure 3-9, Figure 3-10, and Figure 3-11) supplies electrical current to operate the electrical components attached to the main frame. It also connects to the instrument panel and engine wire harnesses.

Instrument Panel Wire Harness

The instrument panel wire harness (Figure 3-12) supplies electrical current to the gauges, lights and switches in the instrument panel. It also connects to the outrigger panel wire harness and transmission wire harness.

Cab Wire Harness

The cab wire harness (Figure 3-13) supplies power to the electrical devices in the cab.



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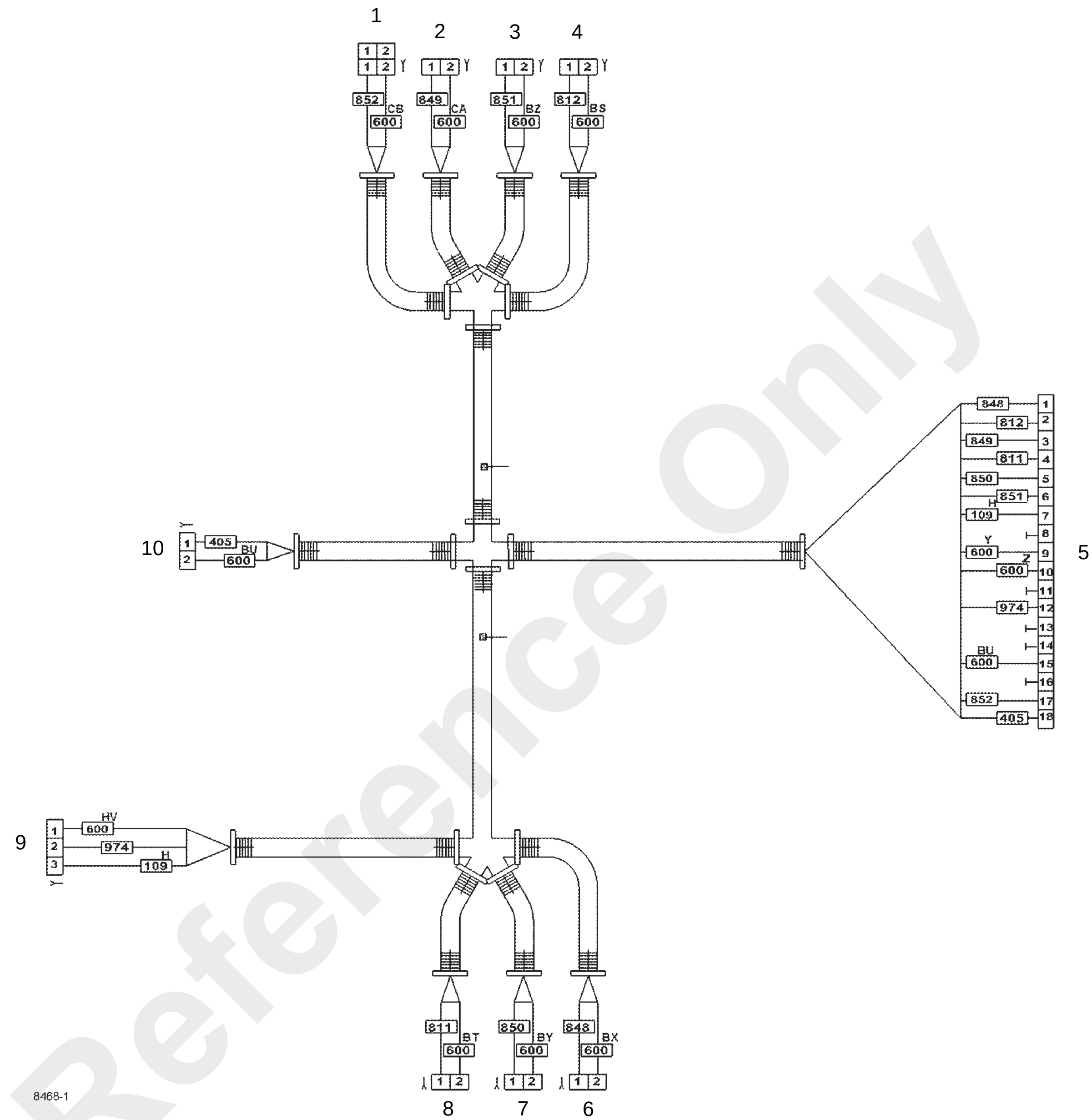
Engine Wire Harness

FIGURE 3-7

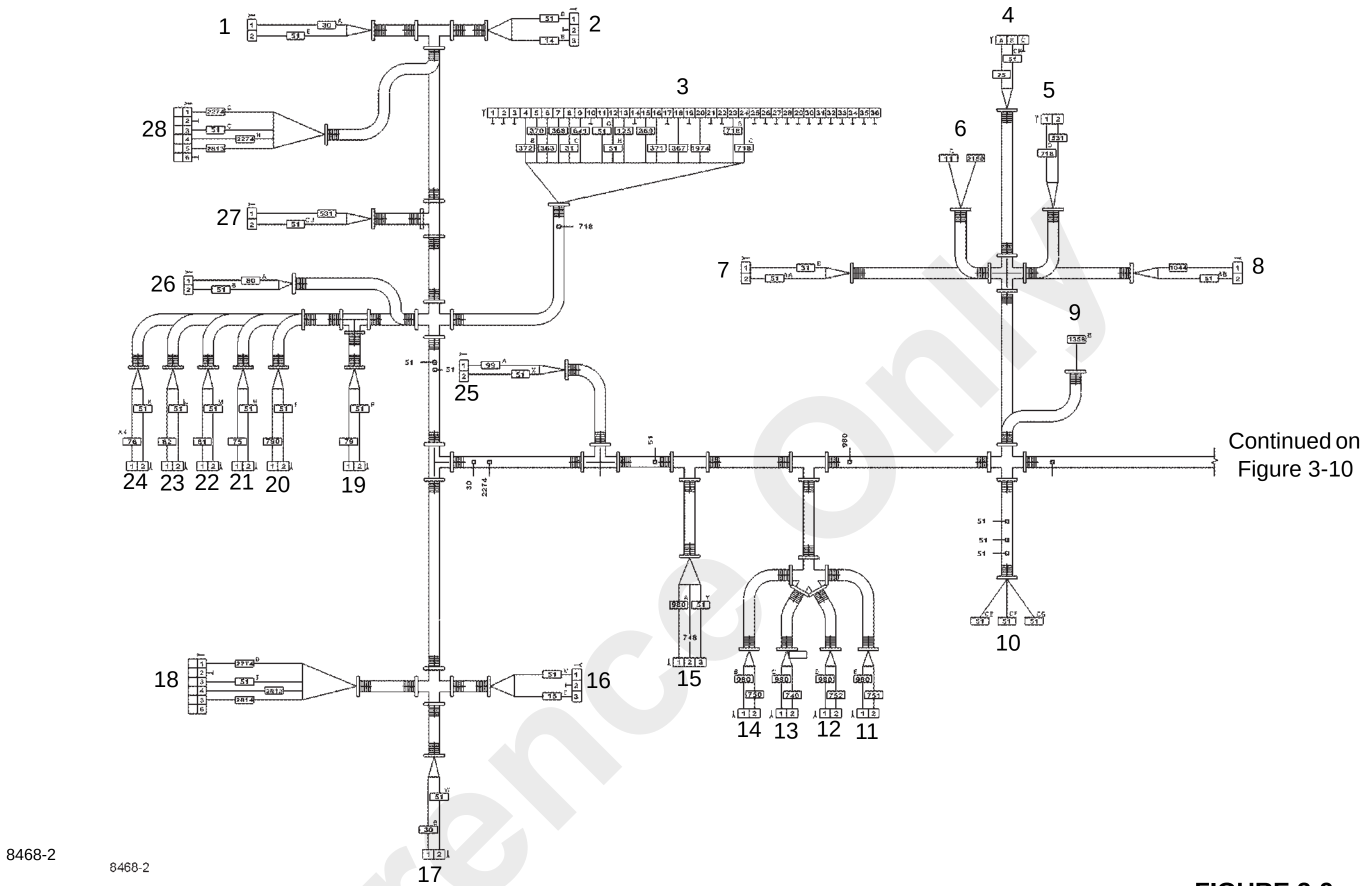


8468-1

Transmission Wire Harness

FIGURE 3-8

Item	Description
1	4WD
2	Forward Low Solenoid
3	Main Shaft Solenoid
4	Reverse High Solenoid
5	Gearbox Connector
6	Reverse Low Solenoid
7	Layshaft Solenoid
8	Forward High Solenoid
9	Speed Sensor
10	Pressure Switch

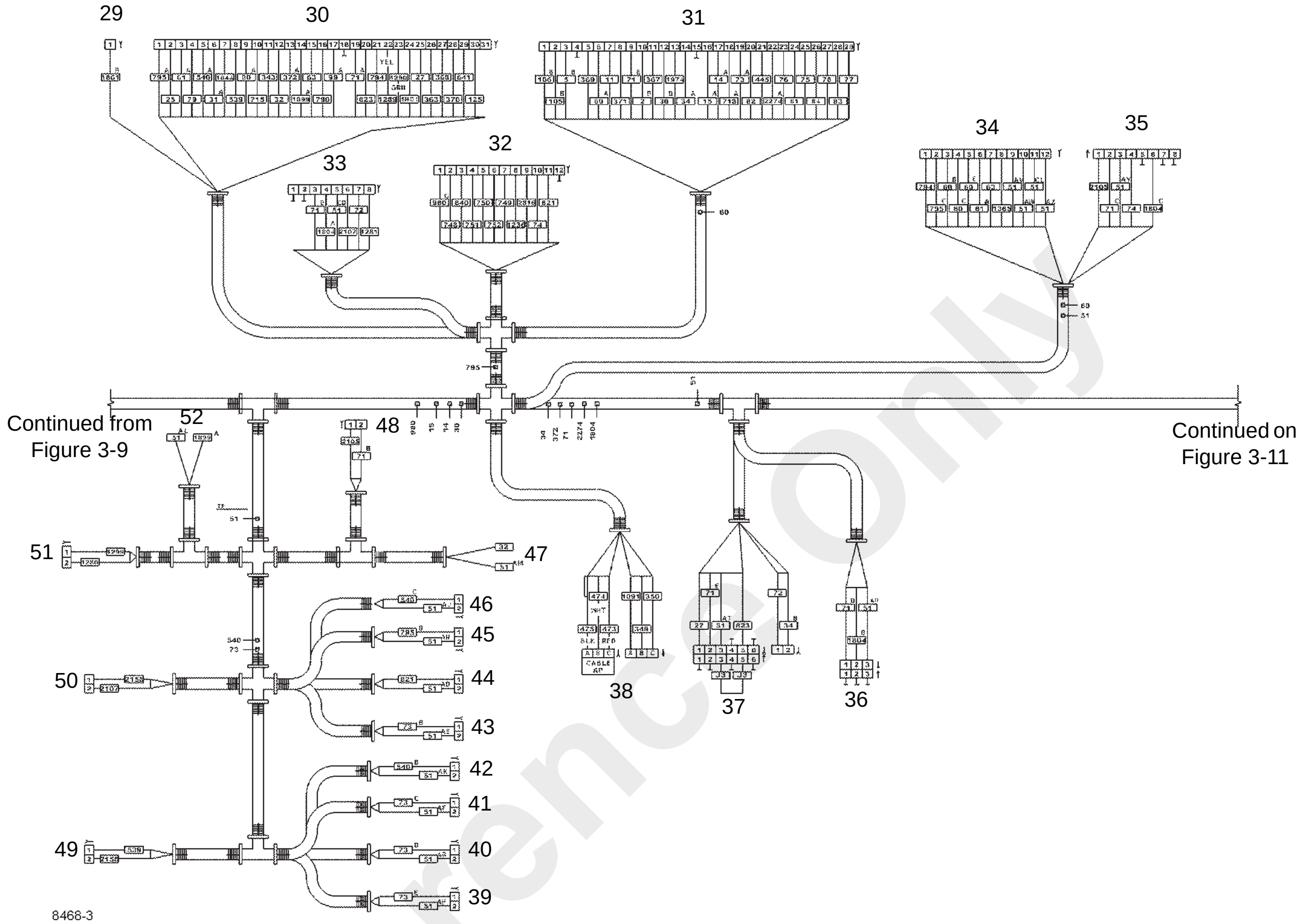


Main Wire Harness Sheet 1

FIGURE 3-9

Item	Description
1	Right Front Headlight
2	Right Front Signal Light
3	Transmission Module
4	Transmission Oil Temperature Switch
5	Transmission Oil Cooling Fan Switch
6	Brake Light Pressure Switch
7	Parking Brake
8	Low Brake Pressure Switch
9	Battery
10	Ground Tab
11	Crab Steer Solenoid
12	4 Wheel Steer Solenoid
13	Crab/4 Wheel Steer Common
14	2 Wheel Steer Solenoid

Item	Description
15	Front Steering Proximity Switch
16	Left Front Signal Light
17	Left Front Headlight
18	Left Hand Front OMS
19	Outrigger Extend
20	Winch
21	Right Front Outrigger Beam
22	Right Front Outrigger Jack
23	Left Front Outrigger Jack
24	Left Front Outrigger Beam
25	Horn
26	Outrigger Retract
27	Transmission Cooler Solenoid
28	Right Hand Front OMS



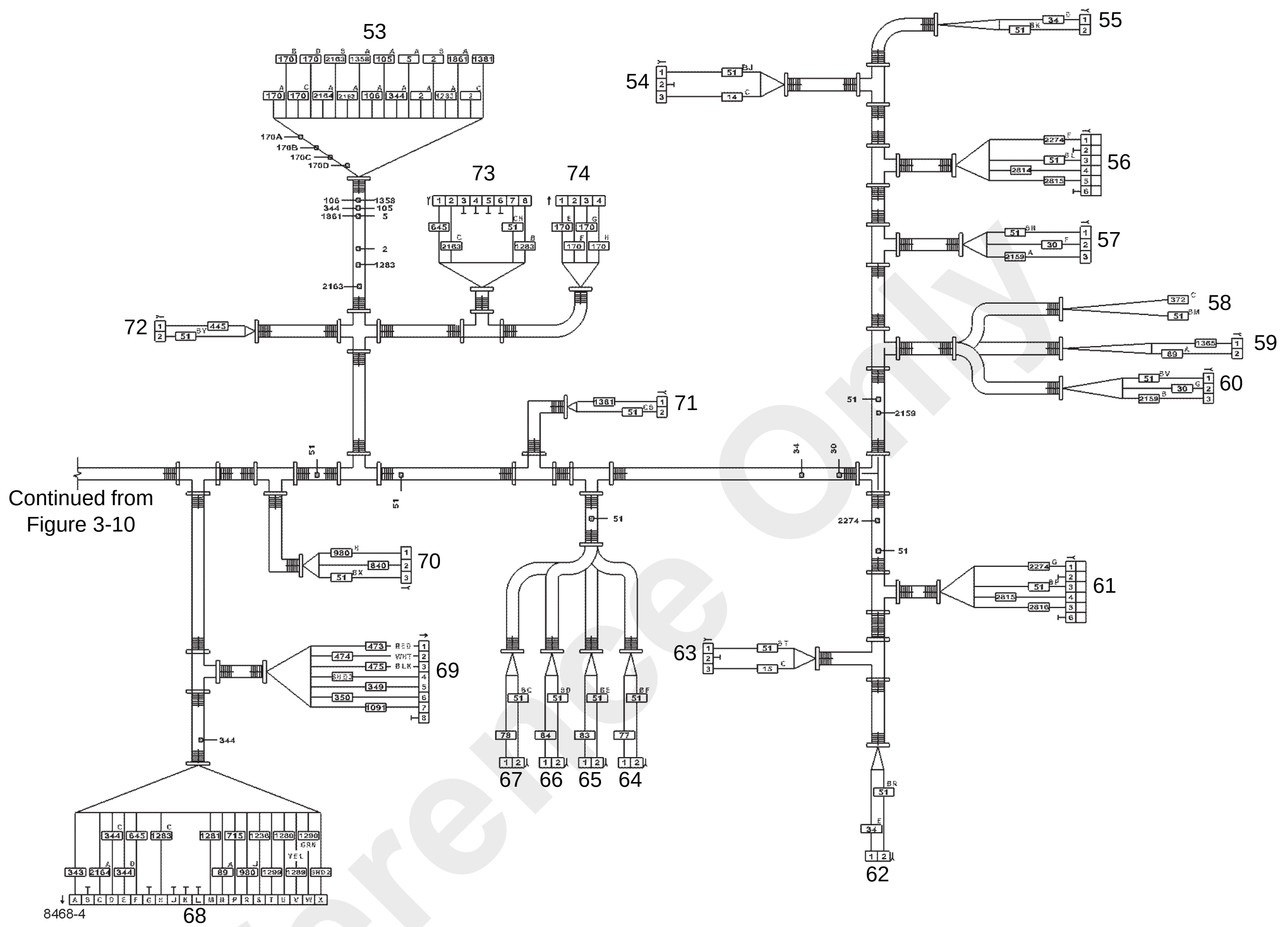
8468-3

FIGURE 3-10

Main Wire Harness Sheet 2

Item	Description
29	To Dash Harness P6
30	To Dash Harness P1
31	To Dash Harness P2
32	To Dash Harness P3
33	To Dash Harness P5
34	Rear Cab Harness
35	Rear Cab Harness
36	Slew Proximity Sensor
37	Swivel
38	Throttle Pedal
39	Hoist Up
40	Boom Down

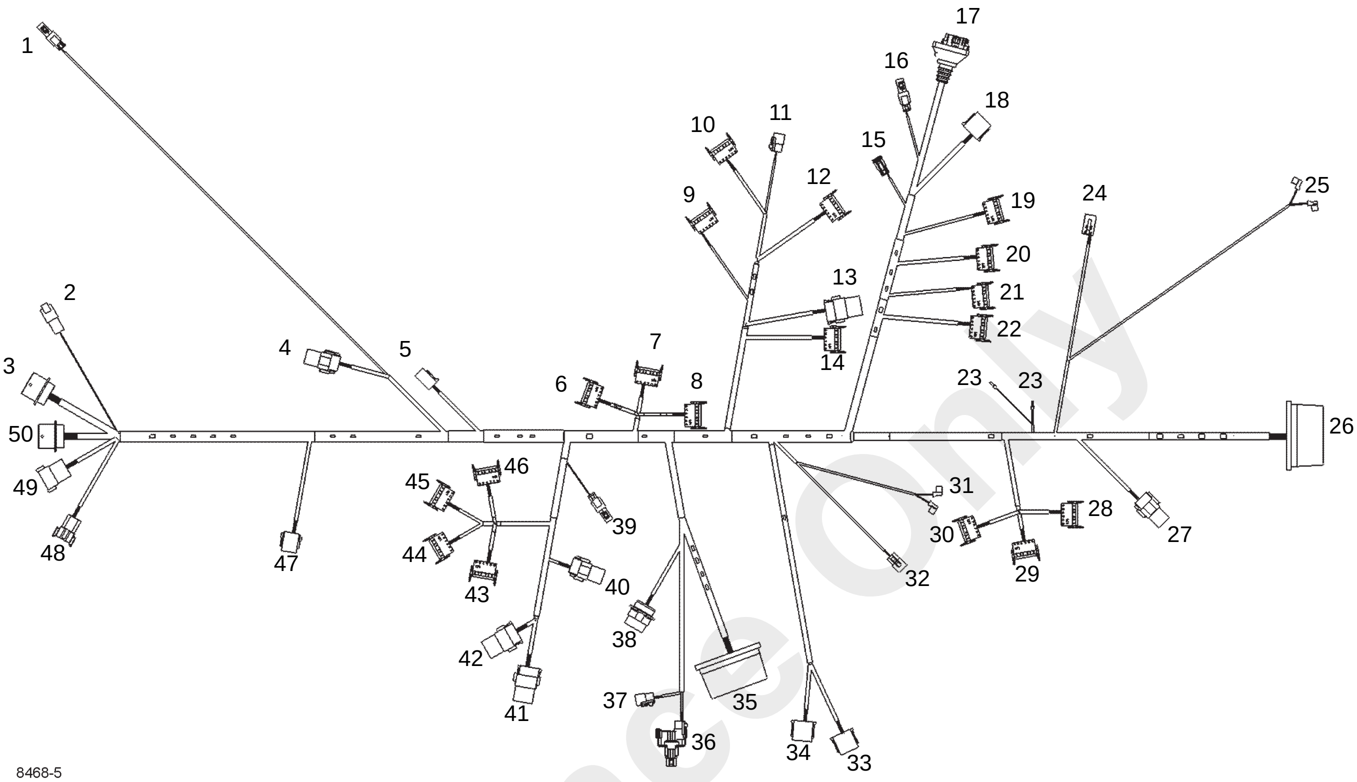
Item	Description
41	Telescope Out
42	Swing Right Unlock
43	Boom Up
44	Hoist Down
45	Crane Power
46	Swing Left Unlock
47	Fuel Sender
48	Load Sense Pressure Switch
49	Swing Right Lock Pressure Switch
50	Swing Left Lock Pressure Switch
51	WIF Sensor
52	Outrigger Alarm



Main Wire Harness Sheet 3

FIGURE 3-11

Item	Description
53	Fuse/Relay Box
54	Right Rear Turn Signal
55	Right Rear Work Light
56	Right Hand Rear OMS
57	Right Rear Stop/Tail
58	Backup Alarm
59	A/C Binary Switch
60	Left Rear Stop/Tail
61	Left Hand Rear OMS
62	Left Rear Work Light
63	Left Rear Turn Signal
64	Right Rear Outrigger Beam
65	Right Rear Outrigger Jack
66	Left Rear Outrigger Jack
67	Left Rear Outrigger Beam
68	To Engine
69	To Engine
70	Rear Steer Proximity Switch
71	Unloader Solenoid
72	Hydraulic Temperature Switch
73	Relay Coils
74	Power Distribution



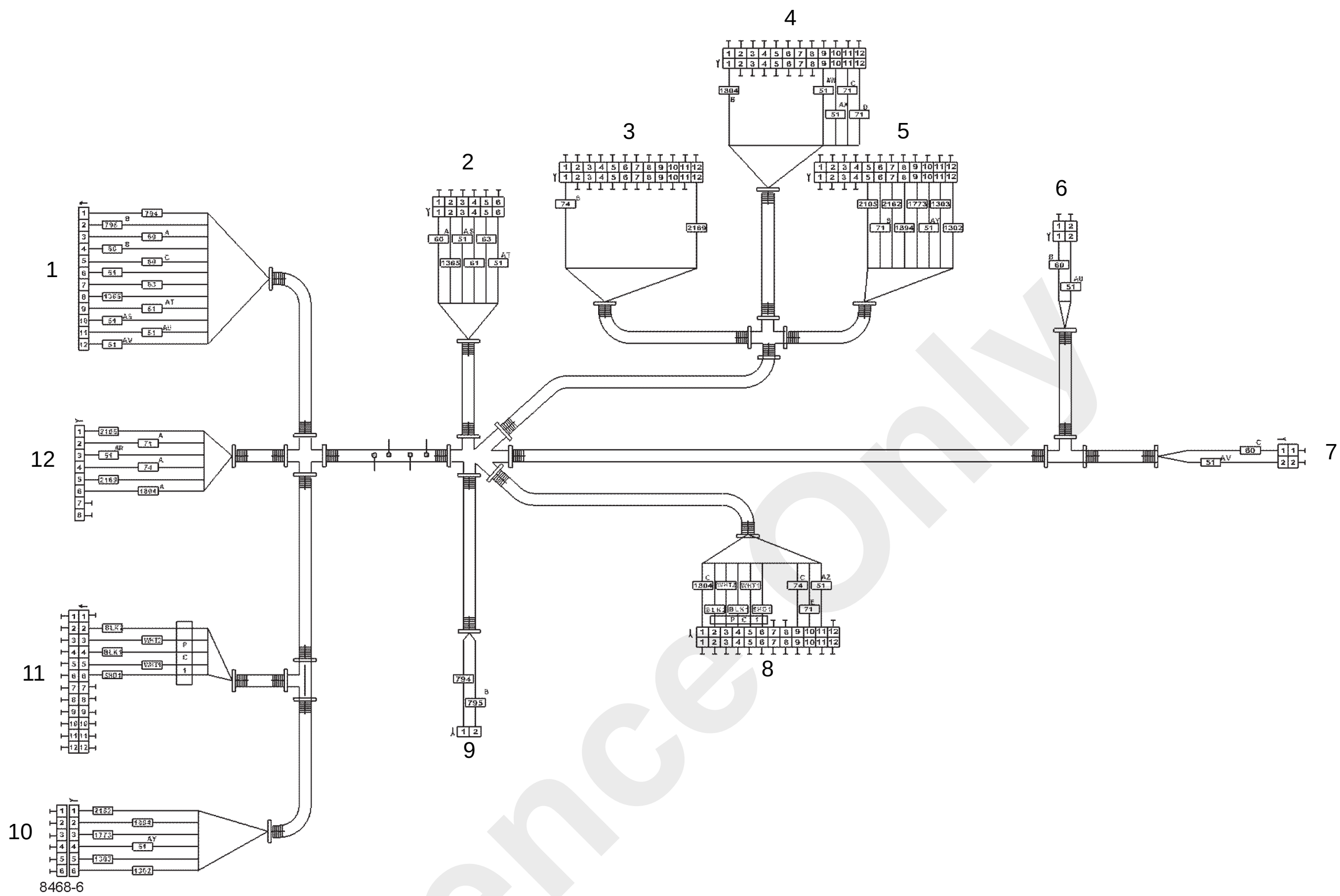
8468-5

Instrument Panel Wire Harness

FIGURE 3-12

Item	Description
1	Skylight Wiper
2	Carrier P6
3	Carrier P1
4	46 Splice
5	Ignition Switch
6	Parking Brake
7	Crane Power
8	Hazard Switch
9	Locked Indicator
10	RCL Override
11	LSI Display
12	Winch Switch
13	71 Splice
14	Swing Lock Switch
15	Screen Toggle Switch
16	Defroster Fan
17	Cluster Gauge
18	RCL Display
19	Defrost Switch
20	Heater Switch
21	Hoist Speed Switch
22	Outrigger Extend/Retract Switch
23	Emergency Stop Switch
24	Windshield Wiper
25	Windshield Washer

Item	Description
26	Fuse Box 1
27	221 Splice
28	Headlights/Worklights
29	2WD/4WD Select Switch
30	Steer Select Switch
31	Transmission Pressure Alarm
32	Flasher
33	Shift/Turn Left
34	Shift/Turn Right
35	Fuse Box 2
36	J1939 Orange
37	J1939 Blue
38	Diagnostic
39	Thumb Thumper
40	Ground Splice 3
41	Ground Splice 1
42	Ground Splice 2
43	Outrigger Left Rear
44	Outrigger Right Front
45	Outrigger Right Rear
46	Outrigger Left Front
47	Return to Center Steer
48	Carrier P5
49	Carrier P3
50	Carrier P2



8468-6

Cab Wire Harness

FIGURE 3-13

Item	Description
1	Carrier
2	Heater/Air Conditioner
3	RCI A
4	RCI B
5	RCI C
6	Dome Light
7	Strobe
8	i 4300 CPU
9	Seat Switch
10	CE Bridging Key
11	i4300 Cable 60
12	Carrier

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 as your guide.

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

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

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

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

Table 3-4
Amp Extraction Tool Table

Description	Amp Part Number	Grove Part Number
14 gauge wire (connectors)	305183	9999100176
12 to 8 gauge wire (connectors)	91019-3	9999100175
4 to 9 circuit (in-line connectors)	453300-1	N/A
15 circuit (in-line connectors)	458944-1	N/A

Table 3-5
Amp Crimping Tool Table

Description	Amp Part Number		Grove Part Number	
	Tool	Die	Tool	Die
14 to 12 gauge wire	69710-1	90145-1	9999100177	N/A
10 to 8 gauge wire	69710-1	90140-1	9999100177	9999100178
4 to 9 circuit (in-line connectors	69710-1	90306-1	9999100177	N/A
15 circuit (in-line connectors	90299-1	--	N/A	--

Table 3-6
Deutsch Extraction Tool Table

Description	Deutsch Part Number	Grove Part Number
12 gauge wire	114010	9999100194
16 gauge wire	0411-204-1605	9999100195
8-10 gauge wire	114008	7902000012
4-6 gauge wire	114009	7902000009

Table 3-7
Deutsch Crimping Tool Table

Description	Deutsch Part Number	Grove Part Number
12, 14, 16, 18, 20 gauge wire	HDT48-00	9999100808
4, 6, 8, 10 gauge wire	HDT 04-08	9999100842

Charging System Troubleshooting

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. Dirty slip rings or bad slip ring connections.	**8.** Inspect slip rings. Clean or repair as required.
High charging rate (battery at full charge)	**1.** Low electrolyte level in battery.	**1.** Add distilled water.
	2. Fault in wiring system.	**2.** Repair or replace faulty wiring.
	3. Loose or dirty connections.	**3.** Clean and tighten connections.
	4. Malfunction in voltage regulator.	**4.** Replace voltage regulator.
Low charging rate (battery discharged)	**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.
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.

Starting System Troubleshooting

Problem	Possible Cause	Solution
Starter motor does not turn	**1.** Open circuit, dirty or loose connections.	**1.** Clean and tighten connections at battery 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.	**5.** Recharge or replace battery.
	6. Travel select lever not in neutral.	**6.** Place lever in "N" position.
	7. Bad neutral start relay.	**7.** Replace relay.

SECTION 4
HYDRAULIC SYSTEM

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

SECTION CONTENTS

TECHNICAL DATA

Hydraulic Pressures:

Main System Pressure (Pump Compensator)	3625 ± 50 psi (24 994± 345 kPa)
Pump Margin Pressure	275 ± 5 psi (1896 ± 35 kPa)
Swing Circuit Relief Valve	2000 ± 50 psi (13 790 ± 345 kPa)
Steering Relief Valve	2500 ± 50 psi (17 237 ± 345 kPa)
Outrigger Relief Valve	2500 ± 50 psi (17 237 ± 345 kPa)
Telescope Circuit Port Relief	2000 ± 50 psi (13 790 ± 345 kPa)
Pilot Control System (Pressure Reducing Valve)	500 ± 25 psi (3447 ± 172 kPa)
Load Sense Relief Valve	3450 ± 50 psi (23 786 ± 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 . . . . . 28 gpm (106 L/min)

Hydraulic Speeds:

	Cycle Times	
	1000 rpm	2500 rpm
Hoist Cylinder (full stroke):		
Up	17 sec	11 sec
Down	14 sec	8 sec
Telescope Cylinder (full stroke):		
Out	90 sec	32 sec
In	83 sec	34 sec
Horizontal Outrigger Cylinders (Individual):		
Out	14 sec	11 sec
In	8 sec	6 sec
Vertical Outrigger Cylinders (Individual):		
Down	21 sec	15 sec
Up	17sec	12 sec
Swing Speed	–	2.0 rpm
Main Hoist Line Speed (Average)	51 fpm (15.5 m/m)	126 fpm (38.4 m/m)

GENERAL DESCRIPTION

General

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

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

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

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

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

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

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

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

Flow - The flow through the system is caused by the pump. The amount of fluid which is sent to a circuit or actuator generally controls the speed of that function. The flow is measured in gallon per minute (gpm) or liter 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 main hoist motor

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

TROUBLESHOOTING

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

Troubleshooting Aids

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 at the end of this manual.
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 gallon per minute (gpm) or liter per minute (Lpm). Normally, the flowmeter is used to check the output of the pump. The flowmeter can also be used to find the location of leakage or restriction in the system. Instructions for installation of the flow meter and the use of the flowmeter are normally included with the flowmeter.
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: pump section, 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 Maintenance, page 5-1.
	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.
	Leakage in hydraulic swivel.	Replace seals on swivel shaft.
	Control valve not fully actuated.	Check spool travel.
	Improper primary pump pressure.	Check and adjust pump pressure settings.
	Faulty pump.	Overhaul or replace pump.
No movement when system is first started.	Low oil level.	Check and add oil.
	Air or restriction in inlet line to pump.	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 gear or shaft in pump.	Overhaul or replace.

Symptom	Possible Cause	Remedy
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 Maintenance, page 5-1.
	Oil too light.	Use correct oil.
	Low oil level.	Check and add oil.
	Dirty oil.	Change oil and filters. See Maintenance, page 5-1.
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.
	Bad seals between pump sections (Swing & Steering).	Replace seals.
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.
	Pilot pressure too low.	Faulty pressure reducing valve. Replace.
	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 4-6.
	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 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 Maintenance, page 5-1.
	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.	Disassembly 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 Maintenance, page 5-1.
Boom constantly getting out-of-sequence	Chain stretch or broken.	Adjust or replace chain.

Standard Outrigger Circuit Troubleshooting

Table 4-4

Symptom	Possible Cause	Remedy
No movement, all outriggers	Electrical problem.	See Electric System, page 3-1.
	Dirt or restriction in the dump valve.	Clean or replace the dump valve.
	Dirt in relief valve, keeping the valve off the valve seat.	Clean the relief valve.
	Relief valve setting too low.	Check and adjust the relief valve setting. See page 4-20.
	Faulty pump section.	Overhaul or replace the pump.
Slow movement, all outriggers	Low engine rpm.	Increase engine speed.
	Leakage in relief valve.	Clean or replace the relief valve.
Slow movement, one cylinder	Solenoid valve on outrigger valve section not fully actuating the valve spool.	Check for restriction or binding in the solenoid valve.
	Internal leakage in the cylinder.	Replace piston seals.
Outrigger extends but does not retract, vice versa	Problem in electrical circuit.	See Electric System, page 3-1.
Outrigger lowers but will not raise, or vice versa	Problem in electrical circuit.	See Electric System, page 3-1.
	Faulty counterbalance valve in base of the cylinder.	Replace the counterbalance valve.
Outrigger vertical cylinder does not hold under load	Leakage in counterbalance valve in base of the cylinder.	Clean or replace the counterbalance valve.
	Internal leakage in cylinder.	Replace the piston seals.
Outriggers operate only on one side	Faulty solenoid valve or open circuit to solenoid valve.	See Electric System, page 3-1.
	Restriction or dirt between the outrigger valve spool and housing.	Remove and clean the valve spool.
	Faulty selector switch.	Replace.

Independent Outrigger Circuit

Table 4-5

Symptom	Possible Cause	Remedy
No movement, all outriggers	Electrical problem.	See Electric System, page 3-1.
	Dirt in dump valve, keeping the valve off the valve seat.	Clean or replace dump valve.
	Faulty pump section.	Overhaul or replace the pump.
No movement, rear outriggers	Electrical problem.	See Electric System, page 3-1.
	Dirt in relief valve, keeping the valve off of the valve seat.	Clean the relief valve.
	Relief valve setting too low.	Check and adjust the relief valve setting. See page 4-20.
No movement, front outriggers	Electrical problem.	See Electric System, page 3-1.
	Dirt in relief valve, keeping the valve off of the valve seat.	Clean the relief valve.
	Relief valve setting too low.	Check and adjust the dump valve setting. See page 4-20.
Slow movement, all outriggers	Low engine RPM.	Increase engine speed.
	Leaking in dump valve.	Clean or replace the dump valve.
Slow movement, one outrigger	Solenoid valve on outrigger valve section not fully actuating the valve spool.	Check for restriction or binding in the solenoid valve.
	Internal leakage in cylinder.	Replace the piston seals.
Outrigger extends but does not retract, or vice versa	Problem in electrical circuit.	See Electric System, page 3-1.
Outrigger lowers but will not raise, or vice versa	Problem in electrical circuit.	See Electric System, page 3-1.
	Faulty counterbalance valve in base of the cylinder.	Replace the counterbalance valve.
Outrigger vertical cylinder does not hold under load	Leakage in counterbalance valve in base of the cylinder.	Clean or replace the counterbalance valve.
	Internal leakage in cylinder.	Replace the piston seals.
Outrigger only on one side operates	Faulty solenoid valve or open circuit to solenoid valve.	See Electric System, page 3-1.
	Restriction or dirt between the outrigger valve spool and housing.	Remove and clean the valve spool.
	Faulty selector switch.	Replace.

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. See Maintenance, page 5-1.
	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 4-18.
	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 Maintenance, page 5-1.
	Faulty swing motor or gearbox.	Repair or replace.

HYDRAULIC SYSTEM

System Description

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

Hydraulic Pump

Description

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

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

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

Test - Pump Output

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

Pressure Regulation

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

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

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

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

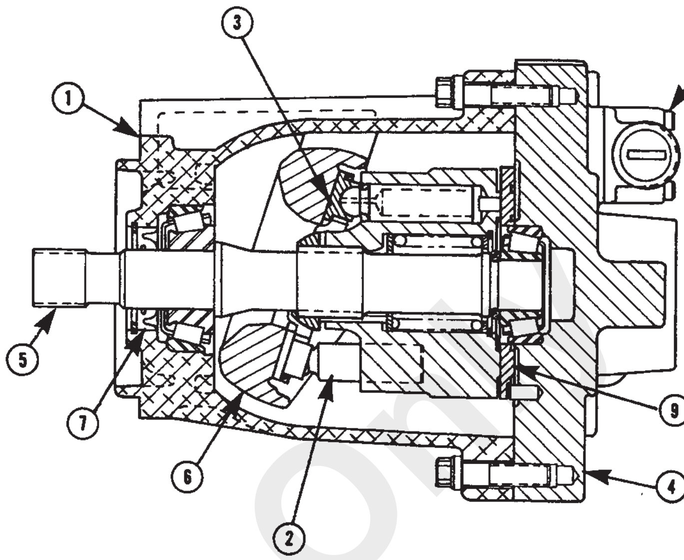


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FIGURE 4-1

Description of Operation

Hydraulic System

The hydraulic system is a closed-center hydraulic system. Which means that hydraulic oil is blocked from returning to tank when the valves spools are in the neutral position. The control valve sections used in the hydraulic system of the main control valve are pressure compensated valve sections incorporating a flow divider principle in their operation. This provides the ability to control multifunction operation when flow demand exceeds pump capacity though slowed down proportionally. This means that all circuits will continue to function regardless of differences in their load and regardless of the pump flow. The flow relationships specified between functions are maintained over the full range of the pump.

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

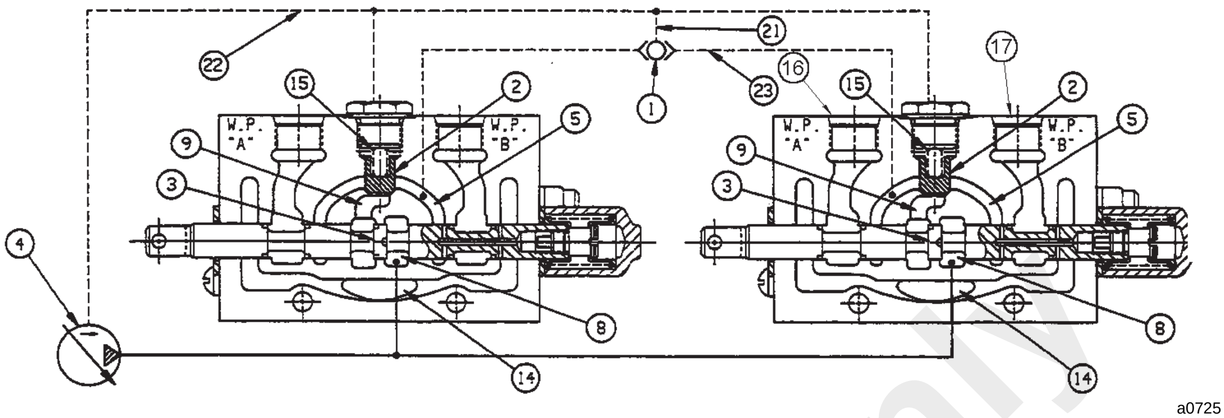
After the spool is activated the work port load pressure is transmitted to the bridge (5). The load sense shuttle (1), in turn, transmits the highest work port pressure to the load sense port of the pump (4) and all compensators (2) within the valve assembly. Pump (4) responds to the load sense signal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

Inlet Section

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

Working Valve Sections

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



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 4-2

HYDRAULIC SWIVEL

General

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

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

Functions

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

Port No. 1

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

Port No. 2

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

Port No. 3

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

Port No. 4

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

Port No. 5

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

Port No. 6

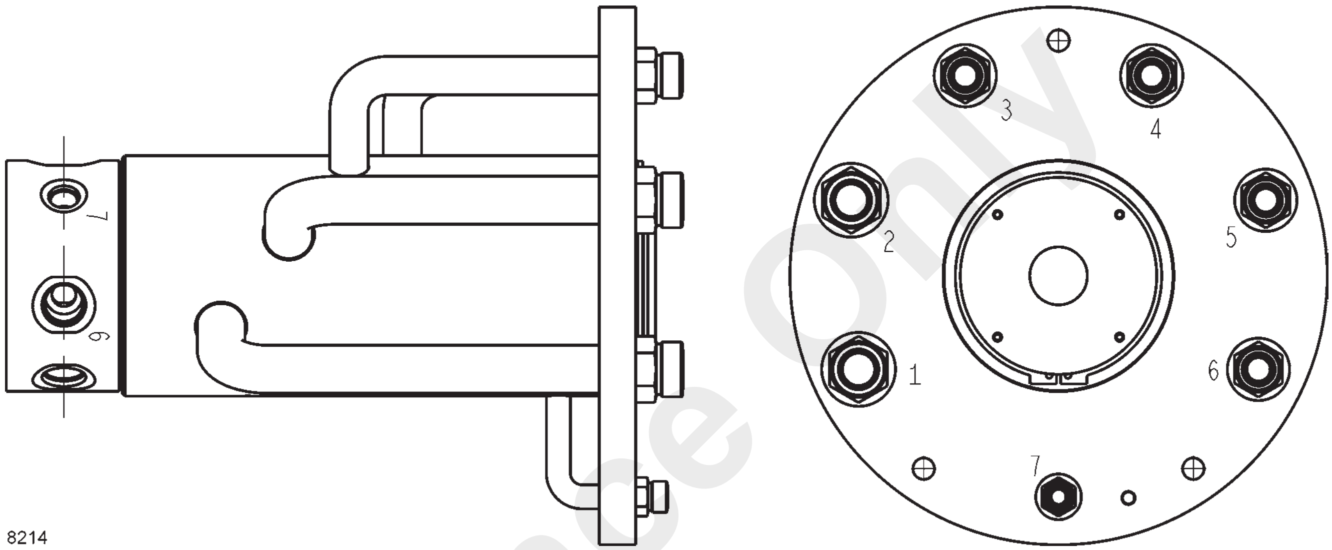
Hydraulic oil under pressure flows through this port when the boom is being extended. When retracting the boom the hydraulic oil under low pressure flows through this port.

Port No. 7

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

Troubleshooting

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



Hydraulic Swivel Port Arrangement, Typical

FIGURE 4-3

LIFT CIRCUIT

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

General

The lift hydraulic circuit includes two lift cylinders, two holding valves, Ports 3 and 4 in the hydraulic swivel, an anti-double block cutout solenoid valve, a valve section of the four-spool control valve (Figure 4-4), and the hydraulic lines.

Oil Flow

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

Raising the Booms

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

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

Lowering the Booms

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

Holding Valve

The holding valve has three functions:

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

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

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

WARNING

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

Lift Cylinder Leakage Check

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

1. Remove the suspected cylinder from the machine.
2. Mount the cylinder in a suitable cylinder stand.
3. Connect a portable hydraulic system to the cylinder base end.
4. Apply pressure to extend the cylinder rod.
5. Check the amount of leakage from the rod port of the cylinder. If the cylinder leaks more than a few drops of oil per minute, replacement of the piston seals is necessary, see page 4-44.

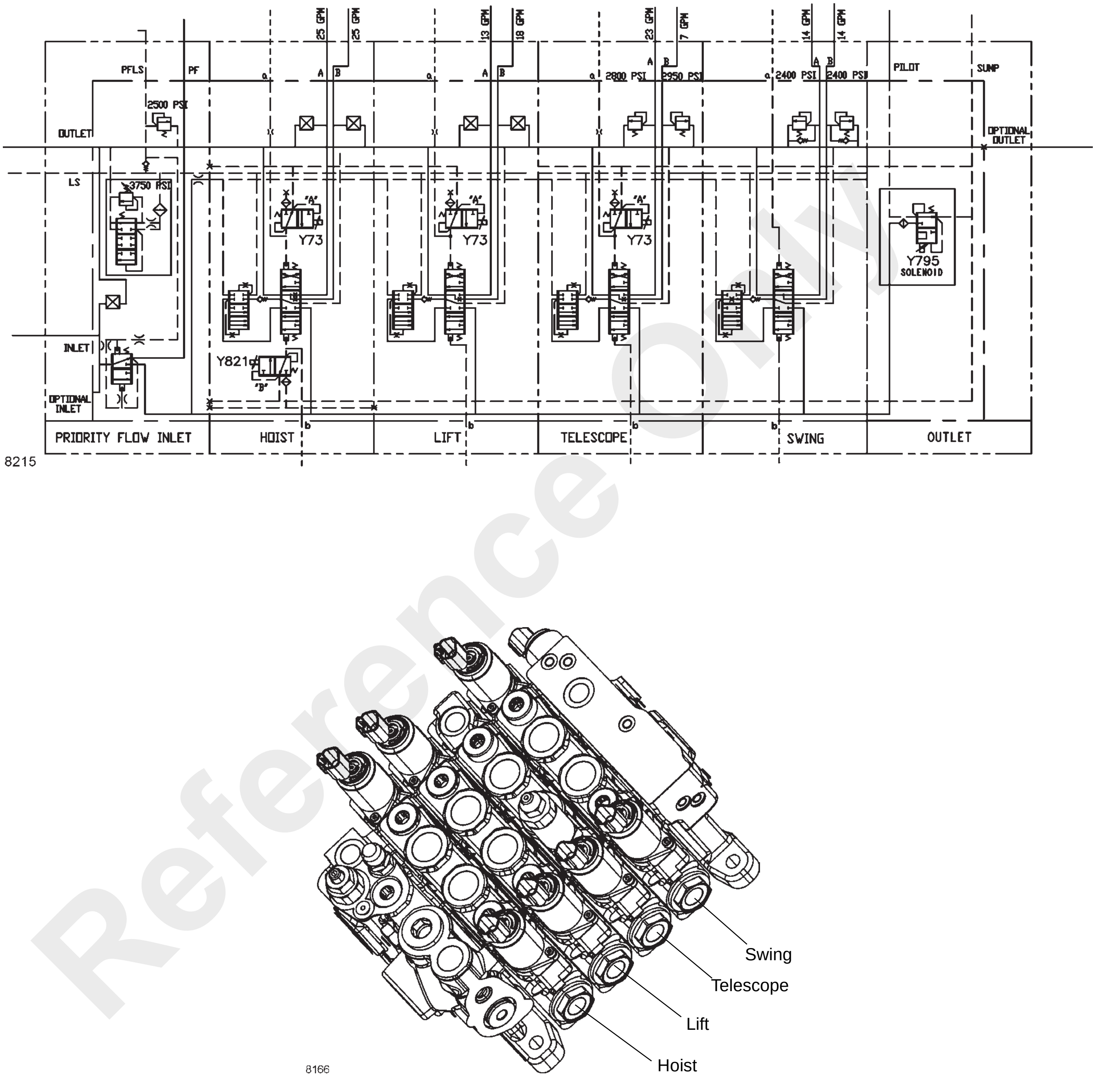

25 GPM
25 GPM
13 GPM
18 GPM
23 GPM
7 GPM
14 GPM
14 GPM
PFLS
PF
2500 PSI
2800 PSI
2950 PSI
2400 PSI
2400 PSI
PILOT
SUMP
OUTLET
OPTIONAL OUTLET
LS
3750 PSI
Y73
Y73
Y73
Y795 SOLENOID
INLET
Y821
OPTIONAL INLET
PRIORITY FLOW INLET
HOIST
LIFT
TELESCOPE
SWING
OUTLET
8215
Swing
Telescope
Lift
Hoist
8166

FIGURE 4-4

TELESCOPE CIRCUIT

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

General

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

Oil Flow

Telescope Out

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

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

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

Telescope In

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

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

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

Holding Valve

The holding valve has three functions:

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

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

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

WARNING

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

Port Relief Valve

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

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

Checking Relief Valve Pressure

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

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

Telescope Cylinder Leakage Test

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

1. Raise the boom a little above the horizontal position.
2. Fully extend the boom.
3. Stop the engine. Move the control lever several times in each direction to release any hydraulic pressure in the circuit.
4. Disconnect the hydraulic hose from bulkhead elbow Figure 4-6 which connects to the rod port of the telescope cylinder. A little oil will drain from the elbow.
5. Start the engine. Actuate the control lever in the direction to extend the boom. Check the amount of leakage from the bulkhead elbow. If the leakage is more than a few drops per minute, replacement of the piston seals is necessary.

Hydraulic Swivel

See page 4-12 for hydraulic swivel information.

HOIST CIRCUIT

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

General

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

Oil Flow

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

Hoist Up

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

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

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

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

Hoist Down

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

Drain Line

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

Brake Holding Valve

The holding valve has three functions:

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

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

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

WARNING

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

Hydraulic Swivel

See page 4-12 for hydraulic swivel information.

SWING CIRCUIT

General

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

Oil Flow

Swing Right

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

Swing Left

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

PILOT CONTROL SYSTEM

General

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

Oil Flow

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

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

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

Pilot System Relief Valve

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

PRESSURE SETTING PROCEDURES

Checking and Adjusting Hydraulic Pressure Settings

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

Pump Margin Pressure Setting

1. With the engine shut off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple @ the G1 port (1, Figure 4-5).
2. Start engine and read the pressure gauge while at engine idle. A reading of 24 ± 1.7 bar (350 ± 25 psi) should be observed.
3. If pressure reading is correct, shut off the engine, and disconnect the pressure gauge.
4. If pressure is incorrect, loosen the margin set screw from the pump compensator valve (4, Figure 4-6).
5. Adjust the margin pressure setting by turning the margin adjusting screw (1, Figure 4-6) until 24 ± 1.7 bar (350 ± 25 psi) 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.

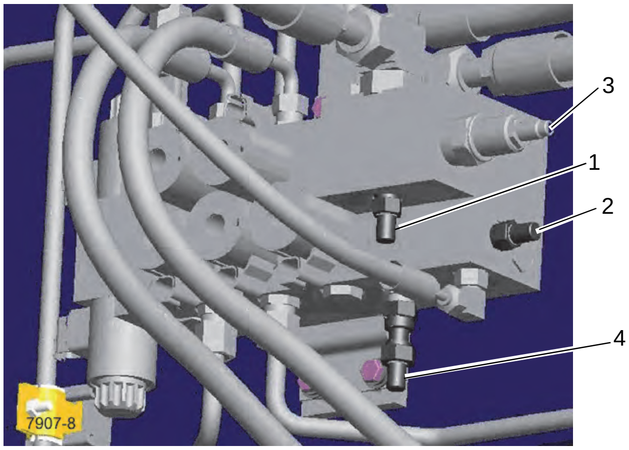


FIGURE 4-5

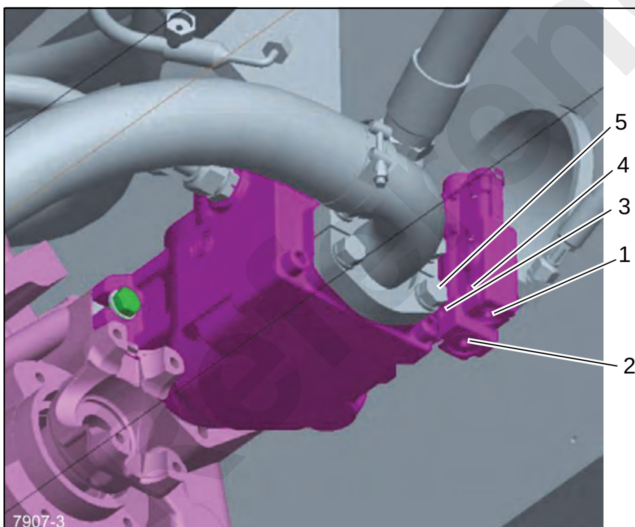


FIGURE 4-6

Pump Compensator Pressure Setting

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

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

1. With the engine shut off, & pressure check diagnostic quick disconnect (Parker PD240) with gauge still installed on test nipple @ the G1 port (1, Figure 4-5).
2. On the control valve, remove the cap on the load sense relief valve (1, Figure 4-7) loosen the jam nut and turn the adjusting screw fully in.
3. Start the engine.
4. Ensure the boom is all the way down. Activate the boom down function at full engine throttle. The pressure gauge should read 276 +/- 3.5 bar (4000 +/- 50 psi).

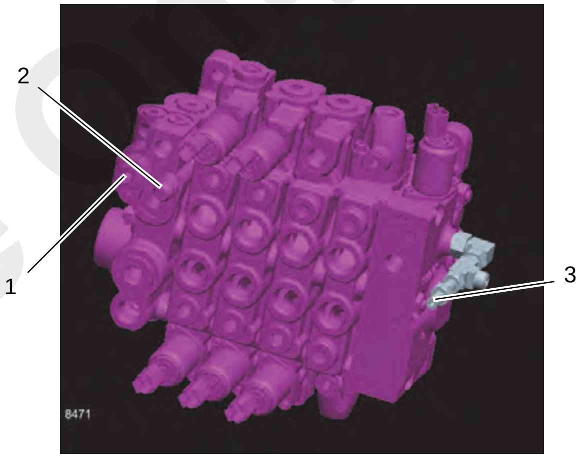


FIGURE 4-7

5. If pressure reading is correct:
   a. Shut off the engine, and disconnect the pressure gauge.
   b. Replace the cap nut on the load sense relief valve.
   c. Set the pressure on the load sense relief valve, refer to *Load Sense Relief Valve Pressure Setting.*
6. If pressure reading is incorrect:
   a. Remove the bolt on the suction hose split flange by the compensator set screw (5, Figure 4-6).
   b. Loosen the set screw from the pump compensator valve (3, Figure 4-6).
   c. While engaging the boom down function with the engine at full throttle, adjust the pump max pressure setting by turning the compensator adjusting screw (2, Figure 4-6) until 276 ± 3.5 bar (4000 ± 50 psi) pressure is obtained on the gauge; clockwise increases pressure, counterclockwise reduces the pressure.
   d. Tighten compensator set screw.
   e. Install and tighten the split flange bolt.

f. Shut off the engine, and disconnect the pressure gauge.

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

Load Sense Relief Valve Pressure Setting

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

1. Install a 0 - 344.73 bar (0-5000 psi) pressure gauge on the load sense test port GLS (2, Figure 4-5) located on the 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 238 ± 3.5 bar (3450 ± 50 psi), if the pressure needs to be adjusted adjust the load sense relief setting by turning the relief valve adjusting screw (1, Figure 4-7) until 238 ± 3.5 bar (3450 ± 50 psi) 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.

Priority Flow Load Sense Relief and Accumulator Relief Setting

1. Install a 0 - 344.73 bar (0-5000 psi) pressure gauge on the G1 port (1, Figure 4-8) 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 relief valve adjusting screw (2, Figure 4-7) until 172 ± 3.5 bar (2500 ± 50 psi) is obtained on the pressure gauge; clockwise increases pressure, counterclockwise reduces the pressure.
4. Shut down the engine and remove the pressure gauge.
5. Install a 0 - 344.73 bar (0-5000 psi) pressure gauge on the G2 port (3, Figure 4-8) located on the brake/steering manifold.
6. With the engine at idle, repeatedly depress the service brake pedal on the cab floor until the gauge pressure reads approximately 117 bar (1700 psi). Once you have found the pressure, push the brake pedal again to recharge. Watch the gauge and verify the low charging limit to be 110 +/- 7 bar (1600 +/- 100 psi) (when it starts to recharge). Then watch gauge as valve is charging it should cut out at 138 +7/-0 bar (2000 +100/-0 psi) if not adjust at UP10 piloted unloading valve (2, Figure 4-8); clockwise increases pressure, counterclockwise reduces pressure. (Note: If charge valve does not cut out check load sense relief valve pressure per Load Sense Relief Valve Pressure Setting procedure).
7. Shut down the engine and remove the pressure gauge.

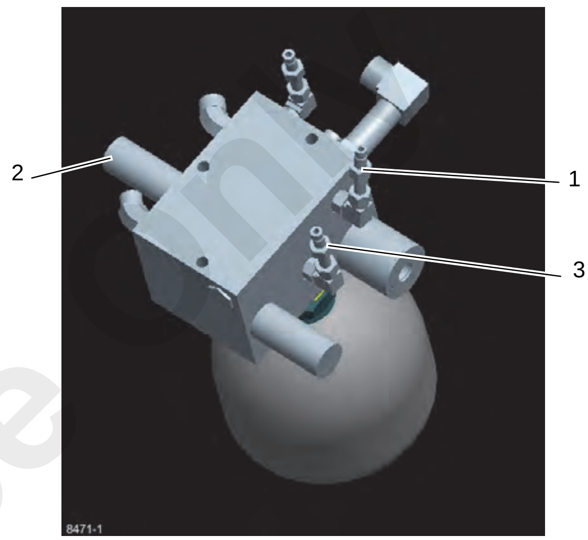


FIGURE 4-8

Outrigger Circuit Pressure Setting

1. Shut off the engine. Install a 0 - 344.73 bar (0-5000 psi) pressure gauge to the front outrigger manifold test point G2 (4, Figure 4-5).

2. Start and accelerate the engine to maximum RPM.

3. Actuate the outrigger enable switch to the extend position while another person observes the pressure gauge. The pressure should be 145 ± 3.5 bar (2100 psi ± 50 psi).

4. If the pressure reading is correct, stop the engine and remove the pressure gauge.

5. If the pressure reading is incorrect:

- **a.** Loosen the jam nut on the outrigger relief valve (3, Figure 4-5) at the front of the machine on the front outrigger housing weldment.
- **b.** Adjust the outrigger circuit pressure by turning the adjustment screw until 145 ± 3.5 bar (2100 psi ± 50 psi) is obtained on the pressure gauge; clockwise increases pressure, counterclockwise reduces the pressure.
- **c.** Tighten the jam nut against the relief valve body.
- **d.** Shut down the engine and remove the pressure gauge.

Supply Pilot Pressure Setting

1. Testing System Pressure

a. With the engine shutdown and the parking brake set, install pressure diagnostic (Parker PD240) with gauge onto pilot test port (3, Figure 4-7) 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 28 ± 3.5 bar (400 ± 50 psi). If the pressure setting is correct shutdown the engine and remove the pressure gauge. If the pressure setting is incorrect, verify the supply current to the crane power solenoid. This pressure is not adjustable.

2. Shut down the engine and remove the pressure gauge.

Procedure for checking Tele Retract Pressure

1. With engine shutdown install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto load sense test port the GLS port (2, Figure 4-5) located on the front outrigger manifold.

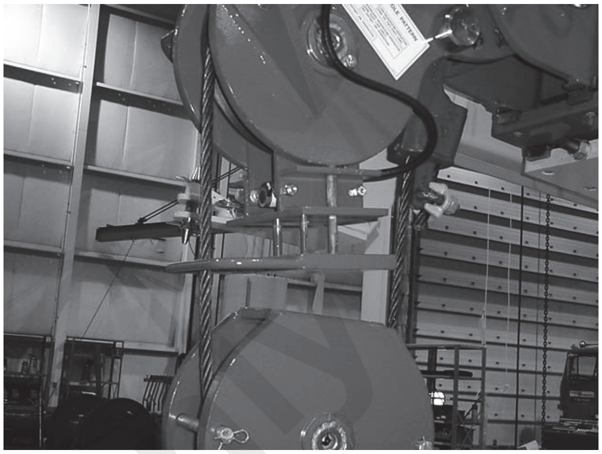
2. Start the engine with the engine at full RPM pull the tele retract lever till boom is fully retracted and hold pressure should be 138 ± 10 bar (2000 ± 150 psi).This pressure is non adjustable. Contact distributor if out of tolerance.

3. Shut down the engine and remove the pressure gauge.

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 4-9) 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.



P0800 FIGURE 4-9

System Function

Refer to the hydraulic schematic at the end of this manual to accompany the following text.

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.

OUTRIGGERS CIRCUITS

General

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

Two outrigger hydraulic systems are available on the crane:

1. Standard controlled outriggers.
2. Optional independently controlled outriggers.

Standard Outrigger Hydraulic System

The standard outrigger hydraulic system (Figure 4-10 and Figure 4-11) includes a priority flow control valve, an accumulator charging valve, a dump valve, a four solenoid outrigger valve, four horizontal outrigger cylinders and four vertical outrigger cylinders and the hydraulic lines.

Optional Independently Controlled Outrigger Hydraulic System

The optional independently controlled outrigger hydraulic system (Figure 4-12 and Figure 4-13) includes a priority flow control valve, an accumulator charging valve, a dump valve, two four solenoid outrigger valves, four horizontal outrigger cylinders, and four vertical outrigger cylinders and hydraulic lines.

Oil Flow

See Figures 4-10 through 4-13 for the following procedure.

Hydraulic oil from the pump flows through the priority flow control valve, through the accumulator charging valve to the dump valve. The dump valve is a normally open valve. When hydraulic oil reaches the valve it flows through it back to tank. When the outrigger switch is actuated in the cab it energizes the dump valve and closes it, allowing oil to flow to the outrigger valve. Depending upon which outrigger function is actuated, the oil flows though the outrigger valve to the outrigger cylinders. The cylinder extends or retracts and pushes oil ahead of the piston through one of the ports of the cylinder. The oil returns to the outrigger control valve and back to tank through the return filter.

Oil Flow - Horizontal Outrigger Extend (Right) and Retract (Left) (Standard Outriggers)

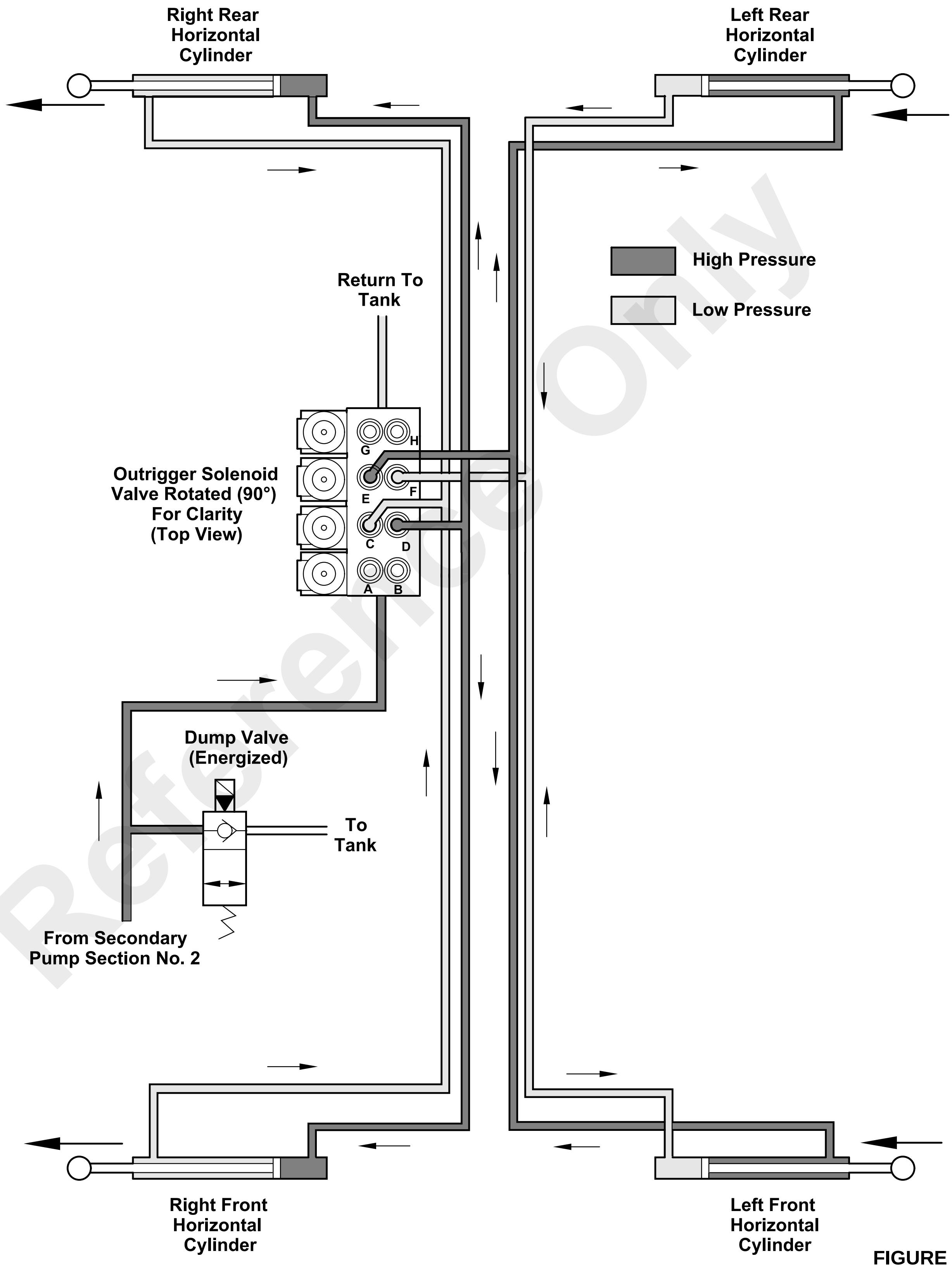


FIGURE 4-10

Oil Flow - Vertical Outrigger Extend (Right) and Retract (Left) (Standard Outriggers)

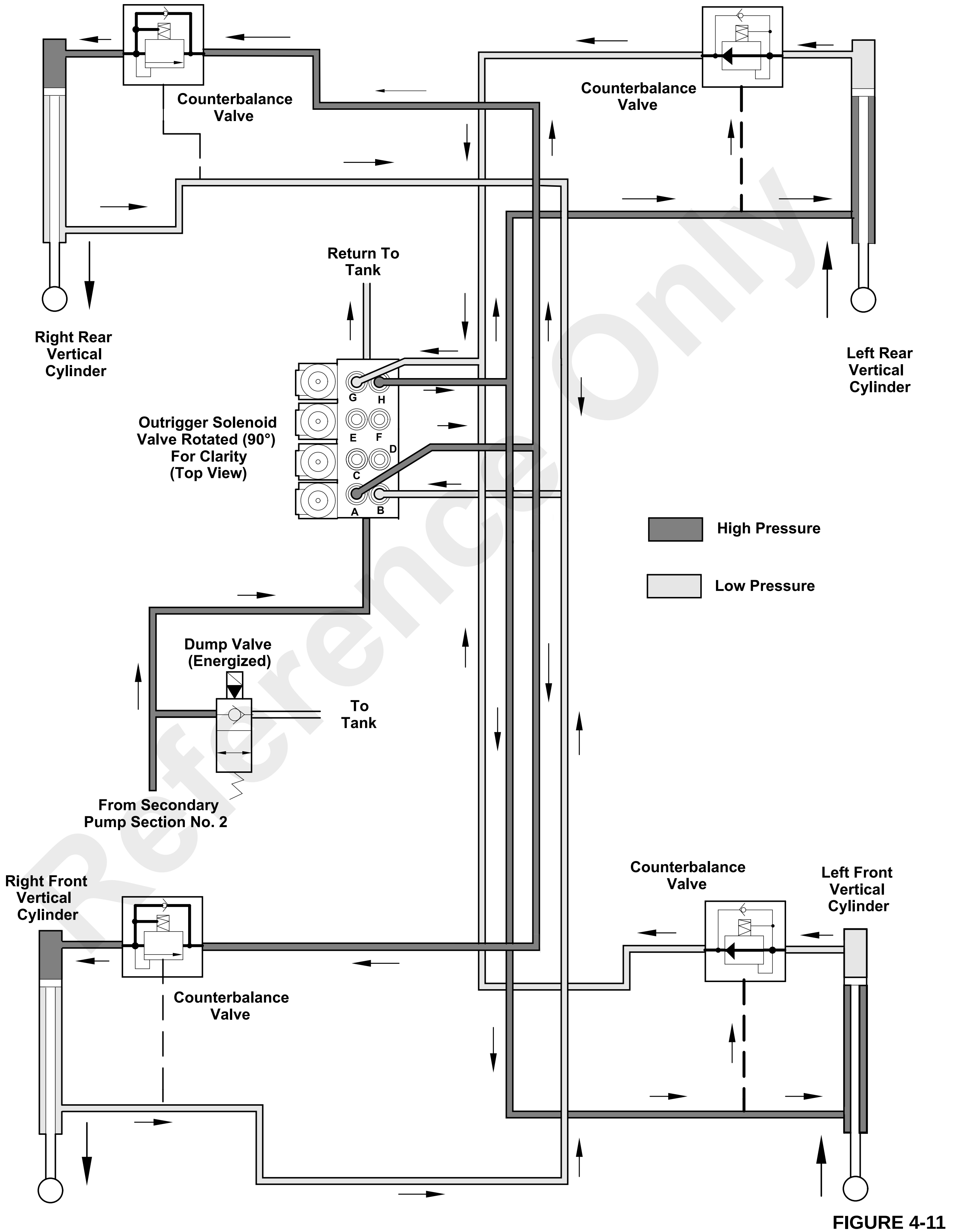


FIGURE 4-11

Oil Flow - Horizontal Outrigger Extend (Right) and Retract (Left)
(Optional Independently Controlled Outriggers)

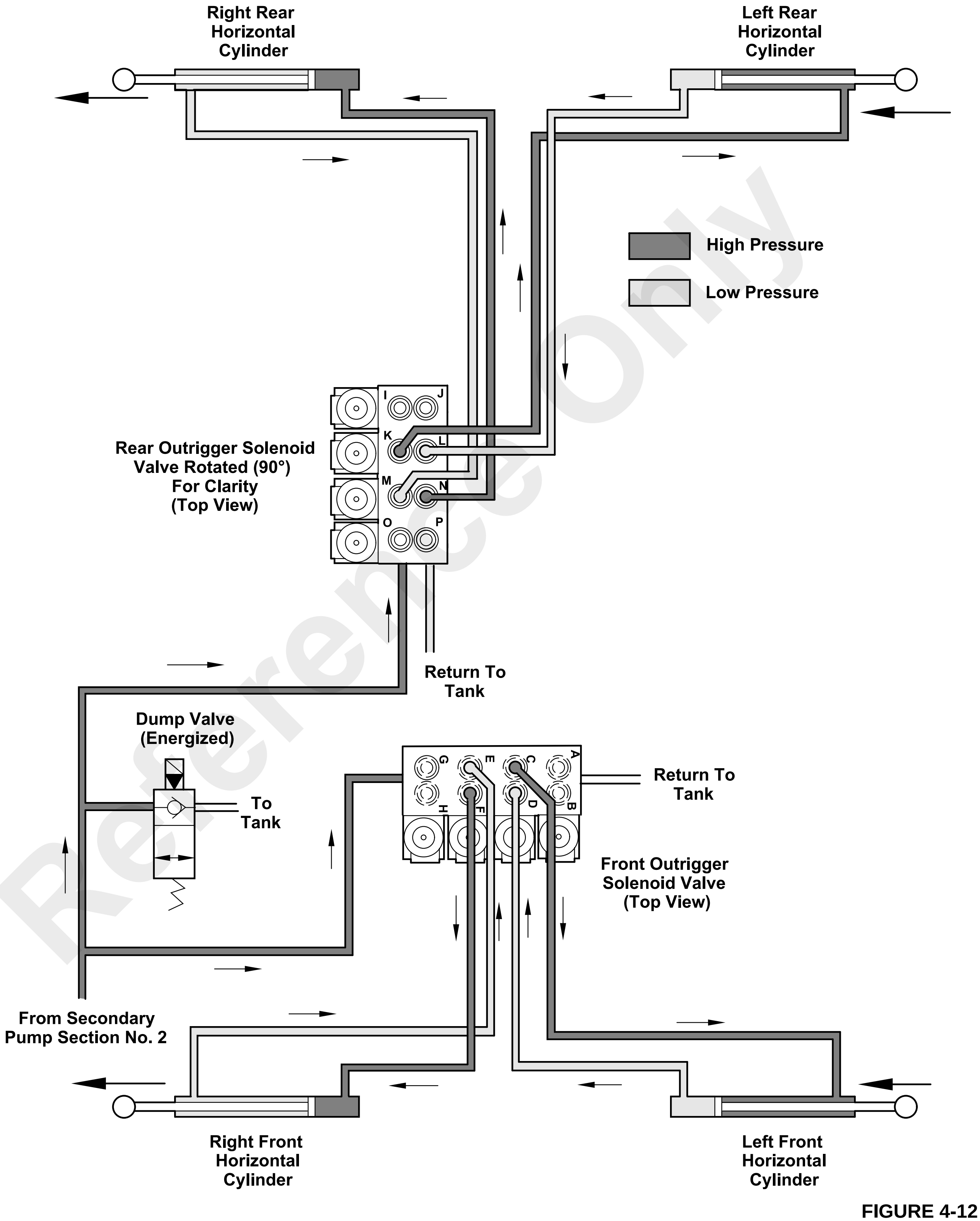


FIGURE 4-12

Oil Flow - Vertical Outrigger Extend (Right) and Retract (Left) (Optional Independently Outriggers)

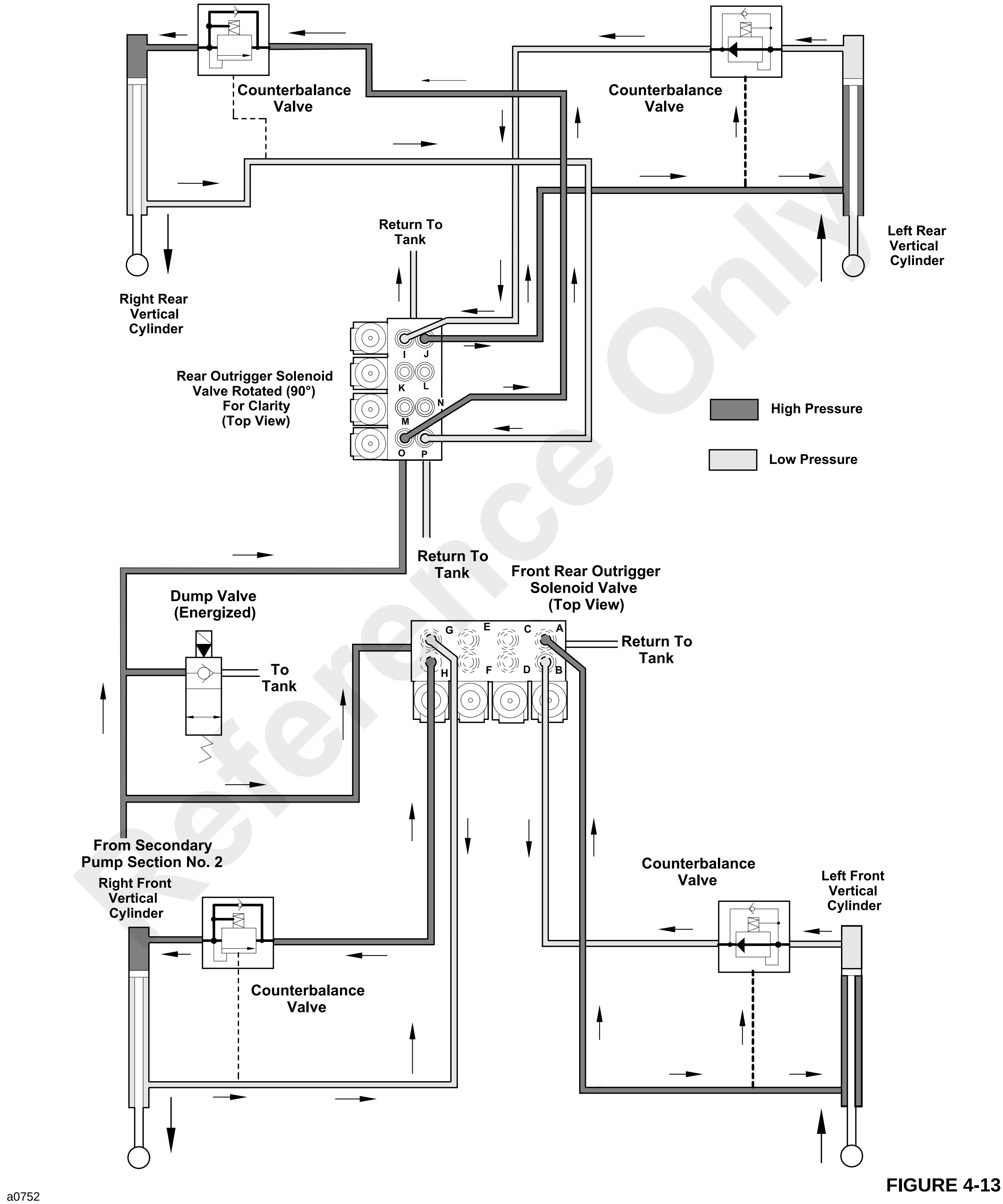


FIGURE 4-13

Outrigger Valve

Description

The outrigger valve consists of a manifold, relief valve, and either four or eight solenoid valves, depending upon which outrigger system is used on the crane.

Each solenoid valve has a closed-center passage, blocking oil at the valve and preventing oil from returning to tank unless the spool is shifted. Oil from the manifold inlet flows directly to each valve section where it is stopped. 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 solenoid valve and manifold back to tank.

A relief valve is installed in the inlet of the manifold and protects the outrigger circuit from high pressure buildup.

Outrigger Valve Ports

For easy identification the ports are given in alphabetical sequence, starting at the ports nearest the inlet and relief valve.

Table 4-7

Port	Function (Under High Pressure)	Sol.	Wire
A	Right Outrigger Down	A	J3
B	Right Outrigger Up	B	J34
C	Right Outrigger In	A	J15
D	Right Outrigger Out	B	J25
E	Left Outrigger In	A	J21
F	Left Outrigger Out	B	J4
G	Left Outrigger Down	A	J17
H	Left Outrigger Up	B	J24

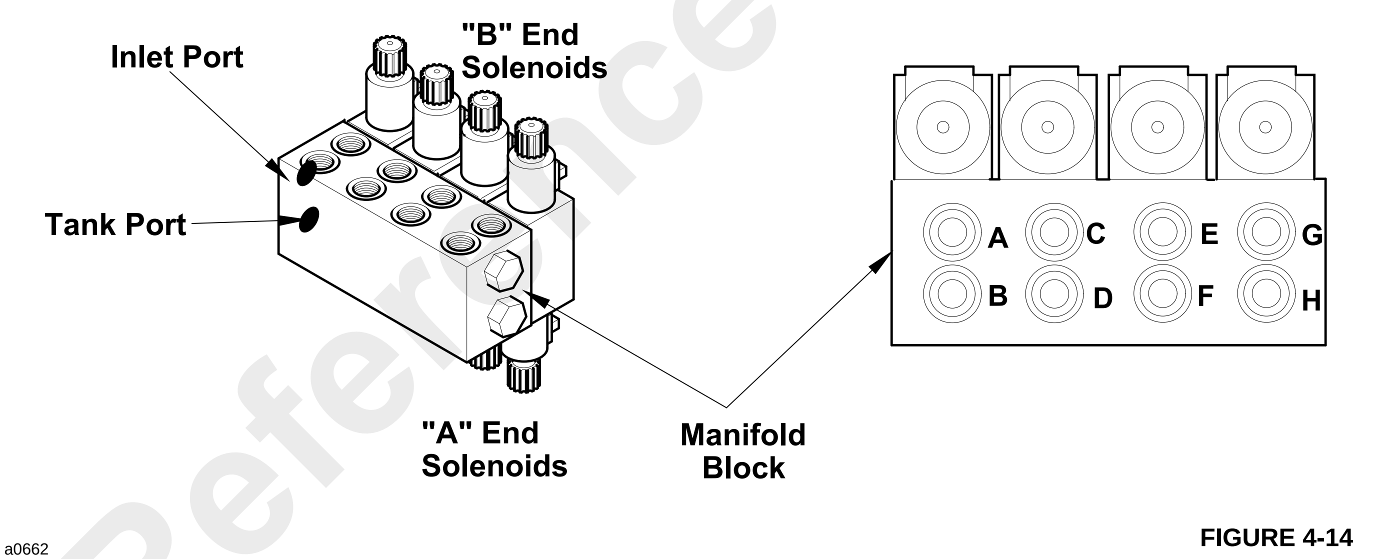


FIGURE 4-14

Table 4-8

Port	Function (Under High Pressure)	Sol.	Wire
A	Left Front Outrigger Up	A	J21
B	Left Front Outrigger Down	B	J4
C	Left Front Outrigger In	A	J17
D	Left Front Outrigger Out	B	J24
E	Right Front Outrigger In	A	J15
F	Right Front Outrigger Out	B	J25
G	Right Front Outrigger Up	A	J34
H	Right Front Outrigger Down	B	J3
I	Left Rear Outrigger Down	A	J20
J	Left Rear Outrigger Up	B	J10
K	Left Rear Outrigger In	A	J32
L	Left Rear Outrigger Out	B	J1
M	Right Rear Outrigger In	A	J31
N	Right Rear Outrigger Out	B	J18
O	Right Rear Outrigger Down	A	J14
P	Right Rear Outrigger Up	B	J33

Counterbalance Valves

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

Oil flows freely through the counterbalance valve and into the cylinder base end 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 from the oil held in the cylinder base end by the counterbalance valve. Pressure increases as the pump tries to overcome the resistance.

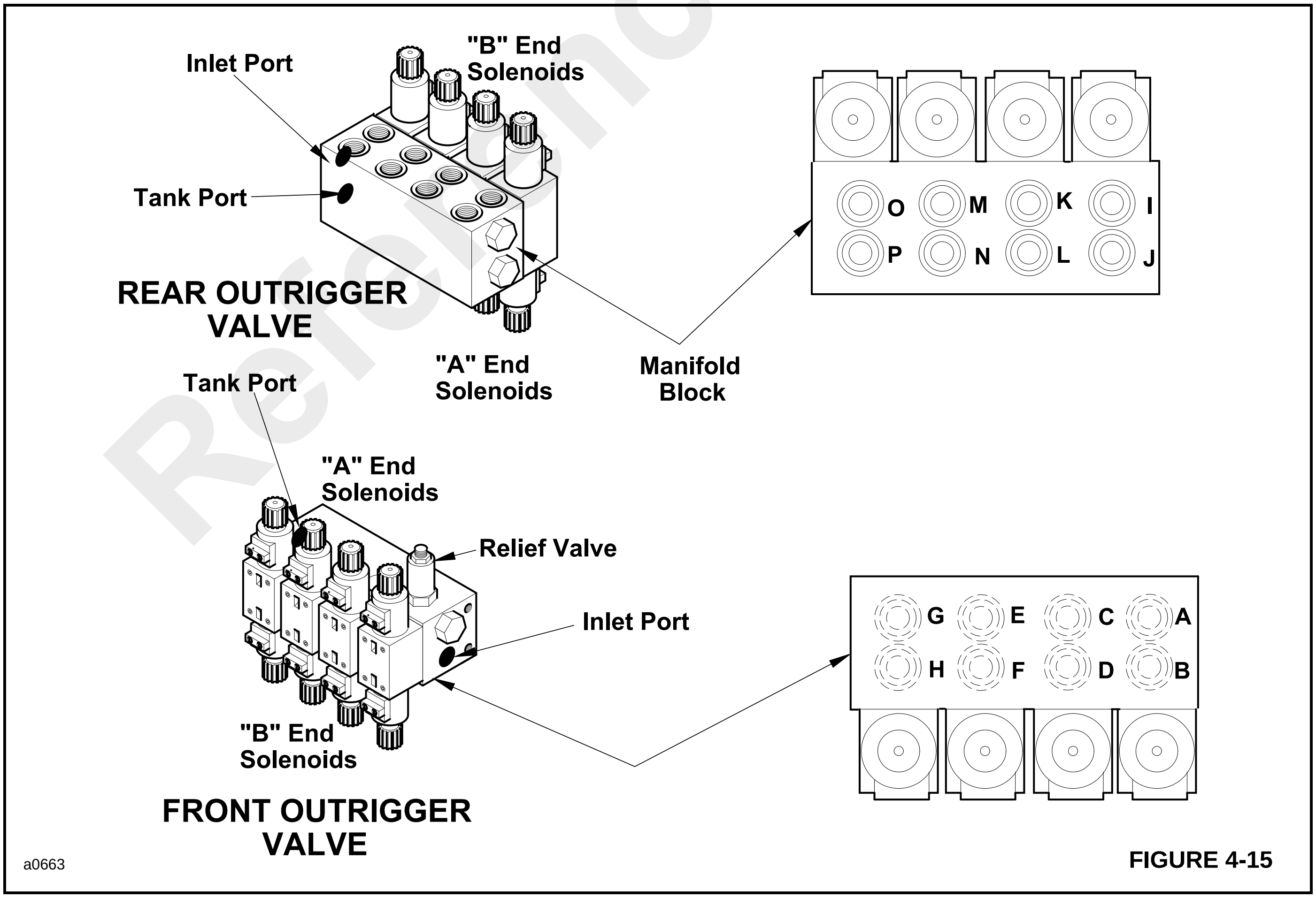


FIGURE 4-15

When the pressure is high enough to overcome the spring in the counterbalance valve plus the pressure in the cylinder base end, the counterbalance valve opens and the cylinder retracts.

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

NOTE: The engine must be running to retract the outriggers. The counterbalance valves inhibit retracting the outrigger jacks simply from the weight of the crane.

Vertical Outrigger Cylinder Leakage Test

If a vertical outrigger cylinder will not hold under load, the problem is either the counterbalance valve or internal cylinder leakage. 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 outrigger cylinder.
5. Start the engine and actuate the control in the direction to lower the outrigger. Check the amount of leakage from the open port. If the leakage is more than a couple of drops per minute, replacement of the piston seals is recommended.

COMPONENT REPAIR

Hydraulic Pump Repair

Removal

1. Place a vacuum on the hydraulic tank to keep the hydraulic fluid from draining when the hydraulic pump is removed. If a vacuum can not be obtained drain the hydraulic tank.
2. Remove the two socket head capscrews securing the pump support bracket to the rear of the pump.
3. Remove the six capscrews securing the pump support bracket to the engine. Remove the pump support bracket.
4. Disconnect the suction line and pressure line from the primary pump (Figure 4-16). Disconnect the load sense and drain lines from the pump. Cap and plug all hoses and ports.

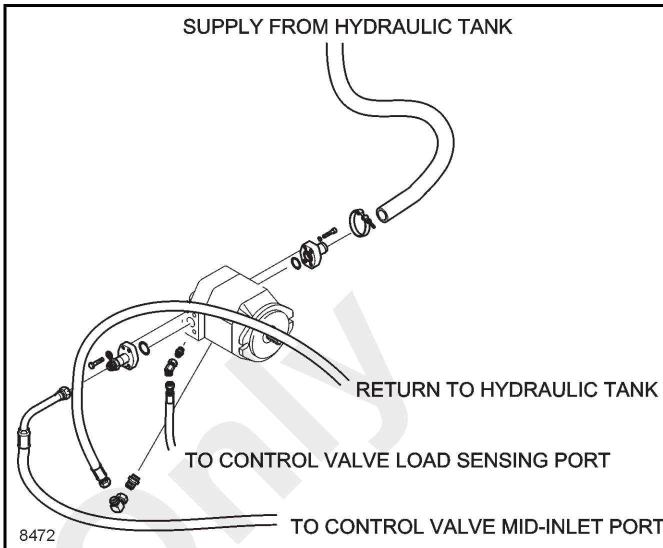


FIGURE 4-16

5. The pump is heavy. Support the pump before removing any attachment hardware. Remove the pump mounting hardware. Remove the pump.

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.

1. Attach the pump fittings to the pump before installing the pump to engine. 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 engine. Position the pump with the compensator at the bottom of the pump. Install the mounting hardware. Tighten the bolts to 88 Nm (65 lb-ft).
3. Attach the suction and pressure hoses to the pump.
4. Install the pump support bracket to the pump and engine. Install the bracket to the engine using existing hardware. Do not tighten the capscrews at this time.
5. Tighten the six pump bracket to engine mounting capscrews to 93.8 Nm (69 lb-ft).
6. Connect the load sense line to the pump compensator. Make sure the hose is routed under the pump support bracket.
7. Connect the pump drain line to the pump. Make sure the hose is routed above the pump support bracket.
8. Fill the hydraulic tank with clean filtered hydraulic oil.

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

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

Pump Start-up

1. Start the engine and let it idle. Do not allow the engine to surge or run excessively fast during the initial start-up. **DO NOT OPERATE ANY HYDRAULIC FUNCTION AT THIS TIME**.
2. Let the pump run for about 60 seconds to release any air that might be in the hydraulic system. Check the suction hose connections for loose clamps, fittings, etc.
3. Adjust the pump to deliver system pressures. Follow the instruction under "Adjusting Hydraulic Pressure Settings,".
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 swing or lift valve section lines or hoses from 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 three capscrews, washers and nuts securing the valve to the mounting plate. Remove the valve and take it to a clean work area.

Disassembly

Complete Valve Assembly

1. Place the valve assembly on the work bench and remove all hydraulic fittings.
2. Position the valve with the load sense section (8, Figure 4-17) facing up.
3. Remove the three nuts (10 and 12) from the studs (9 and 11) at the load sense section (8).
4. Slowly, lift the load sense section from the studs.

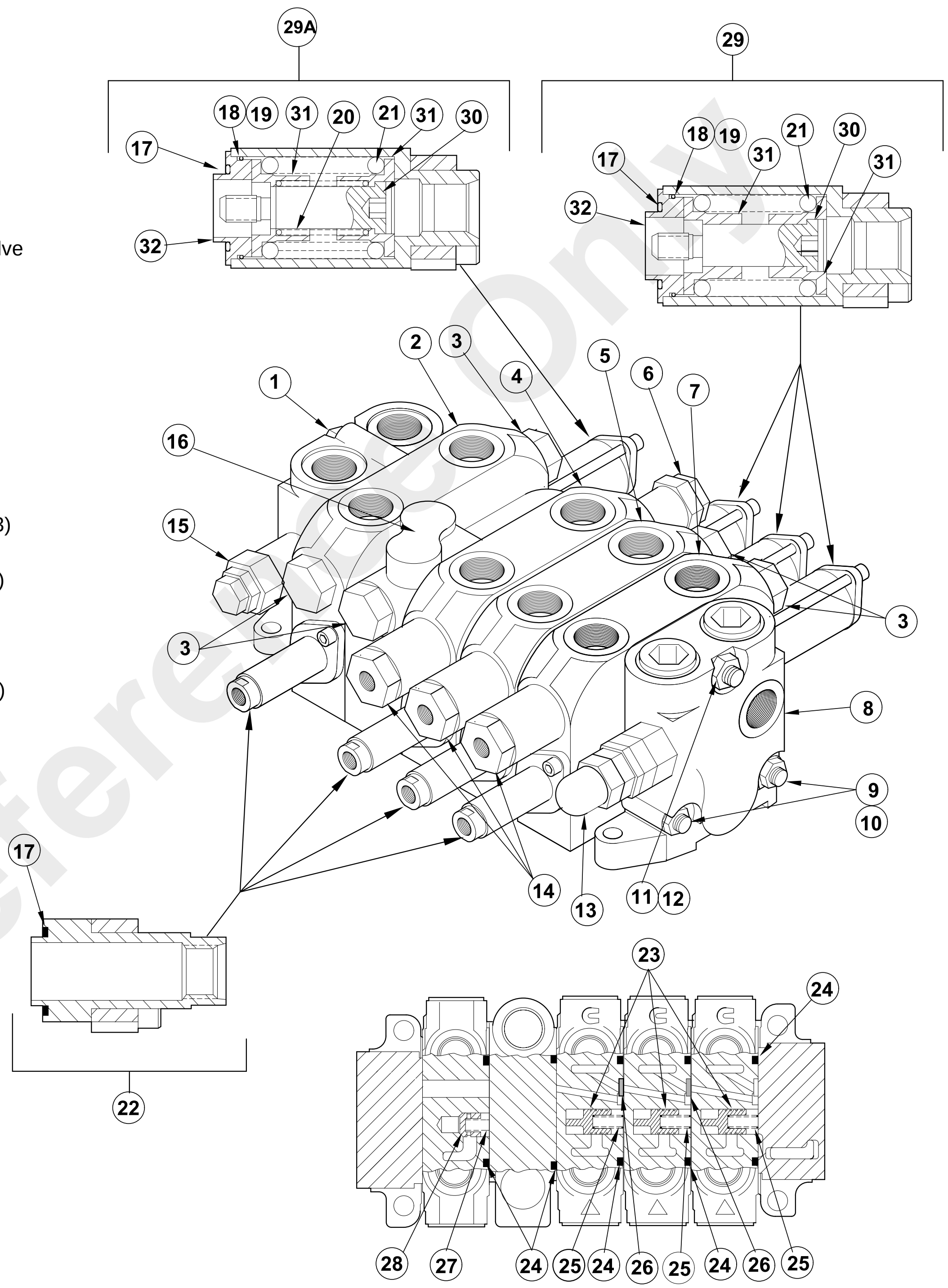
NOTE: Be careful when separating the valve sections. The working sections (2, 4, 5 and 7) have spring loaded check valve assemblies. The spring could fly out of the valve section when the section is removed.

5. Slowly, lift the three working valve sections (7, 5, and 4) from the studs.
6. Slowly, lift the mid-inlet valve section (16) from the studs.
7. Slowly, lift working valve section (2) from the studs.
8. Remove the studs (9 and 11) from inlet section (1).
9. Remove and discard O-rings (24) from the valve sections.

Spool Section

1. Remove load check spring (25 or 27, Figure 4-18) and load check poppet (23 or 28).
2. Remove cap assembly (22) by removing the two socket head capscrews. Remove and discard O-ring (17).
3. On the opposite end, remove the cap assembly (29 or 29A) by removing the two socket head capscrews. Remove and discard O-ring (17).

Item	Description
1	Inlet/Outlet Section
2	Working Section
3	Shut-off Plug (5)
4	Working Section
5	Working Section
6	Port Relief Valve
7	Working Section
8	Load Sense Section
9	Studs (2)
10	Nut (4)
11	Stud
12	Nut (2)
13	Load Sense Relief Valve
14	Anti-Void Valve
15	Relief Valve
16	Mid-Inlet Section
17	O-ring (8)
18	O-ring (4)
19	Backup Ring (4)
20	Spring
21	Spring (4)
22	Cap Assembly (4)
23	Load Check Poppet (3)
24	O-ring (6)
25	Load Check Spring (3)
26	Seal (2)
27	Load Check Spring
28	Load Check Poppet
29	End Cap Assembly (3)
29A	End Cap Assembly
30	Spool end (4)
31	Spring end (4)
32	Retainer



a0758

FIGURE 4-17

4. Slowly loosen spool end shoulder screw (30). The screw is under pressure from spring (21), be sure to hold the spring seats (31) and spring (21) when removing screw (30).
5. Remove spring seats (31) and spring (21). On end cap assembly (29A), remove spring (20).

NOTE: Valve section 2 has a different spring than valve sections 5, 6 and 7. Be sure not to mix the springs.

6. If equipped, remove anti-void valve assembly (14).
7. If equipped, remove port relief (6).
8. Remove shut-off plug(s) (3).
9. If a valve spool must be removed, keep it with its valve housing. Do not mix valve spools and valve housings.

Assembly

Spool Section

1. If any valve spool was removed from its valve housing, apply petroleum jelly to the spool and then insert the spool into the section.
2. Coat all seals with a light coat of hydraulic oil, and then install O-ring (17, Figure 4-17), O-ring (18) and backup ring (19) onto retainer (32).
3. Install two spring seats (31) and spring (21) in end cap (29 or 29A). On end cap (29A), also install spring (20). Secure these items using spool end shoulder screw (30). Tighten the screw to a torque of 8.2-10.8 Nm (6-8 lb-ft).
4. Install the end cap assembly and secure with two socket head capscrews. Tighten to a torque of 8.2-10.8 Nm (6-8 lb-ft).
5. Install O-ring (17) onto cap assembly (22). Attach the assembly to the valve housing using two socket head capscrews. Tighten to a torque of 8.2-10.8 Nm (6-8 lb-ft).
6. Install the shut-off plug(s) (3). Tighten to a torque of 39.4-50.0 Nm (29-36 lb-ft).
7. If equipped, install the anti-void valve assembly (14). Tighten to a torque of 39.4-50.0 Nm (29 - 36 lb-ft).
8. If equipped, install port relief valve (6). Tighten to a torque of 39.4 - 50.0 Nm (29 - 36 lb-ft).

Complete Valve Assembly

1. Lay the valve components on a clean, flat work surface.
2. Assemble nuts (10 and 12, Figure 4-17) to one end of each stud (9 and 11). Insert the studs through the stud holes in the inlet valve section (1). Lay the inlet section on the work bench with the studs facing up.
3. Place O-ring (24) in position on the face of the inlet section.
4. Place the first spool valve section (2) (Swing), O-ring side up over the studs onto inlet section (1). Place O-ring (24) 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 mid-inlet section (16) over the studs and onto valve section (2). Position O-ring (24) on the mid-inlet section.
6. Install the second spool valve section (5) (Telescope). Position O-ring (24) on the valve section.
7. Repeat step 6 for the third and fourth spool valve sections (6 - Hoist) and (7 - Lift).
8. Position load sense valve section (8) on the last working valve section and hand tighten stud nuts (10 and 12).
9. Position the valve assembly with the mounting pads of the end sections on a flat surface. To obtain proper alignment of the end sections relative to the spool sections, apply a downward force. Snug tie rod nuts (10 and 12) to about 13.6 Nm (10 lb-ft). Final torque is 44.8 Nm (33 lb-ft) on larger nut and 19 Nm (14 lb-ft) on the smaller nuts.

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 4-18), the relief valve poppet and the check valve.

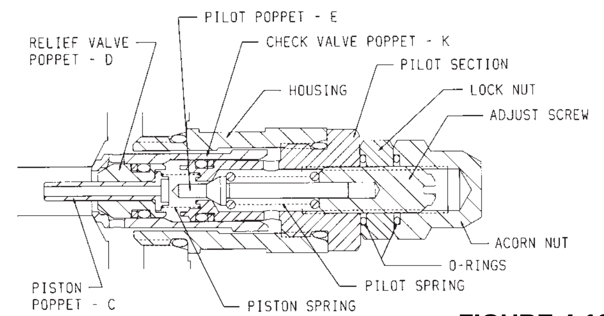


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FIGURE 4-18

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.

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.

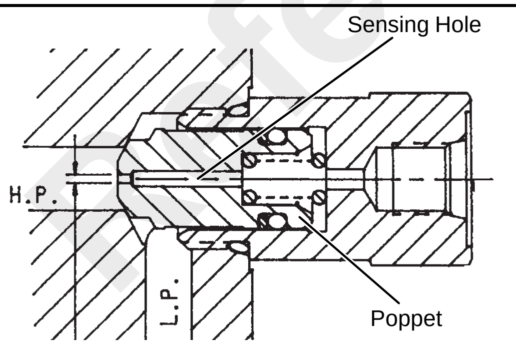
Relief Valve Troubleshooting

Table 4-9

Problem	Probable Cause	Remedy
Can't get pressure	Poppet D, E, or K stuck open or contamination under seat. (Figure 4-20).	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 4-20)	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.



a0973 **FIGURE 4-19**

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 three capscrews, washers and nuts.
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 Valve

Removal

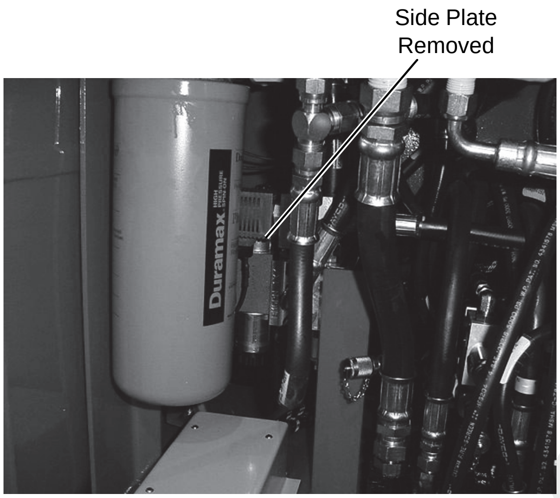
NOTE: On units with standard outriggers, one outrigger valve is used. On units with independent outriggers, two outrigger valves are used. Removal instructions for both valves are the same except where noted.

1. Stop the engine and engage the parking brake. Place chocks under the wheels.
2. Disconnect the battery cables from the battery. For safety, disconnect the negative (-) cable first.

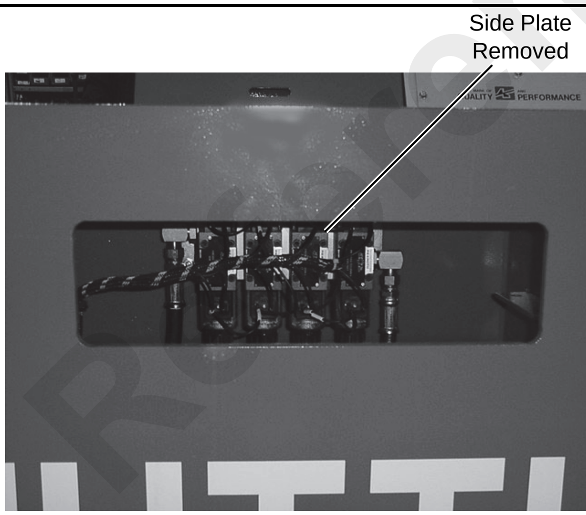
3. *Standard Outriggers* - Remove the side panel to gain access to the valve area (Figure 4-20).

   Independent Outriggers - Access to the valves can be obtained through the cutout opening in the front plate of the crane (Figure 4-21).

   Independent Outriggers with Auxiliary Front Winch - The front top deck plate must be removed to gain access to the valve.



p0812 **FIGURE 4-20**



p0803 **FIGURE 4-21**

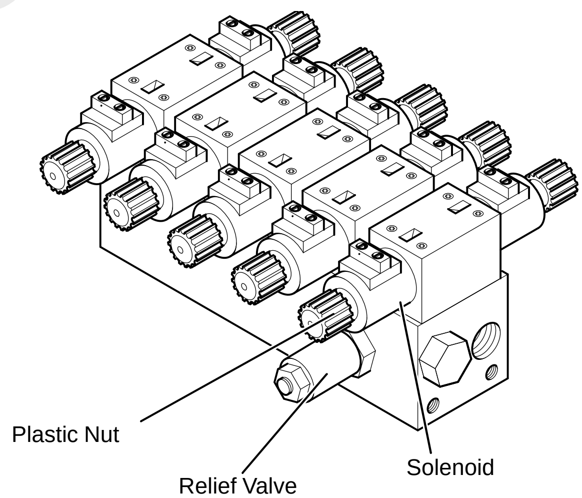
4. Individual sections can be removed from the manifold block without removing the complete valve. Disconnect the electrical leads from the outrigger valve solenoids. Remove the four socket head capscrews securing the valve section to the manifold block. Remove the valve section.

5. If the complete valve assembly must be removed, tag all hydraulic lines for correct assembly. Clean the valve and connecting lines. Disconnect the hydraulic lines from the valve ports. Put plugs in the hose ends and cap the valve ports to keep dirt out of the hydraulic system. Remove the valve mounting screws and remove the valve.

Solenoid Replacement

The solenoids on each valve section can be removed without removing the valve section from the manifold valve.

1. Stop the engine and engage the parking brake. Place chocks under the wheels.
2. Disconnect the battery cables from the battery. For safety, disconnect the negative (-) cable first.
3. Gain access to the outrigger valve. See “Removal” procedures on page 4-34.
4. Tag and then disconnect the wire leads from the solenoid.
5. Remove the plastic nut (Figure 4-22) from the solenoid shaft. Slide the solenoid off of the shaft.



a0494 **FIGURE 4-22**

6. Place the new solenoid over the solenoid shaft and install the plastic nut.
7. Connect the wire leads to the solenoid.
8. Connect the battery cables. Positive cable first; negative cable second.
9. Start the engine and test outrigger function.
10. Install any removed covers or plates.

Installation

1. If complete valve assembly is being installed, put the valve assembly in position and secure it with four capscrews, washers and nuts. Connect the hydraulic lines to the manifold block and connect the wire leads to the solenoids.
2. If a valve section is being installed, place the valve section in position and fasten with four socket head capscrews. Connect the wire leads.
3. Connect the battery cables to the battery. Positive cable first; negative cable second.
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.

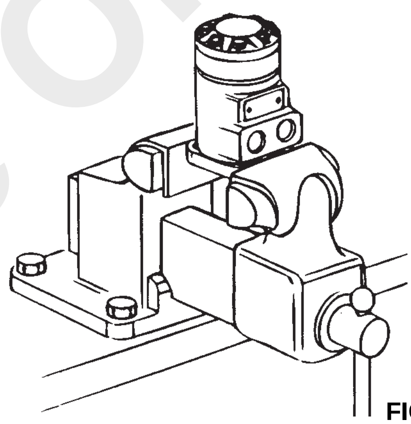
2. Before disconnecting the hydraulic lines, clean the port area of the swing motor thoroughly. Disconnect the hydraulic lines from the swing motor. Put caps and plugs on the hoses and ports to keep dirt out.
3. Remove the two mounting socket head capscrews and lockwashers from the swing motor. Remove 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 4-23) with the output shaft facing down. When clamping use protective devices on the jaws, such as soft jaws, pieces of rubber or wood.

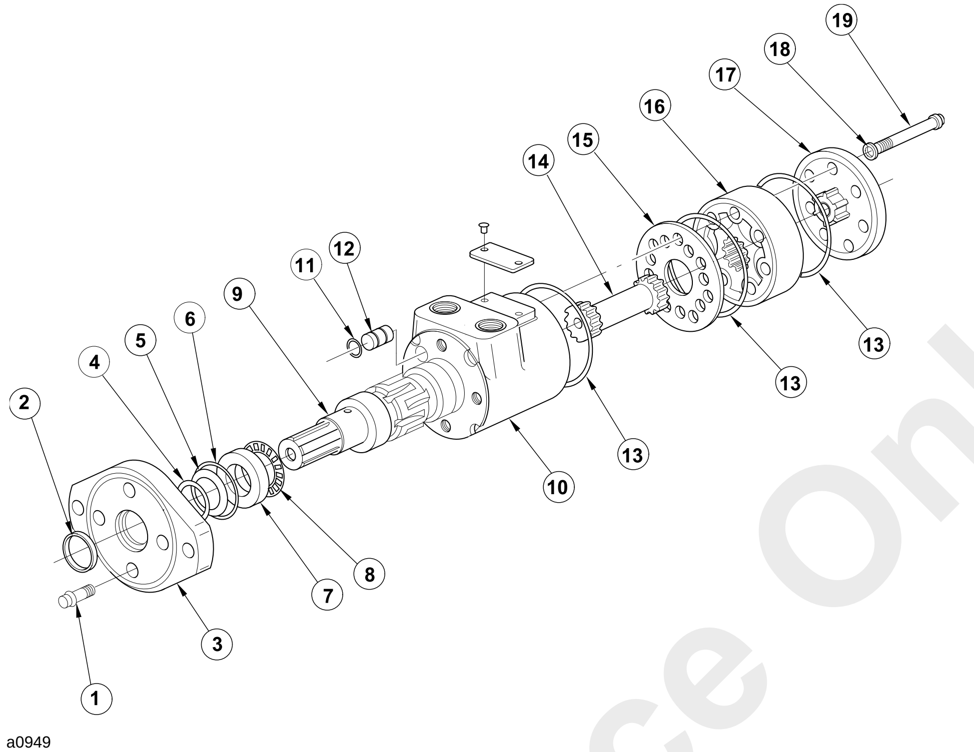
NOTE: Although not all drawings show the motor in a vice, it is recommended that you keep the motor in the vice during disassembly and assembly. Follow the clamping procedure explained in Step 1.



a0763

FIGURE 4-23

2. Remove seven capscrews (19, Figure 4-24) 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 4-24

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 4-25. DO NOT clamp on housing. Excessive clamping pressure on side of housing causes distortion.

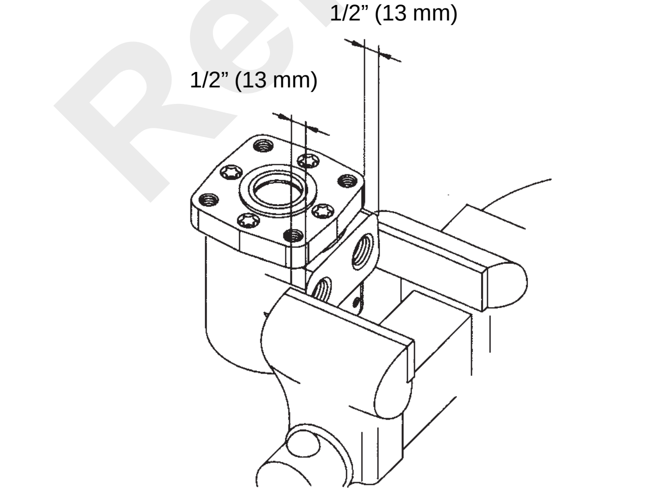


FIGURE 4-25

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 4-26. **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.

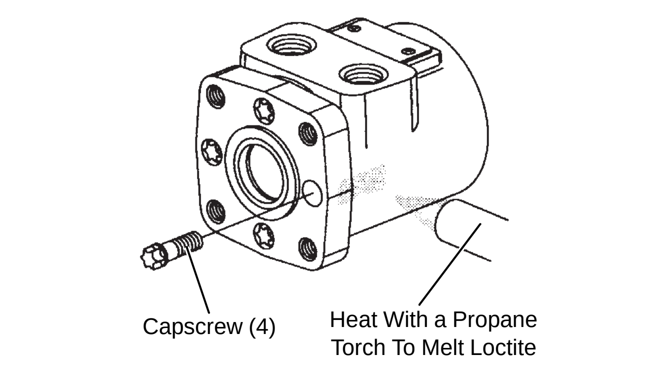


FIGURE 4-26

12. Carefully remove flange (3, Figure 4-24) 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.

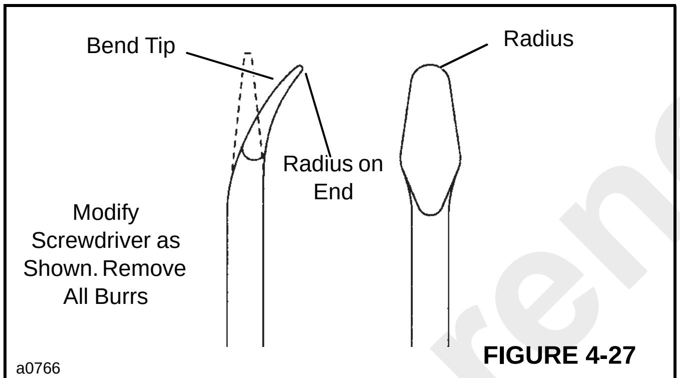


FIGURE 4-27

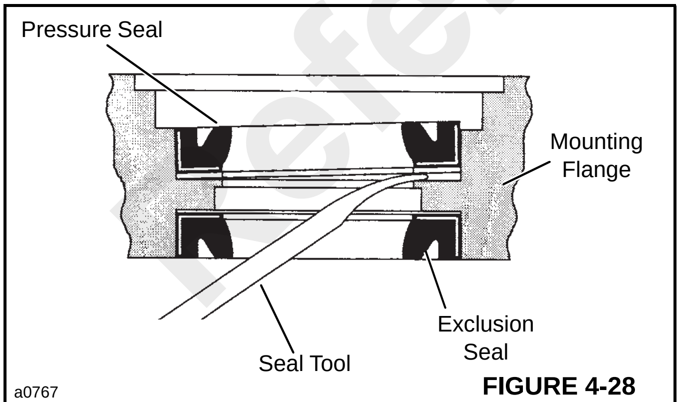


FIGURE 4-28

14. A metal plug (12, Figure 4-24), with O-ring (11), plugs a machined hole in the housing. It is not necessary to remove the plug and replace the O-ring unless leakage occurs around the plug. To remove the plug, insert a 5 mm (0.187 in) hex key through the port opening and push it out.

Inspection/Cleaning

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

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

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

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

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

1. Wash the housing with a suitable solvent to remove oil, grease and debris. Pay particular attention to the four tapped holes on the flange end.

2. Blow dry with compressed air. Clean and dry the tapped holes.

3. Wire brush the screw threads to removed 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 4-24) 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 4-29) and install the shaft into housing (10, Figure 4-24).

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

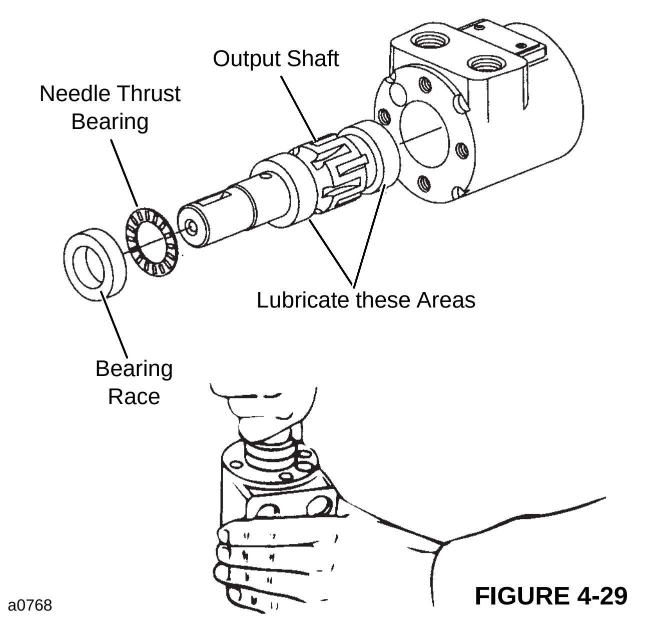


FIGURE 4-29

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 4-29). 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 4-24) in flange (3) with the lips of the seal facing out (see Figure 4-30). 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 4-31. 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 4-24) into groove in flange (3).

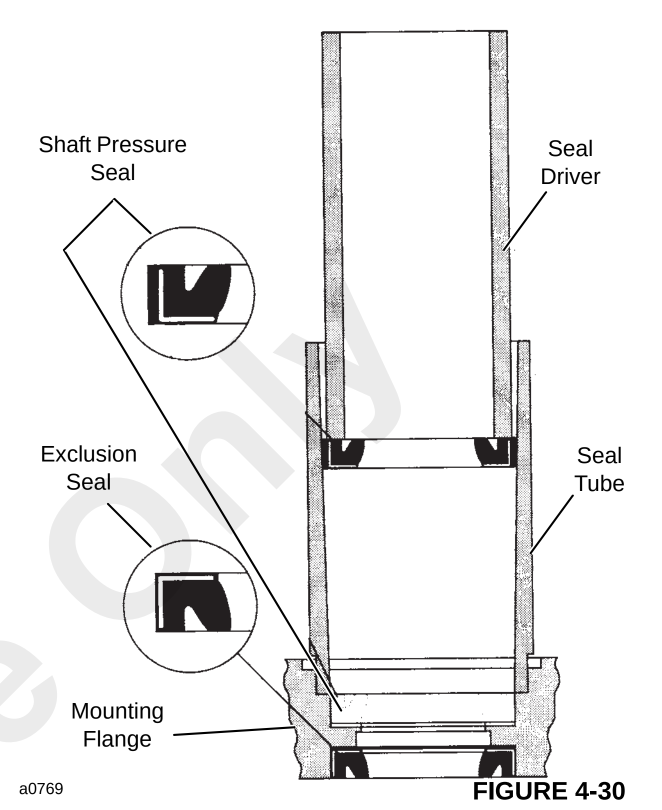


FIGURE 4-30

8. It is recommended to apply a light coat of Loctite Primer NF in tapped holes of housing (10). Allow the primer to air dry for at least 1 minute. Do not force dry with air jet; the primer will blow away.

   Use of primer is optional. With primer, Loctite curing time is approximately 15 minutes. Without the primer the curing time is approximately 6 hours.
9. Apply 3 or 4 drops of Loctite sealant at the top of the threads for each of the four holes in the housing (see Figure 4-31). 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.

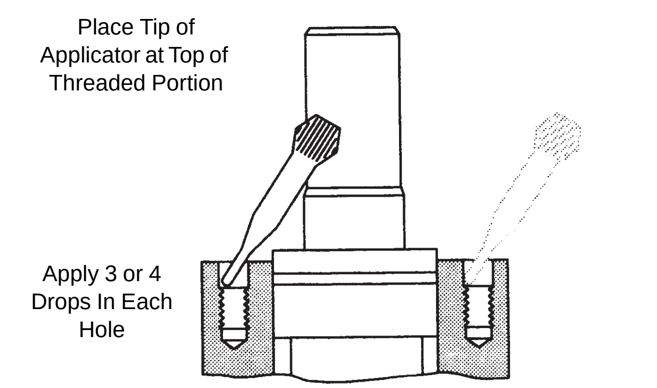


FIGURE 4-31

10. Before installing the flange and seal assembly over shaft (9, Figure 4-24), 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 4-32).

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

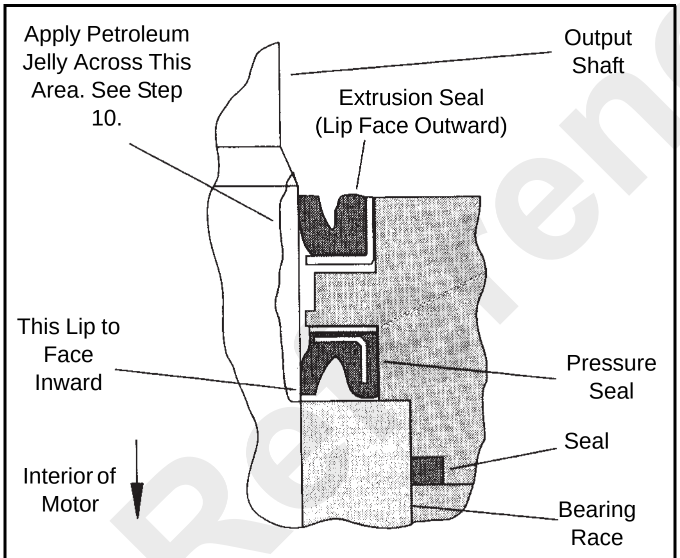


FIGURE 4-32

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 1 ounce (35 mm) of clean hydraulic oil in the output shaft cavity.

14. Install O-ring (13, Figure 4-24) in the housing groove. Avoid twisting the seal.

Timing Procedure

15. Install drive shaft (14, Figure 4-24). Use a felt tip pen to mark one drive tooth. Align this mark with the timing dot on the output shaft (Figure 4-33).

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

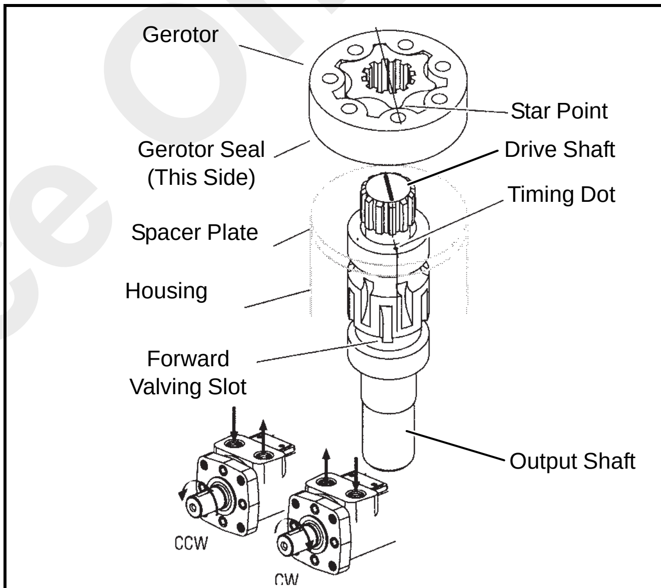


FIGURE 4-33

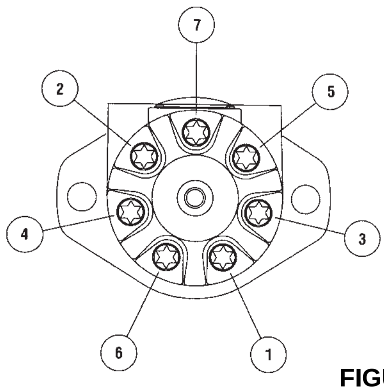
16. Install spacer plate (15).

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 4-33).

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 4-34.



a0980 FIGURE 4-34

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 4-35) from the pump. Discard all O-rings.

Disassembly

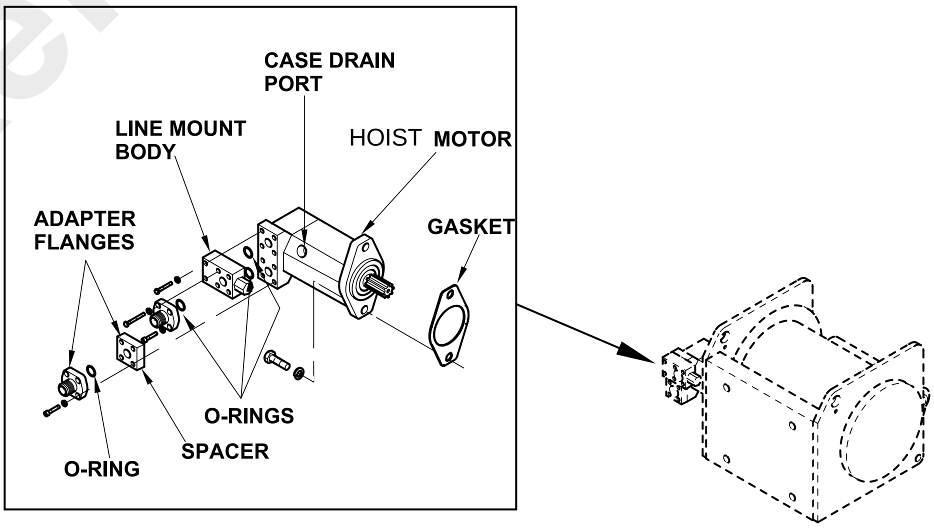
The hoist motor is not field serviceable. It must either be replaced or returned to your distributor for repair.

Installation

1. Install the line mount body (Figure 4-35), 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 inhibit 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 4-35) 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.



a0773 FIGURE 4-35

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 stop 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 three hex socket flat head capscrews (1, Figure 4-36) from flange (2). Remove the flange (2), O-ring (3) and thrust washer (4). Discard the thrust washer and the O-ring.
2. Carefully pull the swivel stem (7) from swivel housing (5). If the swivel can not be pulled from the housing, hit the top of the swivel shaft with a soft hammer.
3. Remove and discard seals (6), seals (8) and O-rings (9).

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 (7, Figure 4-36) on the work bench in the vertical position.
3. Walk the lower seal (6) down the swivel stem one flow groove at a time until it reaches the swivel stem base. Carefully work the seal until it slips into the seal groove at the swivel stem base.
4. Install one O-ring (9) into each of the seal grooves of stem (7). Make sure that the O-ring is not twisted in the groove.
5. Slip one seal (8) over the top of the spool and walk the seal down the swivel one flow groove at a time until it reaches the bottom seal groove.
6. A seal assembly tool must now be fabricated from a piece of 19 mm (3/4 in) wide fiberglass packing tape approximately 457 mm (18 in) long. Fold the tape in half with glue sides together (Figure 4-37). No glue can be exposed on the tape.
7. See Figure 4-37 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.
8. 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 4-37. 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	Flat Head Screw (3)
2	Flange
3	O-ring*
4	Thrust Washer*
5	Swivel Housing
6	Seal (2)*
7	Swivel Stem
8	Seal (8)*
9	O-ring (8)*

* Included in Seal Kit

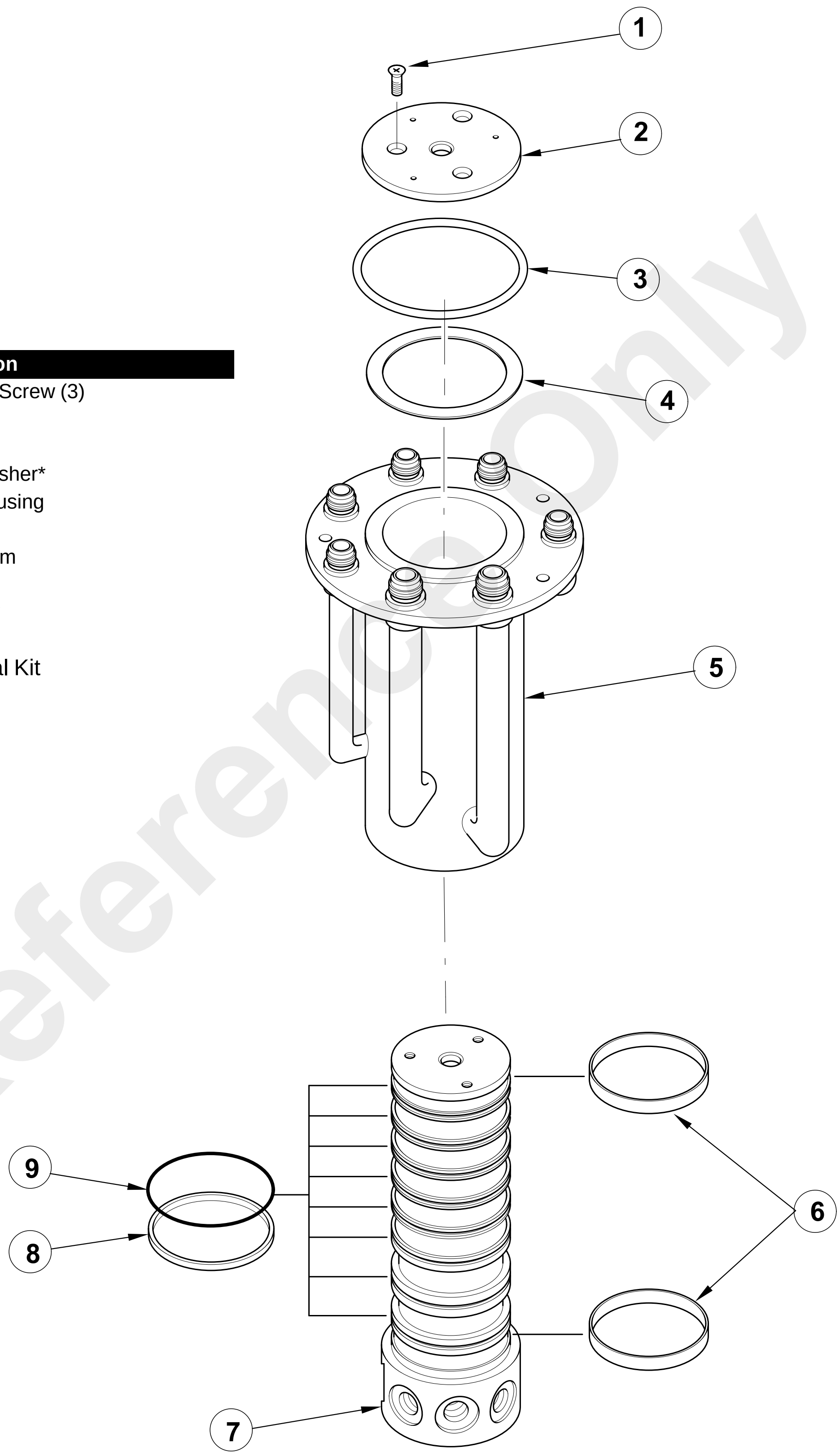


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FIGURE 4-36

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.

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

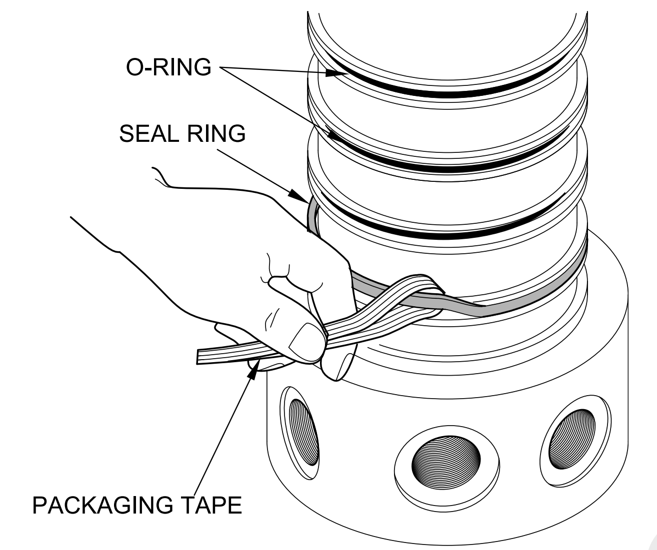


FIGURE 4-37

10. Repeat steps 5 through 8 for the remaining seal grooves.
11. Install the top seal (6, Figure 4-36) to stem (7).
12. Place the swivel housing (5) on the work bench with bottom of the housing up. 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 (4), O-ring (3) and plate (2).
15. Install three hex socket flat head capscrews (1) and tighten to a torque of 41 Nm (30 lb-ft).

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 stop to the bottom of the hydraulic swivel using three bolts and lockwashers.
3. Connect the hydraulic lines to the lower ports of the hydraulic swivel.
4. Fill the lower hydraulic system by adding recommended hydraulic oil through the upper ports of the hydraulic swivel.
5. Connect the hydraulic lines to the upper ports.
6. Start the engine and move the hydraulic oil through the swivel 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. Telescope 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 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 off 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.

Published 04/07/2015 Control # 569-00

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.

WARNING

Flying Parts Hazard!

If air or hydraulic pressure is used to force out the piston assembly, ensure that the head gland is securely installed in the cylinder tube.

5. Fasten the eye of the rod in a vise with soft jaws. Put a support under the opposite end of the rod to hold the rod level. Use care not to cause damage to the chrome surface of the rod.
6. The piston is fastened to the rod either by internal threads or with a locking nut. To remove the piston:
   - **a.** On pistons with internal threads, remove the set screw from the piston. Use a spanner wrench to loosen and remove the piston.
   - **b.** On pistons which are fastened with a locking nut, use a socket wrench 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 in) 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 243 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 4-10

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)

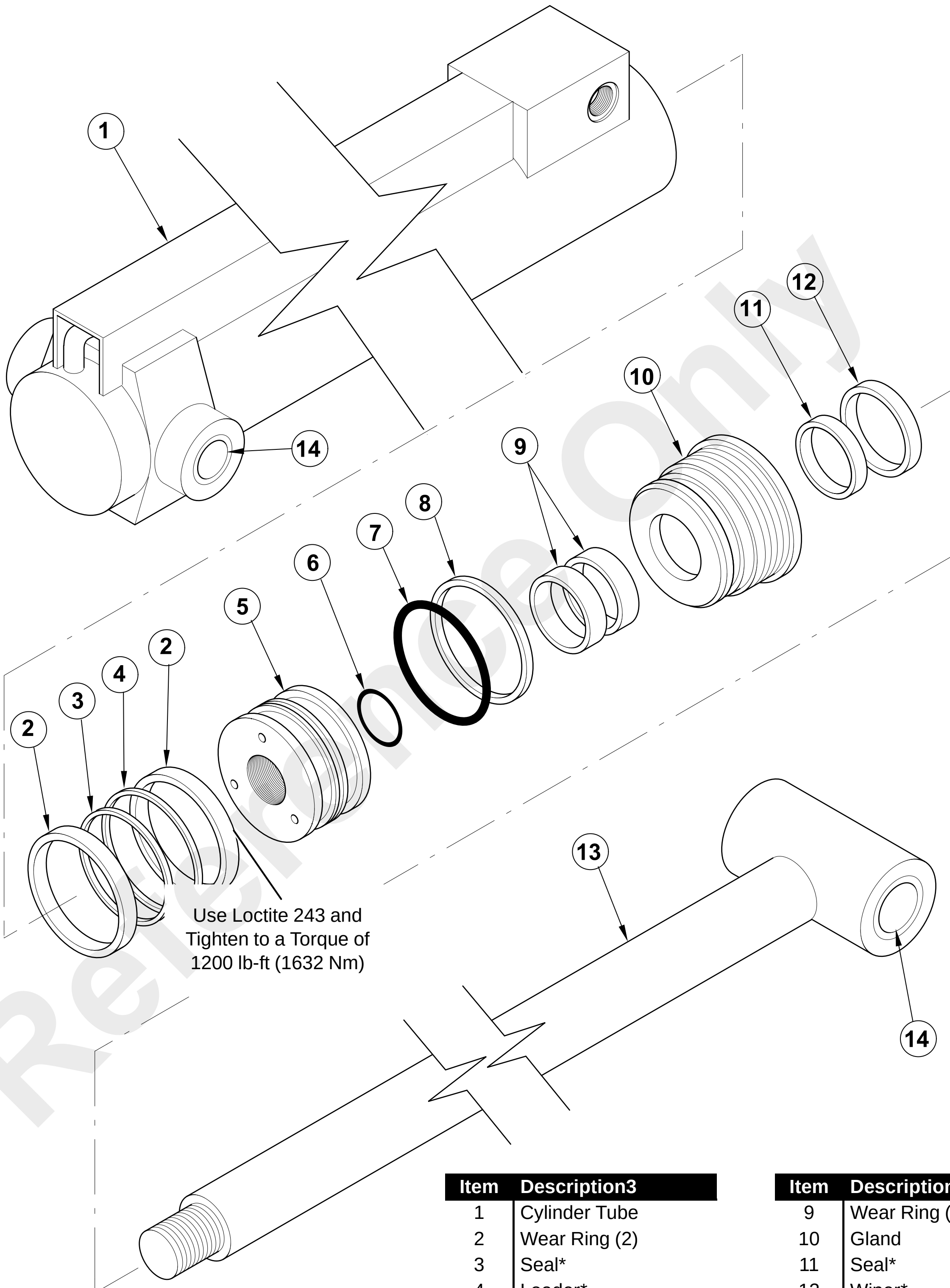
2. Move the cylinder rod through two complete strokes at 5510 kPa (800 psi) to remove air from the cylinder. Look for external leaks. If the pressure difference between cylinder ports is more than 689 kPa (100 psi) during the second stroke, the cylinder assembly is not acceptable. Disassemble and inspect 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 4-10) 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 4-10) 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.



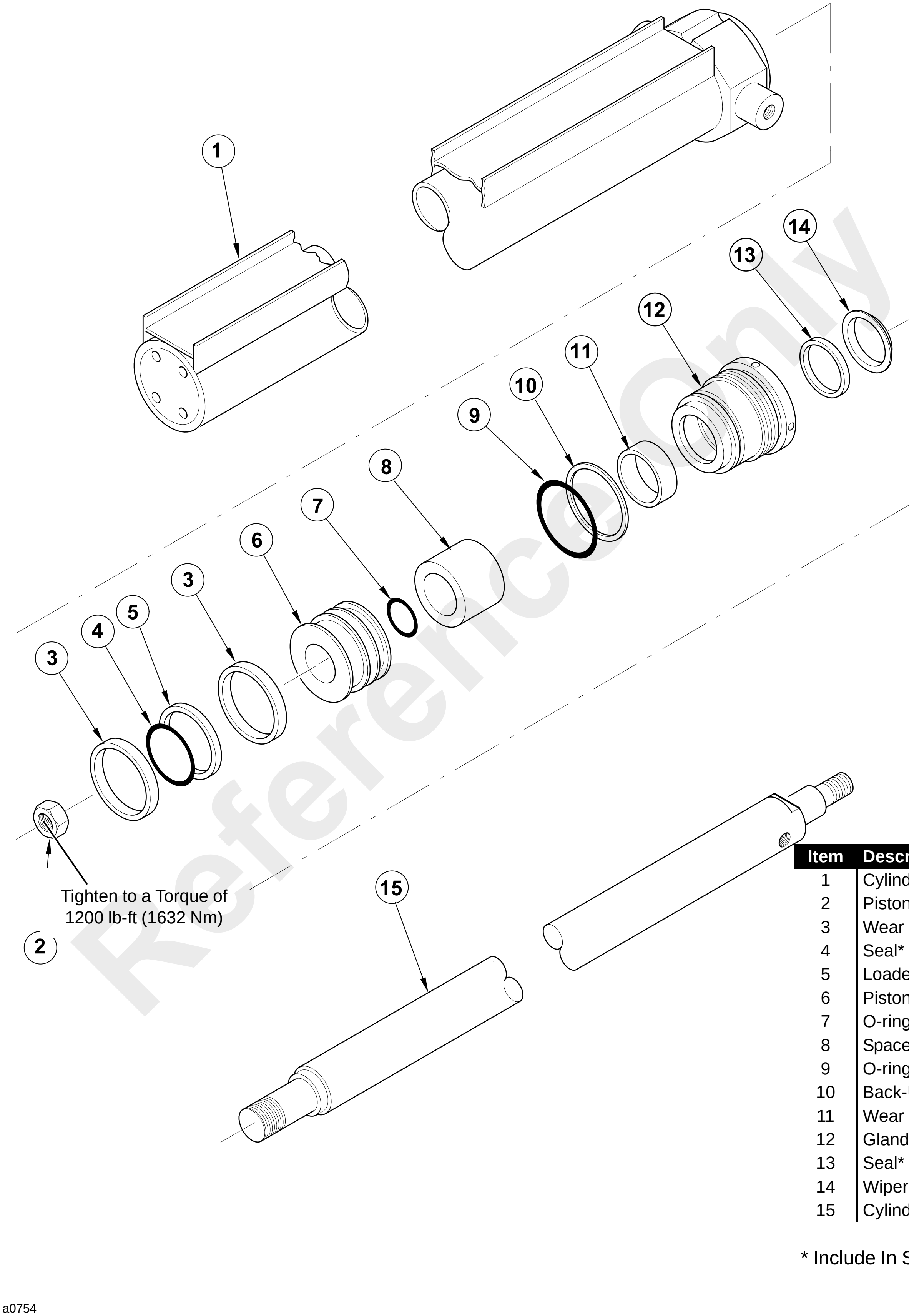
Item	Description3
1	Cylinder Tube
2	Wear Ring (2)
3	Seal*
4	Loader*
5	Piston
6	O-ring*
7	O-ring*
8	Back-Up Ring*

Item	Description3
9	Wear Ring (2)*
10	Gland
11	Seal*
12	Wiper*
13	Cylinder Rod
14	Bushing (4)

* Include In Seal Kit

a0755

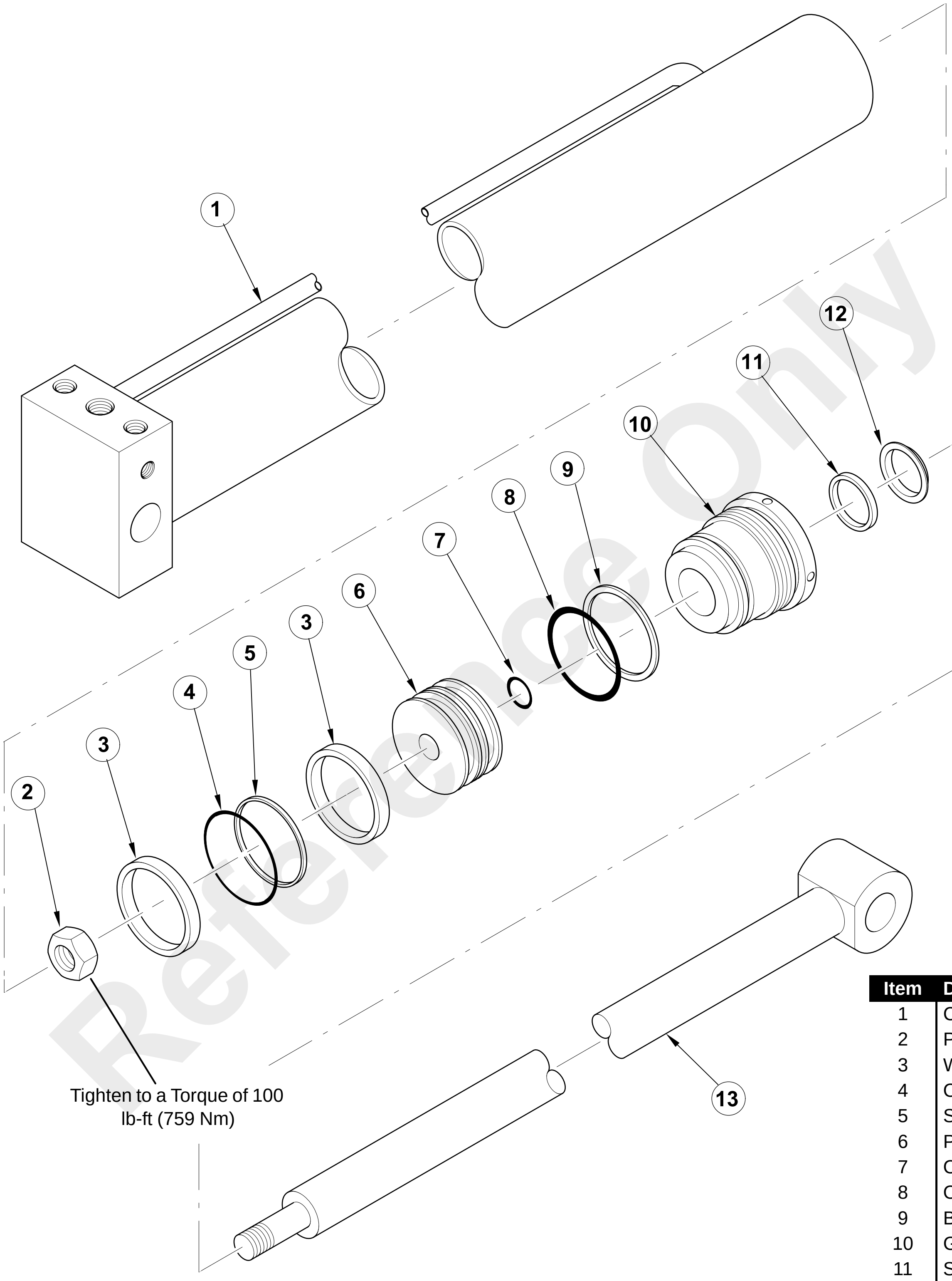
FIGURE 4-38



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

* Include In Seal Kit

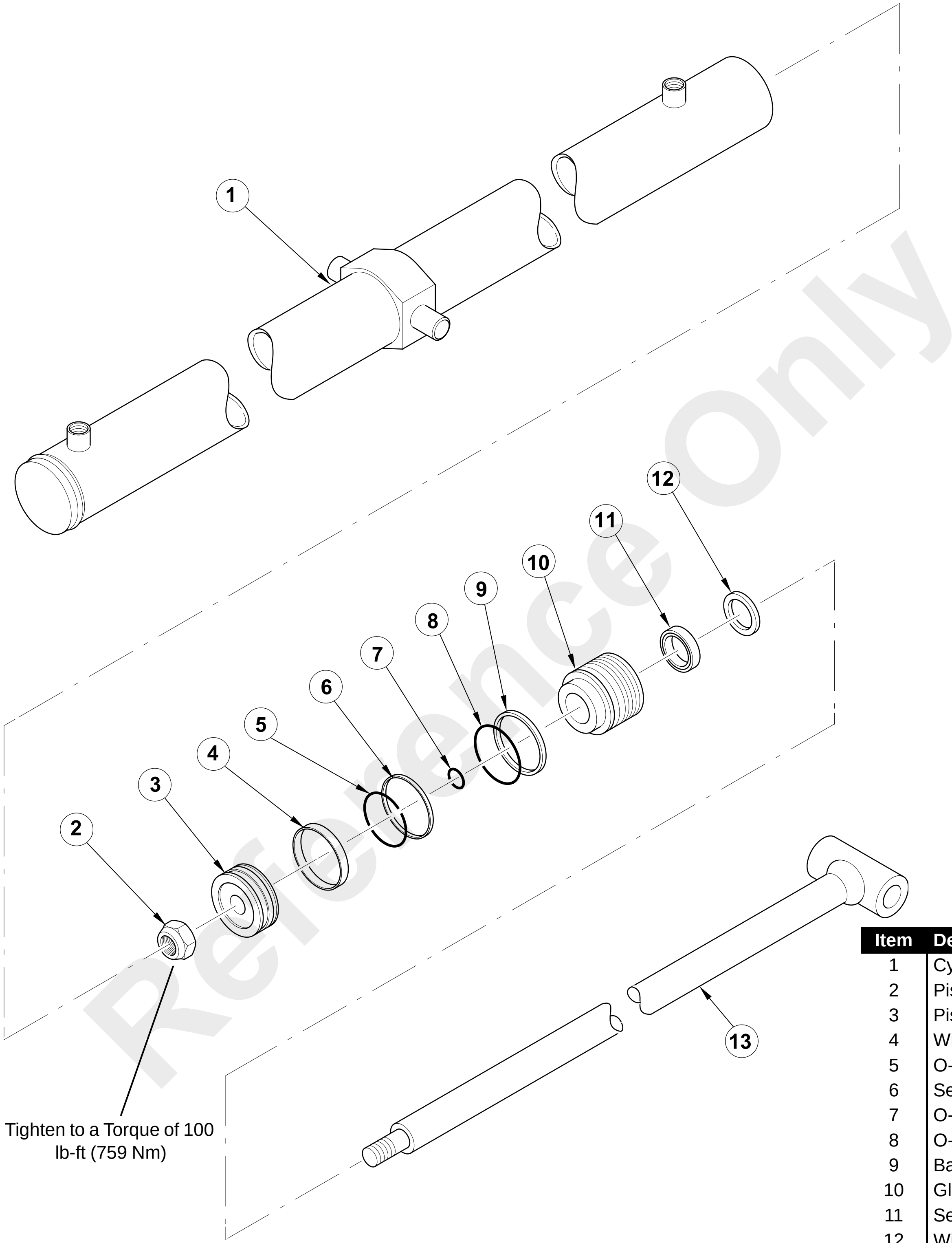
FIGURE 4-39



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

* Include In Seal Kit

FIGURE 4-40



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

* Include In Seal Kit

a0757

FIGURE 4-41

UNDER DECK WINCH

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

SECTION 5
MAINTENANCE

SECTION CONTENTS

INTRODUCTION

General

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

The intervals in the Maintenance Schedule are average operating conditions and must be understood as the MINIMUM maintenance necessary for the machine. Shorten 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 hour meter to make sure that all necessary maintenance is done according to schedule.

ENVIRONMENTAL PROTECTION

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

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

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

When filling and draining crane components, observe the following:

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

LUBRICANTS AND CAPACITIES

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

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

Maintenance Records

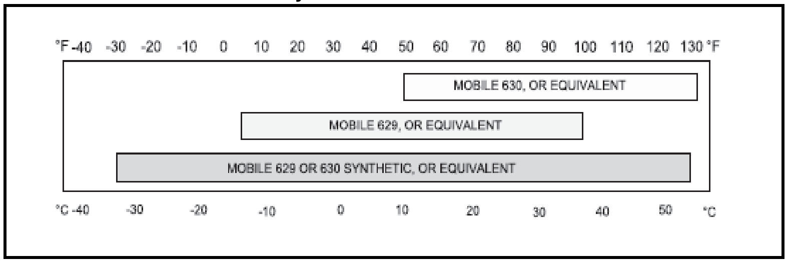
Dated records must be kept for inspection of critical components such as, brakes, crane hooks, wire ropes, hydraulic cylinders and relief valve pressure settings. These records must be kept where they can be easily obtained and reviewed.

NOTE: The following list of lubricants does not constitute an unconditional guarantee of the performance of the lubricant mentioned. It is intended solely as a guide to the type of lubricant recommended for a given application.

Table 5-1
Machine Lubricants and Capacities

ITEM	Capacity		Fluid/Lubricant
	qt/gal	ls	
Engine Crankcase (Diesel) Without Filter Change With Filter Change	 5.5 qt 7.0 qt	 5.2 6.6	See engine manual
Cooling System	18.8 qt	17.8	50/50 Mixture of Glycol Antifreeze & Water (See engine manual)
Supplemental Coolant Additive (SCA)			6829012858 Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000
Fuel Tank	18.5 gal	70.0	See engine manual
Transmission	4 gal	15.1	Mobil ATF 210 (Type F), or equivalent
Front Drive Axle: Wheel Hubs (2) Housing	 2.1 qt 2.1 gal	 1.98 7.1	 Mobil 424 hydraulic oil (ISO 46/68) Mobil 424 hydraulic oil (ISO 46/68)
Swing Gearbox	A/R	A/R	Lithium based, E.P. No. 2 bearing grease
Hoist Gearbox (Tulsa Model)	1-1/2 - 2 qt	1.4 - 1.9	SAE 90 EP gear lube
Hoist Gearbox (Braden Model)	6.5 pt	3.10	SAE 90 EP gear lube
Hoist Brake (Tulsa Model)	1/2 - 1 pt	0.2 - 0.5	SAE 20-20 motor oil
Swing Gear and Pinion	A/R	A/R	Open gear lube
Hydraulic Tank	23.5 gal	88.9	Mobil fluid 424 (ISO 46/68) Very Cold Temperatures: Mobil DTE 10M Series if the viscosity is between 80 to 170 SUS at maximum operating temperature.

Chart 1. Recommended Planetary Gear Oil



After First 50 Hours of Operation (New Cranes)

Table 5-2

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 Chains	Inspect chains for looseness and tighten
Boom Slides	Lubricate
Wheel Mounting Nuts	Check Torque

Cranes not in Regular Use

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

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

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

PREVENTIVE MAINTENANCE

Maintenance Schedule and Checklist

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

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

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

SERVICE/CHECK	INTERVAL							See Page
	Daily Before Operation	50 Hours	100 Hours	250 Hours	500 Hours	1000 Hours	2000 Hours	
Inspect The Anti-Double Blocking System	X							5-13
Inspect The Wire Rope	X							5-13

SERVICE/CHECK	INTERVAL							See Page
	Daily Before Operation	50 Hours	100 Hours	250 Hours	500 Hours	1000 Hours	2000 Hours	
Inspect Reeving, Clamps and Connections	X							5-13
Inspect The Lifting Hook	X							5-13
Inspect Safety Devices	X							5-13
Check Controls Operation	X							5-13
Check Engine Crankcase Oil Level	X							5-14
Check Transmission Oil Level	X							5-14
Check Engine Coolant Level	X							5-14
Check Fuel Level	X							5-13
Check Tire Pressure	X							5-16
Drain Water From Engine Fuel Filter/Water Separator	X							5-15
Check Air Cleaner Restriction Indicator	X							5-16
Check Hydraulic Oil Level	X							5-15
Inspect Wire Rope and Sheaves		X						5-17
Apply Grease to All Lubrication Fittings		X						5-17
Lubricate the Boom Slides		X						5-18
Lubricate the Boom Chains		X						5-18
Clean Air Cleaner Dust Cup		X						5-17
Inspect The Engine Fan Belts			X					5-19
Check Wheel Nut Torque			X					5-19
Lubricate the Swing Gear and Pinion				X				5-23
Lubricate the Wire Rope				X				5-22
Inspect The Boom Chains				X				5-20
Inspect All Hydraulic Hose				X				5-21
Replace Engine Crankcase Oil*				X				5-23
Replace Engine Oil Filter*				X				5-23
Clean Radiator Fins and Core				X				5-23
Clean Battery and Connections				X				5-22
Torque Critical Bolts				X				5-23
Check Axle Wheel Hub Lubricant Level (2)					X			5-28
Check Axle Housing Lubricant Level					X			5-28
Check Boom Hoist Gearbox & Brake Lubricant Level					X			5-28
Lubricate the Outrigger Slides					X			5-27

SERVICE/CHECK	INTERVAL							See Page
	Daily Before Operation	50 Hours	100 Hours	250 Hours	500 Hours	1000 Hours	2000 Hours	
Add Grease to Swing Gearbox					X			5-27
Replace Fuel Filter Elements (Diesel)					X			5-27
Replace In-Line Fuel Filter					X			5-27
Inspect the Parking Brake Pads					X			5-26
Inspect Tires for Damage					X			5-26
Check SCA level in cooling system					X			5-27
Lubricate the Wheel Bearings (Rear Axle)						X		5-34
Check Swing Gear To Pinion Backlash						X		5-35
Change the Transmission Oil and Filter						X		5-29
Replace the Axle Wheel Hub Lubricant (2)						X		5-31
Replace the Axle Housing Lubricant (1)						X		5-30
Replace the Hoist Gearbox and Brake Lubricant (Tulsa Model)						X		5-32
Replace Hoist Gearbox Lubricant (Braden Model)						X		5-32
Replace the Hydraulic Oil						X		5-34
Replace the Hydraulic Oil Filter						X		5-35
Check the cooling system and replace the Engine Coolant							X	5-36
Adjust the overhead set (valve lash), steam clean the engine, and replace the crankcase breather element							X	See engine manual.
Inspect the Crane Structure and Booms for Damage							X	5-36
Test the Rated Capacity Limiter (RCL) - Optional							X	5-36

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

LUBRICANTS

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
HTF	HTF- Hydraulic Transmission Fluid	80057784
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
EPGL-5	EPGL-5- Gear Lubricant	A6-829-003479
Transynd	Transynd- Synthetic Transmission Fluid	A6-829-101690

LUBRICATION POINTS

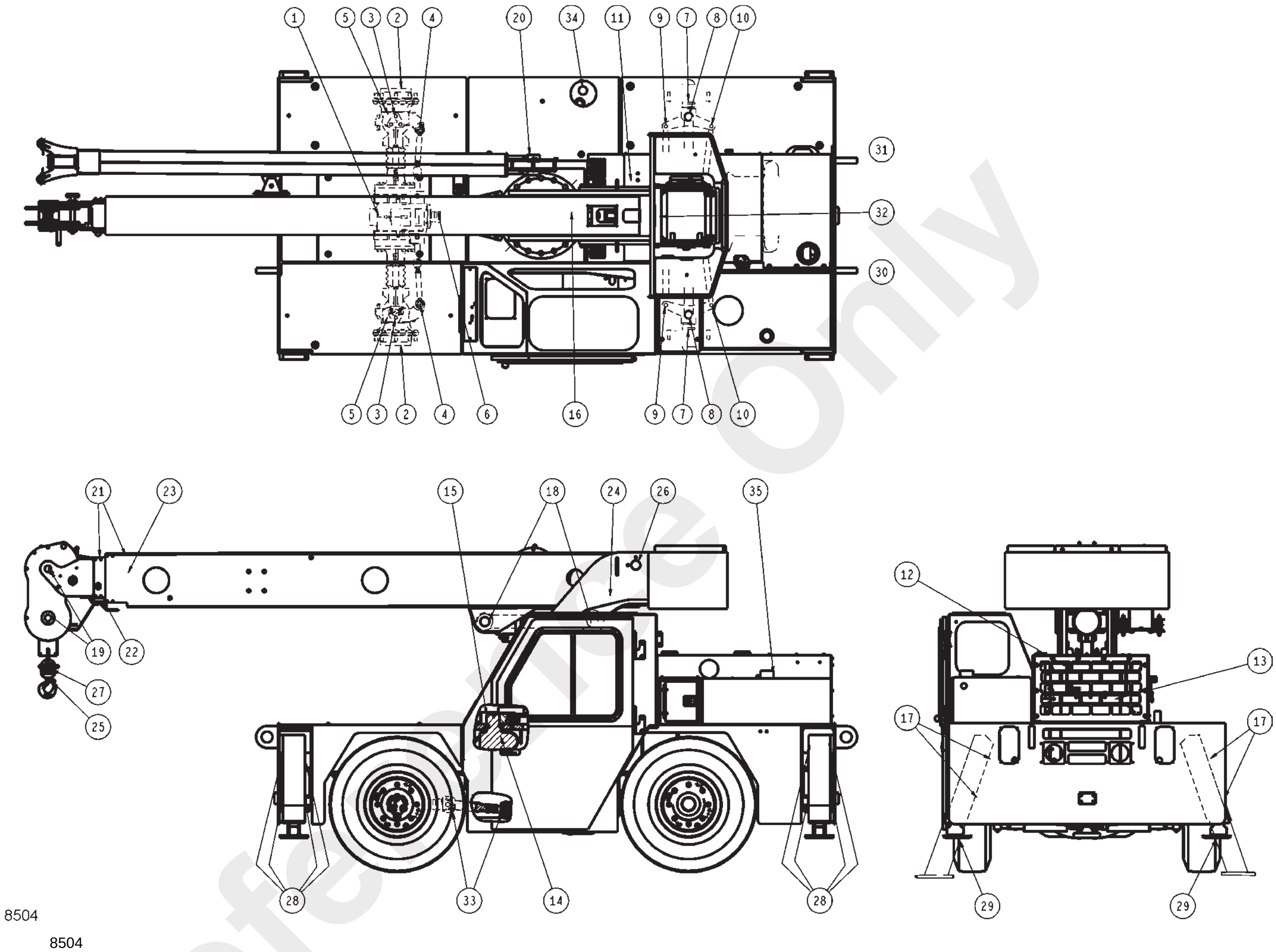


FIGURE 5-1

No	Location Name	Capacity	Symbol	Instruction
Front Drive/steer Axle				
1	Differential	2.1 Gal (8 Liters)	HYDO	
2	Planetary Hub Gears	0.21 Gal (0.8 Liters)	HYDO	
3	Kingpin Bearings		EP-MPG	
4	Steer Cylinder Bearing		EP-MPG	
5	Universal Joints		EP-MPG	
6	Brake Caliper		EP-MPG	

No	Location Name	Capacity	Symbol	Instruction
Rear Steer Axle				
7	Hub Bearings		EP-MPG	
8	Kingpin Bearings		EP-MPG	
9	Steer Linkage Bearing		EP-MPG	
10	Steering Cylinder		EP-MPG	
Engine & Trans.				
11	Engine Crankcase	5.8-7.4 Qts (5.5-7.0 L)	EO-15W-40	See Note 4
12	Engine Coolant	3.7 Gal (13.9 Liters)	AFC	See Notes 2 & 10
13	Transmission	4.5 Gal (17.0 Liters)	HTF	
Turntable				
14	T/T Gear Box		EP-MPG	
15	T/T Gear & Pinion		EP-OGL	
16	T/T Bearing		EP-MPG	
Cylinders				
17	O/R Cylinder		ASC	See Note 6
18	Lift Cylinder		EP-MPG	See Note 6
Boom				
19	Boom Nose Sheaves		EP-MPG	
20	Jib Boom Sheave		EP-MPG	
21	Boom Sections		EP-MPG	See Note 9
22	Tele Cylinder Wear Pads		EP-MPG	
23	Boom Extension Sheave		EP-MPG	
24	Boom Ret Sheave		EP-MPG	
25	Hook Block Swivel Bearing		EP-MPG	
26	Boom Pivot Shaft		EP-MPG	
27	Hook Block Sheaves		EP-MPG	
Outriggers				
28	Slide Box		EP-MPG	See Note 7
29	Jack Tube		EP-MPG	See Note 8
Hoist				
30	Hoist Gearbox	1.0 Qts (0.95 Liters)	EPGL-5	
31	Hoist Brake	0.25 Qts (0.24 Liters)	Transynd	
32	Cable Follower		EP-MPG	
Misc.				
33	Driveline Joints		EP-MPG	
34	Fuel Tank	17.0 Gal (64.4 Liters)		
35	Hydraulic, Oil Tank	34.5 Gal (130.6 Liters)	HYDO	See Notes 4 & 5

Notes:

1. All pintle hooks, etc. shall be oiled or greased as required.

2. A mixture of 50% AFC and 50% water is required for all standard units.

3. All moveable control links and clevis pins shall be lubricated with ASC.

4. Final fluid levels shall be adjusted by use of dip sticks, markings or filler plugs.

5. The hydraulic oil shall meet or exceed manitowoc cleanliness spec. 6829014631.

6. Apply to pins prior to assembly.

7. Both sides.

8. All sides.

9. Lubricate all surfaces in contact with wear pads.

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

Grease Fittings

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.

	BOOM AND MAIN FRAME	
NO	LOCATION	QTY
1	Mast Bearing (SeeFigure 5-2)	2
2	Boom Pivot (See Figure 5-3)	2
3	Retract Chain Roller - 2nd Boom Section (See Figure 5-4)	2
4	Boom Head Sheaves and Pivot (See Figure 5-5)	2
5	Extend Chain Roller Assembly (See Figure 5-6)	2
6	Lift Cylinder Pivots (See Figure 5-7	2

	DRIVE TRAIN	
NO	LOCATION	QTY
7	Steering Knuckles - Rear Axle (See Figure 5-8)	2
8	Steering Cylinder Pivot Ends - Rear Axle (See Figure 5-9 and Figure 5-10)	2
9	Steering Link Pivot Ends - Rear Axle (SeeFigure 5-11)	2
10	Steering Knuckles - Front Axle - (See Figure 5-12)	4
11	Drive Shaft (See Figure 5-13)	3
12	Parking Brake (See Figure 5-14)	1

	OPTIONAL EQUIPMENT AND ACCESSORIES	
NO	LOCATION	QTY
13	Drop Block (See Figure 5-15)	1
14	Jib Boom Head Sheave (See Figure 5-16)	1
15	Jib Boom Deflector Sheave (See Figure 5-17)	1

Two Fittings Located on Inside Surface of Bearing Ring

Mast Bearing Lube Points

p0305

FIGURE 5-2

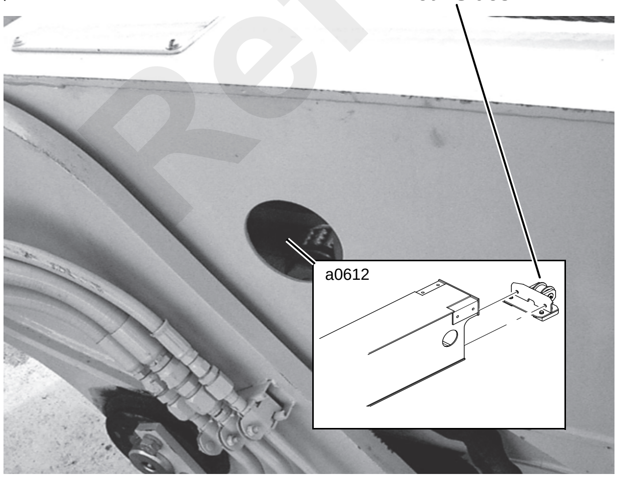
p0306

Boom Pivot Lube Points

FIGURE 5-3

p0469

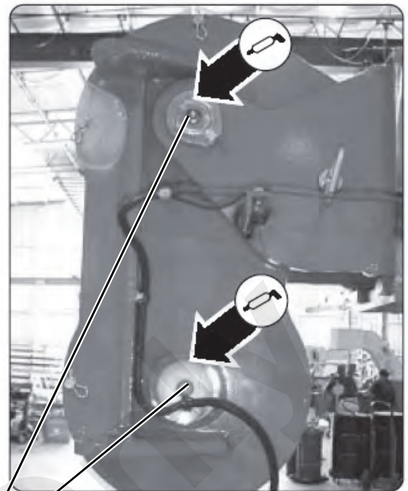
Both Sides



Retract Chain Roller Lube Points

FIGURE 5-4

p0498

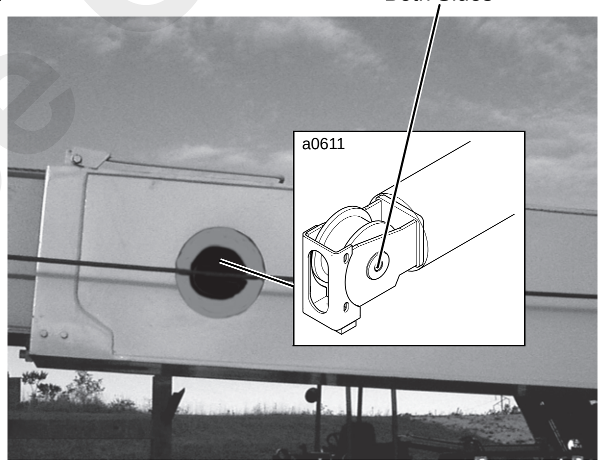


Boom Head Lube

FIGURE 5-5

p0470

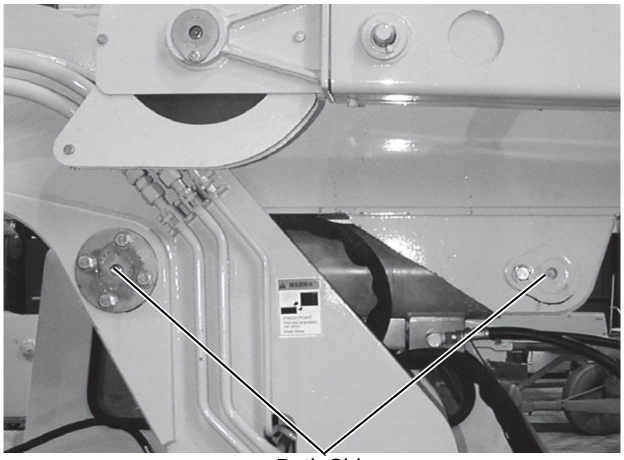
Both Sides



Extend Chain Roller Lube Points

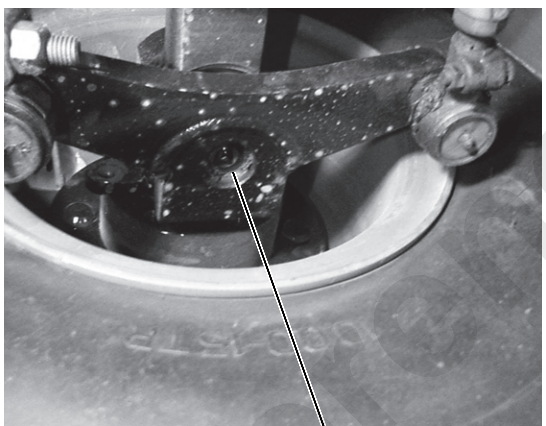
FIGURE 5-6

p0307



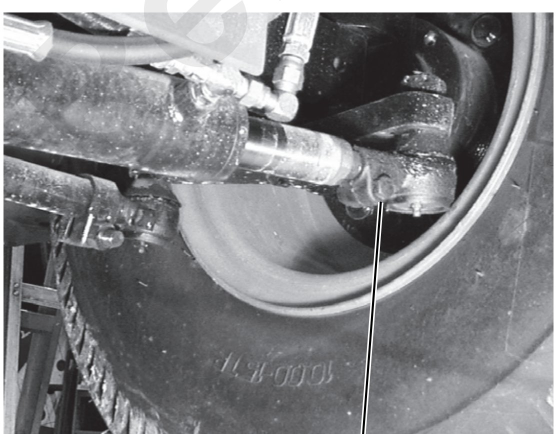
Lift Cylinder Lube Points **FIGURE 5-7**

p0308

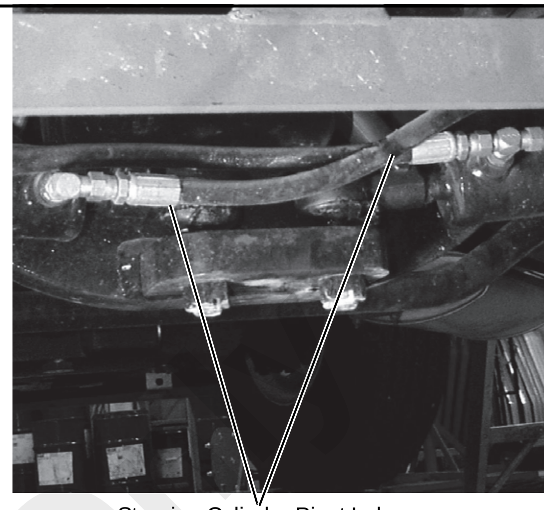


Steering Knuckle Lube Points (Rear Axle) **FIGURE 5-8**

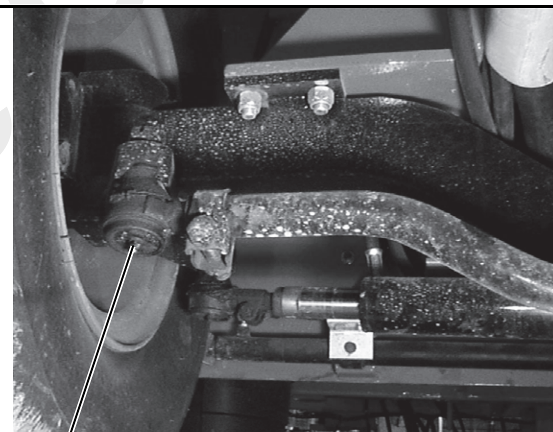
p0308



Steering Cylinder Pivot Lube Points- Rod End (Rear Axle) **FIGURE 5-9**



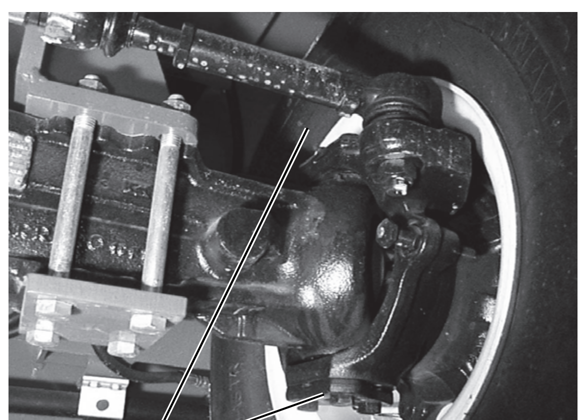
p0309 Steering Cylinder Pivot Lube Points - Base End (Rear Axle) **FIGURE 5-10**



Steering Link Pivot Lube Points (Rear Axle)

p0310 **FIGURE 5-11**

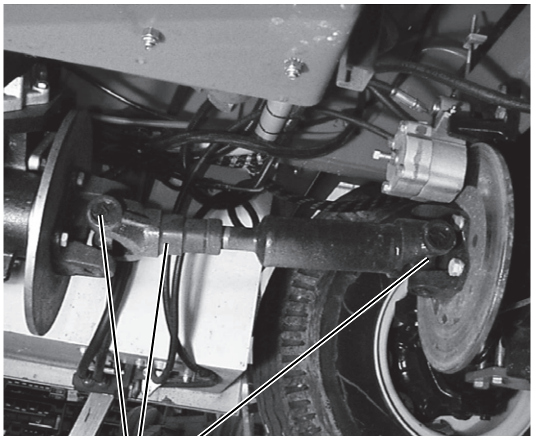
p0311



Steering Knuckle Lube Points (Front Axle) **FIGURE 5-12**

5

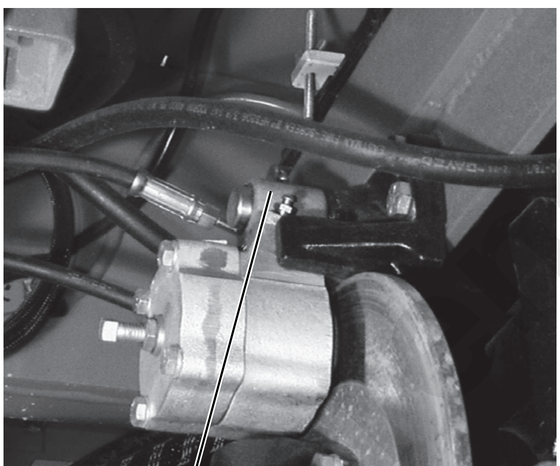
p0312



Drive Shaft Lube Points

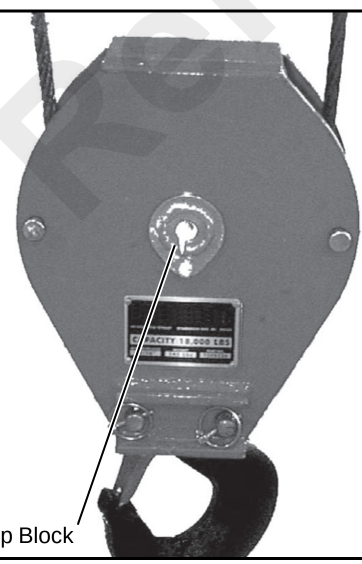
FIGURE 5-13

p0313



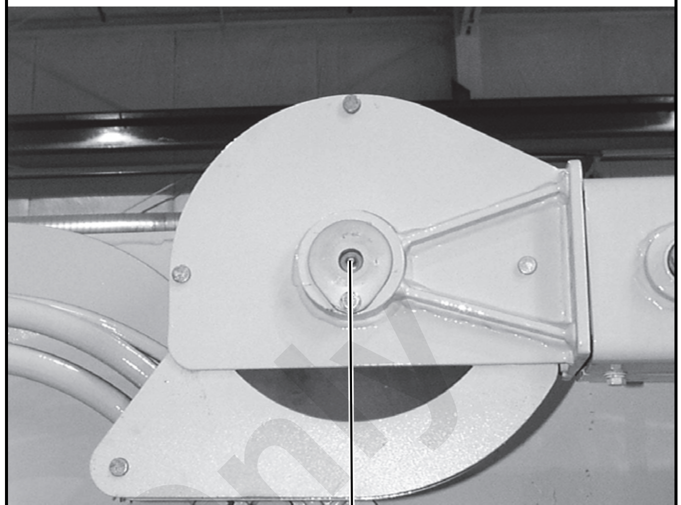
Parking Brake Lube Point

FIGURE 5-14



p0447 Drop Block

FIGURE 5-15



Boom Extension Head
Sheave Lube Point

p0315

FIGURE 5-16

Boom Extension Deflector
Sheave Lube Point

p0316

FIGURE 5-17

SCHEDULED MAINTENANCE

Daily (Walk-around)

NOTE: You must read and understand the warnings and basic safety rules, found in Section 1, Introduction of this manual, before performing any operation or maintenance procedures.

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

Inspections

Inspect the Anti-Double Blocking System

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

Raise the drop block until it 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 the 50 Hour Scheduled Maintenance in Wire Rope and Sheave Inspection, 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. Examples of safety devices include, backup alarm, horn, and beacon light.

If any are 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.

W0015

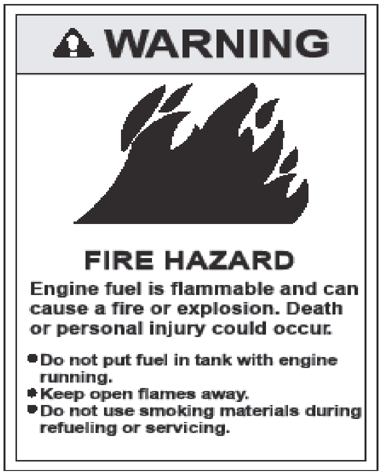


FIGURE 5-18

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.

W0033

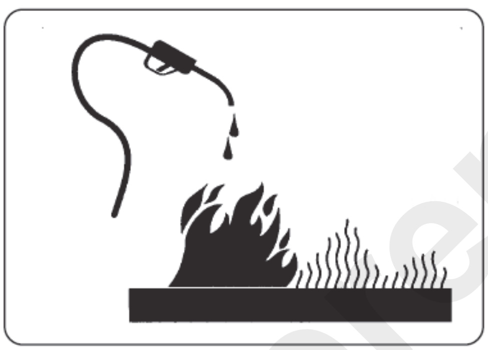


FIGURE 5-19

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

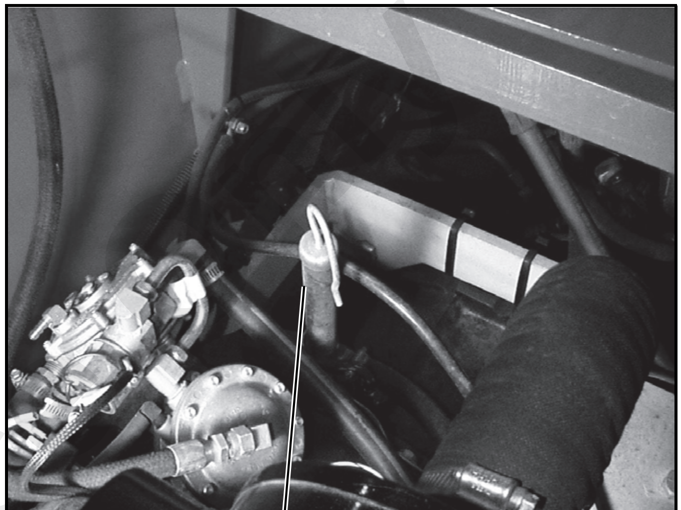
Tighten the fuel cap securely. If the cap is lost, replace only with original equipment.

Check the Engine Crankcase Oil Level

1. Level the crane, engage the parking brake and shut off the engine.
2. Lift the engine compartment cover and prop it in place using the furnished prop rod.
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 when the oil is cold.
2. Level the crane, engage the parking brake and shut off the engine.
3. Open and support the engine compartment cover. Remove the transmission dipstick (Figure 5-20) and check the oil level. Oil should be between the minimum and maximum marks on the dipstick.



p0317 FIGURE 5-20

4. If oil has to be added, add only recommended oil until it is between the two marks. **DO NOT OVERFILL**.
5. Install the dipstick and close the engine compartment cover.

Check Engine Coolant Level

W0020

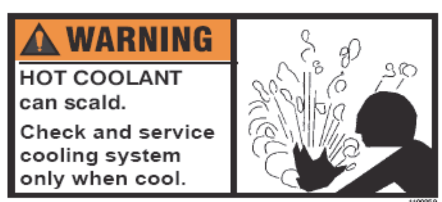


FIGURE 5-21

- **Never** remove the radiator cap while the cooling system is hot. Check coolant level only when the coolant temperature is cool. 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. Look through the grate behind the engine, coolant should be visible in the sight gauge (Figure 5-22).
3. If level is low, add only 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.

Radiator Overflow Container Sight Gauge

8465 **FIGURE 5-22**

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 Hydraulic Oil Level

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

W0017

FIGURE 5-23

1. Be sure the boom is fully retracted and lowered and the outriggers are retracted and up.
2. Level the crane, engage the parking brake and shut off the engine.
3. Check the oil level in the sight gauge (Figure 5-24) on the side of the tank. Oil should be visible in the gauge. If not, add recommended oil to the tank until it is visible.

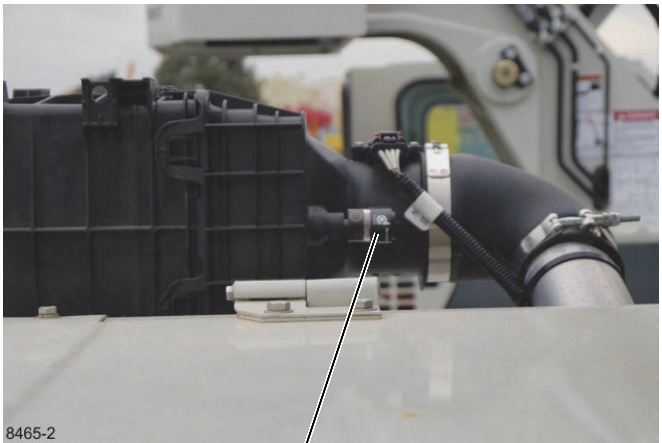
NOTE: The pump used on this crane requires clean hydraulic oil for proper operation. Contaminated oil can cause damage to the pump. Before adding any hydraulic oil to the hydraulic system, be sure the oil has been filtered through a 10-micron (absolute), or less, filter.

Sight Gauge

8465-1 **FIGURE 5-24**

Check the Air Cleaner Restriction Indicator

The air cleaner is equipped with a filter restriction indicator (Figure 5-25). 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.



Air Cleaner Restriction Indicator - Typical

p0468 **FIGURE 5-25**

Removing Elements

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

1. Remove the housing cover.
2. Remove the element as gently as possible, until you get it outside of the housing. Accidently 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. 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.
4. Always clean the gasket sealing surfaces of the housing. An improper gasket seal is one of the most common causes of engine contamination. Make sure that all hardened ridges are completely removed, both on the bottom and top of the housing.

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 or gasket sealing problems. A dust trail or pattern on the element clean side is a sign that the element was not firmly sealed or that a dust leak exists. Make sure the cause of the leak is identified and rectified before replacing the element.

Installing the Element

1. Install the element over the opening in the housing and slide it all the way in.
2. 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.
3. Install the air cleaner housing cover and clamps.
4. Reset the air cleaner restriction indicator by pushing in the reset button (Figure 5-26).

a0450

Reset Button

FIGURE 5-26

Check the Tire Pressure

Check the air pressure in the crane's four tires. Correct pressure is 8.62 bar (125 psi). This pressure will differ from the recommended tire pressure from the tire manufacture.

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

50 Hours of Operation/Weekly

NOTE: You must read and understand the warnings and basic safety rules, found in Section 1 of this manual, before performing any operation or maintenance procedures.

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

Clean the Air Cleaner Dust Cup

Inspect the VacValve (Figure 5-27) for damage. Replace if any of the following is found:

- It remains open.
- It is cracked.
- It is torn.
- It is missing.

If any of the above conditions are found, replace the VacValve. Dust particles that are normally expelled can deposit themselves onto the filter element and will shorten the element service life.

8465-3 **FIGURE 5-27**

Wire Rope and Sheave Inspection

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

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

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

Inspection

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

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

General Inspection

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

1. Wire Rope - Inspect for damage, rust or wear to the wire rope. Keep a record of each inspection. Replace the wire rope if any of the conditions in Figure 5-28 are present.
2. Sheaves - Inspect sheaves for damage and/or wear. The sheave grooves must be smooth and a little larger than the wire rope. Use a sheave gauge to check the size of the sheave groove. Rough edges, narrow or worn grooves will cause damage to the wire rope. Replace any worn or damaged sheaves.

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

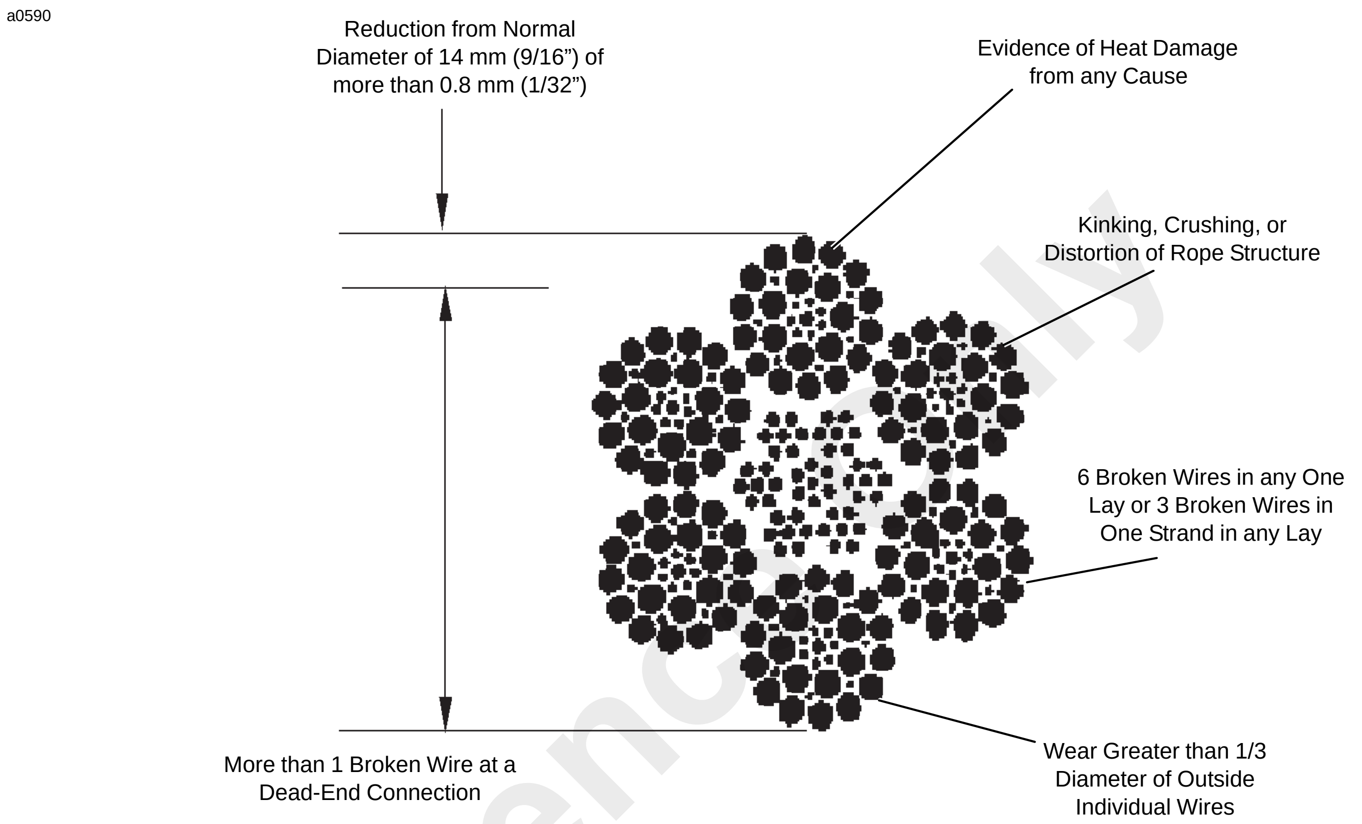
Grease Fittings

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

Lubricate the Boom Slides

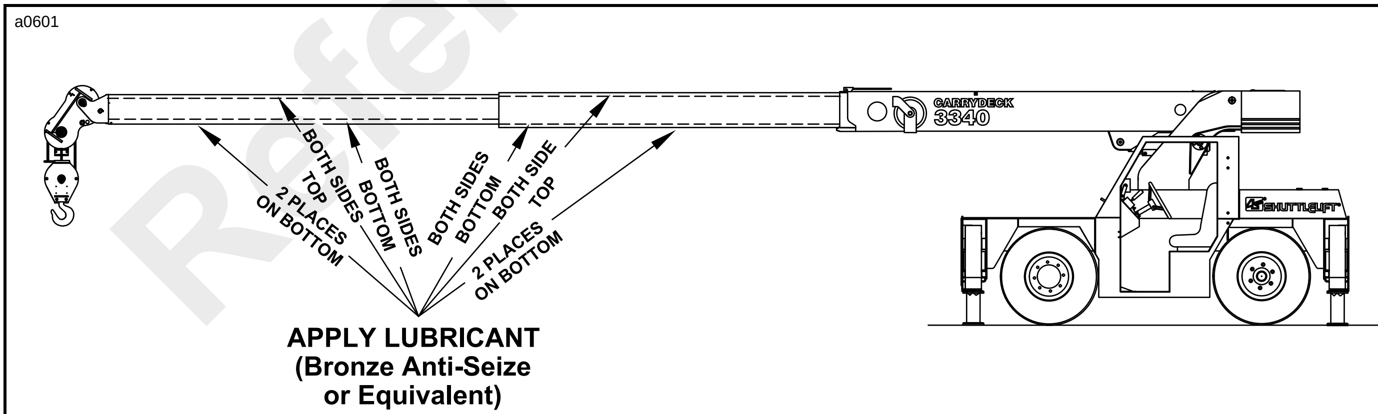
1. Lower the boom and then extend it to its maximum out position.
2. Engage the parking brake and shut off the engine.
3. Clean the old lubricant from the booms.
4. Apply bronze anti-seize, or equivalent, to the boom sliding surfaces (Figure 5-29) on the boom sections. Only use a small amount of lubricant 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.



Wire Rope Inspection Criteria

FIGURE 5-28



Boom Slide Lubrication

FIGURE 5-29

Lubricate the Boom Chains

NOTE: One of the most important, but overlooked factors causing premature wear or breakage of chains is inadequate lubrication. In addition to reducing internal friction, maintaining a film of lubricant on all chain surfaces will inhibit rust and corrosion.

Published 04/07/2015 Control # 569-00

The boom retract chain is lubricated through the access holes in the boom. Align the holes to expose sections of the boom chain. Each section must be lubricated as directed below.

NOTE: Use a good grade of spray chain lubricant. If none is available, use preheated oil (15° to 37°C [60° to 100°F]) to provide a better penetration of oil to the chain joints.

Apply ample lubricant to each pin, between the inner and outer side plates and between the inner side plates and roller. **DO NOT**, under any circumstances apply grease lubricant to the chain. Grease will not penetrate to the pin bearings. Lack of lubricant in the pin bearings is usually indicated by squealing or groaning sounds when the boom is extended or retracted.

NOTE: Under normal operating conditions, especially in dusty environments, lubricated chains will accumulate a paste-like buildup of grime. This buildup should never be permitted to accumulate sufficiently to seal off the clearances, thereby restricting the lubricant to the bearing surfaces. Whenever the buildup is excessive, the buildup must be removed by cleaning and the chain immediately lubricated. **DO NOT** steam clean or use degreasers; use a suitable solvent.

100 Hours of Operation

NOTE: You must read and understand the warnings and basic safety rules, found in Section 1 of this manual, before performing any operation or maintenance procedures.

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

Check Wheel Nut Torque

Check the torque on the wheel nuts in a crisscross pattern. Wheel torque should be 225 lb-ft (302Nm).

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.

FIGURE 5-30

Belts that are too loose see excessive vibration and increased wear. Belts that are too tight produce wear on the belts 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 5-31.

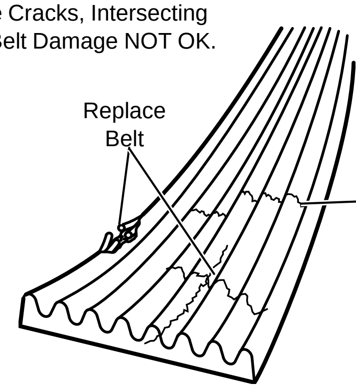
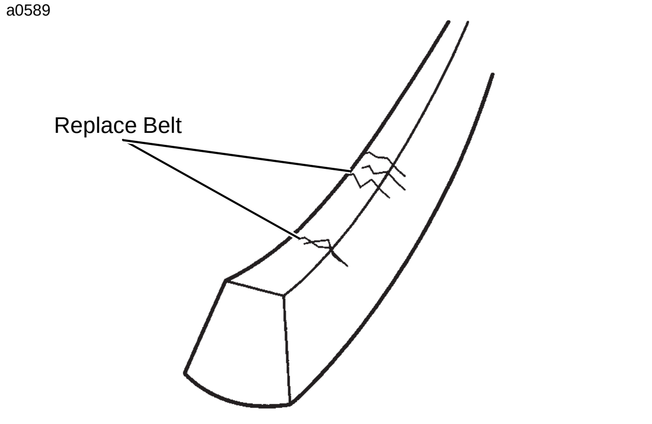


FIGURE 5-31

5

Any cracking on V-belts is not acceptable. Replace any V-belt that has cracking. See Figure 5-32



V-Belt Inspection - General

FIGURE 5-32

Any ribbed belt or V-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.

250 Hours of operation/Monthly

NOTE: You must read and understand the warnings and basic safety rules, found in Section 1 of this manual, before performing any operation or maintenance procedures.

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

Inspecting the Boom Chains

1. Place the booms in the fully lowered position.
2. Extend the booms to expose all of the side access holes.
3. Visually inspect the chains through the access holes. A light may be needed to see most of the chain. Look for any damage to the chains.

NOTE: If chain damage is found during the inspection, **DO NOT USE THE CRANE**. Cease operation and replace the damaged chain before placing the crane back in service. A damaged chain could break, causing boom to not function properly. Personal injury or property damage could result.

4. Damage could be any of the following:
   - **a.** A crack or complete break of a link plate, particularly an outer plate on either side of the chain (Figure 5-33).

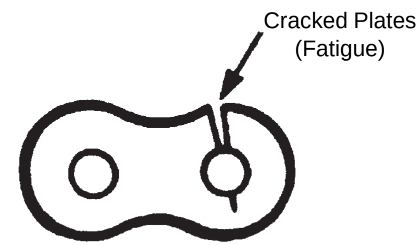


FIGURE 5-33

   - **b.** Distortion or spreading of an outside link plate, evidenced by increasing clearance between overlapping link plates, or between the inner link plates and the roller. This indicates a hidden break in a pin (Figure 5-34).

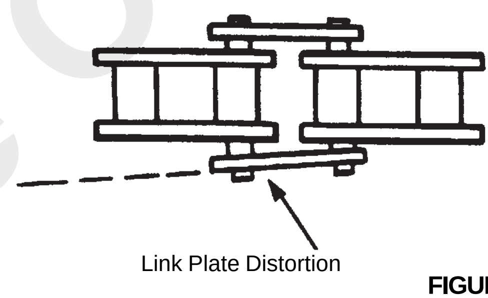


FIGURE 5-34

   - **c.** Looseness between the riveted ends of a chain pin and the outer link plates. If a pin is broken, the normal rigid riveting may loosen, leaving a visible clearance around the exposed ends of the pin (Figure 5-35).

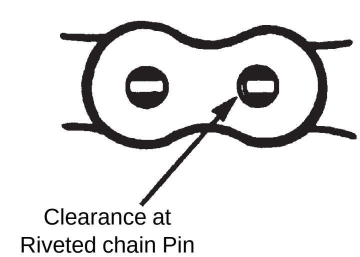


FIGURE 5-35

   - **d.** The pin head rivets should be examined to determine if the V-flats are still in the correct alignment. Chain with rotated or displaced heads or abnormal protrusion (Figure 5-36) should be replaced immediately.

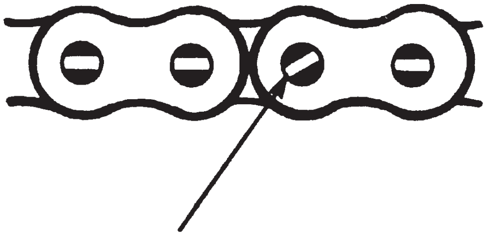


FIGURE 5-36

Inspect the Boom Chain Tension

The boom chains should be checked for the correct tension to ensure proper retraction of the boom sections.

Lower Retract Chain

To check for correct tension on the lower retract chain loosen the jam nut on the retract chain adjusting screw (Figure 5-37). Check the retract chain for looseness by prying the retract rod adjusting nut away from the plate (Figure 5-37). If a gap is present adjust the chain tension.

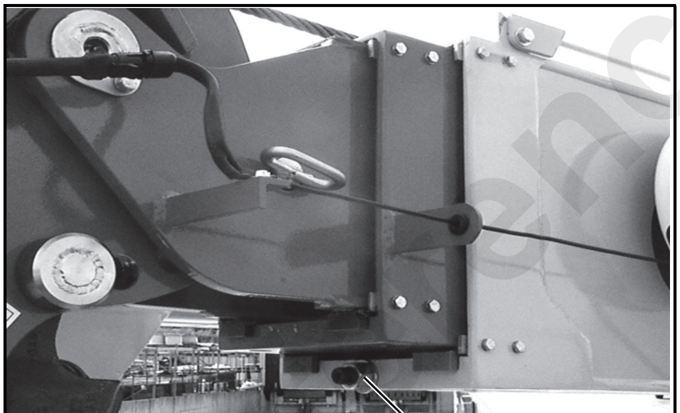


FIGURE 5-37

Upper Extend Chain

Check the extend chain for looseness by prying the extend rod retaining nut away from the bulkhead plate (Figure 5-38). If a gap is present adjust the chain tension.

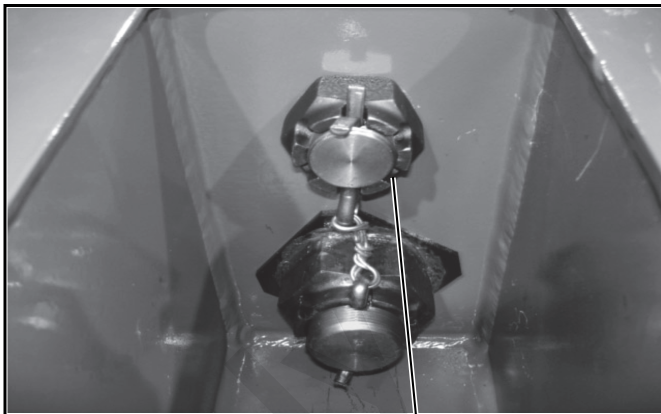


FIGURE 5-38

Inspect Hydraulic Hoses

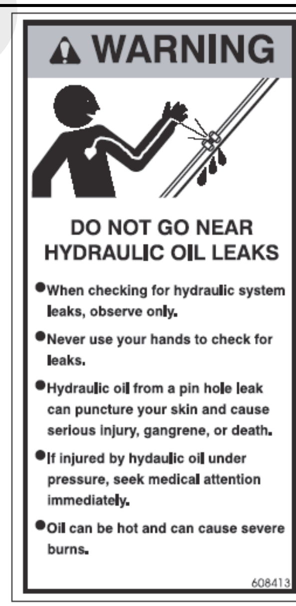


FIGURE 5-39

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.

5

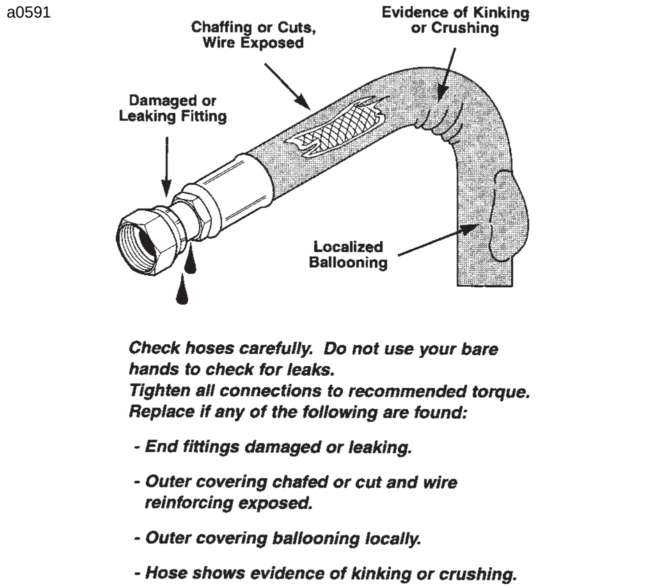


FIGURE 5-40

Clean Battery and Cables

FIGURE 5-41

1. Open the battery compartment cover (Figure 5-42).

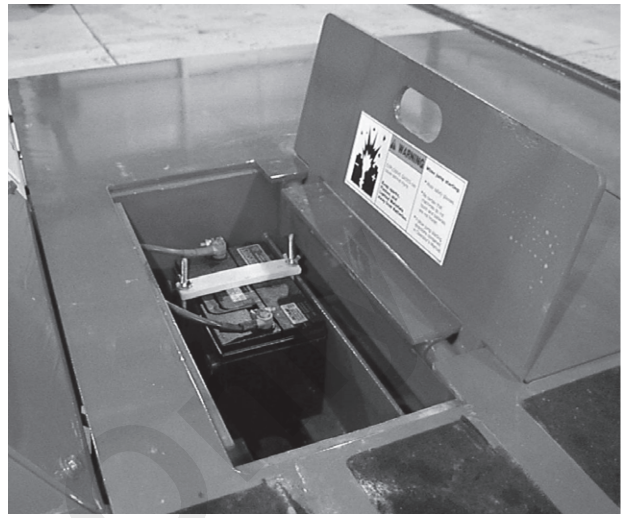


FIGURE 5-42

2. Tighten all battery mounting hardware to keep the battery securely in place.
3. Disconnect the battery cables.
4. Sprinkle the top of the battery with baking soda. Apply water to wash the baking soda from battery. Be careful not to get any of the solution into the battery
5. Clean the battery posts and cable ends with a battery brush.
6. Coat the battery posts with petroleum jelly and reinstall the battery cables.
7. Close the battery box cover.

Cleaning the Radiator

NOTE: To inhibit 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 over heat due to blocked air through the radiator fins and core.

Lubricate the Wire Rope

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

1. Unwind the wire rope from the hoist drum.
2. Be sure the wire 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. Preheating the oil to between 18° and 36°C (60° and

100°F) will help the oil penetrate into the wire rope. Use a brush or cloth to apply the oil.

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

Lubricate the Swing Gear and Pinion

1. Engage the parking brake and shut off the engine.
2. Remove both guards covering the swing gear and pinion.

w0022

FIGURE 5-43

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

3. Using a brush, apply open gear lube to the pinion and swing gear teeth (Figure 5-44).

p0324

FIGURE 5-44

4. Start the engine and rotate the mast through several complete cycles to distribute the lubricant evenly.
5. Shut off the engine.
6. Install the guards over the exposed pinion and swing gear.

Replace the Crankcase Oil and Filter

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

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

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

NOTE: Hot oil can cause personal injury.

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

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

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

Torquing 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 3/4” mounting bolts (4) see *Torque Values page 1-9*. Refer to Figure 5-45 for bolt locations.

p0323

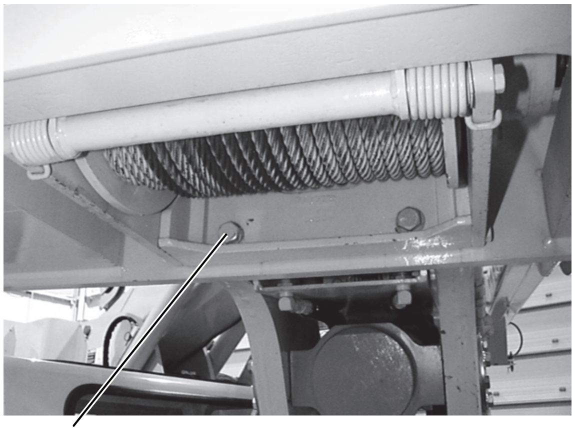


FIGURE 5-45

Swing Gearbox Mounting Bolts

Torque the 1/2” gearbox mounting bolts (4) see *Torque Values page 1-9*. Refer to Figure 5-46 for bolt locations.

p0324

FIGURE 5-46

Mast Mounting Bolts

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

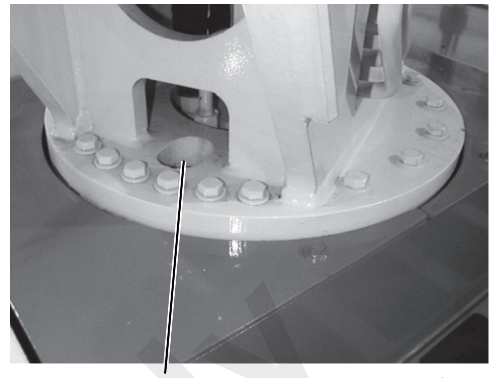
Make a record of any loose bolts. If any bolt does not hold to correct torque after the second check, remove and replace the bolt. A loose bolt indicates possible failure of the bolt.

Use the torque sequence shown in Figure 5-48 when checking the torque on the bolts.

Swing Bearing to Frame Bolts

Torque the 3/4” bearing to frame mounting bolts (24) see *Torque Values page 1-9 for torque value.* To gain access to the bolts, rotate the mast until a bolt is visible in the access hole in the mast mounting plate (Figure 5-48). Rotate the mast as needed and tighten each bolt in a criss cross pattern as shown in Figure 5-47 until all bolts are torqued.

p0325



Bearing to Frame Mounting Bolts

FIGURE 5-47

Mast to Swing Bearing Mounting Bolts

Tighten the 5/8” mast to bearing mounting bolts to*Torque Values page 1-9* for torque value. See Figure 5-49. Tighten each bolt in a crisscross pattern. See Figure 5-48.

a0602

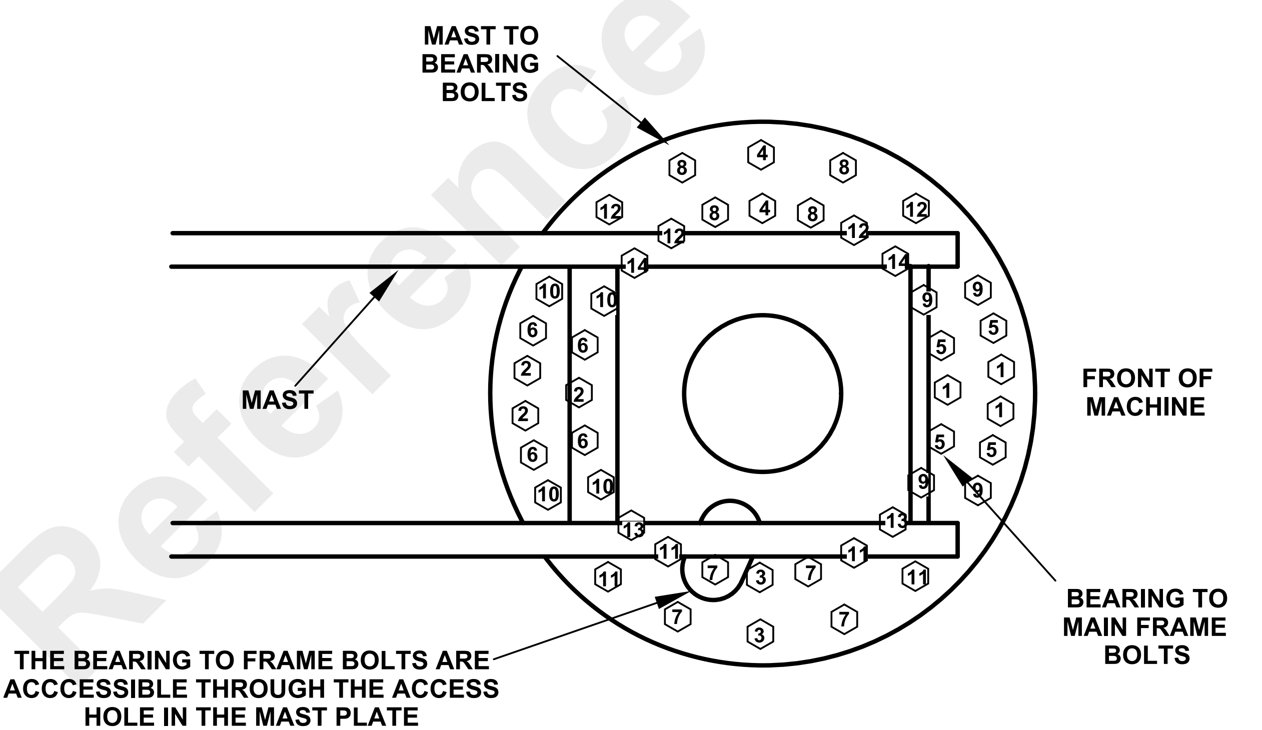
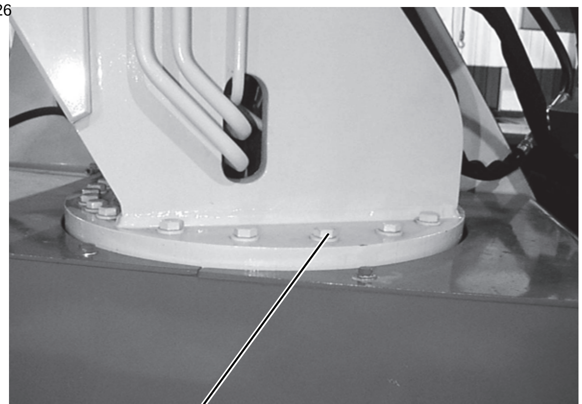


FIGURE 5-48

p0326



Mast Mounting Bolts

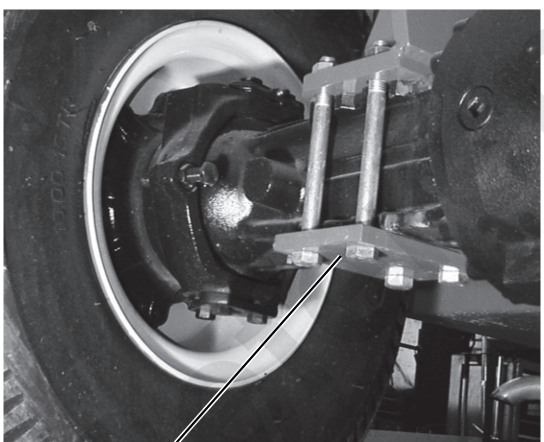
FIGURE 5-49

Front Axle Mounting Bolts

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

Torque the 3/4” axle mounting bolts (8) see *Torque Values page 1-9* for torque value. See Figure 5-50 for location.

p0327



Both Sides

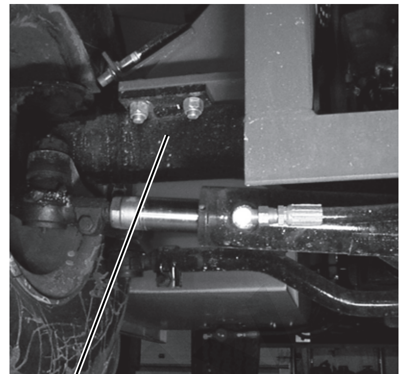
FIGURE 5-50

Rear Axle Mounting Bolts

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

Torque the 5/8” axle mounting bolts (8) see *Torque Values page 1-9* for torque value. See Figure 5-51 for location.

p0328



Both Sides

FIGURE 5-51

500 Hours Of Operation/Three Months

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

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

Inspect the Tires

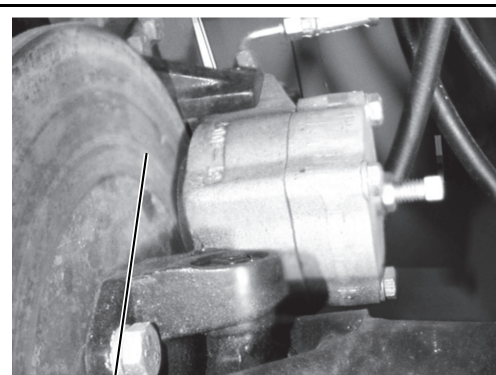
Inspect the tires for any signs of damage, such as cracks, large gouges, deterioration, etc. If damage is found, it must be carefully analyzed to determine if the tire is safe to use. Replace all tires that are unsafe.

Inspect 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.

Inspect the thickness of the brake pads (Figure 5-52. Replace the brake pads if they are 7.1 mm (0.28 in) thick or less.

p0329



Both Sides of Disc

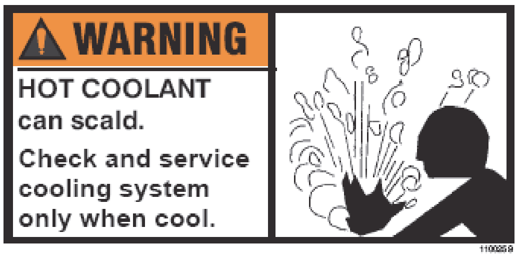
FIGURE 5-52

Replacing Fuel Filter

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

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

Adding Rust Inhibitor to Engine Cooling System



w0020 **FIGURE 5-53**

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 5-54. Do not over lubricate. Extend and retract the beams several times to spread the grease.

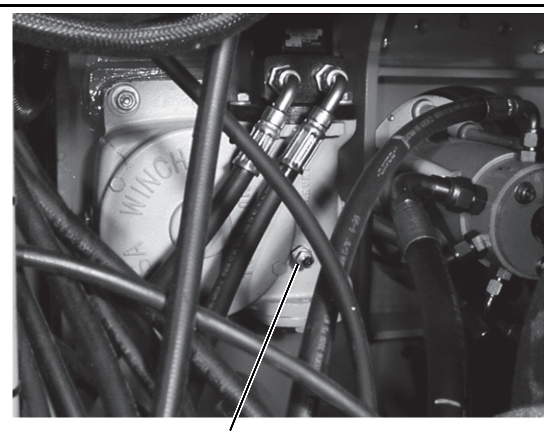
p0448 **FIGURE 5-54**

Add Grease to the Swing Gearbox

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

The grease fitting for adding grease to the swing gearbox can only be reached from under the crane. It will be necessary to use a light to see the fitting.

1. Lower the boom, engage the parking brake and shut off the engine. Remove the ignition key.
2. Clean the grease fitting (Figure 5-55), located on the swing gearbox housing.



p0330 **FIGURE 5-55**

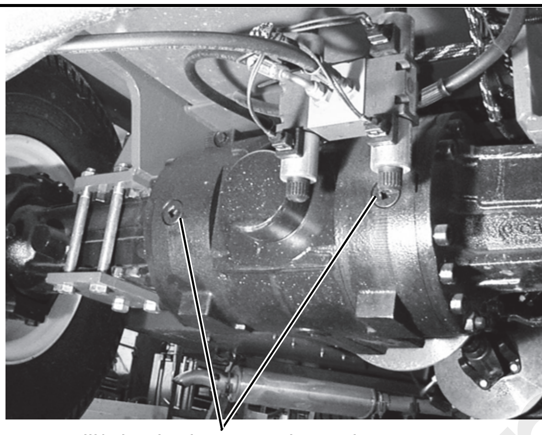
3. Clean around the check plug, located below the gearbox mounting flange. Remove the check plug.

4. Apply Lithium Base, E.P. No. 2 bearing grease to the fitting. Fill gear box until grease exits the check plug hole.
5. Install the check plug.

Check the Axle Housing Lubricant Level

It is necessary to climb under the crane to check the axle housing 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 both fill/check plugs (Figure 5-56) in the brake housings and remove the plugs.



Fill/Check Plugs - Axel Housing

p0319

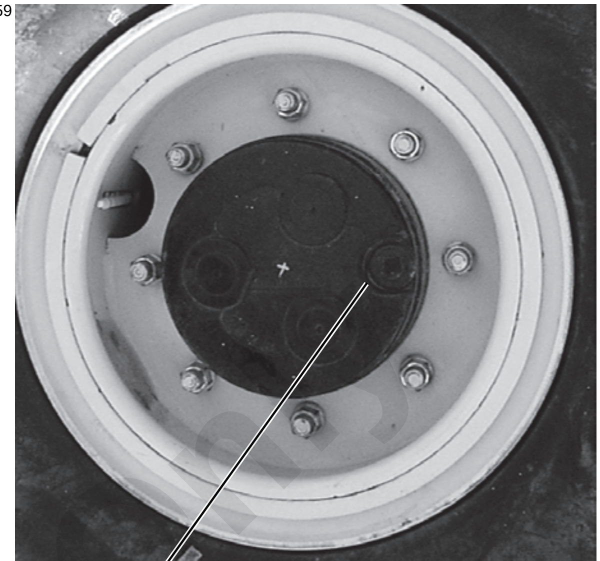
FIGURE 5-56

2. Check the lubricant level, which should be even with the bottom of each fill/check hole.
3. If necessary, add oil to fill the housings to the recommended level.

Check the Wheel Hub Lubricant Level

1. Position the wheel so that the fill/check plug is horizontal with the ground (Figure 5-57).
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 oil to fill the hub to the recommended level.
5. Repeat Steps 1 through 4 for the other wheel hub.

p0459



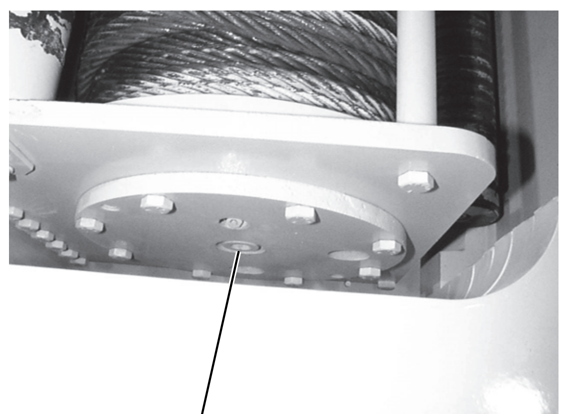
Fill/Check Plug - Wheel Hub

FIGURE 5-57

Check Hoist Gearbox and Brake Lubricant (Tulsa Model)

1. Engage the parking brake and shut off the engine.
2. Lower the boom to its lowest position.
3. Clean around the fill/check plug (Figure 5-58) and then remove the plug.

p0320



Hoist Gearbox Check Plug Location

FIGURE 5-58

4. Check the lubricant level, which should be even with the bottom of the fill/check plug hole.
5. If necessary, add SAE 90 EP gear lube to fill to the bottom of the fill/check plug hole.
6. Clean around the area of the brake breather (Figure 5-59). Remove the breather.

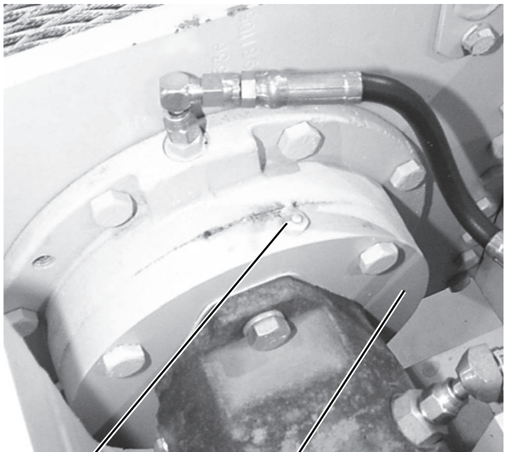


FIGURE 5-59

7. Remove the check plug (Figure 5-58).
8. Check the lubricant level, which should be level with the bottom of the check plug hole.

DANGER

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

9. If necessary, add Mobil 424 hydraulic oil, or equivalent, through the breather hole to fill the brake level with the bottom of the check plug hole.
10. Install both the breather and the check plugs.

Check Hoist Gearbox and Brake Lubricant (Braden Model)

1. Lower the boom to its lowest position.
2. Engage the parking brake and shut off the engine.
3. Clean the lubricant level sight gauge (Figure 5-60).
4. Using a mirror, and light if needed, check the lubricant level in the sight gauge. Lubricant must be visible in the sight gauge.
5. If lubricant must be added, rotate the hoist drum until the drain/fill plug is visible in the access hole aligned with the level sight gauge.Clean around the drain/fill and then remove it. Add recommended lubricant (see Section 8) through the plug hole until it exits the fill plug hole. Install the plug.

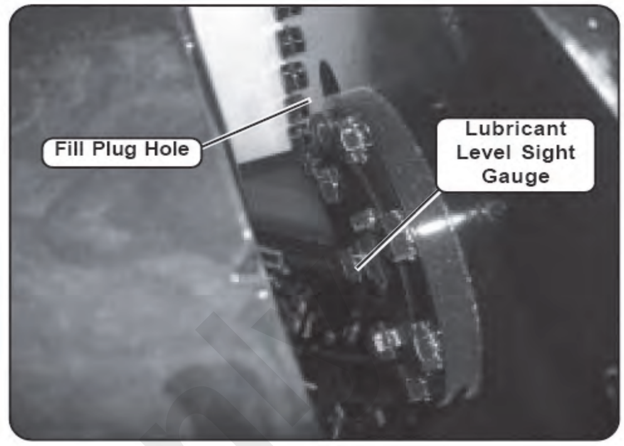


FIGURE 5-60

DANGER

Failure to use the proper type and viscosity of planetary gear oil may contribute to intermittent brake clutch slippage which could result in property damage, severe personal injury or death. Some gear lubricants contain large amounts of EP (extreme pressure) and anti-friction additives which may contribute to brake clutch slippage and damage to brake friction discs and seals. Oil viscosity with regard to ambient temperature is also critical to reliable brake clutch operation. Test have indicated that excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Make certain that the gear oil viscosity in the hoist is correct for prevailing ambient temperature.

1000 Hours of Operation/Six Months

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

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

Replace the Transmission Oil and Filter

1. Engage the parking brake and shut off the engine. Remove the ignition key.

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

NOTE: When the strainer is removed, oil will gush out. Keep to one side when you remove the strainer.

5

2. Place suitable container under the strainer (Figure 5-61). Remove the strainer and gasket and drain the oil into the container. Discard the gasket.

P0331

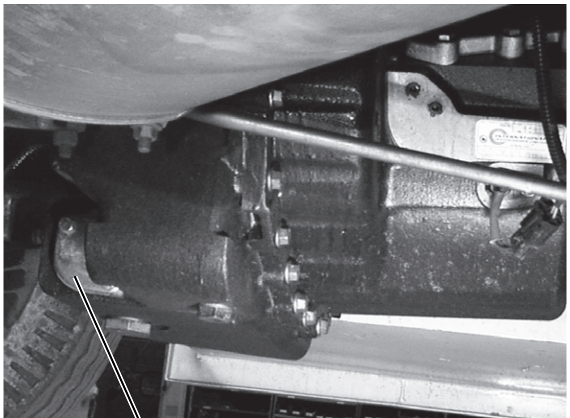


FIGURE 5-61

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

3. Place the container under the drain plug and remove the drain plug (Figure 5-62). Drain any oil left in the transmission into the container. Install the drain plug.

P0332

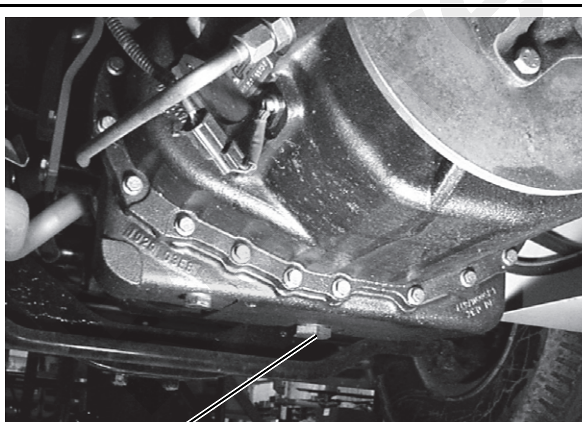


FIGURE 5-62

4. Clean the strainer in a suitable solvent.
5. Install the cleaned strainer and a new gasket. Tighten the strainer mounting bolts to a torque of 7.4 lb-ft *(10 Nm)*.
6. Remove the transmission oil filter by unscrewing it from the transmission housing (Figure 5-63). Properly discard the filter.

P0333

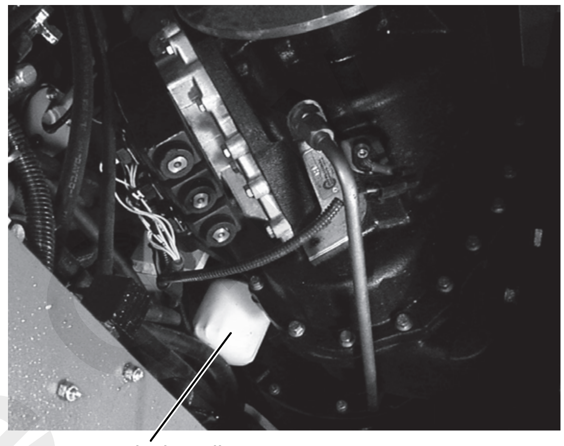


FIGURE 5-63

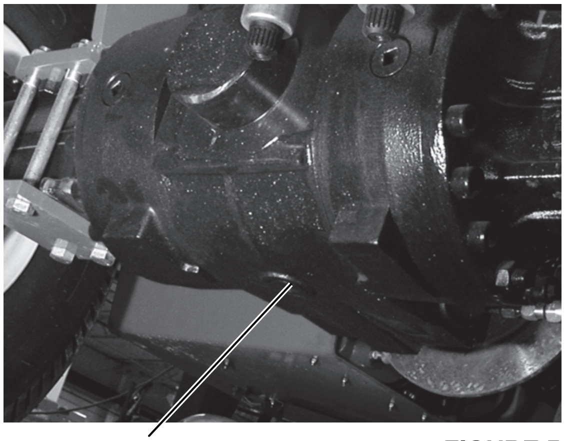
7. Coat the seal of the new filter with clean transmission oil.
8. Screw on the transmission filter until it touches the filter head. Then, turn the filter another 3/4 of a turn to seat the seal.
9. Fill the transmission with Mobil ATF 210 transmission fluid to the full mark on the dipstick (approximately 15.1 l [4 gal]).
10. Start the engine and let it run at idle speed for approximately five minutes. This allows the oil to fill the transmission filter, torque converter and hoses.
11. Stop the engine, wait approximately one minute and then check oil level. If low, add oil to the full mark on the transmission dipstick. **DO NOT OVERFILL**.

Replace the Axle Housing Lubricant

NOTE: It is necessary to climb under the crane to drain the differential 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 5-64). Remove the drain plug and drain the fluid into the container. Install the drain plug.

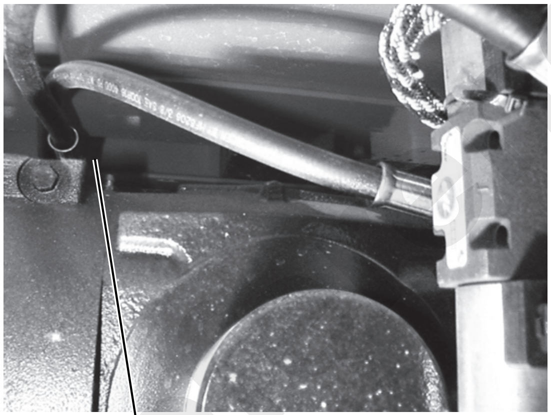
P0334



Axle Housing Drain Plug **FIGURE 5-64**

2. Clean around both brake housing breathers (Figure 5-65). Remove both breathers and clean them in a suitable solvent. When clean install them back into the brake housings.

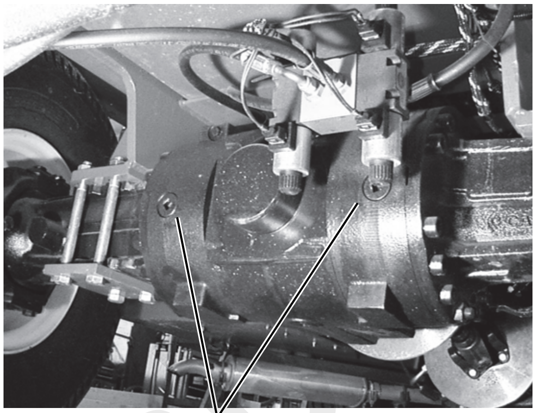
p0335



Axle Housing Breathers **FIGURE 5-65**

3. Clean around the two check/fill plugs in the axle brake housings (Figure 5-66). Remove both plugs.

p0319



Axel Housing Check/Fill Plugs **FIGURE 5-66**

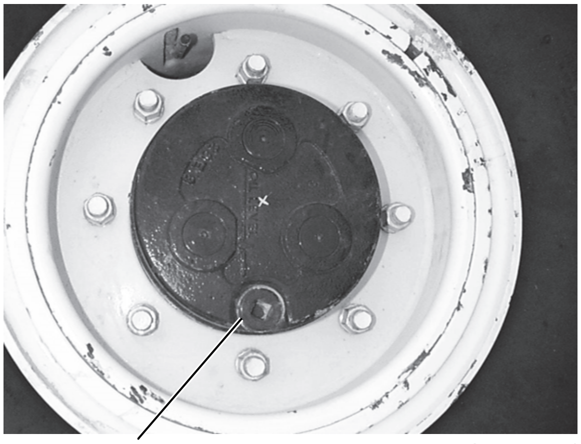
4. Fill the differential and brake housings with appropriate oil through both check fill plugs. Fill until the oil reaches the bottom of each fill hole.

5. Install both check/fill plugs.

Replace the Axle Wheel Hub Lubricant

1. Drive the crane until one of the front axle wheel hub drain plugs is located at the bottom of the wheel hub (Figure 5-67).

p0460



Drain Position **FIGURE 5-67**

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 5-68).

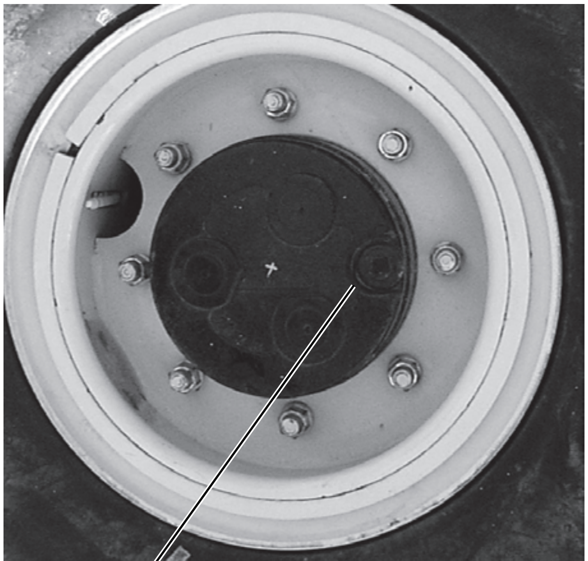


FIGURE 5-68

4. Fill the wheel hub with appropriate oil 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 wheel hub.

Replace the Hoist Gearbox and Brake Lubricants (Tulsa Model)

Hoist Gearbox

1. Lower the boom to lowest position, engage the parking brake. Leave the engine running.
2. Rotate the drum until the drain plug is visible through the hole (Figure 5-69) in the side of the mounting bracket.

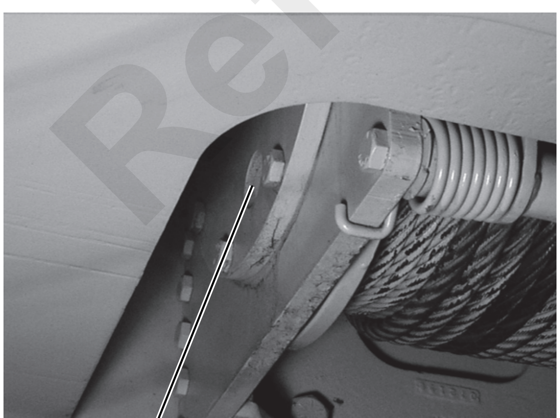


FIGURE 5-69

3. Clean around the gearbox breather and the fill/check plug hole. Remove the gearbox breather (Figure 5-70) and clean it in a suitable solvent. After it is cleaned, install the breather.
4. Remove the fill/check plug (Figure 5-70).
5. Place a suitable container under the drain plug.

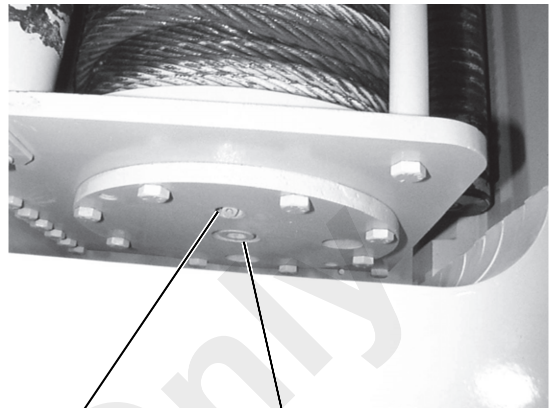


FIGURE 5-70

6. Using a ratchet wrench with an extension and a 3/8” hex wrench attached, remove the drain plug. Allow the fluid to drain into the container. Examine the oil for signs of significant metal particles. If any particles are found, the gearbox may require disassembly and repair.
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 SAE 90 EP gear lube.
9. Install the fill/check plug.

Hoist Brake

1. Clean around the brake breather (Figure 5-71). Remove the breather and clean it in a suitable solvent. Remove the check plug.

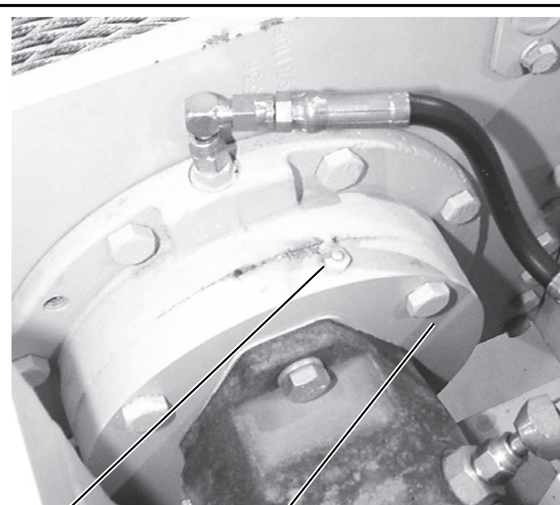


FIGURE 5-71

2. Place a suitable container under the brake drain plug (Figure 5-72). Clean around the drain plug and then remove the plug and allow the fluid to drain into the container.

p0337

FIGURE 5-72

3. Install the drain plug.

⚠ DANGER

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

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4. Fill the brake through the breather hole until fluid is even with the bottom of the check plug hole. Use SAE 20-20W motor oil.

5. Install the breather and check plug.

Replace the Hoist Gearbox Lubricant (Braden Model)

1. Lower the boom to its lowest position and engage the parking brake.

2. Rotate the hoist drum until the drain/fill plug aligns with the lower access hole (Figure 5-73) in the hoist side plate.

3. Clean around the hoist breather (Figure 5-74) and the drain/fill plug. Remove the breather and clean it in a suitable solvent. After it is cleaned, reinstall it.

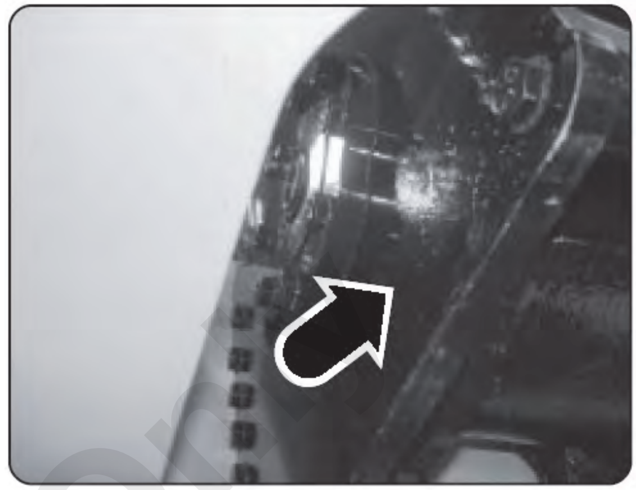


FIGURE 5-73

4. Install a 1” pipe nipple in the threads of the drain hole in the hoist drum.

5. Place a suitable container under the drain plug.

6. Using a 5/16 inch Allen wrench, remove the drain/fill plug and allow the fluid to completely drain into the container. Examine the oil for signs of significant metal particles. If particles are found, the gearbox may require disassembly and repair.

7. Remove the 1” pipe nipple and then rotate the hoist drum until the open drain hole aligns with the access hole even with the lubricant level sight gauge (Figure 5-74).

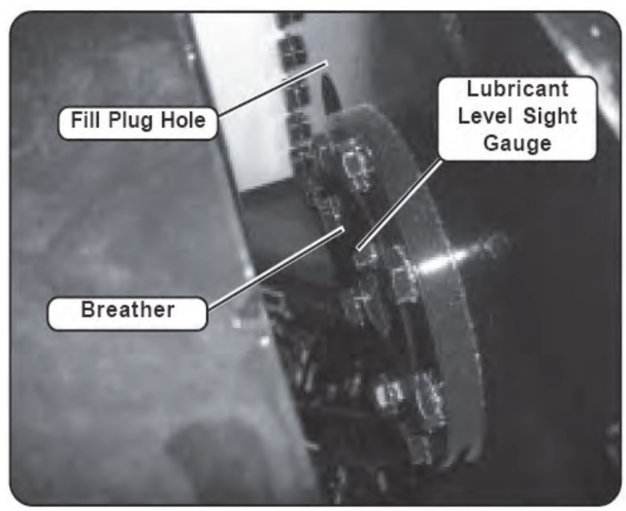


FIGURE 5-74

5

DANGER

Failure to use the proper type and viscosity of planetary gear oil may contribute to intermittent brake clutch slippage which could result in property damage, severe personal injury or death. Some gear lubricants contain large amounts of EP (extreme pressure) and anti-friction additives which may contribute to brake clutch slippage and damage to brake friction discs and seals. Oil viscosity with regard to ambient temperature is also critical to reliable brake clutch operation. Tests have indicated that excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Make certain that the gear oil viscosity in the hoist is correct for prevailing ambient temperature.

Lubricate the Rear Axle Bearings

The rear axle wheel bearings should be lubricated with grease. The hubs have to be removed to gain access to the wheel bearings.

Replace the Hydraulic Oil

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

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

NOTE: The pump used on this crane requires clean hydraulic oil for proper operation. **Contaminated oil can cause damage to the pump and other components.** 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 pump, located in front of the engine.
6. Loosen the suction hose clamp at the hydraulic pump. Remove the hose and let the oil drain from the hydraulic tank drain into the container. **DO NOT** remove the suction hose from the pump.
7. When the tank is drained, connect the suction line to the pump. Tighten the clamp. Be sure the suction hose is tight and the clamp on the pump suction hose is tight.
8. Remove the wheel and tire under the hydraulic tank. It will make it much easier to reach under the hydraulic tank if the wheel and tire are removed. Block the frame.
9. Disconnect all hoses from hydraulic tank (Figure 5-75). Secure the main pump suction line so that the hydraulic oil in the hose will not drain out.

NOTE: **DO NOT** lower the pump suction line lower than the pump. The pump requires that it be full of oil at start-up. Lowering the hose lower than the pump will drain the oil from the pump and cause damage to the pump when it is started.

p0446

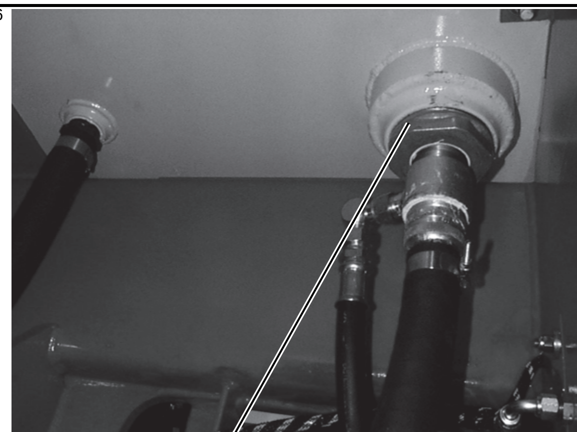


FIGURE 5-75

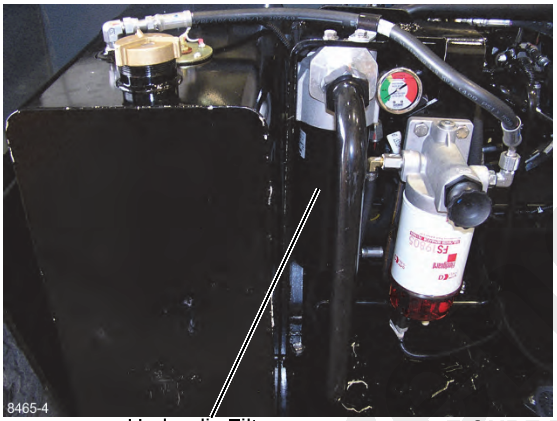
10. Remove the suction strainer from the hydraulic tank and clean it in a suitable solvent.
11. Remove the fill strainer from the fill tube and clean it in a suitable solvent.
12. Clean the inside of the hydraulic tank and remove any sediment.
13. Install the fill strainer, suction strainer, suction hoses and return hose to the hydraulic tank.
14. Replace the hydraulic oil filter. See “Replacing the Hydraulic Oil Filter” below.
15. Install the wheel and tire assembly. Tighten the wheel nuts to 405 Nm (300 lb-ft).

16. Fill the hydraulic tank with Mobil #424 hydraulic oil to the bottom of fill stainer or to sight gauge.
17. After the tank is filled, start the engine and operate each function until all the cylinders and lines are filled.
18. Fully retract and lower the boom and retract the outriggers. Check the hydraulic oil level. Oil must be to the bottom of the fill strainer. Add hydraulic oil if necessary.
19. Visually check for leaks.

Replace the Hydraulic Oil Filter

1. Engage the parking brake and shut off the engine.
2. Remove the side panel to expose the hydraulic compartment and the hydraulic filter (Figure 5-76).

8465-4



Hydraulic Filter

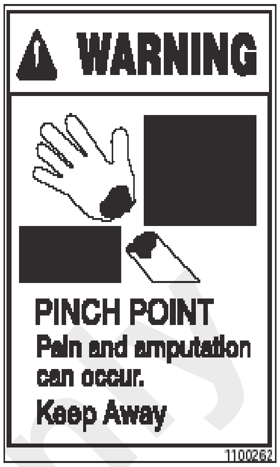
FIGURE 5-76

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

Check Swing Gear/Pinion Backlash

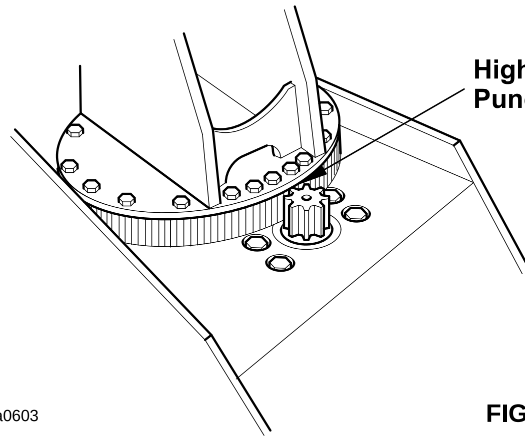
1. Remove the cover to expose the swing pinion and ring gear.

w0022



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

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 5-77).
3. Using a feeler gauge, check the backlash between the gear and pinion. There should be no clearance between the swing gear tooth and the pinion tooth. If there is any clearance, adjust the backlash. See Section 11.



a0603

FIGURE 5-77

2000 Hours Of Operation/Yearly

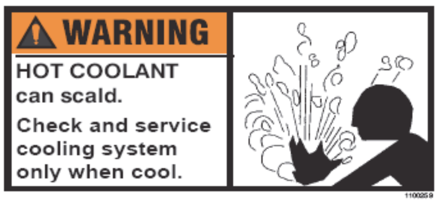
NOTE: You must read and understand the warnings and basic safety rules, found in *Safety Practices page 2-1* of this manual, before performing any operation or maintenance procedures.

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

5

Replace the Engine Coolant

w0020



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

Inspect the Crane Structure and Booms for Damage

Thoroughly inspect the crane structure and booms for the following:

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

Testing the Rated Capacity Limiter (Optional)

See the Rated Capacity Limiter manual furnished with this crane and test the indicator according to instructions in the manual.

Miscellaneous Maintenance

Batteries/Charging System

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

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

w0019

Checking the Charging System

Check the voltmeter reading on the instrument panel. Normal voltmeter readings are as follows:

Normal Operating Ranges

Engine above idle - 14 to 16 volts
Engine stopped - 10 to 14 volts

A reading of less than 10 volts with the engine at low idle indicates a low battery charge.

A reading of less than 14 volts with the engine speed above low idle indicates a problem in the charging system. The system should be checked out by an 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 (See Jump Starting, in the Operation and Maintenance Manual) and letting the engine run.

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

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

Replacing the Battery

NOTE: The fluid in electric storage batteries contains sulfuric acid, which is 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, perform the following First Aid suggestions.

Battery Electrolyte First Aid

External Contact - Flush with water.

Eyes - Flush with water for at least 15 minutes and get immediate medical attention.

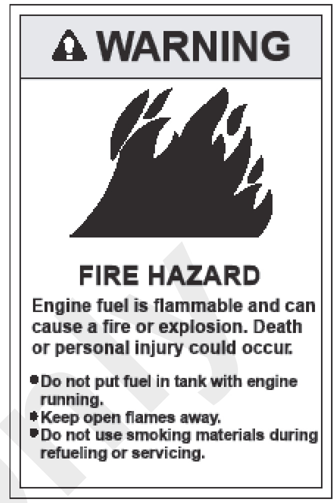
Internal - Drink large quantities of water. Follow with Milk of Magnesia, beaten egg or vegetable oil. Get immediate medical attention.

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

w0015



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.

5

CARWELL® RUST INHIBITOR

Protecting Cranes From Rusting

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

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

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

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

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

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

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

The most common causes of corrosion include the following:

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

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

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

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

Cleaning Procedures

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

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

CAUTION

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

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

- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

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

Inspection and Repair

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

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

CAUTION

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

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

For scratches and marks in areas of low visibility:

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

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

Application

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

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

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

- Do not apply to recently primer 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 on the unit.
- Use of pressure pots to apply the treatment to the unit being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

Refer to Figure 5-78.

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; Valves, hose end and fittings, Swivel, pumps, axles, drive lines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose end and fittings, wire rope on hoist roller tensioning springs on hoists, all

unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.

- Boom applications areas are; pivot pins, hose end and fittings, jib pins and shafts, all bare metal surfaces, headache ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.

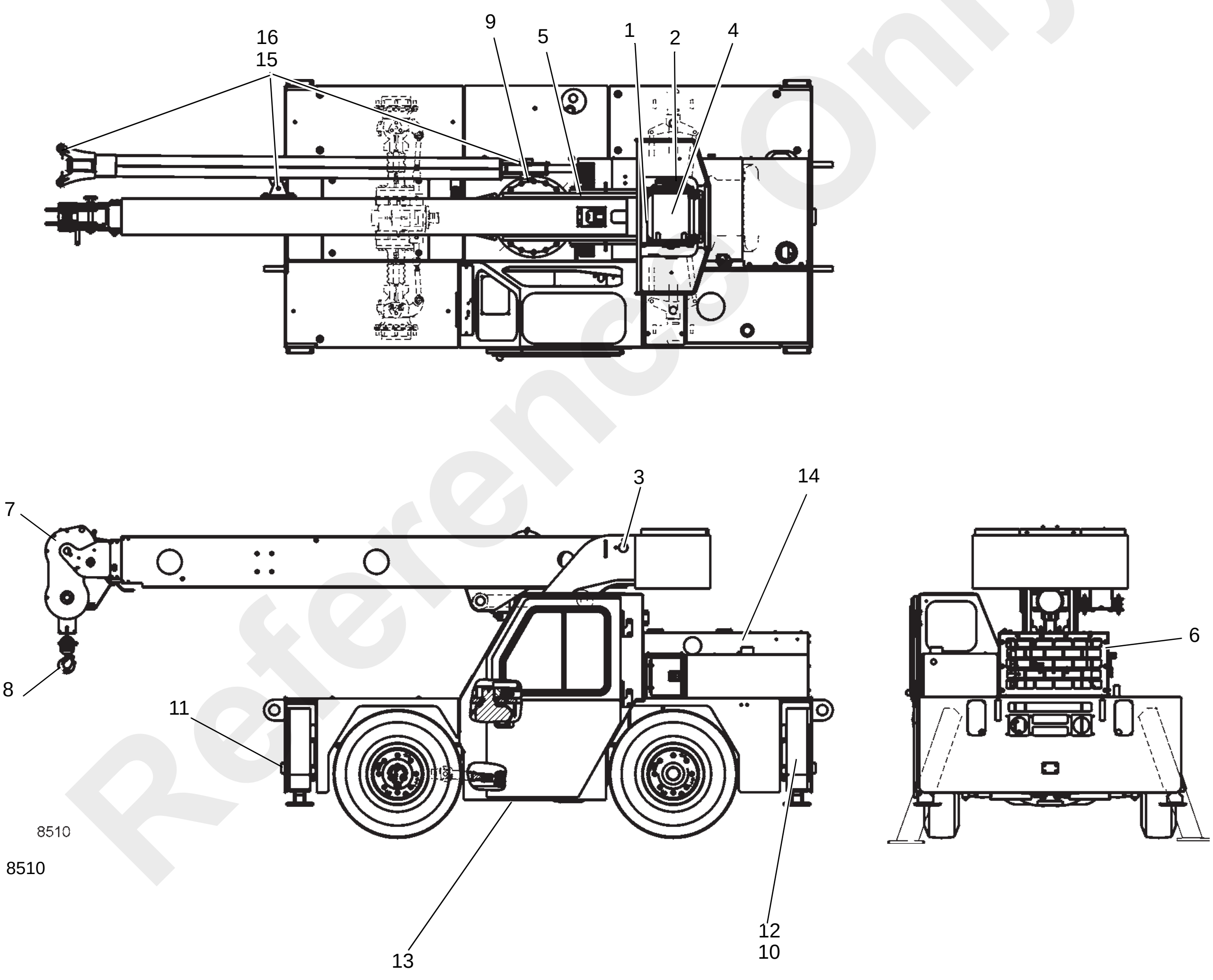


FIGURE 5-78

Item	Description
1	Hoist Tension Spring
2	Hoist Hose Connections
3	Pivot Shaft
4	Wire Rope
5	Hose Connections inside turntable
6	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
7	Boom Nose Pins, Clips
8	Headache Ball/Hook Block
9	Turntable Bearing Fasteners
10	O/R Pins, Clips
11	Hook block Tiedown Cable
12	O/R Hose Connections
13	Entire underside of unit
14	Powertrain Hardware inside compartment
15	Boom Extension Pins, Clips - Option
16	Boom Extension Hanger Hardware - Option

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. Refer to the engine manual furnished with the crane for engine diagnosis, repair and component replacement.

ENGINE TYPE

The engine is a Cummins QSB3.3 Tier 4i diesel.

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 the engine Electronic Control Module (ECM). The throttle gives variable control of the engine speed.

ENGINE CRANKCASE SYSTEM

The engine crankcase system must be well lubricated to inhibit damage to the engine. The correct type of oil must be used, as well as proper maintenance at regular intervals. For correct intervals, see SECTION 5.

Crankcase Oil Data

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

Oil Performance Recommendations

CF-4, CH-4, CI-4, or CJ-4 for use in naturally aspirated engines and in engines that operate in light duty service including standby and emergency operation (equivalent to MIL-L-2104B).

Sulfated Ash Limit of 1.0% by weight is recommended. Oils with higher ash count may produce deposits on valves that can progress to guttering and valve burning.

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

Oil Viscosity Recommendations

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

Viscosity Grades

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:

Parameter (Test Method)	Specification
Performance	API Classification CF-4, CH-4, CI-4, or CJ-4-Turbocharged
Viscosity	10,000 mPa°s maximum at -35°C (-31°F) 4.1mm (0.16 in) Squared Minimum at 100°C (212°F)
Pour Point (ASTM D-97)	Maximum at 5°C (41°F) Below the Lowest Expected Ambient Temperature
Sulfated Ash Content	Maximum of 1.85% by weight (ASTM D-874)

Recommended SAE Viscosity Grades.

15W40 or 20W40	-10°C (+14°F) and above
10W30	-23° to -10°C (-10° to +14°F)
Synthetic Oil	Below -23°C (-10°F) - See Arctic Operation

ENGINE COOLING SYSTEM

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

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

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

Coolant Requirements

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

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

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

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

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

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

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

USE SOFT WATER, DISTILLED WATER OR DEIONIZED WATER to reduce the potential and severity of silicate dropouts.

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

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

Thermostat

A malfunctioning thermostat can result in the engine running hot or cold. If it becomes necessary to replace the thermostat refer to 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 SECTION 3.

ENGINE FUEL SYSTEM

Diesel Engine Fuel System Description

The diesel engine fuel system (Figure 6-1) includes a fuel tank, a fuel level sender and gauge, a fuel filter, a fuel pump, fuel lines from the tank to the fuel pump to the fuel filter, fuel lines from the fuel filter to the fuel injector pump to and from the fuel injectors back to the fuel tank.

A fuel supply line carries fuel from the bottom of the fuel tank to the engine fuel pump. A line carries the fuel from the engine fuel filter to the engine fuel pump. 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.

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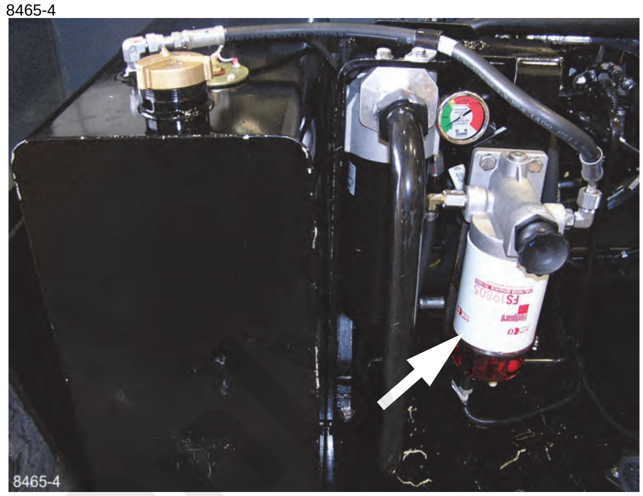


FIGURE 6-1

Fuel Level Sender and Gauge

The fuel level sender and gauge are described in the Section 3, Electrical System.

Fuel Pump

The fuel pump is installed on the engine and is used to pump fuel from the fuel tank and send it under pressure to the fuel filter and injection pump.

Fuel Filter

The filter (Figure 6-1) is used to collect contaminants and water that has accumulated in the fuel and is not picked up by the in-line filter. It must be serviced at regular intervals. See Section 5, Preventive Maintenance for maintenance intervals.

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

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

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

Fuel Injection Pump

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

Types of Fuel to Use

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

WARNING

DO NOT mix gasoline or alcohol with diesel fuel. This mixture can cause an explosion.

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

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

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

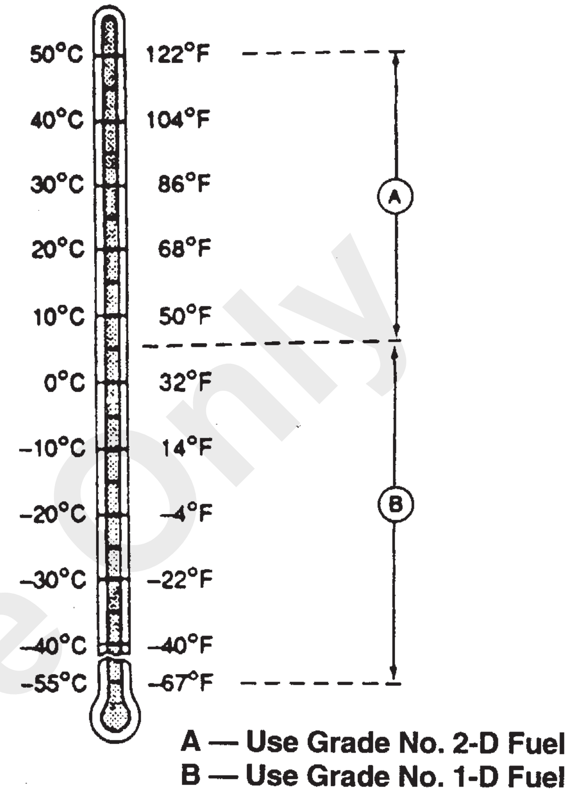


FIGURE 6-2

NOTE: If engine is operating at temperatures -40° to -57°C (0-40° 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 Diesel (ULSD), with a maximum sulfur content of 15 ppm in the United States and 10 ppm in the European Union, 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.

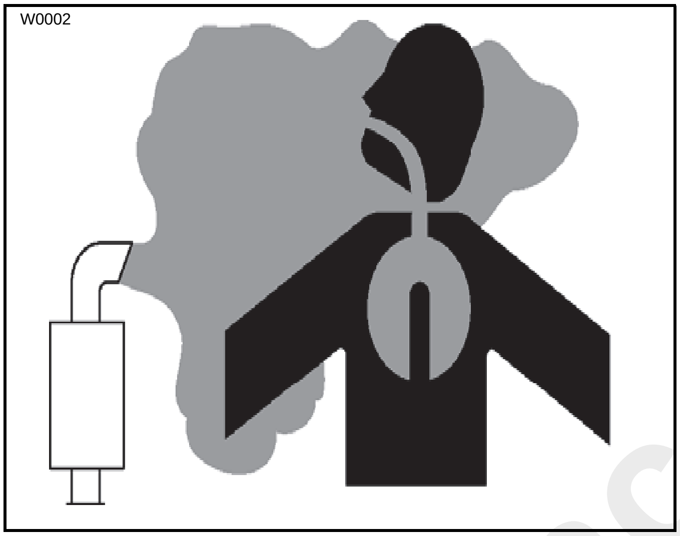
ENGINE AIR INTAKE SYSTEM

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 regular maintenance intervals. Make sure all clamps on the intake tube and filter are tight. If dust or foreign materials enter the engine, permanent damage can be caused to the engine.

NOTE: **NEVER** run the engine without an air cleaner installed.

ENGINE EXHAUST SYSTEM



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

The exhaust system is installed under the frame to minimize the transfer of noise and vibration into the operator's compartment.

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

When installing exhaust parts, make sure there is sufficient clearances between the hot exhaust part 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.

TROUBLESHOOTING

Problem	Probable Cause	Action
Engine hard to start or will not start.	**1.** Improper starting procedure.	**1.** Review starting procedure in Engine Operators Manual.
	2. No fuel.	**2.** Check fuel gauge.
	3. Air in fuel line (s).	**3.** Bleed the fuel line (s).
	4. Crankcase oil too heavy. (cold weather starting).	**4.** Use oil with proper viscosity.
	5. Improper type of fuel.	**5.** Use 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 filter.
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 system.
	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 or sender.	**2.** Check gauge, sender and all connections.

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.** See Engine Operators Manual. Check for plugged radiator/oil cooler fins.
	5. Below normal engine temperature.	**5.** Remove and check thermostat.
	6. Faulty engine.	**6.** See 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/coolant fins.	**3.** Clean fins.
	4. Faulty radiator cap.	**4.** Replace the radiator cap.
	5. Cooling system needs flushing.	**5.** Flush cooling system.
	6. Defective thermostat.	**6.** Replace the thermostat.
	7. Defective temperature gauge or sender.	**7.** Check and replace.

REMOVAL AND INSTALLATION

Removal

DANGER

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.

1. Either block all four tires or lower the outriggers to inhibit movement during engine removal.
2. Remove the engine cover.
3. Disconnect the battery ground cable from the transmission mounting bolt. Remove the battery cable from the engine starter.
4. Disconnect the frame electrical wire harness from the engine electrical wire harness.
5. Tag all wires that are connected to the transmission. Disconnect all wires from the transmission
6. Drain the radiator. Disconnect the upper and lower hoses from the radiator.
7. Disconnect the transmission cooling lines from the radiator. Put plugs and caps on all lines to keep dirt out of the system.
8. Remove the radiator.
9. Remove the air cleaner and intake hose(s).

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

10. Disconnect the fuel lines from the engine. Plug or cap the lines to prevent leakage.
11. If equipped, disconnect the heater hoses from the engine.
12. Drain the hydraulic oil tank. Disconnect all hydraulic lines from the hydraulic pumps. See SECTION 4.
13. Disconnect the drive shaft from the transmission. See SECTION 8.
14. Disconnect the exhaust pipe from the exhaust manifold of the engine.

15. If equipped, remove the optional cold start kit from the bracket inside the chassis frame.
16. Disconnect the engine ground cable from the engine or the engine flywheel.
17. Attach chains to two engine lifting brackets and to an overhead crane.
18. Remove the front engine mounting hardware.
19. Remove the bolts, washers, rubber mounts and nuts securing the rear engine support mounting bracket to the transmission.
20. Using a trolly jack, raise the transmission so it can be removed out the rear of the chassis.
21. Using the overhead 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. Lower the engine and transmission into the chassis until the rear mounting bolts, washers, rubber mounts and nuts can be installed. Install the hardware and tighten.
4. Install the front engine mounting hardware and tighten.
5. Connect the hydraulic lines to the pumps. See SECTION 4. Fill the hydraulic tank
6. If equipped, connect the heater hoses to the engine.

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

7. Connect the fuel lines to the engine.
8. Connect the engine ground cable to the engine.
9. If equipped, connect the cold start kit.
10. Connect the exhaust pipe to the turbo charger. If a gasket is used, install a new gasket.
11. Connect the drive shaft to the engine. See SECTION 8.
12. Install the air cleaner and intake hose.
13. Install the radiator in place on the chassis.
14. Connect the transmission cooling lines to the radiator. Connect the upper and lower radiator hoses.
15. Fill the radiator with recommended coolant.
16. Connect all leads from the transmission harness to the transmission.
17. Connect the engine wire harness to the frame wire harness.
18. Install the engine cover.
19. Connect the battery cables to the starter and engine flywheel housing
20. Check complete installation to be sure all components are installed and secure.
21. Fill the engine and transmission with recommended oil.

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.

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. Check coolant level after engine has run for several minutes. Add coolant if necessary.
24. Adjust the throttle control, if necessary.
25. Stop the engine and check for leaks. Tighten fittings if necessary.

ENGINE PUMP AND BRACKET REMOVAL AND INSTALLATION

NOTE: In the following section the illustration and photos are of the Tier 3 engine, the assembly for the Tier 4 engine is similar.

Special Tools

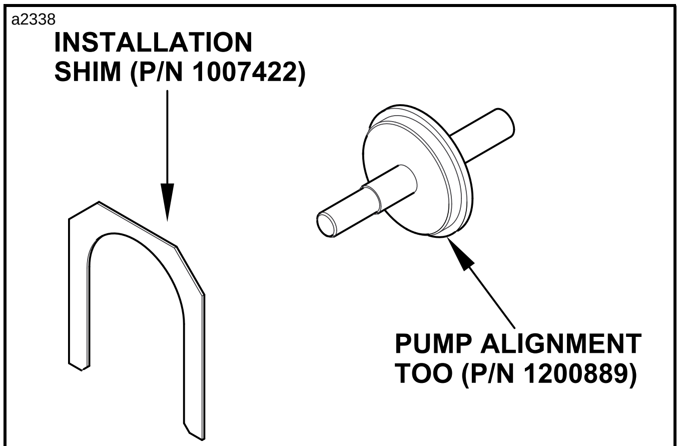


FIGURE 6-3

The special tools shown in Figure 6-3 are available from Marine Travelift.

Removal

NOTE: The engine does not have to be removed from the chassis to remove the pump and brackets. The following instructions explain how to remove and install the pump and brackets with the engine installed in the chassis.

1. Set the machine on a level, firm surface.
2. Extend and lower each outrigger. Place a block under each outrigger pad to raise the machine for easy access to the pump and brackets.

NOTE: **DO NOT** solely rely on the outriggers to support the machine. Place supports under the machine to support the frame along with the outriggers.

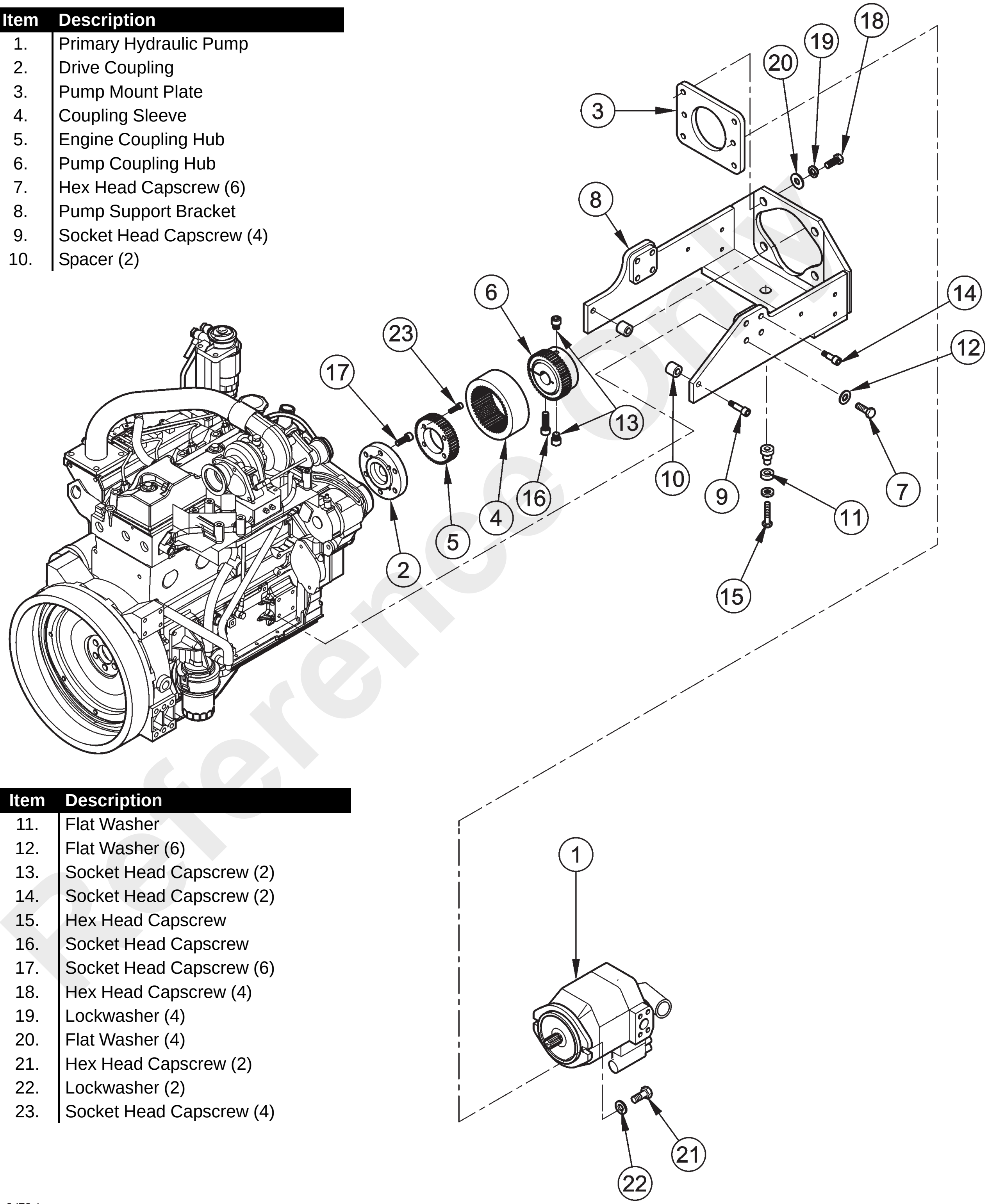
3. Swing the boom to the side to gain access to the engine compartment. Remove the engine compartment shroud.
4. Disconnect both battery cables from the battery.
5. Remove both rear tires. This will make it easier to obtain access to the engine.
6. Drain the hydraulic oil from the hydraulic tank into a CLEAN suitable container of approximately 25 gal (94.6 l).

NOTE: If the hydraulic oil drained from the hydraulic tank is to be reused, make sure the container is completely clean. Contamination in the hydraulic oil could damage the hydraulic pump after start up.

7. Disconnect and cap all hydraulic hoses at the hydraulic pump.
8. Remove two capscrews (14) and flat washers (15).
9. Remove six capscrews (11), lockwashers (15), and flat washers (16). Remove pump support bracket (7).
10. Support pump (1) and remove two capscrews (21), lockwashers (22), and flat washers (23). Remove pump (1).
11. Remove bolt (15) and washer (11) attaching pump mounting bracket (8) to the frame.

8472-1

Item	Description
1.	Primary Hydraulic Pump
2.	Drive Coupling
3.	Pump Mount Plate
4.	Coupling Sleeve
5.	Engine Coupling Hub
6.	Pump Coupling Hub
7.	Hex Head Capscrew (6)
8.	Pump Support Bracket
9.	Socket Head Capscrew (4)
10.	Spacer (2)



Item	Description
11.	Flat Washer
12.	Flat Washer (6)
13.	Socket Head Capscrew (2)
14.	Socket Head Capscrew (2)
15.	Hex Head Capscrew
16.	Socket Head Capscrew
17.	Socket Head Capscrew (6)
18.	Hex Head Capscrew (4)
19.	Lockwasher (4)
20.	Flat Washer (4)
21.	Hex Head Capscrew (2)
22.	Lockwasher (2)
23.	Socket Head Capscrew (4)

8472-1

FIGURE 6-4

12. Attach a hook and chain to the engine and overhead crane as shown in Figure 6-5. Between the chain and overhead crane, attach a come-along.

p1432

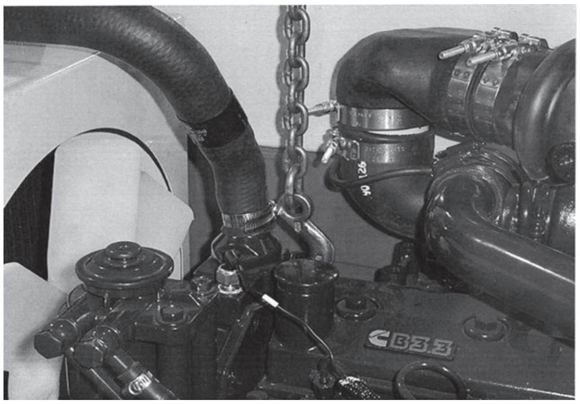


FIGURE 6-5

13. Using the come-along, raise the engine a minimum of 13 mm (1/2 in). See Figure 6-6

p1433

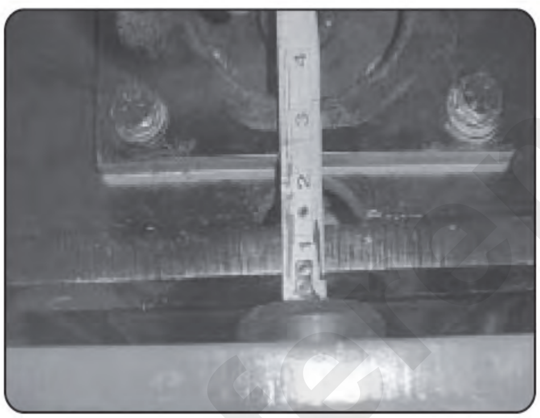


FIGURE 6-6

NOTE: When raising the engine, watch for fan interference with the engine shroud. Do not allow the fan to come in contact with the shroud, damage to the fan could occur. Also, watch for any other interferences.

14. Remove two shoulder bolts (14, Figure 6-4). Remove two shoulder bolts (9).

15. Remove eight capscrews (7) and flat washers (12). Remove pump mounting bracket (8) and two spacers (10).

16. Loosen clamping bolt (16).

17. Remove two socket head capscrews (13) from pump coupling (6).

18. Remove pump coupling (6) and coupling sleeve (4).

19. Remove four capscrews (23) and then remove engine coupling hub (5).

20. Remove six capscrews (17) and drive coupling (2).

Installation

NOTE: The following figures show the engine mounted in an engine stand. Installation instructions are the same for an engine installed in the machine.

1. Install adapter (2, Figure 6-4) using six capscrews (17), as shown in Figure 6-7. Apply Loctite® 243 to the capscrew threads and then tighten the capscrews to a torque of 30 Nm (22 lb-ft).

2. Install engine coupling hub (5) using four capscrews (23), as shown in Figure 6-7. Apply Loctite® 243 to the capscrew threads and then tighten the capscrews to a torque of 30 Nm (22 lb-ft).

p1433

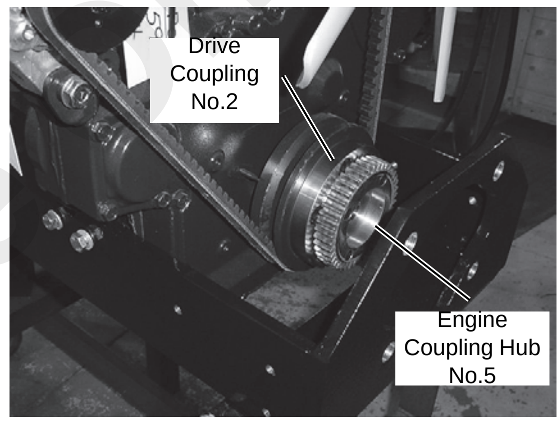


FIGURE 6-7

3. Position pump bracket (8, Figure 6-4) into position as shown in Figure 6-9. Apply Loctite® 243 to the threads of six capscrews (7, Figure 6-4), then install the capscrews along with six flat washers (12) into both sides of the bracket. Do not tighten the bolts.

p1414

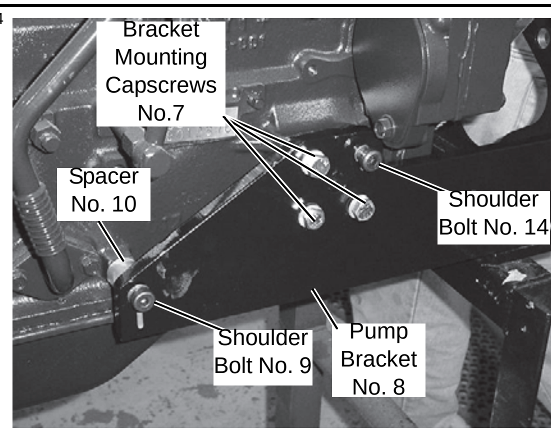


FIGURE 6-8

4. Coat the collar of shoulder bolts (14) with an anti-seize compound. Apply Loctite® 243 to the threads of the shoulder bolts and install them through the bracket into the engine block on both sides (Figure 6-8). Do not tighten the bolts.

5. Install spacers (10, Figure 6-4) between the pump bracket and engine block (Figure 6-8) on both sides. Coat the collar of shoulder bolts (9, Figure 6-4) with an anti-seize compound. Apply Loctite® 243 to the threads of the shoulder bolts and install them through the bracket and spacer into the engine block. Tighten shoulder bolts (9 and 14) to a torque of 63 Nm (46 lb-ft). Tighten capscrews (14) to a torque of 52 Nm (39 lb-ft).
6. If pump plate (3, Figure 6-4) was removed or is being replaced, install it as shown in Figure 6-9. Use bolts (18), lockwashers (19) and flat washers (20).

p1415

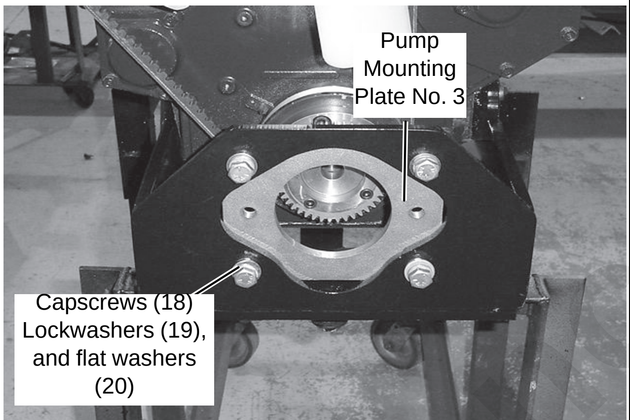


FIGURE 6-9

7. Insert the pump alignment tool (Figure 6-3) into the pilot hole in the center of engine coupling hub (5, Figure 6-4) and into pump mounting plate (3) as shown in Figure 6-10. Tighten the pump mounting plate hardware to a torque of 87 Nm (64 lb-ft). Remove the pump alignment tool.

p1416

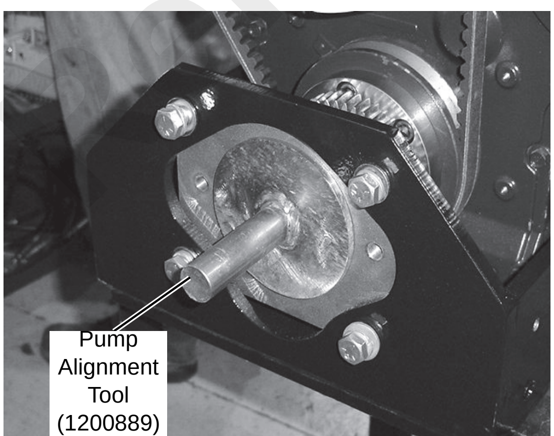


FIGURE 6-10

8. Test fit the pump coupling hub (6, Figure 6-4) onto the pump shaft. It should slide on by hand. Then, insert the pump coupling hub (6) into coupling sleeve (4). See Figure 6-11.

p1417

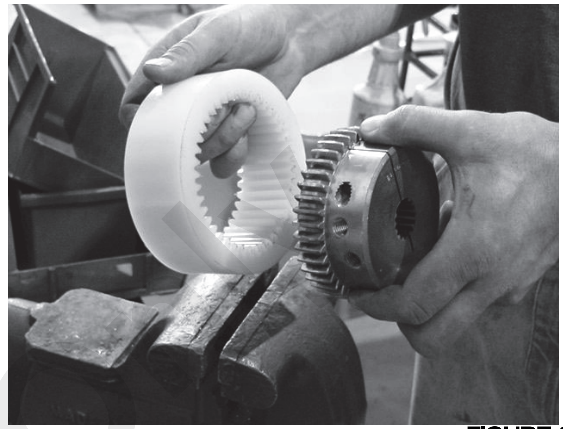


FIGURE 6-11

9. Insert the assembly through the top of the pump mounting bracket with the pump coupling hub facing away from the engine. Slide the assembly over the engine coupling hub. See Figure 6-12.

p1418

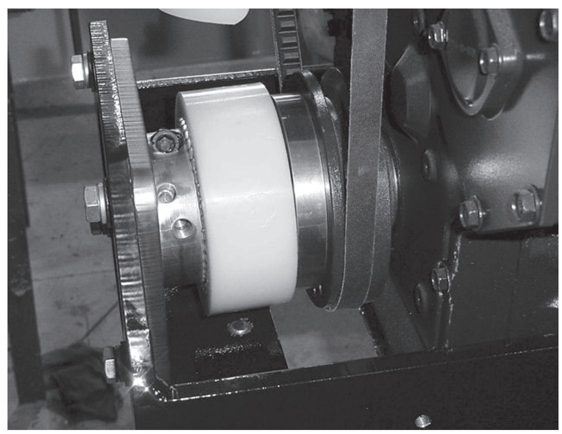


FIGURE 6-12

10. Apply Loctite® 243 to the threads of socket head capscrews (13, Figure 6-4) and install them into the pump coupling (6) as shown in Figure 6-13. Tighten the socket head capscrews.

p1419

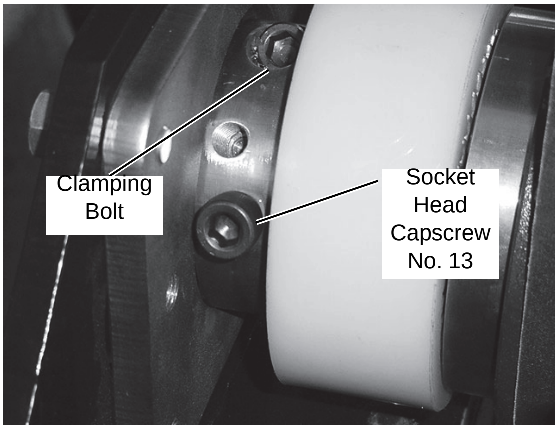


FIGURE 6-13

11. Insert the installation shim (Figure 6-3) behind coupling sleeve (4, Figure 6-4) as shown in Figure 6-14.

p1420

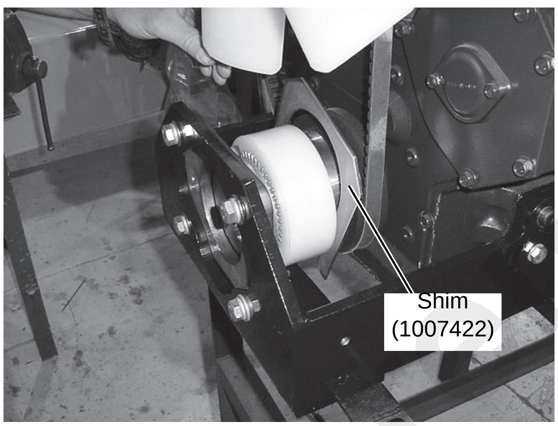


FIGURE 6-14

12. Install pump (1, Figure 6-4) as shown. Apply Loctite® 243 to the threads of capscrews (21, Figure 6-4). Attach the pump with capscrews (21), lockwashers (22), and flat washers (23). Tighten the capscrews to a torque of 87 Nm (64 lb-ft).

13. Push pump coupling hub (5, Figure 6-4) towards the engine with socket head capscrews (13) against coupling sleeve (4), the sleeve against the shim, and the shim against drive coupling (2). Tighten clamping bolt (16, Figure 6-4). Tighten the bolt to a torque of 86 Nm (63 lb-ft). Remove the installation shim.

14. Attach all hoses to the hydraulic pump.

15. Lower the engine and install the front mounting hardware (15 and 11, Figure 6-4).

16. Remove the lifting chain.

17. Install the alternator and connect the wires to the alternator and engine bracket.

18. Fill the hydraulic oil reservoir.

NOTE: The hydraulic system requires clean hydraulic oil for proper operation. Contaminated oil can cause damage to the pump and other components. Before adding any hydraulic oil to the hydraulic system, be sure the oil is filtered through a 10-micron (absolute) or less filter.

19. Connect the battery cables.

20. Start the engine and let it idle. Check for hydraulic leaks around the pump. Tighten any loose fittings, clamps, and hoses if loose.

21. Install the rear tires and raise the outriggers.

22. Tighten the wheel lug nuts to a torque of 408 Nm (300 lb-ft).

SECTION 7
TRANSMISSION AND TORQUE CONVERTER

SECTION CONTENTS

TECHNICAL DATA

General Technical Data

Description	Full electrohydraulic transmission unit with input, reverse, and mainshaft clutch packs. Torque converter is integral.
Designation	PS750
Weight (dry)	220 kg (484 lb)
Number of Teeth: Transfer Gear Layshaft	 45 18
Gear Ratios: 1st 2nd 3rd 4th	 5.72:1 3.23:1 1.77:1 1.00:1
Torque Converter Dia.	279 mm (11 in)
Torque Converter at Stall	2.20:1
Torque Converter Color Code Identification: Color Coded Dots	 2 Purple 1 White
Minimum Engine RPM at Converter Stall: 2nd Gear 3rd Gear	 2075 rpm 2050 rpm

Converter Pressures (in neutral):	PSI...........................*Bar*
Converter IN at 122°F (50°C)	
1000 rpm 2000 rpm.	40-60.....................*2.8-4.1* 70-90......................*4.8-6.2*
Converter OUT at 122°F *(50°C)*	PSI..........................*Bar*
1000 rpm 2000 rpm	27-33.....................*1.9-2.3* 33-39......................*2.3 - 2.7*
Converter Inlet Relief Valve Pressure (Max.)	95..........................*6.5*
Lubrication Pressures (in neutral)	PSI.........................*Bar*
At 122°F *(50°C)*	
1000 rpm 2000 rpm	2.0-4.0...................0.14-0.28 4.0-8.0................... 0.28-*0.55*
Mainline Pressure (in neutral)	PSI..........................*Bar*
At 122°F *(50°C)*	
1000 rpm 2000 rpm	130-145..................*9.0 - 10.0* 140-160..................*9.7-11.0*
Flow Rates (in neutral)	GPM..............................*LPM*
Cooler at 122°F *(50°C)*	
1000 rpm 2000 rpm	2.8-3.6........................*10.4-13.6* 3.8-5.3.........................*14.5-20.0*
Pump at 122°F *(50°C)*	
1000 rpm 2000 rpm	2.9-4.0.......................*11.0-15.0* 6.0-7.8.........................*22.5-29.5*
The following clutch pressures should be the same as the Mainline Pressure to within 10 PSI *(0.7 bar)*: Input Clutch Pressure (high and low ratio) Reverse Clutch Pressure (high and low ratio) Layshaft Clutch Pressure Mainshaft Clutch Pressure	

Clutch Solenoid Technical Data

Type	4-way, 3-position, directional control
Operating Flow	9.85 gpm *(40 L/min)*
Operating Pressure	145 psi (10 bar)
Leakage (maximum)	50 cc/min @ 40°C, 10 bar (14 in/min.@104°F,145psi)
Coil Operating Voltage	+12V DC nominal (9V-16V)
Pull-in Voltage	+10.5V (max.) @ 25°C (77°F) air
Dropout Voltage	+ 1.5V (min.) at 20°C (68°F) air
Peak Voltage	+ 26V DC for 5 minutes at 0°C (32°F)
Coil Resistance	4.9 ohms ± 5% @ 20°C (68°F)

DESCRIPTION OF OPERATION

Torque Converter

The torque converter (Figure 7-1) is the hydraulic link between the engine and the drive train. There are three main components in the torque converter:

- A turbine
- An impeller (pump)
- A stator and One-Way Clutch

The **impeller** is the pump for the torque converter. This component starts the movement of the oil to the other components. The impeller is connected to the engine flywheel through the torque converter and a drive plate. The impeller rotates at engine speed. Similar to a centrifugal pump, the impeller takes oil at the inner diameter and releases the oil at the outer diameter.

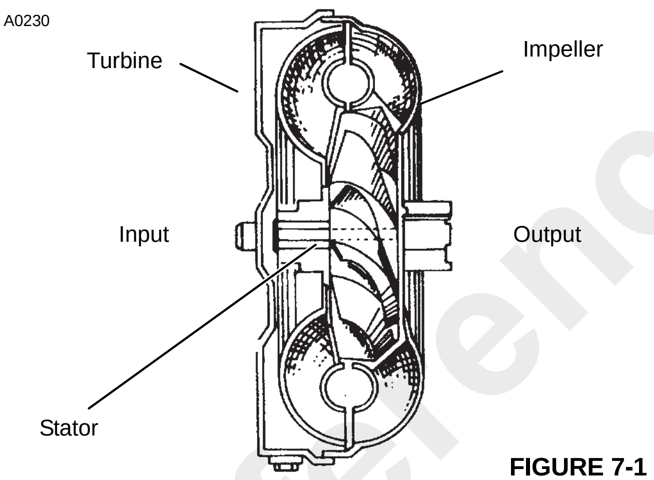


FIGURE 7-1

Cross Section of Torque Converter

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

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

The torque converter and transmission have a common hydraulic system. Figure 7-1 shows the arrangement of the system.

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

Transmission

The Powershift Transmission (Figure 7-2) is an electo-hydraulic transmission unit. Gear shifting and direction selection are controlled using multi-disc clutch packs.

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

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

The Powershift transmission consists of a torque converter **A** (Figure 7-2), input clutch assembly **B**, forward clutch **C**, layshaft assembly **E**, main shaft assembly **D**, and a parking brake disc **J** mounted on spline output shaft **K**.

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

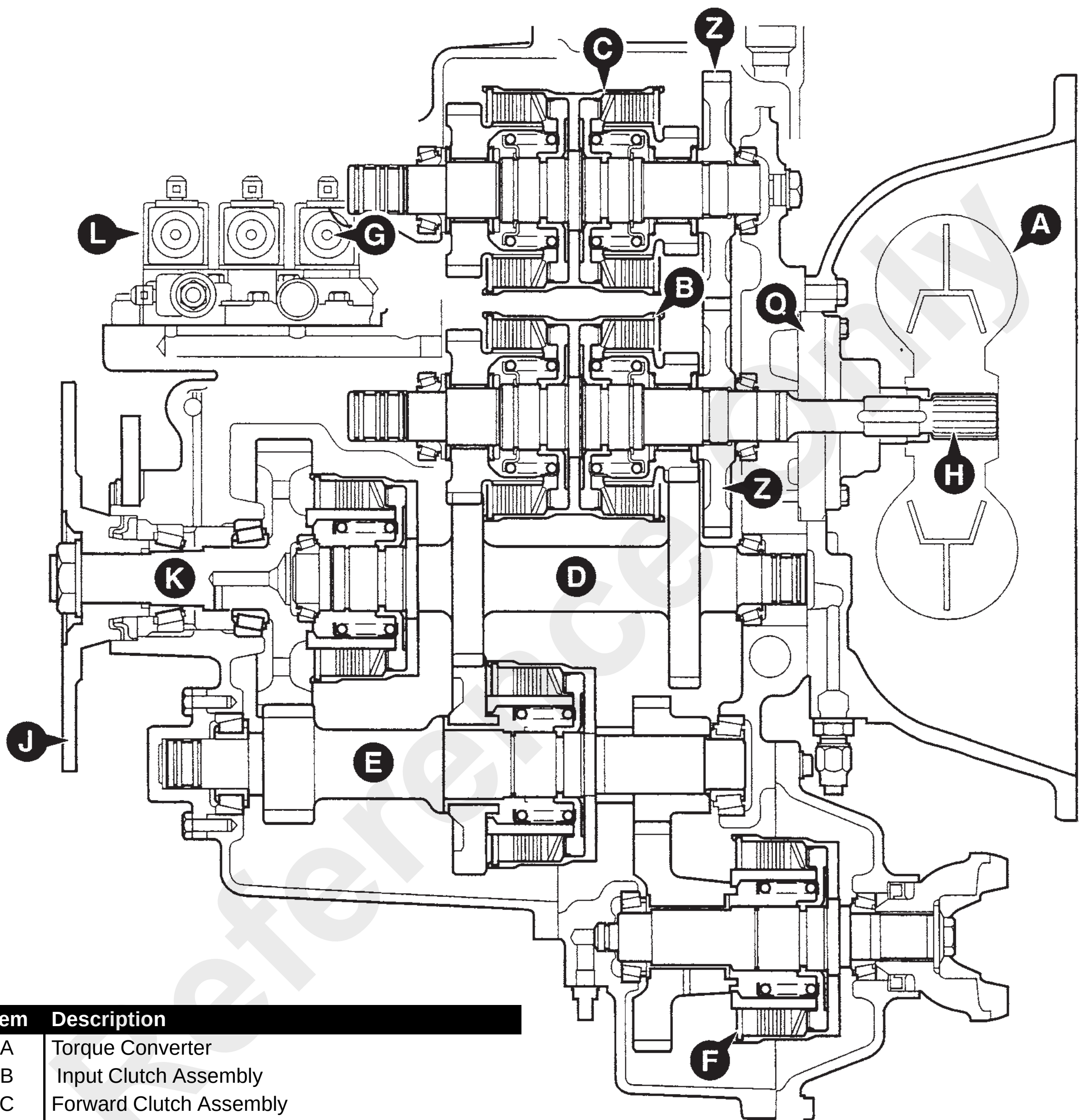
The input clutch assembly **B** contains two hydraulically operated clutches; one clutch provides reverse low ratio drive and other a reverse high ratio drive. The three-position solenoid **G**, when energized, directs pressurized oil to either the reverse low or reverse high clutch.

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

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

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

7



Item	Description
A	Torque Converter
B	Input Clutch Assembly
C	Forward Clutch Assembly
D	Main Shaft Assembly
E	Layshaft Assembly
F	4 WD Clutch Assembly (Not used)
G	3-Position Solenoid Valve (Reverse Travel)
H	Input Shaft
J	Parking Brake Disc
K	Spined Output Shaft
L	3-Position Solenoid Valve (Forward Travel)
M	3- Position Solenoid Valve (Mainshaft/ Layshaft
Q	Pump
Z	Spur Gears

FIGURE 7-2

Hydraulic Operation

When the Powershift Transmission is operated, multi-disc clutch packs are pressurized and engaged. The engaged clutch packs then transfer drive from the engine to the road wheels (via the torque converter **A** [Figure 7-3], input shaft **H** and the drive shafts).

Different combinations of engaged clutches give four gear ratios in forward and reverse drive. There must always be two clutches engaged before the crane will drive: a direction ratio clutch (i.e., forward low) and a drive clutch (i.e., layshaft or mainshaft).

Figure 7-3 shows 1st gear reverse selected, therefore, the two engaged clutches will be reverse low ratio clutch **B** and layshaft drive clutch **E**.

For purpose of this description, clutches not used when 1st gear reverse is selected are not shown.

Oil from the pump **Q** is fed through an internal passage by way of the filter **Y** to pressure the pressure maintenance valve **R**, which maintains a constant pressure to the solenoid valve adapter blocks **S**.

The solenoid adapter block houses the solenoid valves, which are used to divert oil to the clutch packs. When the solenoids are actuated oil flows through the valves to the clutch pack.

Excess oil from the maintenance valve flows through the casing to the torque converter. Oil enters the converter between the converter hub and stator support, and leaves between the stator and the input shaft. Pressure in the converter is controlled by relief valve **T** which dumps oil from the converter line back to the sump.

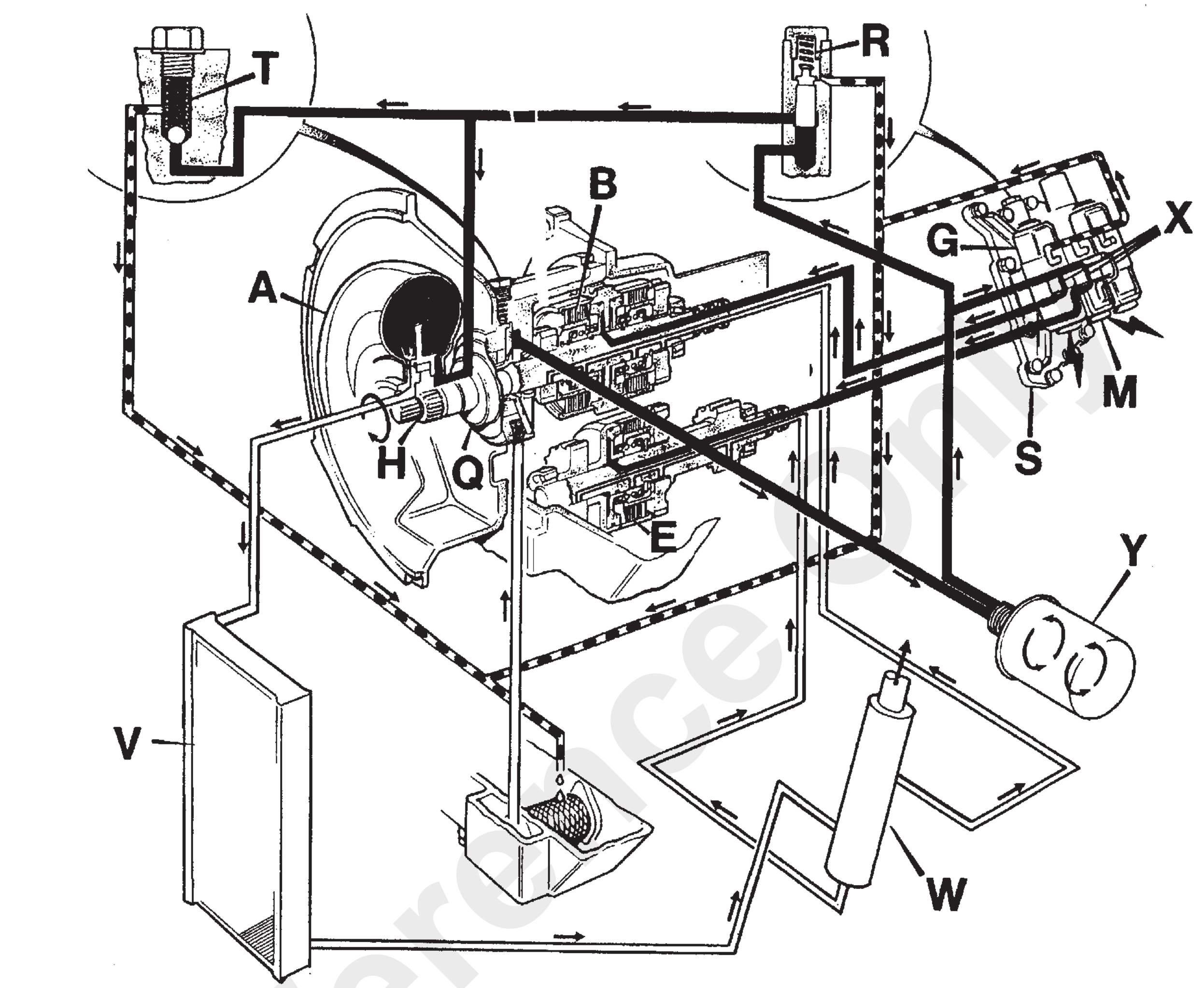
Oil from the torque converter flows out of the transmission unit to the external oil cooler **V**. From the cooler, the oil flows to pipe cluster **W** (the pipe cluster is only used on earlier transmissions, on later transmissions oil flow is incorporated within the casing, which distributes the oil to pass through the center of all clutches for lubrication purposes).

In neutral the flow of pressurized oil is blocked at the solenoid valves.

Restrictor orifice **X** in the feed lines to the solenoid valves modulates the pressure to the clutches. This ensures a smooth clutch engagement. Pressure from the clutches not engaged will vent back to the sump by way of internal passages and the solenoid spools.

With 1st gear reverse selected valves **G** and **M** are energized. The energized valves cause internal spools to move, which then divert pressurized oil to clutch packs **B** and **E** by way of internal passages.

The drive from the engine is then transferred by way of the engaged clutches and gears to the output flange and finally to the road wheels.



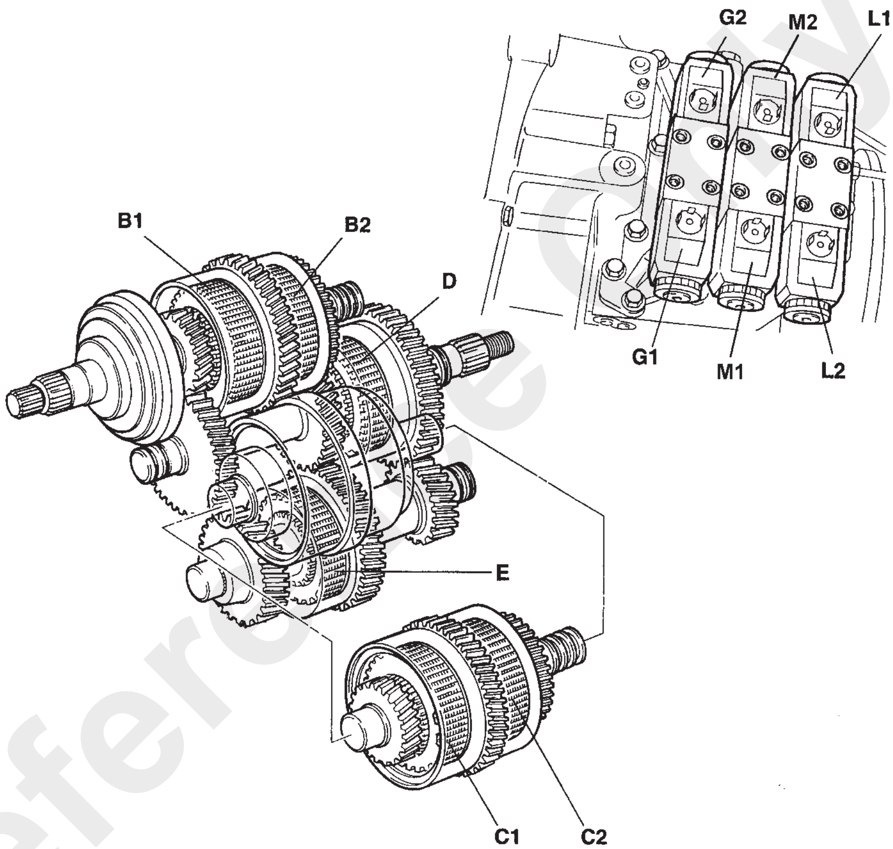
Two-Wheel Drive Transmission Hydraulic Circuits

Item	Description
A	Torque Converter
B	Reverse Low Ratio Clutch
E	Layshaft Drive Clutch
G	3-Position Solenoid Valve (Reverse)
H	Input Shaft
M	3-Position Solenoid Valve (Mainshaft/Layshaft)
Q	Pump
R	Pressure Maintenance Valve
S	Adapter Block
T	Relief Valve
V	Oil Cooler
W	Pipe Cluster
X	Restrictor Orifices
Y	Oil Filter

FIGURE 7-3

Drive Paths

The drive paths and engaged clutches for the four forward and four reverse drive speeds are shown on the following pages.



Clutch Identification (Figure 7-4)

Item	Description
B1	Reverse Low Ratio Clutch
B2	Reverse High Ratio Clutch
C1	Forward Low Ratio Clutch
C2	Forward High Ratio Clutch
D	Mainshaft Clutch
E	Layshaft Clutch

Solenoid Identification (Figure 7-4)

Item	Description
G1	Reverse Low Solenoid
G2	Reverse High Solenoid
L1	Forward Low Solenoid
L2	Forward High Solenoid
M1	Layshaft Solenoid
M2	Mainshaft Solenoid

FIGURE 7-4

Drive Paths - Forward

1st Gear Forward

Clutches Engaged

C1 - Forward Low Ratio

E - Layshaft

Solenoids Active

L1 - Forward Low Ratio

M1 - Layshaft

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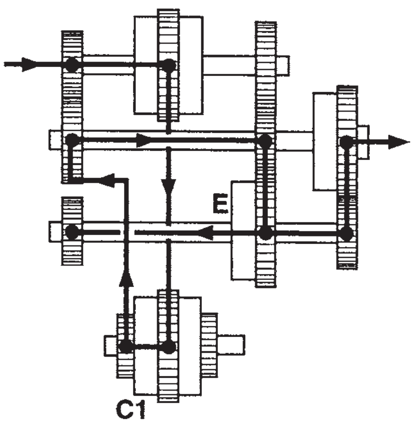

2nd Gear Forward

Clutches Engaged

C2 - Forward High Ratio

E - Layshaft

Solenoids Active

L2 - Forward High Ratio

M1 - Layshaft

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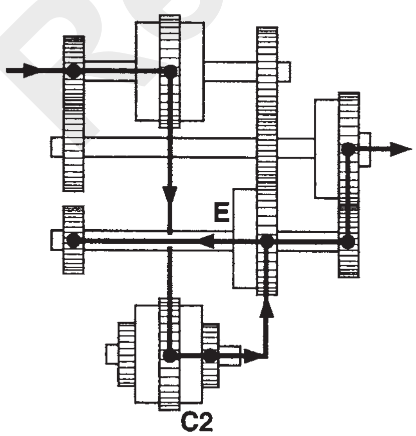

3rd Gear Forward

Clutches Engaged

C1 - Forward Low Ratio

D - Mainshaft

Solenoids Active

L1 - Forward Low Ratio

M2 - Mainshaft

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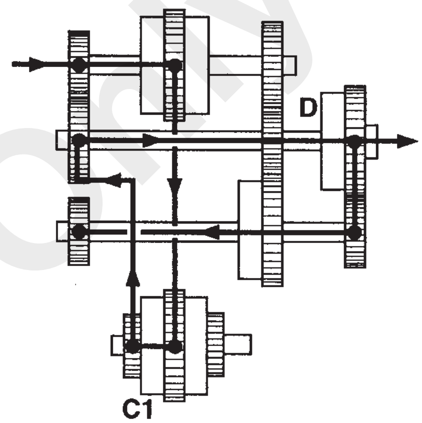

4th Gear Forward

Clutches Engaged

C2 - Forward High Ratio

D - Mainshaft

Solenoids Active

L2 - Forward High Ratio

M2 - Layshaft

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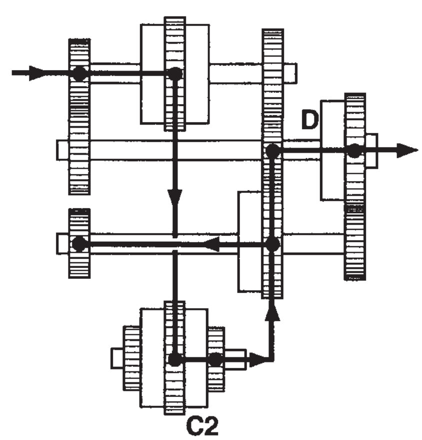

Drive Paths - Reverse

1st Gear Reverse

Clutches Engaged

B1 - Reverse Low Ratio

E - Layshaft

Solenoids Active

G1 - Reverse Low Ratio

M1 - Layshaft

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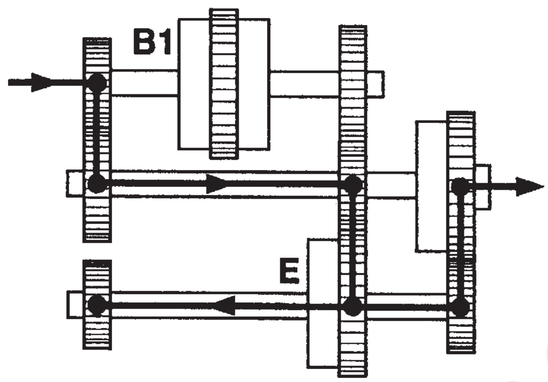

2nd Gear Reverse

Clutches Engaged

B2 - Reverse High Ratio

E - Layshaft

Solenoids Active

G2 - Reverse High Ratio

M1 - Layshaft

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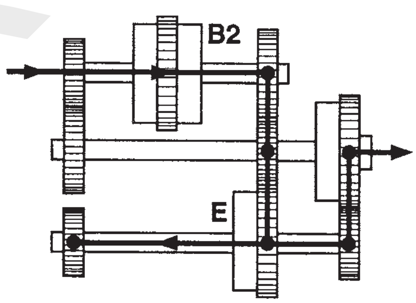

3rd Gear Reverse

Clutches Engaged

B1 - Reverse Low Ratio

D - Mainshaft

Solenoids Active

G1 - Reverse Low Ratio

M2 - Mainshaft

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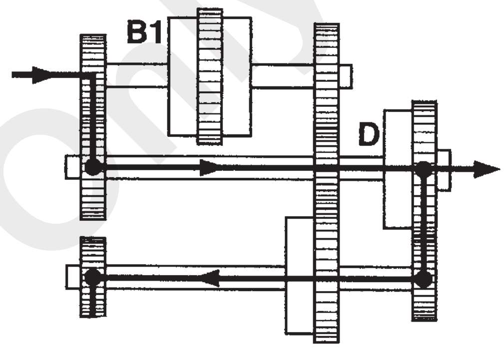


4th Gear Reverse

Clutches Engaged

B2 - Reverse High Ratio

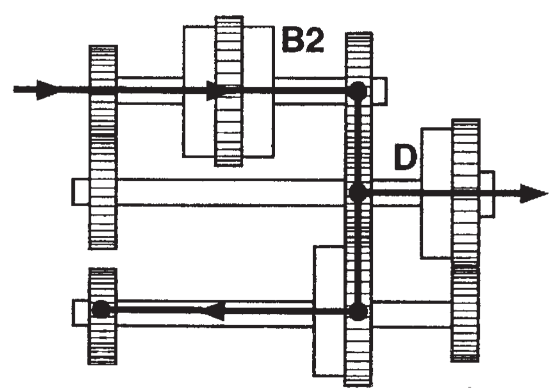
D - Mainshaft

Solenoids Active

G2 - Reverse High Ratio

M2 - Mainshaft

A0793



7

Clutch Operation

The transmission's reverse high and reverse low clutch assemblies (Figure 7-5) are operated by the double solenoid valve.

In neutral, the flow of pressurized oil to the clutches is blocked by the solenoid valve.

When energized, the solenoid valve, depending on which coil is energized, diverts pressurized oil through the shaft to the appropriate clutch in the assembly. Oil from the other clutch is vented back to tank through the solenoid valve spool.

NOTE: The forward high and forward low clutch assembly operates the same way.

The mainshaft and layshaft assemblies each have a single clutch. The principle of operation is similar to the Forward/ Reverse, High/Low clutch assemblies; i.e. the mainshaft/ layshaft solenoid valve diverts pressurized oil to either the mainshaft clutch or the layshaft clutch.

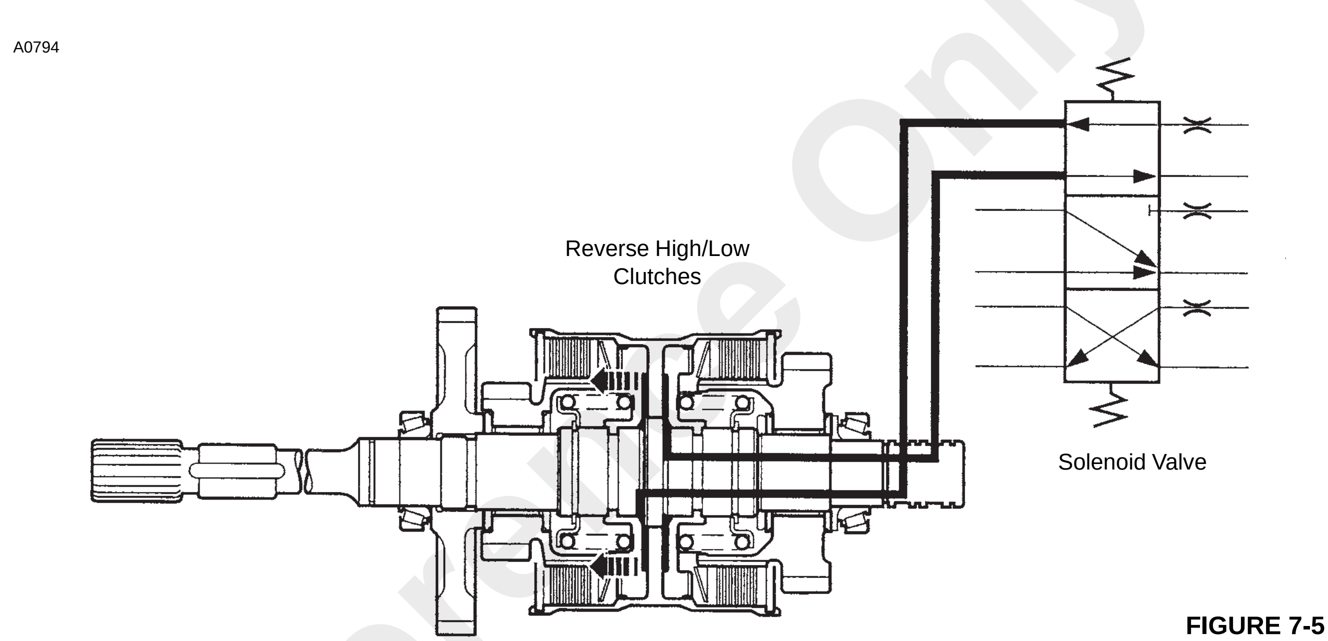


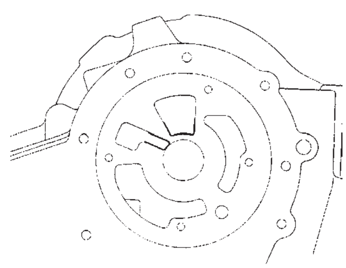
FIGURE 7-5

TROUBLESHOOTING

General Troubleshooting

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

Problem	Possible Cause	Remedy
Low Pump Flow	**1.** Low oil level. **2.** Blocked suction strainer. **3.** Worn pump.	**1.** Add oil to transmission. **2.** Clean suction strainer. **3.** Repair or replace the pump.
High Converter Out Pressure	**1.** Oil cooler/lines blockage.	**1.** Clean cooler, remove blockage.
Low Lubrication Pressure	**1.** Low mainline pressure. **2.** Oil cooler/lines blockage. **3.** Ruptured lubrication line. **4.** Converter internal leakage. **5.** Converter relief valve faulty. **6.** Leakage at pump to case (indicated by low cooler flow. **7.** Restriction in converter feed.	**1.** See problem “Low Mainline Pressure. **2.** Clean cooler, remove blockage.” **3.** Repair line. **4.** Check and replace converter. **5.** Check, repair or replace the relief valve. **6.** Check, replace or repair the pump. **7.** See item 10 in problem “OverHeating.”
Low Clutch Pressure and/or Clutch Slipping	**1.** Low mainline pressure. **2.** Worn pump. **3.** Blocked restrictor orifice in solenoid valve block. **4.** Clutch seals worn. **5.** Clutch piston rings worn. **6.** Mechanical failure.	**1.** See problem “Low Mainline Pressure.” **2.** Check flow and repair or replace if necessary. **3.** Remove solenoid(s) and clear restriction. **4.** Confirm with clutch leakage test. Replace seals if worn. **5.** Confirm with clutch leakage test. Replace piston rings if worn. **6.** Strip and rebuild clutch. Replace parts as required.

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

7

Troubleshooting (Electrical)

System Operation

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

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

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

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

Transmissions are furnished with six solenoid valves (RH, RL, MS, LS, FL and FH) See arrangement in Figure 7-7. Two of the solenoid valves control speed ranges while the remaining four control speed and the direction of travel.

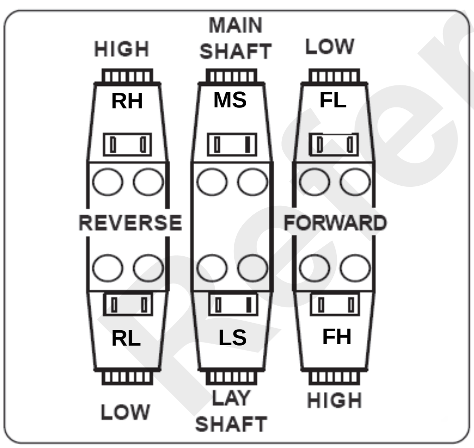


FIGURE 7-7

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

The following table shows which solenoid valves are energized for the four speeds and two directions of travel.

Table 7-1
Solenoid Valve Energizing Sequence

Gear	Direction	Valves
First	Forward	FL and LS
Second	Forward	FH and LS
Third	Forward	FL and MS
Fourth	Forward	FH and MS
First	Reverse	RL and LS
Second	Reverse	RH and LS
Third	Reverse	RL and MS
Fourth	Reverse	RH and MS

Electronic Control Unit (ECU)

The Electronic Control Unit (ECU) is designed to do two things:

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

It is a microprocessor controlled unit which is mounted under the dash in the operators' cab. A wire harness connects the ECU to the transmission harness, which connects to the solenoids, the oil pressure switch and a speed sensor, on the transmission. A second harness connects the unit to various switches and selectors in the cab (See Figure 7-8).

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

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

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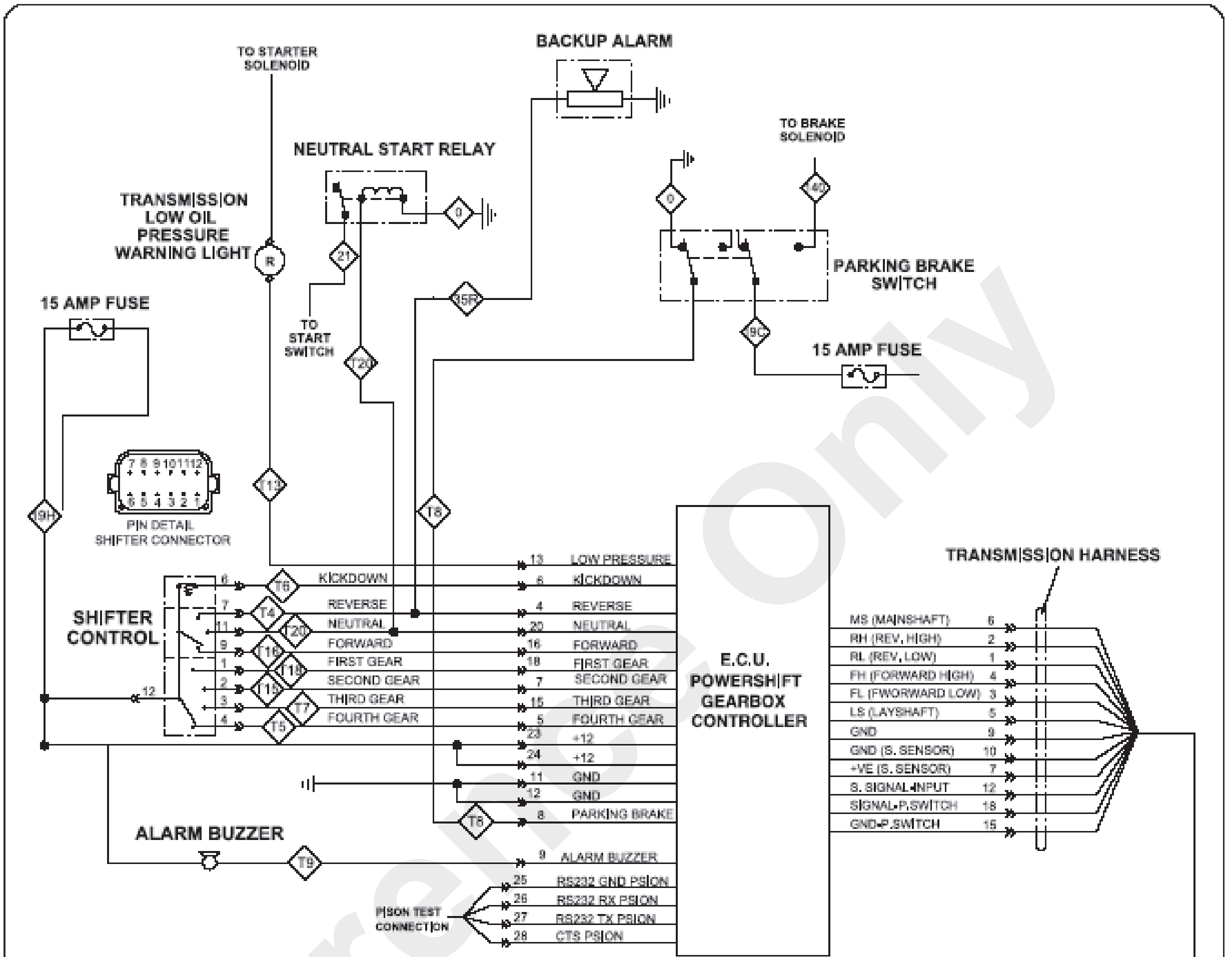


TL	SPEED SENSOR	
TERM	WIRE	DEST.
1	600HV	SB
2	974	TA12
3	109H	TA7

TB	LOW PRESS.	
TERM	WIRE	DEST.
1	405	TA18
2	600BU	TA15

TH	FORWARD HIGH	
TERM	WIRE	DEST.
1	811	TA2
2	600BT	SB

TG	FORWARD LOW	
TERM	WIRE	DEST.
1	849	TA1
2	600CA	SA

TD	REVERSE LOW	
TERM	WIRE	DEST.
1	848	TA3
2	600BX	SB

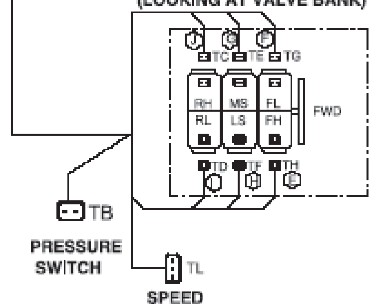
TC	REVERSE HIGH	
TERM	WIRE	DEST.
1	812	TA4
2	600BS	SA

TE	MAINSHAFT	
TERM	WIRE	DEST.
1	851	TAG
2	600CB	SA

TF	LAYSHAFT	
TERM	WIRE	DEST.
1	850	TAS
2	600BY	SB

HEXAGONAL BOXES REFER TO LABELS ON CONNECTORS

TRANSMISSION VALVE ASSEMBLY (LOOKING AT VALVE BANK)



GEAR	FORWARD	REVERSE
1ST	FL + LS	RL + LS
2ND	FH + LS	RH + LS
3RD	FL + MS	RL + MS
4TH	FH + MS	RH + MS

FIGURE 7-8

Electrical Troubleshooting Chart

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

Finding Electrical Problems

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

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

Checking Solenoid Operation

	Solenoids Figure 7-9
Forward 1st	Forward Low (FL) and Layshaft (LS)
Forward 2nd	Forward High (FH) and Layshaft (LS)
Forward 3rd	Forward Low (FL) and Mainshaft (MS)
Forward 4th	Forward High (FH) and Mainshaft (MS)
Reverse 1st	Reverse Low (RL) and Layshaft (LS)
Reverse 2nd.	Reverse High (RH) and Layshaft (LS)
Reverse 3rd	Reverse Low (RL) and Mainshaft (MS)
Reverse 4th	Reverse High (RH) and Mainshaft (MS)

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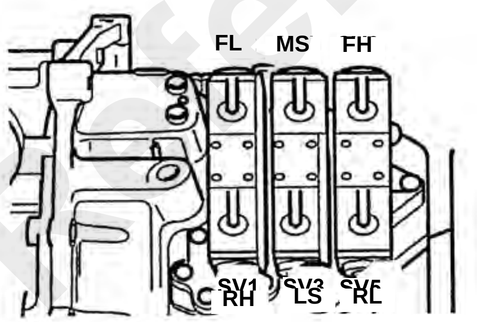

RH Reverse High **MS** Main Shaft
FL Forward Low **RL** Reverse Low
LS Layshaft **FH** Forward High

FIGURE 7-9

The correct operation can be confirmed as follows:

1. Chock the wheels.
2. Disable the machine neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located beneath the dash. See Figure 7-10.

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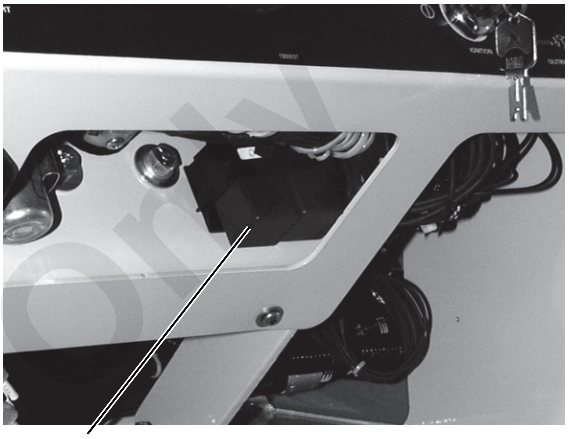


Neutral Start Relay Location **FIGURE 7-10**

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

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

7

Checking for (+ V) Supply to Solenoids

1. Chock all four tires, or lower all outriggers.
2. Disable the machine neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located beneath the dash. See Figure 7-10.
3. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
4. Select the desired gear on the shift control lever.
5. Identify the two solenoids which give the required gear from Figure 7-9.
6. Remove the electrical connector on the solenoids relating to gear selection.
7. Test across the connector terminals with a test lamp or voltmeter.

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

Energized solenoid (ON) = full battery charge

De-energized solenoid (OFF) = reduced voltage (Typically 5 - 9 V)

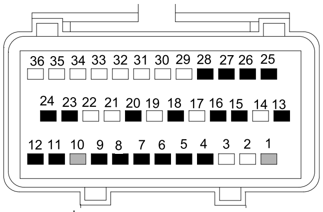
This reduced voltage should not be interpreted as a problem. When an electrical load is placed across the terminals this voltage drops to zero.

Checking the Instrument Panel Harness

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

1. Chock the four tires, or lower all outriggers.
2. Disable the machine neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located beneath the dash. See Figure 7-10.
3. Disconnect the instrument panel wire harness from the ECU. The instrument panel wire harness connector is the larger of the two ECU connectors.
4. Check the condition of the connector and socket for signs of water entry. Check the condition of the rubber seal in the instrument panel wire harness connector.
5. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to the neutral state.
6. Test the voltages on the pins in the harness connector **(DO NOT check the ECU pins)** using a test lamp or voltmeter. See Figure 7-2 for pin identification.
7. If the lamp illuminates, or the voltmeter shows full battery charge, where indicated in the table, then the integrity of the harness and power supply to the ECU is verified.

Table 7-2
Instrument Panel Wire Harness Check



See Notes Below

Key for the table:

X	Full battery charge
-	No voltage measured with key On
N.C.	Pin not connected

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

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

NOTE: ECU operation - pressing the kickdown button places the transmission in the next lowest gear (i.e. 4th goes to 3rd, 3rd goes to 2nd, 2nd goes to 1st). This lasts until the timer runs out or another gear and/or direction is selected.

7

Checking Parking Brake Switch

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

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

Checking Sensor Operation

Machines equipped with a transmission ECU have a speed sensor installed (Figure 7-11). The sensor detects the speed of rotation of the output shaft for the transfer gear and sends this information to the ECU.

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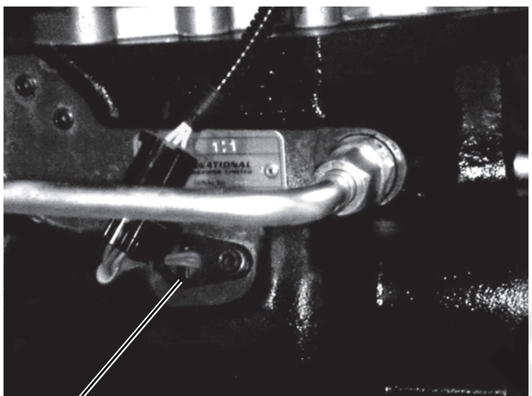


Speed Sensor

FIGURE 7-11

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

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

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

1. Park the crane on a firm, level ground. Engage the parking brake and set the forward/reverse lever to the neutral position.
2. Turn off the engine and remove the ignition key.
3. Disconnect the speed sensor from the wire harness.
4. Remove the speed sensor from the transmission. Place a suitable container underneath to catch the oil.
5. Check that the sensor is working by connecting a volt/ohm meter to the pins in the speed sensor connector and checking the voltage reading. Connect the positive (+) meter lead to the pin for the RED wire and the negative (-) meter lead to the pin for the BLUE wire. Move a piece of metal in front of sensor. When the metal passes the front of the sensor, the meter should be registering 12 VDC. If it does not register 12 VDC, replace the speed sensor.
6. While the sensor is removed, check the sensor for damage.
7. If the sensor is working properly, the problem is most likely in the harness itself. Repair or replace the harness.

Speed Sensor Depth

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

Tips on Common Problems

ECU Mounting

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

Speed Sensors

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

Occasionally sensors are out of tolerance or installed incorrectly.

Harnesses

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

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

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

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

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

No 4th Gear

There are two main causes for this problem:

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

Erratic / Sticking Gears

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

TESTING

Solenoid Identification

When Testing Individual Clutch Pressures (It Is necessary to isolate the clutch being tested. For instance, to check the layshaft clutch, you could select 1st gear forward. This would energize the layshaft and forward low clutches. Because we only want to check the layshaft clutch pressure and not the forward low clutch pressure, remove the electrical connector to the forward low clutch BEFORE selecting 1st gear.

Use the Tables 5-3 and 5-4 to determine which solenoid electrical connectors should be removed when pressure-testing individual clutches. Table 5-3 identifies the solenoid connectors (see Figure 7-12) and Table 5-4 identifies which clutches are engaged when the various gears are selected.

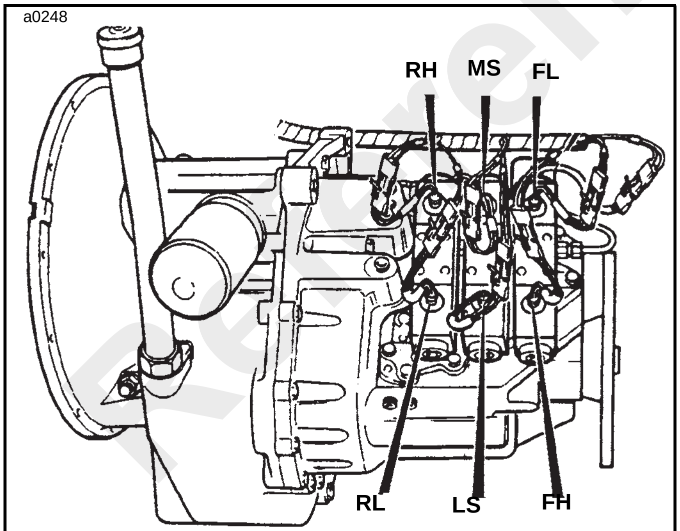


FIGURE 7-12

Table 5-3
Solenoid Description

Item	Solenoid Description
RL	Reverse Low
RH	Reverse High
LS	Layshaft
MS	Mainshaft
FH	Forward High
FL	Forward Low

Table 5-4
Solenoid Valve Energizing Sequence

Gear	Direction	Clutches Engaged Solenoids
First	Reverse	Reverse Low & Layshaft, RL &LS
Second	Reverse	Reverse High & Layshaft RH & LS
Third	Reverse	Reverse Low & Mainshaft RL & MS
Fourth	Reverse	Reverse High & Mainshaft RH & MS
First	Forward	Forward Low & Layshaft FL & LS
Second	Forward	Forward High & Layshaft FH & LS
Third	Forward	Forward Low & Mainshaft FL & MS
Fourth	Forward	Forward High & Mainshaft FH & MS

Test For Clutch Leakage

WARNING

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

Isolating a Suspect Clutch

Stop the engine, connect a 0-2040 kPa (0-300 psi) pressure gauge to the test connector **A**, Figure 7-13 (mainline pressure test point).

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

Start the engine and run at 1000 rpm. Engage1st gear forward. Record the pressure reading. Repeat the test for all gear ratios in forward drive and record the pressure readings as shown below.

Readings should not vary between clutches by more than 69 kPa (10 psi). In the example shown, we can see that pressure is low when 2nd and 4th gear forward is selected, indicating clutch leakage.

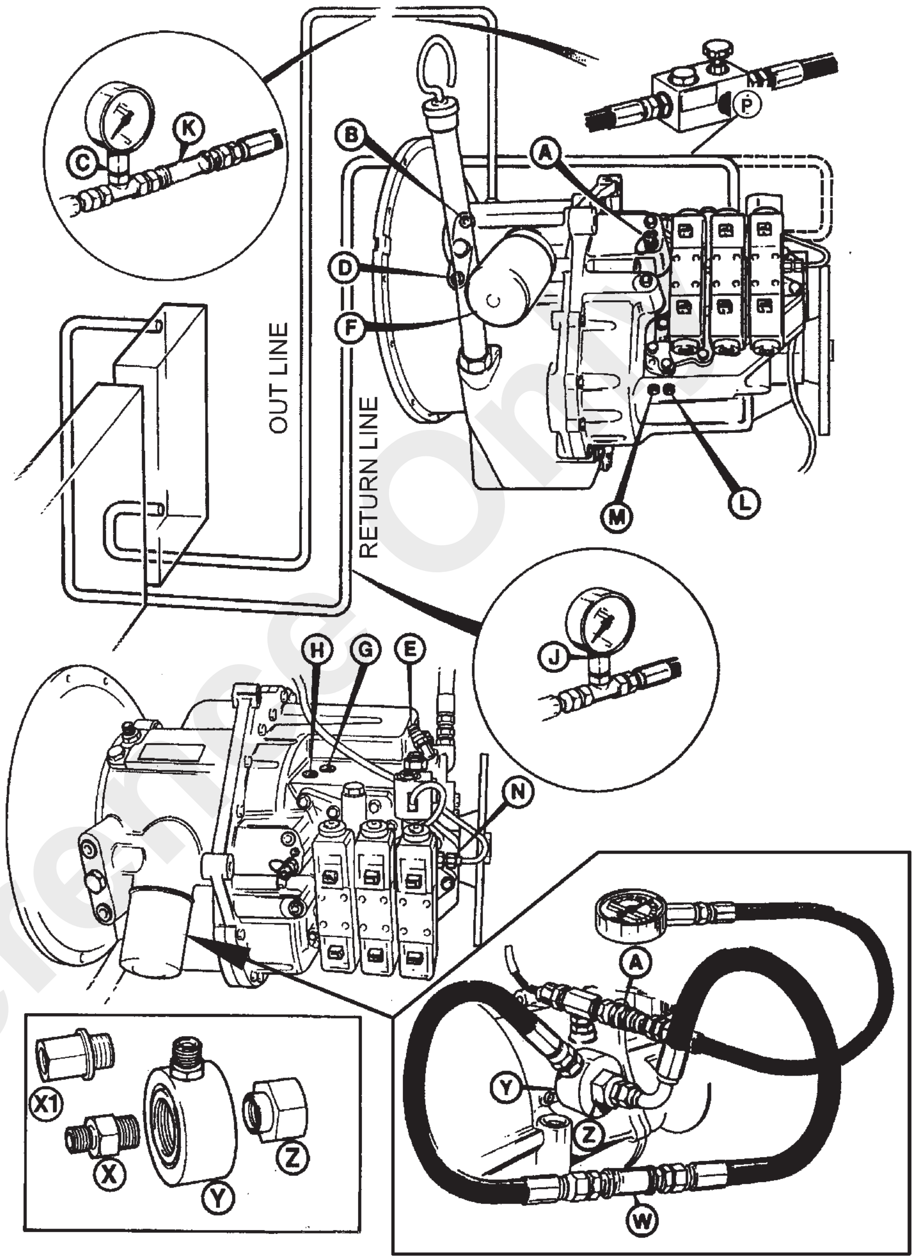
From the example you can see that the forward clutch high is used for selection of both 2nd and 4th gear forward. We know from the table that the mainshaft and the layshaft clutches are working normally (1st and 3rd gear selection show normal operating pressures). So it can be assumed that the forward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

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

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

Example Only

Gear Selected	Ratio Clutch	Mainshaft of Layshaft Clutch	PSI	kPa
First	Forward Low	Layshaft	140	952
Second	Forward High	Layshaft	125	850
Third	Forward Low	Mainshaft	140	952
Fourth	Forward High	Mainshaft	125	850



Item	Description
X	1901976
X1	1901978
Y	1901977
Z	1901979

Test Points

Item	Description	Item	Description
A	Mainline Pressure	H	Reverse low ratio clutch pressure
B	Converter inlet/converter relief valve pressure	J	Lubrication Pressure
C	Converter outlet pressure	K	Cooler flow (flowmeter in line from cooler to transmission)
D	Mainshaft clutch pressure	L	Forward high ratio clutch pressure
E	Layshaft clutch pressure	M	Forward low ratio clutch pressure
F	Pump flow (remove filters and fit adapters	N	4-wheel drive clutch pressure (not used)
G	Reverse high ratio clutch pressure	P	Load valve

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FIGURE 7-13

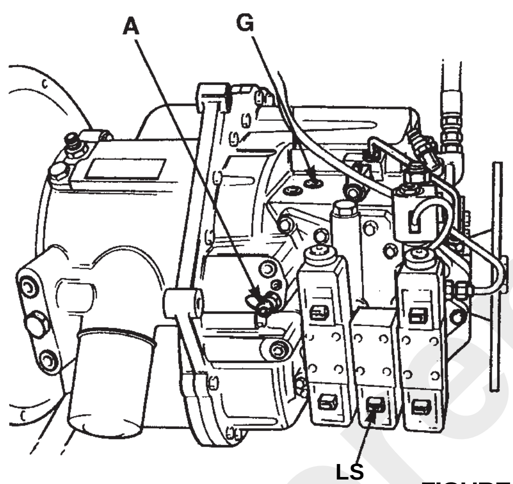
7

Individual Clutch Leakage Test

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

When testing other suspect clutches, connect a gauge to the relevant suspect clutch pressure test point. See Figure 7-13 for position of individual clutch pressure test points. Because the reverse high clutch is suspect, a gear must be selected that will use the reverse high clutch, in this instance 2nd gear reverse.

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



a0248 **FIGURE 7-14**

3. Remove the layshaft clutch solenoid feed connector **LS**, Figure 7-14. This ensures only the reverse high clutch is energized when 2nd gear reverse is selected.

NOTE: See Figure 7-12 for identification and position of solenoid feed connectors when testing other suspect clutches.

4. Raise the tires off of the ground using the outriggers.

NOTE: When performing this test the tires will rotate. Be careful to stay away from the rotating tires.

5. Start the engine and run at 1000 rpm, select 2nd gear reverse. Note the pressure readings on both gauges, which should not vary more than 0.7 bar (10 psi). If the difference on the gauges is greater than 69 kPa (10 psi) do the following:
   - **a.** Stop the engine and interchange the gauges.
   - **b.** Start the engine and run at 1000 rpm. Select 2nd gear reverse. If the difference on the gauges is still greater than 0.7 bar (10 psi), service the reverse high clutch.
   - **c.** If after interchanging the gauges, the readings are different than in step 4, have the gauges calibrated and repeat the test procedure.

Converter Stall Test

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

NOTE: **DO NOT** stall the converter longer than10 seconds or the transmission fluid will overheat. Make sure that the oil level is correct and at normal operating temperature.

Before completing the following test, remove the transmission dipstick. If there is any sign of smoke emitting from the dipstick tube, **STOP THE TEST IMMEDIATELY** and service the transmission.

1. Ensure that the engine and transmission are at normal working temperatures. Run the engine at maximum speed and check the **High Idle Speed**. See Engine Technical Data in the engine operators' manual.
2. The crane must not move during this test. Apply the foot brake firmly. If necessary, set the machine against a fixed obstruction.
3. Select 2nd gear forward and run engine at maximum RPM. Record the engine speed from the tachometer. Repeat the test for 3rd gear forward and record the speed reading.
4. Repeat step 3, except this time select 2nd gear reverse and 3rd gear reverse respectively. Record the speed readings.

NOTE: Using 2nd and 3rd gears in forward and reverse will ensure that all clutches are energized during the test.

5. All recorded readings should be as specified in Torque Converter Stall in technical data.

If the engine speeds are below the stated figures, either the engine is loosing power and should be serviced/overhauled or the torque converter reaction member clutch is slipping.

To check the engine, select Neutral, open the throttle fully, and lower the booms fully to bring the main relief over relief. The engine speed should fall slightly below the Maximum Governed Speed. If engine speed is correct, the torque converter reaction member is slipping.

If engine speed is higher than the Maximum Governed Speed, check the transmission for clutch slippage or internal leakage. To isolate a suspected clutch, tabulate the recorded readings as shown in the example below.

In the example shown, the engine speed is abnormally high when 2nd gear forward is selected indicating a slipping clutch.

From the example, it is evident that the layshaft clutch is working normally (2nd gear reverse indicates 1985 rpm). Therefore, it follows that the suspect clutch is the forward high. Assuming all other possible faults have been eliminated (see Troubleshooting), this clutch should be serviced.

Example Only:

Gear Selected	Ratio Clutch	Mainshaft or Layshaft Clutch	RPM
Second	Forward High	Layshaft	2060
Third	Forward Low	Mainshaft	1990
Second	Reverse High	Layshaft	1985
Third	Reverse Low	Mainshaft	1980

Pressure and Flow Tests

WARNING

Fine jets of hydraulic oil at high pressure can penetrate the skin. Do not use your hand to check for hydraulic leaks. Do not put your face close to suspected leaks. Hold a piece of cardboard close to suspected leaks and inspect the cardboard for signs of hydraulic oil. If hydraulic oil penetrates your skin, get medical help immediately.

WARNING

Take care when disconnecting hydraulic hoses and fittings. The oil will be hot and could cause burns.

WARNING

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

Before completing any transmission pressure/flow tests, make sure that the oil level is correct and is at normal operating temperature.

Pump Flow

NOTE: Special adapters are required to perform the following test. Contact your distributor. See Figure 7-13.

1. Stop the engine, remove the filter F and filter head adapter from the transmission. Install a special test adapter **X** onto the threaded spigot. Install special test adapter **Y** and secure with adapter **Z**. Connect a flowmeter **W**.
2. Start the engine and run at 1000 rpm. With the transmission in neutral, the flowmeter will show the pump flow. Compare this reading with the pump flow specifications. A low reading indicates a worn pump or blocked suction strainer.
3. Repeat step 2 and note the gauge reading with the engine running at 2000 rpm. Indicates same fault as in step 2.
4. Stop the engine and remove all test adapters. Install the filter.

Mainline Pressure

See Figure 7-13.

1. Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to the test connector **A**.
2. Start the engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will show the mainline pressure. Compare this pressure reading with the one listed on page 7-2. Either a faulty pressure maintenance valve or a worn pump can cause a low reading. A high reading may indicate a faulty pressure maintenance valve.
3. Repeat step 2 and note gauge reading with engine running at 2000 rpm. Indicates same fault as in step 2.
4. Stop the engine and remove the test gauge.

Converter Out Pressure/Oil Cooler Flow Rate

See Figure 7-13.

1. Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge and flow meter into the converter out line as shown at **C** and **K** respectively.
2. Run the engine at 1000 rpm with the transmission in neutral. The pressure gauge indicates the converter out pressure and the flow meter indicates the oil cooler flow rate. Compare both readings with the specifications on page 7-2. A blocked oil cooler could cause a high pressure together with a low flow.
3. Repeat step 2 and note the gauge reading with engine running at 2000 rpm. Same fault as indicated in step 2.
4. Stop the engine, remove the test gauge and flow meter and install hoses to original position.

7

Converter In Pressure

See Figure 7-13.

1. Connect a 0-20 bar (0-300 psi) pressure gauge to test point **B**.

2. Install a load valve **P** into the converter out line.

NOTE: Make sure the load valve is in the OPEN position (the adjusting knob screwed fully out) before starting the following pressure test. If the load valve is not fully open, damage to the converter seals will occur.

NOTE: **DO NOT** allow the pressure to exceed 110 bar (150 psi) or damage to the converter seals will occur.

3. Start the engine and run at 1000 rpm. With the transmission in neutral, slowly screw down the load valve **P** while observing the gauge reading which should rise to the converter relief valve setting specified.

4. If the reading is higher than specified the converter relief valve is faulty. A low reading indicates a leaking pump seal or faulty converter relief valve.

5. Stop the engine and remove the test gauges and install hoses to original position.

Lubricating Pressure

See Figure 7-13.

1. Stop the engine and connect a suitable pressure gauge into the return line from the oil cooler to the transmission as shown in **J**.

2. Start the engine and run at 1000 rpm. With the transmission in neutral, the pressure gauge will indicate the lubricating pressure. Compare the pressure reading with the specifications on page 7-2.

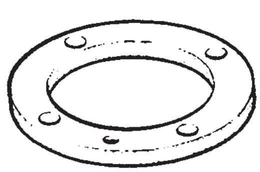
3. Repeat step 2 and note the pressure with the engine running at 2000 rpm.

4. Stop the engine and remove the pressure gauge.

Transmission Repair

Special Service Tools

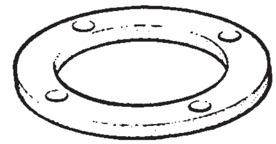
a0254



P/N 1900449

End Float Setting Tool **FIGURE 7-15**

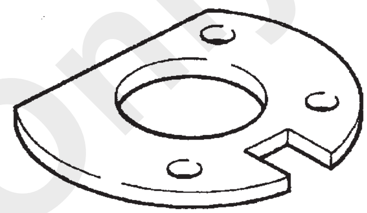
a0249



P/N 1001834

Reverse Clutch End Float Setting Tool **FIGURE 7-16**

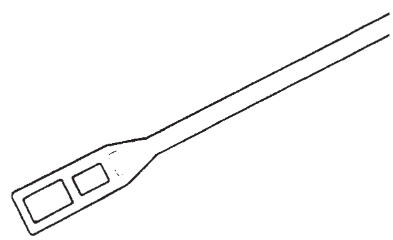
a1397



P/N 1001833

End Float Setting Tool **FIGURE 7-17**

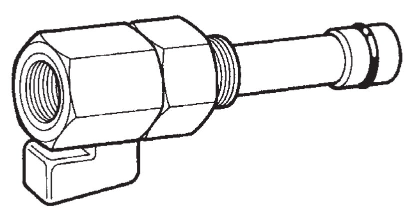
a0180



P/N 1900365

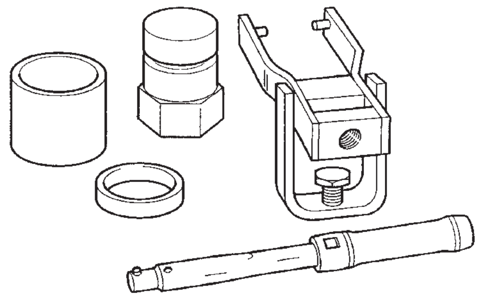
Drive Coupling Spanner For Yoke Couplings **FIGURE 7-18**

a1411



P/N 1903746

Mainshaft Air Line Adapter **FIGURE 7-19**



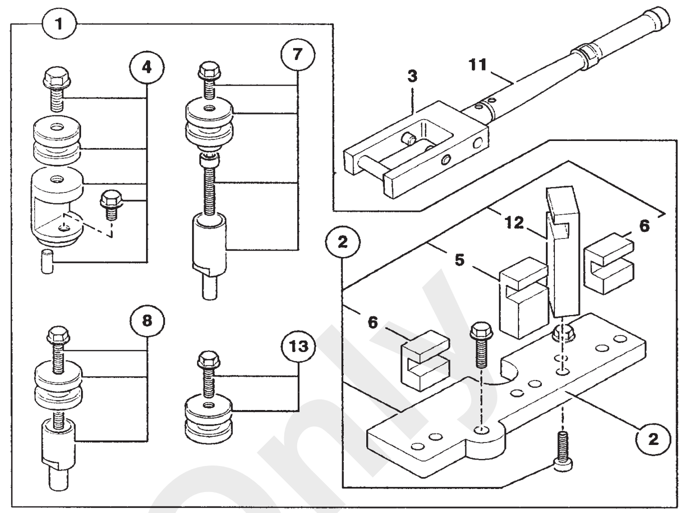
Item	Description
1902712	Seal
1902713	Stake Nut
1902714	Setting Tool Kit
1902715	Torque Wrench
1902737	Space Kit (Includes Spacers Listed Below

Item	Description	Item	Description
1902716	Spacer - 12.75 MM	1902729	Spacer - 13.40 MM
1902717	Spacer - 12.80 MM	1902730	Spacer - 13.45 MM
1902718	Spacer - 12.85 MM	1902731	Spacer - 13.50 MM
1902719	Spacer - 12.90 MM	1902732	Spacer - 13.55 MM
1902720	Spacer - 12.95 MM	1902708	Spacer - 13.60 MM
1902721	Spacer - 13.00 MM	1902709	Spacer - 13.65 MM
1902722	Spacer - 13.05 MM	1902707	Spacer - 13.70 MM
1902723	Spacer - 13.10 MM	1902710	Spacer - 13.75 MM
1902724	Spacer - 13.15 MM	1902711	Spacer - 13.80 MM
1902725	Spacer - 13.20 MM	1902733	Spacer - 13.85 MM
1902726	Spacer - 13.25 MM	1902734	Spacer - 13.90 MM
1902727	Spacer - 13.30 MM	1902735	Spacer - 13.95 MM
1902728	Spacer - 13.35 MM	1902736	Spacer - 14.00 MM

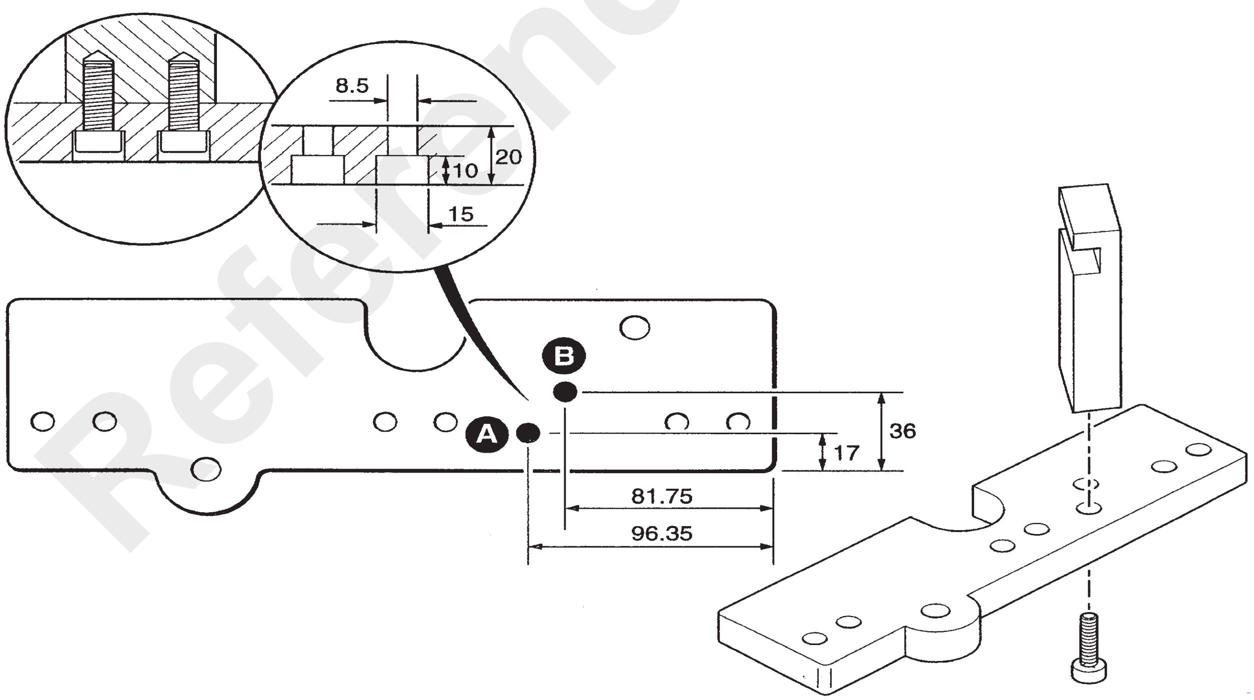
Setting Tool Kit

FIGURE 7-20

1. **End Play Checking Kit - P/N 1902739 (Includes Items 2 - 13)**
2. Base Plate and Bolts
3. Yoke
4. Mainshaft Adapter
5. Pillar (20.75 mm)
6. Pillar (45.75 mm)
7. Setting Body (54 mm)
8. Setting Body (64 mm)
9. Setting Tool (12 mm)
10. Setting Tool (10 mm)
11. Setting Wrench - 0 - 74 lb-ft (0-100 Nm)
12. * Pillar, Input Shaft (P/N 1902740)
13. * Setting Body (P/N 1902741)



* If these items are not in your kit, they may be ordered separately, but base plate **2** will have to be drilled to secure item **12**, see **A** and **B**. Dimensions in mm.



End Play Checking Kit

FIGURE 7-21

Servicing the Torque Converter

Removal

1. Remove complete power unit. See Sections 6 and 6A.
2. Fasten engine to an engine stand.
3. Using an overhead crane and chains to support the weight of the transmission, remove the twelve capscrews (2, Figure 7-22) and lockwashers (3) securing the transmission to the engine flywheel housing.

CAUTION

The transmission weighs approximately 220 kg (484 lb) dry. Use adequate hoist and chains. Personal injury could occur from improperly supported transmission.

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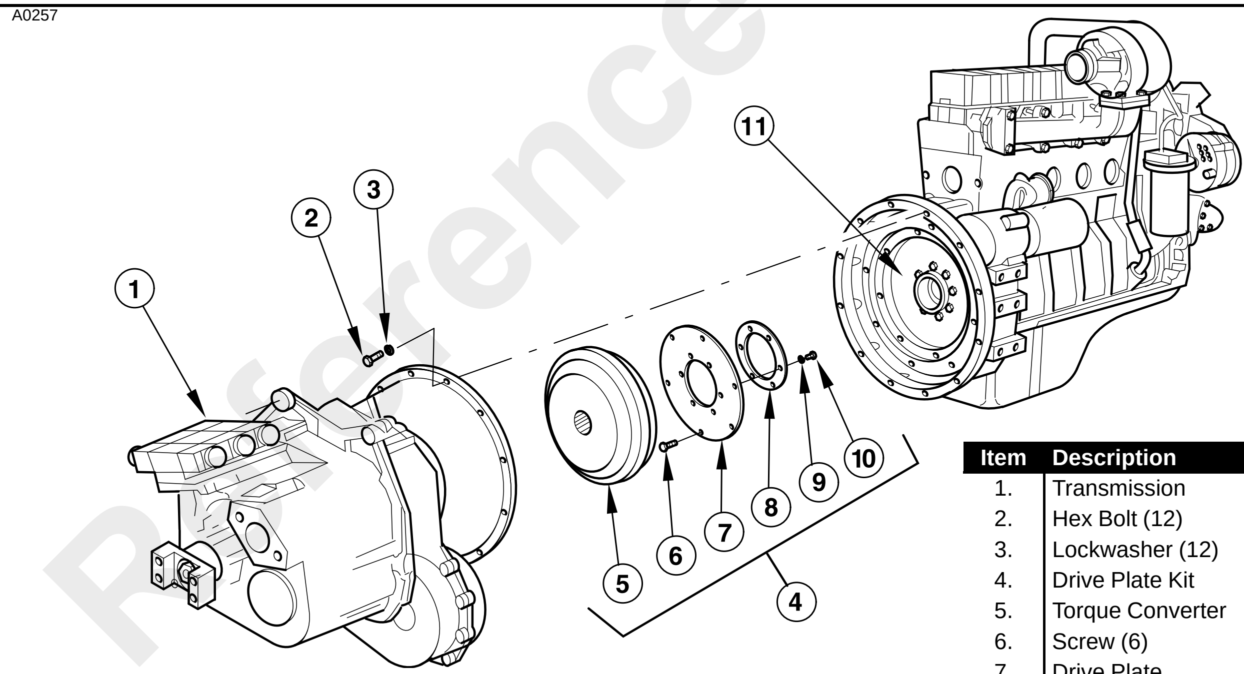
4. Remove the transmission (1) and place it in a clean work area where the torque converter can be removed. It is recommended that the transmission be mounted in a service fixture.
5. The torque converter assembly (4) is fastened to the engine flywheel (11) through a drive plate (7). Remove the six drive plate mounting screws (6) to remove the torque converter and drive plate.
6. Remove the six bolts (10) and lockwashers (9) securing torque converter (5) to drive plate (7) and remove the drive plate and its reinforcement (8).
7. Replace the complete torque converter. The parts are not serviced separately. Replace drive plate if there is distortion or damage.

NOTE: It is recommended that the torque converter be replaced any time system contamination occurs. It is not possible to completely clean the torque converter by flushing to remove the contamination. Replacement of the complete assembly is necessary to prevent early failure of other components in the system.



Item	Description
1.	Transmission
2.	Hex Bolt (12)
3.	Lockwasher (12)
4.	Drive Plate Kit
5.	Torque Converter
6.	Screw (6)
7.	Drive Plate
8.	Reinforcement
9.	Lockwasher
10.	Bolt (6)
11.	Engine

FIGURE 7-22

Installing with Alignment Tool

Ensure that the flywheel face, drive plate and hardware are clean and free from burrs or other surface imperfections.

1. Place the drive plate and annulus (1 Figure 7-23) onto the torque converter.

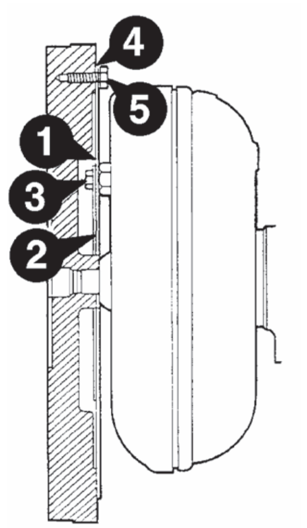


FIGURE 7-23

2. Place the torque converter alignment tool **A** (Figure 7-24) over the torque converter spigot, making sure that the tool locates in two of the converter bolt holes as shown. It is important to note that the converter drive tube must be protected against damage or contamination at all times.

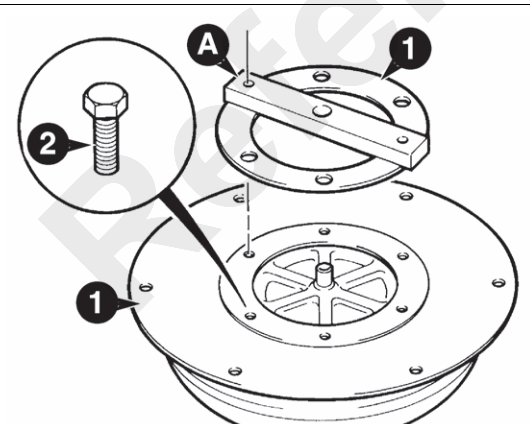


FIGURE 7-24

3. Apply Loctite® 243 to the threads of four new special drive plate retaining bolts (2), attaching the drive plate to the torque converter. Tighten the bolts to 40 Nm (30 lb-ft). Remove the alignment tool and install the remaining two bolts. Tighten to a torque of 40 Nm (30 lb-ft).

4. Locate the torque converter and drive plate assembly on the flywheel. Install three bolts to attach the drive plate to the flywheel. Check the converter run-out as shown in B of Figure 7-25, which should not exceed 0.38 mm (0.015 in). Adjust as necessary.

NOTE: In the unlikely event that the run-out exceeds 0.38 mm (0.015 in), remove the converter and check the spigot for burrs, remove the drive plate and rotate it 180° on the torque converter. Repeat steps 2 to 4.

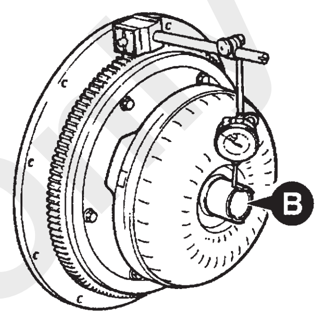


FIGURE 7-25

5. Remove the torque converter and drive plate/annulus assembly from the flywheel.

6. Install the converter assembly to the transmission/ engine:

- **a.** Install the torque converter with its drive plate/ annulus sub-assembly onto the transmission input shaft, making sure that the dogs on the converter pump drive shaft engage with the recesses in the pump. Also take care not to damage the oil seal.
- **b.** Rotate the engine flywheel so that one bolt hole is in the six o'clock position.
- **c.** Rotate the torque converter and drive plate assembly so that one bolt hole is in the six o'clock position.
- **d.** Install the transmission/torque converter assembly to the engine.
- **e.** Remove the access plate from the bottom of the engine flywheel housing and, through the access hole, fit and hand tighten one bolt (3, Figure 7-23) in the six o'clock position.

NOTE: It is important to mount washers (4) with the outside diameter radius against the drive plate, that is, facing towards the flywheel.

- **f.** Rotate the flywheel until the next bolt hole is accessible. Apply Loctite 243 to the threads of the next bolt (3) then fit and hand-tighten. Repeat this operation until all bolts are installed. Finally, torque all bolts (3) to 19 Nm (14 lb-ft), rotating the flywheel each time to align the bolts with the access hole. Re-install access plate.

Installing without Alignment Tool (Optional)

If the torque converter alignment tool (A) is not available, the following method should be used to replace the converter.

1. Assemble the drive plate and drive plate annulus (1, Figure 7-23) to the torque converter using bolts (3), finger tighten at this time.
2. Bolt drive plate to flywheel and check that run-out of pump drive shaft (B) does not exceed maximum permissible 0.38 mm (0.015 in). If incorrect, tap torque converter by hand to reposition.
3. When correct, mark position of flywheel and drive plate, then remove drive plate and annulus from flywheel.
4. Apply Loctite 243 to threads of bolts (3) and tighten to 40 Nm (30 lb-ft).
5. Fit torque converter/drive plate sub-assembly to flywheel; align marks, then fit washers (4) and bolts (5). Apply Loctite 243 to bolts (5) and tighten to 19Nm (14 lb-ft).

NOTE: It is important to mount washers (4) with the outside diameter radius against the drive plate (that is, facing toward the flywheel).

When installing transmission to washers converter assembly, ensure that the dogs on the converter oil seal spigot engage with the recesses on the transmission input. Take care not to damage the oil seal.

Servicing the Transmission

NOTE: Special tools are required to service the transmission. If the tools on pages 7-27 through 7-29 are not available, DO NOT ATTEMPT to service the transmission. The tools are available from your distributor.

Removal

1. Remove complete power unit. See *Engine and Engine Systems*, page 6-1.
2. Fasten engine to an engine stand.
3. Drain the transmission. See 1000 Hours Maintenance.

CAUTION

The transmission weighs approximately 220kg (484 lb) dry. Use adequate hoist and chains. Personal injury could occur from improperly supported transmission.

4. Using an overhead crane and chains to support the weight of the transmission, remove the 12 bolts (2, Figure 7-29) and lockwashers (3) that fasten the transmission housing (1) to the engine flywheel housing. Remove the transmission and torque converter assembly and place in a clean, work area where the torque converter can be removed. It is recommended that the transmission be mounted in a service fixture.

Transmission Gearbox Repair

Figure 7-30 shows all the components which are referred to in the disassembly/assembly procedures. Item numbers correspond with numbers in the instructions and following illustrations. Depending on transmission, some of the items shown may not be installed (e.g. 5, 7, and 38.)

Safety

WARNING

DO NOT BURN FLUOROELASTOMERIC MATERIALS!
If contamination of skin or eyes occurs, wash the affected area with a continuos supply of clean water or with calcium hydroxide solution for 15 - 60 minutes. Get medical attention immediately.

WARNING

Certain seals and gaskets may contain fluoroelastomeric materials such as Viton, Fluorel and Technoflon. Fluoroelastomeric materials subject to high temperatures can produce highly corrosive hydrofluoric acid. **THIS ACID CAN SEVERELY BURN.**

New fluoroelastomeric components at ambient temperature require no special safety precautions.

Use of fluoroelastomeric components whose temperatures have not exceeded 300°C (572°F) require no special safety precautions. If evidence of decomposition (e.g. charring) is found, see the next paragraph for safety instructions. DO NOT TOUCH COMPONENTS OR SURROUNDING AREA.

Used fluoroelastomeric components subjected to temperatures greater than 300°C (572°F) (e.g. engine fire) must be treated using the following safety procedure. Make sure that heavy duty gloves and safety glasses are worn:

- Ensure that components have cooled then remove and place materials into plastic bags.
- Thoroughly wash contaminated area with a 10% calcium hydroxide or other suitable alkali solution, if necessary use wire wool to remove burnt remains.
- Thoroughly wash contaminated area with detergent and water.
- Contain all removed material, gloves etc, used in this operation in sealed plastic bags and dispose of in accordance with Local Regulations.

Disassembly

1. Remove the torque converter assembly.
2. Make sure all the oil is drained from the casing by removing the drain (4, Figure 7-26) and screen (2).

NOTE: Stay clear of the transmission when removing the strainer. Oil will gush out when the strainer is removed.

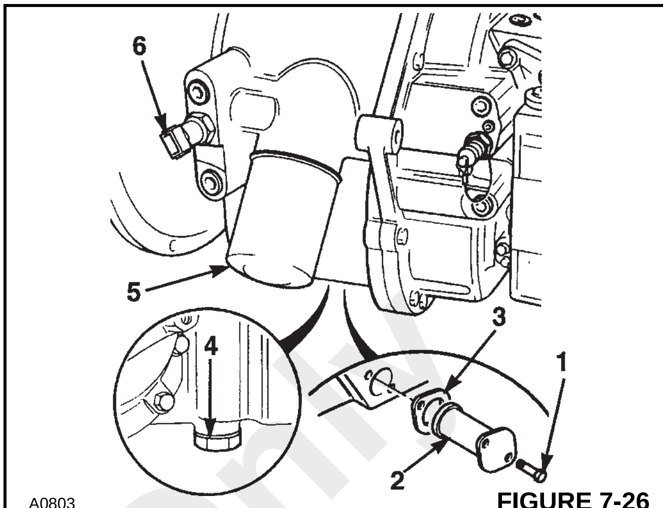


FIGURE 7-26

3. Remove and discard oil filter (5).
4. Remove pressure switch (6).
5. Remove the speed sensor (7, Figure 7-27).

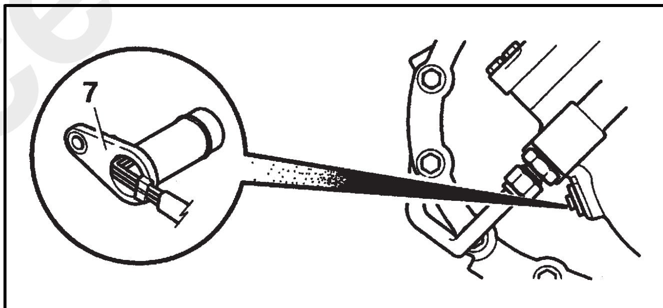


FIGURE 7-27

6. Remove the plastic water seals (8, Figure 7-28) to reveal capscrews (9). Unscrew capscrews (9) and remove reverse high/low clutch solenoid valve (10).
7. Similarly, remove the mainshaft/layshaft clutch solenoid valve (11).
8. Similarly, remove the forward high/low clutch solenoid valve (12).
9. When the solenoid valves are removed, remove and discard the four O-rings (13) from each valve body.

   See page 7-70 for solenoid valve repair.

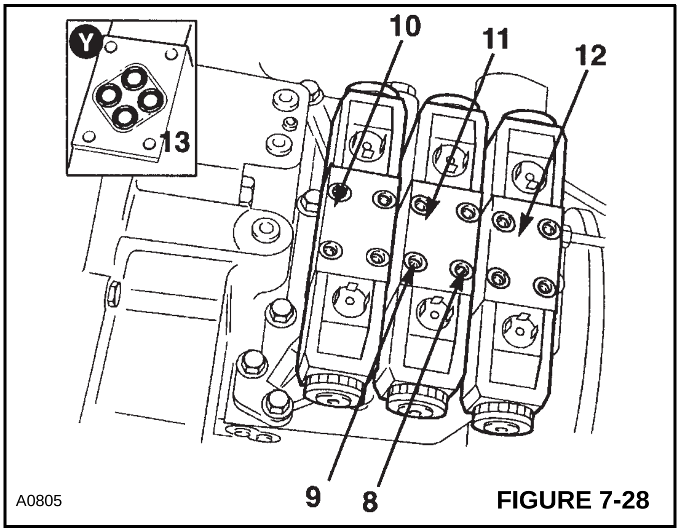


FIGURE 7-28

10. Unscrew four bolts (14, Figure 7-29) and remove the transmission pump assembly (15).

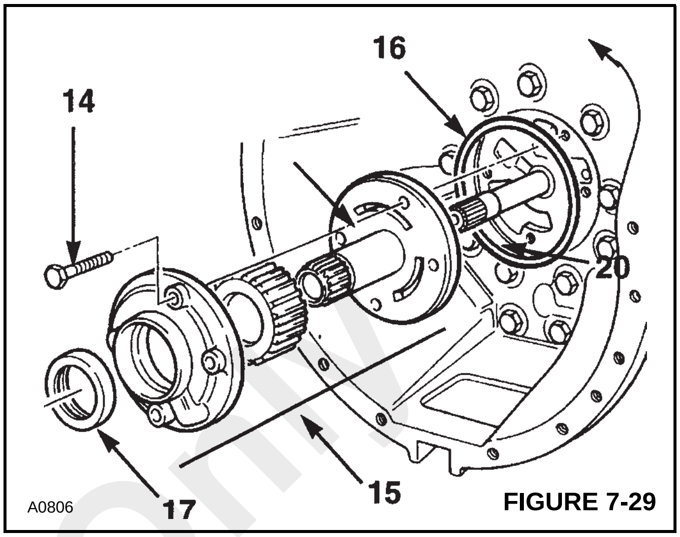


FIGURE 7-29

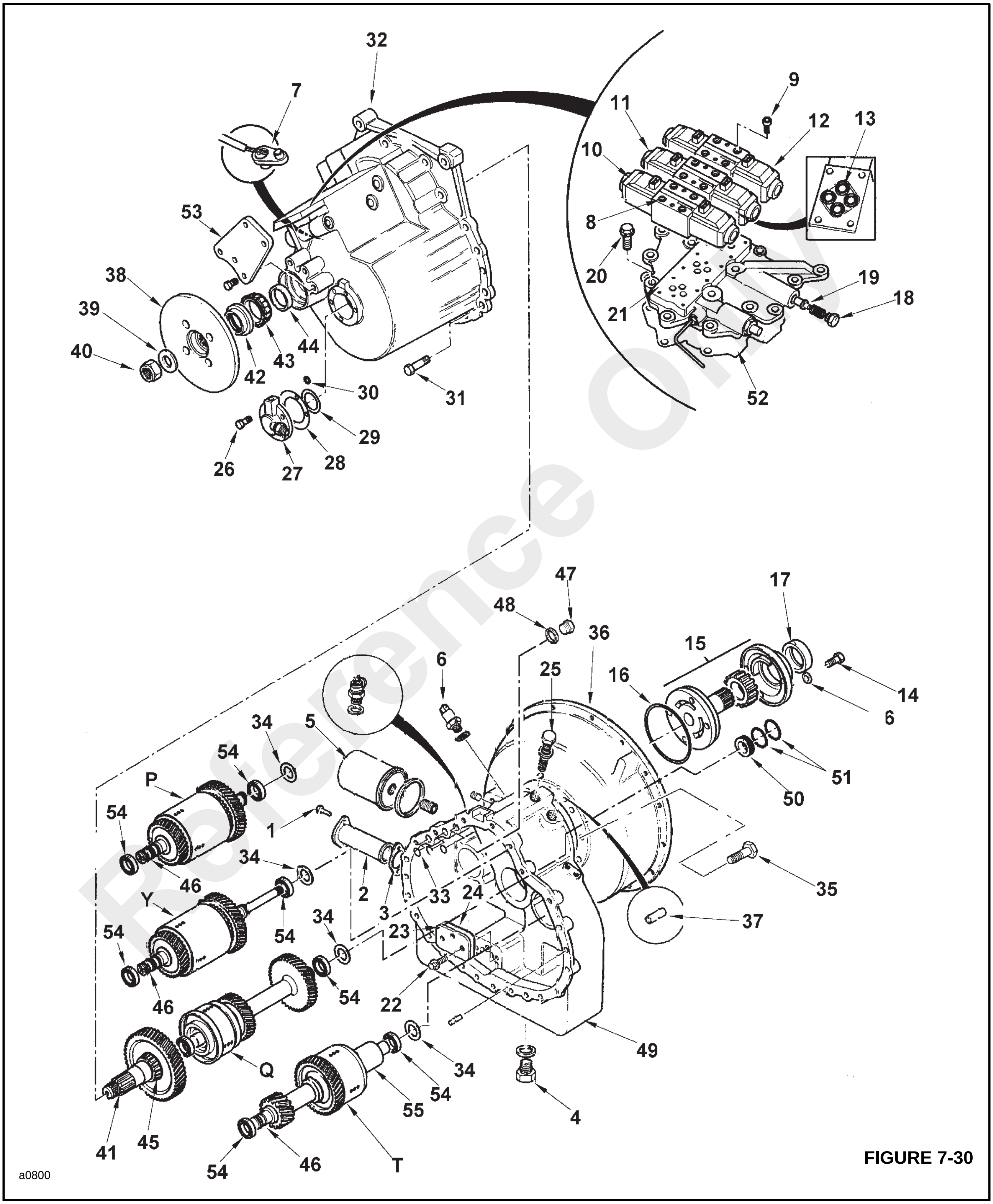

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FIGURE 7-30

Component Identification for Figure 7-30

Figure 7-30 shows all the components which are referred to in the disassembly/assembly procedures. Item numbers correspond with numbers in the instructions and the following illustrations.

Item	Description	Item	Description
1	Bolt	31	Case Mounting Bolts
2	Oil Strainer	32	Transmission Rear Case (Output end)
3	Gasket	33	O-ring (3)
4	Drain plug	34	Shim(s)
5	Oil Filter	35	Case Mounting Bolts (11)
6	Oil Pressure Switch	36	Flywheel Housing
7	Speed Sensor	37	Dowels(2)
8	Sealing Caps (6)	38	Brake Disc
9	Capscrew (6)	39	Output Shaft Washer
10	Solenoid Control Valve (Forward High/Low	40	Output Shaft Nut
11	Solenoid Control Valve (Mainshaft/Layshaft)	41	Output Shaft
12	Solenoid Control Valve (Reverse High/Low)	42	Oil Seal
13	O-rings (12)	43	Outer Taper Roller Bearing
14	Transmission Pump Mounting Screws (4)	44	Spacer
15	Transmission Pump Assembly	45	Inner Taper Roller Bearing
16	Pump Sealing Ring	46	Piston Ring Seals
17	Pump Housing Oil Seal	47	Forward Shaft Sealing Plug
18	Plug	48	Sealing Washer
19	Pressure Maintenance Valve	49	Transmission Front Case (Input End)
20	Bolt (14)	50	Spacer
21	Solenoid Adapter Block	51	O-ring (2)
22	Screw (3)	52	Adapter Block Gasket
23	Baffle Plate	53	Brake Mounting Plate
24	Gasket	54	Taper Roller Bearing (8)
25	Torque Converter Relief Valve	55	Spacer
26	Cover Bolts (4)	56	Copper Washer
27	Layshaft End Cap	P	Forward Clutch Assembly
28	Gasket	Q	Mainshaft Clutch Assembly
29	Shim(s)	T	Layshaft Clutch Assembly
30	O-ring	Y	Input Clutch Assembly

11. Remove and discard pump sealing ring (16).
12. Separate the pump components.
13. Remove and discard oil seal (17) from the pump housing.
14. Unscrew plug (18, Figure 7-31) and remove the pressure maintenance valve spool and spring (19).
15. Unscrew fourteen bolts (20) and remove solenoid adapter block (21).
16. Remove and discard gasket (52).

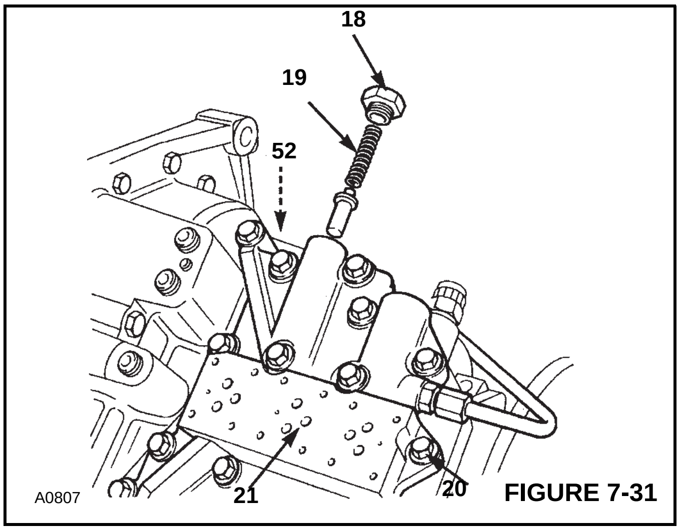


FIGURE 7-31

7

CAUTION

The transmission weighs approximately 220kg (484 lb) dry. Use adequate hoist and chains. Personal injury could occur from improperly supported transmission.

17. Position the transmission vertically, standing on the face of the flywheel housing as shown in Figure 7-32.
18. Remove torque converter relief valve ball, tapered spring and sealing washer (25).
19. Remove four bolts (26) and remove layshaft end cap (27). Discard sealing gasket (28).
20. Remove layshaft shim (29) and O-ring (30).
21. Unscrew nineteen bolts (31) and lift off rear end casing (32).

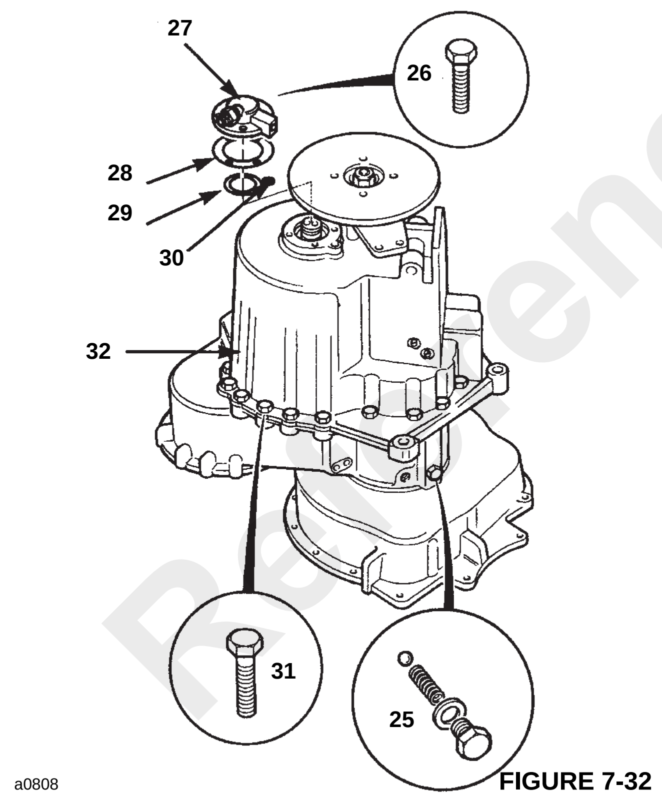


FIGURE 7-32

NOTE: Sealant holds the two casings together, carefully tap the casings while prying the casings apart at locations X in Figure 7-33. DO NOT pry open between the casings or the sealing faces will be damaged.

NOTE: Make sure that the internal components, except spined output shaft and brake disc, remain seated in the front casing. If necessary, rotate the brake disc back and forth slightly to dislodge the internal components.

22. Remove and discard three O-rings (33, Figure 7-33).
23. Tilt and lift out layshaft assembly (T).

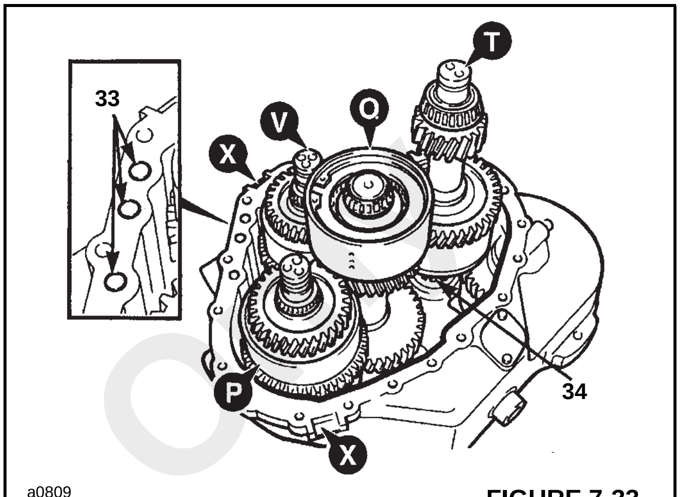


FIGURE 7-33

NOTE: For reference, the clutch assemblies are identified as follows.

P = Forward Clutch Q = Mainshaft

T = Layshaft V = Input Clutch

24. This step requires the help of an assistant. Have the assistant SLIGHTLY lift and tilt both the main shaft (Q) and input clutches (V) as shown in Figure 7-33; then tilt and lift out the forward clutch (P).
25. Slightly lift input clutch (V) and at the same time tilt and lift out main shaft (Q).
26. Lift out input clutch (V).

NOTE: Retrieve shims (34) from casing for reuse. Disassembly and assembly procedures for the shaft and clutch assemblies are given elsewhere in this section.

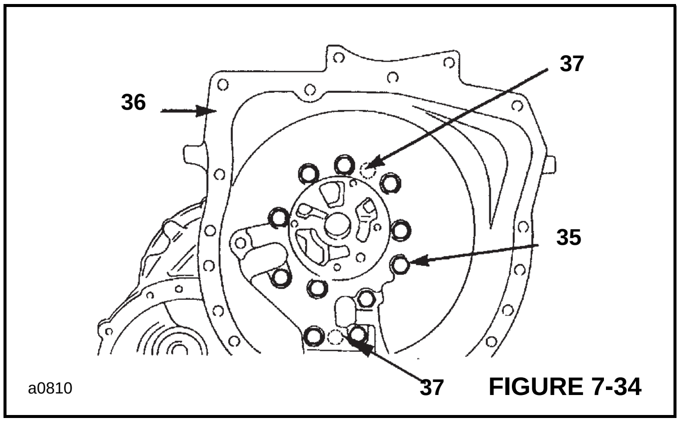


FIGURE 7-34

27. Unscrew eleven bolts (35, Figure 7-34) and remove flywheel housing (36). It may be necessary to tap the housing with a soft hammer to release the flywheel from dowels (37).

28. Mark the position of the brake disc (38, Figure 7-35) on the spline output shaft (41). While holding the disc, unscrew output shaft nut (40) and remove with washer (39). Support output shaft (41) from beneath and lift off the brake disc. Remove the output shaft assembly.

NOTE: Due to ratio options some transmissions feature a larger output gear (Z). When removing the output shaft (41) the gear may hit the gearbox housing, preventing removal. For shaft removal procedures see Output Shaft Removal - Larger Diameter Gear.

29. Pry out oil seal (42) and discard.

30. Remove outer taper bearing (43).

31. Remove spacer (44) and retain for assembly, if type **Y**.

NOTE: If spacer (44) is the collapsible type (**X,** Figure 7-35), discard it. It is recommended replacing it with a solid spacer. See Assembly step.

32. Using a suitable puller, remove inner bearing (45).

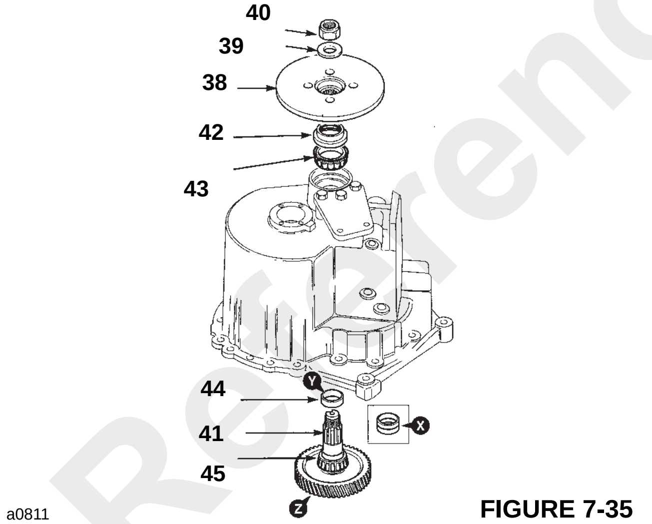


FIGURE 7-35

33. Remove and discard two O-rings (51, Figure 7-36) from casing (49).

34. Carefully, from inside casing (49), tap out spacer (50).

35. Finally, after disassembly, make sure casings and parts have been thoroughly cleaned using suitable solvents before starting the assembly procedures. Be sure the suction strainer is thoroughly cleaned and dried before assembly.

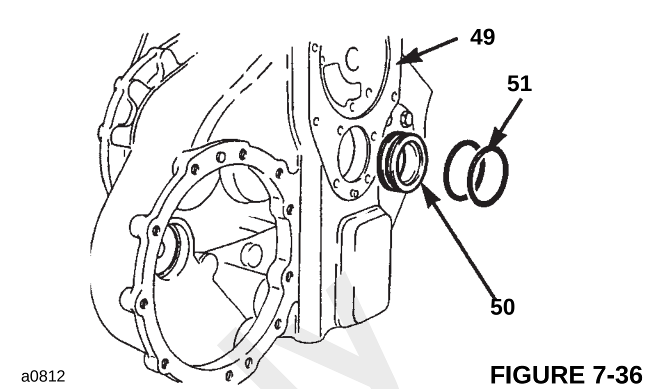


FIGURE 7-36

Assembly

NOTE: Before starting the assembly of the transmission, make sure that all casings and components, including the suction strainer, have been thoroughly cleaned with a suitable solvent.

When assembling, coat bearings with a Lithium Base, E.P. No. 2 bearing grease. Replace all O-rings, seals and gaskets.

Remember that dirt in the transmission system will cause damage to the transmission and its associated parts, particularly the transmission pump.

1. Using a new gasket, install the suction strainer. Apply Loctite 243 to bolts (1, Figure 7-37) and tighten to a torque of 10 Nm (7 lb-ft).

If removed, install bearing cups into gear casing.

NOTE: If the transmission has not been thoroughly cleaned during overhaul, any particles below 200 microns (0.2 mm) can pass through the existing suction strainer and into the transmission pump before being caught in the pressure filter.

It is recommended that a special 75 micron (0.075 mm) service suction filter be temporarily installed.

7

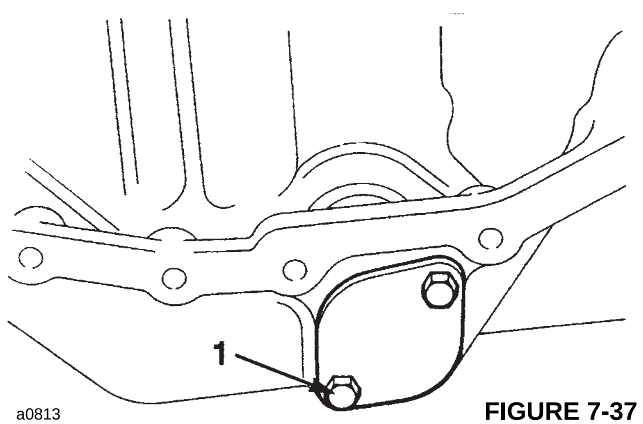


FIGURE 7-37

2. Lightly oil output shaft inner bearing (45, Figure 7-38) and cup and install to output shaft 41.

NOTE: The transmission should be rebuilt with a solid spacer 44, which is the preferred option. However, in the absence of the special tools required or of a solid spacer, a collapsible spacer may be installed.

See Figure 7-20 for Setting Tool Kit.

a. Install the solid spacer 44 (13.70 mm thick, P/N 1902707) over output shaft 41 and assemble into casing 36.

b. Lightly oil output shaft outer bearing 43 and cup and install to output shaft 41, do not install oil seal 42 at this time.

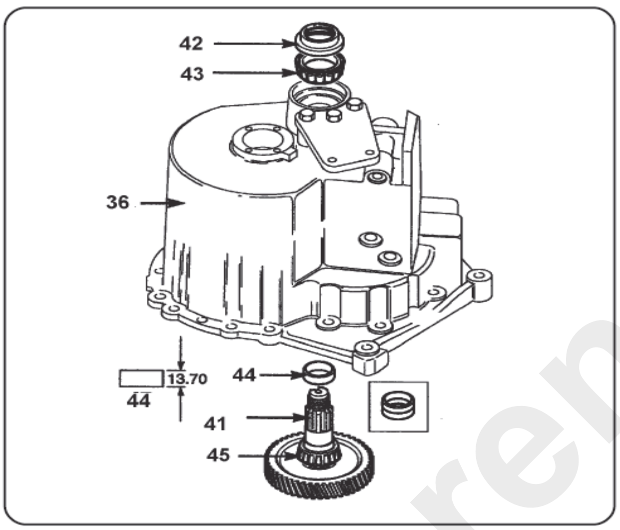


FIGURE 7-38

3. Install special tool sleeve (A, Figure 7-43), which temporarily replaces the output flange, and secure with special tool nut B, tighten to a torque of approximately 50 Nm (37 lb-ft). For special tool, see Figure 7-20.

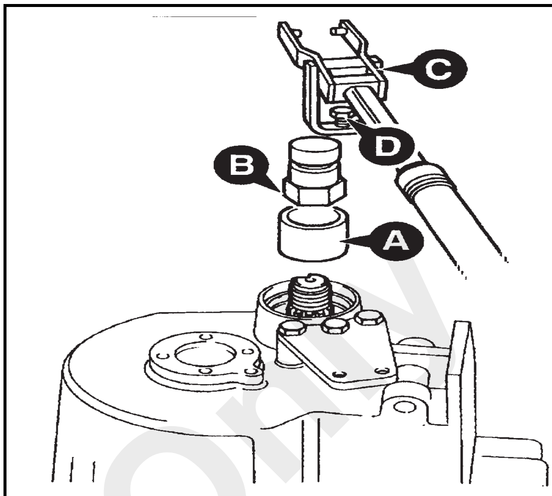
NOTE: Check for end play while tightening nut B, if there is no end play check the following:

a. The bearing cups are pushed fully into the casing.

b. The correct bearings are installed.

c. The solid spacer (44, Figure 7-38) is 13.70 mm thick.

d. Install special tool pillar C so that the fork end engages in special tool nut B, tighten bolt D.



a1387

FIGURE 7-39

4.

a. Install dial test indicator (E, Figure 7-43).

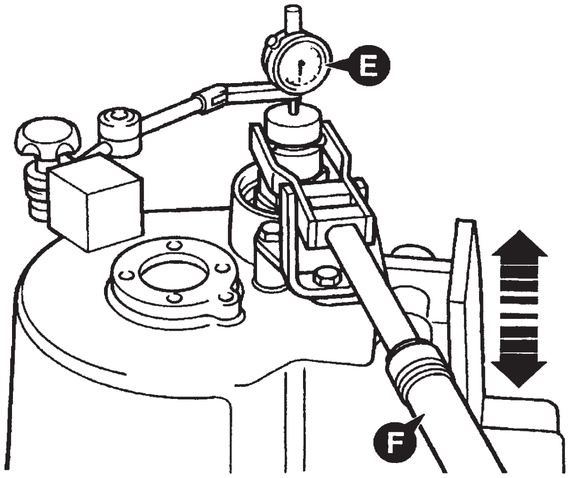
b. Set torque wrench to 35 Nm (27 lb-ft) and measure the end play while rotating the output shaft.

c. To select the right size spacer 44, Figure 7-38 subtract the end play obtained at step B from the solid spacer 44 (13.70 mm). Also, subtract 0.120 mm to allow for bearing tolerances and pre-load. If there is no spacer of this size, install the next smallest spacer.

Example:

Service spacer	13.70
Subtract end play	00.41
=	13.29
Subtract tolerance & pre-load	00.12
Results	13.17
Use next smallest spacer i.e.	13.15

If the "Result" measurement is outside the spacer kit range, check the assembly of the bearings. If the bearings are assembled correctly, use a collapsible spacer. See installation procedure.



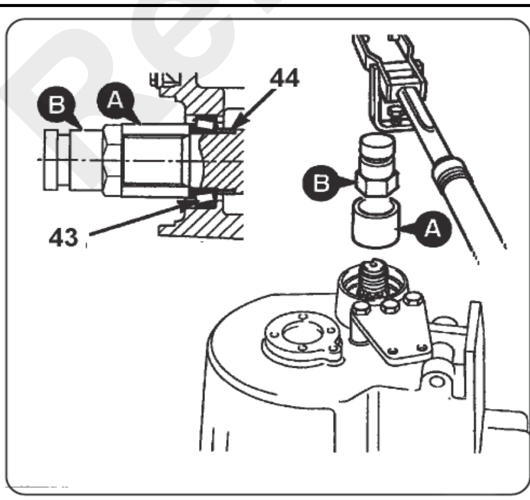
a1388 **FIGURE 7-40**

d. Remove nut (B, Figure 7-41), sleeve A, outer bearing 46 and install correct size spacer 44. Take care to avoid damaging the outer bearing.

NOTE: In order to remove bearing 43, the output shaft 41, Figure 7-38 must be removed. Due to ratio options some transmissions feature a larger diameter output gear. When removing the output shaft the gear may contact the gearbox housing, preventing removal. For shaft removal procedure, see Output Shaft (Larger Diameter Gear).

e. Install sleeve A and initially tighten nut B to approximately 50 Nm (37 lb-ft). Check that there is no end play and rolling torque is less than 1.5 Nm (1.0 lb-ft).

f. If the rolling torque measured is too high, install the larger size spacer. If the rolling torque is too low, install the next smaller size spacer.



a2344 **FIGURE 7-41**

5.

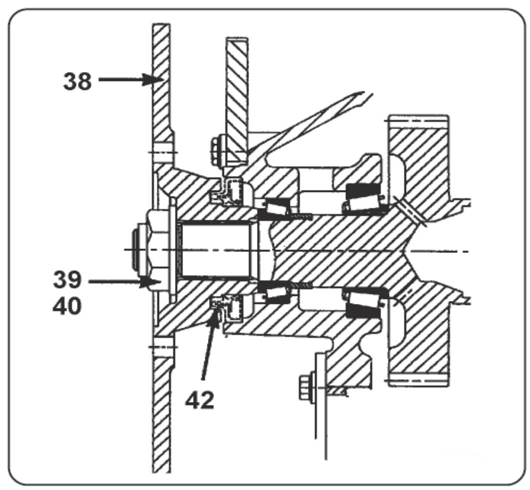
a. Remove nut B and sleeve A, Figure 7-41. Install a new seal 42 (apply grease between the lips before installation). Assemble the parking brake flange (38) (the flange may be a tight fit).

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

b. Install a NEW retaining nut (40) and washer (39) and progressively tighten to a torque of 300 Nm (221 lb-ft). Provided the correct size spacer has been selected, the combined seal and bearing rolling torque should not exceed a maximum of 2.0 Nm (1.5 lb-ft) when the nut is fully tightened to proper torque.

NOTE: If the rolling torque measured is too high, install the next larger size spacer. If the rolling torque is too low, install the next smaller size spacer.

c. Finally, stake nut (40) into the slot on the shaft.



a2343 **FIGURE 7-42**

6. Position the transmission vertically on wooden blocks to provide clearance for the input shaft. Install bearing cups into input and forward positions. Coat the pump end bearings with a Lithium Base, E.P. No. 2 bearing grease. Then carefully lower input clutch (V, Figure 7-43) and forward clutch P into casing.

NOTE: To inhibit damaging the input shaft piston ring seals (46), it is permissible to remove the seals prior to assembling the case halves. However, this is applicable only while measuring the shaft end play. INSTALL THE SEALS BEFORE FINAL ASSEMBLY.

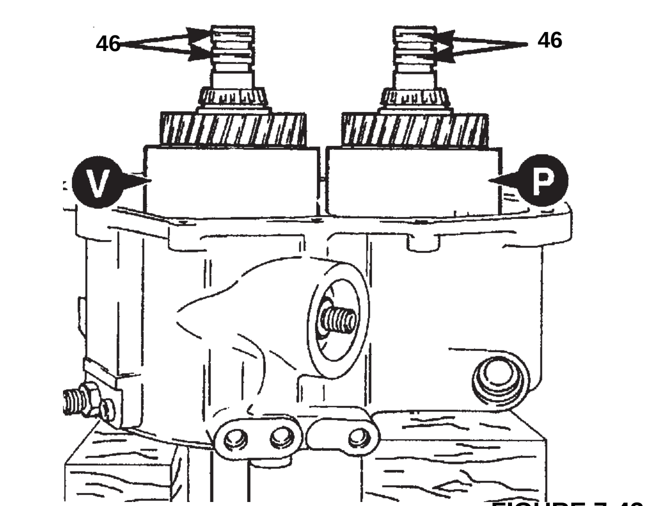


FIGURE 7-43

7. Assemble the two case halves using four equally spaced bolts (31, Figure 7-44). Tighten the bolts to a torque of 56 Nm (42 lb-ft).

NOTE: Assembling the case halves at this stage is a temporary arrangement to enable measurement of the input and reverser shaft end play. DO NOT apply Loctite 243 to the bolts at this stage or bond the mating surfaces.

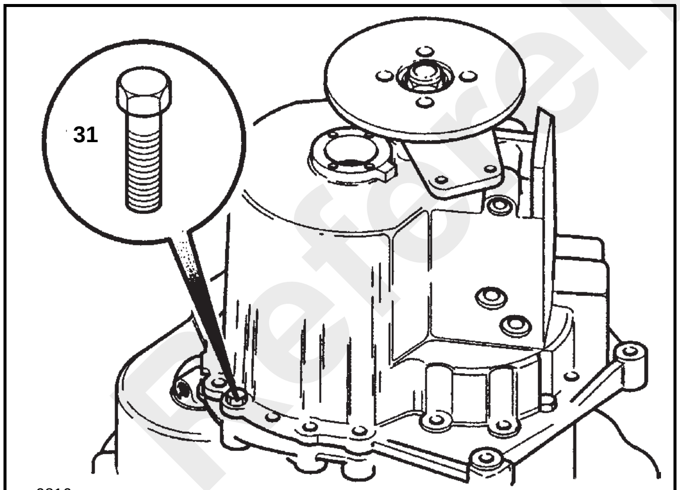


FIGURE 7-44

8. Measure the end play of the input shaft using the end play checking kit (See Figure 7-21).

NOTE: Numbers in Figure 7-45 correspond with numbers in Figure 7-21.

   a. If it has not already been done, insert an M10 bolt into the recessed hole in the base plate 2 and mount pillar 12. Tighten the bolt ensuring that the slot in the pillar faces the input shaft. Mount the base plate onto the transmission casing.

   b. Select adapter tool 13 and screw into the tapped hole in the input shaft. Locate yoke 3 and wrench 11 into the adapter tool 13 and pillar 12. Set the wrench to 35 Nm (27 lb-ft).

   c. Using a magnetic block, mount the dial test indicator (DTI) A with the probe on the head of adapter 13 and adjust to zero.

   d. While rotating the input shaft back and forth, using the spline wrench B to seat the bearings, lift and depress wrench 11 and note the reading on the DTI.

   e. Remove wrench 11 and base plate 2 from the transmission casing.

   f. Calculate the required thickness of shims to give the correct end play, which should be 0.03 - 0.08 mm (0.001 - 0.003 in).

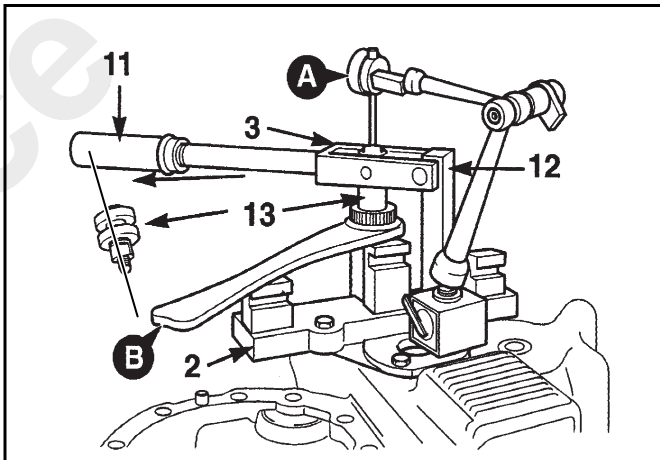
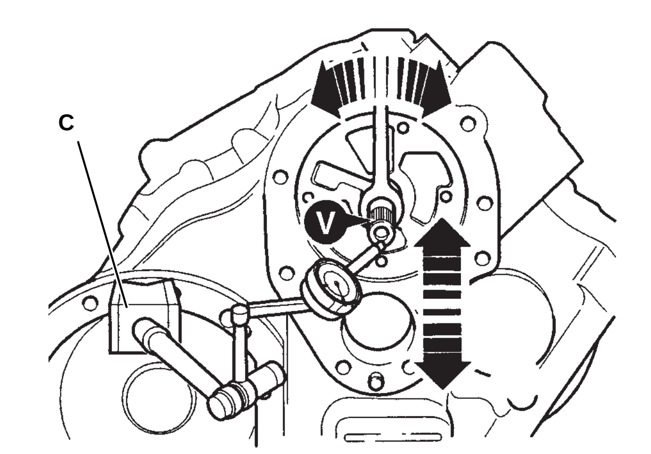


FIGURE 7-45

9. If the end play checking kit is not available, use the following procedure.

   a. Protect the input shaft (V, Figure 7-46) with a metal sleeve and clamp vice grips into position on the shaft. Set the dial test indicator (DTI) as shown in Figure 7-46 at C and using the vice grips as a lever, rotate the shaft to seat the bearings fully while measuring the end play. Remove the DTI and vice grips from the transmission.

   b. Calculate the required thickness of shims to give a correct end play, which should be 0.03 - 0.08 mm (0.001 - 0.003 in).

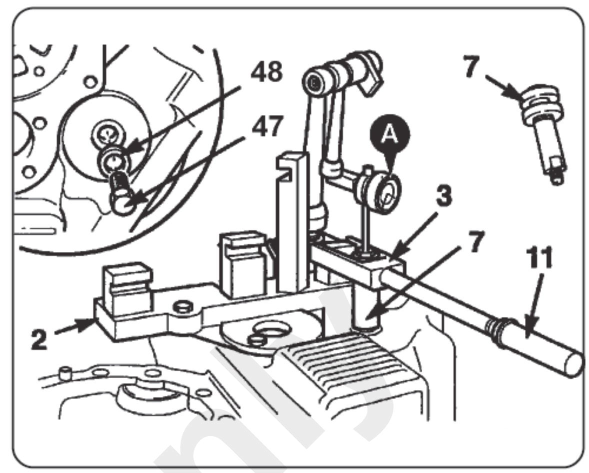


a0817 **FIGURE 7-46**

10. Measure the end play of the forward shaft using the end play checking kit (See Figure 7-21).

NOTE: Numbers in Figure 7-47 correspond with numbers in Figure 7-21.

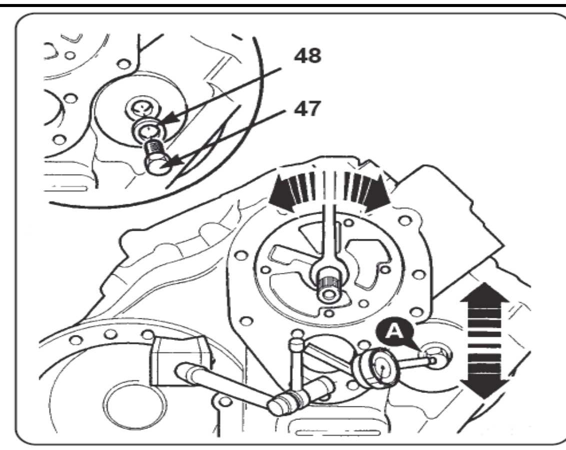
- **a.** Remove plug (47, Figure 7-47) and sealing washer (48) from the transmission casing. Discard washer (48).
- **b.** Select adapter 7 from the kit and screw into the tapped hole in the reverser shaft.
- **c.** Mount base plate 2 onto the transmission casing and locate yoke 3 and wrench 11 into adapter 7. Set wrench to 35 Nm (27 lb-ft).
- **d.** Using a magnetic block, mount the dial test indicator (DTI) A with the probe on the head of adapter 7 and adjust to read zero.
- **e.** While rotating the forward shaft back and forth, using the spline wrench B to seat the bearings, lift and depress wrench 11 and note the reading on the DTI.
- **f.** Remove wrench 11 and base plate 2 from the transmission casing.
- **g.** Calculate the required thickness of shims to give the correct end play, which should be 0.03 - 0.08 mm (0.001 - 0.003 in).



a2345 **FIGURE 7-47**

11. If the end play checking kit is not available, use the following procedure:

- **a.** Remove plug (47, Figure 7-48) and sealing washer 48 from the transmission casing. Discard washer 48.



a0819 **FIGURE 7-48**

- **b.** Protect the input shaft with a metal sleeve and clamp vice grips into position on the shaft.
- **c.** Screw a suitable M10 bolt A into the tapped hole in the end of the forward clutch shaft. Set up a dial test indicator (DTI) as shown at C and rotate the shaft to seat the bearing fully using the vice grips on the input shaft. With a lever under the bolt head, move the shaft back and forth and measure the end play (The end play should be set as near as possible to the minimum tolerance). Remove the DTI and vice grips from the transmission. Keep the bolt in the reverser shaft.

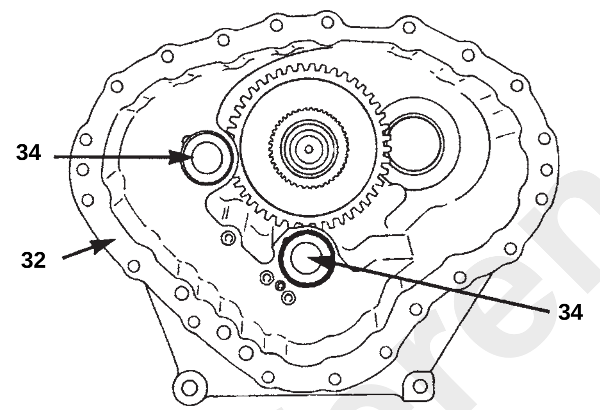
d. Calculate the required thickness of shims to give the correct end play, which should be 0.03 - 0.08 mm (0.001 - 0.003 in).

12. Separate the two casing halves and add or subtract shims (34, Figure 7-49) installed beneath the outer races in the rear (output) case 32 to correct input and forward shaft end float. Repeat steps 10 and 11, or 12 and 13 to recheck the end play.

NOTE: Production transmissions have the shims installed in the front case; however when servicing the transmission, it is permissible to install shims (34) in the rear case as shown.

When correct end play has been achieved, remove the input and reverser clutch shafts and install piston ring seals 46 removed in step 6.

NOTE: Do not reinstall the input and forward clutch shafts at this time. They must be installed with the other shafts into the transmission - see steps 13 to 15.



a0820

FIGURE 7-49

13. Install input clutch (V, Figure 7-50) and main shaft (Q) simultaneously into the front case as shown. Before installing make sure that all the piston ring seals have been replaced with new seals and lightly greased and fully seated in their grooves. (See PTFE Piston Ring Seal Installation Procedure). Also ensure that both the input clutch and main shaft taper roller bearings have been coated with a Lithium Base, E.P. No. 2 bearing grease.

a. Install all remaining bearing cups. Install main shaft end spacer 50. DO NOT install O-rings at this point. See NOTE below.

End spacers have extraction holes to assist removal. Install the spacer with the extraction holes facing towards you.

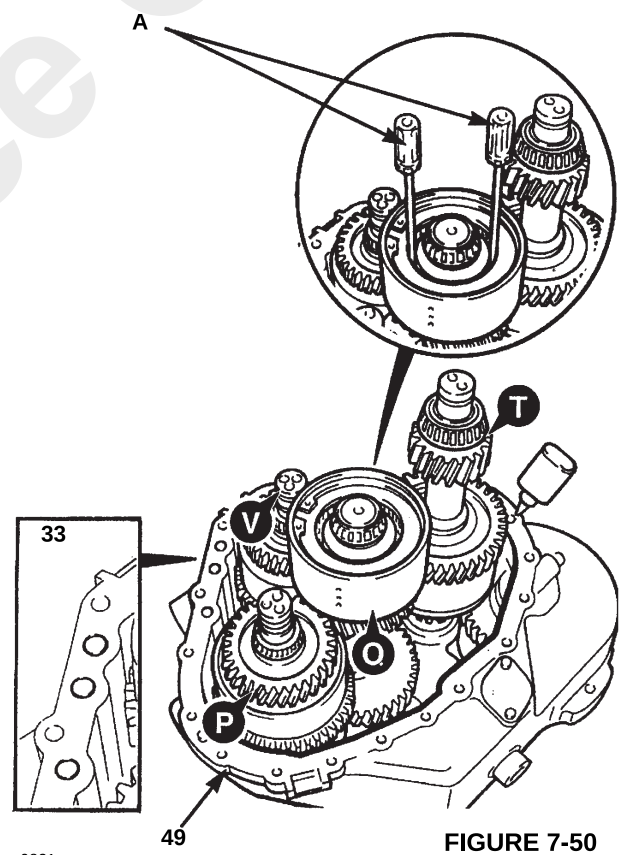
NOTE: This is a preparatory step for setting the main shaft end play. At a later point it will be necessary to remove the end spacer so that shims can be installed to set the end play. If the O-rings are left on at this point, the spacer will be difficult to remove. New O-rings are installed after the correct main shaft end play has been set.

b. Install the end play setting tool P/N 1900449 (Figure 7-15) over the main shaft end bearing and spacer. Tighten the bolts to 52 Nm (42 lb-ft).

14. This step requires the help of an assistant. Have the assistant SLIGHTLY raise and tilt the input clutch **V** and mainshaft **Q**. While the assistant is holding the two units, install forward clutch (P).

15. Coat the layshaft taper roller bearings with a Lithium Base, E.P. No. 2 bearing grease and install the layshaft assembly (T) into the front case.

The arrangement of the clutch assemblies should now be as shown in Figure 7-50. Make sure all bearings are fully seated, and that the relevant gears have meshed correctly.



a0821

FIGURE 7-50

16. Using two small rods or screwdrivers (A, Figure 7-50), align all the friction/counter plates of the main shaft clutch.

17. Install three new O-rings (33) in the front case (49). Coat the O-rings with grease to hold in position.

NOTE: Do not apply an excessive amount of Loctite 574 around the O-rings. Too much can dislodge the O-rings.

18. Apply Loctite 574 to the front case mating face. Prior to installing the rear case, ensure that all bearings have been coated with a Lithium Base, E.P. No. 2 bearing grease. Ensure that all piston ring seals are fully seated and have been coated with grease.

19. Make sure all the friction/counter plates in the main shaft clutch are aligned (see Step 16). Carefully lower the rear (output) case into position, taking care to align the output gear splines with the main shaft clutch friction/counter plates. If the casing does not drop down onto the dowels, gently rotate the disc back and forth to center the plates. Apply Loctite 243 to bolts and tighten to a torque of 56 Nm (42 lb-ft).

NOTE: To aid in assembly of the rear case, use tool P/N 1903746 (Figure 7-19) and an airline to clamp the pack and hold it position when lowering rear case into position.

Do not use the retaining bolts or external force to close the casing joint or the plates will be damaged.

20. Using a new gasket (28, Figure 7-51), temporarily install the layshaft end cap (27) and shims (29). Tighten retaining bolts (26) to a torque of 56 Nm (42 lb-ft).

NOTE: Installing the layshaft end cap at this stage is a temporary arrangement to enable the measurement of the layshaft end play. Do not apply Loctite 243 to the retaining bolts at this time.

NOTE: Take care not to damage the gasket because it must be used during final assembly.

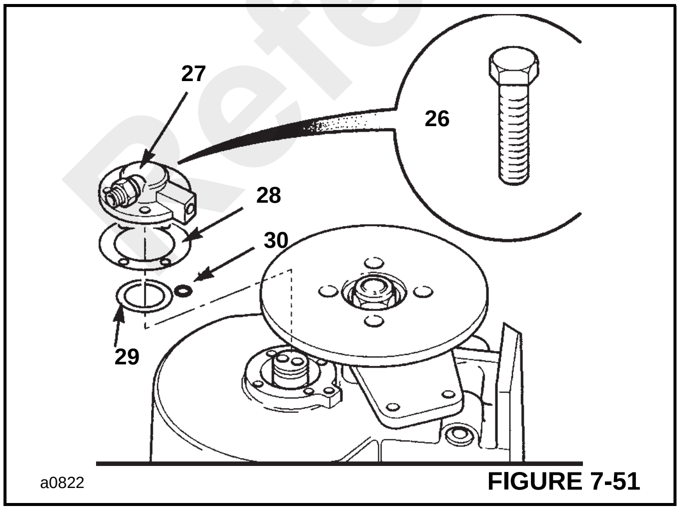


FIGURE 7-51

21. Measure the end play for the layshaft using the end play checking kit.

NOTE: Numbers in Figure 7-52 correspond with numbers in Figure 7-24.

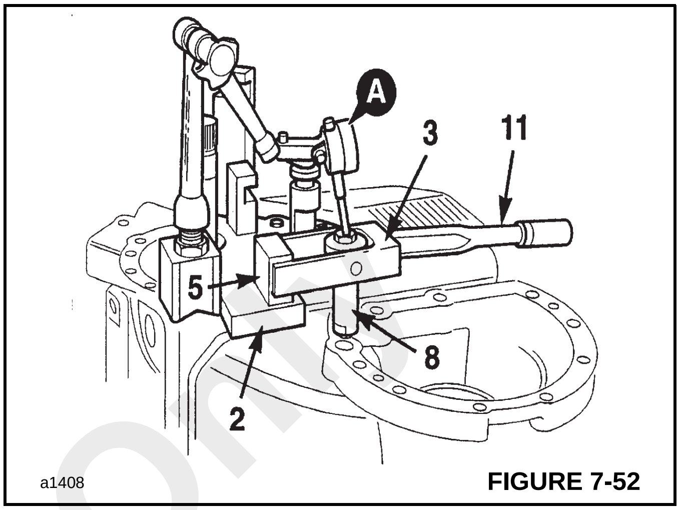


FIGURE 7-52

a. Place the transmission on a work bench with the input side up so that the drive shaft mounted flange can be turned.

b. Secure base plate 2 on the face of the casing using existing tapped holes for the mounting bolts. Tighten the bolts to a torque of 56 Nm (42 lb-ft).

c. Select adapter 8 from the kit (Figure 7-24) and screw it into the tapped hole in the layshaft.

d. Locate yoke 3 and wrench 11 into adapter 8 and pillar 5. Set the wrench to 35 Nm (26 lb-ft).

e. Using a magnetic block, mount a dial test indicator (DTI) A with the probe on the head of adapter 8 and adjust to zero.

f. While rotating the layshaft back and forth using the flange on output shaft to seat the bearings, lift and depress wrench 11 and note the reading on the DTI.

g. Remove wrench 11 and adapter 8 from the layshaft assembly.

h. Calculate the required thickness of shims to give correct end play, which should be 0.03 - 0.08 mm (0.001 - 0.003 in). The end shaft play should be set as near as possible to the minimum tolerance.

22. If the end play checking kit is not available, use the following procedure.

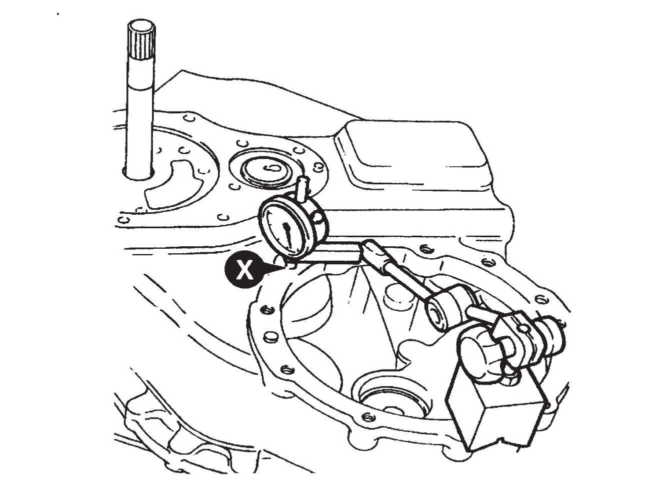
Set up a dial test indicator (DTI) as shown in Figure 7-55 on a suitable M10 bolt and measure layshaft end play, which should be 0.03 - 0.08 mm (0.001 - 0.003 in). Rotate the shaft (using the flange) while measuring to seat the bearing fully.

NOTE: When measuring the end play, rotate the flange on 2WD transmissions.

7

NOTE: Access to the layshaft end face is gained through the 4WD bolt hole X, as shown in Figure 7-53.

Calculate the required thickness of shims to give correct end play, which should be 0.03 - 0.08 mm (0.001 - 0.003 in). The end shaft play should be set as near as possible to the minimum tolerance.



a1409 **FIGURE 7-53**

23. Remove the layshaft end cap (27, Figure 7-54). Coat the layshaft outer bearing with a Lithium Base, E.P. No. 2 bearing grease and add or subtract shims 29 to give correct end play (install shims between the outer race of bearing and layshaft end cap).

Ensure the gasket is used when calculating the shim thickness.

24. Install new O-ring (30) in end cap (27). Coat the O-ring with grease to hold in position.

25. Install the layshaft end cap (27) with new gasket (28). Apply Loctite 243 to bolts (26) and tighten to a torque of 56 Nm (42 lb-ft).

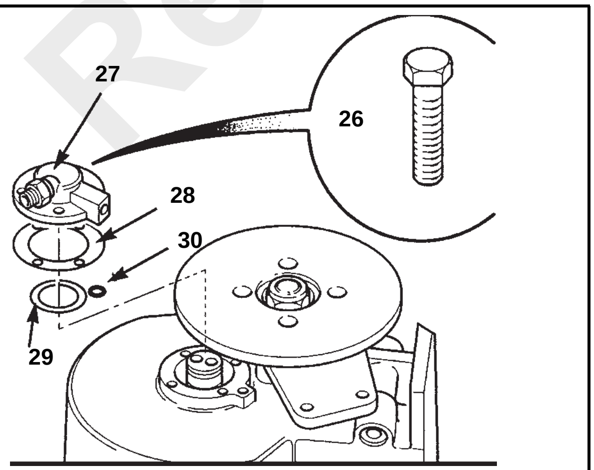
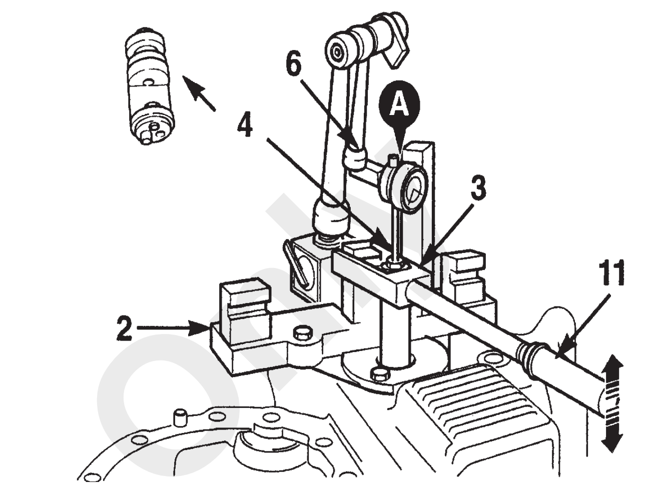


FIGURE 7-54

26. Measure the end play of the main shaft using the end play checking kit (see Figure 7-21)

NOTE: Numbers in Figure 7-55 correspond with numbers in Figure 7-22.



a1414 **FIGURE 7-55**

a. Install adapter 4 into tapped hole in the main shaft securing it with an M10 x 20 bolt.

b. Mount base plate 2 onto the transmission and locate yoke 3 and wrench 11 into adapter 4 and pillar 6. Set the wrench to 35 Nm (26 lb-ft).

c. Using a magnetic block, mount the dial test indicator (DTI) A with the probe on the head of adapter 4 and adjust to read zero.

d. While rotating the main shaft back and forth seat the bearings, lift and depress wrench 11 and note the reading on the DTI.

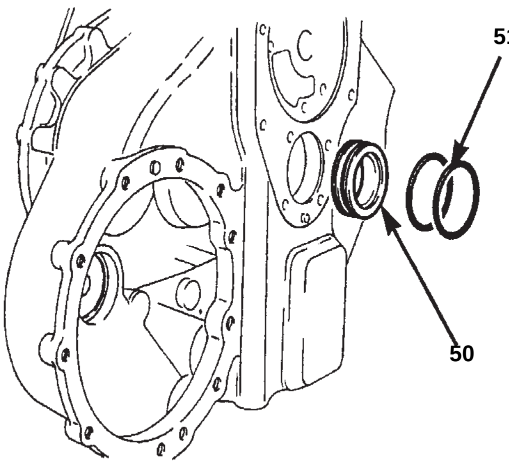
NOTE: To rotate the main shaft, use an air line and adapter tool (Figure 7-19) and rotate the output flange.

e. Remove wrench 11, adapter 4, and end play setting tool from the main shaft assembly.

f. Add or subtract shims to correct the end play. (The end play should be set as close as possible to the minimum tolerance.) The shims must only be installed between the bearing outer race and spacer. When the correct end play has been established - INSTALL SPACER 50 WITH NEW O-RINGS 51 (Figure 7-57)

g. Repeat steps 9A - 9E to recheck end play on the input shaft.

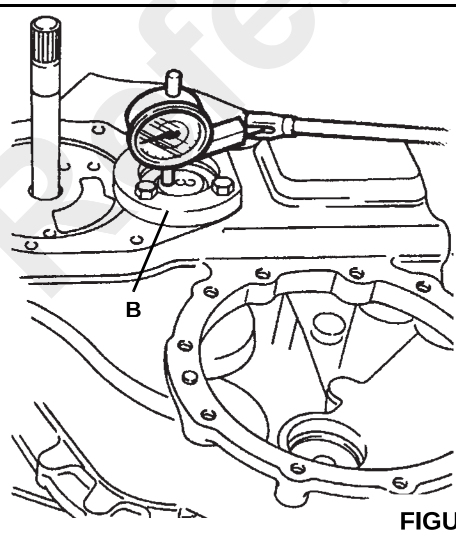
h. Remove bolt A (see step 12) from the forward shaft and install plug (50, Figure 7-56) using new O-rings 51.



a0824 FIGURE 7-56

27. If the end play checking kit is not available, use the following procedure.

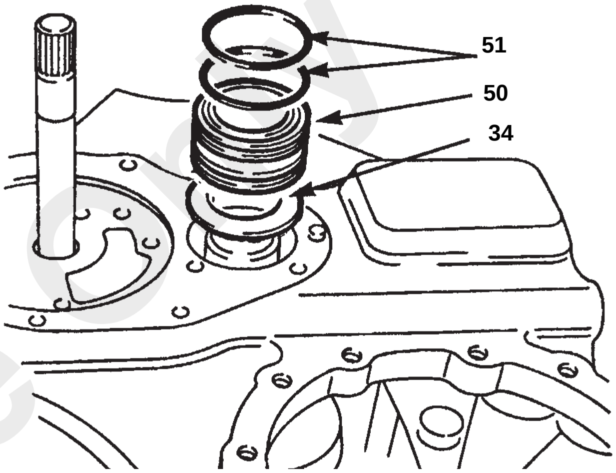
- **a.** Install end play tool B (P/N 1900449) over the main shaft end bearing and spacer (Figure 7-57). Tighten the bolts.
- **b.** Screw a suitable bolt into the tapped hole in the end of main shaft and using a suitable lever under the bolt, move the main shaft back and forth when measuring the end play.
- **c.** Set up a dial test indicator as shown in Figure 7-57. Measure the main shaft end play, which should be 0.03 - 0.08 mm (0.001 - 0.003 in). Rotate the main shaft (use the brake disc) while measuring in order to seat the bearing fully.



a0827 FIGURE 7-57

NOTE: To rotate the main shaft, use air and adapter tool P/N 1902746 (see Figure 7-19)

- **d.** Add or subtract shims (34, Figure 7-58) to correct the end play. (The end play should be set as near as possible to the minimum tolerance.) The shims must only be fitted between the bearing outer race and spacer (50). When the correct end play has been established - Install spacer (50) with new O-rings (51).



a0827 FIGURE 7-58

28. If the pump flow/pressure was below normal, coat the machined surface of the pump with engineers' blue and insert into the pump housing. Rock the pump several times and remove. Check the machine faces for contact. Remove high spots as necessary until full face contact is made. Thoroughly clean all surfaces with a suitable solvent and dry before installing.

Make sure all bearings have been lubricated with Lithium Base, E.P. No. 2 bearing grease. Apply Loctite 574 to mating face of flywheel housing. Install the flywheel housing, locating it on dowels (37, Figure 7-59). Apply Loctite 243 to bolts (35) and tighten to a torque of 56 Nm (42 lb-ft).

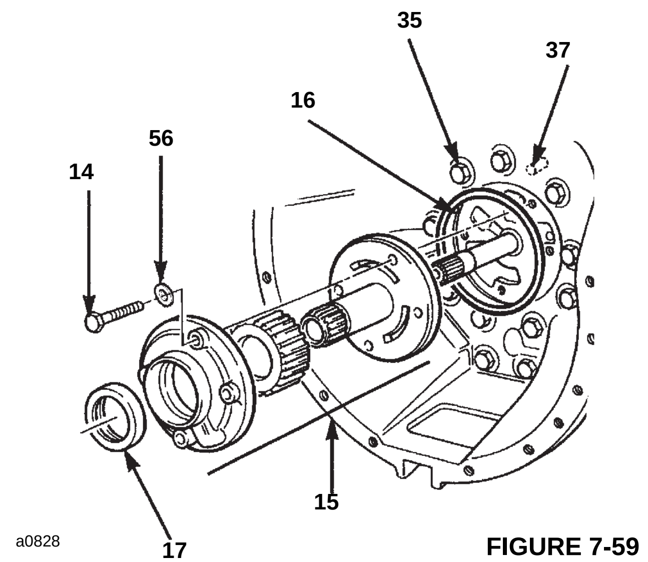


FIGURE 7-59

NOTE: On some gearboxes, locating dowels in the bell housing have been removed and the pump provides the location for the bell housing. If the pump and bell housing are removed, the pump MUST be installed before the bell housing.

NOTE: When the transmission pump only is being installed, the flywheel housing need not be removed, provided it was correctly aligned when last installed.

29. If disassembled, assemble pump (15, Figure 7-59). Install the pump taking care to align mounting holes. Apply Loctite 243 to bolts (14) and using new seal washers (56), tighten the bolts to a maximum torque of 25 Nm (18 lb-ft). Use a new pump housing seal (17). Install new O-ring (16). Ensure a sufficient quantity of clean new oil (Mobil ATF 210) is added to pump for initial start-up lubrication of the gears.

NOTE: After installing the transmission pump, rotate gear **A** to ensure it has clearance and turns freely.

NOTE: There are two types of pump housing seals 17 depending on the pump type installed. Ensure the correct seal is installed:

Existing seal outside diameter = 68 mm (2.67 in)

Alternate seal outside diameter = 68.22 mm (2.68 in)

30. Install torque converter relief valve ball and tapered spring (25, Figure 7-60). Make sure that the larger diameter of the tapered spring is located securely over the spigot on the plug. Using a new seal washer, install the plug and tighten.

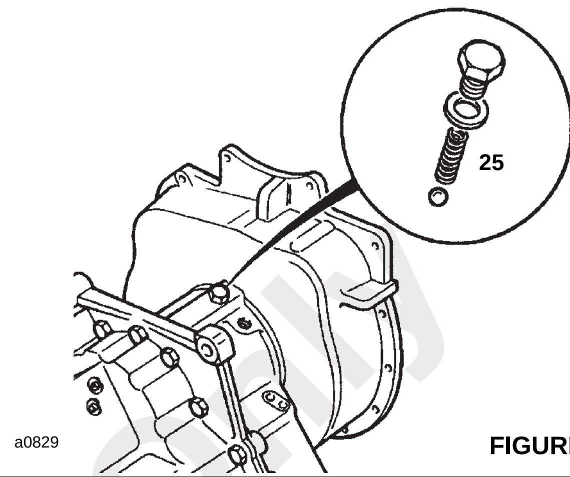


FIGURE 7-60

31. Before installing the solenoid adapter block to the casing, be sure that the M8 oilway plug (A, Figure 7-61) is installed. Apply Loctite 243 to the threads of the plug and screw into position 1 mm (0.04 in) below the valve block surface.

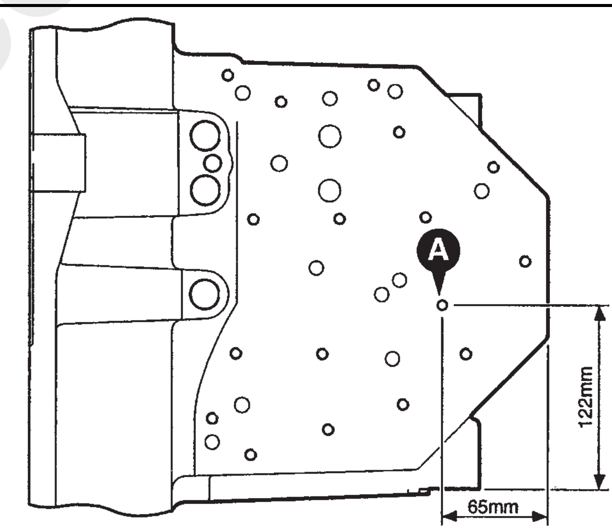


FIGURE 7-61

Using a new gasket (52, Figure 7-62), install the solenoid adapter block (21) to the casing. Apply Loctite 243 to bolts and tighten to a torque of 25 - 28 Nm (18 - 20 lb-ft).

32. Assemble the pressure maintenance valve spool and spring (19,Figure 7-62) into adapter block (21). Install and tighten plug (18). Do not overtighten as damage to the aluminum housing could result.

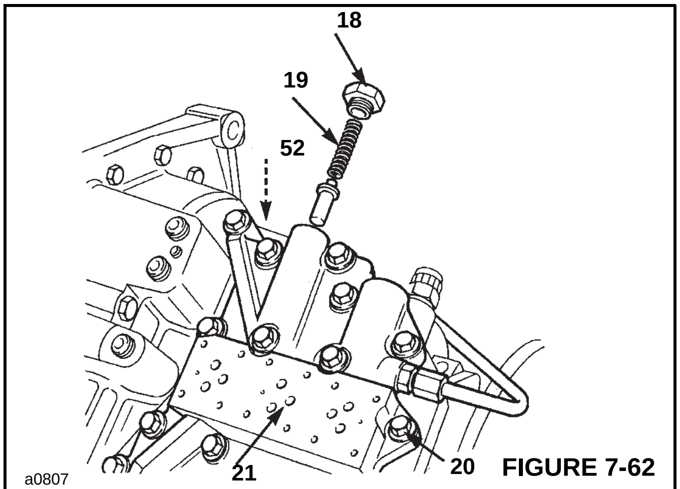


FIGURE 7-62

33. Install new O-rings (13, Figure 7-63) into each valve body.

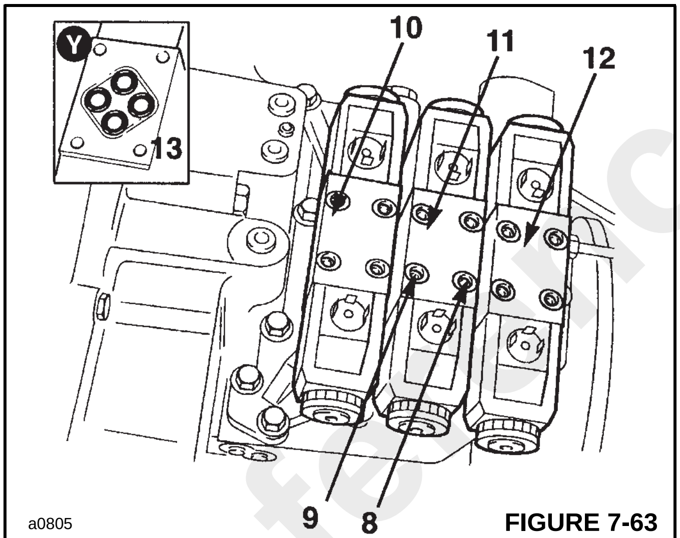


FIGURE 7-63

34. Position the reverse high/low clutch solenoid (12) onto the adapter block. Install capscrews (9) and tighten to a torque of 5 Nm (4 lb-ft).

35. Repeat step 34 for the main shaft/layshaft clutch solenoid (11) and for the forward clutch solenoid (10).

NOTE: The mounting holes will only align when the solenoid valve has been positioned correctly on the adapter block.

36. After assembly, insert the plastic caps (8) into the mounting screw counter-bores to inhibit water and dirt entry which could inhibit removal at a later date.

37. Coat the seal of a new filter (5, Figure 7-64) with transmission oil. Screw the filter on until it just contacts the filter head. Turn the filter at least another 3/4 turn.

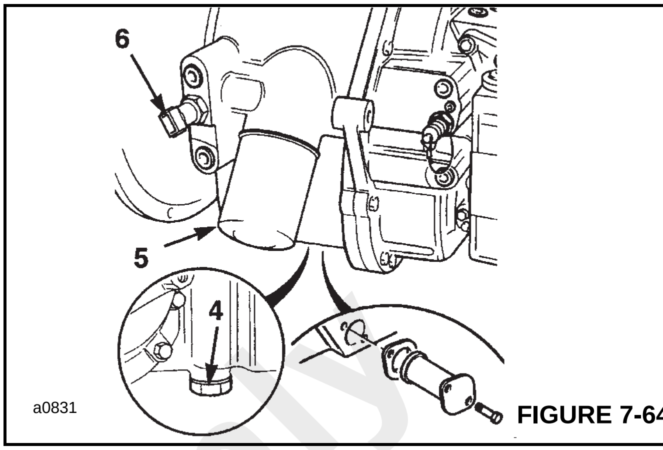


FIGURE 7-64

38. Install the drain plug (4) with a new sealing washer. Tighten to a torque of 203 Nm (150 lb-ft).

39. Install pressure switch (6) with a new sealing washer. Tighten to a torque of 28 Nm (21 lb-ft).

40. Install the electronic speed sensor (B, Figure 7-65). Use a new O-ring (C).

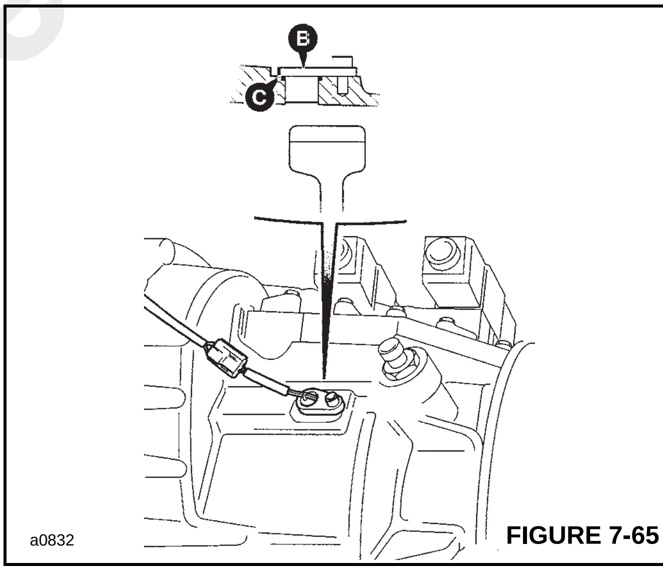


FIGURE 7-65

Installation

1. Install the torque converter.

2. Clean and lubricate the splines of the transmission input shaft on the engine.

3. Align the transmission input shaft splines with the splines of the torque converter impeller and assemble the transmission/torque converter housing to the engine flywheel housing. Install the 12 bolts and lockwashers and tighten to proper torque. See *Fasteners and Torque Values*, page 1-8.

4. Install the power unit into the machine. See *Engine and Engine Systems*, page 6-1.

5. Connect all removed hydraulic lines, electrical harnesses, cables, etc. Fill the transmission with recommended fluid. See *Maintenance*, page 5-1.

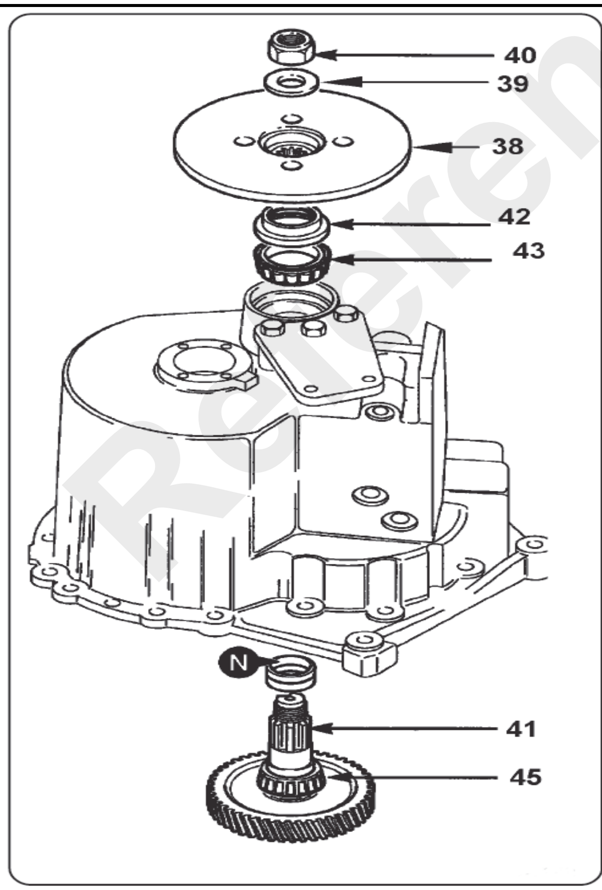
Installing a Collapsible Spacer

When assembling a transmission and the special setting tool (Figure 7-20) or if the correct solid spacer is not available, install a collapsible spacer using the following procedure:

1. Install output shaft inner bearing (45, Figure 7-66). Install a new collapsible spacer N over output shaft 41. Apply a Lithium Base, E.P. No 2 bearing grease to the output bearing and assemble into output end of casing.
2. Apply a Lithium Base, E.P. No. 2 bearing grease to outer bearing 43 and install the bearing followed by a new oil seal 42. Assemble the drive shaft plate 38, retaining nut 40, and washer 39.
3. Tighten retaining nut 40- to achieve a rolling torque of 1.5 - 2.8 Nm (1.1 to 2.1 lb-ft).

NOTE: If the rolling torque figure is accidently exceeded, the output shaft must be disassembled and new collapsible spacer must be installed.

4. Stake the nut into its slot in the shaft.



a0833 **FIGURE 7-66**

Output Shaft Removal - Larger Diameter Gear

In the event of output gear (A, Figure 7-67) hitting the transmission housing (at position B) when removing output shaft (1), proceed as follows:

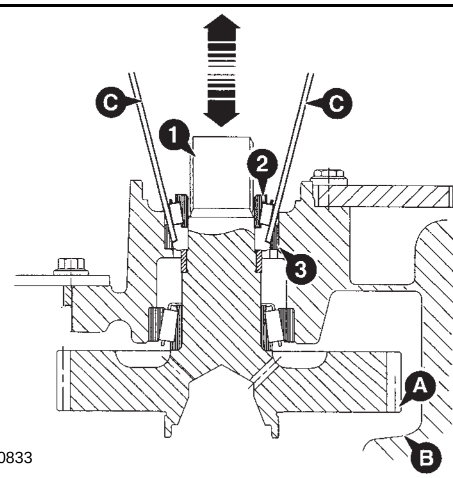
NOTE: The following procedure will be required when disassembling the transmission and after initial assembly, since the shaft may have to be removed when setting the end play.

To facilitate output shaft removal the bearing inner cup/taper rollers (2) must first be removed from shaft (1).

1. Push output shaft (1) until gear (A) contacts the housing at position (B). Be sure not to damage the housing or gear (A).

NOTE: If the output shaft is being removed after initial assembly, typically to set end play, take extreme care to avoid damage to the bearing outer cup (3) and inner cup/taper rollers (2). Use aluminum spacers (c), DO NOT USE HARDENED STEEL ITEMS SUCH AS SCREWDRIVERS.

2. Pull output shaft (1) up. Position suitable aluminum spacers (C) between the taper rollers (2) and bearing outer cup (3).
3. Push the output shaft down, the inner cup/taper rollers (2) will be forced further up the shaft (1) allowing them to be removed.
4. If inner cup/taper rollers (2) are still engaged on shaft (1) repeat steps 2 and 3 using thicker spacers (C).
5. With bearing inner cup/taper rollers (2) removed, the output shaft and gear can be lowered and tilted to one side, allowing gear (A) to clear the housing and output shaft (1) can be removed.



a0833 **FIGURE 7-67**

Installation of 75 Micron Strainer

If the transmission has not been thoroughly cleaned during overhaul, any particles below 200 microns (0.2 mm) can pass through the existing suction strainer and into the transmission pump before being caught in the pressure filter. Contamination can cause scoring of bearings and clutch housings.

It is recommended that a special 75 micron (0.075 mm) service suction strainer be temporarily installed after overhaul and be carried out to clean the system to inhibit damage to the transmission.

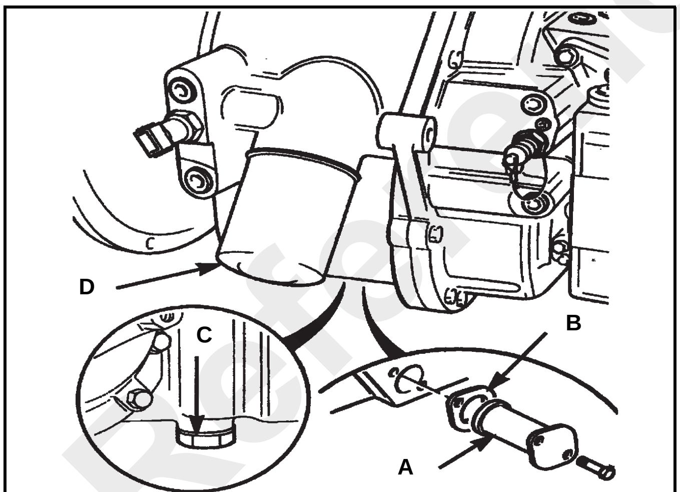
The need to change the transmission filter after 100 hours of operation after a major overhaul is not required PROVIDED the transmission failure was not caused by oil cooler failure and procedure of installing a 75 micron service strainer is carried out.

Service Procedure

1. During overhaul, clean the transmission of as much debris as possible and install a 75 micron service suction strainer A and gasket B, Figure 7-68.

P/N 1902923 - 75 micron Service Suction Strainer

P/N 1001435 - Gasket



a1656 **FIGURE 7-68**

2. If there is a significant amount of debris it is recommended that the oil cooler and the transmission cooling lines be cleaned.

a. After the transmission has been installed in the crane, fill the transmission with recommended fluid. The transmission should be overfilled for initial start-up.

b. Disconnect the oil feed line E, Figure 7-69 and place it in a suitable container. Run the engine at idle and drain oil into the container. This will inhibit contaminated oil being pumped into the transmission. Keep the transmission full of oil at all times.

c. Stop the engine and reconnect the oil feed line. Check the oil level and fill if necessary. Do not overfill.

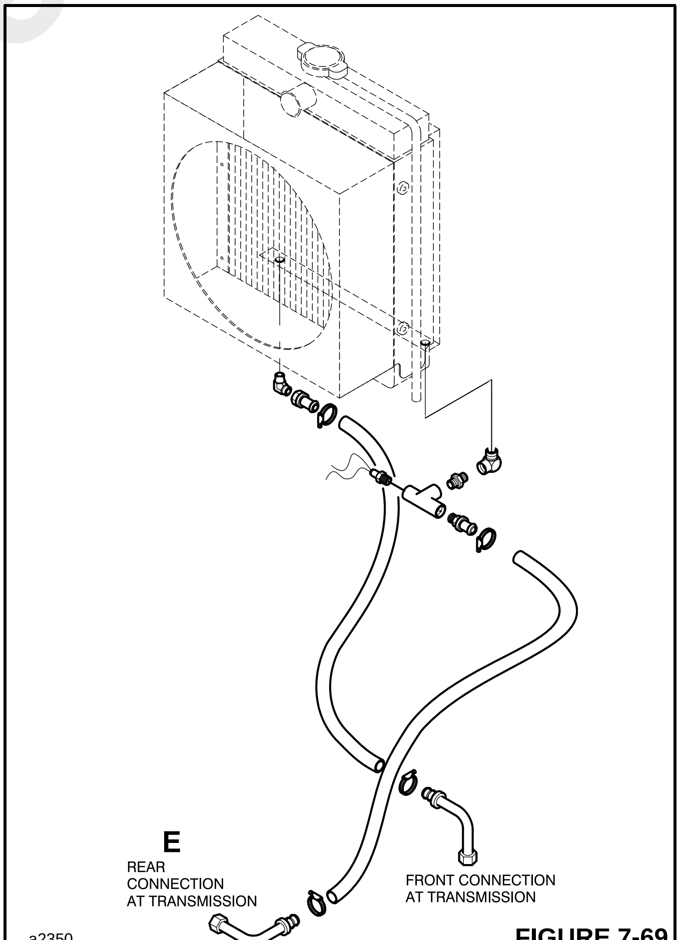
3. Run the engine until the transmission is at working temperature and carry out functional checks.

4. Remove the service suction strainer A, Figure 7-68 and drain the oil through the strainer, not the drain plug C. The oil MUST NOT be reused as it will be contaminated. Clean the service suction strainer and magnet and retain for future use.

5. Install the production suction strainer (200 micron) strainer and a new pressure filter D, Figure 7-68.

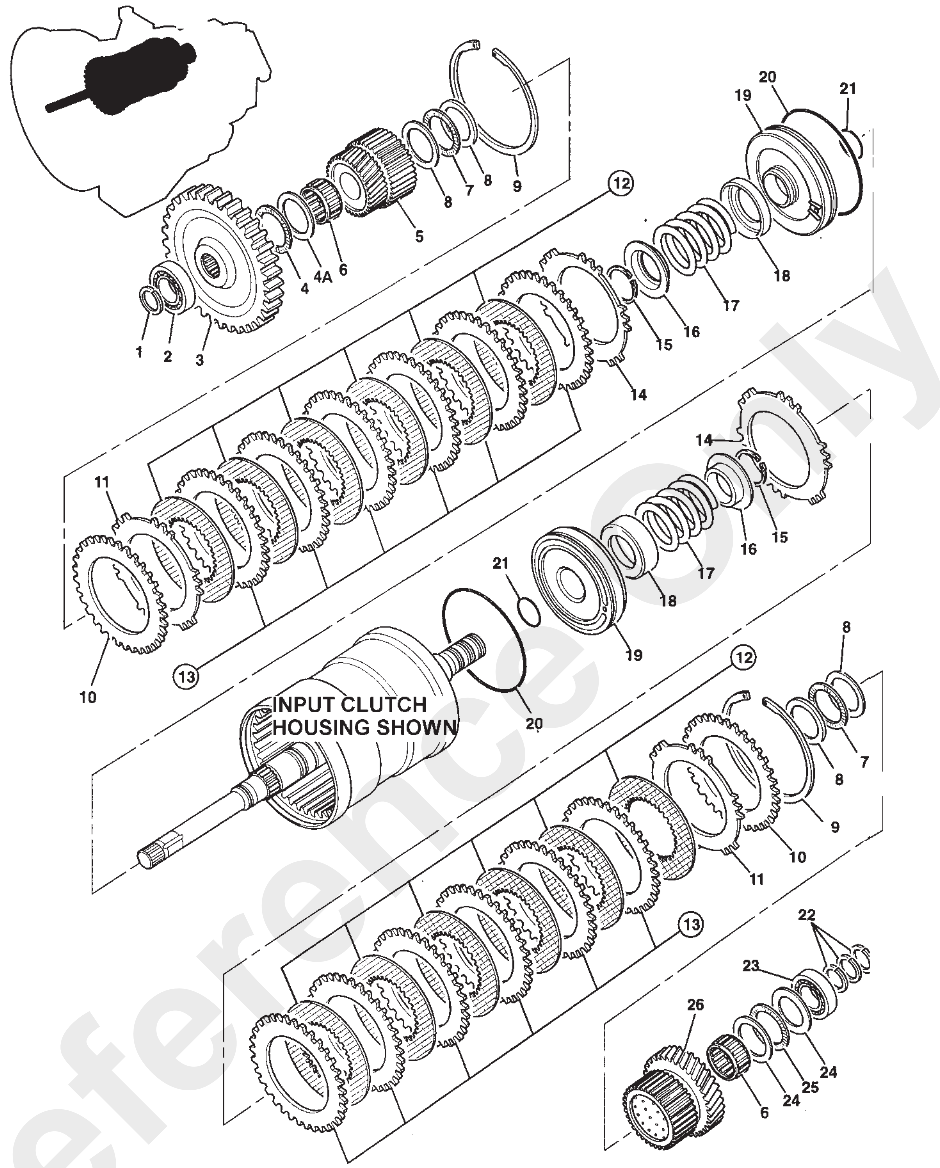
6. The pressure filter should also be changed after a further 100 hours of operation, if the cause of the transmission failure was oil cooler failure.

7. Replenish the oil system with clean recommended transmission fluid.



a2350 **FIGURE 7-69**

a0834



Item	Description	Item	Description
1	Piston Ring Seal	13	Counter plates (12)
2	Bearing	14	Disc spring
3	Gear	15	Retaining ring (2)
4	Needle thrust bearing	16	Spring retaining plate (2)
4a	Thrust washer	17	Spring (2)
5	Hub assembly	18	Oil baffle (2)
6	Needle roller bearing	19	Piston (2)
7	Thrust washer (2)	20	O-ring (2)
8	Thrust washer (4)	21	O-ring (2)
9	Retaining ring (2)	22	Piston ring seals (2)
10	Shim (2)	23	Bearing
11	Pressure end plate.(2)	24	Thrust washer (2)
12	Friction plates (12)	25	Needle roller thrust bearing

FIGURE 7-70

Disassembly

The following instructions are for repair of both the input and forward clutch assemblies.

NOTE: Use both Figure 7-70 and Figure 7-71 for reference. Item numbers are the same in both illustrations.

1. Carefully remove piston ring seal (1).

NOTE: If the piston ring seals are excessively worn, then check for burrs or damage on the shaft grooves. If necessary, remove the burrs with a fine grade abrasive paper and oil.

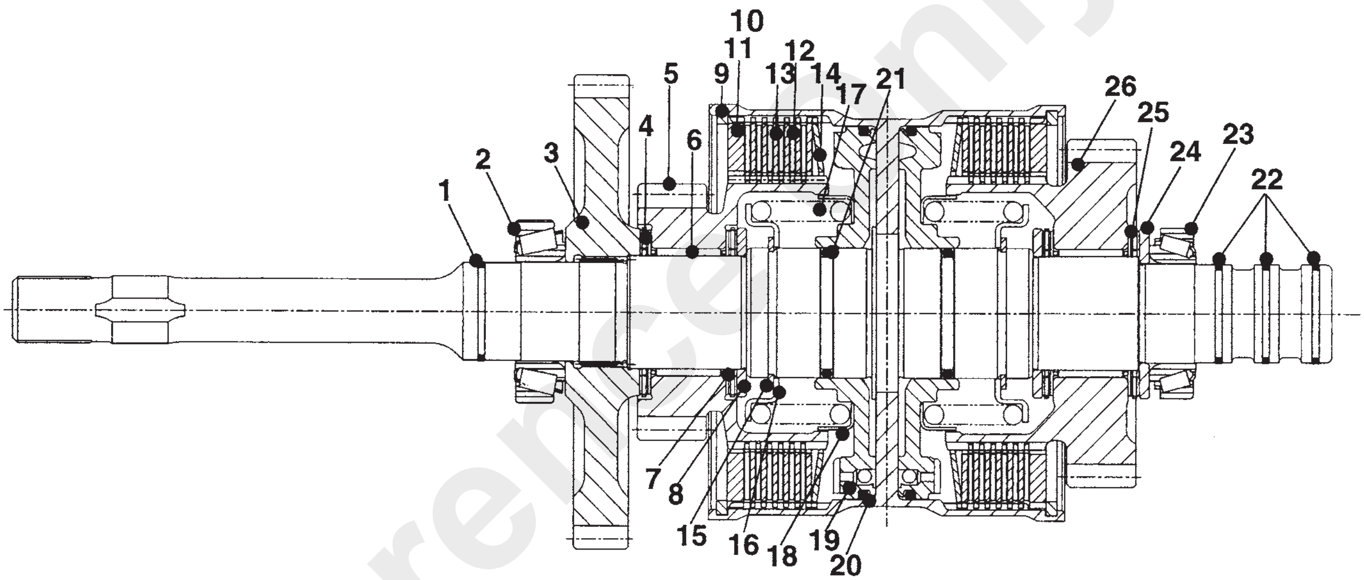
2. Remove the clutch end bearing (2) and gear (3), using a collet tool and press.

3. Remove the needle roller thrust bearing (4) and thrust washer (4A).

4. Remove the gear and splined hub assembly (5) along with needle roller bearing (6).

5. Remove needle roller thrust bearing (7) and thrust washers (8).

6. Remove friction/counter plates retaining ring (9).



a0835

FIGURE 7-71

7. Remove pressure end plate (11) and shim (10).

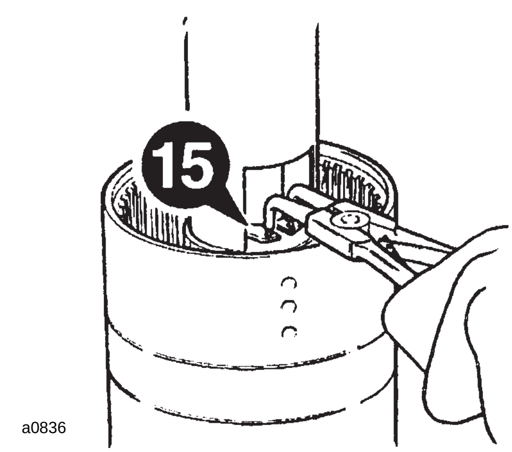
8. Remove friction plates (12) and counter plates (13). Keep them together in sets. DO NOT mix the plates with those of other clutches.

9. Remove disc spring assembly (14).

10. Position the clutch assembly in a press along with a cutaway tube (Figure 7-72). Compress piston spring and then remove retaining ring (15).

11. Lift off spring retaining plate (16).

12. Remove spring (17) and oil baffle (18).



a0836

FIGURE 7-72

13. Knock the clutch shaft on piece of aluminum (or wood) to remove piston (19).

NOTE: If the piston does not loosen when the shaft is knocked on aluminum, then hand pump air down the shaft oil inlet hole.

14. Remove and discard piston and shaft O-rings (20 and 21).
15. To disassemble the opposite clutch, carefully remove piston ring seals (22).
16. Loosen clutch end bearing (23) by tapping the assembly on a piece of wood. Then remove the bearing using a puller.
17. Remove needle roller thrust bearing (25) and thrust washers (24).
18. Remove the gear and splined hub assembly (26) along with needle roller bearing (6).
19. Repeat steps 5 to 14.

Assembly

Visually inspect the friction and counter plates:

- Counter plates - light scoring/polishing is permissible, plates that are flat, worn or heavily marked or scored must be replaced with a new set.
- Friction Plates - the cross hatching should be clearly visible, plates that are flat, have friction material damage or scoring must be replaced with a new set.

DO NOT mix old and new plates. If a plate is damaged/worn install a complete new set.

Needle roller thrust bearings should slide into position freely, do not bend or distort the cage to install. If the cage has been distorted, install new bearings.

Take care when handling disc spring assemblies (14, Figure 7-67) to avoid marking or damage, which could result in stress cracking. If in doubt install a new disc spring.

1. Install new O-rings (20 and 21), lubricate with oil then press piston (19) fully into bore of clutch housing.
2. Install oil baffle (18), piston spring (17). Make sure the spring seats in the piston.
3. Install spring retaining plate (16).
4. Compress spring and secure with retaining ring (15).
5. Install disc spring assembly (14). Make sure that the disc spring is installed with the teeth towards the clutch pack. Make sure the teeth **are not** aligned with the lubrication slots in the housing.
6. Install one counter plate (13), then install one friction plate (12) followed by another counter plate. Continue alternating friction and counter plates. Finish with a friction plate.
7. Install pressure end plate (10). Make sure teeth **are not** aligned with the lubrication slots in the housing. Do not install shim (11) at this stage.
8. Install the clutch friction/counter plates retaining ring (9).
9. Using a dial test indicator as shown in Figure 7-73, measure the end play of the pressure end plate. End play should be 1.90 to 2.50 mm (0.075 - 0.098 in).

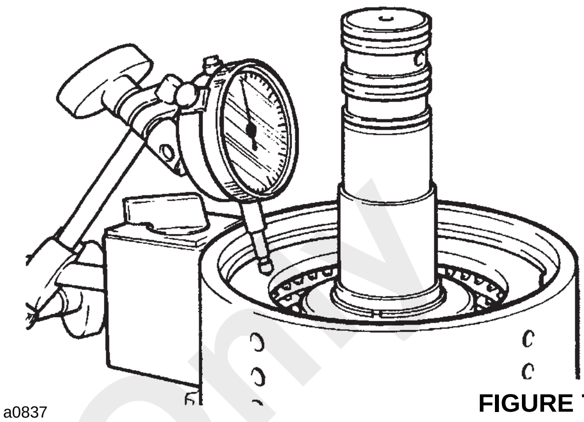


FIGURE 7-73

To adjust the end play, there is a choice between a 6.0 mm (0.23 in) or a 6.5 mm (0.25 in) pressure end plate (11) with either a shim (10) or extra counter plate (13) between retaining ring (9) and pressure end plate (11).

10. Install thrust washers (8) and needle roller thrust bearing (7).
11. Install gear and spline hub assembly (5).

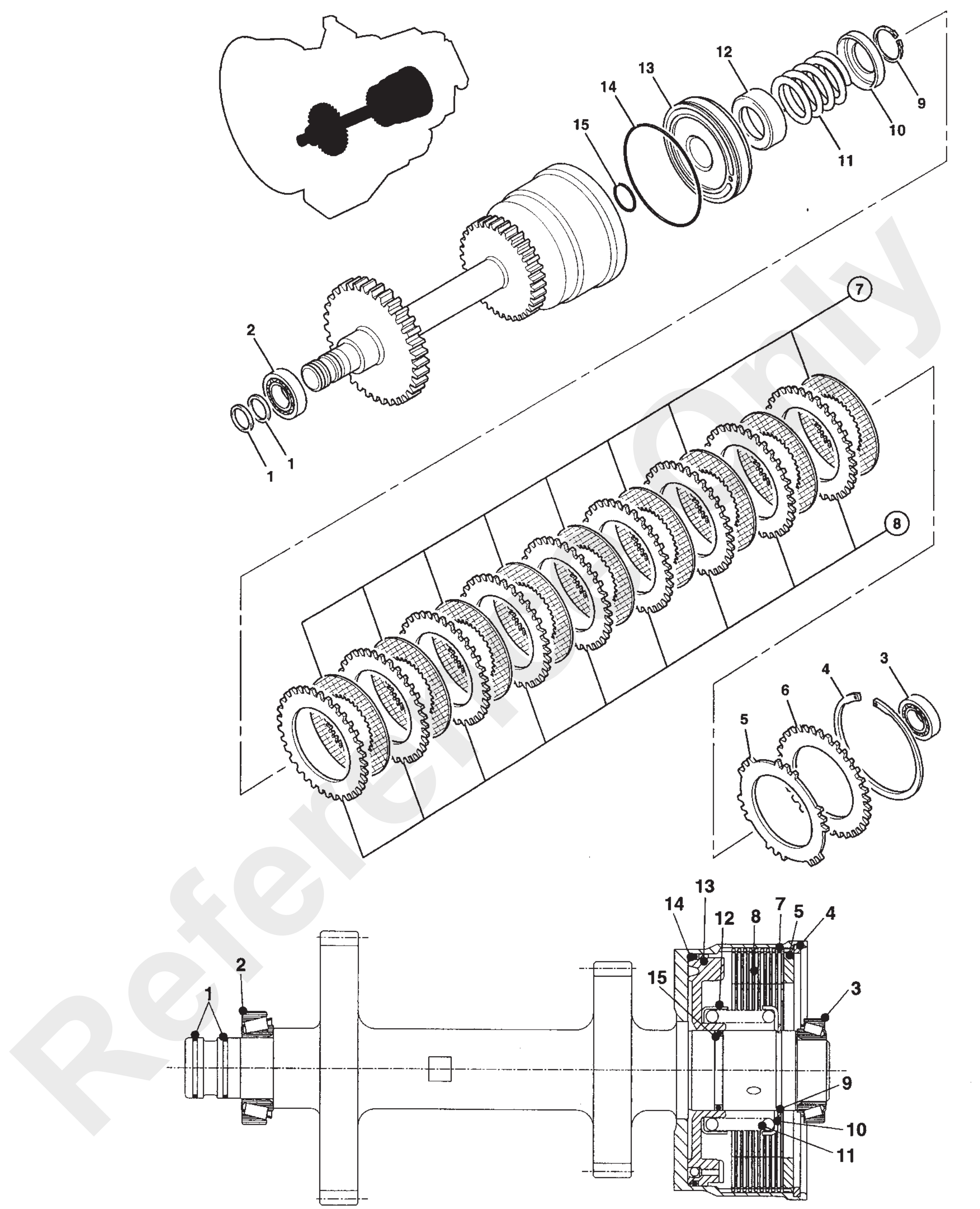
NOTE: Prior to installing the gear, align teeth of clutch using a thin rod (screwdriver).

12. Install needle roller bearing (6).
13. Install needle roller thrust bearing (4) and thrust washer (4A).
14. Coat the clutch end bearing (2) with a Lithium Base, E.P. No. 2 bearing grease and press gear (3) and bearing (2) onto the shaft.
15. Install piston ring seal (1). See *(PTFE) Piston Ring Seal Installation Procedure*, page 7-58.
16. Repeat steps 1 to 10 for the opposite clutch.
17. Install gear and spined hub assembly (26) onto the shaft.

NOTE: Prior to installing the gear, align teeth of clutch using a thin rod (screwdriver).

18. Install needle roller bearing (6).
19. Install needle roller thrust bearing (25) and thrust washer (24).
20. Coat the clutch end bearing (23) with a Lithium Base, E.P. No. 2 bearing grease and press the bearing onto the shaft.
21. Install piston ring seals (22). See *(PTFE) Piston Ring Seal Installation Procedure*, page 7-58.

Mainshaft Clutch Repair



Item	Description	Description	Description
1	Piston ring seal (2)	9	Retaining rings
2	Taper roller bearing	10	Spring retaining plate
3	Bearing	11	Spring
4	Retaining ring	12	Oil baffle
5	End plate	13	Piston
6	Shim	14	O-ring
7	Friction Plates (9)	15	O-ring
8	Counter plates (9)		

FIGURE 7-74

Disassembly

1. Carefully remove piston ring seals (1, Figure 7-74).

NOTE: If the piston ring seals are excessively worn, then check for burrs or damage on the shaft grooves. If necessary, remove the burrs with a fine grade abrasive paper and oil.

2. Remove taper roller bearing (2) using a collet tool and press.

NOTE: The bearing normally would not be removed unless it was damaged. If a collet tool is not available, it is permissible to use a standard bearing puller, although damage to the bearing cage may occur which will require a new bearing.

3. At the opposite end, loosen the clutch end bearing (3) by tapping the assembly on a piece of wood. Remove end bearing using a puller.

4. Remove friction/counter plates retaining ring (4).

5. Remove pressure end plate (5) and shim (6), if installed.

6. Remove clutch friction plates (7) and counter plates (8). Keep them together as a set. DO NOT mix the plates with those of other clutches.

7. Position the clutch assembly in a press along with a cutaway tube (Figure 7-75). Compress the spring and remove retaining ring (9).

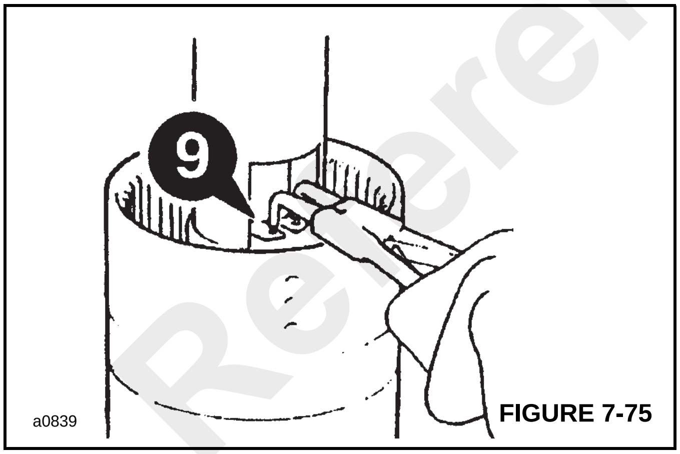


FIGURE 7-75

8. Lift off spring retaining plate (10).

9. Remove spring (11) and oil baffle (12).

10. Knock the clutch on a piece of aluminum (or wood) to remove piston (13).

NOTE: If the piston does not loosen when the shaft is knocked on aluminum, then hand pump air down the shaft oil inlet hole.

11. Remove and discard piston and shaft O-rings (14 and 15).

Assembly

Visually inspect the friction and counter plates:

- **Counter plates** - light scoring/polishing is permissible, plates that are flat, worn or heavily marked or scored must be replaced with a new set.
- **Friction Plates** - the cross hatching should be clearly visible, plates that are flat, have friction material damage or scoring must be replaced with a new set.

DO NOT mix old and new plates. If a plate is damaged/worn install a complete new set.

Needle roller bearings should slide into position freely, do not bend or distort the cage to install. If the cage has been distorted, install new bearings.

1. Install new O-rings (15 and 14). Lubricate with oil and then press piston (13) fully into bore of hub. Install pressure end plate (5). Do not install shim (6) at this stage. Make sure the teeth are not aligned with the lubrication slots in the housing.

NOTE: A spring disc is not installed in this clutch pack.

2. Install the clutch friction/counter plates retaining ring (4).

3. Using a dial test indicator as shown in Figure 7-76, measure the end play of the pressure end plate. End play should be 0.075 - 0.098 inches *(1.9 - 2.5 mm)*.

To adjust the end play, there is a choice between a 0.23 inch *(6.00 mm)* or a 0.25 inch *(6.5 mm)* pressure end plate (5) with either a shim (6) or extra counter plate (8) between retaining ring (9) and pressure end plate (5).

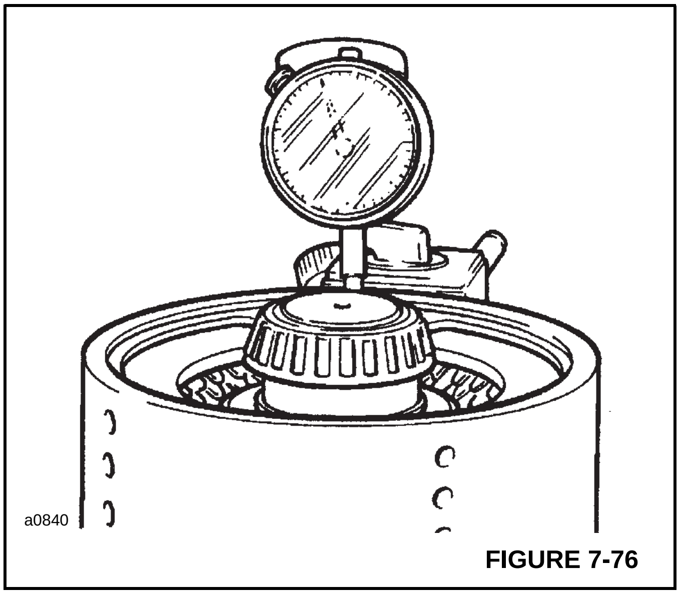


FIGURE 7-76

4. Coat the clutch end bearings (3 and 2) with a Lithium Base, E.P. No. 2 bearing grease and press the bearings onto the shaft.

5. Install piston ring seal (1). See *(PTFE) Piston Ring Seal Installation Procedure*, page 7-58.

Layshaft Clutch Repair

Component Identification for Figure 7-77

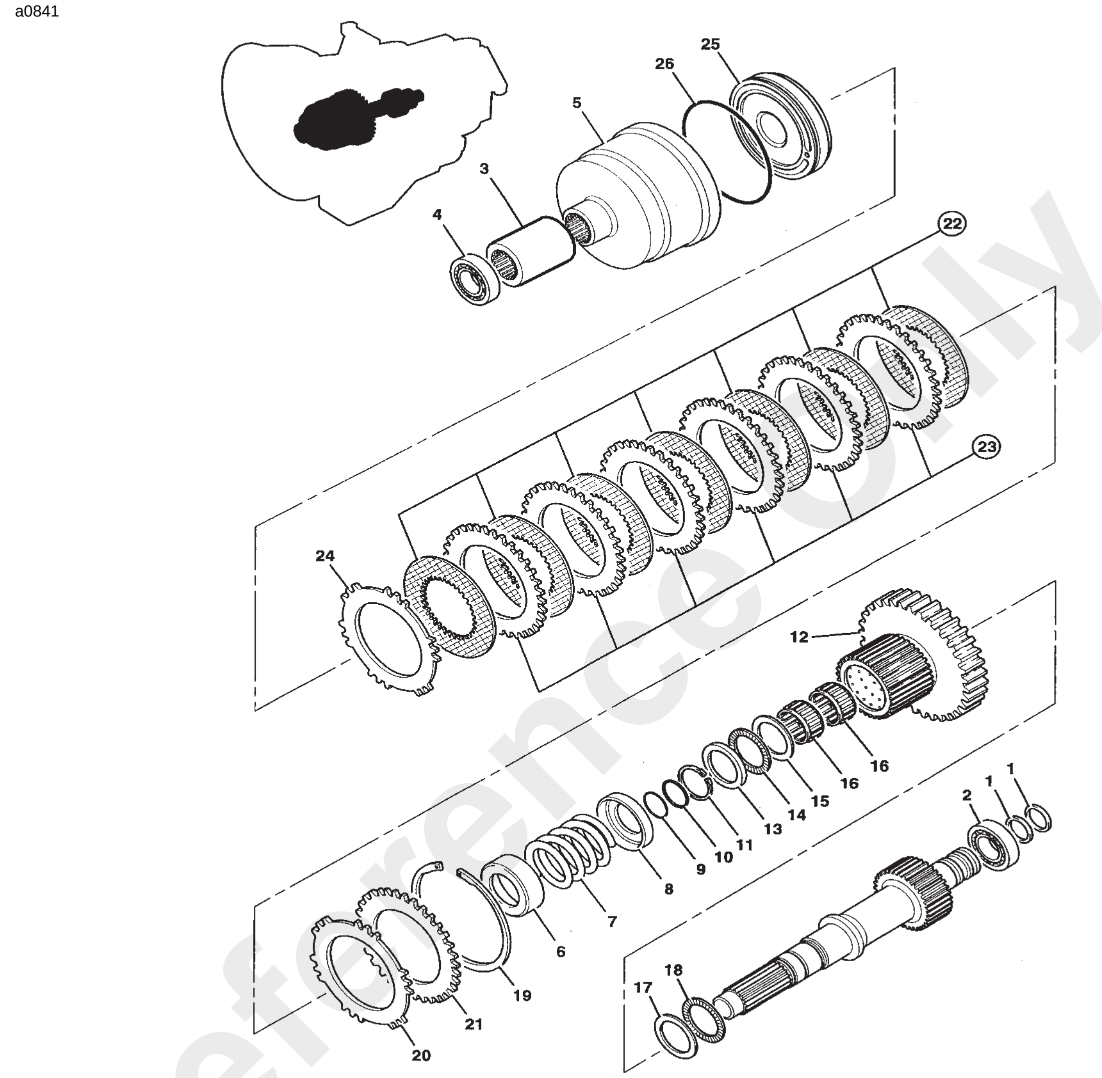


FIGURE 7-77

Item	Description	Item	Description
1	Piston Rings (2)	14	Needle Thrust Washer
2	Taper Roller Bearing	15	Thrust Bearing
3	Spacer	16	Needle Roller Bearing (2)
4	Taper Roller Bearing	17	Thin Thrust Washer
5	Piston Housing	18	Needle Thrust Washer
6	Spring Retainer Plate	19	Retaining Ring
7	Spring	20	Pressure Plate
8	Oil Baffle	21	Shim
9	O-ring	22	Friction Plates (7)
10	O-ring	23	Counter Plates (6)
11	Retaining Ring	24	Pressure Plate
12	Splined Hub	25	Piston
13	Thrust Washer	26	O-ring

Disassembly

NOTE: Use both Figure 7-77 and Figure 7-78 for reference. Item numbers are the same in both illustrations.

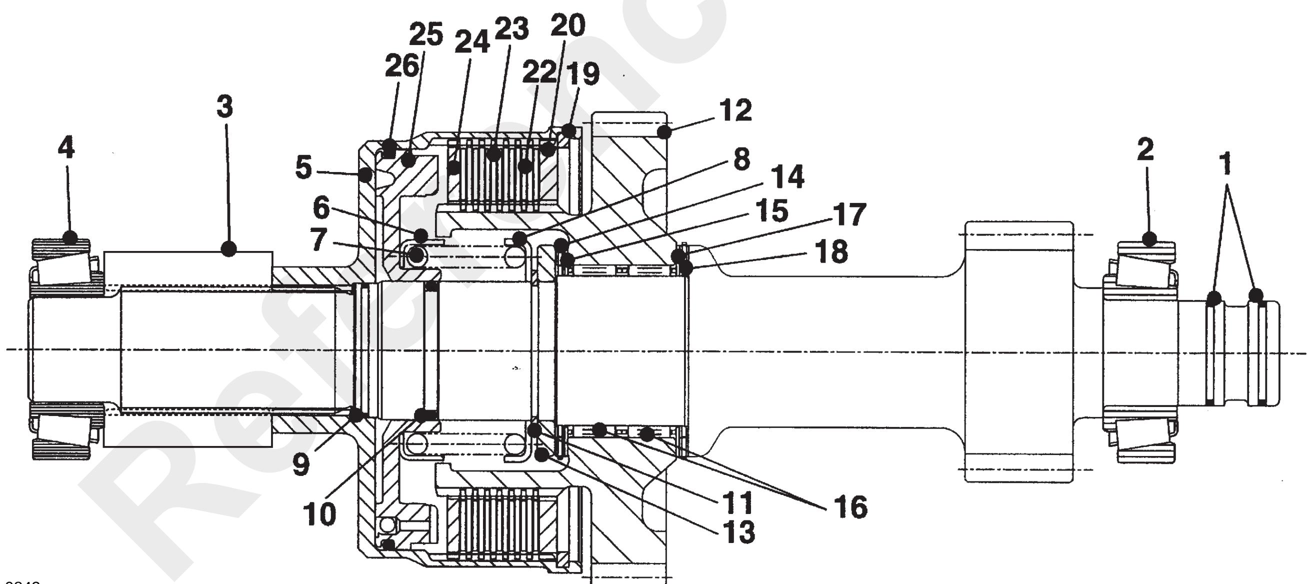
1. Carefully remove piston rings (1).

NOTE: If the piston ring seals are excessively worn, then check for burrs or damage on the shaft grooves. If necessary, remove the burrs with a fine grade abrasive paper and oil.

2. Remove taper roller bearing (2) using a collet tool and press.

NOTE: The bearing normally would not be removed unless it was damaged. If a collet tool is not available, it is permissible to use a standard bearing puller, although damage to the bearing cage may occur which will require a new bearing.

3. At the opposite end, use a suitable puller to remove both the spacer (3) and the taper roller bearing (4).
4. Lift off piston housing (5) complete with the clutch pack.
5. Lift off spring retainer plate (6).
6. Remove spring (7) and oil baffle (8).
7. Remove and discard the two O-rings (9 and 10) located on the layshaft.
8. Remove retaining ring (11).
9. Remove the gear and splined hub (12) together with thrust washer (13), needle thrust bearing (14) and thin thrust washer (15).
10. Remove two needle roller bearings (16).
11. Remove thin thrust washer (17) and needle thrust bearing (18).
12. Remove the clutch friction/counter plate retaining ring (19).
13. Remove the outer pressure end plate (20) and shim (21), if installed.
14. Remove clutch friction plates (22) and counter plates (23). Keep them together as a set. DO NOT mix the plates with those of other clutches.
15. Remove inner pressure plate (24).
16. Remove piston (25).
17. Remove and discard piston O-ring (26).



a0842

FIGURE 7-78

Assembly

Visually inspect the friction and counter plates:

- **Counter plates** - light scoring/polishing is permissible, plates that are flat, worn or heavily marked or scored must be replaced with a new set.
- **Friction Plates** - the cross hatching should be clearly visible, plates that are flat, have friction material damage or scoring must be replaced with a new set.

DO NOT mix old and new plates. If a plate is damaged/worn install a complete new set.

Needle roller bearings should slide into position freely, do not bend or distort the cage to install. If the cage has been distorted, install new bearings.

1. Install new O-ring (26) onto piston (25). Lubricate with oil and then press piston fully into bore of housing (5).

2. Install inner pressure end plate (24). Make sure the teeth are not aligned with the lubrication slots in the housing.

NOTE: The inner pressure end plate is 4 mm (0.157 in) thick and should not be confused with the outer pressure end plate which is either 6.0 mm (0.23 in) or 6.5 mm (0.25 in) thick.

3. Install one friction plate (22) followed by one counter plate (23). Continue installing alternating friction and counter plates. Finish with a friction plate.

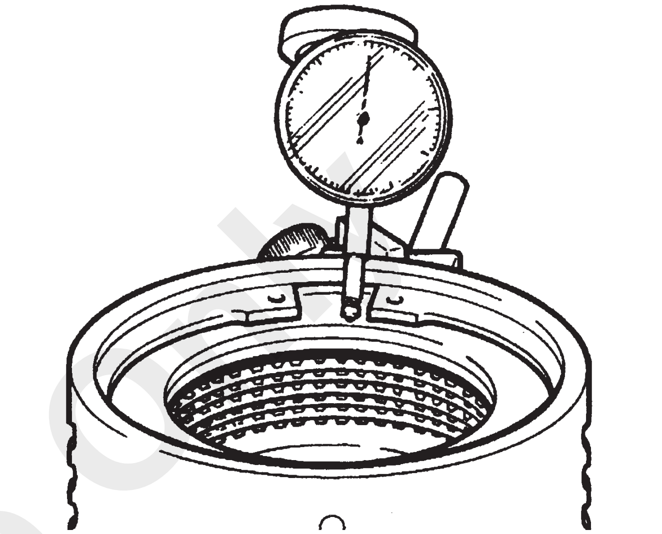
4. Install pressure end plate (20). Make sure the teeth **are not** aligned with lubricating slots in the housing. Do not install shim (21) at this stage.

NOTE: A spring disc is not installed in this clutch pack.

5. Install clutch friction/counter plate retaining ring (19).

6. Using a dial test indicator as shown in Figure 7-79, measure the end play of the pressure end plate. End play should be 1.90 - 2.5 mm (0.075 - 0.098 in).

To adjust the end play, there is a choice between a 6.0 mm (0.23 in) or a 6.5 mm (0.25 in) pressure end plate (20) with either a shim (21) or extra counter plate (23) between retaining ring (19) and pressure end plate (20).



a0843

FIGURE 7-79

7. Install needle roller thrust bearing (18) and thrust washer (17).

8. Install two needle roller bearing (16).

9. Install gear and splined hub (12).

10. Install thin thrust washer (15) followed by needle roller thrust bearing (14) and thrust washer (13).

11. Install retaining ring (11).

12. Install spring retaining plate (8).

13. Install two new O-rings (9 and 10) to the layshaft.

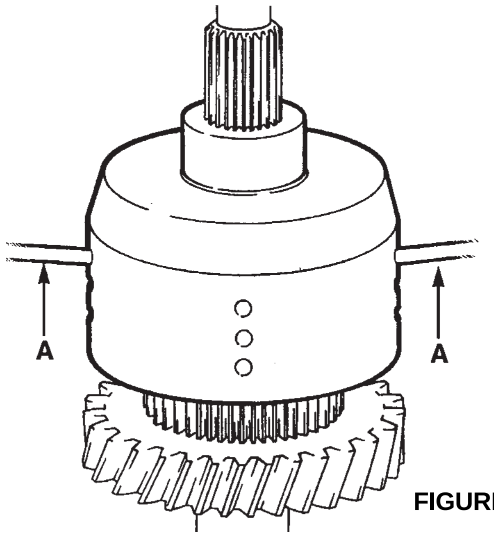
14. Install spring (7) and oil baffle (6).

7

15. Prior to installing the clutch assembly, align teeth of clutch plates using a thin rod (screw driver).

Wedge the plates together by inserting two blunt tools (small round screwdrivers A, Figure 7-80) through the bottom holes at the side of the clutch housing.

Position the clutch assembly on the layshaft splined hub.



a0844 **FIGURE 7-80**

16. Position spacer (3) on the layshaft spline.

17. Coat clutch end bearing (4) with a Lithium Base, E.P. No. 2 bearing grease. Grease and press the taper roller bearing and spacer (3) into place using a bench press.

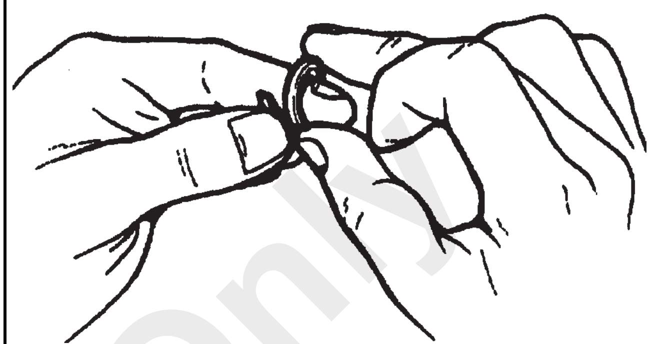
When the taper roller bearing and spacer have been fully installed on the layshaft, remove the two blunt tools used to wedge the clutch plates. Finally, rotate the gear to make sure that the clutch has been correctly installed.

18. Coat the taper roller bearing (2) with a Lithium Base, E.P. No. 2 bearing grease and press the bearings onto the shaft.

19. Install piston ring seal (1). See *(PTFE) Piston Ring Seal Installation Procedure*, page 7-58.

(PTFE) Piston Ring Seal Installation Procedure

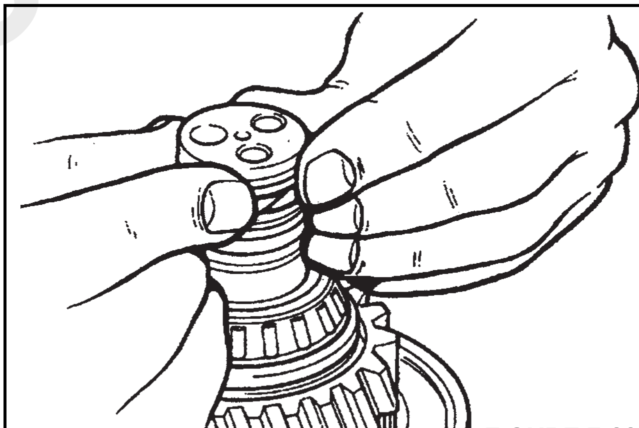
1. Wind the PTFE piston ring around your finger, as shown in Figure 7-81, so that the seal forms a coil.



a0844 **FIGURE 7-81**

2. Coat the seal with grease and install the seal to the shaft (Figure 7-82).

Make sure that the seal sits below or is flush with the outer diameter of the shaft. If necessary, use finger pressure as shown to make the seals flush with the shaft.



a0313 **FIGURE 7-82**

NOTE: If the seal is not set below or flush with the diameter of the shaft, the seal will be cut when the shaft is installed to its mating components.

Solenoid Valve

Disassembly/Assembly

The numerical sequence shown in Figure 7-83 is intended as a guide for disassembly.

For assembly the sequence should be reversed.

For clarity, only one solenoid has been numbered in the disassembly sequence.

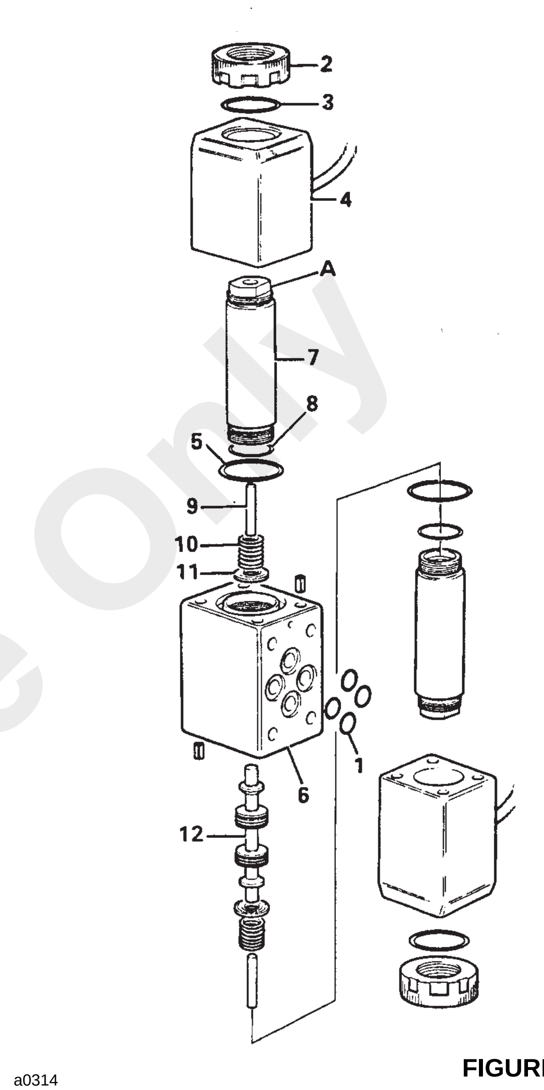


FIGURE 7-83

SECTION 8
AXLES/DRIVE SHAFTS/WHEELS AND TIRES

SECTION CONTENTS

DESCRIPTION

Front Axle

The front axle (Figure 8-1) is a rigid-mounted steering drive axle, attached to the frame of the crane by eight bolts and nuts. The axle includes two axle beam trumpets, two reduction drive hubs, a three-piece spiral bevel input, a steering cylinder linkage assembly and inboard brakes.

Rear Axle

The rear axle (Figure 8-2) is rigid-mounted steering non-drive axle, attached to the crane frame with eight bolts and self-locking nuts. The axle includes a steering beam, two steering knuckles, two wheel hubs, and a steering linkage including two steering cylinders.

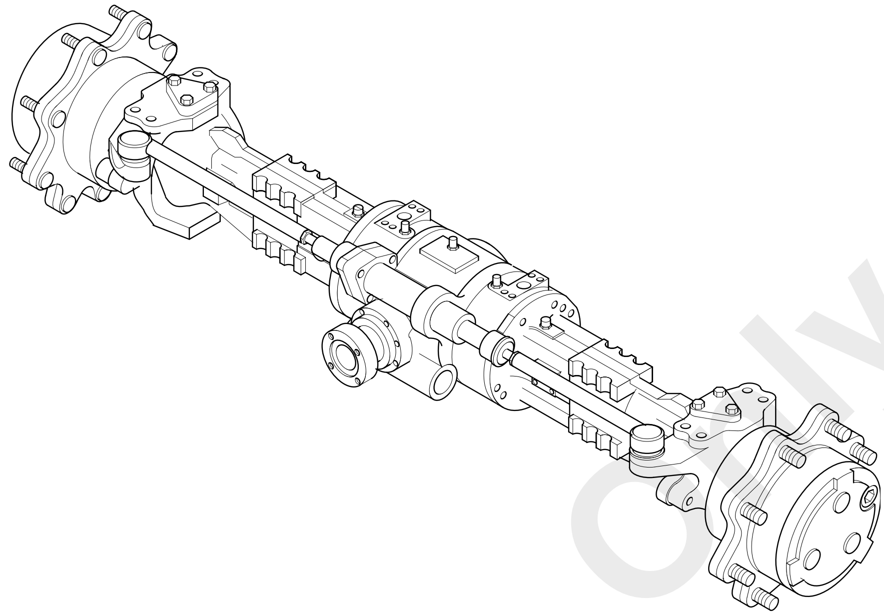

A0723

FIGURE 8-1

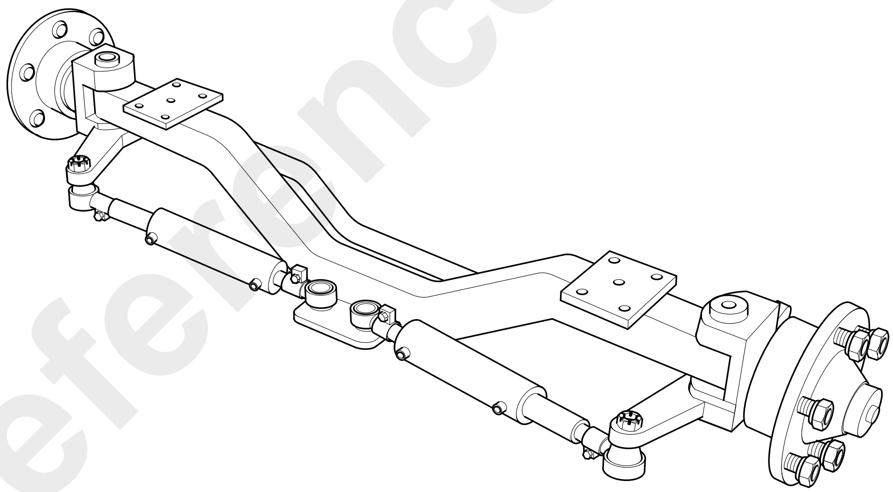

A0855

FIGURE 8-2

TECHNICAL DATA

Front Steering Drive Axle

Type...3-piece spiral bevel input with epicyclic hub reduction and inboard braking

Installation..Rigid pad mount

Number of steering cylinders........................One

Weight (dry)..355 kg (783 lb)

Type of brakes..Wet disc brake

Number of brake discs (each side)....................One

Number of brake counterdiscs (each side)......Two

Nominal brake disc thickness.............4.83 mm (0.19 in)

Nominal brake counterdisc thickness....5.0-10.8 mm (0.197 - 0.425 in)

Maximum brake disc wear...............0.15 mm (0.006 in)

Nominal brake piston stroke............1 mm (0.039 in)

Oil displacement for brake actuation..........9 cc (0.3 oz)

Oil specification for brake actuation..........Mobil Fluid 424 (ISO 46/68)

Pinion flange type..DIN 1410

Toe-in..0°

Steering Angle..35°

Bevel gear reduction...1.55:1

Hub reduction..6.00:1

Total Reduction...10.66:1

Bevel gear set backlash.........................0.15 - 0.20 mm (0.006 - 0.008 in)

Pinion bearings (measured D=34.8 mm without seal).......P = 9.2 ÷ 13.8 daN

Total pinion ring gear bearing pull (measured D = 34.8 mm without seal)..................................T = (P+3.85)˜(P+5.8) daN

Rear Steering Non-drive Axle

Installation..Rigid pad mount

Weight...185 kg (408 lb)

Number of steering cylinders..........................Two

Brakes...None

Toe-In..0°

Toe-Out..0°

TOE-IN/STEERING ANGLE ALIGNMENT

Front Steering Axle

Toe-in Check and Adjustment

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's hydraulics or jacks to support the machine when working under it.

Disconnect the battery cables while you're under the machine to prevent the engine from being started.

Checking with Axle on Machine

1. Place the wheels in the straight forward position.
2. Take measurements from the tire to the crane frame at the four positions A, B, C and D indicated in Figure 8-3. All four dimensions must be equal.

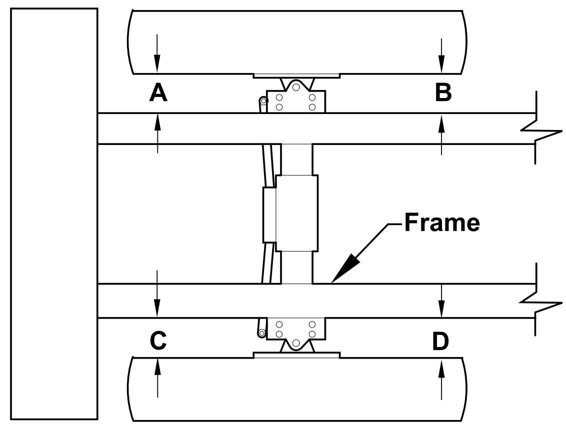
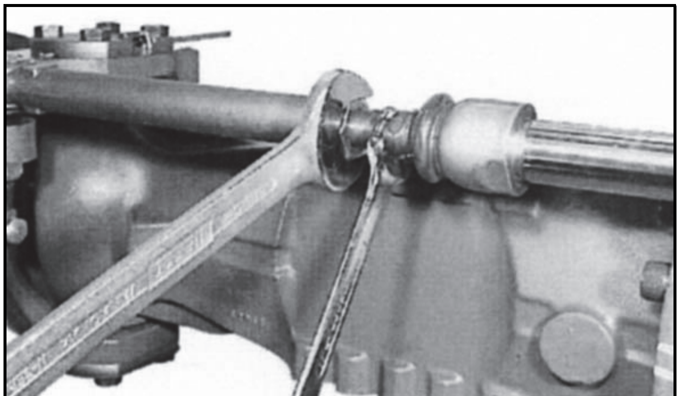


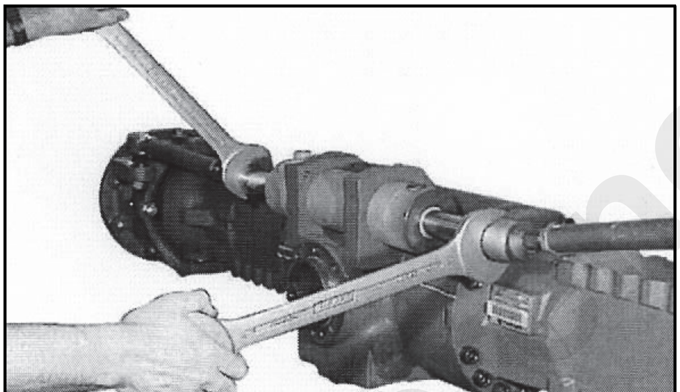
FIGURE 8-3

3. If toe-in is incorrect, loosen the jam nuts (Figure 8-4) securing the guide rods to the cylinder rod.



P0663 **FIGURE 8-4**

4. Using two wrenches on the guide rods (Figure 8-5), screw in or out the two tie rods equally until both dimensions are equal.

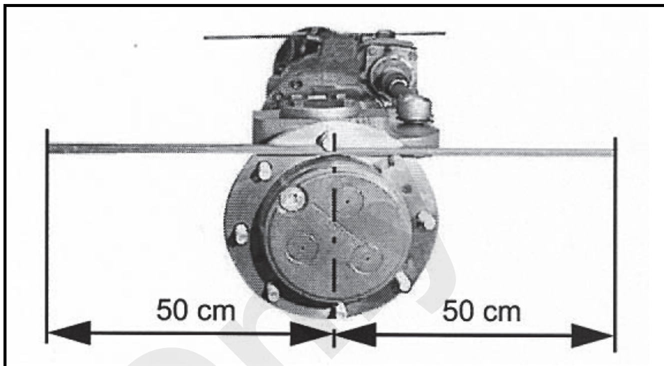


P0662 **FIGURE 8-5**

5. After the adjustment is correct, tighten the jam nuts (Figure 8-4) against the guide rods.

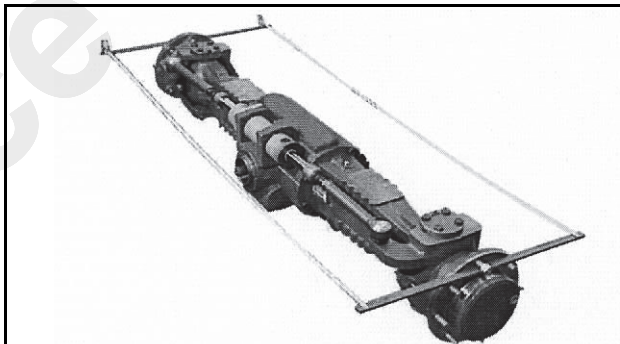
Checking with Axle Removed from Machine

1. Place two equal (one-meter) long linear bars on the wheel sides of the hubs and lock them in place with two nuts on the wheel stud bolt (Figure 8-6)



P0660 **FIGURE 8-6**

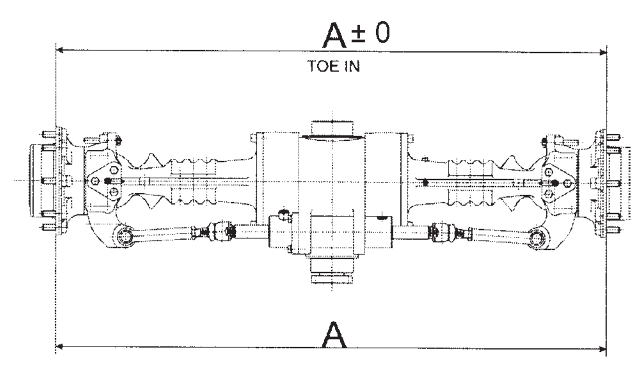
2. Measure the distance in millimeters between the bar ends (both ends) with a tape line (Figure 8-7).



P0661 **FIGURE 8-7**

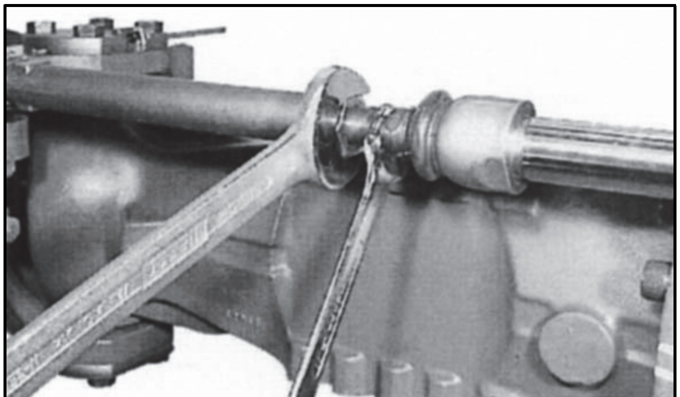
NOTE: Record the minimum value, swinging the measurement point.

3. Check that there is no difference in the measurements (Figure 8-8). Both measurements must be the same.



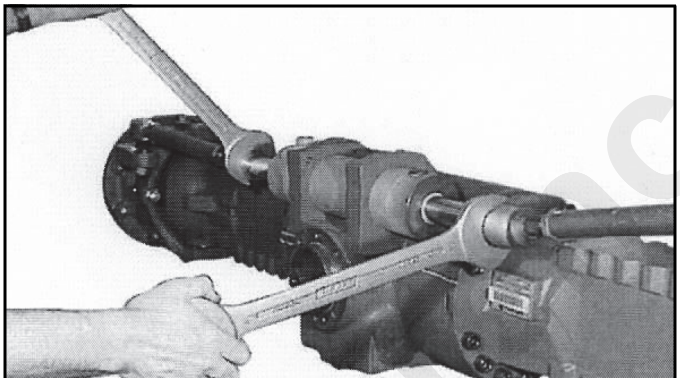
A0722 **FIGURE 8-8**

4. If tow-in is incorrect, loosen the jam nuts (Figure 8-9) securing the guide rods to the cylinder rod.



P0663 **FIGURE 8-9**

5. Using two wrenches on the guide rods (Figure 8-10), screw in or out the two tie rods equally until both dimensions are equal.



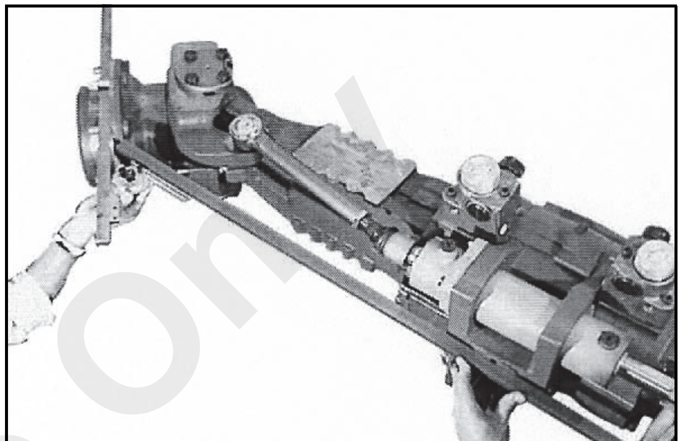
P0662 **FIGURE 8-10**

6. After the adjustment is correct, tighten the jam nuts (Figure 8-9) against the guide rods.

Steering Angle Check and Adjustment

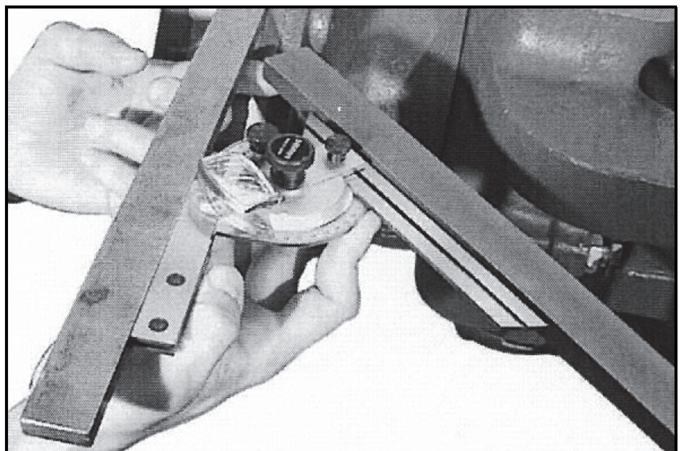
NOTE: Some of the following figures do not show the exact axle used on your crane, but the procedure is the same.

1. Use the same bars assembled for the toe-in adjustment, page 8-5.
2. Steer the axle to maximum steering position.
3. Hold a long bar against the steering cylinder mounting brackets on the axle (Figure 8-11), so that the two bars form an acute angle.



P0664 **FIGURE 8-11**

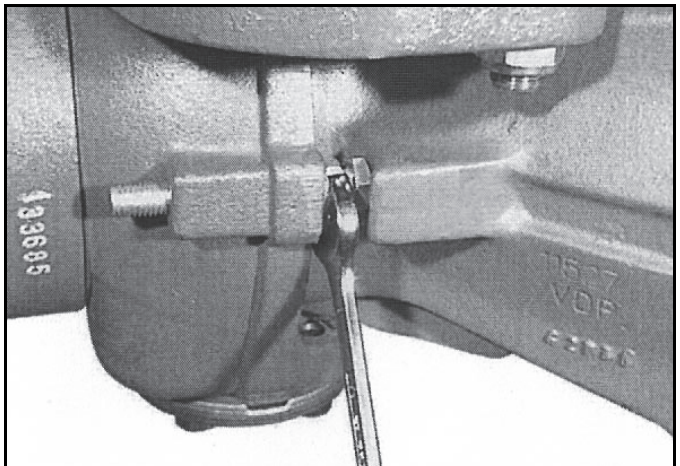
4. Adjust a goniometer to 35° and position it on the long bar (Figure 8-12).



P0665 **FIGURE 8-12**

5. Check the angle between the two bars. If not 35° adjust the angle.

6. Loosen the lock nut on the steering angle screw (Figure 8-13).



P0804 **FIGURE 8-13**

7. Screw the adjusting screw in or out until the correct angle is obtained.
8. When the angle is adjusted correctly, steer completely in the opposite direction and repeat steps 3 through 7.

Rear Steering Axle

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's hydraulics or jacks to support the machine when working under it.

Disconnect the battery cables while you're under the machine to prevent the engine from being started.

Checking / Adjusting Toe-in

Checking with Axle on Machine

1. Place the wheels in the straight forward position.
2. Take measurements from the tire to the crane frame at the four positions A, B, C and D indicated in Figure 8-3. All four dimensions must be equal.

NOTE: If more than 6 mm (1/4 in) of adjustment is necessary, make the adjustment on both ends of the tie rod. Make sure both clamps on the tie rod are tight when finished.

3. On one end of tie rod loosen the ball joint clamp (Figure 8-14).
4. Remove the cotter pin from the castle nut. Remove the castle nut.

P0690

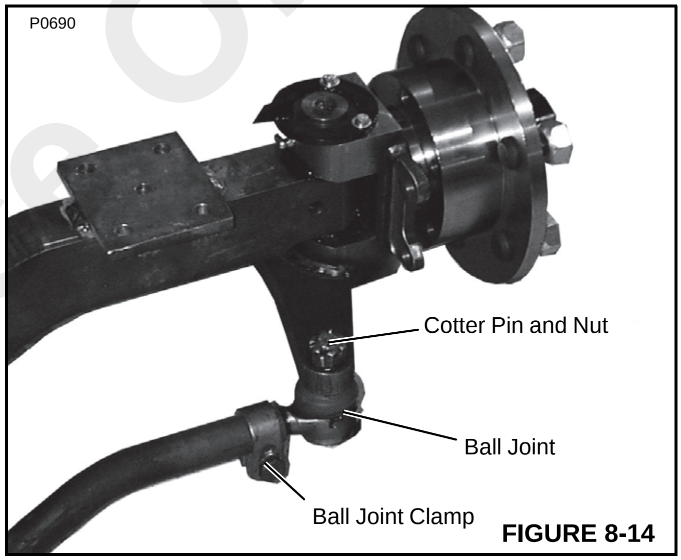


FIGURE 8-14

5. Remove the ball joint from the steering knuckle.
6. Either screw the ball joint in or out to obtain equal dimensions.
7. When the correct dimensions are obtained, tighten the castle nut and install the cotter pin.
8. Tighten the ball joint clamp.

Checking with Axle Removed from Machine

1. Align the wheel hubs in straight forward position.
2. Measure the distance between the hubs on both sides of the axle (Figure 8-15).
3. Both dimensions must be the same.
4. If incorrect, use steps 3 through 8 under *Checking with Axle on Machine*, page 8-6 to adjust the measurements.

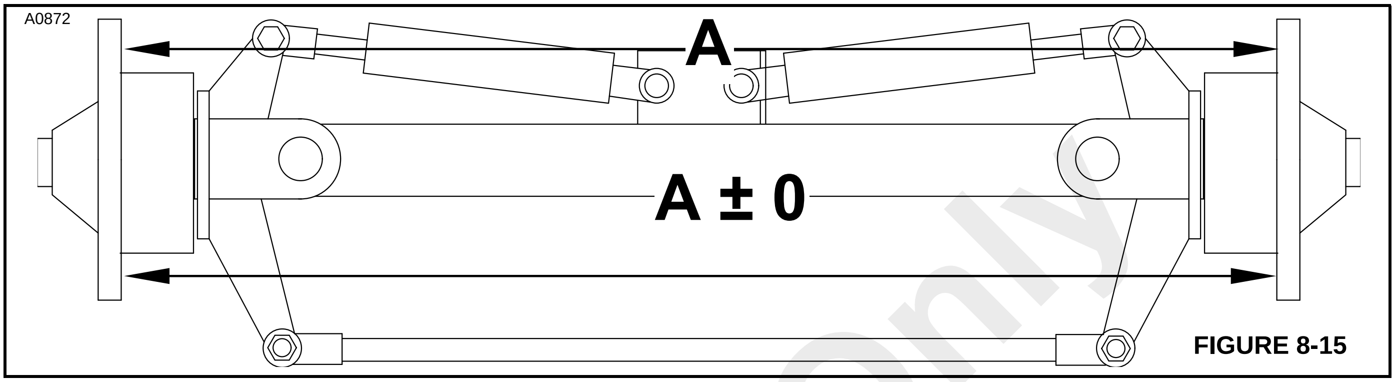


FIGURE 8-15

FRONT DRIVE AXLE PROBLEMS AND DIAGNOSIS

Table 8-1

PROBLEM	CAUSE	RECOMMENDED REPAIR
Noise while driving	**1.** Excessive play between pinion and bevel gear **2.** Worn pinion and bevel gear. **3.** Worn pinion bearings **4.** Pinion bearing loose **5.** Excessive axle pinion play **6.** Worn differential bearings **7.** Differential bearings loose **8.** Bevel gear out of roundness **9.** Low lubricant level **10.** Poor or wrong lubricant **11.** Bent halfshaft	**1.** Adjust. **2.** Replace **3.** Replace **4.** Adjust. **5.** Adjust preload only. **6.** Replace **7.** Adjust preload. **8.** Replace **9.** Add lubricant **10.** Replace **11.** Replace
Noise while moving in neutral	**1.** Noises coming from axle are usually heard when crane moves in neutral gear, but are not loud **2.** Incorrect play between pinion and bevel gear (sound heard while decelerating disappears while increasing speed **3.** Pinion or input flange worn out	**1.** Replace or adjust (see above) **2.** Adjust. **3.** Replace
Intermittent noise	**1.** Bevel gear damaged **2.** Differential housing bolts loose	**1.** Replace bevel gear set **2.** Tighten to torque.
Constant noise	**1.** Bevel gear or pinion damaged **2.** Worn bearings **3.** Pinion spline worn **4.** Bent halfshaft	**1.** Replace bevel gear set **2.** Replace **3.** Replace **4.** Replace
Noise while steering	**1.** Worn differential gears **2.** Worn differential housing or spider **3.** Differential thrust washers worn **4.** Half shaft spline worn	**1.** Replace **2.** Replace **3.** Replace **4.** Replace

FRONT DRIVE AXLE REPAIR

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's hydraulics or jacks 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.

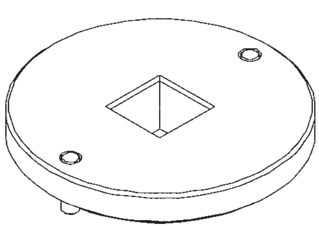
Removal

1. Lower the outriggers to raise the front axle. Place blocks under the front of the frame. Remove the front wheels and tires.
2. Disconnect the drive shaft from the axle flange.
3. Disconnect the brake lines from the axle. Cap the lines and plug the brake ports.
4. Disconnect the hydraulic hoses from the steering cylinder. Plug and cap the hoses and ports.
5. Place a wheel jack under the axle beam. Remove the axle mounting bolts and nuts. Carefully lower the axle. Remove the axle from under the machine.

Disassembly

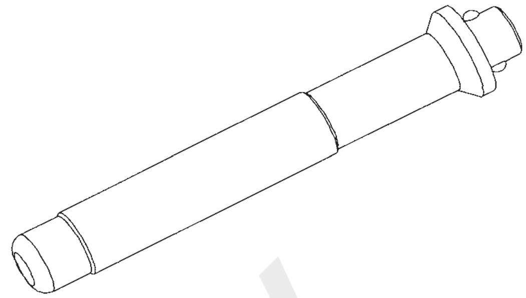
Special Tools

NOTE: SPECIAL TOOLS are required to disassemble and assemble the axle. Do not attempt to repair the axle unless the tools listed, or equivalent, are present at the time of repair. A complete list of tools is available in the Parts Manual.



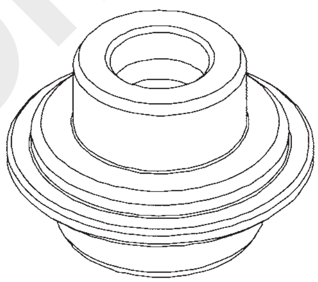
Wench for differential housing lock nut
P/N 1901763

A0677 **FIGURE 8-16**



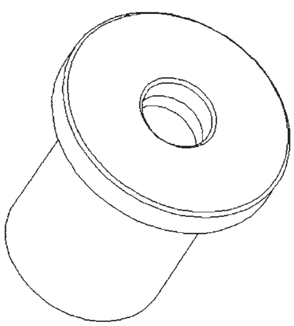
Interchangeable handle
P/N 1901764

A0676 **FIGURE 8-17**



Driver for oil seal
P/N 190765

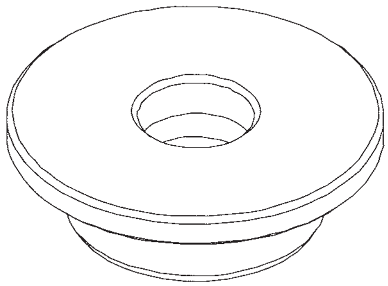
A0675 **FIGURE 8-18**



Driver for swivel bushing
P/N 1901766

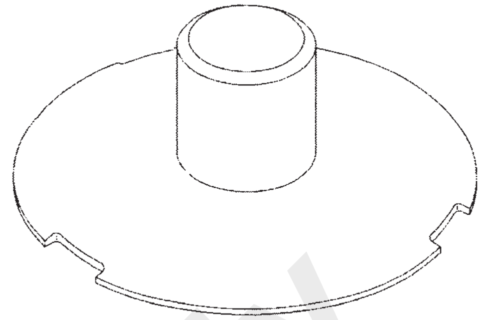
A0681 **FIGURE 8-19**

8



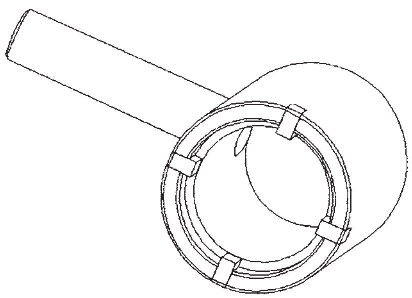
Driver for wheel hub oil seal
P/N 1901767

A0680 **FIGURE 8-20**



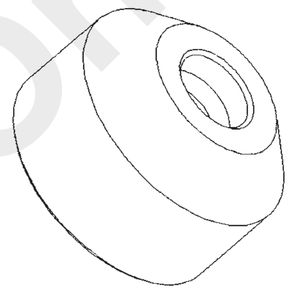
Driver for piston
P/N 1901770

A0685 **FIGURE 8-23**



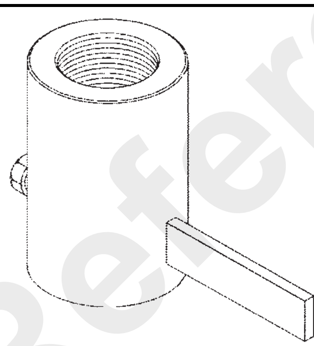
Wrench for pinion lock nut
P/N 1901768

A0679 **FIGURE 8-21**



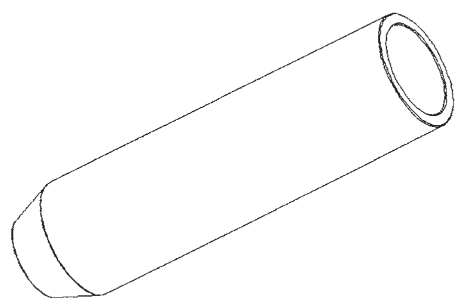
Driver for differential bearing cone
P/N 1901771

A0684 **FIGURE 8-24**



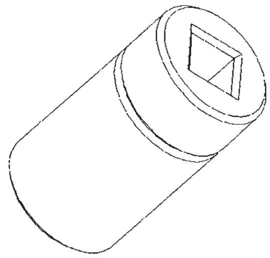
Pinion/crown wheel measurement bushing
P/N 1901769

A0678 **FIGURE 8-22**



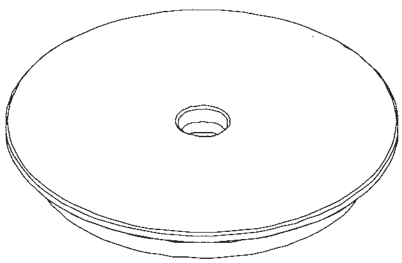
Driver for pinion bearing cone
P/N 1901772

A0683 **FIGURE 8-25**



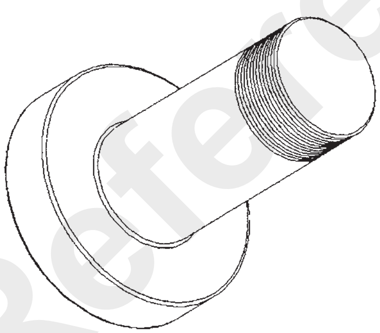
Pinion shaft lock wrench
P/N 1901773

A0682 **FIGURE 8-26**



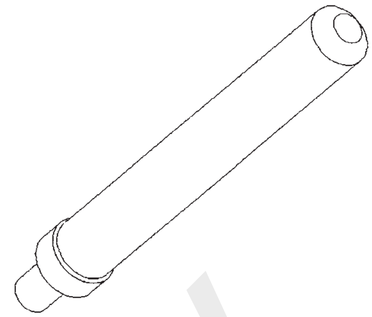
Driver for Bearing
P/N 1901774

A0689 **FIGURE 8-27**



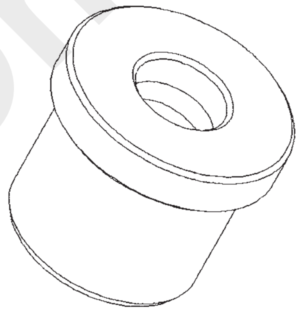
False Pinion
P/N 1901775

A0688 **FIGURE 8-28**



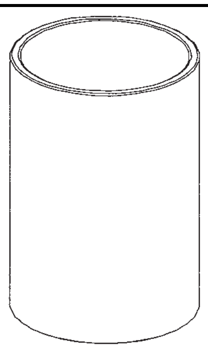
Driver for bushing
P/N 1901776

A0687 **FIGURE 8-29**



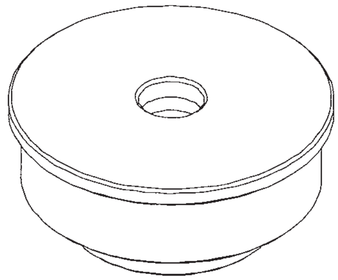
Driver for bushing
P/N 1901777

A0686 **FIGURE 8-30**



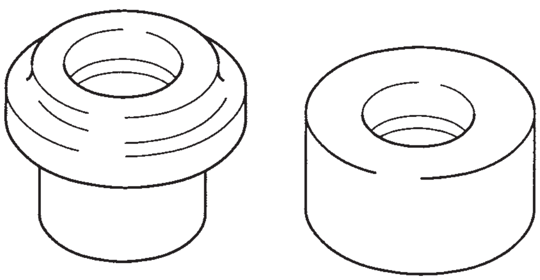
False differential for distance measure
with false pinion
P/N 1901778

A0693 **FIGURE 8-31**



Driver for pinion oil seal
P/N 1901779

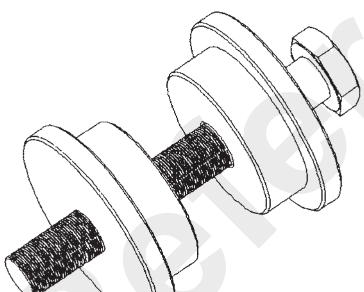
A0692 **FIGURE 8-32**



Driver for king pin bushing
P/N 1901780

Driver - king spherical joint
P/N 1901781

A0691 **FIGURE 8-33**

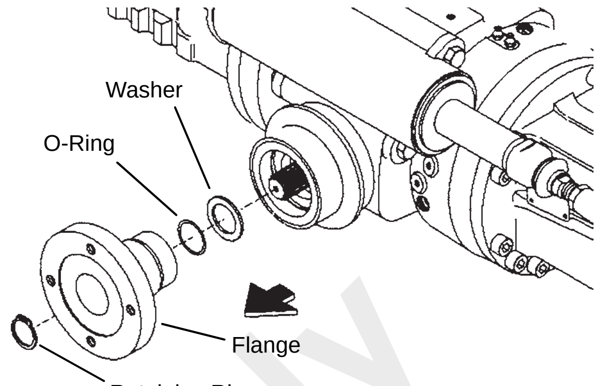


Kit for bearing cup assembly in center housing
P/N 1901782

A0690 **FIGURE 8-34**

Flange Disassembly

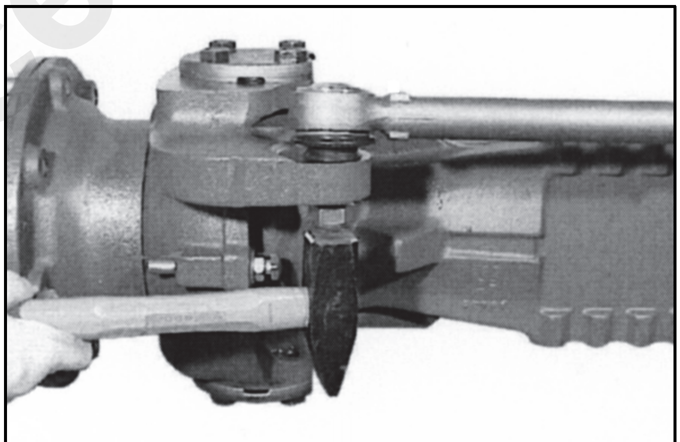
1. Remove the retaining ring Figure 8-35).
2. Remove the flange off of the input shaft.
3. Remove the O-ring and washer.



A0694 **FIGURE 8-35**

Steering Cylinder Removal

1. Loosen the hex nut (Figure 8-36) on one of cylinder tie rod ends until none of the threads on the tie rod end are exposed. Using a hammer, hit the nut to drive the tie rod end from the swivel housing. There is a possibility the nut could be damaged. An alternative is to use a tie rod end fork to remove the tie rod, less damage will occur.

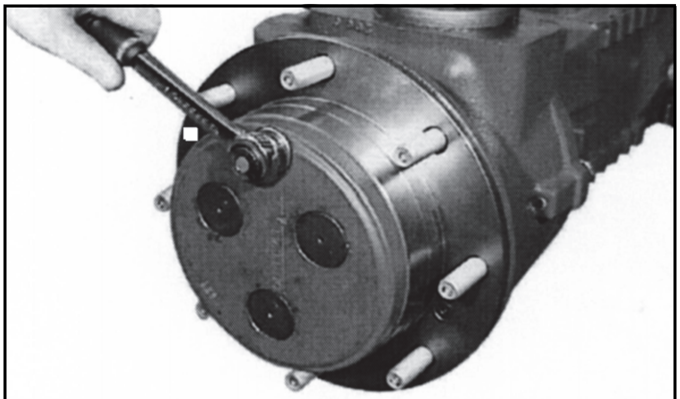


P0586 **FIGURE 8-36**

2. Mark the tie rod for identification during assembly. Remove tie rod from the cylinder rod. Be careful not to tamper with the length of the tie rod assembly. If measurement is changed, the axle will have to be checked for toe-in.
3. On the other end of the cylinder, repeat steps 1 and 2.
4. Remove three cap screws fastening the cylinder to the axle housing. Remove the cylinder. It may be necessary to drive the cylinder out of its mounting brackets using a rubber hammer.
5. Take the cylinder to a clean work area for disassembly.

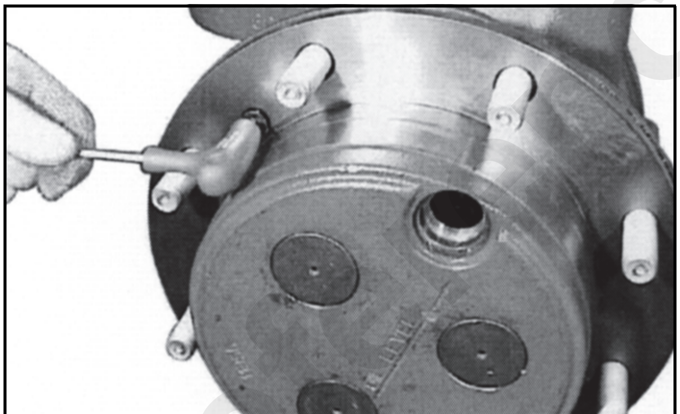
Wheel Hub Disassembly

1. Position the hub with the drain plug to the top of hub (Figure 8-37). Loosen the drain plug slightly to remove any pressure that may have built-up in the hub.



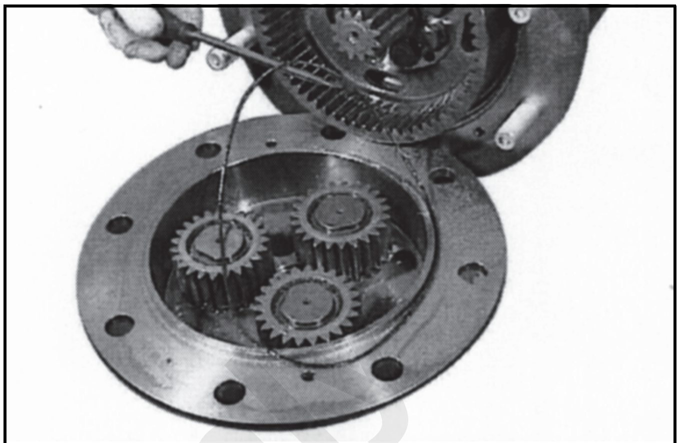
P0587 **FIGURE 8-37**

2. Position the drain plug at the bottom of the hub. Remove the plug and drain the lubricant into a suitable container.
3. Remove the two screws (Figure 8-38) fastening the planetary carrier to the wheel hub.



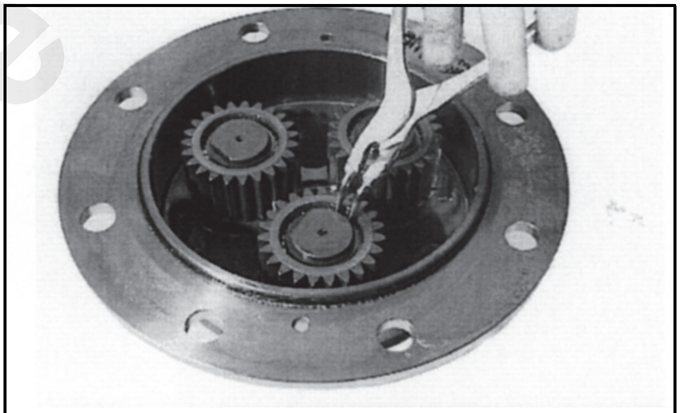
P0588 **FIGURE 8-38**

4. Remove the planetary carrier from the wheel hub. Place the planetary carrier on clean work bench and check for wear. Remove the O-ring (Figure 8-39) and check its condition.



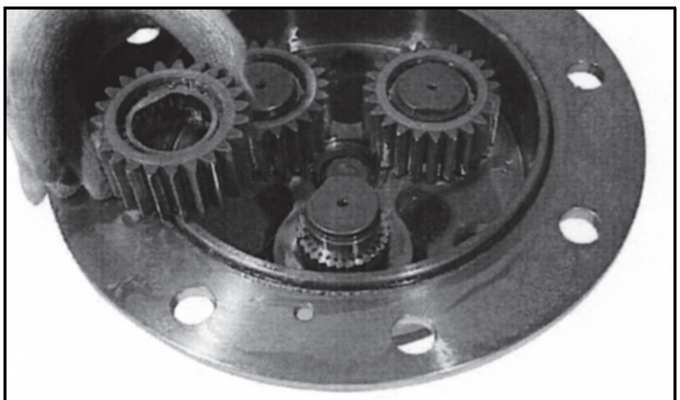
P0589 **FIGURE 8-39**

5. Should any of the planetary gears need replacement perform the following:
   - **a.** Remove the retaining ring (Figure 8-40) from the pin shaft.



P0590 **FIGURE 8-40**

   - **b.** Remove the washer and planetary gear (Figure 8-41) from the pin shaft.



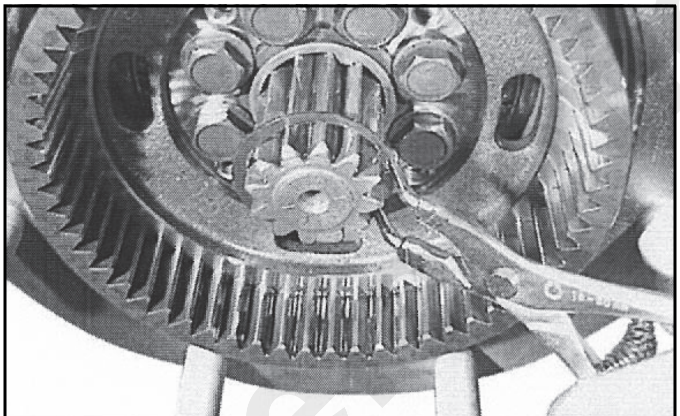
P0591 **FIGURE 8-41**

c. Remove all of the rollers (Figure 8-42) and check their condition. If any gear pin shaft is damaged, replace the entire planetary carrier assembly.

P0592 **FIGURE 8-42**

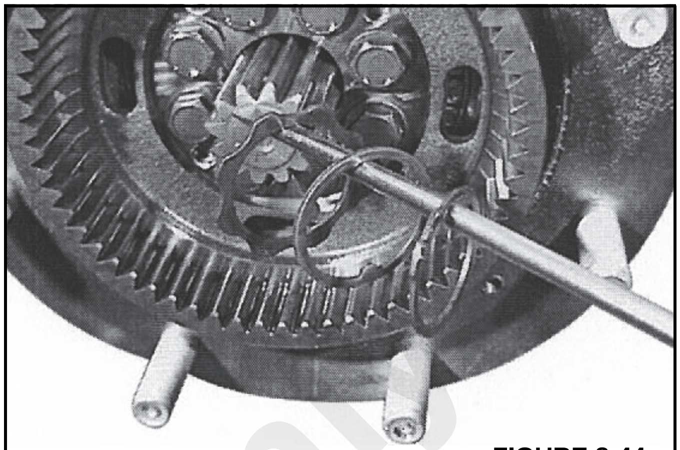
NOTE: Before disassembling the splined sleeve, it is advisable to secure it with a hoist or other supporting device to inhibit it from accidentally falling and injuring the mechanic or causing damage to the hub.

6. Remove the retaining ring (Figure 8-43) from the u-joint shaft using suitable pliers.



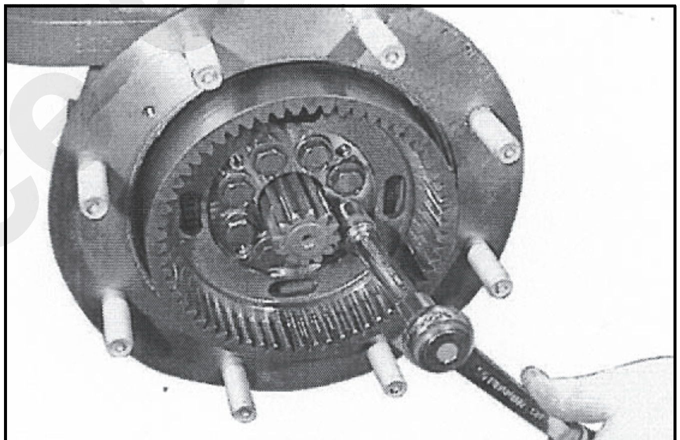
P0593 **FIGURE 8-43**

7. Remove the axle shaft washers (Figure 8-44).



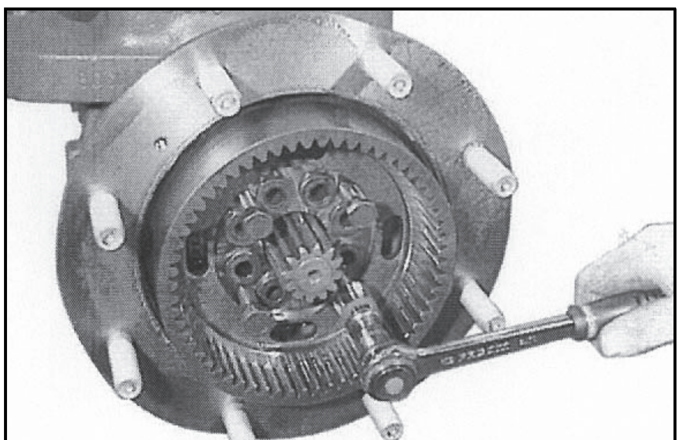
P0594 **FIGURE 8-44**

8. Unscrew and remove the nine fastening screws (Figure 8-45) from the hub-lock ring gear.



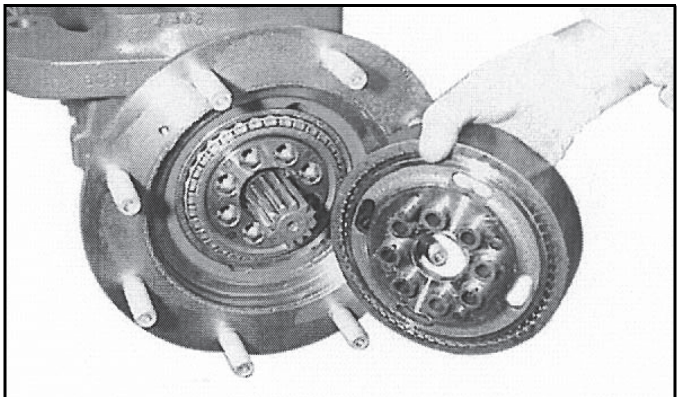
P0595 **FIGURE 8-45**

9. Remove the hub-lock gear from its housing by using two of the removed screws as jack screws. Screw the two screws into the threaded extraction holes (Figure 8-46).



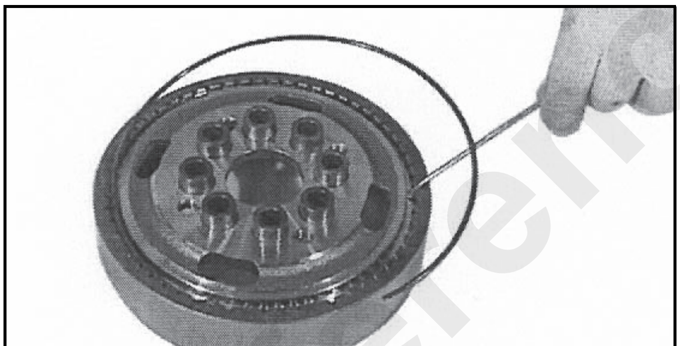
P0596 **FIGURE 8-46**

10. Remove the hub-lock ring gear together with the epicyclic ring gear (Figure 8-47).



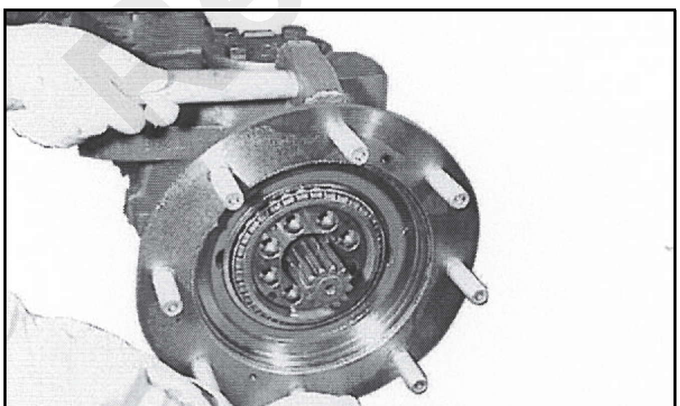
P0597 **FIGURE 8-47**

11. Remove the steel stop ring and disconnect the hub-lock ring gear from the epicyclic ring gear (Figure 8-48). Check the components for wear and damage. Only if necessary, use a hammer and SPECIAL TOOL P/N 1901776 to remove the centering bushings from the hub-lock ring gear.



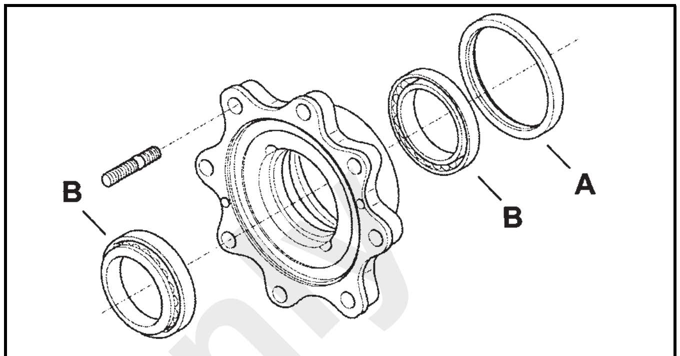
P0598 **FIGURE 8-48**

12. Using pry bars and a hammer, remove the hub (Figure 8-49). Remove the bearing cone.



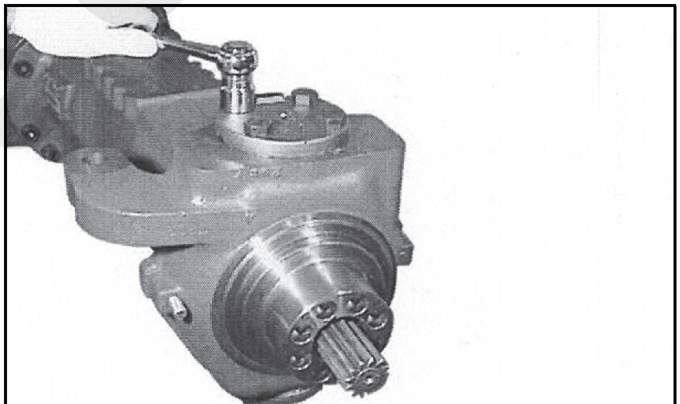
P0599 **FIGURE 8-49**

13. Place the hub on a flat surface and remove seal ring (**A**, Figure 8-50) with a pry bar. The seal will be damaged during removal. Remove bearing cups (**B**) from both sides of the hub using a driver and hammer. Remove the bearing cone from the swivel housing end, using a suitable puller.



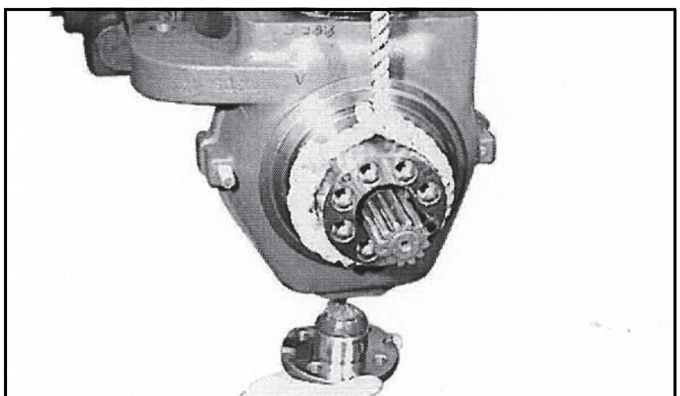
A0695 **FIGURE 8-50**

14. Unscrew and remove the screws from the upper and lower king pins (Figure 8-51).



P0600 **FIGURE 8-51**

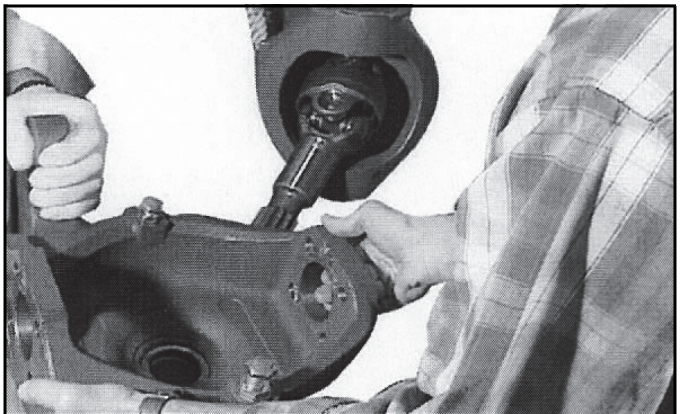
15. Secure the swivel housing with a rope or sling attached to a hoist before removing the king pins (Figure 8-52). Remove the king pins.



P0601 **FIGURE 8-52**

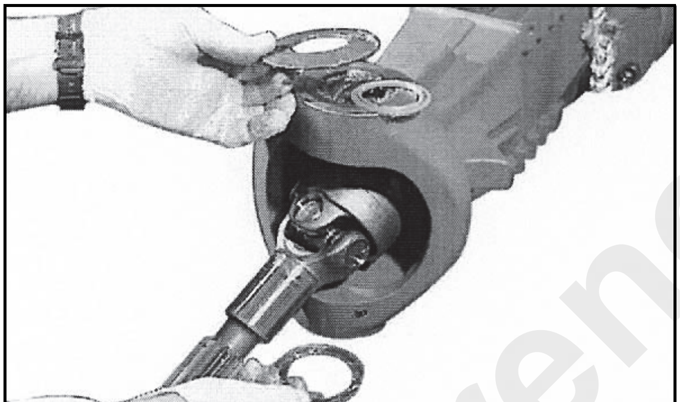
16. Remove the swivel housing from the axle beam and from the short axle shaft of the u-joint (Figure 8-53).

8



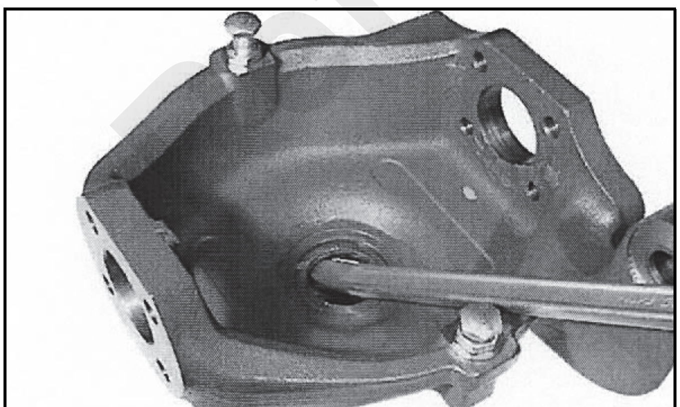
P0602 FIGURE 8-53

17. Remove the Belleville washers and shim from the upper and lower side of the axle beam (Figure 8-54).



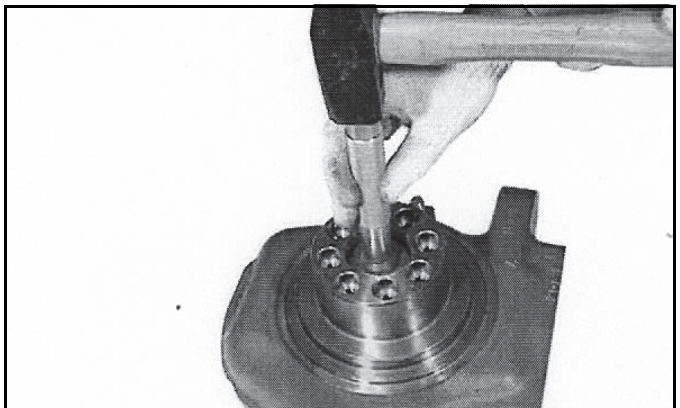
P0603 FIGURE 8-54

18. Place the swivel housing on a flat surface and pry out the oil seal ring (Figure 8-55). The seal ring will be damaged during this procedure.



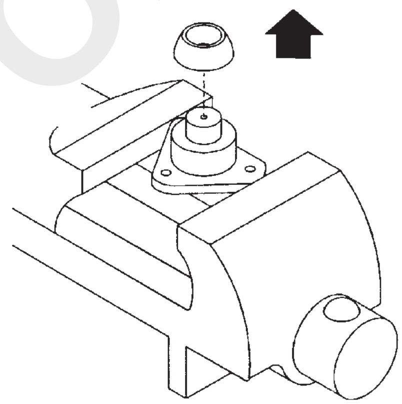
P0604 FIGURE 8-55

19. Turn the swivel housing over and using the SPECIAL TOOL P/N 1901766 and hammer remove the bushing (Figure 8-56).



P0605 FIGURE 8-56

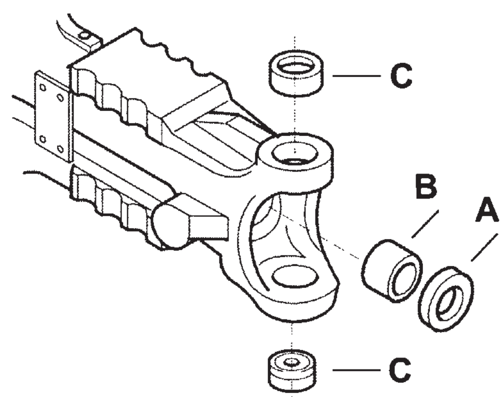
20. Using a suitable puller, remove the bushings from the king pins (Figure 8-57).



A0696 FIGURE 8-57

Axle Beam and Brake Disassembly

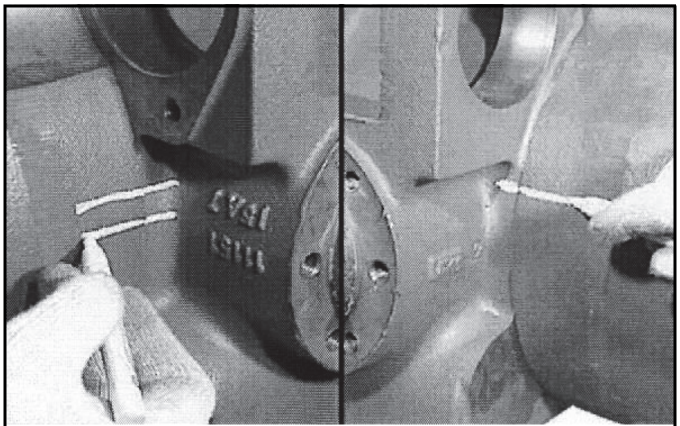
1. Pry the seal ring (**A**, Figure 8-58) from the axle beam. The seal ring will be damaged during the removal procedure. Using a chisel and hammer, remove bushing (**B**) from the axle beam. Using a suitable puller, remove bushings (**C**) from the king pin housings.



A0697 FIGURE 8-58

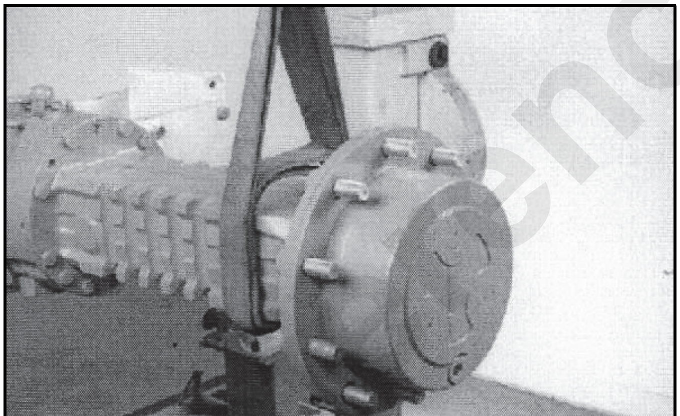
Manitowoc Crane Care

2. Put alignment marks on the axle beam and on the differential supporting flanges (Figure 8-59) to identify the right and left sides during assembly.



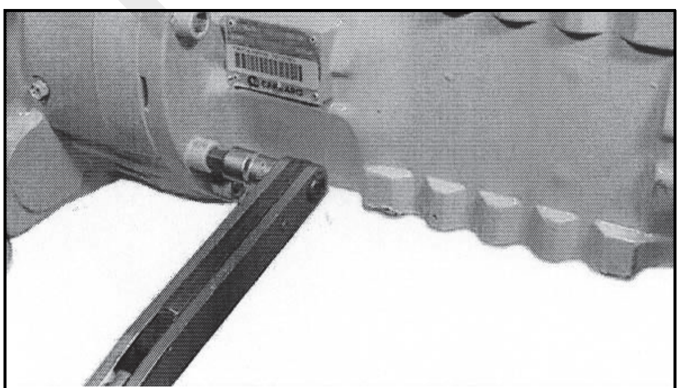
P0606 **FIGURE 8-59**

3. Place the axle on supports. The center housing and two axle beams must have their own supports, which must support each component during disassembly. If supports are not available, use a hoist and sling to support each part separately (Figure 8-60).



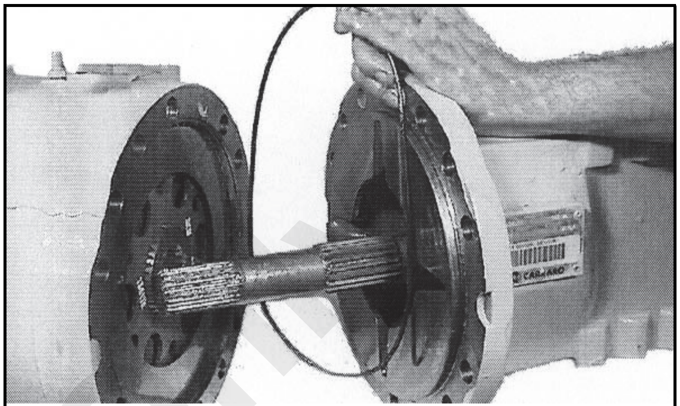
P0607 **FIGURE 8-60**

4. Unscrew the screws securing the axle beam to the center housing (Figure 8-61).



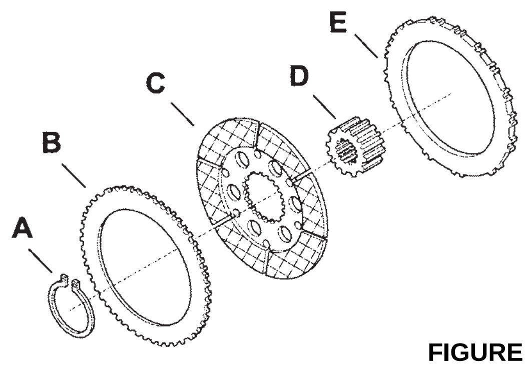
P0608 **FIGURE 8-61**

5. Remove the axle beam (Figure 8-62). When removing the axle beam be careful that the brake discs do not fall from the brake flange. Remove the O-ring from the axle beam.



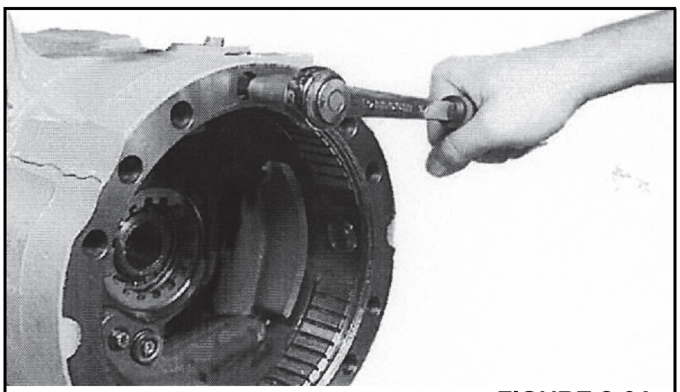
P0609 **FIGURE 8-62**

6. Remove brake counter disc (**B**, Figure 8-63). Remove retaining ring (**A**). Remove brake disc (**C**). Remove brake splined sleeve (**D**). Remove brake counter disc (**E**).



A0698 **FIGURE 8-63**

7. Secure the brake flange using a sling and hoist. Unscrew the upper screw and lower stud bolt (Figure 8-64). Remove the differential supporting flange from the center housing, together with the bevel gear backlash adjusting ring nut.



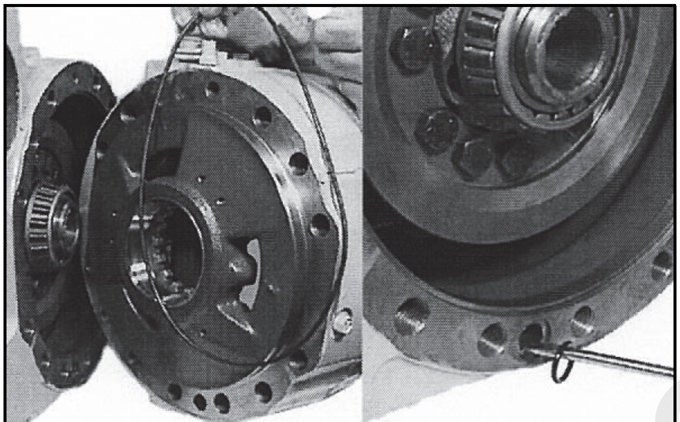
P0610 **FIGURE 8-64**

8

⚠ CAUTION

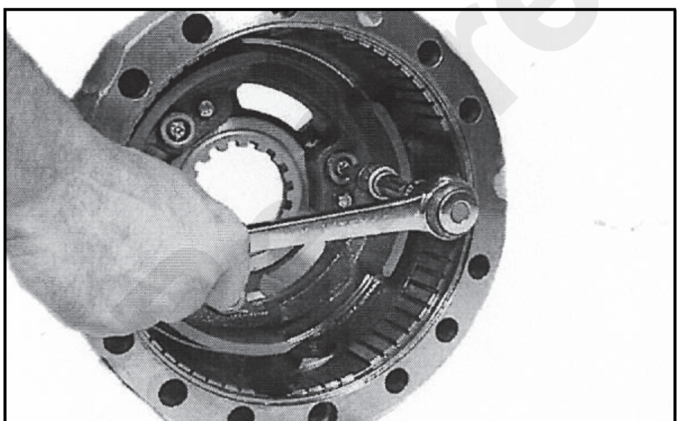
This procedure frees the differential housing, which could fall if not properly supported causing possible personal injury.

8. Remove the O-ring from the brake flange and the O-ring from the oil pipe hole (Figure 8-65). Check the O-rings for damage.



P0611 **FIGURE 8-65**

9. Place the brake flange on a workbench or place in a vise with soft jaws. Unscrew the upper self-adjust screws (Figure 8-66) and remove the springs and bushings.



P0612 **FIGURE 8-66**

10. Remove the brake flange bleed screw (Figure 8-67). Remove the piston out from the front of the brake flange.

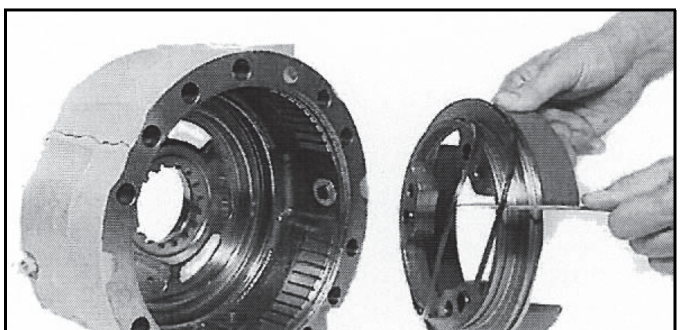
If necessary, use compressed air through the bleed screw port to eject the piston. The piston may eject with force, be sure no part of your body or other persons are in the way of the ejecting piston.

⚠ CAUTION

When using compressed air to remove the piston, pressure is created behind the piston resulting in possible forcible ejection of the piston. Keep clear of the front of the brake flange. Possible personal injury could result from the ejected piston.

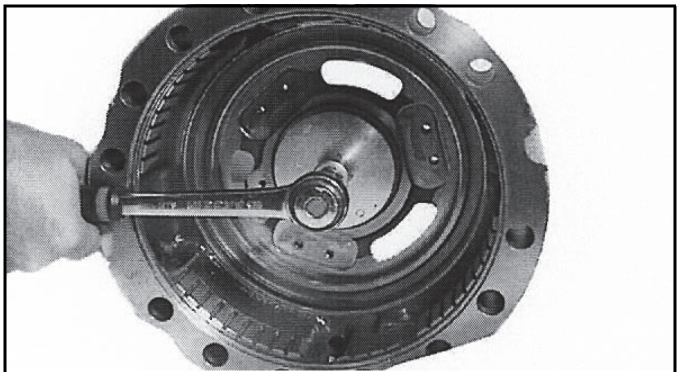
P0613 **FIGURE 8-67**

11. Remove the quad rings (Figure 8-68) from the piston and check their condition.



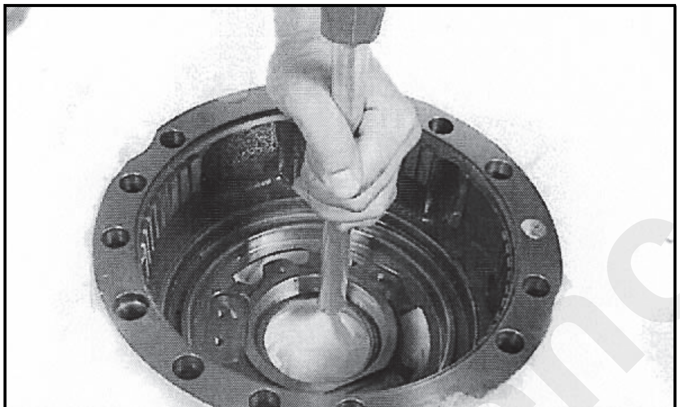
P0614 **FIGURE 8-68**

12. Remove the ring nut retainer by removing the fastening screw (Figure 8-69). Using SPECIAL TOOL P/N 1901773, unscrew and remove the ring nut.



P0615 **FIGURE 8-69**

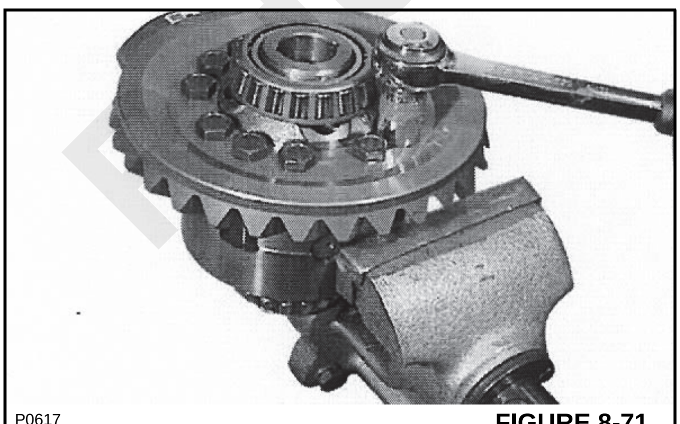
13. Using a hammer and driver, remove the bearing cup from the brake flange (Figure 8-70).



P0616 **FIGURE 8-70**

Differential Disassembly

1. Place the differential in a vice with soft jaws. Remove the bevel gear crown screws (Figure 8-71).

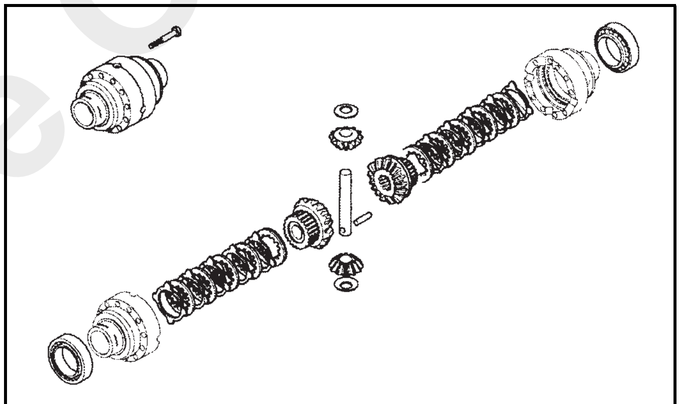


P0617 **FIGURE 8-71**

2. Mark the two differential housing halves to aid in correctly positioning the housing halves during assembly. Separate the two differential housing halves (Figure 8-72).

P0618 **FIGURE 8-72**

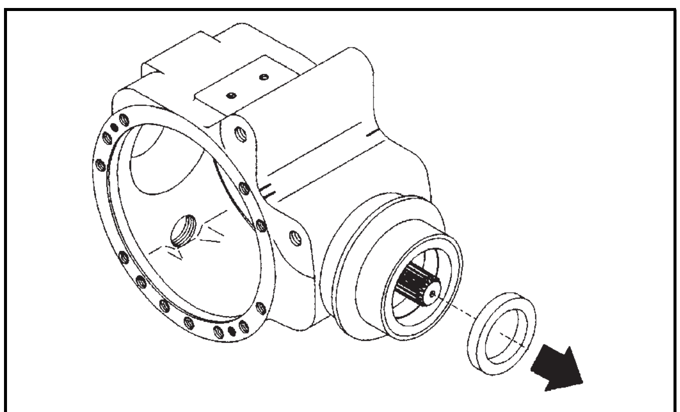
3. Disassemble the components (Figure 8-73). Check for proper operation and for any damage or wear to the components. Remove the bearings from the differential housing halves using a suitable puller.



A0699 **FIGURE 8-73**

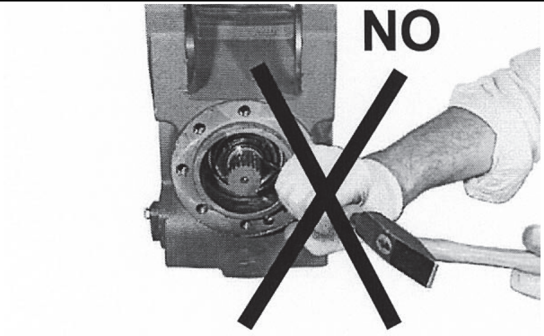
Pinion Disassembly

1. Using a puller, remove the seal ring (Figure 8-74) from the center housing. The seal ring will be damaged.



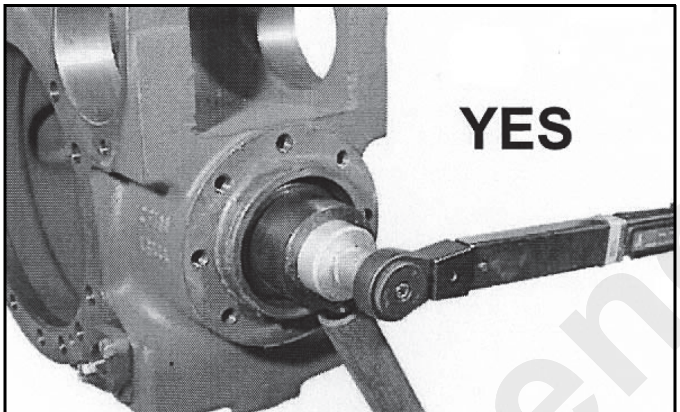
A0700 **FIGURE 8-74**

2. Position the center housing on a flat surface. Do not pry the ring nut out of housing (Figure 8-75). Damage to the bevel pinion threads will occur.



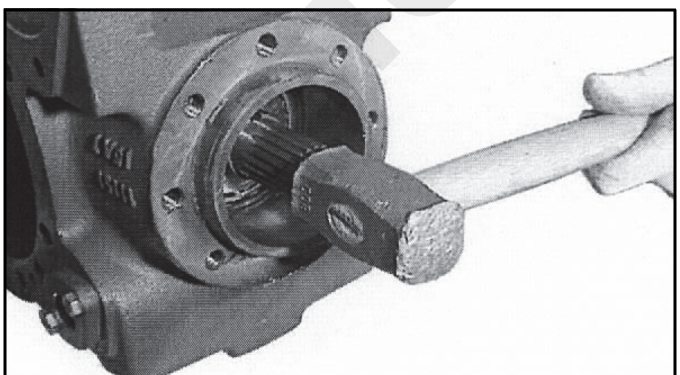
P0619 **FIGURE 8-75**

3. Remove the ring nut (Figure 8-76) with SPECIAL TOOLS P/N 1901768.



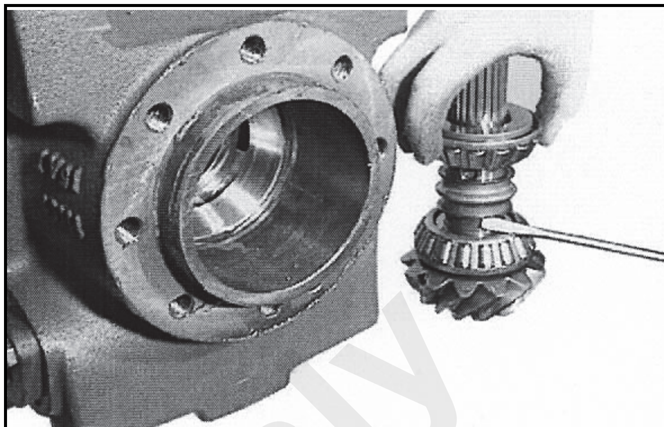
P0620 **FIGURE 8-76**

4. Using a soft hammer, strike the end of the splined end of the pinion to remove the pinion assembly from the housing (Figure 8-77).



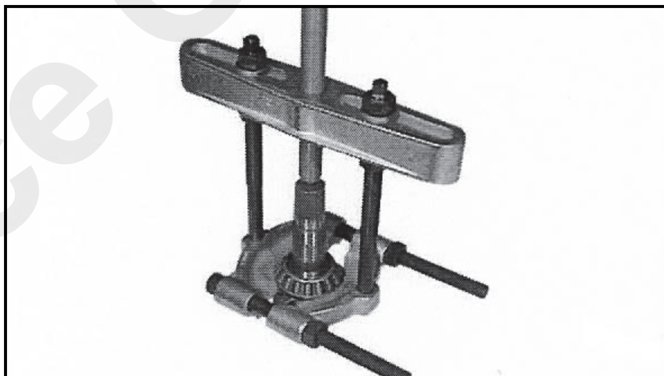
P0621 **FIGURE 8-77**

5. Remove the washers, elastic spacer and bearing cones from the pinion (Figure 8-78). The elastic spacer must be replaced with a new one.



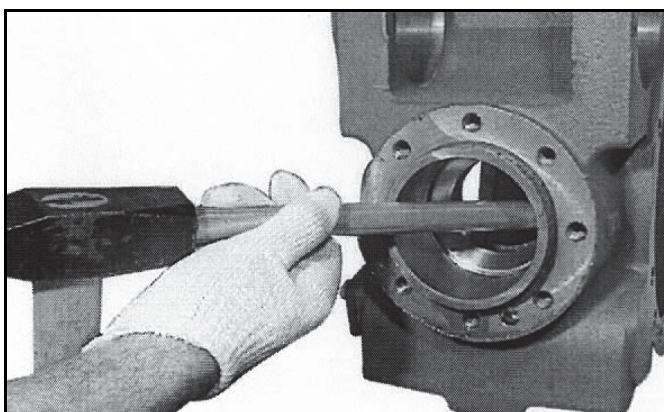
P0622 **FIGURE 8-78**

6. Using a suitable puller, remove the bearing cone from the bevel pinion (Figure 8-79). Remove the adjusting shim under the bearing and check for wear and damage.



P0623 **FIGURE 8-79**

7. Using a chisel and hammer, remove the taper roller bearing cups from the center housing (Figure 8-80).

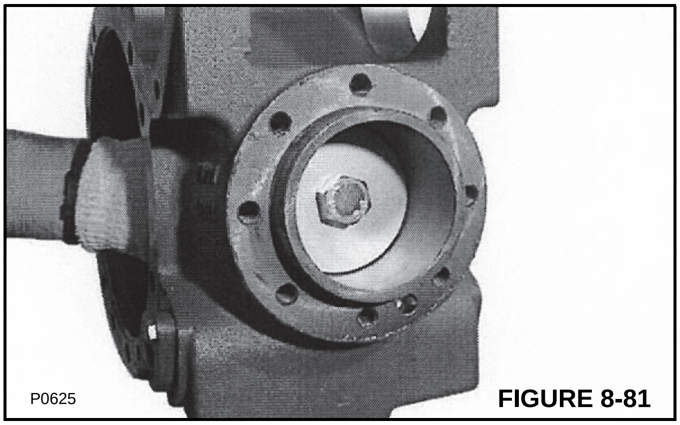


P0624 **FIGURE 8-80**

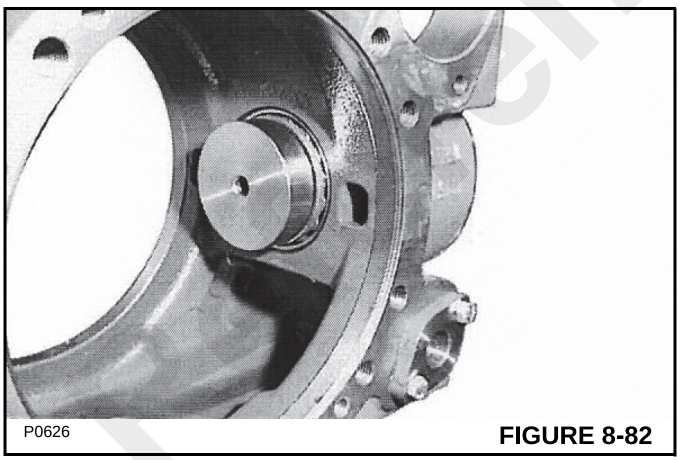
Assembly

Pinion Assembly

1. Place the center housing on a work bench. Using SPECIAL TOOL P/N 1901782, press the taper roller bearing cups (Figure 8-81) into the center housing until they seat.

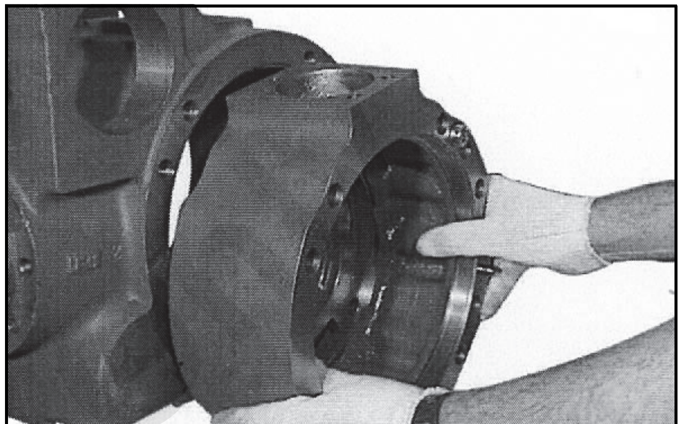

P0625
FIGURE 8-81

2. SPECIAL TOOL P/N 1901775 *(False Pinion)* is needed for this procedure. Insert the false pinion, together with its bearings and ring nut, in the bearing cups in the housing (Figure 8-82) installed in step 1. Tighten the assembly to remove any play (backlash) in the assembly.

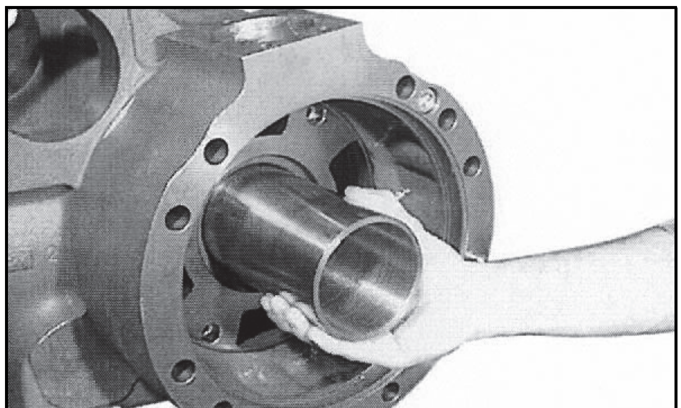

P0626
FIGURE 8-82

3. Check the correct positioning of the right and left brake flanges, using the reference marks on them and the center housing (Figure 8-83).

   Assemble the two brake flanges and secure them with their mounting screws (screw in at least two screws, diametrically opposed to each other in each flange).


P0627
FIGURE 8-83

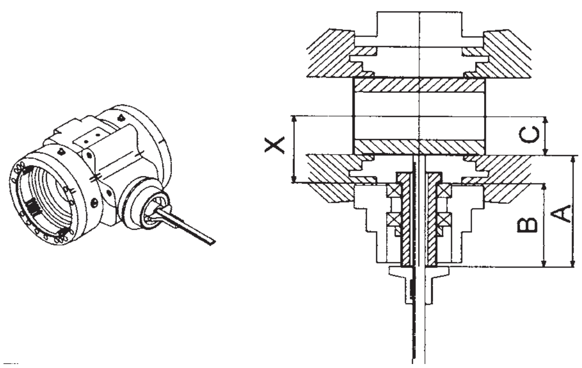
4. Insert SPECIAL TOOL P/N 1901778 *(false differential box)* into the center housing (Figure 8-84). Check that the false differential box is inserted into both brake flange housings.


P0628
FIGURE 8-84

5. Measure the distance measurements described below using a depth gauge through the hole in the false pinion (Figure 8-85).

   X = (conical distance to be measured)
   A = (measured value)
   B = (known value - **100 mm**)
   C = (known value - **45 mm**)

   Measured values all millimeters.



A0701 **FIGURE 8-85**

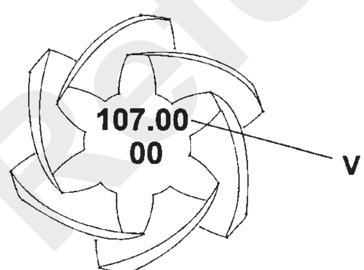
6. To determine the amount of shims (**S**) required between the pinion and bearing perform the following calculation:

   a. Subtract the (**V** - requested conical distance) value stamped on the pinion head (Figure 8-86) from the measured (**X**) value.

      S=X-V

   b. (**X**) value is found by adding measurements (**A** and **C**) together and subtracting **B**.

      X=(A+C)-B



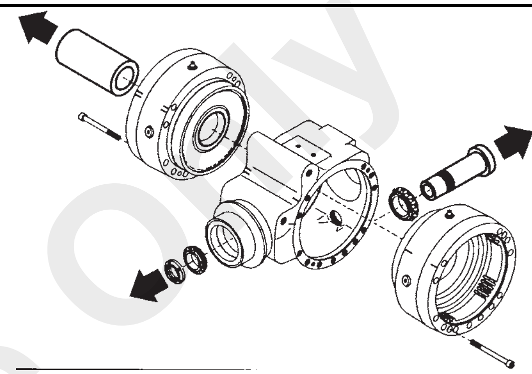
A0702 **FIGURE 8-86**

7. Choose the suitable shim from the available shims in Table 6-1. Shims may be found in the parts manual supplied with the crane.

Table 8-2.

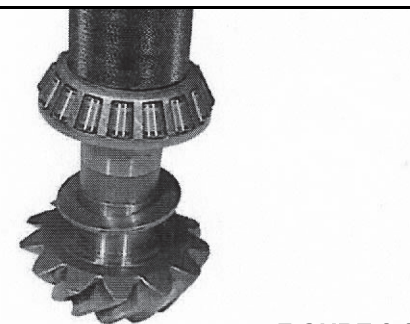
S = SHIM RANGE										
Thick (MM)	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4

8. Remove the false pinion, the bearings and the ring nut from the center housing (Figure 8-87). Remove the false differential box from the center housing. Remove the two brake flanges from the center housing.


A0704 **FIGURE 8-87**

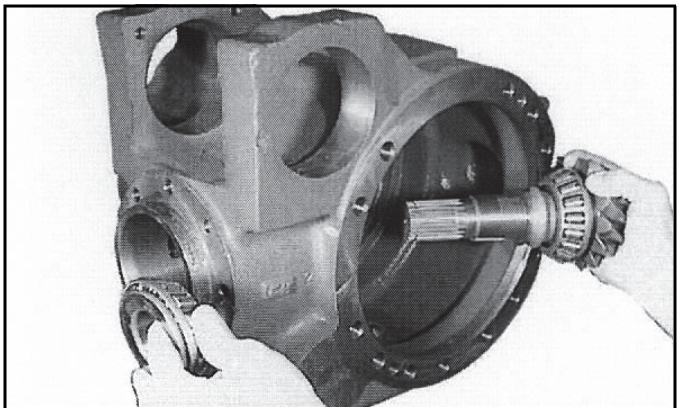
9. Insert the shims (**S**) chosen in step 7 on the pinion shaft with the chamfer edge against the gear (Figure 8-88). Using SPECIAL TOOL P/N 1901772 press the bearing onto the pinion shaft. Be sure it is fully set. Install the washers and new elastic spacer onto the shaft.

NOTE: Always use a new elastic spacer.


P0629 **FIGURE 8-88**

10. Insert the bevel pinion assembly into the center housing and the second bearing cone onto the pinion end (Figure 8-89).

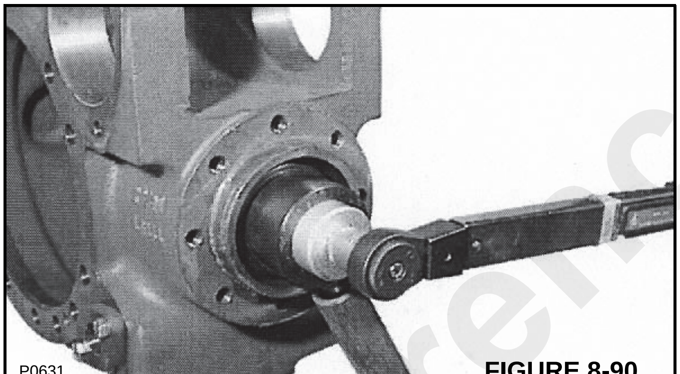
    In order to properly install the bearing use SPECIAL TOOL P/N 1901772 and a hammer to drive the bearing into position. Hold a sledge hammer against the gear while driving the bearing.



P0630 FIGURE 8-89

11. Assemble onto the pinion shaft a new ring nut washer and ring nut retainer.

Screw the ring nut in, using SPECIAL TOOLS P/N 1901768 and P/N 1901773 (Figure 8-90).



P0631 FIGURE 8-90

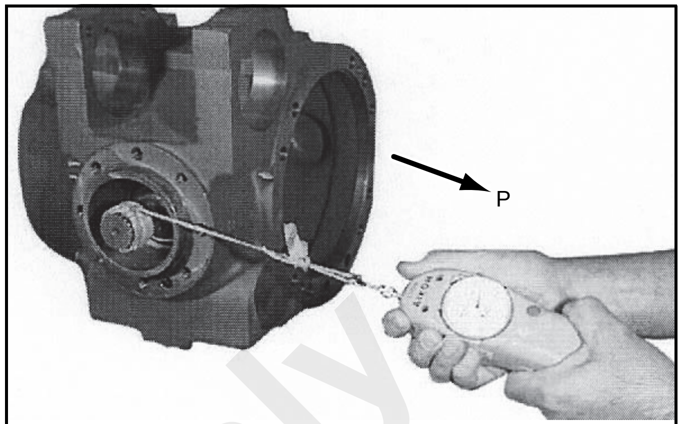
NOTE: The torque setting is determined by the pre-loading measurement on the bearings. Tighten the ring nut step by step. If it is tightened too much, the elastic spacer should be replaced and the procedure repeated. When checking the pre-load, it is advisable to hit the pinion ends slightly with a soft hammer to set the bearings.

12. To check the bearing pre-load, use a dynamiter and string. Wind the string around the spline end of SPECIAL TOOL (P/N 1901772) inserted on the pinion shaft (Figure 8-91).

NOTE: The pre-load measurement should be done without the seal ring installed.

With the dynamiter attached to the string, pull the dynamiter and take a reading. Tighten or loosen the ring nut until 9.2 - 13.8 daN *(20 - 31 pounds)* of force is required to turn the pinion. When the correct turning force is obtained, peen the ring nut using a hammer and a chisel.

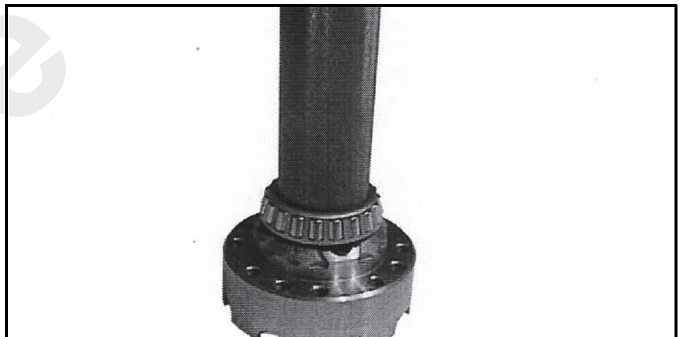
P = 9.2 - 13.8 daN
(20 - 31 pounds)



P0632 FIGURE 8-91

Differential Assembly

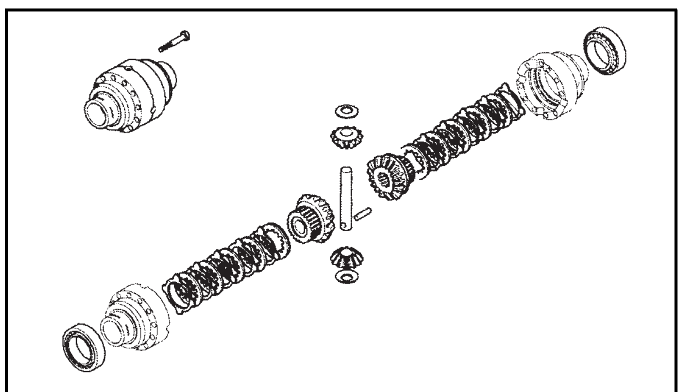
1. Install the bearing cones of the new taper roller bearings on the differential housing halves (Figure 8-92). Use SPECIAL TOOL P/N 1901771 and a hammer.



P0633 FIGURE 8-92

2. Place a housing half on a work bench and assemble all of its inner components (discs, counterdiscs, planetary gears, sun gears, thrust washers and pins) as shown in Figure 8-93.

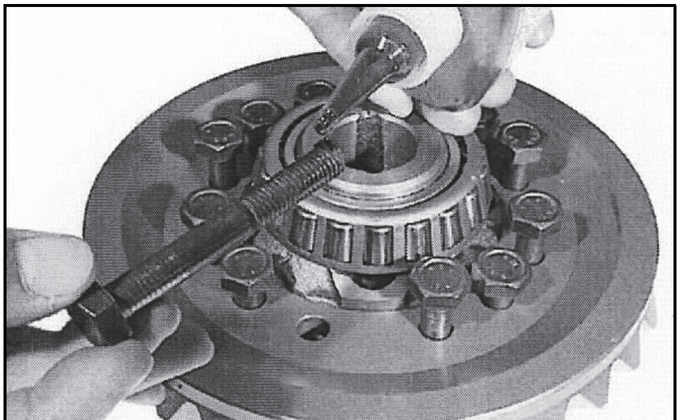
Join the two housing halves, aligning the reference marks made during disassembly.



A0699 FIGURE 8-93

8

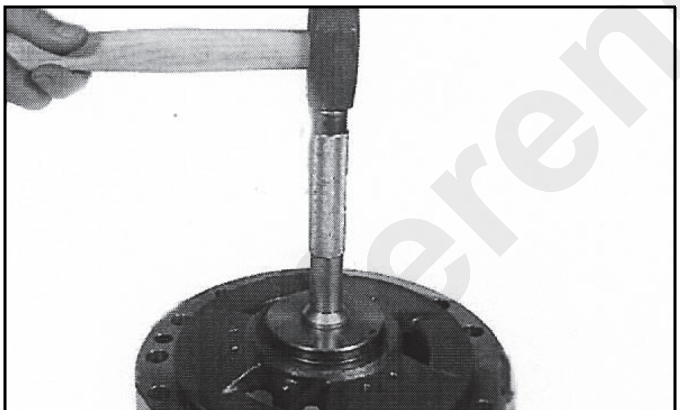
3. Position the ring bevel gear on the assembled differential housing (Figure 8-94). Apply Loctite 270 on the threads of screws. Install the screws and tighten to a torque of 95 Nm (70 lb-ft).



P0634 FIGURE 8-94

Brake Flange and Differential Housing Assembly

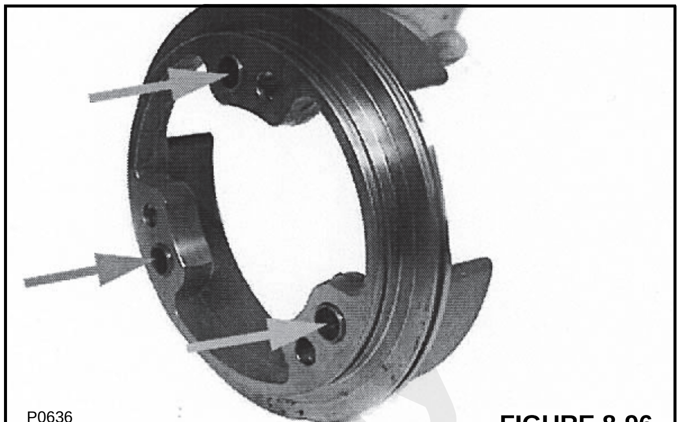
1. Place the brake flange on a flat surface. Install the cup of the taper roller bearing in position using SPECIAL TOOL P/N 1901771, the interchangeable handle P/N 1901764 and a hammer (Figure 8-95).



P0635 FIGURE 8-95

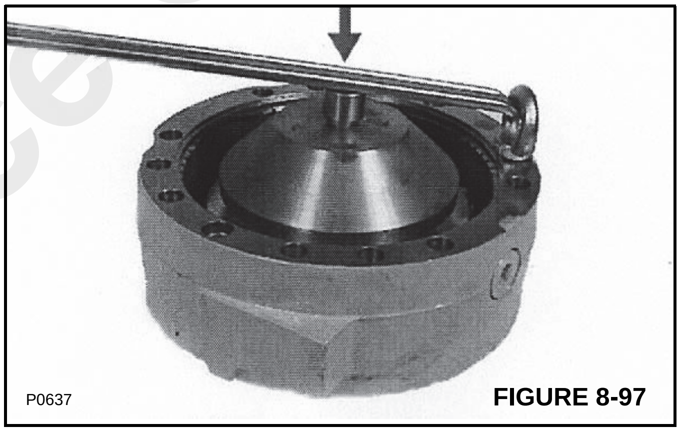
2. Install the washers into the self-adjust housings (Figure 8-96) of the brake piston. Push the washers into the holes until they align with the piston supporting inner surface.

   Install the quad rings on the piston and coat the quad ring surface of the piston with a light coat of grease.



P0636 FIGURE 8-96

3. Install the piston into the brake flange and position SPECIAL TOOL P/N 1901779 or a flat disc on the piston (Figure 8-97). With a lever anchored to an eyebolt, exert just enough pressure to insert the piston into the brake flange.

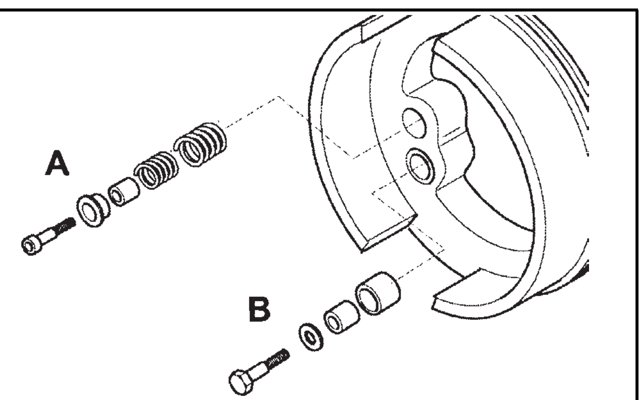


P0637 FIGURE 8-97

4. Install the self-adjust kit components in the correct sequence (Figure 8-98).

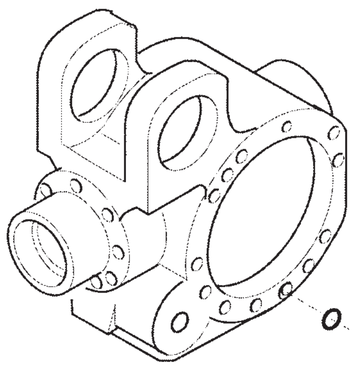
   Install the first three self-adjusting groups (**A**) and tighten the screw to a torque of 10 Nm (7.35 lb-ft).

   Install the remaining three groups (B) and tighten the screws to a torque of 10 Nm (7.35 lb-ft).



A0705 FIGURE 8-98

5. Install a new O-ring (Figure 8-99) in the oil pipe hole on the center housing. Lubricate the O-ring before installation.



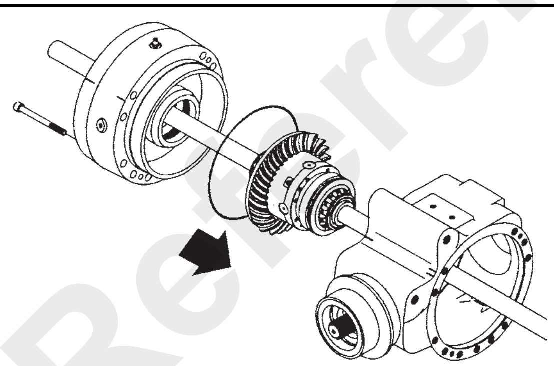
A0706 **FIGURE 8-99**

6. Install a new O-ring on the brake flange (Figure 8-100).

7. Repeat steps 1-6 for the second brake flange.

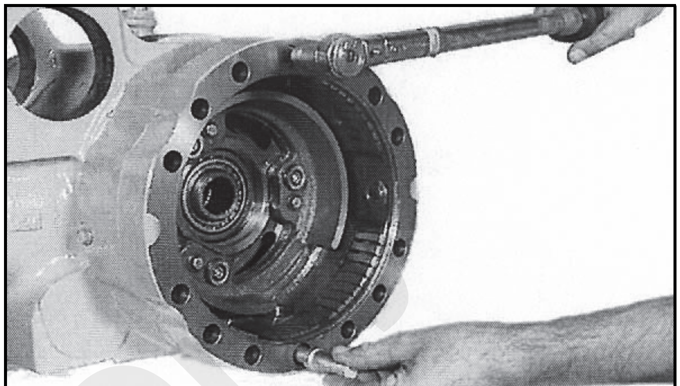
8. First, position the brake flange on the side of the ring bevel gear. Then, using a round bar inserted through the differential assembly install the assembly into the center housing. Check reference marks from disassembly for correct flange positioning.

NOTE: Be sure the differential assembly is installed on the correct side of the center housing. It is possible to install it on the wrong side.



A0707 **FIGURE 8-100**

9. Install the upper screw and lower stud bolt to fasten the brake flange to the center housing (Figure 8-101). Tighten the upper bolt to a torque of 80 Nm (59 lb-ft). Tighten the lower stud bolt to 120 Nm (88 lb-ft).

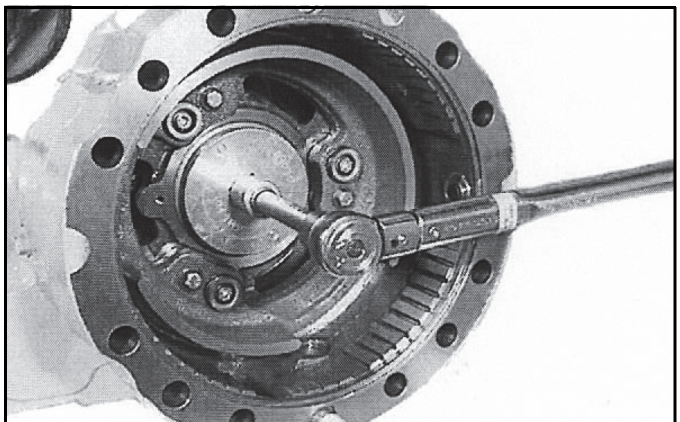


P0638 **FIGURE 8-101**

10. Install the second brake flange on the opposite side of the center housing. Install upper screw and lower stud as in step 9.

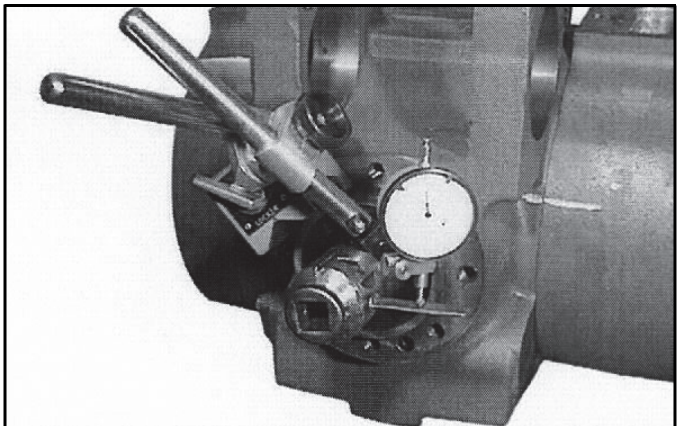
Install and hand tighten the two ring nuts (one each side of the differential housing). Using SPECIAL TOOL P/N 1901763 tighten both ring nuts evenly until bearing backlash is eliminated (Figure 8-102). Then measure the pinion-ring gear backlash.

NOTE: Tighten each ring nut in steps until tight. Do not overtighten.



P0639 **FIGURE 8-102**

11. Install SPECIAL TOOL P/N 1901769 to the end of the pinion shaft (Figure 8-103). Using a dial indicator mounted so that the feeler is in contact with the bracket surface of the SPECIAL TOOL at 90° Move the pinion shaft in both directions while holding the differential from moving and read the dial indicator. Check that the measured backlash is within the range of **0.15 - 0.20 mm (0.006 - 0.008 in).**



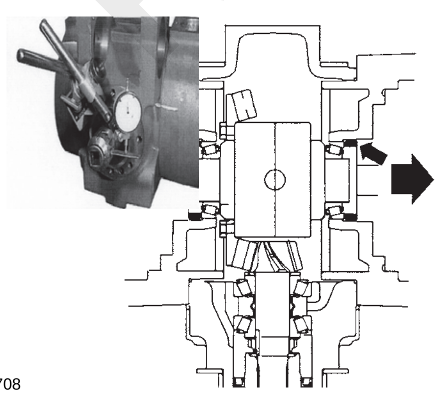
P0640 **FIGURE 8-103**

If the backlash in not correct, adjust the ring nuts using SPECIAL TOOL P/N 1901763.

When adjusting the ring nuts, remember that:

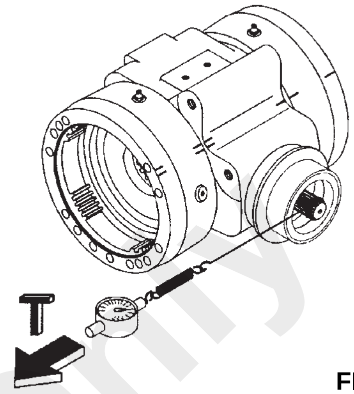
- If **the measurement backlash is less** than the given tolerance range, screw in the ring nut from the side opposite the bevel gear and unscrew the ring nut on the bevel gear side the same amount.
- If **the measured backlash is higher** than the given tolerance range, screw in the ring nut on the side of the bevel gear and unscrew the side opposite the same amount.

12. When the pinion-bevel gear backlash has been adjusted, check that there is a minimum pre-loading on the differential housing bearings (Figure 8-104).



A0708 **FIGURE 8-104**

13. Measure the total pre-loading (**T**) of the bearing (pinion-bevel gear system), using a dynamometer whose cord is wound on the pinion spline end (Figure 8-105).



A0709 **FIGURE 8-105**

The measured value should be within the following range:

T=(P+1.72) - (P+2.58) POUNDS
T=(P+3.85) - (P+5.8) daN

P is the pre-loading measured on the pinion in Step 12, Pinion Assembly.

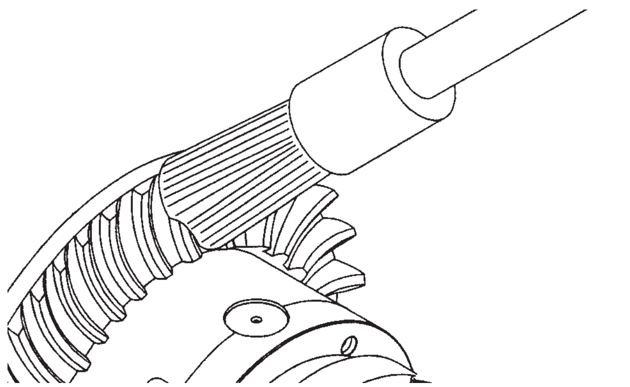
NOTE: The Pre-load should be measured without the seal ring being installed

If the measurement is not within the tolerance range, check the assembly of each component and then adjust the pre-load using the two ring nuts on the differential.

- If **the total pre-load is less** than the given range, tighten the two ring nuts the same amount, keeping the pinion-bevel gear backlash value unchanged.
- If **the total pre-load is higher** than the given range, loosen the two ring nuts the same amount, keeping the pinion-bevel gear backlash value unchanged.

Recheck the backlash and preload.

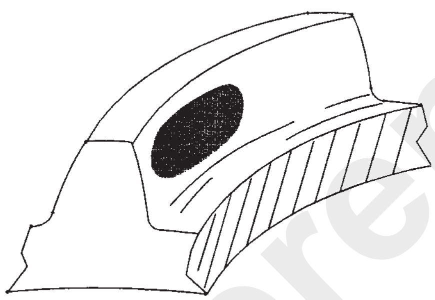
14. To test the tooth contact of the pinion with the bevel gear, paint the teeth of the bevel gear with red lead paint (Figure 8-106). The test should always be performed on both sides of the bevel gear teeth.



A0710 **FIGURE 8-106**

15. Correct Contact. (Figure 8-107)

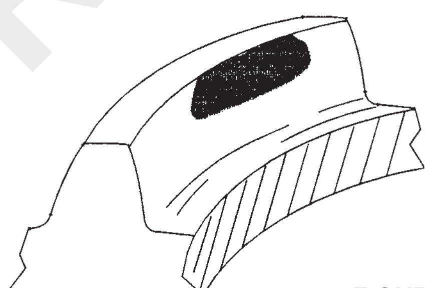
The bevel gear is adjusted correctly, the mark on the pinion teeth will be regular.



A0711 **FIGURE 8-107**

16. Excessive contact on the tooth tip - Z contact. (Figure 8-108)

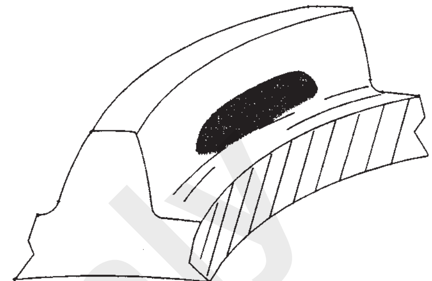
Move the bevel gear away from the pinion to adjust the backlash. See Figure 8-110.



A0712 **FIGURE 8-108**

17. Excessive contact at the tooth base - X contact. (Figure 8-109)

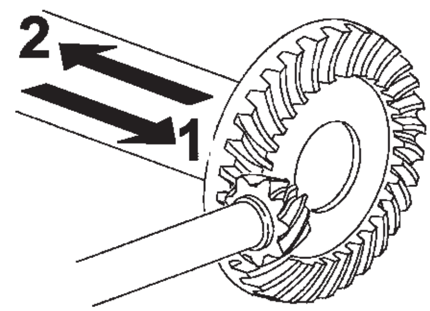
Move the bevel gear toward the pinion to adjust the backlash. See Figure 8-110.



A0713 **FIGURE 8-109**

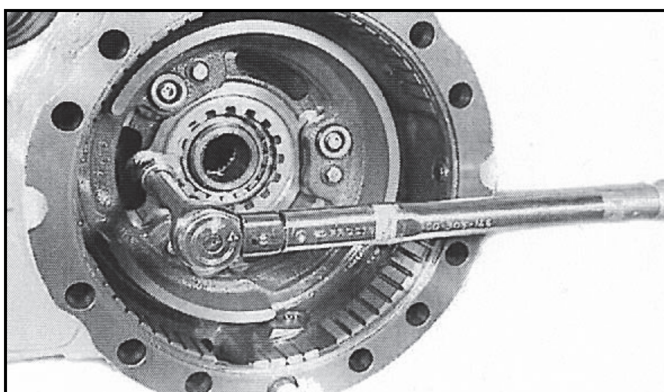
18. Movements to correct backlash (Figure 8-110):

1. Move the bevel gear for type **X** contact adjustment.
2. Move the bevel gear for type **Z** contact adjustment.



A0714 **FIGURE 8-110**

19. Install the ring nut retainer turning the ring nut slightly to align it with the retainer (Figure 8-111). Install the ring nut retainer screw and tighten to a torque of 13 Nm (9.5 lb-ft).



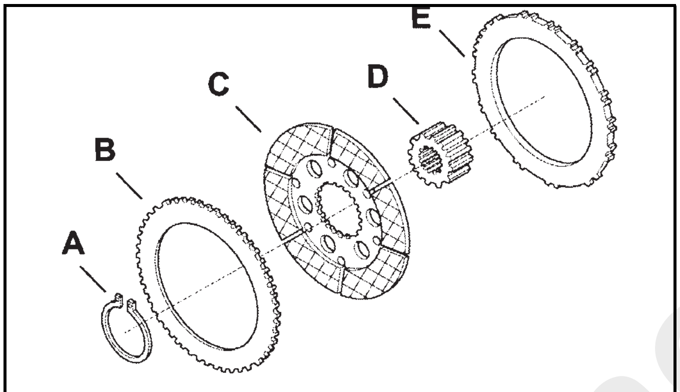
P0641 **FIGURE 8-111**

Axle Beam and Brake Assembly

1. Inspect the friction disc and counterdiscs for signs of burning. If burning is found, replace the discs. Also, check the discs for wear. Replace any disc that is out of tolerance.

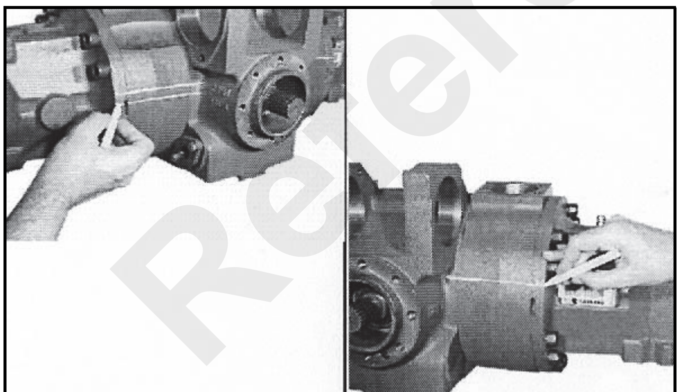
   Assemble the components of the brake assembly inside the brake flange in the sequence shown in Figure 8-112: counterdisc (**E**), coupling (**D**) with the retainer ring groove outward, friction disc (**C**), retaining ring (**A**) and counterdisc (**B**).

NOTE: If new brake discs are being used, dip them in Mobil Fluid 424 hydraulic oil before assembling.



A0715 **FIGURE 8-112**

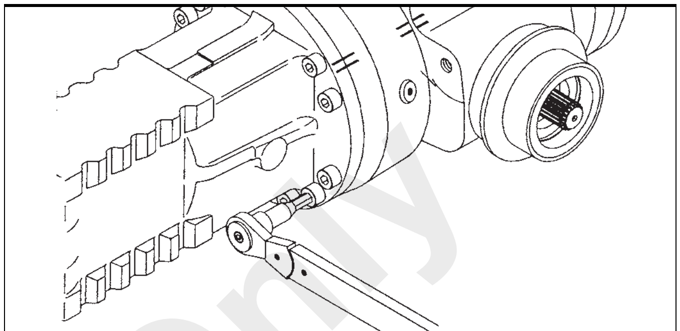
2. To ensure correct assembly of the axle beams, check the reference marks (Figure 8-113) made during disassembly.


P0642 **FIGURE 8-113**

NOTE: Be sure to properly support the axle beams and center housing during this assembly procedure.

3. Install a new O-ring into the axle beam housing. Install the axle beam on the brake flange (Figure 8-114). Be careful to align the mounting holes.

   Install the mounting bolts and tighten to a torque of 320 Nm (235 lb-ft).

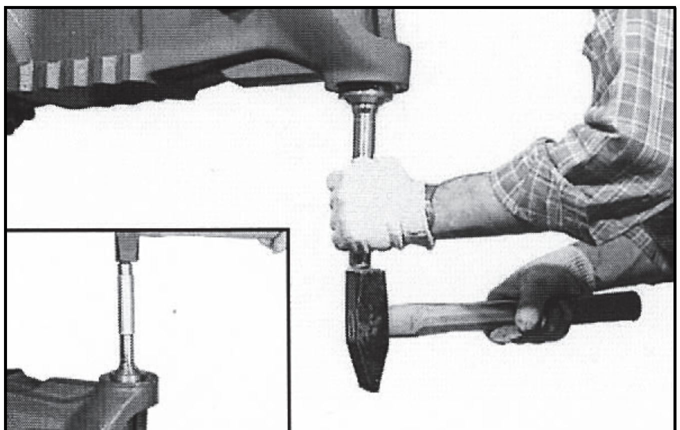

A0716 **FIGURE 8-114**

Axle Beam Group Assembly

1. Install the upper king bushing on the axle beam with SPECIAL TOOL P/N 1901780 and a hammer (Figure 8-115).

   Install the cup of the ball bearing on the lower part of the axle beam with SPECIAL TOOL P/N 1901780 and a hammer.

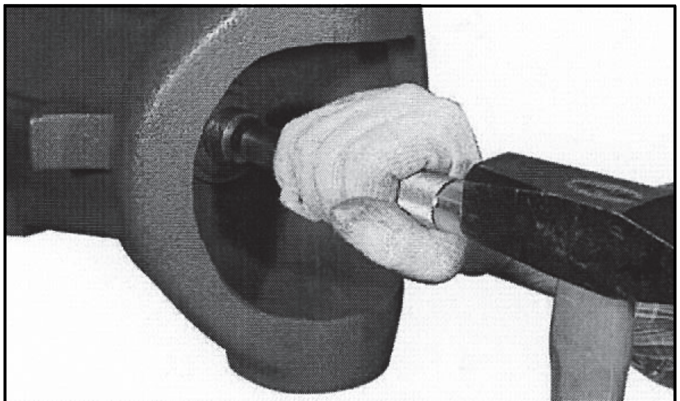
NOTE: To make the installation easier, cool the bearing.


P0643 **FIGURE 8-115**

2. Install the bushing in the axle beam housing with SPECIAL TOOL P/N 1901777 and a hammer (Figure 8-116).

   Fill 3/4 of the seal ring cavity with grease and apply a sealing compound on seal ring's outer surface.

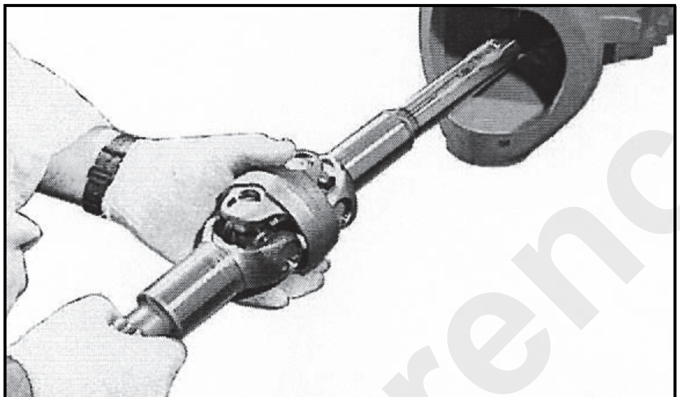
   Install the seal ring in the axle beam with SPECIAL TOOL P/N 1901765 and a hammer.



P0644 FIGURE 8-116

3. Lubricate the bushing and lips of the ring seal. Install the U-joint inside the axle beam (Figure 8-117).

NOTE: Be careful not to damage the ring seal.



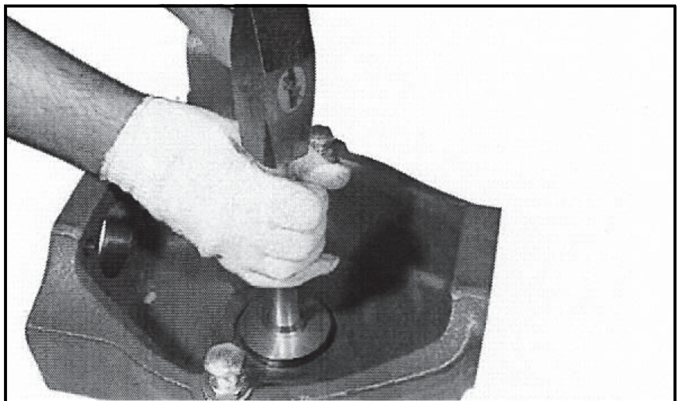
P0645 FIGURE 8-117

Wheel Hub Assembly

1. Install the bushing into the swivel housing with SPECIAL TOOL P/N 1901766 and a hammer or press (Figure 8-118).

   Fill 3/4 of the ring seal cavity with grease. Apply sealing compound on the outer metallic surface of the ring seal.

   Install the ring seal into the swivel housing with SPECIAL TOOL P/N 1901767 and a hammer.

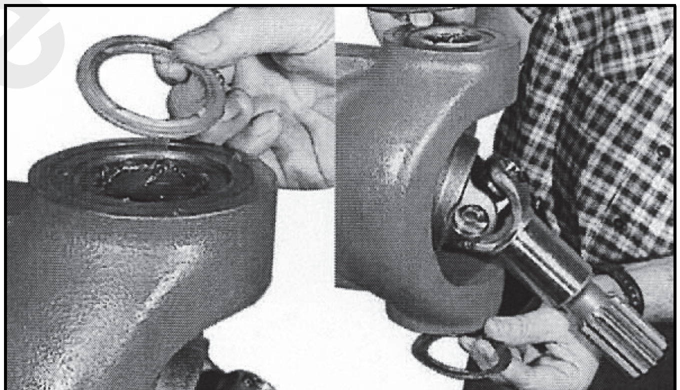


P0646 FIGURE 8-118

2. Grease the inside of the kingpin cavities of the swivel housing.

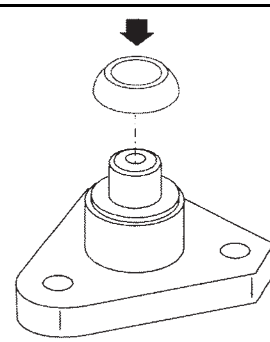
   Place a shim under the Belleville washer and install this assembly in each kingpin cavity (Figure 8-119).

NOTE: Be sure the shim is under the Belleville washer.



P0647 FIGURE 8-119

3. Place the lower kingpin on a workbench and install the bearing cone (Figure 8-120) with SPECIAL TOOL P/N 1901781, using a press.



A0717 FIGURE 8-120

8

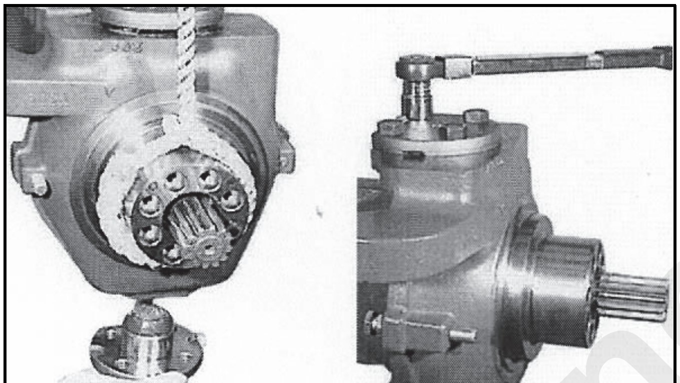
4. Secure the swivel housing with a rope and hoist (Figure 8-121).

NOTE: Be sure the swivel housing is securely fastened before lifting it in place. Possible personal injury could result from a falling swivel housing.

Lubricate the lips of the ring seal. Tape the splined end of the axle shaft to protect the ring seal during installation of the swivel housing. Install the swivel housing to the axle beam.

Position the upper and lower king pins to the swivel housing. Install the mounting screws and tighten to a torque of 190 Nm (140 lb-ft).

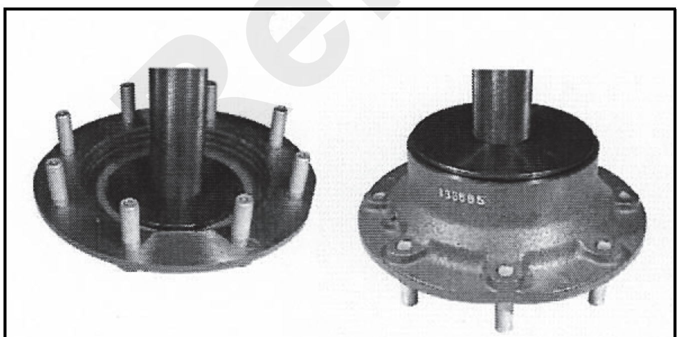
Be sure the Belleville washers remain in position.



P0648 **FIGURE 8-121**

5. Place the wheel hub on a workbench and install the two taper roller bearing cups with SPECIAL TOOL P/N 1901774 and a press or hammer (Figure 8-122).

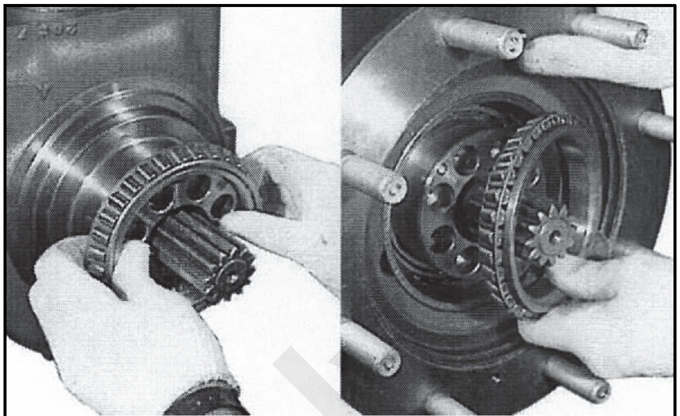
Apply sealing compound on the ring seal outer surface and install the ring seal in the wheel hub with SPECIAL TOOL P/N 1901774 and a hammer.



P0649 **FIGURE 8-122**

6. Install the bearing cone on the swivel housing end (Figure 8-123).

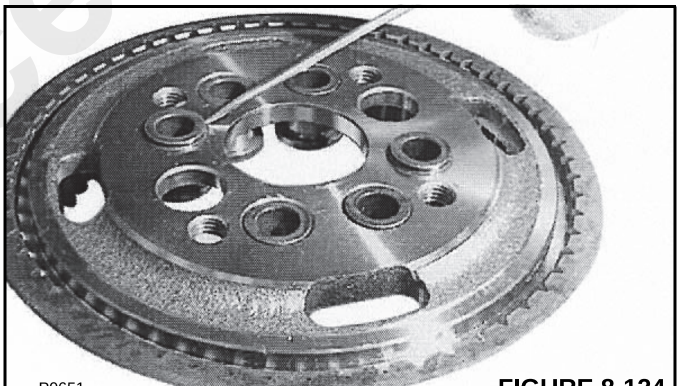
Install the wheel hub on the swivel housing and then install the other bearing cone in position.



P0650 **FIGURE 8-123**

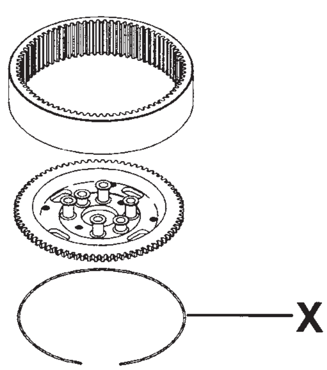
7. Place the wheel carrier on a workbench and install the bushings (Figure 8-124) level to the carrier surface using SPECIAL TOOL P/N 19001776.

At least two bushings (diametrically opposed) should be set slightly higher than the carrier surface to be used as dowel pins.



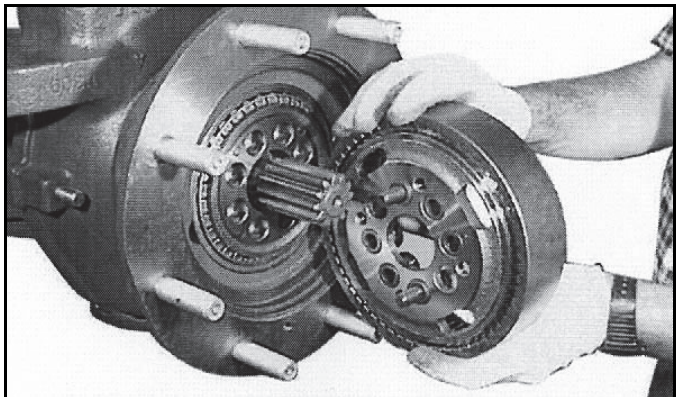
P0651 **FIGURE 8-124**

8. Pre-assemble the wheel carrier, epicyclic ring gear with the special lock ring (**X**) shown in Figure 8-125.



A0718 **FIGURE 8-125**

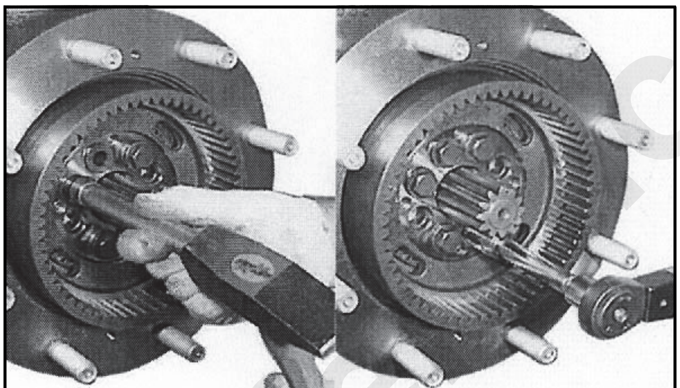
9. Install the wheel carrier assembly on the wheel hub using the two projecting bushings as dowel pins



P0652 **FIGURE 8-126**

10. Drive the dowel bushings flush using SPECIAL TOOL P/N 1901776 and a hammer (Figure 8-127).

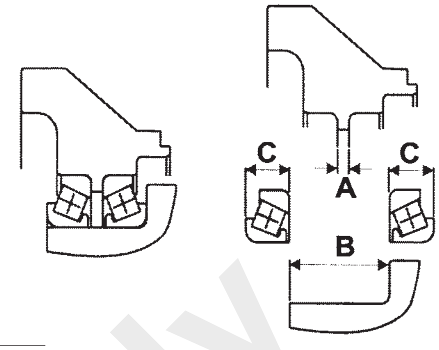
Install the wheel carrier mounting screws and tighten to a torque of 120 Nm (88 lb-ft).



P0653 **FIGURE 8-127**

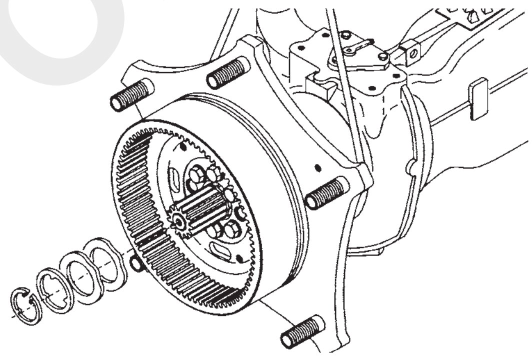
11. The installation of the wheel carrier does not require any pre-loading or backlash adjustments. Although, when installing new components check the dimensions shown in Figure 8-128.

A = 5.900 - 5.950 mm (0.232 - 0.234 in)
B = 52.229 - 52.279 mm (2.056 - 2.058 in)
C = 23.070 - 23.172 mm (0.908 - 0.912 in)



A0719 **FIGURE 8-128**

12. Install the rings and shim onto the axle shaft and lock with the retaining ring (Figure 8-129).



A0720 **FIGURE 8-129**

Epicyclic Reduction Gear Assembly

1. Gather all the components of the epicyclic planetary gear assembly (Figure 8-130). Be careful not to loose any of the rollers.

P0592 **FIGURE 8-130**

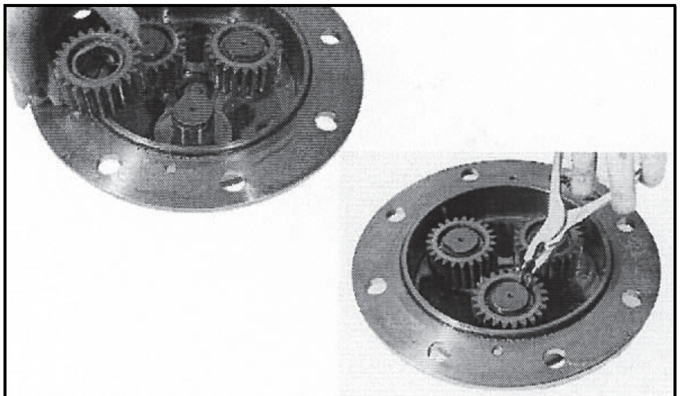
8

2. Place the planetary carrier on a workbench.

Install the epicyclic planetary gears onto the planetary pins (Figure 8-131). Then install the rollers inside the planetary gears.

Install the washers.

Install the retaining rings with a suitable pliers, to secure the gears.

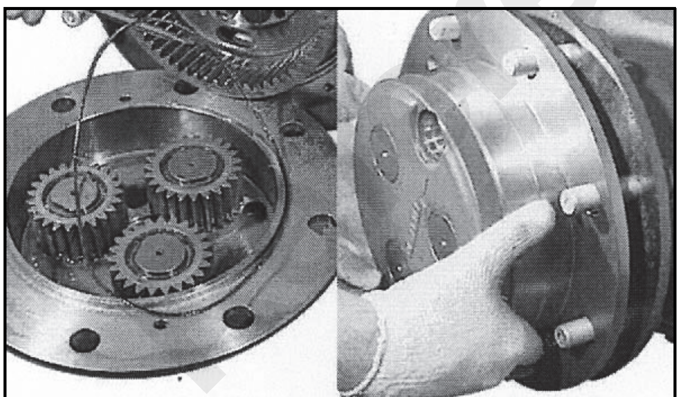


P0654 FIGURE 8-131

3. Install a new O-ring on the planetary carrier (Figure 8-132).

Position the epicyclic planetary gear assembly on the wheel hub.

Install the mounting screws and tighten to a torque of 25 Nm (18 lb-ft).

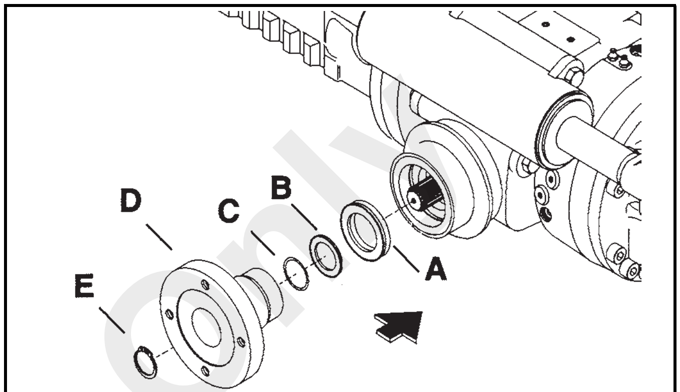


P0655 FIGURE 8-132

Flange Assembly

1. Install seal ring (**A**, Figure 8-133) in the center housing with SPECIAL TOOL P/N 1901779 and a hammer.

Insert washer (**B**) onto the splined pinion end. Install new O-ring (**C**) and flange (**D**). Secure the assembly with retaining ring (**E**).



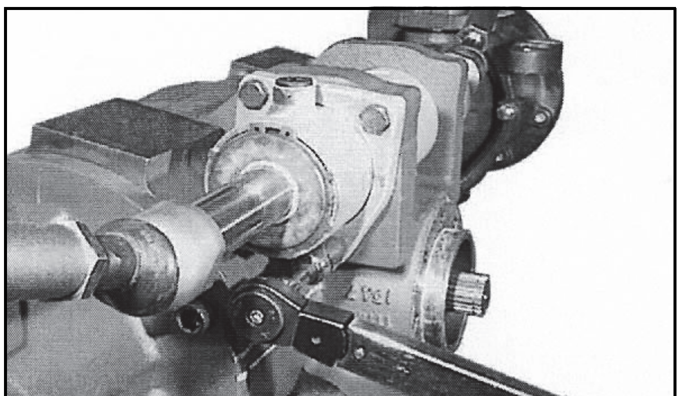
A0721 FIGURE 8-133

Steering Cylinder

1. Install the tie rods to the ends of the cylinder rod (Figure 8-134) and tighten to a torque of 300 Nm (221 lb-ft).

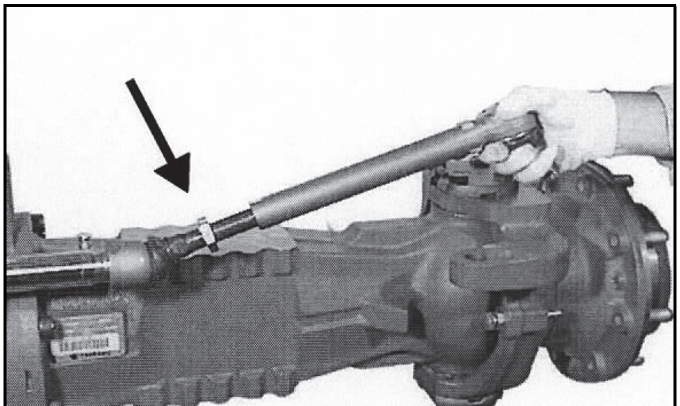
Position the steering cylinder through the mounting flanges of the center housing with the tie rods attached.

Install the three mounting screws and tighten to a torque of 120 Nm (88 lb-ft).



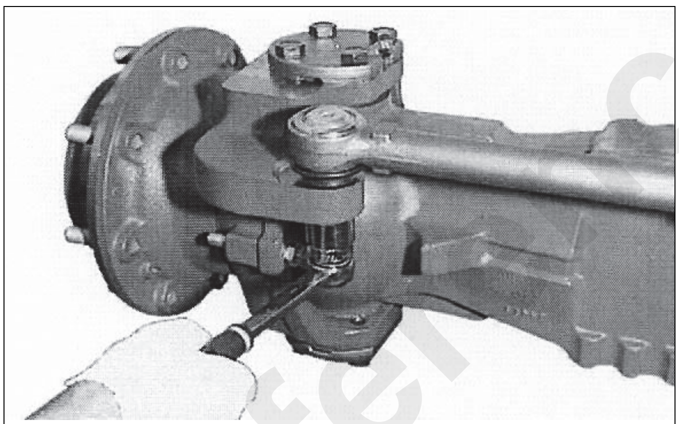
P0656 FIGURE 8-134

2. Loosen the jam nut on the guide rod and adjust the guide so that the ball joint can be inserted into the swivel housing (Figure 8-135).



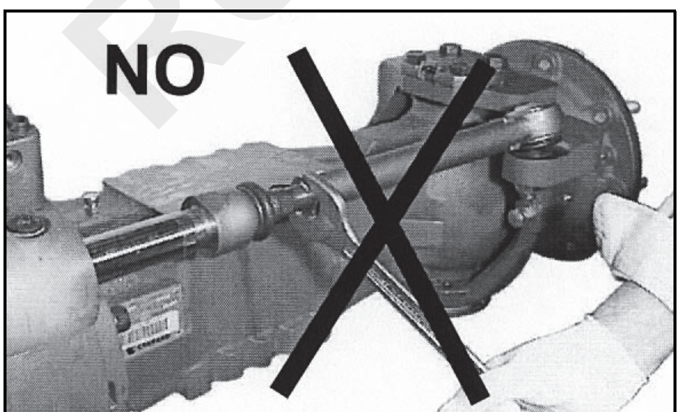
P0657 FIGURE 8-135

3. Insert the ball joint in the swivel housing (Figure 8-136). Install the lock nut and tighten to a torque of 220 Nm (162 lb-ft).



P0658 FIGURE 8-136

4. Tighten the jam nut only after the toe-in adjustment has been performed.



P0659 FIGURE 8-137

Toe-in Adjustment

See page 8-3 for toe-in adjustment procedures

Steering Angle Adjustment

See page 8-5 for steering angle adjustment.

Installation

WARNING

Crushing Hazard!

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's hydraulics or jacks to support the machine when working under it.

Disconnect the battery cables while you're under the machine to prevent the engine from being started.

1. Position the axle under the frame and install mounting bolts and nuts. Tighten to a torque of 362 Nm (266 lb-ft).
2. Connect the drive shaft to the axle flange.
3. Connect the hydraulic hoses to the steering cylinder
4. Connect the brake lines to the axle brake housings.
5. Fill the axle differential, brake housings and wheel hubs with proper lubricant. See *Maintenance*, page 5-1.
6. Install the rims and tires. Do not lower the tires to ground until the axle is tested for proper operation.

7. If the axle has been repaired, test the axle for proper operation:
   a. Set the parking brake to lock the pinion shaft.
   b. With the help of another person, standing on the opposite side, begin rotating each wheel forward as much as possible (both wheels will become blocked after awhile).
   c. Free the right wheel and rotate the left wheel forward. Rotate the right wheel in opposite direction. The left wheel will turn freely without difficulty and the right wheel will turn in the opposite direction if axle assembly has been performed correctly. Repeat the procedure in the opposite direction (reverse gear).

      IF ONE OF THE WHEELS DOES NOT ROTATE FREELY IN BOTH DIRECTIONS, then check step by step all assembly procedures. Check that the brakes are installed properly and are functioning correctly.

8. Bleed the brakes. See *Brake System*, page 9-1.
9. Lower the wheels to the ground.
10. Bleed the steering lines, see *Steering System*, page 10-1.

REAR STEERING AXLE REPAIR

WARNING

Crushing Hazard!

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Disconnect the battery cables while you're under the machine to prevent the engine from being started.

Removal

1. Lower the outriggers to raise the rear axle. Place blocks under the rear of the frame. Remove the rear wheels and tires.
2. Disconnect the hydraulic hoses from the steering cylinder. Plug and cap the hoses and ports.
3. Place a wheel jack under the axle beam. Remove the axle mounting bolts (36, Figure 8-138) and self-locking nuts (35). Carefully lower the axle. Remove the axle from under the machine.

Disassembly

Axle Hub

1. If axle is attached to the frame, remove the rear wheels and tires. See warning above.
2. Remove hub cap (20, Figure 8-138). Then remove the cotter pin (19), slotted nut (21), washer (22) and outer bearing cone (18).
3. Pull hub (24) from spindle (9 or 10).
4. Remove the inner bearing cone (15) from the hub.
5. Remove outer oil seal retainer (14) and felt seal (13). Do not remove inner oil seal retainer (12) and spacer (11) from the spindle unless replacement is necessary.
6. Repeat steps 2 though 5 on the other side.

Steering Knuckle

NOTE: The steering knuckle can be removed without disassembling the axle hub.

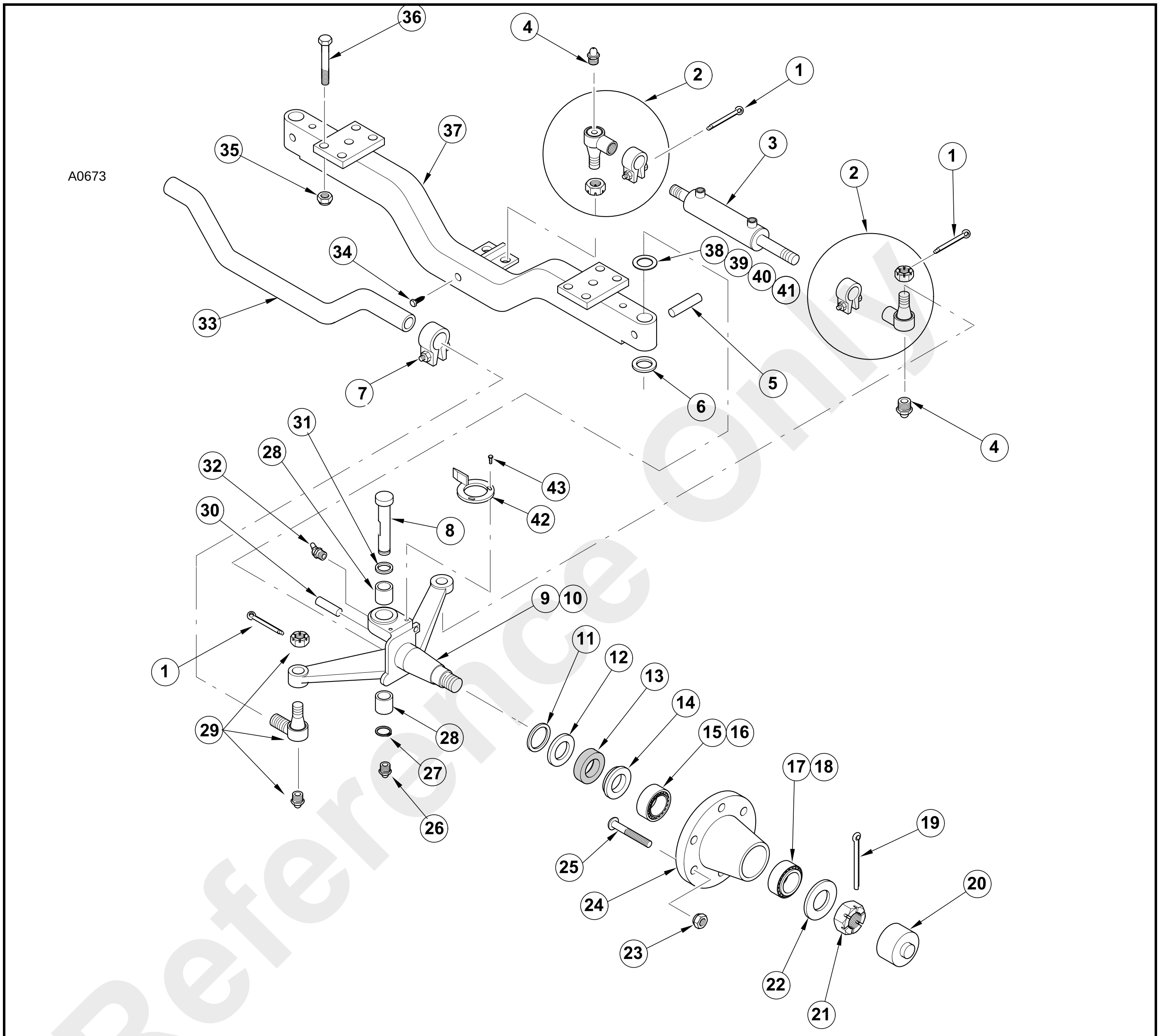
1. Disconnect the steering cylinder (3) from one of the steering knuckles (9 or 10, Figure 8-138).
2. Remove cotter pin (1) and slotted nut (part of item 29). Disconnect ball joint (29) from the steering knuckle using a tie rod fork and hammer.
3. Using a hammer and soft punch, remove retainer pin (5).
4. Remove retainer ring (27). Remove pin (8) and thrust washers (6 and 31). Then remove steering knuckle (9 or 10). Use care not to damage shims (38 - 41) when removing the steering knuckle. Keep the shims together for assembly.
5. If necessary, repeat the steps 1 through 4 for the other steering knuckle.

Inspection

Clean all parts thoroughly.

Make a careful inspection of all bearing cups and cones; including those not removed. Replace if rollers or cups are worn or show indication of damage or distortion. Bearing cones and cups must be replaced as a set.

Replace all parts which have damage. Also, replace any bolts with rounded corners, and all lockwashers and seals at time of assembly.



Item	Description	Item	Description	Item	Description	Item	Description
1	Cotter Pin (6)	12	Oil Seal Retainer (2)	23	Hex Nut (12)	34	Tap Screw
2	Socket Assembly (4)	13	Seal (2)	24	Axle Hub (2)	35	Self-Locking Nut (8)
3	Steering Cylinder (2)	14	Oil Seal Retainer (2)	25	Wheel Stud (12)	36	Capscrew (8)
4	Grease Zerk (4)	15	Bearing Cone (2)	26	Grease Zerk (4)	37	Steering Axle Beam
5	Retainer Pin (2)	16	Bearing Cup (2)	27	Retainer Ring (2)	38	Shim (2)
6	Thrust Washer (2)	17	Bearing Cup (2)	28	Bearing (4)	39	Shim (2)
7	Clamp (2)	18	Bearing Cone (2)	29	Tie Rod End (2)	40	Shim (2)
8	Pin (2)	19	Cotter Pin (2)	30	Stud (4)	41	Shim (2)
9	Right Steering Knuckle	20	Hub Cap (2)	31	Thrust Washer (2)	42	Steering Bracket
10	Left Steering Knuckle	21	Slotted Nut (2)	32	Grease Zerk	43	Capscrew (2)
11	Spacer (2)	22	Flat Washer (2)	33	Tie Rod		

FIGURE 8-138

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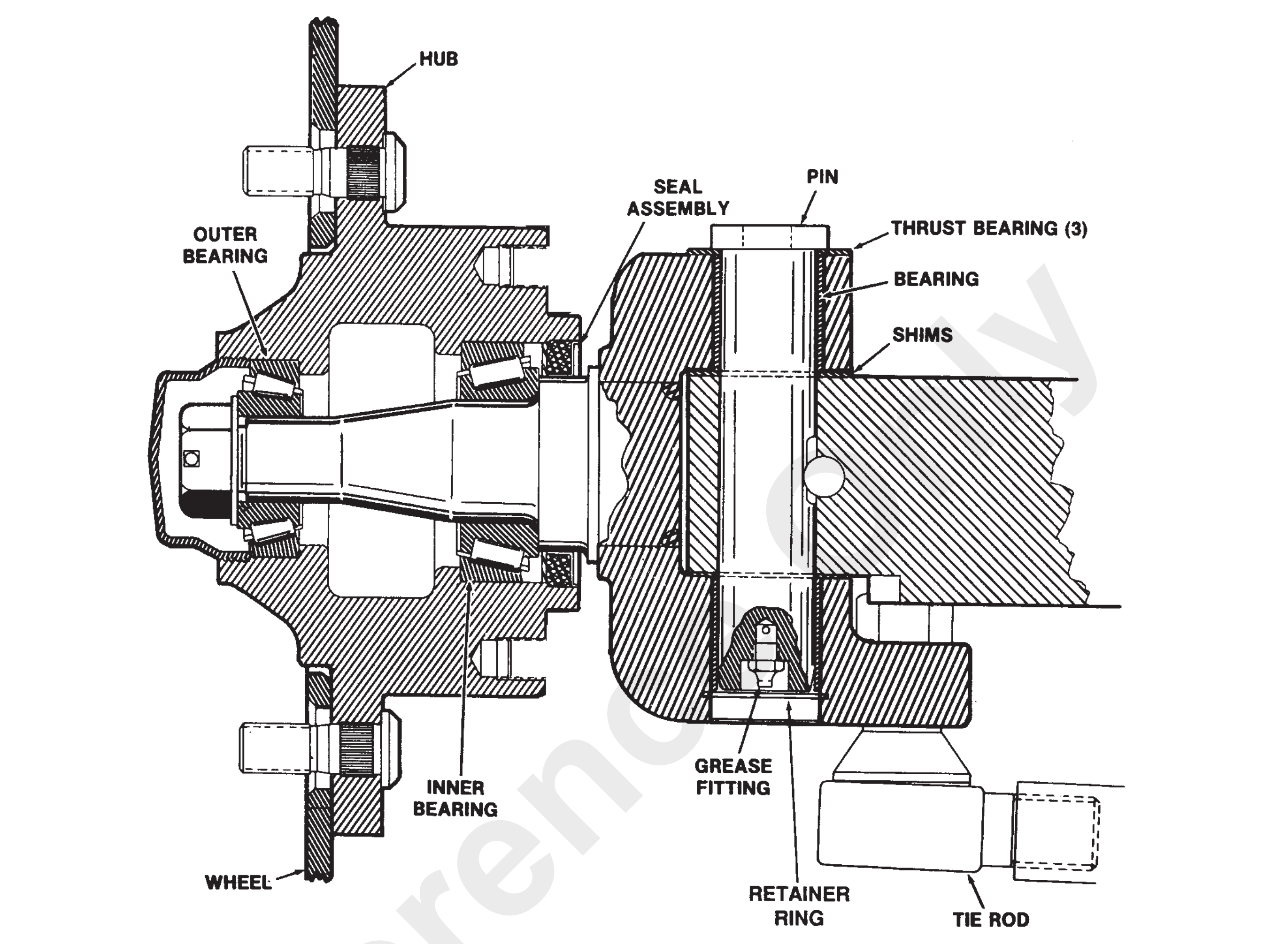

HUB
SEAL ASSEMBLY
PIN
THRUST BEARING (3)
OUTER BEARING
BEARING
SHIMS
GREASE FITTING
INNER BEARING
WHEEL
RETAINER RING
TIE ROD
A0674

FIGURE 8-139

Assembly

⚠ WARNING

Crushing Hazard!

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's hydraulics or jacks to support the machine when working under it.

Disconnect the battery cables while you're under the machine to prevent the engine from being started.

Steering Axle

1. If the bearings (28, Figure 8-138) were removed, press new bearings into the pin bores of steering knuckles (9 and 10). The top of the bearings must be flush with the top of pin bore as shown in Figure 8-139.
2. Apply petroleum jelly to thrust washers (6 and 31, Figure 8-138) and install them on the axle beam (37).
3. Position the steering knuckle on the axle beam. By hand, lift the steering knuckle and install shims (38 - 41) until the steering knuckle fits tightly against the axle beam (minimum vertical movement). Shims are available in four sizes from 0.127 - 0.601 mm (0.005 to 0.024 in).
4. Align the hole in the axle beam (37), thrust washer (6), shims (38 - 41) and steering knuckle (9 or 10). Install thrust washer (31) and pin (8). When installing the pin, be sure the machine flat for the retainer pin (5) is toward the axle center. Install retainer pin (5). Using a soft punch and hammer, install retainer ring (27).
5. Connect ball joint (29) to the steering knuckle with the slotted nut. Install cotter pin (1).
6. Connect the steering cylinder (3) to the steering knuckle.
7. Repeat steps 2 through 6 for the opposite steering knuckle (6 or 9).
8. Apply grease to grease zerks (4, 26 and 32) and grease fitting in item 29

Axle Hub

1. Pack inner bearing cone (15, Figure 8-138) and outer bearing cone (18) with wheel bearing grease. Install the bearing cones into hub (24).
2. Install spacer (11) and inner oil seal retainer (12), if removed. Install felt seal (13) on spindle against inner oil seal retainer (12). Install outer oil seal retainer (14) on the spindle.
3. Install the assembled hub on the spindle of the steering knuckle.
4. Install washer (22) and slotted nut (21).
5. Rotate the hub while tightening the slotted nut (21) snug until tight to displace grease. Then, back off nut until the hub rotates free, usually 1/4-1/2 turn and install cotter pin (19).
6. Install hub cap (20).
7. Repeat steps 1 through 6 for the opposite axle hub.

Installation

⚠ WARNING

Crushing Hazard!

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's hydraulics or jacks to support the machine when working under it.

Disconnect the battery cables while you're under the machine to prevent the engine from being started.

1. Use a wheel jack to move the steering axle into position under the crane. Raise the axle and install the eight mounting bolts (36, Figure 8-138) and eight self-locking nuts (35). Tighten the bolts to 245 Nm (180 lb-ft).
2. Connect the hydraulic lines to the steering cylinders.
3. Install the wheels and lower the tires to ground.
4. Bleed air from the steering lines. See Section 8, Steering System.
5. Check wheel alignment, page 6-7.

DRIVE SHAFTS

Checking for Bearing Wear

At each trunnion, check the drive shaft for side movement. As wear in the bearings increases, the side movement will increase. Movement must be at a minimum to prevent vibration during operation

Removal

NOTE: Before removing the drive shaft mark both companion flanges and mark the sliding joint.

Make note of which way the drive shaft is installed between the transmission and axle. Remove the attaching hardware and remove the drive shaft.

Disassembly

1. Place a flange yoke (1, Figure 8-140) in a vice. Using pliers, remove the 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 journal cross (2, Figure 8-140) from the drive shaft using the procedure in step 2. After the snap rings are removed, use a hammer and soft drift, with a flat face slightly smaller than the diameter of the bearing, to remove the bearings.
4. Repeat steps 1 through 3 for the other end.
5. To disassemble the slip tube (3) from the slip yoke (4), unscrew the dust cap and pull the two yokes apart.

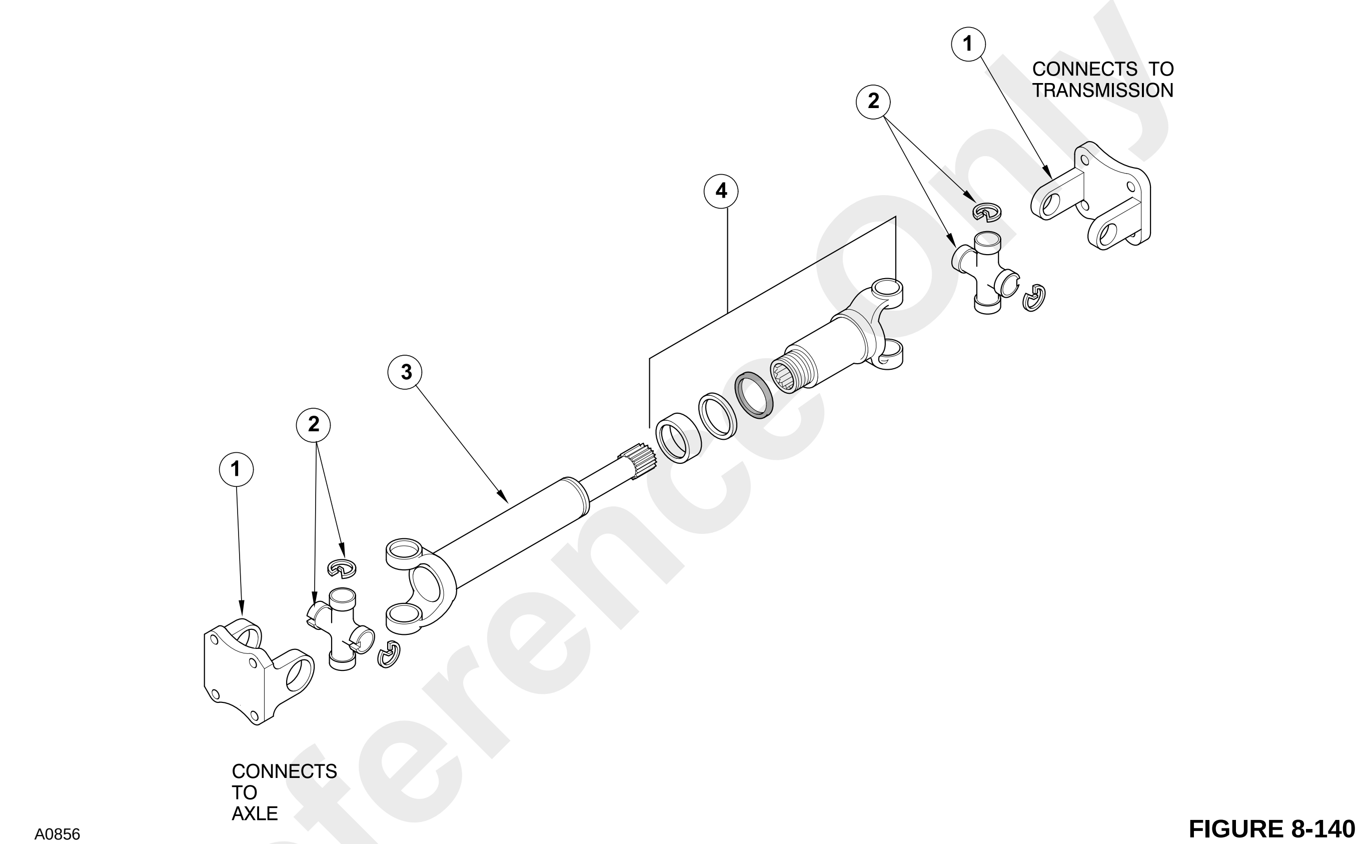


FIGURE 8-140

Inspection

Clean all parts in 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 them with brush and 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.

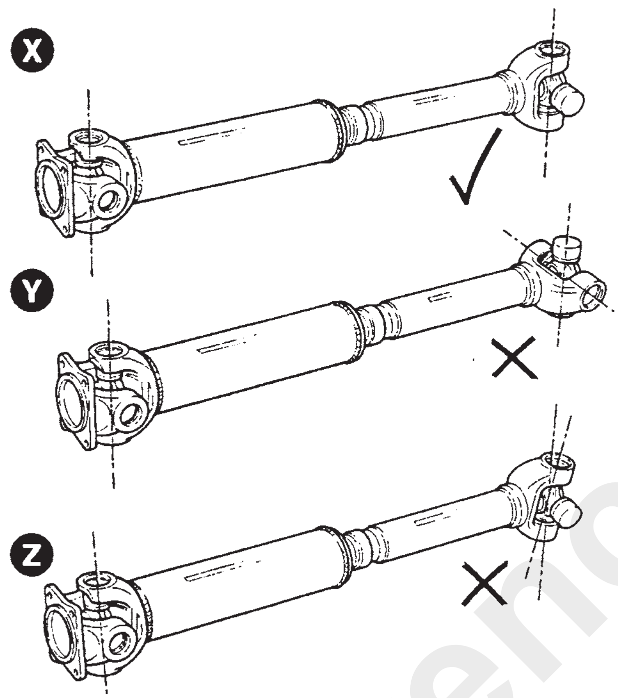
Check for damage to the splines of the sleeve yoke. Make sure the splines are clean and smooth. Look for damage or distortion of the drive shaft tube. Damage can cause failure of the drive shaft under high torque loads. The drive shaft must be straight to inhibit vibration during operation. Replace the drive shaft if there is damage.

Assembly

1. If new journal and bearings are not being installed, inspect the seals in the bearing caps. If they are damaged in any way, replace the complete journal and bearing assembly.
2. Install the journal cross into the yoke of slip tube (3, Figure 8-140).
3. Apply a small amount of SAE 140 oil to the trunnions on the journal cross. Press the bearing 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 into the grooves.
4. Repeat steps 1 through 3 on the opposite end of the drive shaft slip yoke end (4).

5. Repeat steps 1 through 3 and install a flange yoke (1) to each end of the drive shaft.

6. Apply SAE 140 oil to the splines on the slip tube (3). Assemble the dust cap assembly to the slip tube. Slide the slip tube into the slip yoke (4). Make sure both ends of the drive shaft are in the same plane. See “X” in Figure 8-141. Tighten the dust cap assembly.



A0316 **FIGURE 8-141**

Installation

1. Fasten the flange yoke to the parking brake disc on the front axle with four capscrews and lockwashers.

NOTE: The drive shaft must have both ends exactly on the same as shown in “X” of Figure 8-141. The yokes must not be at right angles as at “Y” or at an intermediate angle as in “Z”.

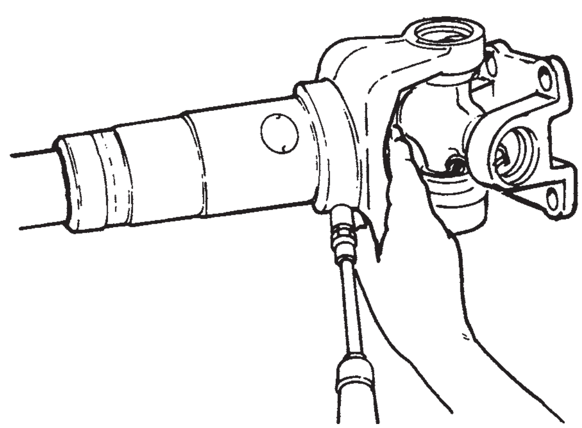
2. Fasten the other end to the transmission with four capscrews and self-locking nuts.

3. Apply a Lithium Base, E.P. No. 2 bearing grease to the three grease fittings on the drive shaft. One fitting on each journal cross and one on the slip yoke. Apply the grease until it exits through the seals. See Lubrication Procedure on page 8-39.

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 engine and check the drive shaft. Make sure the drive shaft yokes are in the same plane. If they are the drive shaft needs to be balanced. Do not drive the crane with an unbalance drive shaft, possible damage to drive train could occur.

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 bearing cross. Apply grease to these fittings after every 50 hours of operation. Use a Lithium Base, E.P. No. 2 bearing grease. Always apply enough grease to remove the old grease. On the slip joint, apply grease to the grease fitting until grease comes through the hole in the end of the shaft. Put your finger over the hole (Figure 8-142) and continue to apply grease until the grease shows at the seal on the slip joint.



A0317 **FIGURE 8-142**

8

WHEELS AND TIRES

WARNING

Flying Objects Hazard!

Never try to disassemble the wheel until all air is released from the tire. The tire retaining ring and rim of the wheel 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.

Table 8-3

Tire Pressure	
Tire Size	**Pressure**
10:00 x 15, 14-ply rated	8.62 bar (125 psi)

Wheel Nut Torque

Tightening order of the studs is shown in Figure 8-143. Check the tightness of the lug nuts after every 50 hours of operation.

Proper wheel nut torque for both axles is 306 Nm (225 lb-ft).

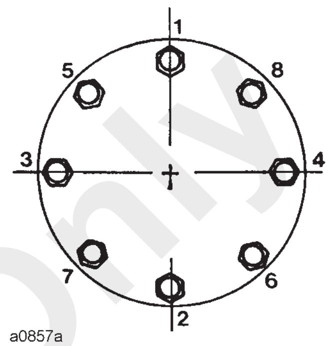


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FIGURE 8-143

SECTION 9
BRAKE SYSTEM

SECTION CONTENTS

TECHNICAL DATA

Table 9-1
FRONT AXLE BRAKES

Type	Wet disc brake
Actuation	Hydraulic piston
Location	Inboard - Axle center casing (2 brake sets)
Brake discs	One each side
Counterdiscs	Two each side
Nominal brake disc thickness	4.83 mm (0.19 in)
Nominal counterdisc thickness	5 - 10.8 mm (0.196 - 0.425 in)
Maximum brake disc wear (each side)	0.15 mm (0.006 in)
Maximum brake counterdisc wear	NA
Nominal brake piston stroke	1 mm (0.030 in)
Oil displacement for brake actuation	8.9 ml (0.30 oz)

Table 9-2
ACCUMULATOR

Type	Piston, Hydro-pneumatic
Volume	2632 cu. cm (120.63 cu. in)
Nitrogen Recharge Pressure	5171 ± 275 kPa (750 ± 40 psi)

Table 9-3
ACCUMULATOR CHARGING VALVE

Nominal Accumulator Charge Rate	10.2 ± 1.9 L/min (2.7 ± 0.5 gal/min)
Nominal High Limit.	13 790 ± 345 kPa (2000 ± 50 psi)
Nominal Low Limit	11 376 ± 345 kPa (1650 ± 50 psi)

Table 9-4
PRIORITY FLOW CONTROL VALVE

Priority Flow Set At	12. 3 L/min (3.25 gpm)
Control Pressure	758 kPa (110 psi)
Relief Valve Setting	17 237 kPa (2500 psi)

DESCRIPTION

There are two brake systems used on the crane; the service brake system and the parking brake system.

Service Brake System

The service brake system (Figure 9-1) consists of the hydraulic pump, a relief valve included in the priority flow control valve, an accumulator charging valve, a low pressure warning switch, an accumulator, a needle valve, a brake modulating valve, a brake light switch and the front axle service brakes.

Description of Operation

Hydraulic Pump

The hydraulic pump supplies hydraulic oil flow to the priority flow control valve (Figure 9-1).

Priority Flow Control Valve

The priority flow control valve in normal operation supplies oil to the accumulator charging valve. If oil is required for the steering operation the priority flow control valve shifts to furnish flow to the steering system. (See *Steering System*, page 10-1.) The priority flow control valve also includes the relief valve used to protect the steering and brake systems.

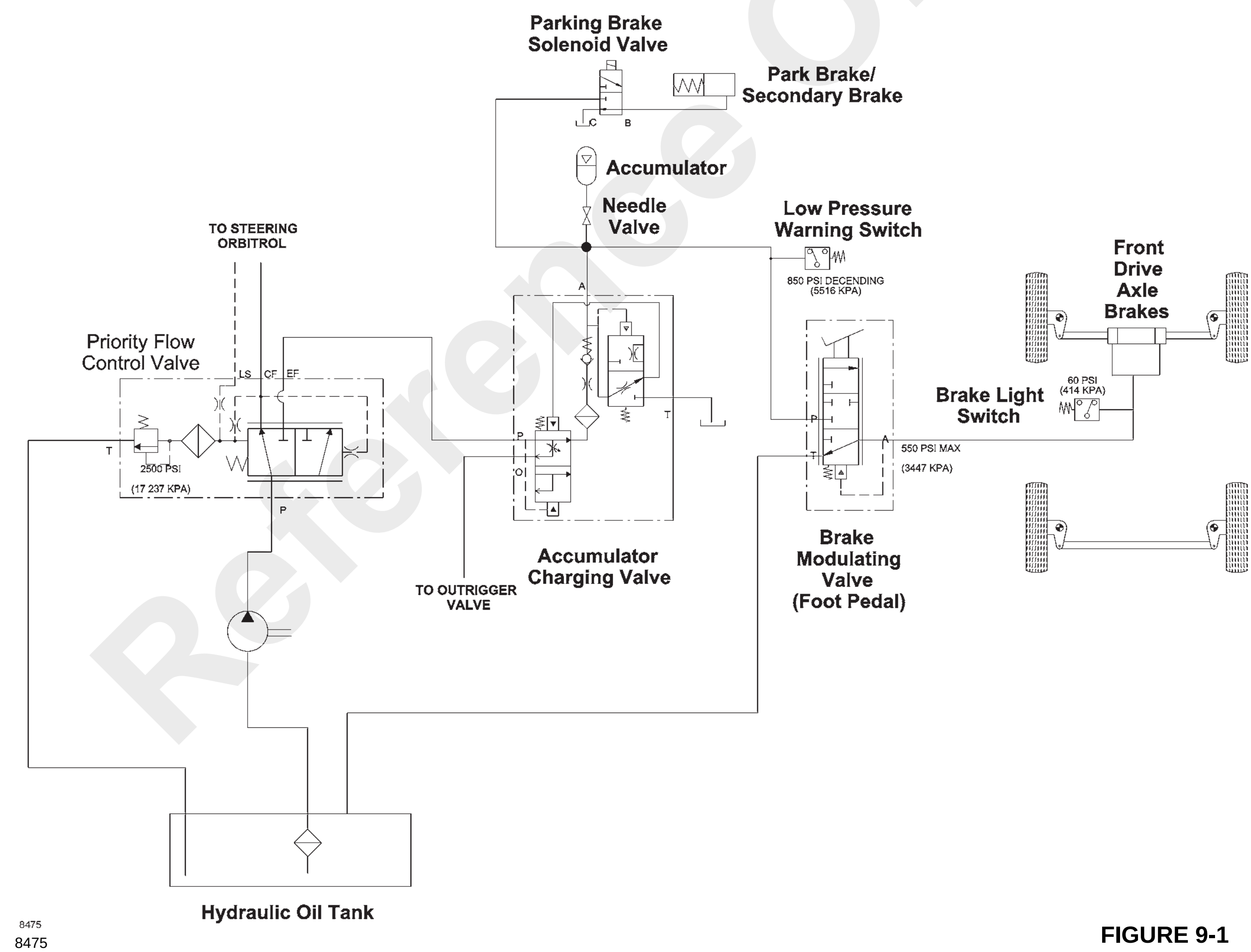


FIGURE 9-1

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 13790kPa (2000 psi) for brake system usage.

Needle Valve

The needle valve is used during service of the brake system. When closed, It shuts off the hydraulic supply from the accumulator, holding a pressure in the accumulator. This eliminates the need to charge the accumulator after brake system service.

NOTE: The needle valve must in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

Brake Modulating Valve

The brake modulating valve is a closed-center spool design. When the valve is in no-applied position, brake port (A, Figure 9-1) is open to tank port (T). As the valve is initially actuated, tank port (T) is closed off from brake port (A). Additional actuation opens pressure port (P) to brake port (A). More input force will increase the pressure to brake port (A) until actuation effort and hydraulic reaction forces are balanced. When actuation is released, the valve returns to its non-applied position.

Brake Light Switch

The brake light switch illuminates the brake lights when the brake modulating valve builds system pressure to 552 kPa (80 psi).

Front Axle Brakes

The front axle brakes are self-adjusting oil immersed and are located on both sides of axle center housing (Figure 9-2). Each brake assembly consists of one brake disc and two counterdiscs. The brakes are applied when the brake modulating valve is actuated. Hydraulic fluid under pressure reacts against the brake pistons, forcing the brake counterdiscs against the brake disc, slowing and/or stopping the crane.

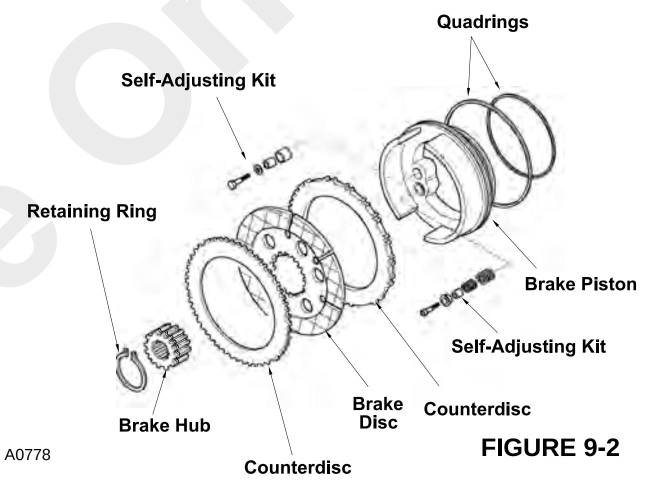


FIGURE 9-2

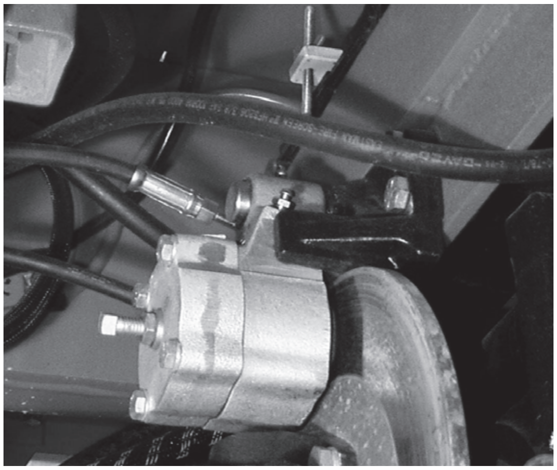
Parking Brake System

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 (Figure 9-1) and uses the accumulator for system pressure.

Parking Brake

The parking brake is a disc-type brake (Figure 9-3). The brake disc is attached to the input shaft of the front axle. The brake is attached to the frame behind the front axle. When the parking brake switch is placed in the engage position, hydraulic supply is shut off to the parking brake and the springs in the parking brake apply the brake pads against the brake disc, holding the crane from moving.



P0314 FIGURE 9-3

Parking Brake Solenoid Valve

The parking brake solenoid valve 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.

MAINTENANCE AND ADJUSTMENTS

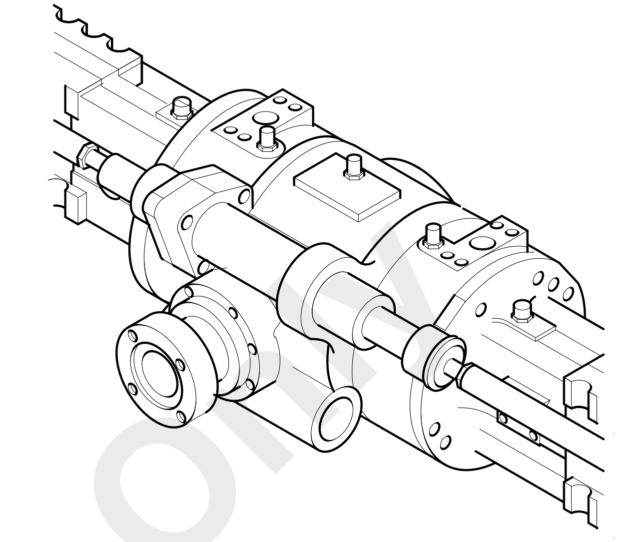
Service Brake Bleeding

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

NOTE: Before working on the brake system, make sure the crane is on level ground and that all four wheels are chocked.

NOTE: 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 is run for several minutes.

1. Engage the parking brake and shut off the engine. Block all wheels on both sides.
2. There are two bleed screws; one for each set of brakes. Attach a tube to one of the brake bleed screws (Figure 9-4) and place the other end in a suitable container.



A0873 FIGURE 9-4

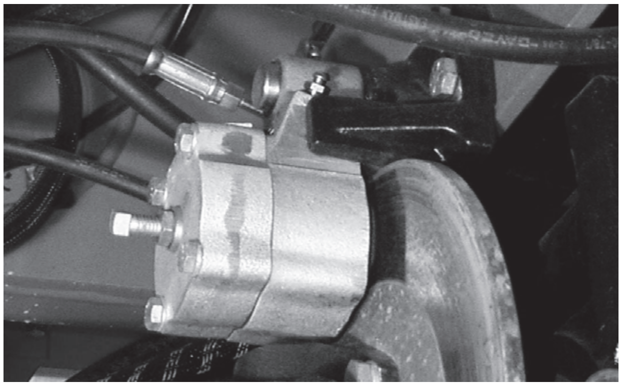
3. Open the bleed screw and apply the brake foot pedal.
4. Observe the fluid exiting the hose. When there is no air being released, close the bleed screw with the pedal still being applied.
5. Repeat steps 2 through 4 using the other bleed screw.

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.

NOTE: The accumulator must be charged before this operation can be performed. If you are not sure the accumulator is charged, engage the parking brake, start the engine and let it run for several minutes.

1. Engage the parking brake and shut off the engine. Block all wheels on both sides.
2. Attach a tube to the bleed screw on the parking brake (Figure 9-5) and place the other end in a suitable container.
3. Open the bleed screw, then disengage the parking brake.
4. Observe the fluid exiting the hose. When there is no air in the fluid being released, close the bleed screw with the parking brake still disengaged.
5. Engage the parking brake.
6. Repeat steps 3-5 as needed until no air is released from the fluid.



P0828 **FIGURE 9-5**

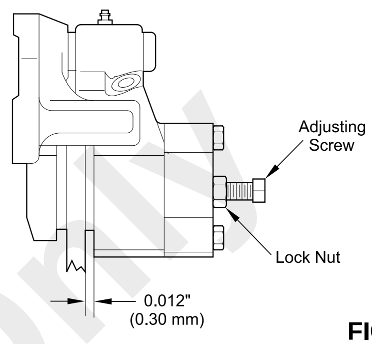
Parking Brake Adjustment

WARNING

Before adjusting the parking brake, make sure that the machine is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the adjustment.

When the parking brake is engaged and it will not hold the crane in position it may be necessary to adjust the parking brake disc pads.

1. Shut off the engine and place chock blocks in front and behind all four wheels. Release the parking brake. Check that the brake moves freely on the guide/slide pin.
2. Loosen the lock nut and adjusting screw (Figure 9-6).
3. Place a 0.030 mm (0.012 in) feeler gauge between the disc and one of the linings.
4. Tighten the adjusting screw until is just possible to remove the feeler gauge.
5. Tighten the jam nut while holding the adjusting screw with a wrench. Remove the feeler gauge.
6. Engage the parking brake. Then, release the parking brake and recheck that the brake moves freely on the guide/slide pin.



A0608 **FIGURE 9-6**

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).

TESTS

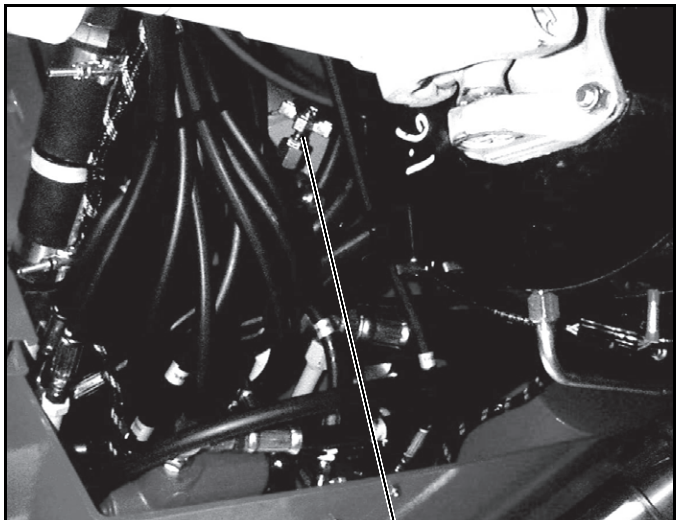
Brake Piston Seal Leakage Test

The following test procedure explains how to check if a brake piston is severely damaged/destroyed or if the seals have a small cut or nick. The test procedure must only be done when the axle is COLD.

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

NOTE: Do not drive the machine with any part of the brake system disconnected. When the test has been completed, reconnect all brake lines and bleed the brake system using recommended procedures, page 9-4.

1. With the engine shutoff and the parking brake engaged, close the accumulator needle valve (Figure 9-7) to shut off hydraulic pressure to the service brakes.

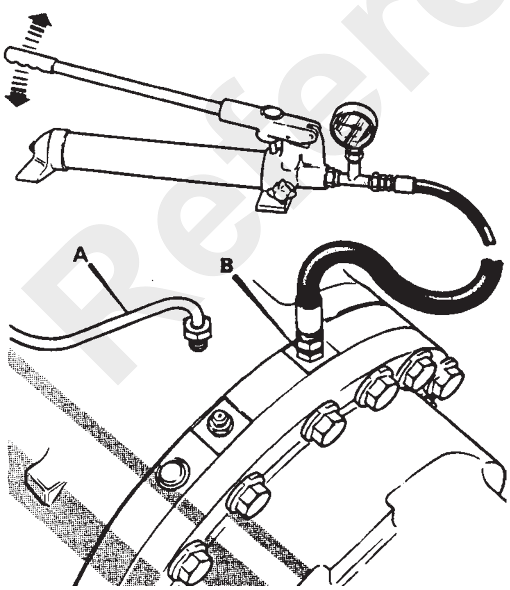


P0718 Accumulator Needle Valve **FIGURE 9-7**

2. Actuate the brake foot pedal until no resistance is felt and the system pressure has been released.

NOTE: Do not disconnect any lines until the brake circuit pressure has been released.

3. Remove and cap the brake piston feed line (A, Figure 9-8).



a0222 **FIGURE 9-8**

4. To check for severe piston seal damage:

   a. Fill the housing of hand pump with recommended lubricant. See *Maintenance*, page 5-1.

   b. Install the hand pump fitted with a 0 to 6890 kPa (0 to 1000 psi) pressure gauge to port (B, Figure 9-8).

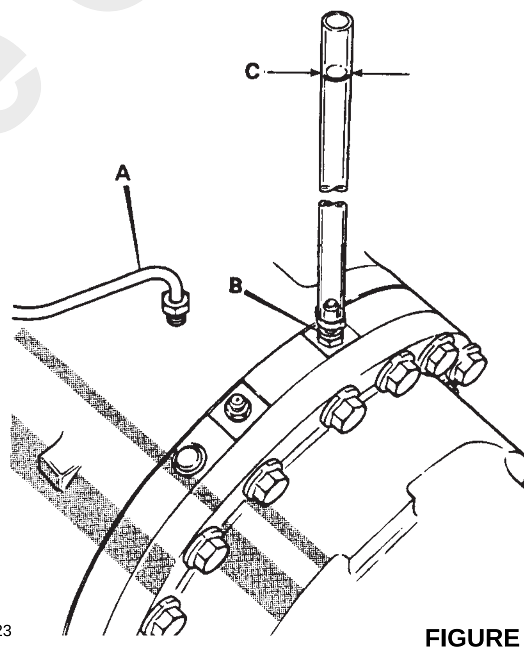
NOTE: The hand pump MUST be filled with recommended oil (see *Maintenance*, page 5-1). System pressure is 3790 kPa (550 psi). DO NOT exceed 4134 kPa (600 psi).

   c. Use the hand pump to generate a pressure in the brake piston housing.

   d. If the pressure falls off rapidly, or if no pressure reading can be obtained, the seals are severely damaged and must be replaced.

5. If pressure falls off slowly, the piston seals may have small cuts or nicks. To verify for small cuts or nicks in the piston seals perform the following test:

   a. Install an adapter fitted with a piece of clear tube (approximately 120 mm (4.75 in) long to the brake piston port (B, Figure 9-9).



A0223 **FIGURE 9-9**

NOTE: The tube must be kept vertical during the test. Use tape to attach the tube to the side of machine.

   b. Fill the tube with recommended oil (see *Maintenance*, page 5-1) three quarters full.

   c. Using a suitable pen, mark the level line (C) of the fluid in the tube.

   d. After approximately 1/2 hour, check if the level has dropped below the original marked line. If it has then check the brake piston seals for slight nicks, cuts or general wear.

6. Repeat steps 3 through 5 for the opposite brake piston seals.

7. Reconnect all brake lines and bleed the brake system as recommended on page 9-4.

SERVICE BRAKE REPAIR

Refer to Front Drive Axle Repair, in Section 8.

PARKING BRAKE REPAIR

Lining Kit Replacement

WARNING

Before replacing the parking brake linings, 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 over you while performing the replacement.

NOTE: The new linings must be kept free of grease, oil, etc.

The lining kit is indicated in Figure 9-10 with a symbol.

1. Close the needle valve located under the accumulator (Figure 9-7). This will shut off accumulator hydraulic pressure to the parking brake. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
4. Loosen lock nut (8, Figure 9-10) and back off adjusting bolt (7).
5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake.
6. Separate the mounting bracket assembly (31, Figure 9-10) from the brake.
7. Clamp the brake in a vice with soft jaws with the clearance slot facing straight up.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

8. Remove two screws (27) through access holes in housing (26). Using a thin blade tool, pry lining (25) from housing (26) and remove the lining and two bushings (24) through the disc clearance slot.
9. Rotate lining assembly (22) until screws (21) are aligned with the access holes in housing (26), see Figure 9-10. Remove the two flat head screws (21). Pry lining (20) from piston (19) and remove the lining through the disc clearance slot.
10. Install new lining (20) into piston (19) through the disc clearance slot. Install new flat head screws (21) and tighten to a torque of 3.4-4.5 Nm (30-40 lb-in).
11. Insert new bushings (24) into new lining (25). Install the new lining into housing (26) through the disc clearance slot. Line up the holes with the housing and fasten with two new screws (27). Tighten to a torque of 2.5-3.2 Nm (22-28 lb-in).
12. Assemble the brake assembly onto mounting bracket (31). Install the parking brake assembly onto the frame of the crane. Attach the hydraulic hose.
13. Adjust the lining clearance as described on page 9-5.
14. Open the accumulator needle valve and then bleed air from the system as described on page 9-4.

9

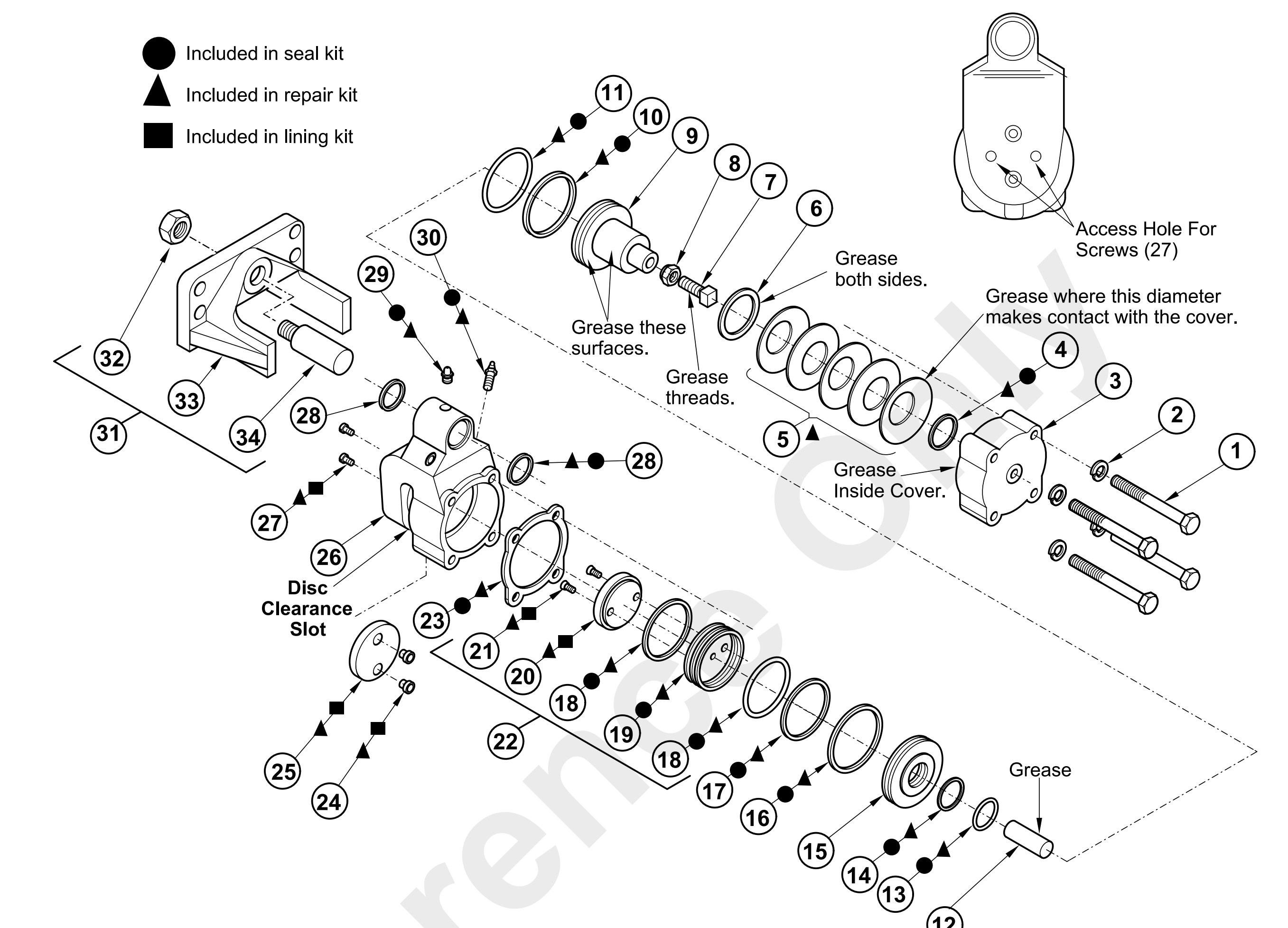


FIGURE 9-10

Item	Description	Item	Description	Item	Description
1	Capscrew (4)	13	O-Ring	25	Lining
2	Lockwasher (4)	14	Backup Ring	26	Housing
3	Cover	15	Piston	27	Screw (2)
4	Seal	16	O-Ring	28	Seal (2)
5	Belleville Springs (5)	17	Backup Ring	29	Grease Zerk
6	Washer	18	O-Ring (2)	30	Bleeder Screw
7	Adjusting Bolt	19	Piston	31	Mounting Bracket Assembly
8	Lock Nut	20	Lining	32	Nut
9	Piston	21	Screw (2)	33	Bracket
10	Backup Ring	22	Lining Assembly	34	Pin
11	O-Ring	23	Gasket		
12	Push Rod	24	Bushing (2)		

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

Repair Kit Installation

The parking brake has a repair kit available. It includes all the parts necessary to rebuild the brake. These parts are indicated in Figure 9-10 with a symbol.

WARNING

Before repairing the parking brake, 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 repair.

NOTE: When removing seals and backup rings be careful not to scratch or mar the pistons.

The new linings must be kept free of grease, oil, etc.

1. Close the needle valve located under the accumulator (Figure 9-7). This will shut off hydraulic pressure to the parking brake. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
4. Loosen lock nut (8, Figure 9-10) and back off adjusting bolt (7).
5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake assembly.
6. Separate the mounting bracket assembly (31, Figure 9-10) from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the cover (3) in a vertical position.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

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

NOTE: Cap (3) is under spring pressure. Use care when removing the cap to prevent personal injury.

10. Loosen but do not remove four capscrews (1). Loosen screws evenly in the order of A, B, C and D as shown in Figure 9-11 until spring preload is released.

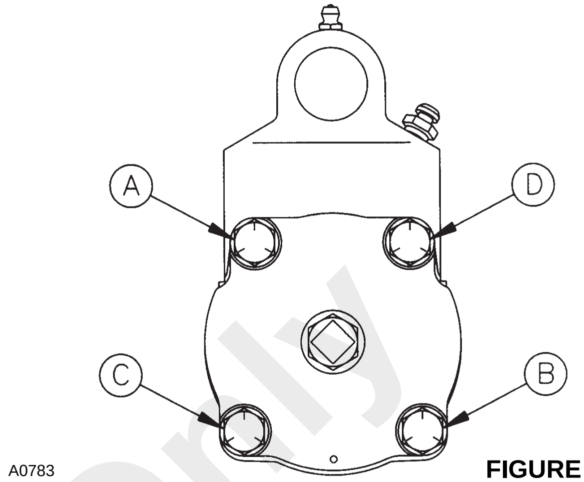


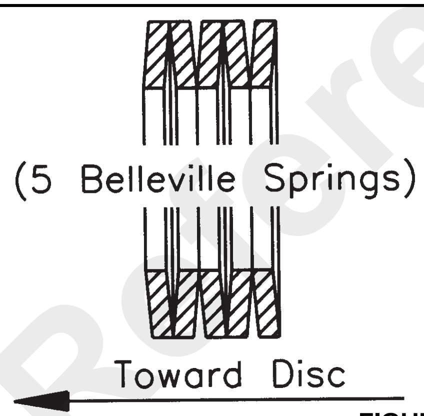
FIGURE 9-11

11. Remove capscrews (1), lockwashers (2), cover (3) and gasket (23). Using a thin blade screw driver, remove seal (4) from cover (3).
12. Remove belleville springs (5) and if present, washer (6). When removing the belleville springs take note of the stacking sequence.
13. Remove piston (9) from housing (26) bore. Remove O-ring (11) and back-up ring (10) from the piston. Push rod (12) should also come out with piston (9).
14. Remove piston (15) from housing (26) bore. Remove O-rings (13 and 16) and back-up rings (14 and 17) from piston (15).
15. Remove lining and piston assembly (22) from housing (26) bore. Holding assembly on a flat surface, separate lining (20) and piston (19) by removing two flat head screws (21). Remove O-rings (18) from piston (19).
16. Loosen vice jaws and rotate the brake so that the disc clearance slot is facing upward. Remove pan head screws (27), lining (25) and bushings (24) from housing (26).
17. Lubricate all rubber components (NOT THE BRAKE LININGS) in clean hydraulic oil. Use the same type as used in the hydraulic system.
18. Clean all parts (EXCEPT LININGS) and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the hydraulic system. Keep all parts free of contaminants, dirt and debris.

NOTE: Coat the surfaces indicated in Figure 9-10 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

19. Install new lining (25) in housing (26) using new bushings (24) and pan head screws (27). Tighten the screws to 2.5-3.3 Nm (22-28 lb-in).

20. Install new lining (20) on piston (19) using new flat head screws (21). Tighten screws to a torque of 3.4-4.5 Nm (30-40 lb-in). Install new O-rings (18) on piston (19) and insert lining and piston assembly (22) into housing (26) bore.
21. Carefully install two new seals (28) in housing (26). Be sure to install the seals the same direction as they were removed.
22. Install bleed screw (30). Tighten to a torque of 12.2-20.3 Nm (9-15 lb-ft).
23. Install new O-rings (13 and 16) and new backup rings (14 and 17) on piston (15). Be sure they are installed in the correct order.
24. Install piston (15) into housing (26) bore. Be sure piston is installed in the correct direction. Be careful not to pinch the O-rings on the inlet ports.
25. Install new backup ring (10) and new O-ring (11) on piston (9). Be sure they are installed in the proper order. Install push rod (12) in bore of piston (9). Install piston into housing (26) bore.
26. Fully lubricate the threads of adjusting screw (7) and lock nut (9) and install into cover (3).
27. Install washer (6), if used, and new belleville springs (5) over end of piston (9). Follow the stacking sequence shown in Figure 9-12.



A0782

FIGURE 9-12

28. Install new seal (4) in cover (3). Be sure inside of cover is coated with grease.
29. Install new gasket (23), cover (3), lockwashers (2) and capscrews (1). Tighten the screws evenly in the order of A, B, C and D as shown in Figure 9-11. When installed, tighten each screw to a torque of 29.8-36.6 Nm (22-27 lb-ft).
30. Assemble the brake assembly onto the mounting bracket (31).
31. Install the parking brake assembly onto the frame of the crane.
32. Attach the hydraulic hose.
33. Adjust the lining clearance as described on page 9-5.
34. Open the accumulator needle valve and then bleed air from the system as described on page 9-4.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

Seal Kit Installation

The parking brake has a seal kit available. It includes all the parts necessary to replace all the seals in the brake. These parts are indicated in Figure 9-10 with a symbol.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

WARNING

Before replacing the parking brake seals, make sure that the 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 repair.

NOTE: When removing seals and back-up rings be careful not to scratch or mar the pistons.

The linings must be kept free of grease, oil, etc.

1. Close the needle valve located under the accumulator (Figure 9-7). This will shut off hydraulic pressure to the parking brake. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
4. Loosen lock nut (8, Figure 9-10) and back off adjusting bolt (7).

5. Remove the bolts and nuts used to fasten the brake mounting bracket to the crane. Remove the parking brake assembly.
6. Separate the mounting bracket (31, Figure 9-10) from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the cover (3) in a vertical position.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

8. Using a sharp bladed tool, carefully remove two seals (28) from housing (26). Note the direction the seals were installed.

NOTE: Cap (3) is under spring pressure. Use care when removing the cap to prevent personal injury.

9. Loosen but do not remove four capscrews (1). Loosen screws evenly in the order of A, B, C and D as shown in Figure 9-11 until spring preload is released.
10. Remove capscrews (1), lockwashers (2), cover (3) and gasket (23). Using a thin blade, remove seal (4) from cover (3).
11. Remove belleville springs (5) and if present, washer (6). When removing the belleville springs take note of the stacking sequence.
12. Remove piston (9) from housing (26) bore. Remove O-ring (11) and back-up ring (10) from piston. Push rod (12) should also come out with piston (9).
13. Remove piston (15) from housing (26) bore. Remove O-rings (13 and 16) and back-up rings (14 and 17) from piston (15).
14. Remove lining and piston assembly (22) from housing (26) bore. Remove O-rings (18) from the lining and piston assembly.
15. Lubricate all rubber components in clean hydraulic oil. Use the same type as used in the hydraulic system. KEEP THE LININGS FREE OF OIL, GREASE AND SOLVENTS.
16. Clean all parts and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the hydraulic system. Keep all parts free of contaminants, dirt and debris.

NOTE: Coat the surfaces indicated in Figure 9-10 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

17. Install new O-rings (18) on lining and piston assembly (22) and insert the assembly into housing (26) bore.
18. Carefully install two new seals (28) in housing (26). Be sure to install the seals the same direction as they were removed.
19. Install new O-rings (13 and 16) and new back-up rings (14 and 17) on piston (15). Be sure they are installed in the correct order.
20. Install piston (15) into housing (26) bore. Be sure piston is installed in the correct direction. Be careful not to pinch the O-ring on the inlet ports.
21. Install new back-up ring (10) and new O-ring (11) on piston (9). Be sure they are installed in the proper order. Install push rod (12) in bore of piston (9). Install piston into housing (26) bore.
22. Fully lubricate the threads of adjusting screw (7) and lock nut (8) and install into cover (3).

NOTE: Completely lubricate belleville springs with a light coat of Lithium Base, E.P. No. 2 bearing grease.

23. Install washer (6), if used, and belleville springs (5) over end of piston (9). Follow the stacking sequence shown in Figure 9-12.
24. Install new seal (4) in cover of (3). Be sure inside of cover is coated with grease.
25. Install new gasket (23), cover (3), lockwashers (2) and capscrews (1). Tighten the screws evenly in the order of A, B, C and D as shown in Figure 9-11. When installed, tighten each screw to a torque of 29.8-36.6 Nm (22-27 lb-ft).
26. Assemble the brake assembly onto the mounting bracket (31).
27. Install the parking brake assembly onto the frame of the crane.
28. Attach the hydraulic hose.
29. Adjust the lining clearance as described on page 9-5.
30. Open the accumulator needle valve and then bleed air from the system as described on page 9-4.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

BRAKE MODULATING VALVE REPAIR

Removal

WARNING

A raised and badly supported 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's hydraulics or jacks to support the machine when working under it.

Disconnect the battery cables while you're under the machine 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. See Figure 9-7.
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 inhibit contaminating the hydraulic system.
6. Remove the three capscrews and self-locking nuts securing pedal mounting plate to the cab floor. Remove the brake modulating valve and pedal assembly.

Disassembly

1. Remove the brake modulating valve from the pedal assembly, by removing two capscrews (13, Figure 9-13).
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 with a black dot in Figure 9-13.

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 9-13) 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 Figure 9-5.

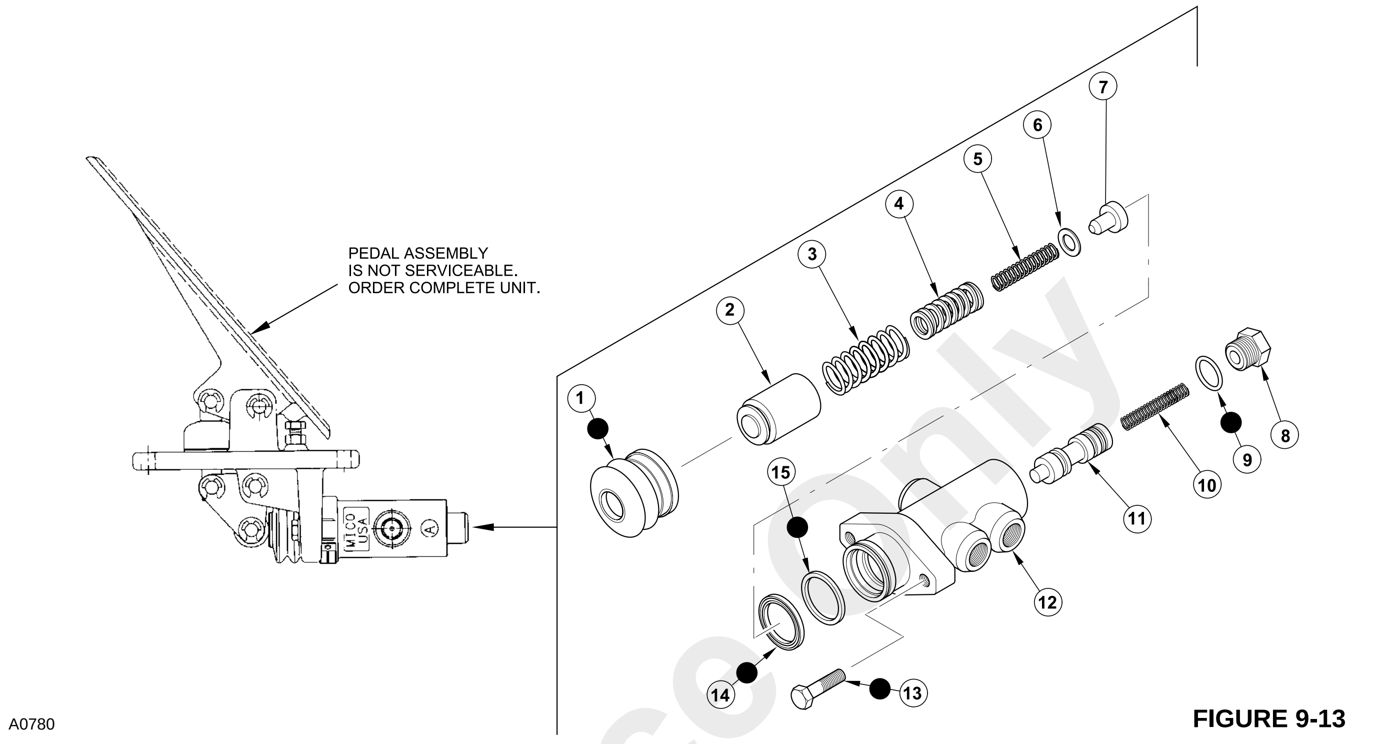


FIGURE 9-13

Item	Description	Item	Description
1	Boot	9	O-Ring
2	Piston Assembly	10	Spring
3	Spring	11	Spool
4	Spring	12	Housing
5	Spring	13	Screw
6	Shim	14	Cup
7	Retainer Assembly	15	Seal
8	End Plug		

TROUBLESHOOTING

Service Brakes

Table 9-5

PROBLEM	POSSILBE CAUSE	REMEDY
Warning light on instrument panel illuminates	**1.** Loss of brake pressure	**1.** Any cause under NO BRAKES.
No brakes	**1.** Fault 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 on page 9-5. **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.** Bleed brake disc. **2.** Perform leakage test on page 9-5. Repair or replace.
Soft brake pedal	**1.** Air in system. **2.** High pressure leaks - external.	**1.** Bleed brake system. See page 9-4. **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. See page 9-5. **3.** Faulty accumulator charging valve. Replace.

Parking Brake

Table 9-6

PROBLEM	POSSIBLE CAUSE	REMEDY
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.
Brake will not hold	**1.** Improperly adjusted parking brake. **2.** Severely worn brake linings. **3.** Faulty parking brake assembly.	**1.** Adjust brake lining clearance. See page 9-5. **2.** Replace brake linings See page 9-7. **3.** Repair or replace.

SECTION 10
STEERING SYSTEM

SECTION CONTENTS

TECHNICAL DATA

Rated pump output..............................37.1 Lpm at 2500 rpm (9.8 gpm at 2500 rpm)

Relief valve setting........................17 225 ± 345 kPa at 2500 rpm (2500 ± 50 psi at 2500 rpm)

Steering Proximity Switch Setting.............3.2 - 5.6 mm (1/8 - 7/32 in)

DESCRIPTION

General

The main components of the steering system are the hydraulic pump (Figure 10-1), the priority flow control valve, the load sensing steering orbitrol, hydraulic tank, one front steering cylinder, two rear steering cylinders and the steering select valve.

When the steering wheel is turned, a pressure demand is sensed by the priority flow control valve through load sensing line between the priority flow control valve and the flow sensing steering orbitrol.

Oil from the hydraulic pump is then distributed through the priority flow control valve and a check valve to the steering orbitrol.

When a turn is made, oil is distributed from the steering orbitrol directly through the steering select valve and/or to the steering cylinders.

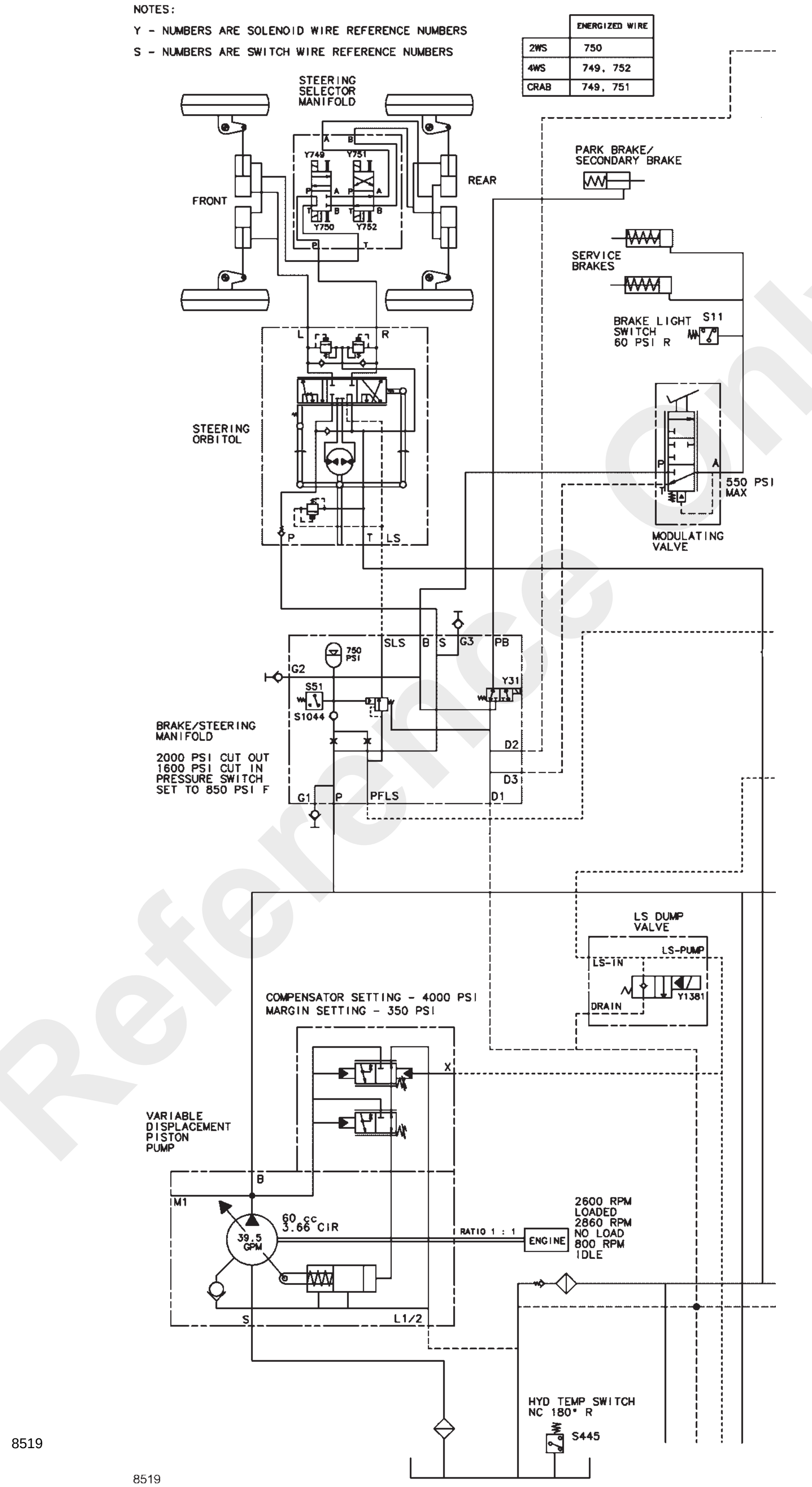
When the steering orbitrol is neutral, the load sense signal is ceased, full pump flow is then distributed to the outrigger and brake circuits through the priority flow control valve.

Maximum steering system pressure is controlled by a relief valve in the priority flow control valve.

Steering Modes

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

- Two-wheel steering
- Four-wheel steering
- Crab steering



8519

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, hydraulic oil under pressure from the steering pump flows through the priority flow control valve to the P port of the steering orbitrol in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbitrol to port P of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operators compartment. When the steering select switch is placed in the two-wheel steering mode solenoid 750 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 orbitrol and back to tank.

Four-wheel Steering

During four-wheel steering, the front wheels steer in the direction that the steering wheel is turned, while the rear wheels turn in the opposite direction. This mode provides an extremely short turning radius. It allows the rear wheels to follow the track of the front wheels, which is an advantage in muddy or sandy conditions.

When turning to the right, hydraulic oil under pressure from the steering pump flows through the priority flow control valve to the P port of the steering orbitrol in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbitrol to port P of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operator's compartment. When the steering select switch is placed in the four-wheel steering mode solenoids 749 and 752 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 orbitrol and back to tank.

Crab Steering

During crab steering all the wheels steer in the same direction. This mode allows the operator to move the machine sideways. This is especially helpful in tight areas on the job.

When turning sideways to the right, hydraulic oil under pressure from the steering pump flows through the priority flow control valve to the P port of the steering orbitrol in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbitrol into port P of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operator's compartment. When the steering select switch is placed in the crab-steering mode solenoids 749 and 751 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 orbitrol and back to tank.

TROUBLESHOOTING

Table 10-1

Symptom	Probable Cause	Action
Slow steering, hard steering, or loss of power assist	**1.** Worn or malfunctioning pump.	**1.** Repair or replace pump.
	2. Priority valve not opening correctly.	**2.** Check for sticky 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 orbitrol.	**6.** Remove and inspect.
	7. Malfunction in 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 orbitrol (causing sleeves to stick open).	**1.** Clean and inspect unit.
	2. Steering actuator centering springs damaged or broken.	**2.** Check orbitrol. Repair or replace.
	3. Steering actuator - position of rotor to shaft slot incorrect.	**3.** See page 10-14. Correct if required.

Published 04/07/2015 Control # 569-00

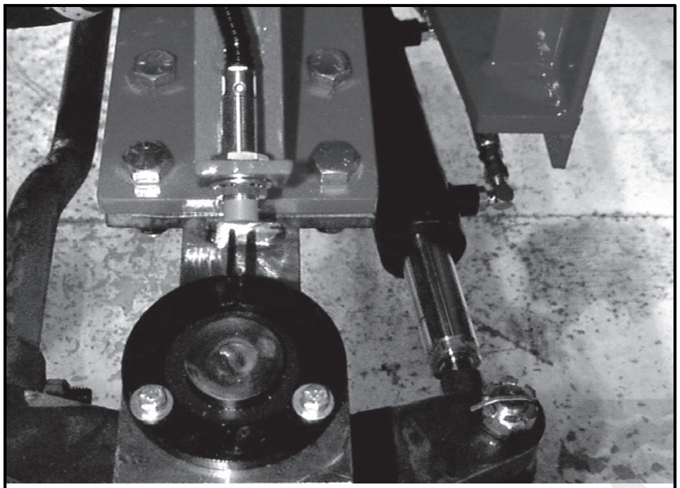
Symptom	Probable Cause	Action
Machine will not turn when the steering wheel is turned	**1.** Insufficient oil level.	**1.** Check for leaks and fill tank.
	2. Leaks in relevant hoses or component connections.	**2.** Check hoses and connections for leaks.
	3. Air in the hydraulic system.	**3.** Bleed system - bleed the load sense line.
	4. Low pump flow.	**4.** Check pump flow. If required repair or replace the pump.
	5. Malfunctioning steering relief valve.	**5.** Replace priority valve.
	6. Worn or damaged part in the steering orbitrol.	**6.** Remove, inspect and repair.
	7. Priority valve not operating correctly.	**7.** Check if the priority valve is sticking, 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 orbitrol.	**10.** Check shaft engagement.
Steering fails to respond to selected mode **NOTE:** The wheels must pass the proximity sensor to actuate relays to change steering mode. See "General" and "Principle of Operation" on page 10-7.	**1.** Selector switch faulty.	**1.** Replace switch.
	2. Proximity switches not operating correctly.	**2.** Check setting of proximity switch, reset or replace switches as required.
	3. Steering mode valve not operating	**3.** Check if spools are sticking. Repair or replace, as necessary.
	4. Leaks in relevant hoses or component connections	**4.** Check hoses and connections for leaks. Tighten or replace.
	5. Electrical failure.	**5.** Check relevant electrical connectors, if problem still persists, do a wiring continuity check on relevant circuits. See page 10-8.
Wander - Tendency of vehicle to deviate from course	**1.** Air in system.	**1.** Correct condition and add fluid. Bleed system and load sense line.
	2. Worn steering linkage.	**2.** Repair or replace linkage.
	3. Loose steering cylinder piston.	**3.** Repair or replace the cylinder.
	4. Severe wear in steering orbitrol.	**4.** Repair or replace the orbitrol.
Slip - A slow movement of steering wheel fails to cause any movement in steering wheels	**1.** Leakage of cylinder piston seals.	**1.** Repair or replace cylinder.
	2. Worn steering orbitrol.	**2.** Repair or replace orbitrol.

Symptom	Probable Cause	Action
Erratic steering	**1.** Air in system due to low level of hydraulic oil, cavitating pump, leaky fitting, pinched hose, etc.	**1.** Correct condition and add fluid. Bleed system and load sense line.
	2. Loose steering cylinder piston.	**2.** Repair or replace cylinder.
	3. Sticking check valve.	**3.** Clean or replace.
	4. Turning steering wheel too rapidly.	**4.** Slow movement.
"Spongy" or soft steering	**1.** Air in hydraulic system. Most likely air trapped in cylinders or lines.	**1.** Correct conditions. Bleed air our of system and load sense line.
	2. Low fluid level.	**2.** Add fluid and check for leaks.
Free wheeling - Steering wheel turns freely with no feel of pressure and no action on steering wheels	**1.** Steering column upper shaft is loose or damaged.	**1.** Tighten the steering wheel nut. Check shaft engineering to orbitrol.
	2. Lower splines of column may be disengaged or broken.	**2.** Repair or replace.
	3. Steering orbitrol meter has a lack of oil. This can happen on start up, after repair, or long down time intervals.	**3.** Usually starting engine will cure the problem. Bleed system if necessary.
	4. Steering cylinder piston seal blown out.	**4.** Determine cause. Correct and replace the seal.
Excessive free play at steering wheel	**1.** Loose steering wheel nut.	**1.** Tighten the nut.
	2. Steering column shaft worn or damaged.	**2.** Repair or replace the steering wheel connection or column.
Excessive free play at steered wheels	**1.** Leaky steering cylinder seals.	**1.** Replace cylinder seals.
Binding or poor centering of steering wheel	**1.** Large dirt particles can cause binding between orbitrol spool and sleeve.	**1.** Clean the orbitrol. Repair or replace, if necessary. If another component has failed. Generating contaminants, flush the hydraulic system while bypassing the orbitrol.
Steering orbitrol locks up	**1.** Large particles of contamination in metering section.	**1.** Clean the orbitrol. Repair or replace, if necessary.
	2. Severe wear and/or broken pin.	**2.** Repair or replace the orbitrol.

STEERING PROXIMITY SWITCHES

General

The purpose of the steering proximity switches in the steering system is to prevent the changing of steering modes until all wheels are aligned forward. The sensors are positioned on the front and rear axles (Figure 10-2) and are activated when a bracket attached to the steering yoke of the axle, is aligned with the sensor.

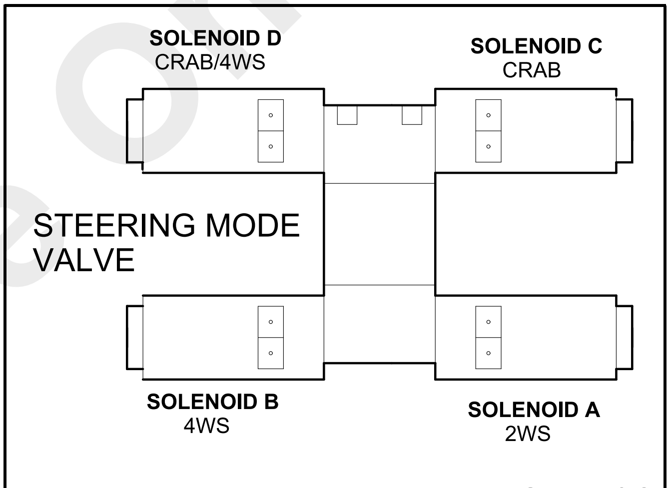


P0719 FIGURE 10-2

Principle of Operation

The steering system electrical circuit includes two sensors (Figure 10-4), one selector switch, one relay box and two solenoid valves. The selector switch is controlled by the operator in the cab to select the steering modes. The relay box, located under the instrument panel, contains relays that control the steering mode solenoid valves.

The system is used to select one of the three steering modes. When the selector switch in the cab is placed in either two-wheel steer, four-wheel steer or crab steer, that particular mode of steering is used to steer the crane. The system, however, will not activate unless the front and rear wheels are in or pass over the forward position. For example, when the front wheels are not aligned forward in two wheel steer mode and the crane must be placed in four wheel steer, placing the steering selector switch, located in the cab, to four wheel steer will not place the steering system in four wheel steer mode. Turning the front wheels to forward position or past, activates the proximity switches and energizes the relays in the relay box, which in turn energize the correct solenoid arrangement (Figure 10-3) to put the steering system in four wheel steer.



A0761 FIGURE 10-3

2WS = Solenoid “A” Energized
Crab = Solenoids “B and C” Energized
4WS = Solenoids “C and D” Energized

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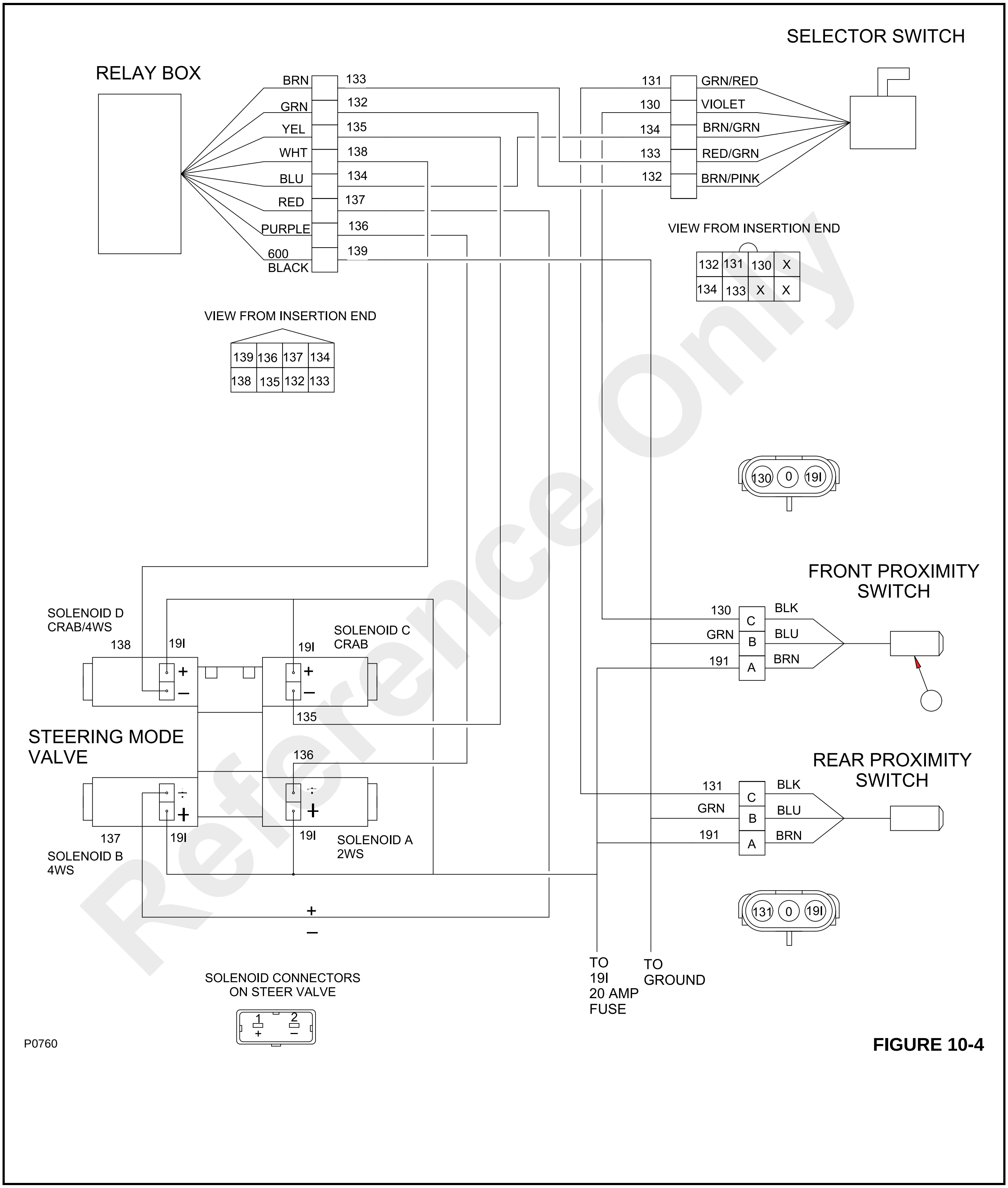

SELECTOR SWITCH
RELAY BOX
BRN 133
GRN 132
YEL 135
WHT 138
BLU 134
RED 137
PURPLE 136
600 BLACK 139
131 GRN/RED
130 VIOLET
134 BRN/GRN
133 RED/GRN
132 BRN/PINK
VIEW FROM INSERTION END
132 131 130 X
134 133 X X
VIEW FROM INSERTION END
139 136 137 134
138 135 132 133
130 0 19I
FRONT PROXIMITY SWITCH
130 C BLK
GRN B BLU
191 A BRN
SOLENOID D CRAB/4WS
138
19I
19I
SOLENOID C CRAB
135
STEERING MODE VALVE
136
137
19I
19I
SOLENOID B 4WS
SOLENOID A 2WS
REAR PROXIMITY SWITCH
131 C BLK
GRN B BLU
191 A BRN
131 0 19I
+
–
TO 19I 20 AMP FUSE
TO GROUND
SOLENOID CONNECTORS ON STEER VALVE
1 2
+ –
P0760

FIGURE 10-4

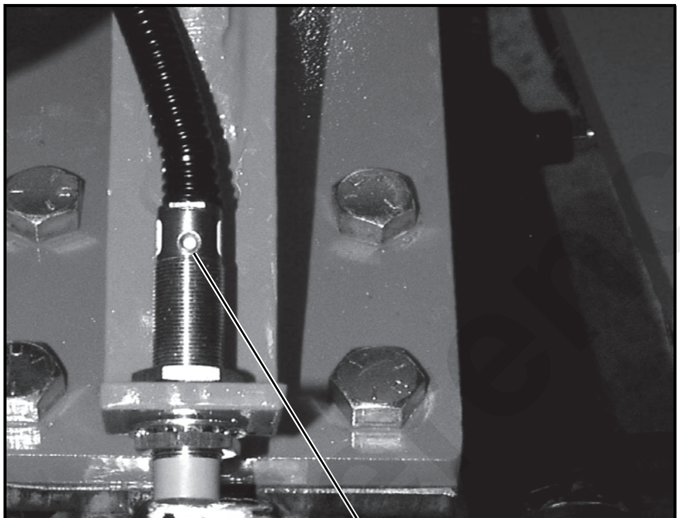
Sensor Operation and Spacing Checks

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 in) to 5.2 mm (7/32 in) in front of the sensor. A yellow light (Figure 10-5) will illuminate, indicating that the sensor is functioning.

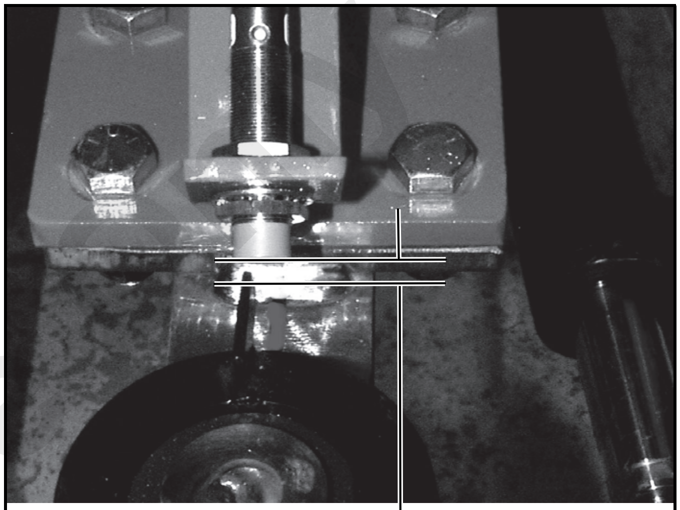


P0720 Sensor Indicator Light **FIGURE 10-5**

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 10-6).



P0721 Sensor Spacing **FIGURE 10-6**

2. Measure the distance between the end of the sensor and edge of the sensor bracket. The sensor spacing must be between 3.2 mm (1/8 in) to 5.6 mm (7/32 in). 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.

STEERING ORBITROL

Description

General

The steering orbitrol (Figure 10-8) 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. See Figure 10-8. 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 10-8). 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 10-8). 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 10-8) in the orbitrol permits steering, with difficulty, when power is lost. A check valve between the IN and OUT ports allows for recirculation of the oil to prevent cavitation when steering without power.

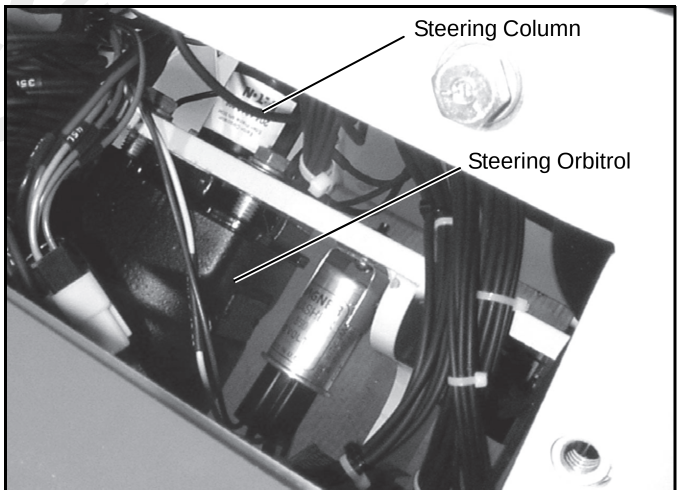
Orbitrol Repair

Special Tools

A spring installation tool, is required to assemble the orbitrol. This tool is available under part number 1900476.

Removal

1. Remove the outside cover plate (Figure 10-7) in front of the operator's compartment.
2. Completely clean around the area of the steering orbitrol.
3. Put tags on the lines to the steering orbitrol for identification at installation.
4. Rotate the steering wheel a small amount in each direction several times, then release to get a balance of pressure in the steering circuit. Slowly loosen the hydraulics lines at ports L and R to release any remaining pressure. Disconnect the hydraulic lines from IN and OUT ports. Put plugs and caps in the ports and hydraulic lines.



P0100

FIGURE 10-7

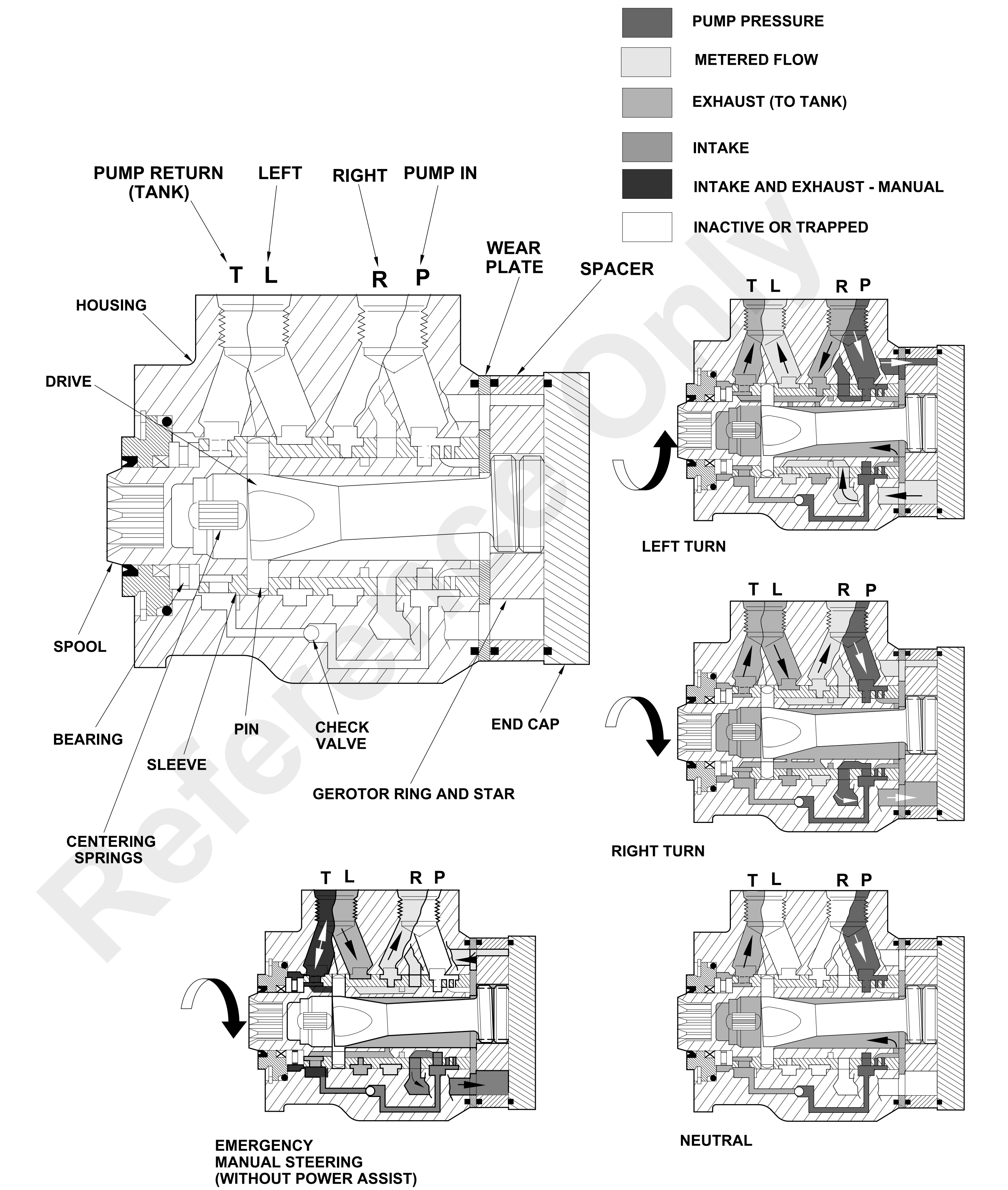

PUMP PRESSURE
METERED FLOW
EXHAUST (TO TANK)
INTAKE
INTAKE AND EXHAUST - MANUAL
INACTIVE OR TRAPPED
PUMP RETURN (TANK)
LEFT
RIGHT
PUMP IN
T L R P
WEAR PLATE
SPACER
HOUSING
DRIVE
SPOOL
BEARING
SLEEVE
PIN
CHECK VALVE
END CAP
GEROTOR RING AND STAR
CENTERING SPRINGS
LEFT TURN
RIGHT TURN
EMERGENCY MANUAL STEERING (WITHOUT POWER ASSIST)
NEUTRAL
P0671

FIGURE 10-8

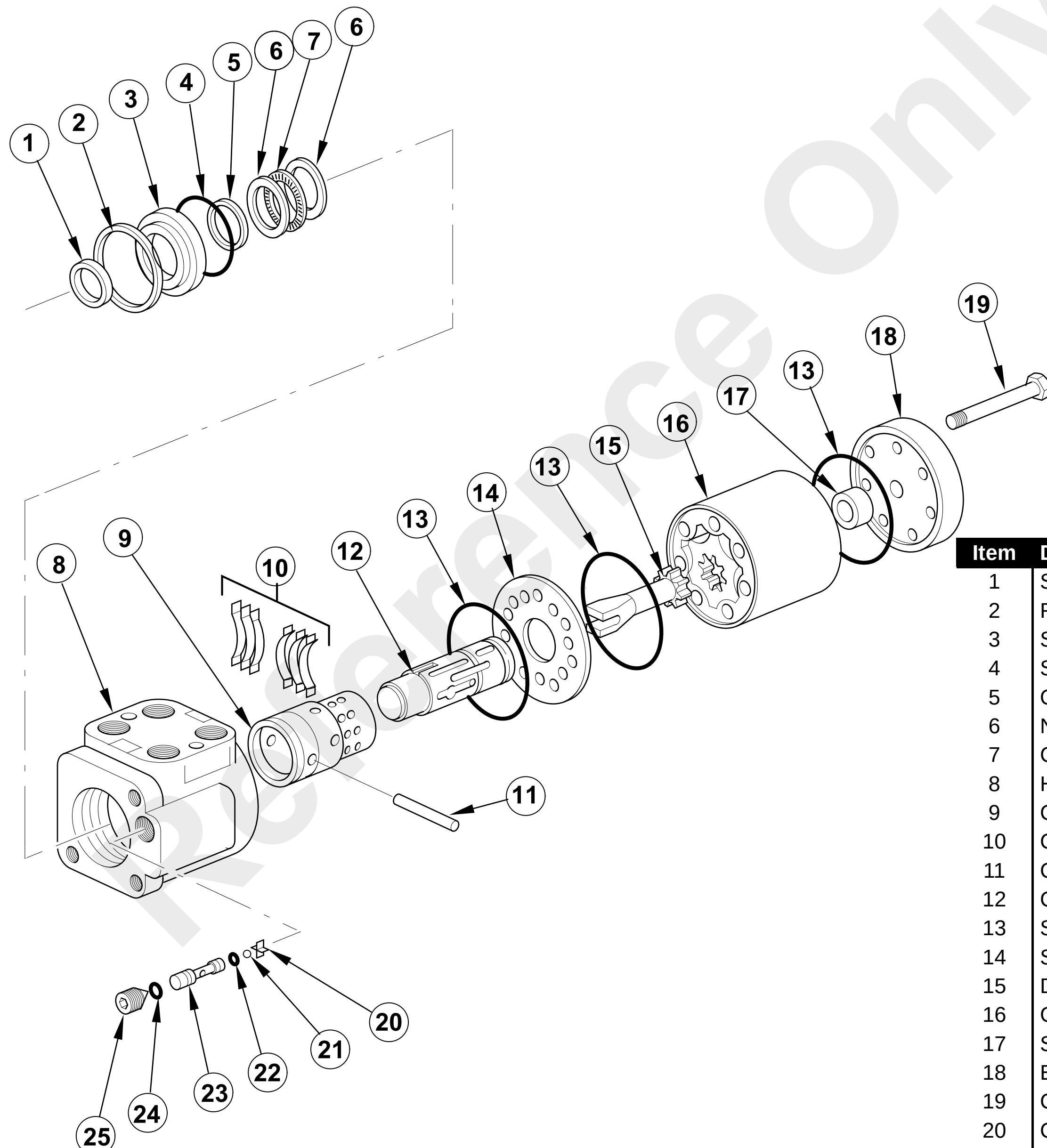
5. Remove the four bolts which fasten the steering column and orbitrol to the mounting bracket. Be sure to hold the steering orbitrol in position while the last bolt is being removed. Remove the steering orbitrol.

Disassembly

Cleanliness is extremely important when repairing a steering orbitrol. Work in a clean area. Use a wire brush to remove foreign materials and debris from around exterior joints of the unit.

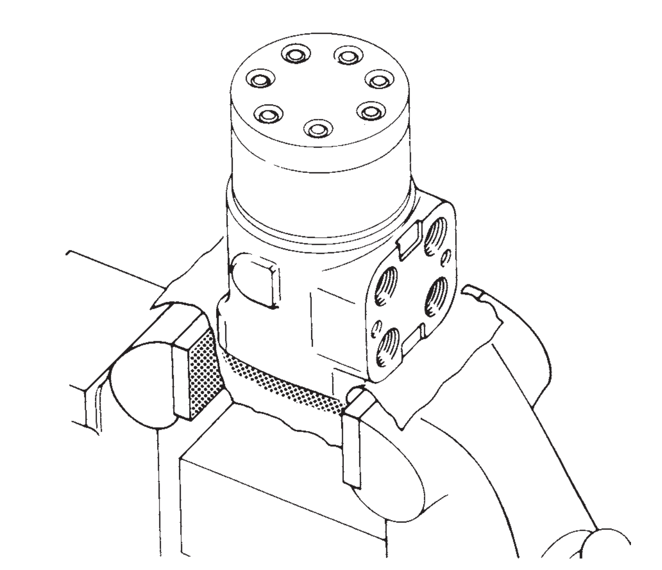
NOTE: Although not all illustrations show the unit in a vice, we recommend that you keep the unit in a vice during disassembly. Follow the clamping procedures explained throughout the instructions.

1. Clamp the unit in a vise, meter end up. Clamp lightly on the edges of the mounting area (Figure 10-10). Use protective material on the vise jaws. Housing distortion could result if the vise jaws are overtightened.



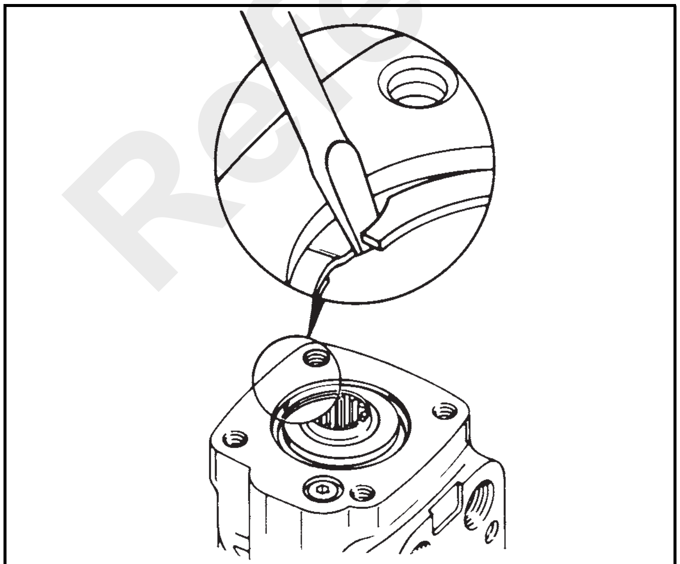
Item	Description
1	Seal
2	Retaining Ring
3	Seal Gland Bushing
4	Seal
5	Quad Ring Seal
6	Needle Bearing Kit
7	Control Part Assembly
8	Housing
9	Control Sleeve
10	Centering Spring (6)
11	Centering Pin
12	Control Spool
13	Seal (3)
14	Spacer Plate
15	Drive
16	Gerotor
17	Spacer
18	End Cap
19	Capscrew
20	Check Ball Retainer
21	Check Ball
22	Seal
23	Seat
24	Seal
25	Set Screw

FIGURE 10-9



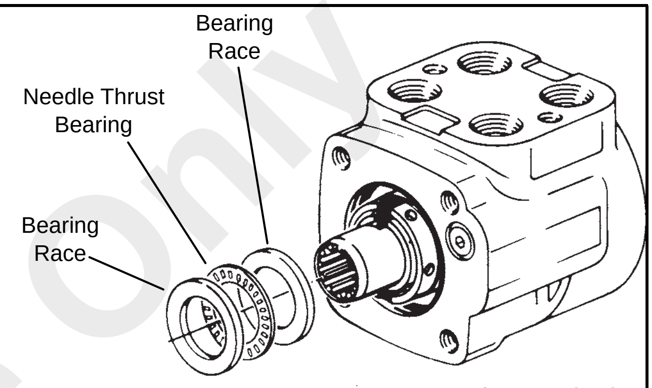
a0328 FIGURE 10-10

2. Remove the seven 6 pt. Torx Drive bolts (19, Figure 10-9). 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 10-11) to pry retaining ring (2, Figure 10-9) from housing (8).



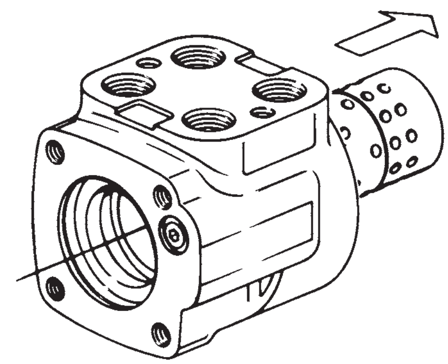
a0329 FIGURE 10-11

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. See Figure 10-12.



a0330 FIGURE 10-12

10. Remove spool and sleeve assembly (10 through 12, Figure 10-9). Remove from rear end of housing (Figure 10-13).



a0335 FIGURE 10-13

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 10-9) 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. See Figure 10-14.
13. Push spool (12) back through and out of sleeve (9). Rotate spool slowly when removing from the sleeve. See Figure 10-14.

10

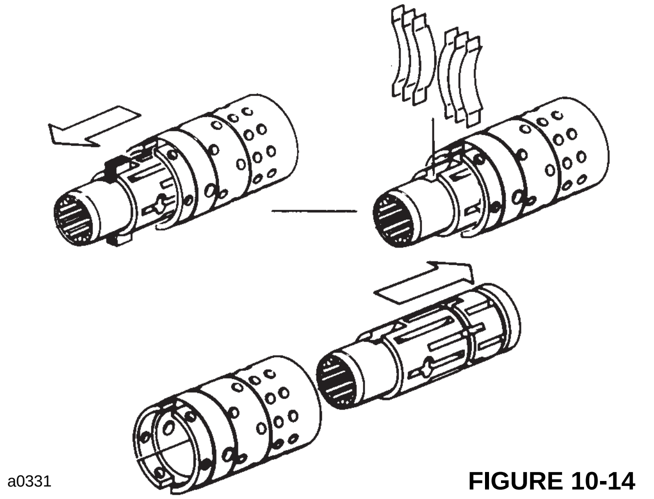


FIGURE 10-14

14. Remove seal (4, Figure 10-9) 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 emory 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 10-9) 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 10-15) line up at the same end. Rotate spool (12, Figure 10-9) while sliding the parts together. Some spools and sleeve sets have identification marks, align these marks as shown in Figure 10-15. Test for free rotation. The spool should rotate smoothly in the sleeve with finger tip force applied at splined end.

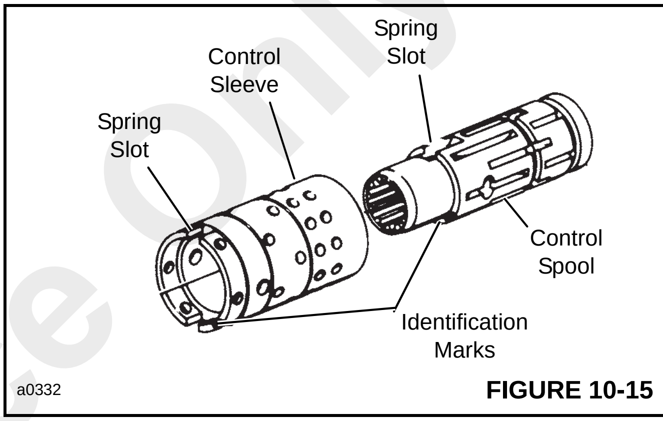


FIGURE 10-15

7. Bring spring slots of both parts in line and stand parts on end on the work bench (Figure 10-16). 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, as shown in Figure 10-16, with spring notches facing the sleeve.

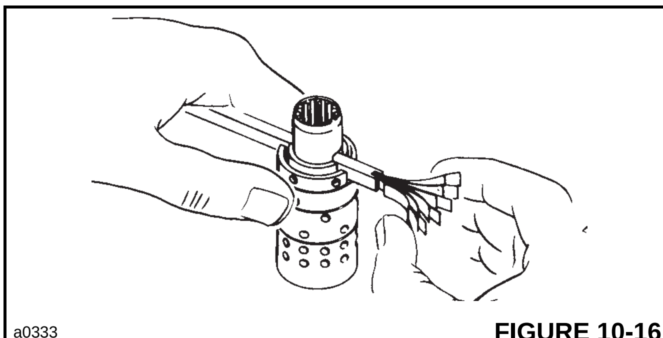


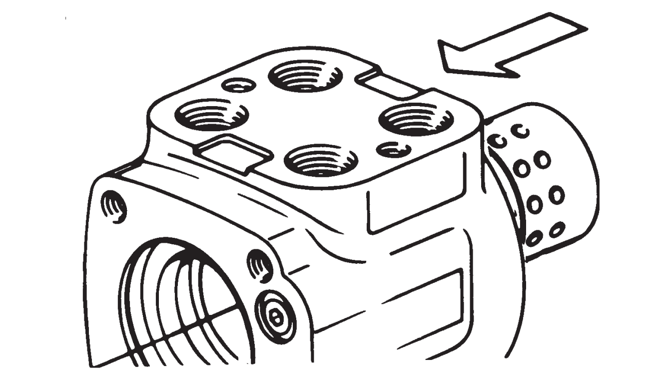
FIGURE 10-16

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 10-9) 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 10-9). See Figure 10-17.



a0334

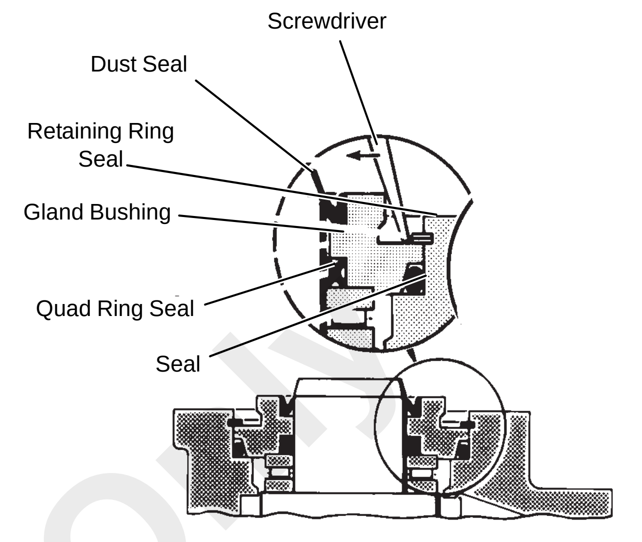
FIGURE 10-17

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 10-9) 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. See Figure 10-18.



a0337

FIGURE 10-18

15. Install quad ring seal (5, Figure 10-9) 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. See Figure 10-18.

16. Install seal gland bushing (3, Figure 10-9) 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 10-9) in the housing (see Figure 10-18). 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 10-9) 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 grove 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 (see Figure 10-19). Install drive (15, Figure 10-9), Make sure you engage the drive with pin (11). To ensure proper alignment, mark the drive as shown in Figure 10-20, Ref. B. Note relationship

between the slotted end of the drive to the splined end of the drive when marking.

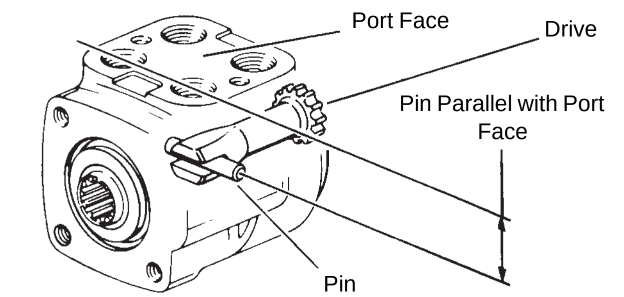


FIGURE 10-19

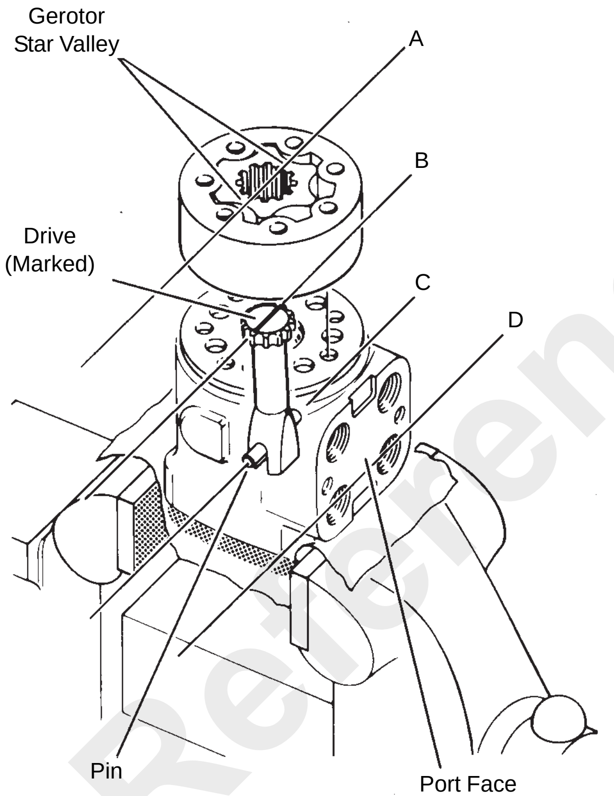


FIGURE 10-20

21. Install seal (13, Figure 10-9) into the gerotor (16).

22. With seal side of the gerotor toward spacer plate (14), align star valleys (Figure 3-24, 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 10-9) 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 150 lb-in, then tighten each screw in sequence shown in Figure 10-21 to a torque of 31 Nm (275 lb-in).

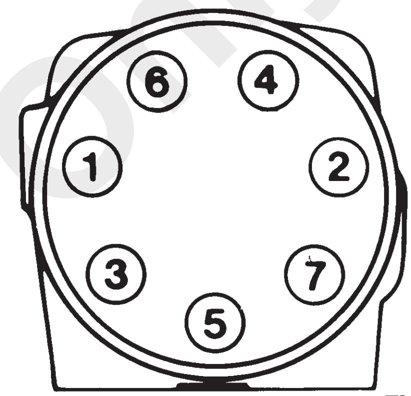


FIGURE 10-21

Installation

1. Locate the steering orbitrol and steering column in position on the mounting bracket under the instrument panel. Secure in place with four bolts and numerous flat washers.

2. Connect the hydraulic lines to the steering orbitrol.

3. Check the hydraulic oil level in the reservoir. Fill if necessary.

4. Start the engine and turn the steering wheel in both directions to fill the lines with hydraulic fluid and bleed air from the system. Check for leaks and repair if necessary.

5. Check the hydraulic oil level in the reservoir. Fill if necessary.

6. Install the outside cover to the operator's compartment.

REAR STEERING CYLINDER

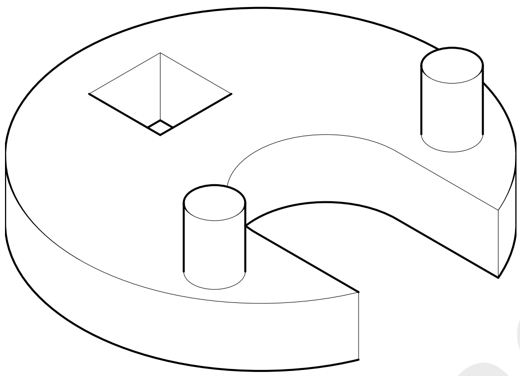
Technical Data

Cylinder Bore...................................57 mm (2.25 in)
Stroke...187 mm (7.38 in)
Rod Diameter...................................38 mm (1.50 in)

Special Torques

Piston Lock Nut.....................................136 Nm (100 lb-ft)

Special Tools



a0668 **FIGURE 10-22**

Cylinder Repair

Removal

WARNING

Crushing Hazard!

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. Raise and support the machine to gain access to the steering cylinders.
2. With the engine not running, turn the steering wheel in both directions to release any pressure in the hydraulic lines to the steering cylinders.
3. Place a tag on the hoses for identification and correct assembly. Be prepared to collect the hydraulic oil as you remove steering lines. Slowly loosen the hydraulic hoses to release any remaining pressure. Install plugs in the hose ends and a caps in the cylinder ports.
4. Make a reference mark to note the position of the clamps on the adjustable ends. The clamps must be installed in the same position at assembly.
5. Remove the cotter pins, slotted nuts and washers from the cylinder ends. Remove the cylinder and take it to a clean work area for disassembly.

Disassembly

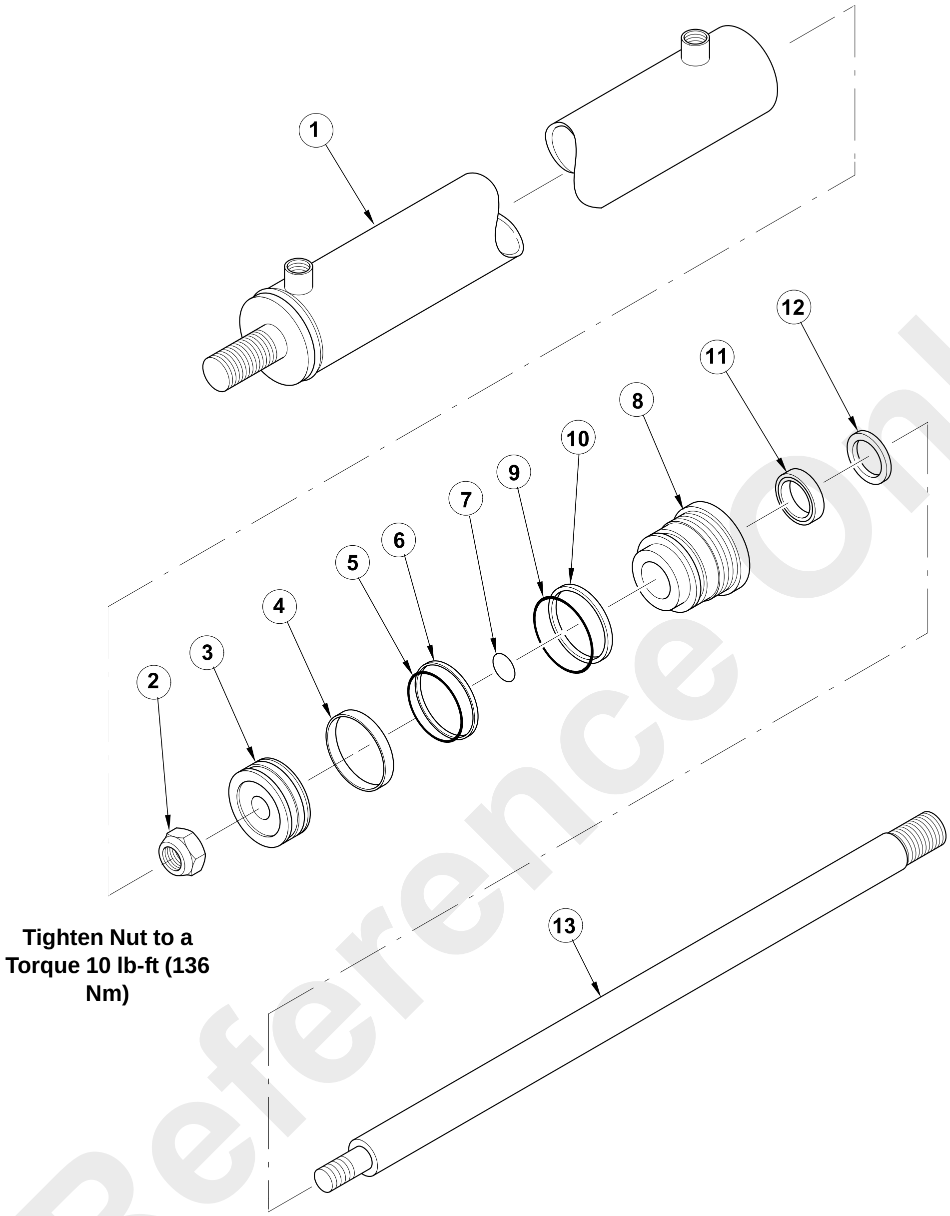
1. Remove the caps from the cylinder ports and drain remaining oil from the cylinder.
2. Fasten the cylinder base in a vice; apply force only across clamp on the adjustable end. To prevent distortion or damage, do not apply force directly to cylinder tube. Use a chain wrench around the solid end of cylinder tube if necessary to prevent rotation of cylinder tube during removal of head.
3. Use a spanner wrench like the one shown in Figure 10-22 and loosen the cylinder head (8, Figure 10-23).
4. Pull the piston and rod (3 and 13) straight out of cylinder tube (1). If the cylinder rod and piston are hard to remove, install the cylinder head back into the cylinder tube and apply shop air to the base port to push the piston out to cylinder head.

WARNING

Flying Objects Hazard!

If air or hydraulic pressure is used to force out the piston assembly, ensure that the piston head is securely installed in the cylinder tube.

5. Fasten the adjustable end of the rod in a vise. Do not clamp to the chrome part of the rod.



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

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FIGURE 10-23

6. Remove nut (2) from the from cylinder rod (13).
7. Remove piston (3) and cylinder head (8) from cylinder rod (13).
8. Remove and discard the piston ring (4), O-rings (5 and 7) and seal (6) from piston (3).
9. Remove and discard the O-ring (9), backup ring (10), rod seal (11), and wiper (12) from cylinder head (8).

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. Replace all seals and rings.

Assembly

1. Install rod seal (11, Figure 10-23) in the bore of the cylinder head. Install wiper seal (12) in the front groove in the bore of the cylinder head. The lip of the wiper must be toward the outside of the cylinder. Install O-ring (9) and backup ring (10) in the groove on the outside of the head. The backup ring must be toward the outside of cylinder.
2. Apply petroleum jelly to the rod seal and wiper. Carefully slide the cylinder head assembly over the piston end of rod (13). Do not try to install the head over the threaded end of the rod. Damage can be caused to the wiper and rod seal by the threads.
3. Install O-ring (7) on piston rod (13). Be careful not to damage the O-ring on the threads.
4. Install piston (3) on piston rod (13) with the wear ring groove towards the rear.
5. Install piston nut (2) and tighten to a torque of 100 lb-ft *(136 Nm)*.
6. Install split piston ring (4). Install O-ring (5) and seal (6) to piston (3).
7. Apply petroleum jelly to the cylinder tube threads and to the O-ring and seal on the piston. Carefully, slide the assembled piston rod into the cylinder tube. Use care to prevent damage to the piston ring and seals during installation. Work the piston rod straight into the cylinder tube.
8. Lubricate O-ring (9) on the outside of cylinder head (8). Slide the cylinder head into the cylinder tube and engage the cylinder head threads. Tighten the cylinder head with the spanner wrench until contact is made between the cylinder head flange and the cylinder tube. Continue to tighten the cylinder head until all turning movement stops and the cylinder head is secure.
9. Test the cylinder before installation.

Test

1. Use an external pump to test the cylinder.
2. Fill the cylinder with clean hydraulic oil. To test the piston seal ring, continue to push oil into the rod end after the cylinder has hit bottom. Test at a pressure of 24132 kPa (3500 psi) in both directions.
3. Move the cylinder rod through two complete cycles at 800 psi (5510 kPa) to remove air from the cylinder. Look for external leaks. If the pressure differences between the 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.
4. 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 on the rod during the four strokes. A thin layer of oil on the cylinder rod is normal. Excessive oil indicates rod seal leakage. Inspect and replace the seal.
5. Fully retract the cylinder rod. Keep the base port open. Apply a test pressure of 24132 kPa (3500 psi) to the rod port. Hold this pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No leakage is permitted.
6. Fully extend the cylinder rod. Keep the rod port open. Apply a test pressure of 24132 kPa (3500 psi) to the base port. Hold this pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No leakage is permitted.
7. Plug both ports to keep contamination out of the cylinder during installation.
8. If the ball joints were removed, install them to the cylinder ends. Turn the ball joint onto the threads 18 turns. Be sure to locate the ball joints as illustrated in Figure 10-24. Then measure the distance from center of one grease fitting to the center of other grease fitting. The dimension should be 504.8 mm (19-7/8 in).

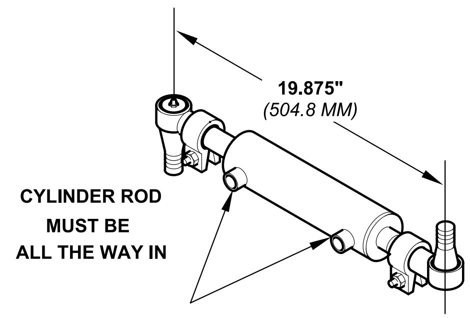


FIGURE 10-24

Installation

1. Be sure the ball joints are installed to the correct dimension.
2. Install the cylinder with the cylinder ports facing out. Tighten each castle nut and install the cotter pin.
3. Connect the hydraulic hoses to the cylinder ports. Make sure they are tight.
4. Lubricate the grease fittings with Lithium based, E.P. No. 2 bearing grease.
5. Check the hydraulic oil level and add oil if necessary.

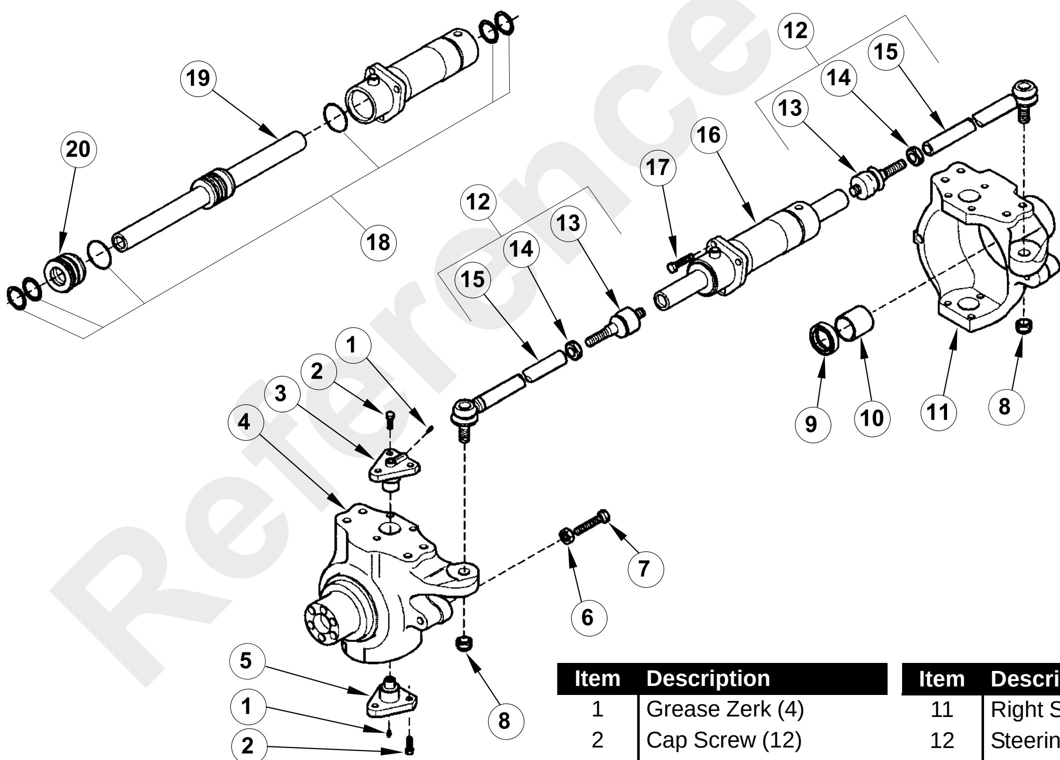
6. Start the engine and operate the cylinder(s) through several complete cycles to remove air from the system. Operate the cylinders slowly and do not let them hit bottom until movement is positive in both directions. After the circuit is filled with oil, the cylinders can be operated normally.
7. Check for leaks and repair if necessary.
8. Check the hydraulic oil level and fill if necessary.

FRONT STEERING CYLINDER

Cylinder Repair

Removal

1. Raise and support the machine to gain access to the steering cylinder.
2. With the engine not running, turn the steering wheel in both directions several times to release any pressure in the hydraulic lines to the steering cylinder.
3. Place a tag on hoses for identification and correct assembly. Be prepared to collect the hydraulic oil as you remove steering lines. Slowly loosen the hydraulic hoses to release any remaining pressure. Install plugs in the hose ends and caps in the cylinder ports.
4. Loosen the hex nut (8, Figure 10-25) on one of the cylinder tie rod ends (12) until none of the threads on the tie rod are exposed. Using a hammer and a tie rod fork, remove the tie rod from the swivel housing.
5. Mark the tie rod for identification during assembly. Remove the tie rod (12) from the cylinder rod. Be careful not to tamper with the length of the tie rod assembly. If measurement is changed, the axle will have to be checked for toe-in.



Item	Description	Item	Description
1	Grease Zerk (4)	11	Right Swivel Housing
2	Cap Screw (12)	12	Steering Tie Rod Assembly (2)
3	King Pin (2)	13	Ball Joint (2)
4	Left Swivel Housing	14	Hex Nut (2)
5	King Pin (2)	15	Tie Rod (2)
6	Hex Nut (4)	16	Steering Cylinder Assembly
7	Cap Screw (4)	17	Cap Screw (3)
8	Lock Nut (2)	18	Seal Kit
9	Seal Ring (2)	19	Rod
10	Bronze Bushing (2)	20	Cylinder Head

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FIGURE 10-25

6. On the other end of the cylinder, repeat steps 4 and 5.
7. Remove three cap screws (17) fastening the cylinder to the axle housing. Remove the cylinder. It may be necessary to drive the cylinder out of its mounting brackets using a rubber hammer.
8. Take the cylinder to a clean work area for disassembly.

Disassembly

1. Place the cylinder in a vice. Do not clamp on the cylinder tube. Clamp onto the square flange attached to the tube.
2. Separate the cylinder head from the cylinder tube and remove it.
3. Pull the cylinder rod out of the cylinder tube.
4. Remove and discard all seals from the cylinder rod piston, cylinder head and cylinder tube.

Assembly

1. Install new seal kit (18, Figure 10-25) to the cylinder rod, cylinder tube and cylinder head.
2. Install the cylinder rod into the cylinder tube being careful not to damage any of the seals in the cylinder tube and on the cylinder rod piston.
3. Install the cylinder head onto the cylinder rod, being careful not to damage any of the seals in the cylinder head.

Installation

1. Install the cylinder to the axle housing using three cap screws (17, Figure 10-25). Tighten the cap screws to a torque of 120 Nm (88 lb-ft).
2. Install the tie rods (12) to the ends of the cylinder rod. Check reference marks to make sure the tie rods are in the correct position. Tighten the tie rods to a torque of 300 Nm (220 lb-ft).
3. Install the ball joint of one of the tie rods into the swivel housing. Install the lock nut and tighten to a torque of 220 Nm (162 lb-ft).
4. Repeat step 3 for the other tie rod.
5. Connect the hydraulic hoses to the steering cylinder.
6. Start the engine and turn the steering wheel in both directions several times to release any air trapped in the steering cylinder and the hoses.
7. Check the steering cylinder and hydraulic lines for leaks.

SECTION 11
STRUCTURAL

SECTION CONTENTS

BOOMS

3-Section Boom Assembly

Refer to three-section boom assembly diagram Figure 11-1 for all part numbers in this section.

The three-section boom assembly includes three boom sections, a telescope cylinder and an extend/retract chain assembly.

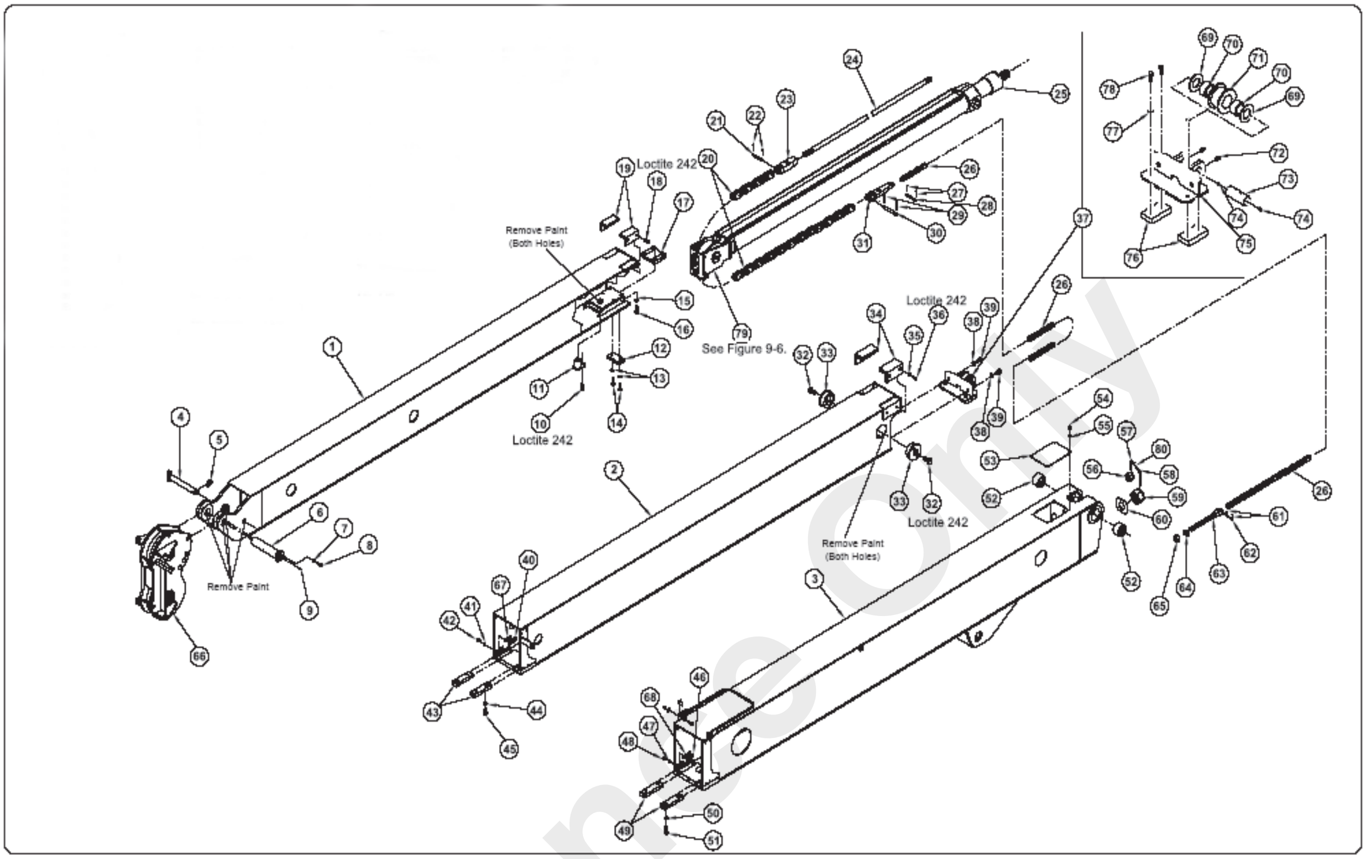
Extending the Booms

The chain assembly used to retract and extend the 3rd boom section consists of an extend rod (24), chain end (23), two chains (20 and 26) connected together by a chain end (31) and an adjustable chain end (63). The top extend chain (20) wraps around a roller assembly (79) at the base end of the telescope cylinder, used to extend the 2nd boom section. Chain (20) is attached to the extend rod (24) with chain end (23). Extend rod (20) attaches to the rear end of the 1st boom section. The other end of chain (20) is attached to chain end (31), which is attached to the 3rd boom section with pin (11). The lower retract chain (26) is attached to the front end of the 1st boom section with chain end (63).

When extending the booms, the telescopic cylinder extends the 2nd boom section. When the cylinder extends it pulls on the upper chain, which extends the 3rd boom section at the same time.

Retracting the Booms

When retracting the booms, the telescope cylinder pulls the 2nd boom section into the 1st boom section. Since the chain assembly is attached to the 3rd boom section and anchored at both ends at the 1st boom section, when the telescope cylinder retracts, the lower retract chain pulls the 3rd section into the 2nd boom section.



Item	Description
1.	3rd Boom Section
2.	2nd Boom Section
3.	1st Boom Section
4.	Pin
5.	Lynch Pin
6.	Pin
7.	Lockwasher
8.	Capscrew
9.	Grease Fitting
10.	Capscrew
11.	Pin
12.	Rear Slide Pad
13.	Lockwasher (2)
14.	Capscrew (2)
15.	Lockwasher (4)
16.	Capscrew (4)
17.	Guide Pad
18.	Capscrew (4)
19.	Top Slide Pad (2)
20.	Extend Chain
21.	Extend Chain Pin
22.	Cotter Pin (2)
23.	Top Extend Chain End
24.	Extend Rod
25.	Telescope Cylinder Assembly
26.	Retract Chain
27.	Cotter Pin (2)
28.	Retract Chain Pin
29.	Cotter Pin (2)
30.	Extend Chain Pin
31.	Bottom Extend Chain End
32.	Capscrew (2)
33.	Eccentric (2)
34.	Top Slide Pad (2)
35.	Lockwasher (4)
36.	Capscrew (4)
37.	Retract Roller Assembly
38.	Lockwasher (2)
39.	Capscrew (2)
40.	Bronze Wear Pad (4)
41.	Lockwasher (8)
42.	Capscrew (8)
43.	Bottom Slide Pad (2)
44.	Lockwasher (4)
45.	Capscrew (4)
46.	Bronze Wear Pad (4)
47.	Lockwasher (8)
48.	Capscrew (8)
49.	Lower Slide Pad (2)
50.	Lockwasher (4)
51.	Capscrew (4)
52.	Bushing (2)
54.	Capscrew (4)
55.	Lockwasher (4)
56.	Castle Nut
57.	Cotter Pin
58.	Cotter Pin
59.	Castle Nut
60.	Washer
61.	Cotter Pin (2)
62.	Retract Chain Pin
63.	Threaded Chain End
64.	Jam Nut
65.	Nut
66.	Pivoting Boom Head
67.	Shim
68.	Shim
69.	Nylatron Spacer (2)
70.	Roller Bearing (2)
71.	Retract Chain Roller
72.	Set Screw (2)
73.	Pin
74.	Grease Fitting (2)
75.	Roller Support Bracket
76.	Bottom Wear Pad (2)
77.	Lockwasher (4)
78.	Capscrew (4)
79.	Roller Assembly
80.	Lock Wire

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FIGURE 11-1

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Maintenance

Boom Slide Pads

See *Maintenance*, page 5-1 for lubrication intervals and instructions.

Boom Chains

See *Maintenance*, page 5-1 for lubrication and inspection intervals and instructions.

Adjustments

Boom Side-to-Side Adjustment

WARNING

When lifting at high boom angles with an extended boom, it is crucial to maintain proper side slide pad adjustment. Visually check the lateral straightness of the boom before raising the load. Lifting with a boom which is not visually straight may cause boom failure and could result in injury or death.

The boom side slide pads on the 1st and 2nd boom sections are adjustable to allow for wear on the pads. Shim pads must be placed behind the slide pads to take up excessive slack in the side movement of the booms. When adding shims behind the wear pads, be sure to add them only behind the slides on the boom section to keep the sections centered.

Replace the wear pads when wear nears the bottom of the chamfer. If the wear extends down to the bolts, damage to the boom sections could occur.

Shims are available from your distributor.

P/N 1005522 = 1.02 mm (0.04 in)

P/N 1005475 = 1.78 mm (0.07 in)

To install the shims:

1. Extend the boom sections until the side slide pads are visible (Figure 11-2)

NOTE: Add shims behind one slide block at a time.

2. At one slide pad, remove the two screws attaching the slide pad to the boom section. Slide the slide pad and existing shims, if used, out from between the boom sections. Place additional shims behind the wear pad and existing shims, if used. Install the wear pad and shims between the boom sections. Install the two screws to secure the slide pad and shim(s) to the boom section. Longer screws may be needed.
3. Repeat step 2 for the remaining slide pads.

Boom Chain Adjustment

Lower Retract Chain

1. Completely retract the boom sections.
2. It is most likely that the chain will be loose due to chain stretching during use. Scribe a line on the 2nd boom section next to the 1st boom section (Figure 11-3).
3. See Figure 11-3 and loosen the jam nut on the lower chain adjusting rod. Tighten the adjusting nut to remove the chain slack. Tighten the chain until the 2nd boom section just starts to move away from the 1st boom section, then stop. This will be indicated in movement of the scribed line on the 2nd boom section. Tighten the jam nut against the adjusting nut. Do not overtighten the chain.

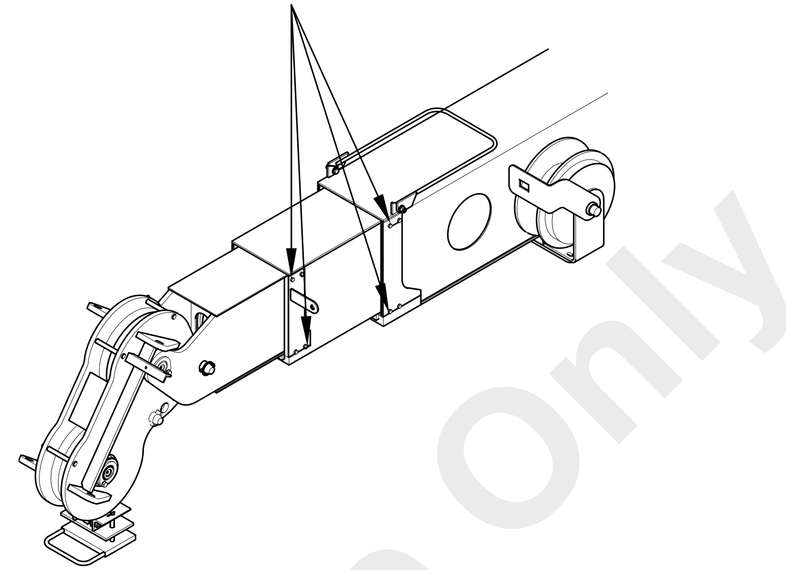


FIGURE 11-2

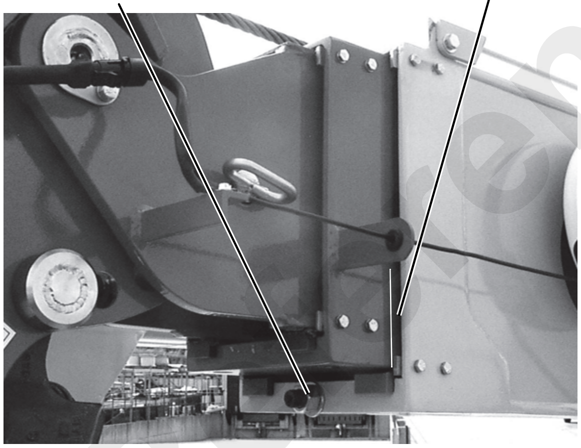


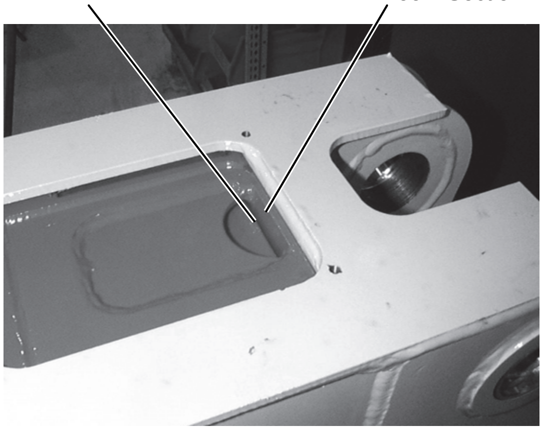
FIGURE 11-3

NOTE: Use the following procedure to check if the chain is too tight after adjusting: Remove the inspection cover from on top of the 1st boom section (Figure 11-4). Then retract the booms and check that the 3rd boom section has bottomed against the 2nd boom section. If the 3rd boom section has not bottomed, the chain is too tight and must be loosened.

4. If the chain is too tight, loosen the jam nut (Figure 11-3) and turn the adjusting nut to loosen the chain. Tighten the jam nut against the adjusting nut. Recheck for correct tightness as described in NOTE above.

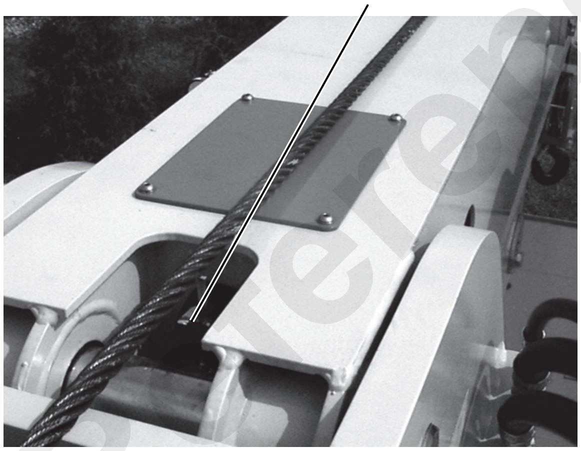
Upper Extend Chain

1. Completely retract the boom sections.
2. Remove the inspection cover from on top of the 1st boom section (Figure 11-4) to expose the ends of 2nd and 3rd boom sections. The boom sections should be bottomed against each other.
3. If the chain is too loose DO NOT use the castle nut (Figure 11-5) to remove the slack. Instead, extend the booms until the extend rod is visible through the inspection opening. Scribe a line on the 3rd section to tell when the section moves. Attach a pipe wrench to the extend rod (Figure 11-6) and turn the rod into the chain end. While turning the extend rod observe the boom section to see when it moves out slightly.



P0680 **FIGURE 11-4**

4. When the boom has extended slightly, remove the pipe wrench and fully retract the booms. Check that the 3rd boom section has bottomed against the 2nd boom section. Repeat steps 3 and 4 until the booms bottom against each other.



P0826 **FIGURE 11-5**

P0829 **FIGURE 11-6**

Boom Repair

Removal

1. Lower the boom to lowest position. Fully retract the booms.
2. Lower the drop block to the ground.
3. Disconnect the wedge assembly from the boom head to free the hoist wire rope.
4. Unwrap the wire rope from the drop block sheaves and the boom head sheaves. Wind the wire rope onto the hoist drum.
5. Disconnect the anti-double blocking system electrical wire from the electrical swivel on top of the hydraulic swivel, or if installed, disconnect the rated capacity limiter (RCL) wire from the electrical swivel.
6. Place a suitable container under the bulkhead fittings at the base of the boom assembly. Disconnect the two telescope cylinder hoses from underneath the boom at the bulkhead fittings and drain oil into the container.

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

7. Using an over head crane and sling or chain arrangement support the boom assembly.
8. Support the lift cylinder by placing a piece of 2 x 4 wood board between lift cylinder load hold valve block and the turntable base or support above with another overhead crane. This will support the cylinder when the rod end pin is removed.
9. Remove the cylinder rod end pin.

10. Remove the boom mounting pin and remove the boom assembly. Place boom on supports capable of handling the weight of the boom.
11. Disconnect the anti-double blocking wire or RCL wire, depending on which is installed, from the boom head and wind it onto the cord reel.
12. If the 1st boom assembly is to be replaced, remove all external components, i.e. double-blocking cable reel, boom angle indicator.

Special Tools

Two special tools are required to disassemble and assemble the 3-section boom. Each tool can be constructed using the dimensions in Figures 11-7 and 11-8.

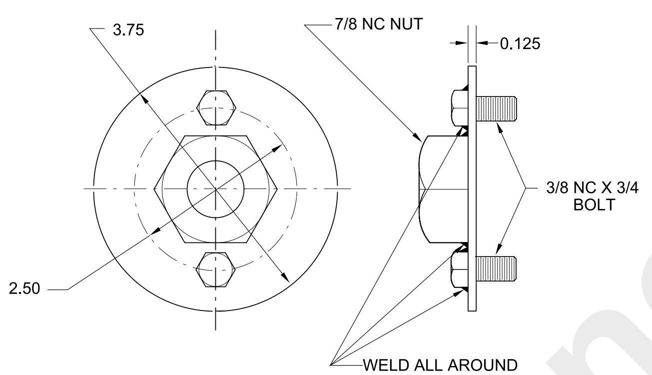


FIGURE 11-7

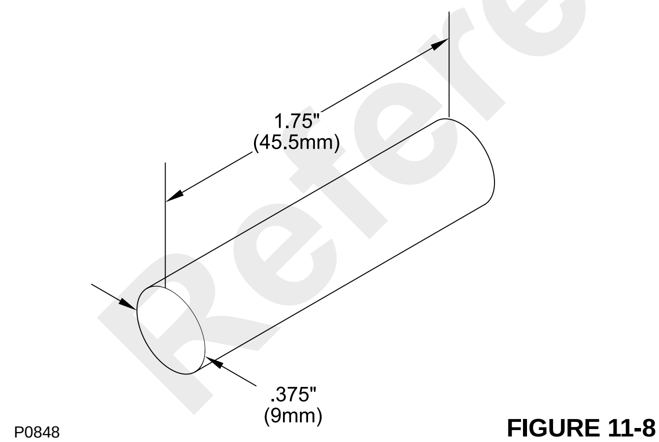


FIGURE 11-8

Disassembly

Refer to three-section boom assembly diagram at the end of this manual for all part numbers in this section.

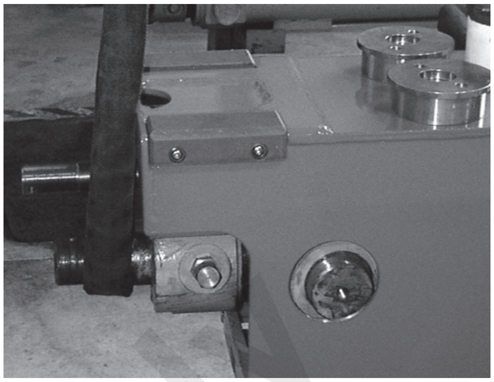
1. At the base of the boom assembly, remove the hoses from the boom. Cap the fittings at the telescope cylinder and plug the hoses at the boom.
2. Attach a sling and overhead crane to the pivoting boom head (66). Remove lynch pin (5) and pin (4). Remove capscrew (7) and lockwasher (8). Remove pin (6) and the pivoting boom head (66).
3. At the front end of the second boom assembly remove eight capscrews (42), lockwashers (41) and four bronze wear pads (40). If wear pads (40) are to be reinstalled, make note as to which wear pad, and shims (67), if installed, were removed from which location.
4. At the front of the 3rd boom assembly, remove eight capscrews (48), lockwashers (47) and four bronze wear pads (46). If wear pads are to be reinstalled, make note as to which wear pad, and shims (68), if installed, were removed from which location.
5. Remove nut (65) from threaded chain end (63). Slide chain end (63) out the 1st boom section and let it hang free.
6. At the base end of the 1st boom assembly, remove cotter pin (57) and castle nut (56) from extend rod (24). Remove cotter pin (58), castle nut (59) and washer (60) from end of cylinder. Do not turn extend rod (24) out of chain end (23) at this time.

WARNING

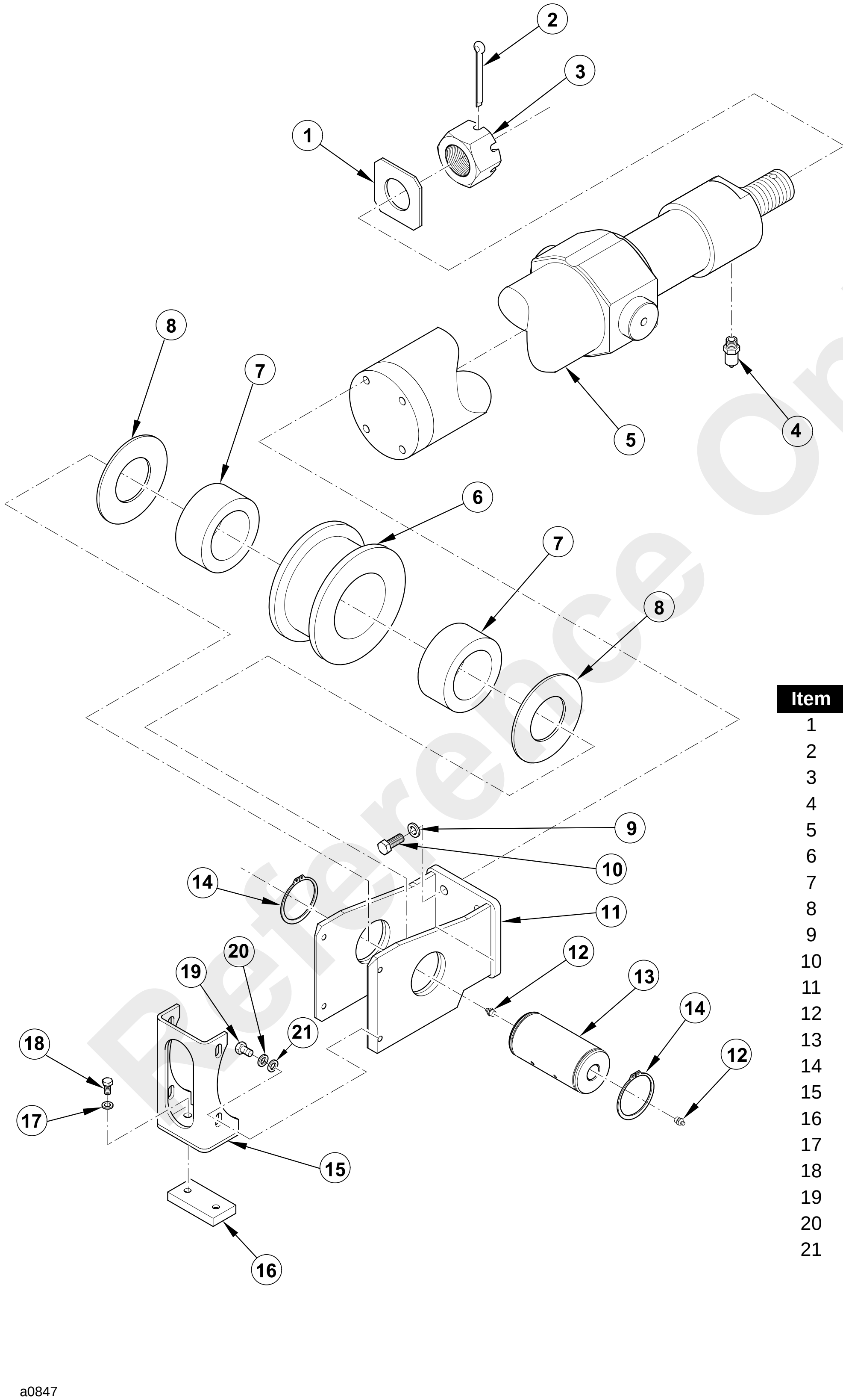
The next step requires pulling on the boom assembly. To inhibit the boom assembly from pulling off of the supports, secure the boom assembly. Should the boom be pulled off of the supports, personal injury could occur.

7. Secure the boom assembly so it does not pull off the supports. Attach an overhead crane and sling to the 2nd boom assembly. Pull the 2nd and 3rd boom sections out of the 1st boom section approximately half way. Remove four capscrews (51), lockwashers (50) and two boom slide pads (49). Continue pulling the 2nd and 3rd boom section out of the 1st boom section until it stops and retract roller assembly (37) is visible through the front access holes of the 1st boom section.
8. Remove two capscrews (39) and lockwashers (38) from retract roller assembly (37).
9. When the retract roller assembly is free, pull the 2nd boom section out the end of 1st boom section. When free, disconnect lower retract chain (26) from the chain end (31) by removing pin (28) and cotter pins (27).
10. Remove retract roller assembly (37) from the 1st boom section.
11. Place the 2nd boom assembly on supports capable of handling the weight.
12. With the 2nd boom assembly supported, remove the two capscrews (32) from eccentrics (33). Remove the eccentrics.

13. Attach an overhead crane and sling to the telescope cylinder as shown in Figure 11-9. Raise the 3rd boom assembly far enough to remove two capscrew (14) and lockwashers (13). Remove rear slide pad (12).



P0670 **FIGURE 11-9**



Item	Description
1	Washer
2	Cotter Pin
3	Castle Nut
4	Counterbalance Valve
5	Telescope Cylinder
6	Chain Sheave
7	Bearing (2)
8	Nylatron Spacer (2)
9	Lockwasher (4)
10	Capscrew
11	Extend Chain Roller Bracket
12	Grease Filling (2)
13	Chain Roller Pin
14	Retaining Ring (2)
15	End Guide Bracket
16	Cylinder End Slide Pad
17	Lockwasher (2)
18	Capscrew (2)
19	Capscrew (4)
20	Lockwasher (4)
21	Flat Washer (4)

FIGURE 11-10

14. See previous WARNING. Secure the 2nd boom section from pulling off the supports. Pull 3rd boom assembly out far enough to attach a sling and overhead crane. Pull the 3rd boom section about half way out. Remove four capscrews (45) and lockwashers (44). Remove two boom slide pads (43). Pull the 3rd boom assembly from the 2nd boom assembly. When the 3rd boom assembly is almost out, raise the boom tip end. This will allow the boom assembly to clear an internal plate that will prevent the boom from being pulled straight out.

15. Place the 3rd boom assembly on suitable supports.

16. Pull the telescope cylinder assembly (25) out, keeping tension on the extend chain, until the roller end of the telescope cylinder assembly is visible through the center access hole.

17. Through the access hole remove four capscrews (19), lockwashers (20) and flat washers (21). Remove end guide bracket (15). Check slide pad (16) and if excessively worn or damaged replace it.

18. Lift up on telescope cylinder assembly, remove four capscrews (16), lockwashers (15) and guide pad (17, Figure 11-10).

19. Pull the telescope cylinder assembly out of the 3rd boom section far enough to see chain end (23, Figure 11-10). Remove two cotter pins (22) and pin (21). Remove chain end (23) and extend rod (24) as an assembly. Note the distance from chain end (23) to end of extend rod (24) for base setting at assembly.

20. Continue pulling telescope cylinder assembly (25) out of the 3rd boom section.

21. Place the telescope cylinder assembly on suitable supports.

22. Remove capscrew (10, Figure 11-10) and pin (11). Remove extend chain (20) and chain end (31) from the 3rd boom assembly.

23. If the telescope cylinder extend roller assembly needs to be disassembled, use Figure 11-10 as a guide. For cylinder repair, see Section 4.

Inspection

Inspect all boom slide pads for wear and/or damage. Replace if necessary.

Inspect the extend and retract chains for damage. See chain inspection in Section 5.

Assembly

NOTE: If new boom sections are being installed the holes for threaded fasteners are tapped at the factory and covered with paint. Before assembling the boom sections, run a tap through all holes to remove the paint.

NOTE: Coat the threads of all fasteners with an anti-seize compound, except where use of Loctite 243 is indicated.

Assembling the Telescope Extend Roller Assembly

Refer to (Figure 11-10) Telescope Cylinder and Extend Roller Assembly.

The following procedure needs only be done if the telescope extend roller assembly was disassembled.

1. Attach the extend chain roller bracket (11) to the base end of telescope cylinder (5) using capscrews (10) and lockwashers (9). Make sure the holes for pin (13) are parallel to the eccentric hubs on telescope cylinder (5).

2. If bearings (7) were removed, install the bearings into extend chain roller (6) as follows:

- **a.** Remove the inner ring from the bearings (7) and coat the rollers with a Lithium Base, E.P. No. 2 bearing grease.
- **b.** Insert the inner rings into the bearings. Install the bearings in roller (6).

3. Using roller pin (13), install the extend chain roller assembly and two nylatron spacers (8) into the chain roller bracket (11).

4. Secure the extend roller pin (13) with two retaining rings (14).

5. If grease fittings (12) were removed, install them into the ends of pin (13). Apply Lithium Base, E.P. No. 2 bearing grease to the two grease fittings.

6. Install cylinder end slide pad (16) to end guide bracket (15) using two capscrews (18) and lockwashers (17).

7. Do not install end guide bracket assembly at this time. It will be installed later during the boom assembly procedure.

Assembling the Retract Roller Assembly

Refer to three-section boom assembly diagram at the end of this manual for all part numbers in this section.

The following procedure needs only be done if the retract roller assembly (37) was disassembled.

1. If bearings (70) were removed, install the bearings into retract chain roller (71) as follows:

- **a.** Remove the inner ring from the bearings (70) and coat the rollers with a Lithium Base, E.P. No. 2 bearing grease.
- **b.** Insert the inner rings into the bearings. Install the bearings in roller (71).

2. Using roller pin (73), install the extend chain roller assembly and two nylatron spacers (69) into roller support bracket (75).

3. Lock the pin in place with two set screws (72).
4. If grease fittings (74) were removed, install them into the ends of pin (73). Apply Lithium Base, E.P. No. 2 bearing grease to the two grease fittings.
5. Install the two bottom pads using four capscrews (78) and lockwashers (77).

Preparing the 2nd Boom Section for Assembly

Refer to three-section boom assembly diagram at the end of this manual for all part numbers in this section.

1. If the two top slide pads (34) were removed, install new pads using two capscrews (36) and lockwashers (35). Coat the thread of capscrew (36) with Loctite 243 before installation.

CAUTION

Lockwashers (35) must be installed with capscrews (36). If they are not, possible damage to the 3rd boom section could occur.

2. The bearing in retract roller assembly (37) must be lubricated with Lithium Base, E.P. No. 2 bearing grease. Apply the grease through the two grease fittings in the roller pin.
3. On new replacement boom sections, check that the bronze wear pads (40) align with the mounting holes. If they do not align, it is permissible to grind away some of the weld to align the holes. Do not install the wear pads at this time. Also, remove the paint from the eccentric mounting hole. If the paint is not removed the anti-double blocking system will not work properly.

Preparing the 1st Boom Section for Assembly

Refer to three-section boom assembly diagram at the end of this manual for all part numbers in this section.

1. If bushings (52) were removed, press new bushings into the boom section.
2. On new replacement boom sections, check that the bronze wear pads (46) align with the mounting holes. If they do not align, it is permissible to grind away some of the weld to align the holes. Do not install the pads at this time.

Assembling the 3rd Boom Section

Refer to three-section boom assembly diagram at the end of this manual for all part numbers in this section.

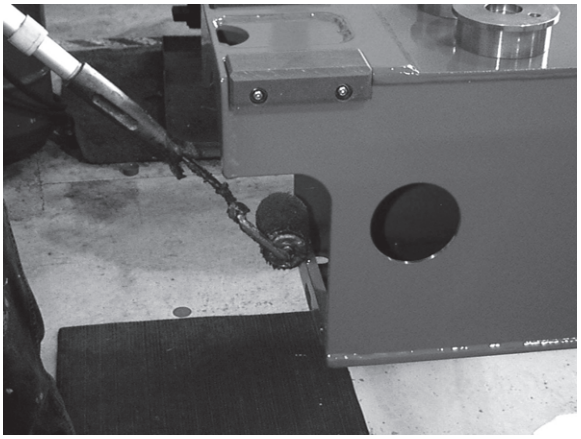
NOTE: Apply anti-seize to all capscrew threads, unless stated otherwise, before installation.

1. If boom slide pads (19) were removed, install new pads using two capscrews (18). Coat the threads of capscrew (18) with Loctite 243 before installation.
2. Install cylinder guide pad (17) using four capscrews (16) and lockwashers (15).
3. Attach chain end (31) to chain (20) with pin (30) and cotter pins (29).
4. From the boom tip end, thread the chain (20), chain end (31) first, into the boom section and fasten chain end to the boom using pin (11) and capscrew (10). Apply Loctite 243 to the threads of capscrew (10) before installation.
5. Attach chain end (23) to other end of chain (20) with pin (21) and two cotter pins (22).
6. Coat the bottom of the telescope cylinder with an anti-seize compound where it will slide on guide pad (17).
7. Using an overhead crane and sling, lift the telescope cylinder assembly (25) and align it with the rear of the 3rd boom section. Then, insert the telescope cylinder at least half way inside the 3rd boom section until the end of the cylinder appears in second access hole from the boom tip end.
8. Thread a puller wire through the 3rd boom section from the cylinder end. Attach the puller wire to chain end (23). Pull the chain through the boom section and onto the tray on top of the telescope cylinder until the chain is tight against the roller of the telescope cylinder assembly.
9. Through the access hole, install the end guide bracket (15) with four capscrews (19), lockwashers (20) and flat washers (21).
10. Extend rod (24) has threaded ends. On the end with the longer threads, coat the threads with an anti-seize compound.
11. Install extend rod (24) into chain end (23) approximately 19 mm (3/4 in). Do not install the rod all the way into the chain end. Fastening the rod to the 1st boom section will not be possible if the rod is threaded in too far.
12. Coat the bottom of the 3rd boom section, where the cylinder slide pad will slide, with an anti-seize compound.
13. Slide the telescope cylinder all the way into the 3rd boom section. When moving the cylinder assembly, pull on the extend chain rod (24) to keep the chain tight.

Installing the 3rd Boom Section Into the 2nd Boom Section

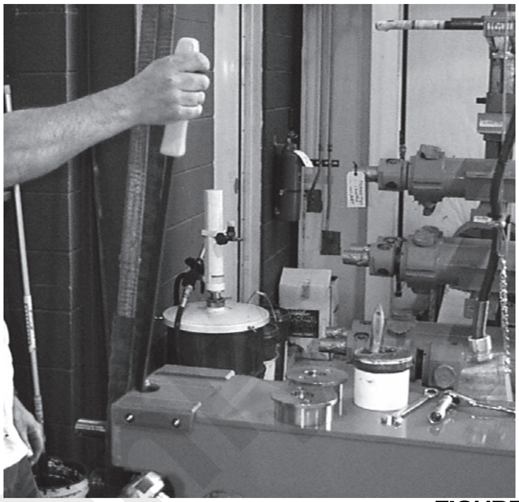
1. Coat the entire lower inside surface of the 2nd boom section with an anti-seize compound using a roller and rod (Figure 11-11). Coat the upper inside surface, where

the 3rd section upper slide pads will slide, with anti-seize compound.



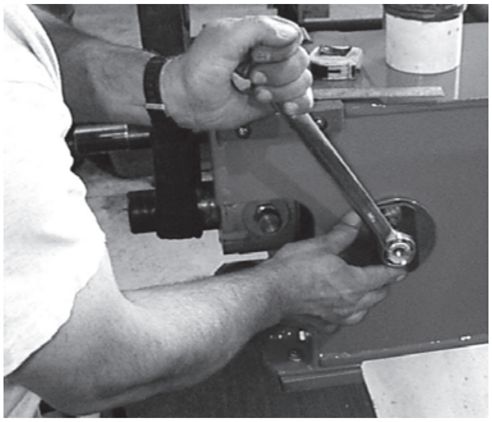
p0669 FIGURE 11-11

2. Using an overhead crane and sling, align the 3rd boom section with the end of the 2nd boom section.
3. Insert the 3rd boom section into the 2nd boom section, raising the boom tip end of the 3rd boom section slightly to clear an internal plate. Then lower tip and continue inserting the 3rd boom section until it is approximately half way in.
4. Coat the tops of the two lower slide pads (43) with an anti-seize compound. Install the two lower slide pads (43) with four capscrews (45) and lockwashers (44). Do not over tighten the capscrews. It is possible to pull the slide pad nuts through the slide pads.
5. Continue inserting the 3rd boom section into the 2nd boom section until it bottoms out.
6. Attach a sling and overhead crane to the threaded rod end of the telescope cylinder (Figure 11-9).
7. Using a pry bar (Figure 11-12), pry the 3rd boom section about 3.2 mm (1/8 in) away from the 2nd boom section.

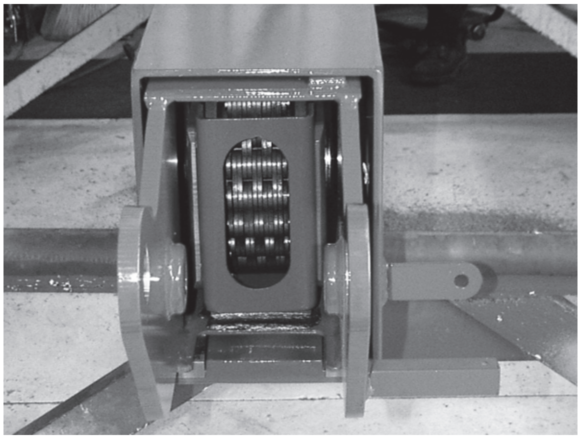


p0671 FIGURE 11-12

8. Using the sling and overhead hoist, raise the 3rd boom section enough to install rear slide pad (12). Install the pad using two capscrews (14) and lockwashers (13). Lower the 3rd boom section.
9. Coat the inside surface of both eccentrics (33) with an anti-seize compound. Coat the threads of capscrew (32) with Loctite 243. Install both eccentrics using capscrew (32). Tighten capscrew (32) to seat the eccentric and then loosen the capscrew.
10. Install retract roller assembly (37) to the 2nd boom section using two capscrews (39). The assembly is installed temporarily to perform a centering measurement.
11. Using a spanner (see Special Tools), turn each eccentric (Figure 11-13) until the telescope cylinder assembly is centered in the 3rd boom section (Figure 11-14).

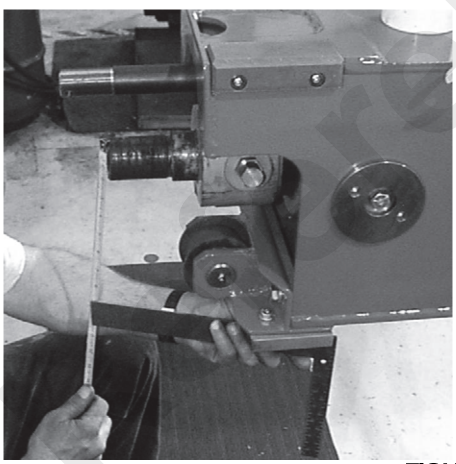


p0672 FIGURE 11-13



90673 FIGURE 11-14

12. At the rear of the boom (Figure 11-15), check for proper height adjustment. Using a tape measure and straight edge, measure from the center of the telescope cylinder threaded rod to the bottom of the slide pad on retract roller assembly (37). It should be 187 mm (7.75 in). If it is not correct, turn the two eccentrics, while maintaining the centering of the telescope cylinder assembly, to either raise or lower the cylinder rod to correct measurement. When the dimension is correct, tighten the two eccentric retaining bolts.



a0674 FIGURE 11-15

13. Check that the telescope cylinder assembly has remained centered. If it is not, adjust it using the eccentrics.

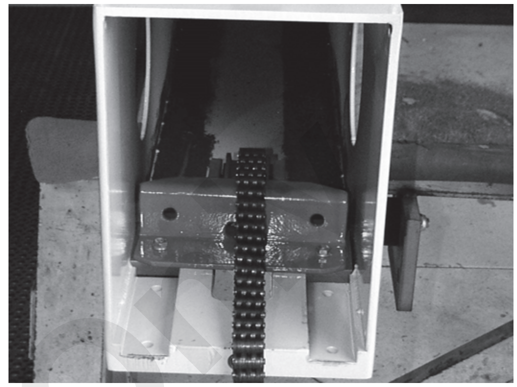
14. Remove retract roller assembly (37) that was temporarily installed in Step 10.

Installing the 2nd Boom Section into the 1st Boom Section

Refer to three-section boom assembly diagram at the end of this manual for all part numbers in this section.

1. Coat the internal slide areas on the 1st boom section with an anti-seize compound.

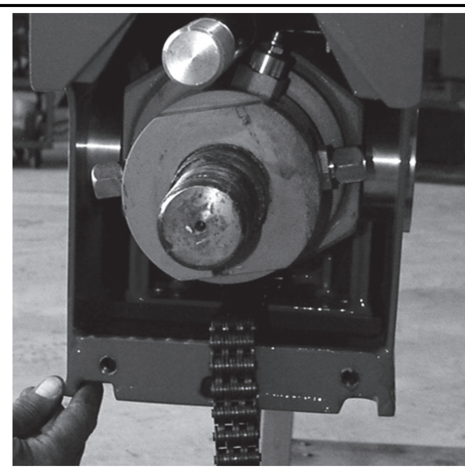
2. Position retract roller assembly (37) in the 1st boom section. See Figure 11-16.



p0675 FIGURE 11-16

3. Place the lower retract chain (26, Figure 11-7) up through bottom access hole and over the roller of the retract roller assembly. See Figure 11-17.

4. Position the 2nd boom assembly in front of the 1st boom assembly close enough to connect the lower retract chain (26), (Figure 11-10) to the chain end (31) using pin (28) and cotter pins (27). See Figure 11-17.



p0676 FIGURE 11-17

5. Insert the 2nd boom assembly into the 1st boom assembly far enough to attach the retract roller chain assembly to the 2nd boom assembly, through the first access hole.

6. Coat the tops of the two lower slide pads (49) with an anti-seize compound. Install the two lower slide pads (49) with four capscrews (51) and lockwashers (50). Do not over tighten the capscrews. It is possible to pull the slide pad nuts through the slide pads.

7. Slide the 2nd boom assembly into the 1st boom assembly far enough that the telescope cylinder hoses can be installed through the rear of the boom. If the 2nd boom assembly will not slide into the 1st boom section it is permissible to hook up a chain jack as shown in Figure 11-18 and jack the boom sections into the 1st boom section.

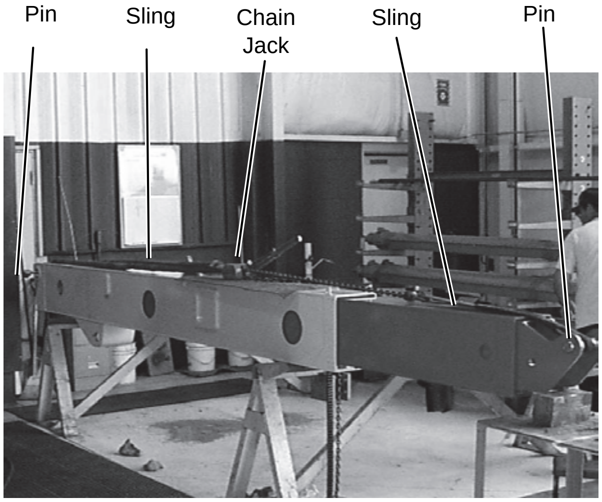


FIGURE 11-18

8. Install the two hoses to the telescope cylinder so they are hanging straight down (Figure 11-19). It may be necessary to rotate the cylinder to align the hose ports.

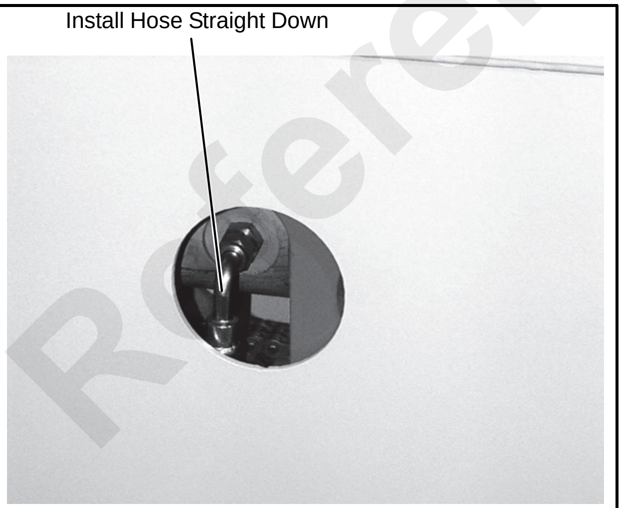


FIGURE 11-19

9. Pull the 2nd boom assembly into the 1st boom assembly until the eccentrics are visible in the access hole.

10. Check that the threaded end of the telescope cylinder aligns with and can be installed in the mounting hole in the boom section (Figure 11-20). If it can not be installed, it must be adjusted as follows:

    a. Loosen the two eccentric mounting capscrews (32).

    b. Using the special spanner turn the eccentrics until the rod can be installed in the mounting hole. There is a shoulder on the cylinder threaded rod that must also clear the hole. Be sure that the telescope cylinder assembly still is centered. Adjusting one eccentric too much may pull the telescope assembly to one side.

    c. Tighten the two eccentric mounting capscrews.

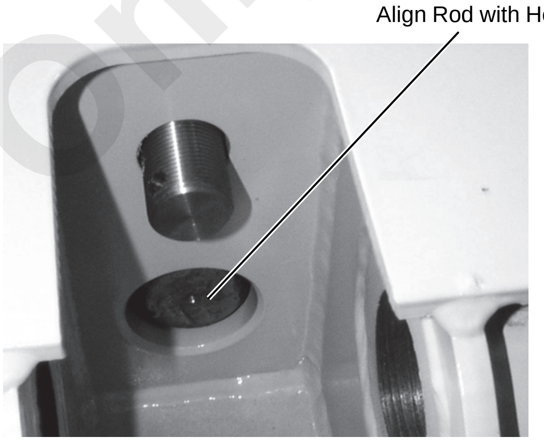


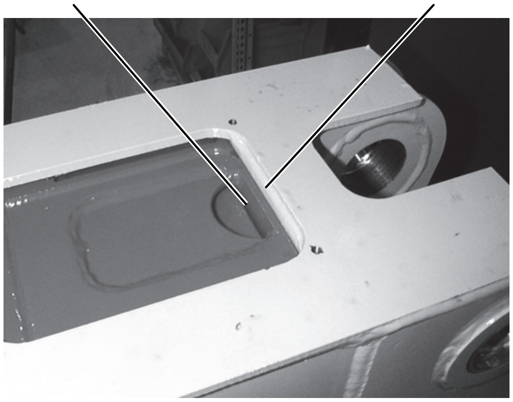
FIGURE 11-20

11. Install the cylinder rod end through the mounting hole. Install extend rod (24) through its mounting hole in the boom section and pull the rod tight.

12. Install washer (60) and castle nut (59). Using a 3-1/8 inch socket, tighten the nut until the cylinder is tight against the mounting plate. Then back off the nut until one of the slots in the nut aligns with the cotter pin hole. Install cotter pin (58).

13. Turn castle nut (56) onto extend rod (24) until the cotter pin hole shows in one of the nut slots. Insert special pin (Figure 11-8) into the cotter pin hole, while installing a 1-7/8" socket onto the nut. The socket will hold the pin in the cotter pin hole.

14. Tighten the nut, which will turn extend rod (24) into the chain end (23). Observe the 3rd boom section through the top access hole (Figure 11-21). When it starts to separate from the 2nd boom section, stop tightening the nut.



p0680

FIGURE 11-21

15. Remove the socket and special pin. Install cotter pin (57) in place of the pin.

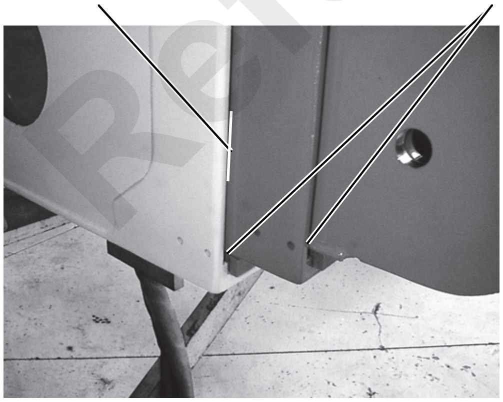
16. Install lock wire (80) between cotter pins (57 and 58).

17. Turn jam nut (64) about 3/4 of the way onto threaded chain end (63).

18. At the front of the 1st boom section install the threaded chain end (63). Install nut (65).

19. Place a pencil mark on the 2nd boom section where the 1st boom section overlaps the 2nd (Figure 11-22).

20. Tighten nut (65) until the pencil mark starts to move away from the 1st boom section. Stop and tighten the jam nut against the boom bracket. Make sure that the chain is not twisted.



p0681

FIGURE 11-22

21. Install the hoses from the two telescope cylinder hoses to the bulkhead in the 1st boom section.

22. At the front of the second boom section (Figure 11-22), install brass wear pads (40) between the 2nd and 3rd boom sections.

    <u>Wear Pad (Units prior to S/N 100710-99)</u>
    P/N 1004468 = 11.18 mm (0.44 in)

    <u>Wear Pads (Units with S/N 100710-99 and After</u>
    P/N 1005703 = 6.35 mm (0.25 in)
    P/N 1005524 = 7.87 mm (0.31 in)

    <u>Shims Units with S/N 100710-99 and After</u>
    P/N 1005522 = 1.02mm (0.04 in)
    P/N 1005475 = 1.78 mm (0.07 in)

    Install the wear pads and, if required, the shims at four places to center the 3rd boom assembly in the 2nd boom assembly.

23. Repeat Step 22 and install the wear pads between the 1st and 2nd boom sections.

24. Locate the pivoting boom head between the 3rd section ears. Install pin (6) and fasten with capscrew (8) and lockwasher (7).

25. Install pin (4) and fasten with lynch pin (5).

26. Install any components that were removed from the 1st boom section prior to disassembly, i.e. boom angle indicator, cord reel.

Installation

1. Connect the anti-double block system wire to the boom head wire.

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

2. Using a sling, or chains and overhead hoist, position the boom assembly between the ears of the mast. Install the mounting pin and fasten with a capscrew and lockwasher.

3. Attach the lift cylinder to the boom assembly.

4. Connect the hoses from the hydraulic swivel to the bulkhead fittings on the boom assembly.

5. Connect the anti-double block system electrical wire to the electrical swivel or connect the rated capacity limiter (RCL) electrical wire to the electrical swivel.

6. Install the wire rope over the boom head and reeve through boom head and drop block sheaves and dead end with wedge and socket. Connect the wedge socket to the pivoting boom head.

WIRE ROPE, SHEAVES AND HOIST BLOCKS

Wire Rope Description

A wire rope is a machine, by definition: “An assemblage of parts, that transmit forces, motion and energy from one to another in some predetermined manner and to some desired end.”

A typical wire rope may contain dozens--even hundreds--of individual wires which are formed and fabricated to operate at close bearing tolerances one to another. When a wire rope bends, each of its many wires slide and adjust in the bend to accommodate the differences in length between the inside and the outside of the bend. The sharper the bend, the greater the movement.

Every wire rope has three basic components (Figure 11-23): (1) The wires which form the strands and collectively provide rope strength; (2) the strands, which are laid helical around the core, and (3) the core, which forms a foundation for the strands. The core used in the crane wire rope is an Independent Wire Rope Core (IWRC), which is actually a smaller rope, or a strand similar to the outer strands of the rope. The IWRC core adds about 7.5% to the nominal strength of the wire rope.

The greatest differences in wire ropes are found in the strands, which may vary widely in the pattern and number of wires which are laid together.

The wires of the rope may be made of various metals, including steel, iron, stainless steel, monel, and bronze. The materials of which wires are made is the primary determination of rope strength. High-carbon steel is used in the crane wire rope.

Carbon steel wire ropes come in various grades. The term “Grade” is used to designate the nominal strength of the wire rope. The most common grades are Traction Steel (TS), Plow Steel (PS), Improved Plow Steel (IPS), Extra Improved Plow Steel (EIPS) and Extra Extra Improved Plow Steel (EEIPS). The wire rope used on the crane is an EIPS Grade.

One cannot determine the grade of wire rope by its feel or appearance. To be sure you are using the proper rope, always obtain the wire rope from your distributor.

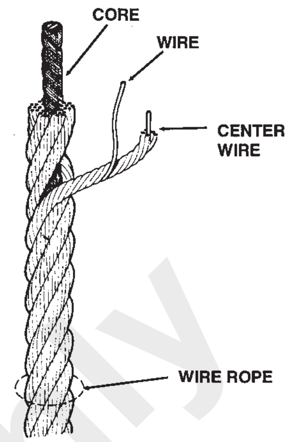


FIGURE 11-23

Wire Rope Safety

The following information is not a complete discussion of wire rope. What follows is a brief outline of the basic information required to safely use wire rope.

- Wire rope WILL FAIL IF WORN-OUT, OVERLOADED, MISUSED, DAMAGED or IMPROPERLY MAINTAINED.
- In service, wire rope looses strength and work capability. Abuse and misuse increases the rate of loss.
- The NOMINAL STRENGTH, sometimes called CATALOG strength, of a wire rope applies ONLY to a NEW, UNUSED rope.
- The Nominal Strength of a wire rope SHOULD BE CONSIDERED the straight line pull which will ACTUALLY BREAK a NEW UNUSED rope. The Nominal Strength of a wire rope SHOULD NEVER BE USED AS ITS WORKING LOAD.
- WIRE ROPES WEAR OUT. The strength of a wire rope begins to decrease when the rope is put to use and continues to decrease with each use.
- NEVER OVERLOAD A WIRE ROPE. This means NEVER use the wire rope where the load applied to it is greater than the working load determined by Manitowoc Cranes, Inc.
- NEVER “SHOCK LOAD” a wire rope. A sudden application of force or load can cause both visible external and internal damage. There is no practical way to estimate the force applied by shock loading a rope. The sudden release of a load can also damage a wire rope.
- Lubricant is applied to the wires and strands of a wire rope when it is manufactured. The lubricant is depleted when the rope is in service and should be replaced periodically. See Section 5, Preventive Maintenance, for lubrication intervals and procedures.

- In the U.S.A., regular INSPECTIONS of the wire rope and keeping of PERMANENT RECORDS SIGNED BY A QUALIFIED PERSON ARE REQUIRED BY OSHA FOR ALMOST EVERY WIRE ROPE APPLICATION. The purpose of the inspection is to determine whether or not a wire rope may continue to be safely used on the application. Inspection criteria, including number and location of broken wires, wear and elongation, have been established by OSHA, ANSI, ASME and similar organizations. Refer to inspection procedures.

  IF IN DOUBT, REPLACE THE ROPE. An inspection should include verification that none of the specified removal criteria for this usage are met by checking for such things as:

  - Surface wear; nominal and unusual.
  - Broken wires; number and location.
  - Reduction in diameter.
  - Rope stretch (elongation).
  - Integrity of end attachments.
  - Evidence of abuse or contact with another object.
  - Heat damage.
  - Corrosion.

  In addition, an inspection should include condition of sheaves, drums and other apparatus with which the wire rope makes contact.

- When a wire rope has been removed from service because it is no longer suitable for use, it must not be reused on another application.
- Every wire rope user should be aware of the fact that each type of fitting attached to a wire rope has a specific efficiency rating which can reduce the working load of the wire rope assembly or rope system, and this must be given due consideration.
- Some conditions that lead to problems in wire rope systems include:
  - Sheaves that are too small, worn or corrugated can cause damage to a wire rope.
  - Broken wires mean a loss in strength.
  - Kinks permanently damage a wire rope and must be avoided.
  - Wire ropes are damaged by knots. Wire rope with knots must never be used.
  - Environmental factors such as corrosive conditions and heat can damage a wire rope.
  - Lack of lubrication can significantly shorten the useful life of a wire rope.
  - Contact with electrical wires and resulting arcing will damage a wire rope.

Inspecting Wire Rope

Inspect entire length of wire rope for any conditions listed in Figure 11-24. If any of the conditions exist, replace the wire rope.

If the wire rope shows severe wear, make a full inspection of sheaves and drums for grooves, correct alignment, etc.

Inspection of Sheaves

Inspect all sheaves for wear and proper alignment.

For maximum life of the wire rope, the sheave grooves must be smooth and must be a little larger than the diameter of the wire rope.

As wear in the sheaves increases, the groove for the wire rope gets smaller, NOT larger. Tracks in the sheaves are caused by the wire rope, and the wire rope will continue to engage the tracks (example; like a chain engaging a sprocket). A twist in the wire rope or a small change of lay will prevent the wire rope from engaging the track in the sheave. The result will be a rapid wear on the wire rope and on the sheave.

Wire Rope Lubrication

Lubricate the wire rope with good grade of spray wire rope lubricant or a light weight oil. A more frequent lubrication (more than monthly) may be required due to operating conditions and usage.

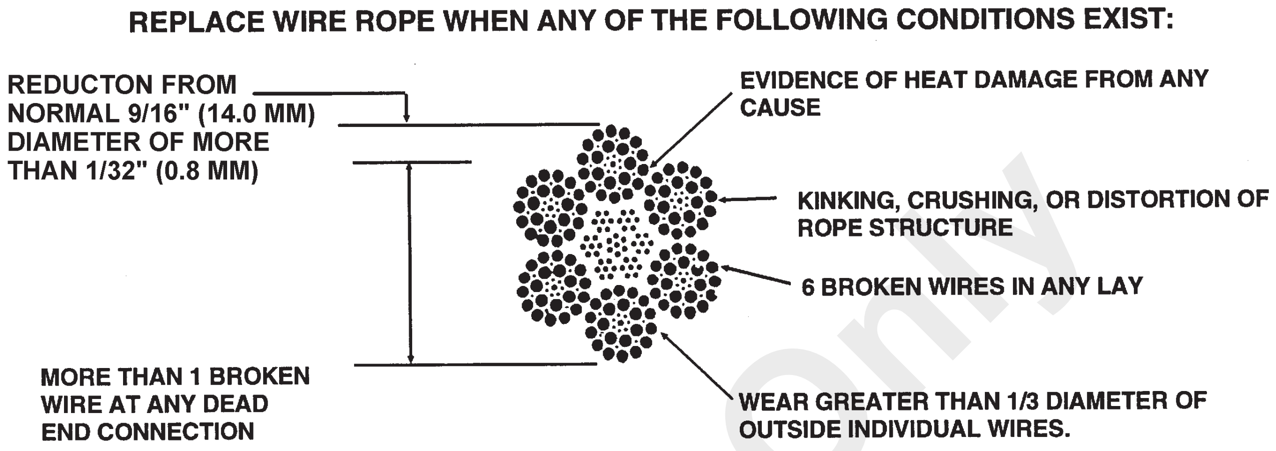
Proper lubrication of the wire rope is just as important as lubrication of other components. The wire rope has many moving parts. Initial lubrication will not last throughout the life of the wire rope. Lubrication is essential to reduce wear and inhibit corrosion of the wires.

CAUTION

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

Thoroughly clean the wire rope prior to application of the oil. Use a wire brush and compressed air to remove all foreign matter and old lubricant.

After cleaning, apply a good grade of wire rope spray lubricant. If not available, apply a light weight oil that will penetrate into the wire rope. Warming the oil before application will aid penetration. Apply the oil with a stiff brush. Penetration and thorough coverage are extremely important. Give the oil as much opportunity as possible to soak into the wire rope. Wipe off excess oil.



A0349

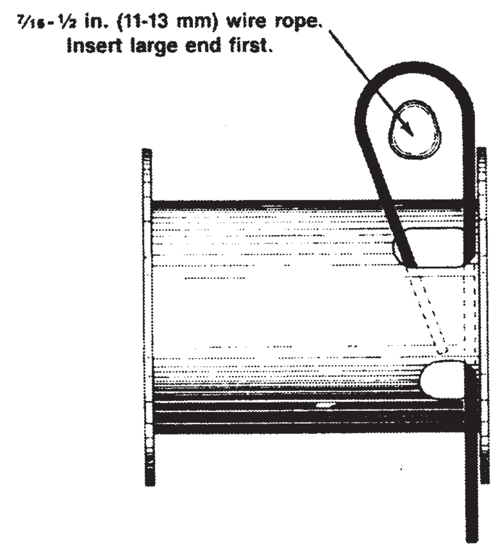
FIGURE 11-24

Wire Rope Installation

Anchoring Wire Rope

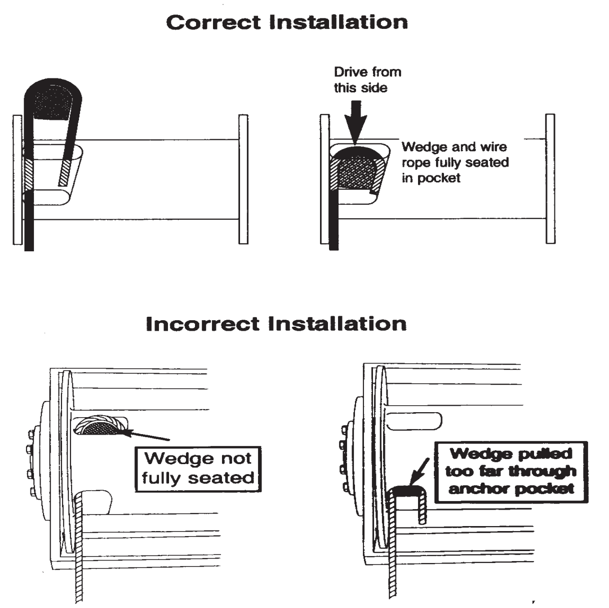
Take the free end of the wire rope and insert it through the small opening on the anchor pocket. Loop the wire rope and push the free end about 3/4 of the way through the pocket. Install the wedge, then pull the slack out of the wire rope. The wedge will fit into the pocket and secure the wire rope into 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 11-25)

Refer to (Figure 11-26) and verify that the wedge is installed correctly.

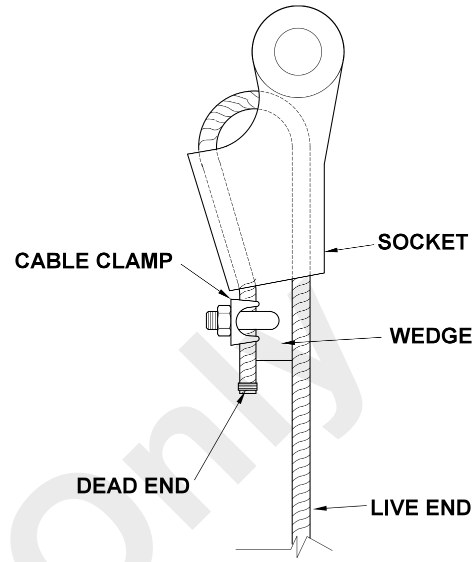


a2274

FIGURE 11-25



a2275 FIGURE 11-26



X = A minimum of 6 rope diameters, but not less than 152 mm (6 in).

a0069 FIGURE 11-27

Installation of Socket and Wedge

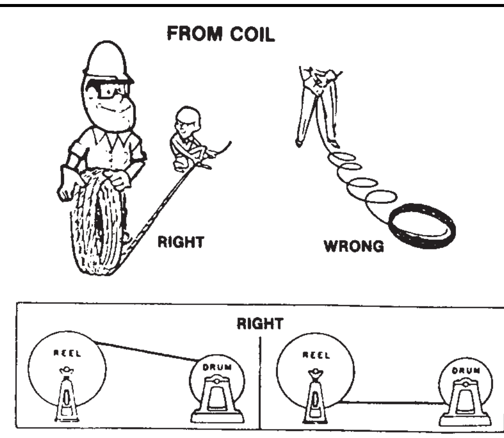
Always connect the socket so that the load is pulled on the same line as the socket (See Figure 11-27).

When installing the wedge, hit the wedge several times with a hammer and wood block to make sure the wedge is fully engaged with the socket. Install cable clamp on the loose end of the wire rope as shown in Figure 11-27.

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

Installation of a New Wire Rope

The wire rope is given a natural bend or winding from the coil. If the wire rope is on a reel, unwind the wire rope from the reel or coil as shown in Figure 11-28. Use care to prevent reverse bend in the wire rope.



A0473 FIGURE 11-28

1. Make sure that the equipment (drum, sheaves, etc.) are in good condition.
2. Unwind enough rope from the reel to connect the wire rope to the hoist drum. Use care to prevent twists or sharp bends.
3. Operate the hoist slowly to move the wire rope directly from the reel to the hoist drum. Keep the wire rope under tension and make sure the wire rope winds correctly on

the drum. Loose windings will increase wear on the wire rope and cause bad performance.

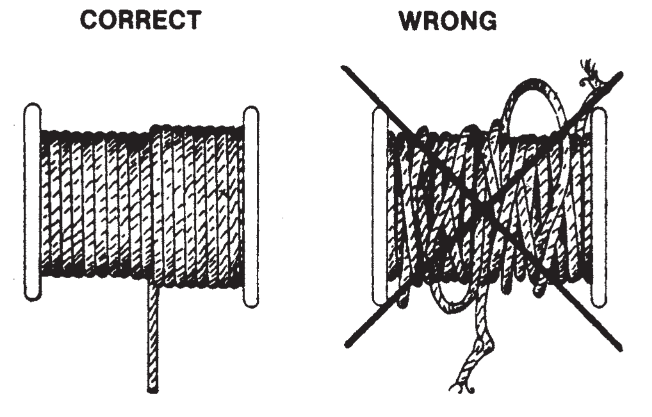


FIGURE 11-29

4. After installation, operate the hoist with a minimum load until you see the wire rope is moving easily over the sheaves and is winding correctly on the hoist drum.

5. Gradually increase the speed and load until the wire rope is moving at normal load and speed. This run-in period adjusts the moving parts to each other.

MAIN HOIST

Theory of Operation

The main hoist design is composed of high speed, low torque gerotor motor, driving through a multiple disc brake, and a pair of planet gear sets to the cable drum.

The multiple disc brake is spring applied and hydraulically released through a port in the brake housing. During inhaul (Figure 11-31) the brake is not released, since the load is driven through a one-way cam clutch, bypassing the brake. When the load comes to a stop, the cam clutch locks up and the load is prevented from moving by the brake.

During payout (Figure 11-32), a brake valve is used to prevent the load from moving faster than desired. This brake valve partially blocks the main line from the motor back to the control valve, allowing only a limited amount of oil through the motor. The brake valve modulates by sensing pressure on the other main line from the main control valve to the motor. Also, any time there is sufficient pressure to modulate the brake valve, this same pressure releases the multiple disc brake.

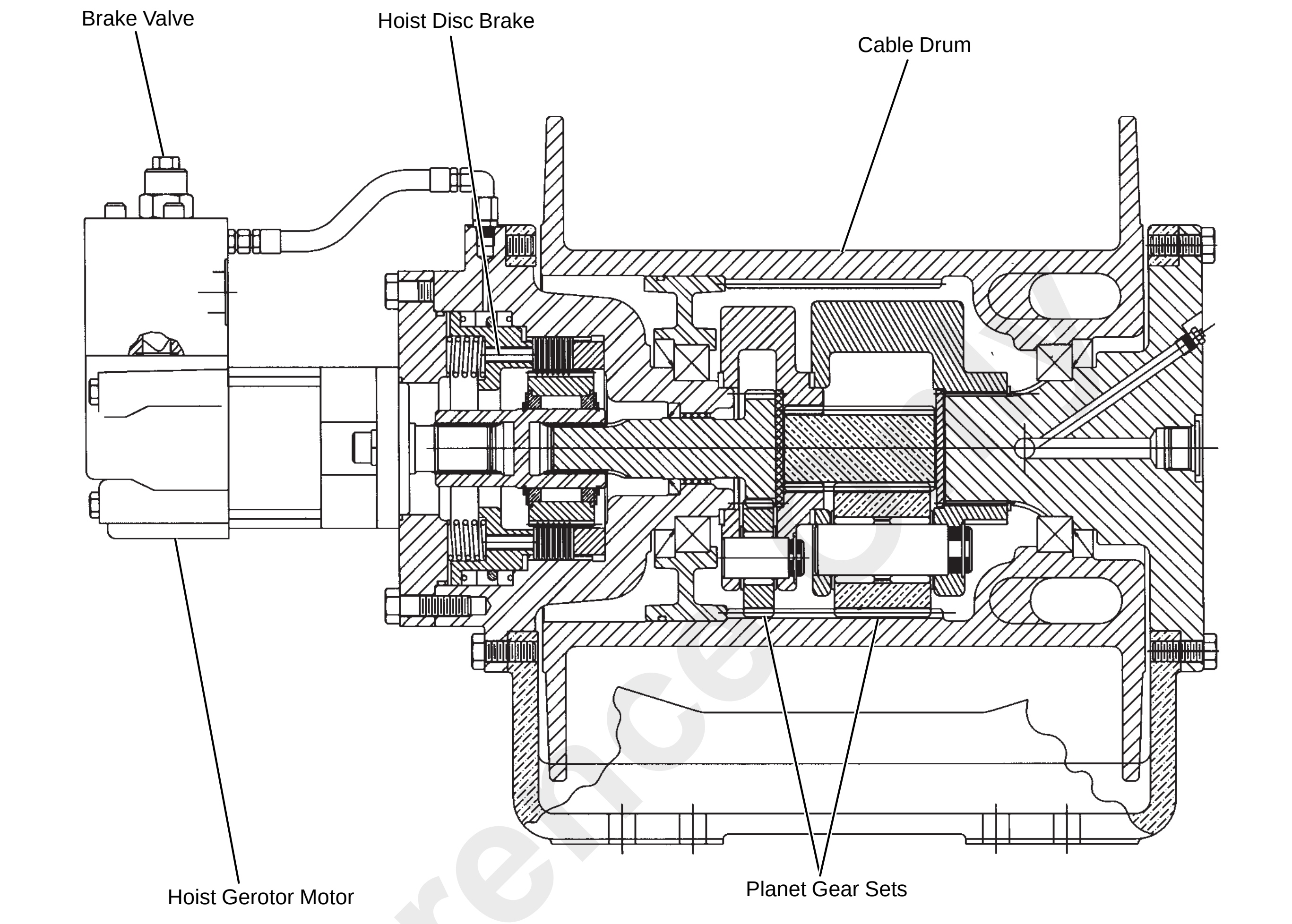


FIGURE 11-30

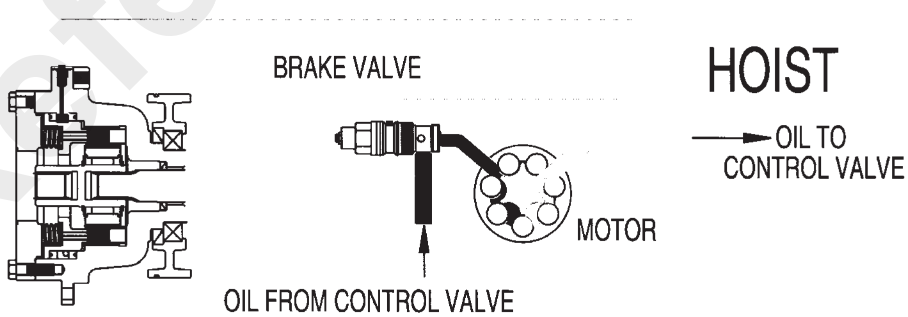
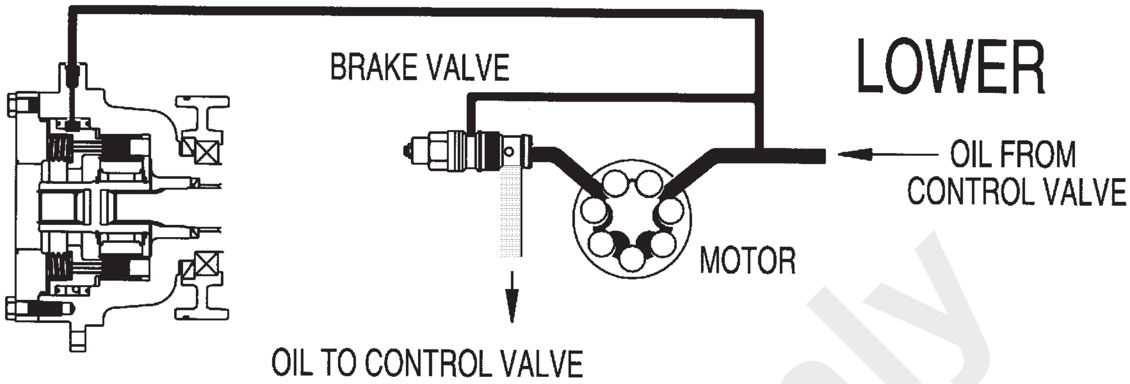
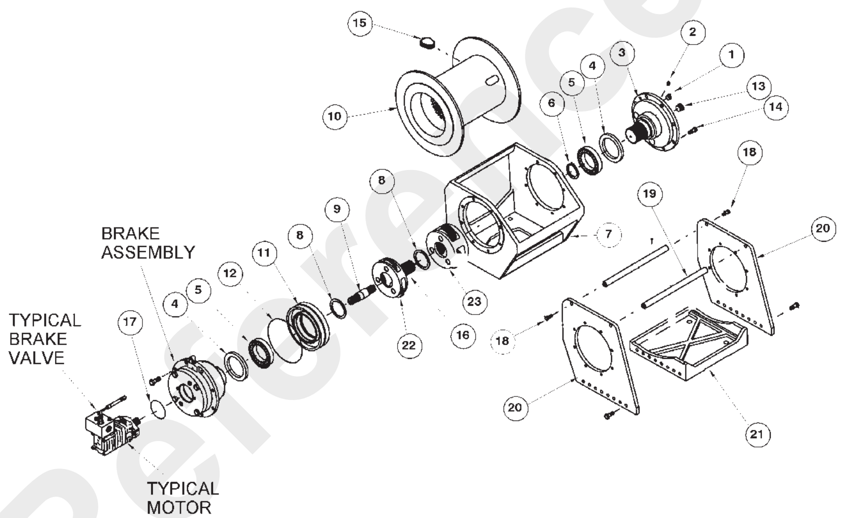


FIGURE 11-31



A0958

FIGURE 11-32



Item	Description
1.	Plug
2.	Breather
3.	Output Shaft
4.	Seal (2)
5.	Bearing (2)
6.	Snap Ring
7.	Mounting Bracket
8.	Thrust Washer (2)
9.	Input Sun Gear
10.	Cable Drum
11.	Bearing Carrier
12.	O-ring
13.	Plug
14.	Capscrew (8)
15.	Thimble
16.	Output Sun Gear
17.	O-ring
18.	Capscrew (20)
19.	Support Rod (2)
20.	Side Plate (2)
21.	Base
22.	Input Planet Set
23.	Output Planet Set

A0958

FIGURE 11-33

Repair

Removal

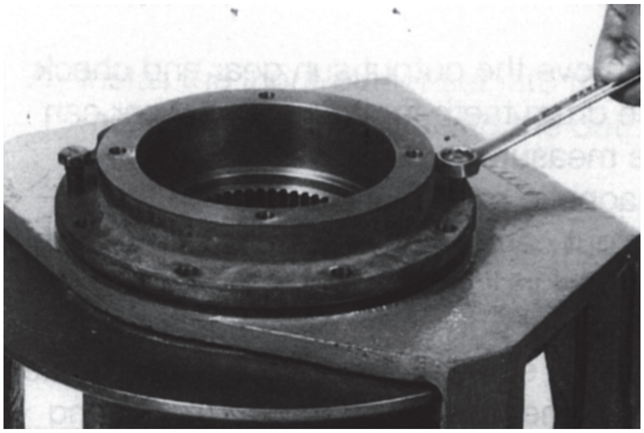
1. Remove the wire rope from the hoist drum.
2. Disconnect and cap or plug all hydraulic lines.
3. Attach an overhead hoist to the hoist and remove the four capscrews and flat washers that attach the hoist to the mast assembly. Remove the hoist.

Hoist Assembly

Disassembly

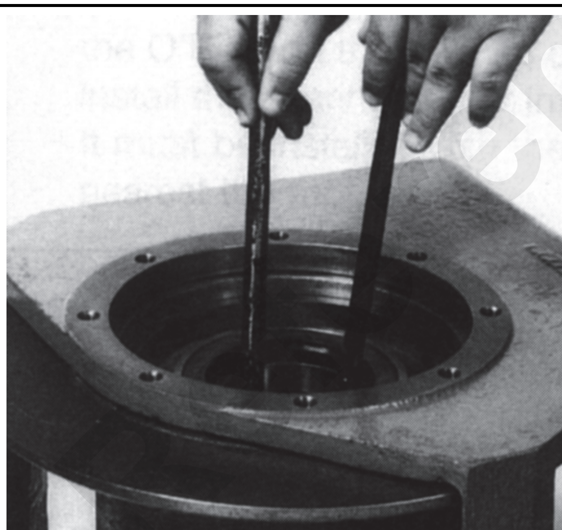
1. Stand the hoist on its end with the motor pointing up.
2. Remove the brake line from the brake valve to the brake port on hoist. See Motor Group. Remove the motor and brake valve from the hoist.
3. Remove the brake subassembly from the hoist by removing eight capscrews holding the brake housing to the mounting bracket. Install two of the capscrews into

the extra two tapped holes (Figure 11-34) and tighten them evenly until the brake housing has come loose from the mounting bracket. See Brake Section for repair instructions.



P0188 **FIGURE 11-34**

4. Using two crows foot pry bars (Figure 11-35), hook the bearing carrier (11, Figure 11-33) from inside and pull it out of the cable drum. Remove the bearing (5) and seal (4) from the bearing carrier (11).



P0189 **FIGURE 11-35**

5. Remove the input sun gear (9, Figure 11-33) from the input planet set (22).

6. Install three 1/4 inch eyebolts (Figure 11-36) into the three planet pins in the input planet set (22, Figure 11-33). Use a piece of chain (Figure 11-36) to pull the planet set from the drum. Inspect the planet set for wear and repair as needed. See Planet Sets for repair instructions.

P0190 **FIGURE 11-36**

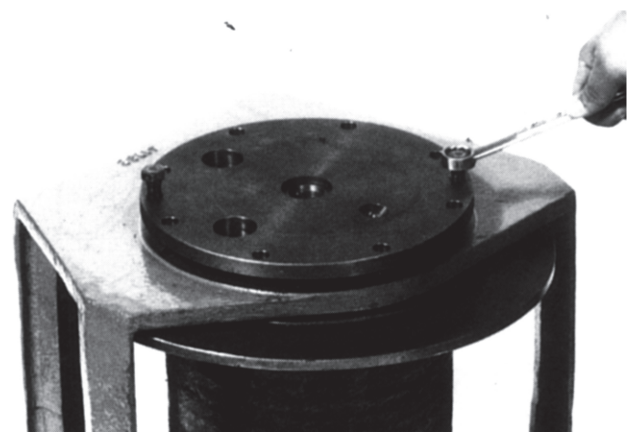
7. Remove the output sun gear (16) and check drum (10) teeth for wear. This wear can be measured as follows:

   a. Place a magnetic base dial indicator on the output carrier (8, Figure 11-33) and adjust the plunger of the dial indicator approximately at the middle of one of planet gear teeth.

   b. Using a screwdriver or your finger, rotate the planet gear back and forth, reading the movement on the dial indicator. If the total movement is greater than 0.64 mm (0.025 in), then the drum should be replaced.

   Using the same procedure as in Step 6, remove the output planet set (23, Figure 11-33) from the drum. Inspect the planet set for wear and repair as necessary. See Planet Sets for repair instructions.

8. Turn the hoist over onto the motor end and remove the capscrews holding the output shaft (3, Figure 11-33) into the mounting bracket. Reference mark for proper assembly. Install two of the capscrews into the extra threaded holes in the output shaft (Figure 11-37) and evenly tighten them until the output shaft is free from the mounting bracket.



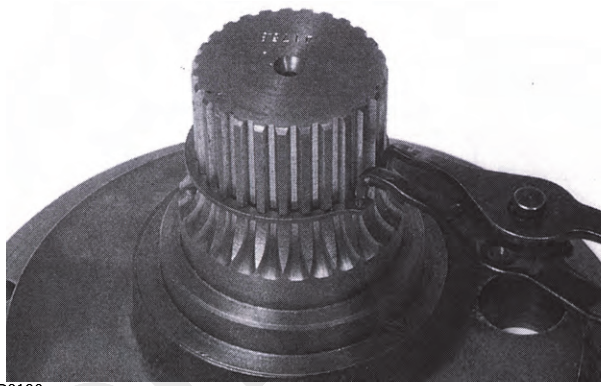
P0191
FIGURE 11-37

9. Reference mark for proper assembly and remove the drum from the mounting bracket.
10. Remove the bearing (5) and seal (4, Figure 11-33) from the drum (10) and inspect the bearing for signs of pitting and spalling.

P0192
FIGURE 11-38

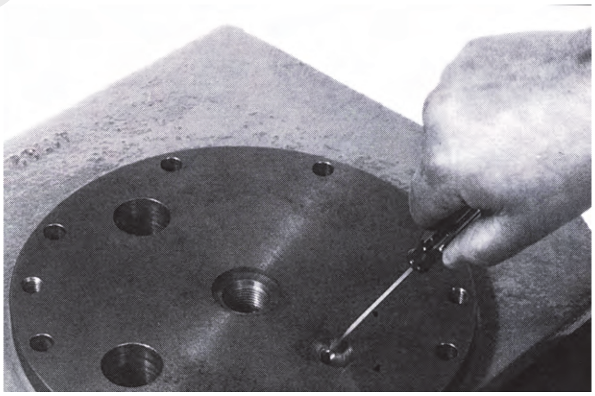
Assembly

1. Thoroughly clean all parts. Replace those which show wear.
2. After inspecting the drum for excessive wear in the gear teeth and both the drum and mounting bracket for structural integrity, install bearing (5, Figure 11-33) and seal (4) into the drum. Stand the mounting bracket up on the motor end and slide the drum into it. Make sure the drum is installed in the same direction as it was removed or the hoist assembly will be wrong when completed.
3. Check the snap ring (6, Figure 11-33) on output shaft (3) to ensure it is in its groove and not bent over (Figure 11-39). Replace if necessary.



P0196
FIGURE 11-39

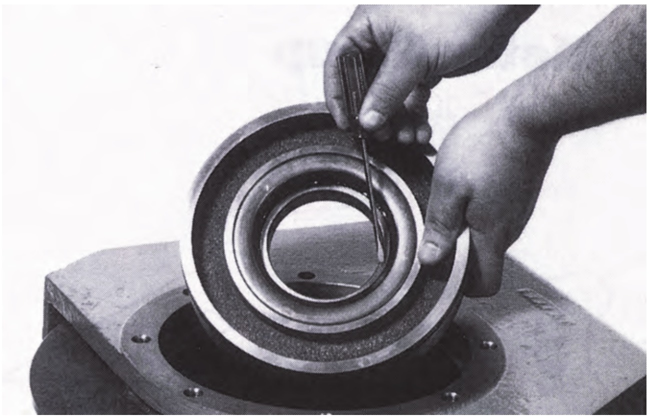
4. Install the output shaft (Figure 11-40) into the bracket and drum, making sure to align the shaft with the bearing in the drum. Make sure the alignment of the fill and drain holes is correct. Tighten the capscrews to 130 to 143 Nm (100 to 110 lb-ft).



P0195
FIGURE 11-40

5. Turn the assembly over onto the output shaft side and install the output planet set (23, Figure 11-33). Use the same eyebolts and chain used to disassemble the unit (Figure 11-36).
6. Put a light coating of grease on the thrust washer (8, Figure 11-33) to keep it in place. Install it into the output planet set and insert the output sun gear (16) into the output planet set.
7. Install the input planet set (22, Figure 11-33) into the drum. Make sure it fits into the output sun gear.
8. Install the input sun gear (9) and thrust washer (8) into the input planet set. Again, coat the thrust washer with a light coat of grease.

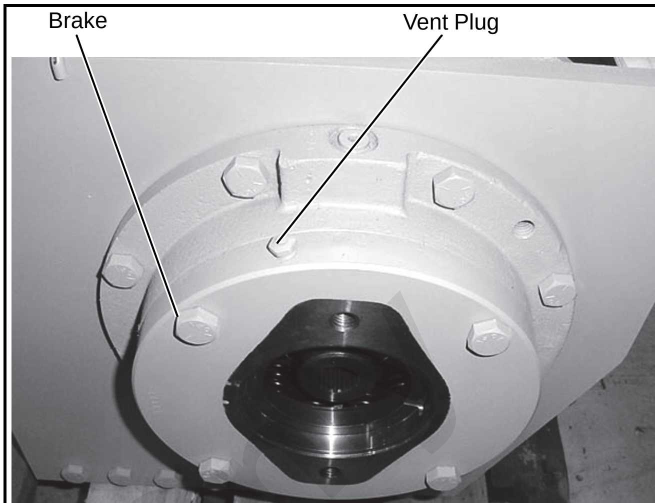
9. Install a new seal (4), O-ring (12) into the bearing carrier (11). Install bearing (5) into the bearing carrier (Figure 11-41). Grease the O-ring on the bearing carrier (Figure 11-42) and install the bearing carrier into the drum. It must be installed with the O-ring nearest the motor end.



P0194 FIGURE 11-41

P0193 FIGURE 11-42

10. Place the brake section into the hoist bracket (Figure 11-43). Make sure that the pilot of the brake section aligns with the bore in the bearing carrier and that the bolts for the motor are aligned properly. Install the mounting capscrews and tighten to a torque of 130 to 143 Nm (100 to 110 lb-ft). Also, make sure that the level and vent plugs (Figure 11-43) in the cover are properly oriented.



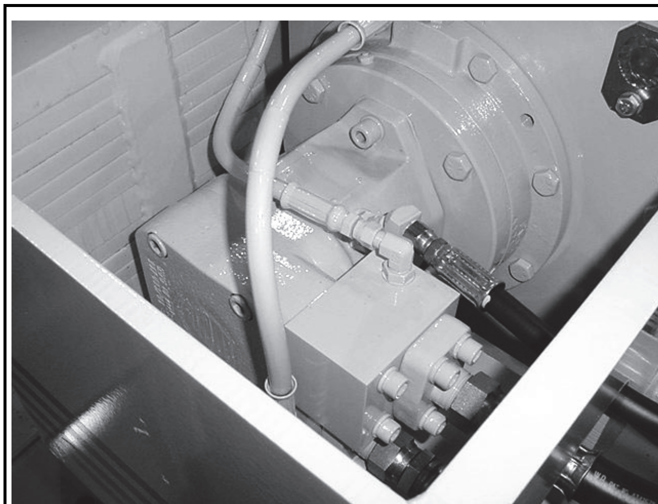
p0830 FIGURE 11-43

11. Install a new O-ring (17, Figure 11-33) on the face of the motor and install the motor/brake valve assembly and connect the hoses.

12. Fill both the gearbox and the brake section with the proper amount and type of lubricant. See table in Section 5.

Motor Group

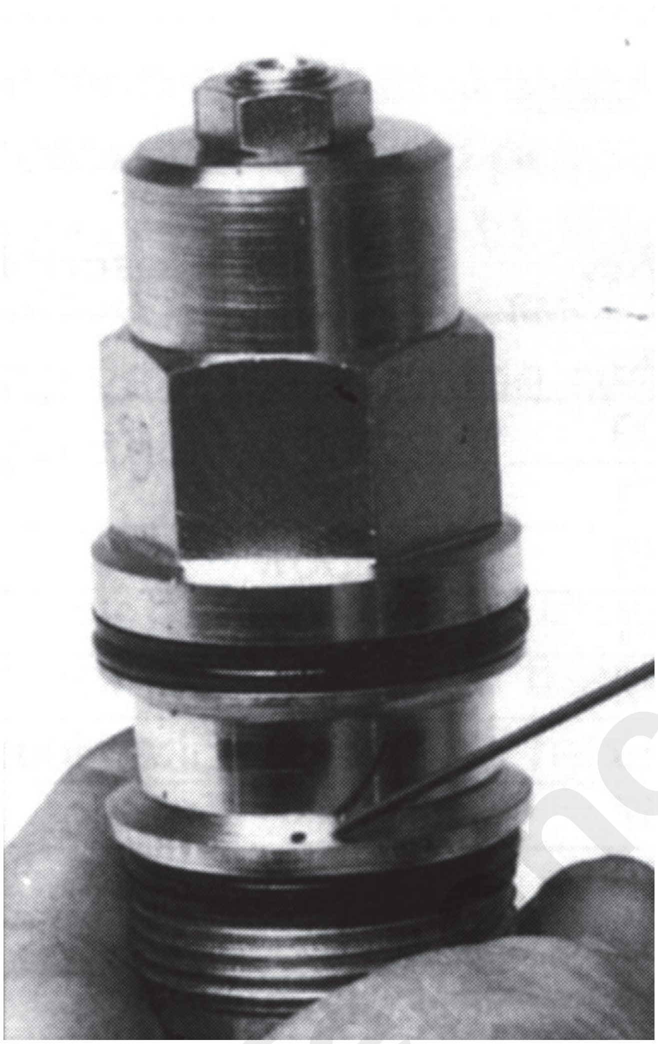
1. Tag the hoses for proper installation and remove them from the motor and brake valve.



P0813 FIGURE 11-44

2. Remove the brake valve from the motor. See Figure 11-44.

3. Remove the cartridge from the brake valve and inspect the metering hole (Figure 11-45) to make sure it is not obstructed. Also, check the O-rings to ensure that they are not cut or flattened. Replace if necessary.



P0199 FIGURE 11-45

4. The motor and cartridge valve are not serviceable in the field.

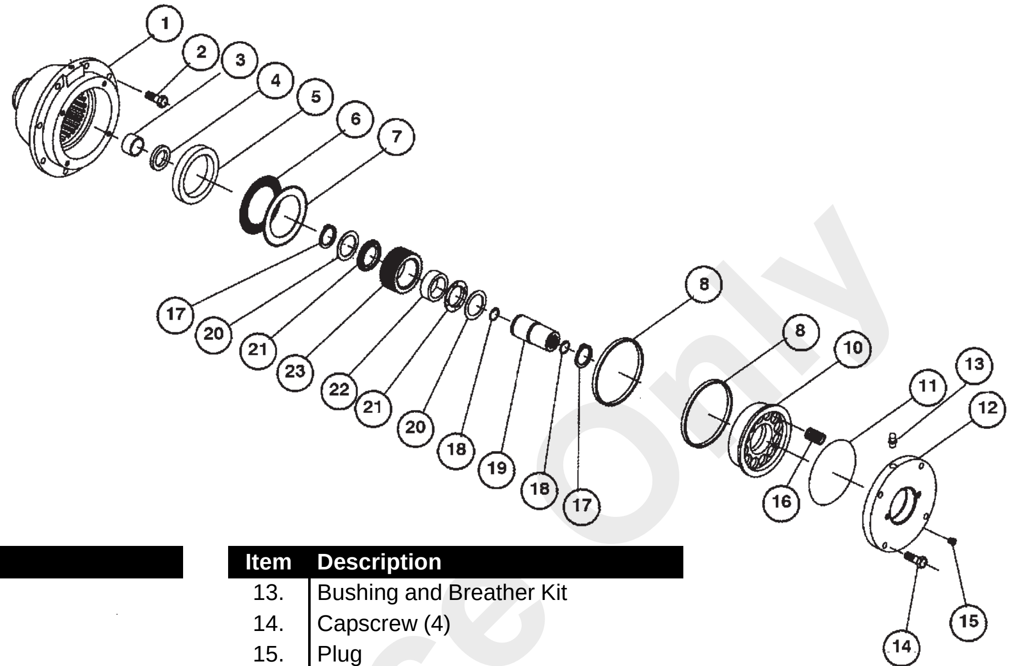
Brake Section

Disassembly

1. Remove the capscrews (14, Figure 11-46) holding the motor cover (12) in place (Figure 11-47). Spring pressure will raise the cover as the capscrews are loosened. Carefully remove cover (12, Figure 11-46) from the brake housing (1).
2. Remove the springs (16, Figure 11-46) from the piston (10) (see Figure 11-48) and check them for free height. Each spring should be 30.5 mm (1.200 in) long with no force on them.
3. Remove the piston (10, Figure 11-46) by installing two pieces of 3/8 NC all-thread (Figure 11-48) in the bottom of two spring pockets. Using jam nuts, screw the all-thread pieces in evenly until the piston is clear of the housing. An alternate way of removing the piston is use a portable power unit or air pressure to pressurized the brake cavity and blow the piston out of the bore.

CAUTION

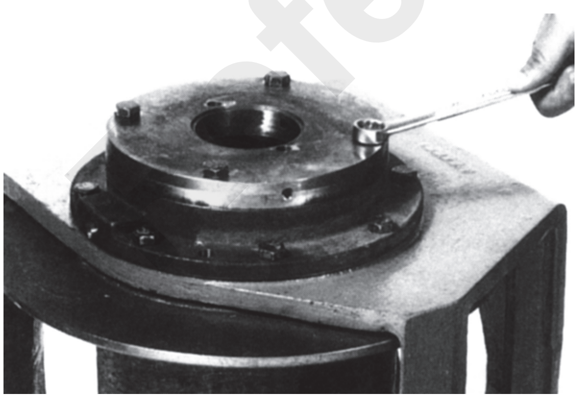
Be careful when using pressure to remove the piston. Piston could expel at a great speed and force causing personal injury.



Item	Description	Item	Description
1.	Brake Housing	13.	Bushing and Breather Kit
2.	Capscrew (8)	14.	Capscrew (4)
3.	Bushing	15.	Plug
4.	Seal	16.	Brake Spring (12)
5.	Spacer	17.	Snap Ring (2)
6.	Friction Disc (7)	18.	Snap Ring (2)
7.	Stator Plate (8)	19.	Brake Driver
8.	Seal (2)	20.	Race (2)
10.	Piston	21.	Bushing (2)
11.	O-ring	22.	Clutch
12.	Brake Cover	23.	Input Shaft

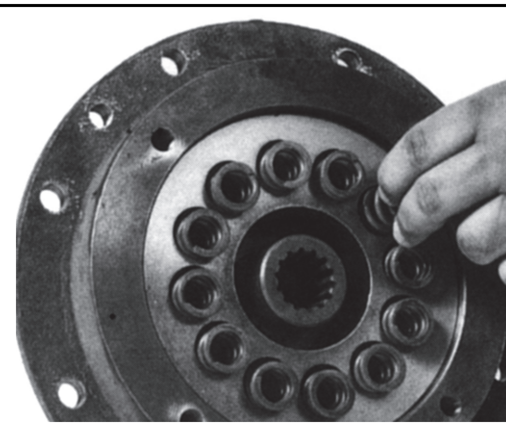
AA0478

FIGURE 11-46



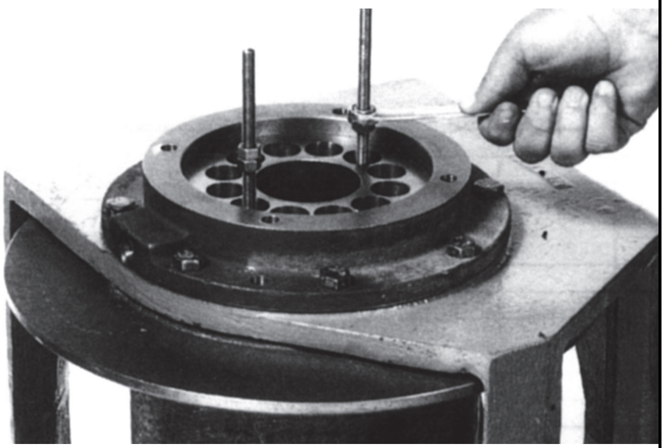
P0200

FIGURE 11-47



P0201

FIGURE 11-48



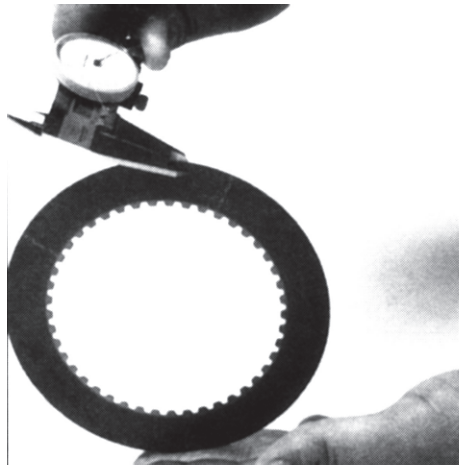
P0202 **FIGURE 11-49**

4. If one or both of the square seals (8, Figure 11-46) remain in the bore of the brake housing (1), remove them.

5. Grasp the brake driver/clutch assembly (items 17 through 23, Figure 11-46) and remove it from the brake housing.

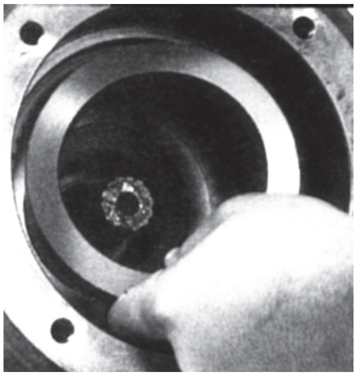
6. Remove the stator plates (7) and friction discs (6) from the brake housing and check them for excessive wear. Replace if necessary. Be sure to check the top stator plate (Figure 11-50) for scoring caused by the removal tools and polish if necessary. Friction discs (6, Figure 11-46) should measure (Figure 11-51) no less than 1.40 mm (0.055 in) thickness and stator plates (7, Figure 11-46) should measure no less than 1.72 mm (0.068 in) thickness.

P0204 **FIGURE 11-50**

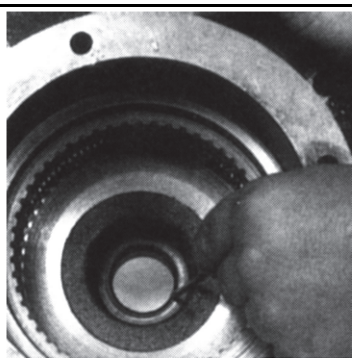


P0203 **FIGURE 11-51**

7. Remove the spacer (5, Figure 11-46) from the brake housing (Figure 11-52). With a hook (Figure 11-53) or pry bar, remove the seal (4).

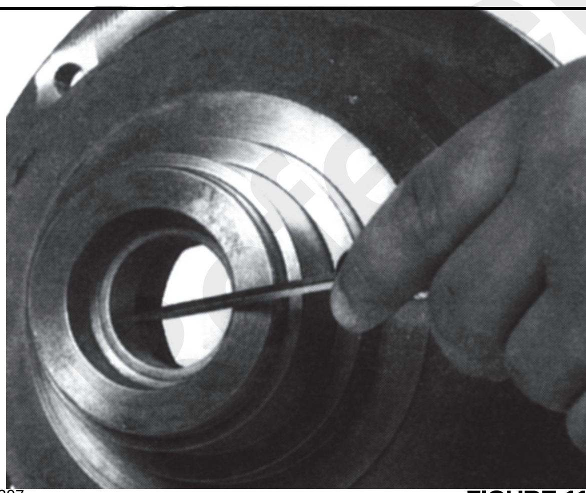


P0205 FIGURE 11-52



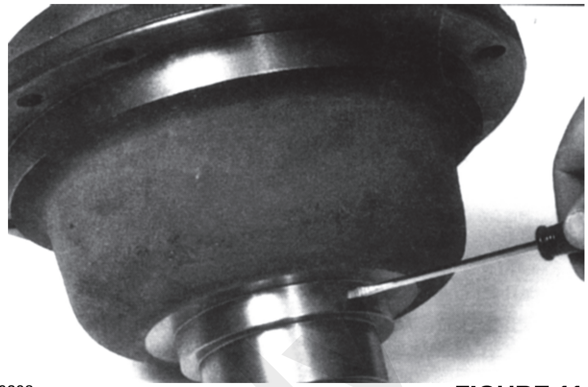
P0206 FIGURE 11-53

8. Examine the bushing (3, Figure 11-46) in the brake housing (1) for wear and if found replace it (Figure 11-54).



P0207 FIGURE 11-54

9. Examine the journal for wear on the brake housing (Figure 11-55) where the seal runs. If severely worn, replace the brake housing.

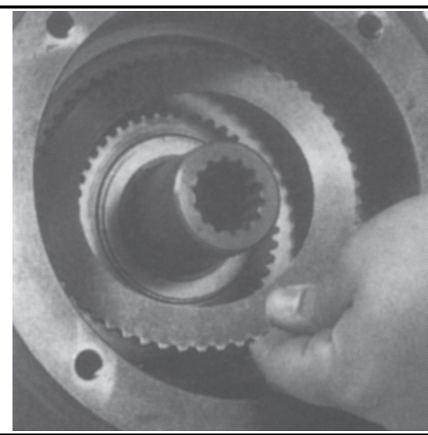


P0208 FIGURE 11-55

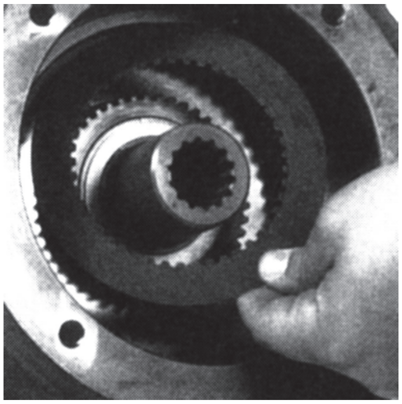
10. Carefully disassemble the brake driver/clutch assembly (17-23, Figure 11-46) noting the direction of lockup on the clutch. The clutch assembly must be assembled with the arrow pointing in the proper direction for the hoist to operate properly. Inspect the area on the driver where the clutch runs. If there is any pitting or spalling on the driver, it and the clutch must be replaced.

Assembly

1. Assemble the driver and clutch assembly. Make sure that the clutch is installed correctly.
2. Install a new seal (4, Figure 11-46) into the brake housing (1), temporarily install the hoist input sun gear, and slide the brake driver/clutch assembly onto the sun gear spline. Install the spacer (5) into the housing.
3. Install the stator plates and the friction discs into the housing starting with a stator plate (Figure 11-56) and followed by a friction disc (Figure 11-57). Alternate stator plates and friction discs until all are installed. There is one more stator plate than friction discs, so you will finish with a stator plate.

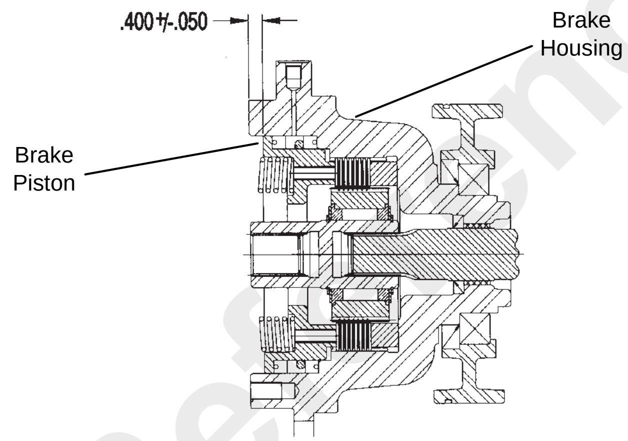


P0210 FIGURE 11-56



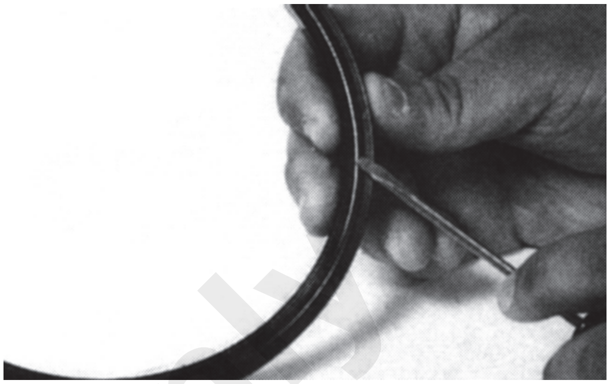
P0211 FIGURE 11-57

After installing plates and discs, set piston in place and check the brake stack-up to make sure that the dimensions are within the tolerance shown in Figure 11-58. If the measurement is greater than shown, either some friction plates have been left out, or the friction plate discs are worn beyond acceptable tolerances. If your measurement is less than shown, too many plates or discs have been inserted or they are not seated properly.



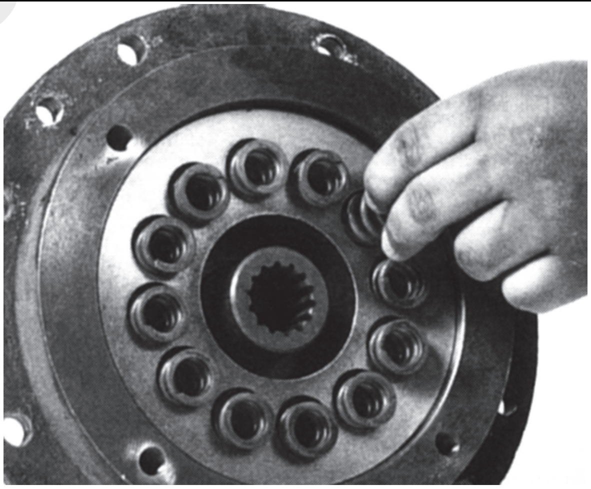
A0479 FIGURE 11-58

4. Inspect each new seal (8, Figure 11-46). Install one seal into the bore of the brake housing with grooves facing out Install the other seal with grooves facing in (Figure 11-59).



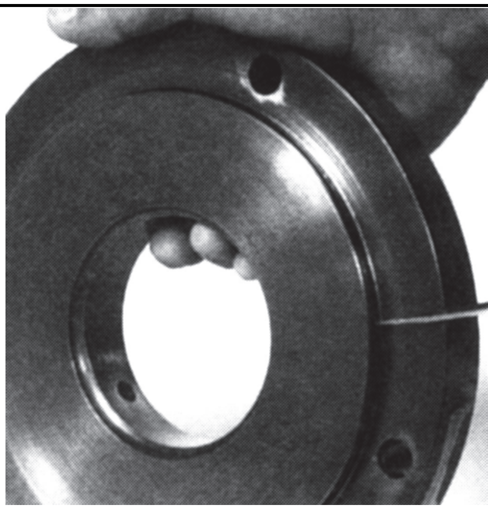
P0212 FIGURE 11-59

5. Install the piston into the brake housing and gently tap it down until it is seated.
6. Install the springs (Figure 11-60) into the spring pockets. If working in a horizontal position, coat the bottom of each spring with grease to keep them in place.



P0213 FIGURE 11-60

7. Coat a new O-ring (Figure 11-61) with light oil and install the O-ring into the groove on the brake cover.



P0214 FIGURE 11-61

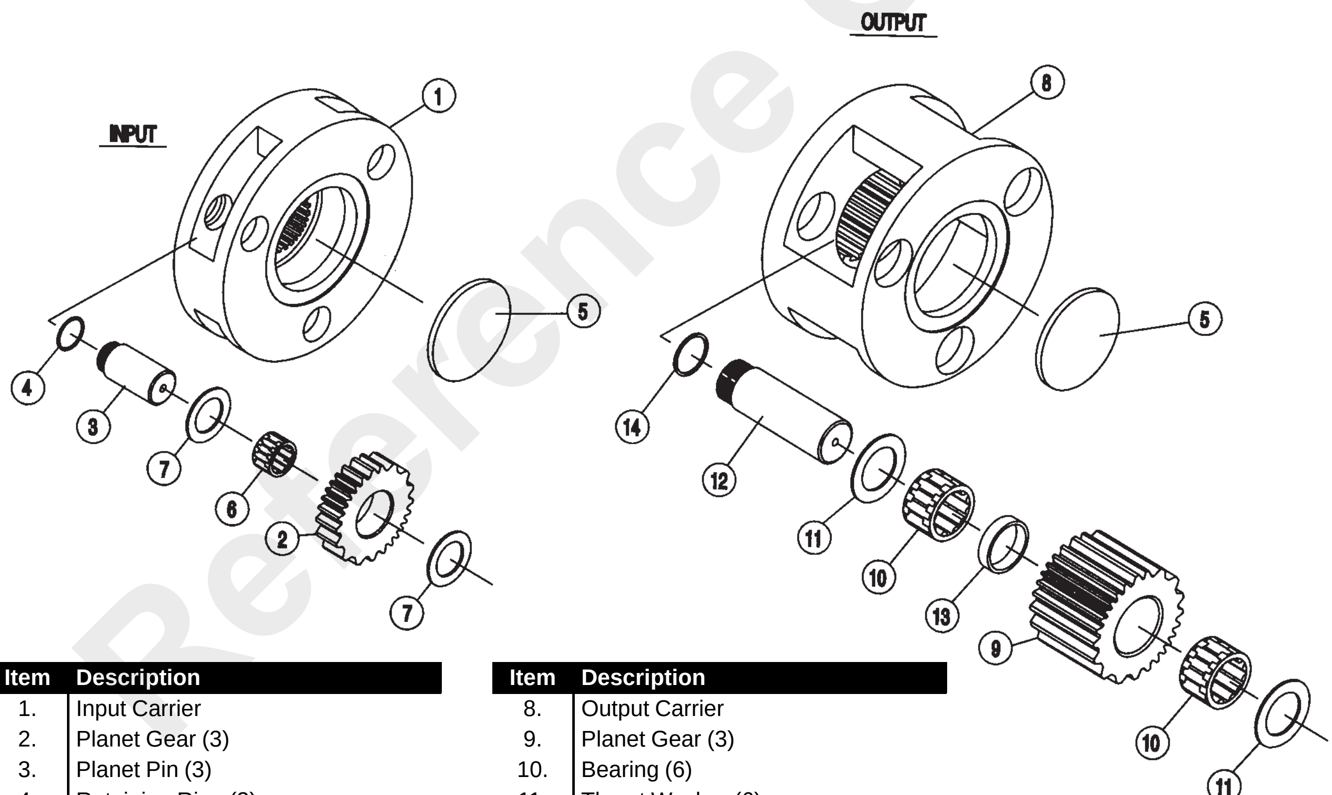
8. Install the cover onto the brake housing and draw it down evenly, alternating between opposite capscrews. Make sure that the cover is properly aligned with brake housing to orient the motor as it should be.

9. Check the brake release with a portable pump. Full release should be obtained at 1034 kPa (350 psi), plus or minus 138 kPa (20 psi). Also, check the brake for proper operation by applying 1929 kPa (280 psi) to the brake port and adapting a torque wrench to input shaft. The torque here in the payout direction should be 129.2 to 156.4 Nm (95 to 115 lb-in).

Planet Sets

1. Remove the retaining ring from the planet pins (Figure 11-63).

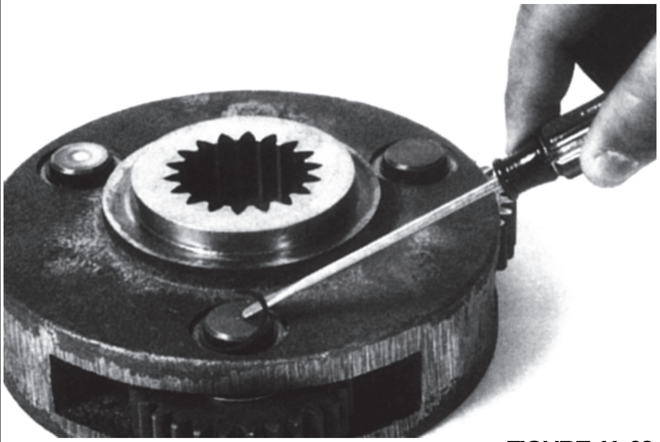
2. Remove pins (3) from the carrier by carefully tapping them out (Figure 11-64).



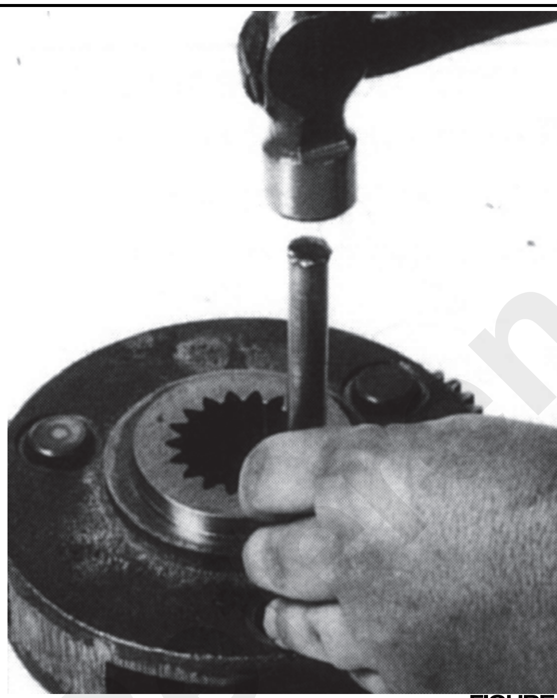
Item	Description
1.	Input Carrier
2.	Planet Gear (3)
3.	Planet Pin (3)
4.	Retaining Ring (3)
5.	Plug (2)
6.	Bearing (3)
7.	Thrust Washer (6)

Item	Description
8.	Output Carrier
9.	Planet Gear (3)
10.	Bearing (6)
11.	Thrust Washer (6)
12.	Planet Pin (3)
13.	Spacer (3)
14.	Retaining Ring (3)

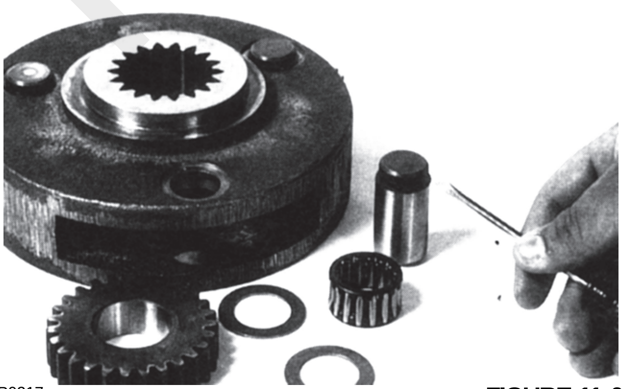
a0480 FIGURE 11-62



P0215 **FIGURE 11-63**



P0216 **FIGURE 11-64**



P0217 **FIGURE 11-65**

3. Remove the planet gears (2), thrust washers (7) and bearings (6) from the carrier (1). See Figure 11-65.

4. Inspect the pins, bearings and gear bores for evidence of wear and replace if necessary.

5. On the output planet sets, note that two bearings (10) with a spacer (13) between them are used.

6. Before assembling the planet sets. Be sure to insert the plugs in the carriers (Figure 11-66).

P0218 **FIGURE 11-66**

7. To assemble the planet sets, be careful to line up the planet pins with the thrust washers and bearing and then press the knurled part of the pin into the carrier. If the pins are not lined up properly, the thrust washers can be shattered during the pressing operation.

MAIN HOIST (BRADEN MODEL)

Description of Hoist

The hoist (Figure 11-67) has four basic component parts:

1. Hoist base

2. Hydraulic motor subassembly

3. Brake cylinder and motor support

4. 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.

The primary planet carrier drives the output planet sun gear, which in turn drives the planet gears. The output planet carrier is spline 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.

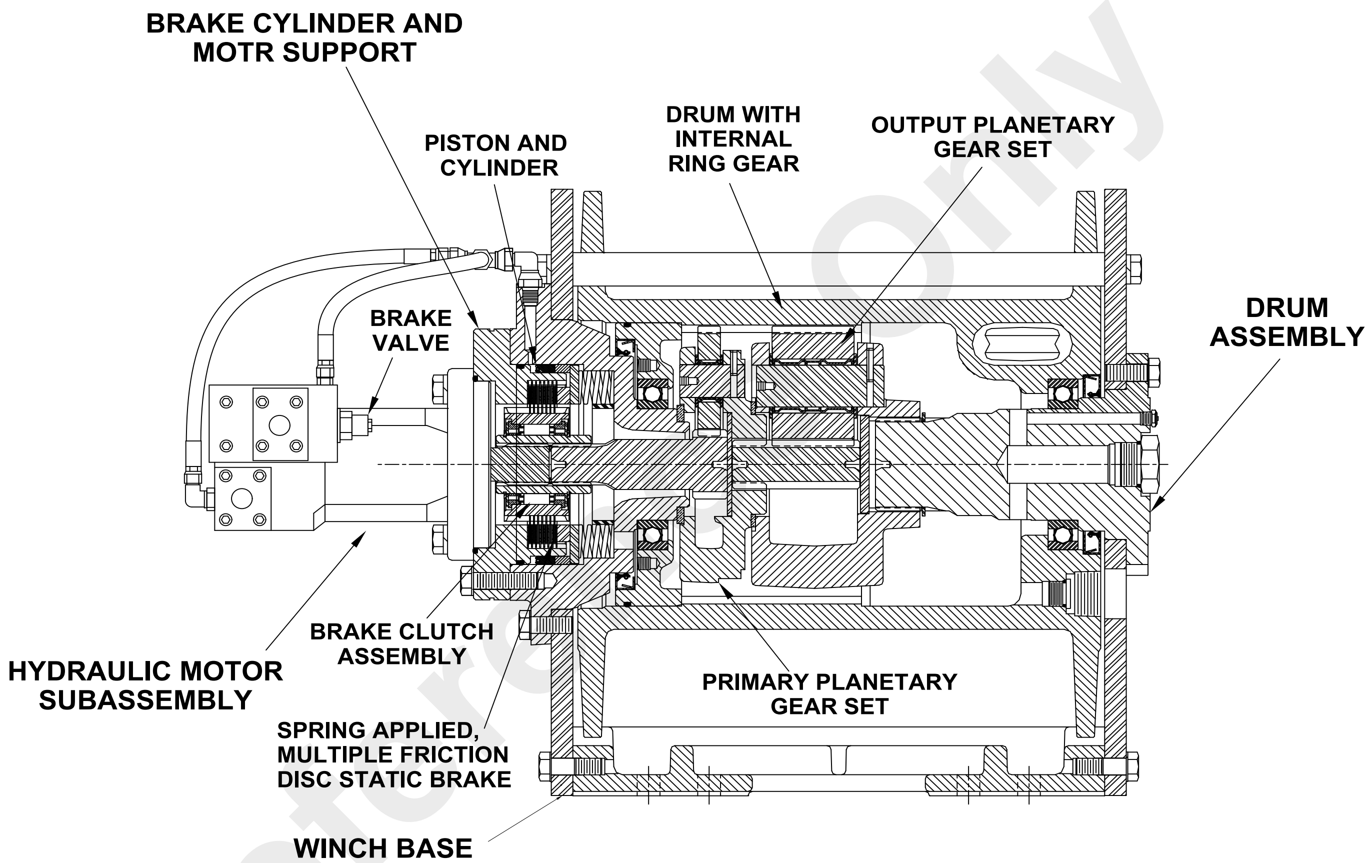


FIGURE 11-67

Dual Brake System -Description

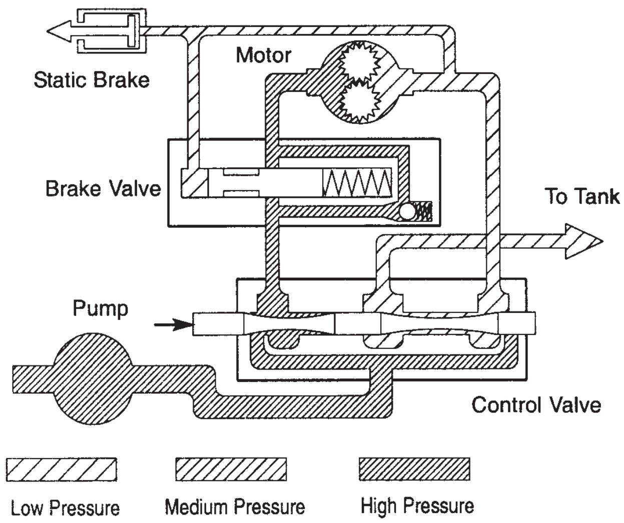
The dual brake system consists of dynamic brake system and a static brake system.

The **dynamic brake system** has two operating components:

1. Brake valve assembly
2. Hydraulic motor

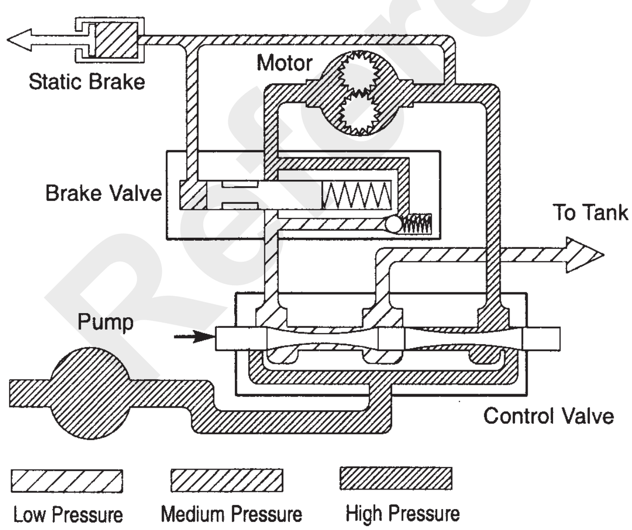
The brake valve is a counterbalance valve which contains a check valve to allow free flow of oil to the motor in the hoisting direction, and a pilot operated, spring loaded spool valve that blocks the flow of oil out of the motor when the control valve is placed in neutral.

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 11-68.



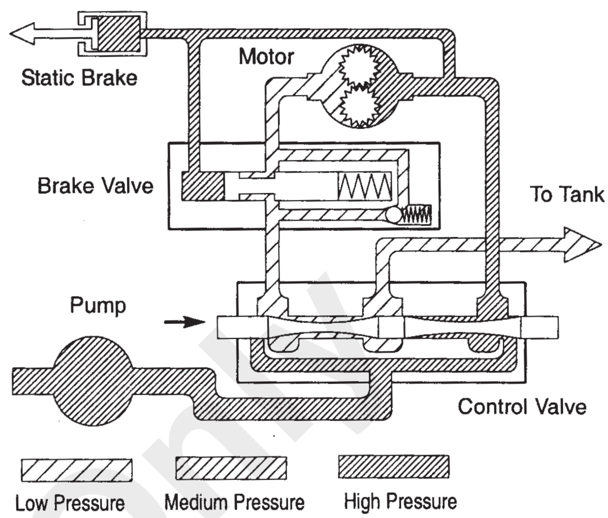
a2206 **HOISTING** **FIGURE 11-68**

When the control valve is placed in the lowering position, the spring loaded, pilot operated spool valve remains closed (Figure 11-69) until sufficient pilot pressure is applied to the end of the spool valve to shift it against spring pressure; opening a flow passage (Figure 11-70). After the pilot operated spool valve cracks open, the pilot pressure becomes flow-dependent and modulates the spool opening which controls the lowering speed.



LOWERING 1

a2208 **FIGURE 11-69**



LOWERING 2

a2207 **FIGURE 11-70**

The static brake system has thee operating components (see Figure 11-67):

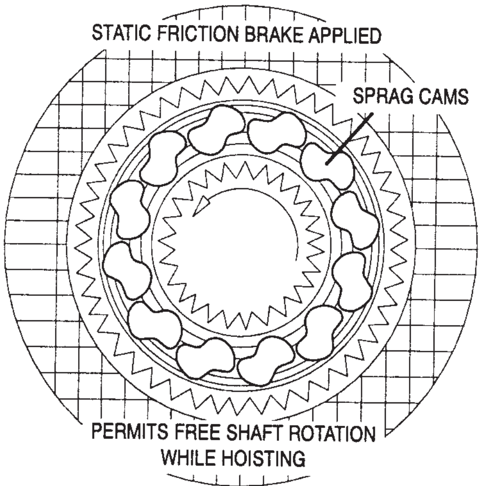
1. Spring applied, multiple friction disc static brake
2. Brake clutch assembly
3. Hydraulic piston and cylinder

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 load holding brake only, and has nothing to do with dynamic braking or rate of descent of a load.

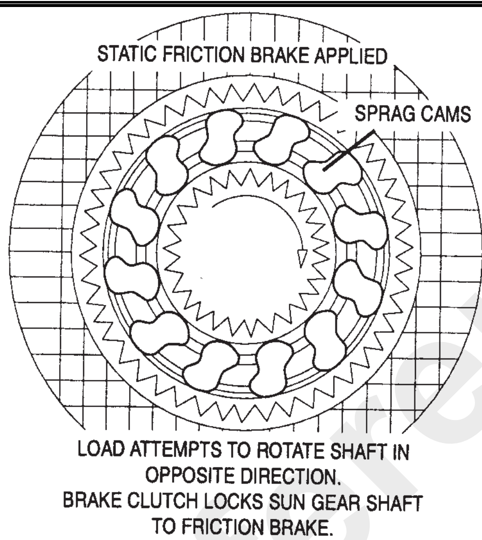
The brake clutch is spline to the primary sun gear shaft between the motor and the primary sun gear. It will allow this shaft to turn freely in the direction to raise a load and lock up to force the brake discs to turn with the shaft in the direction to lower a load. See Figure 11-71 and 11-72.

The hydraulic cylinder, when pressurized will release the spring pressure on the brake disc, allowing the brake discs to turn freely.



a2209

FIGURE 11-71



a2210

FIGURE 11-72

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 11-84). The friction brake remains fully engaged. The hoist, in raising a load, is not affected by any braking action. See Figure 11-81.

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 11-72).

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 11-68 and 11-69. 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.

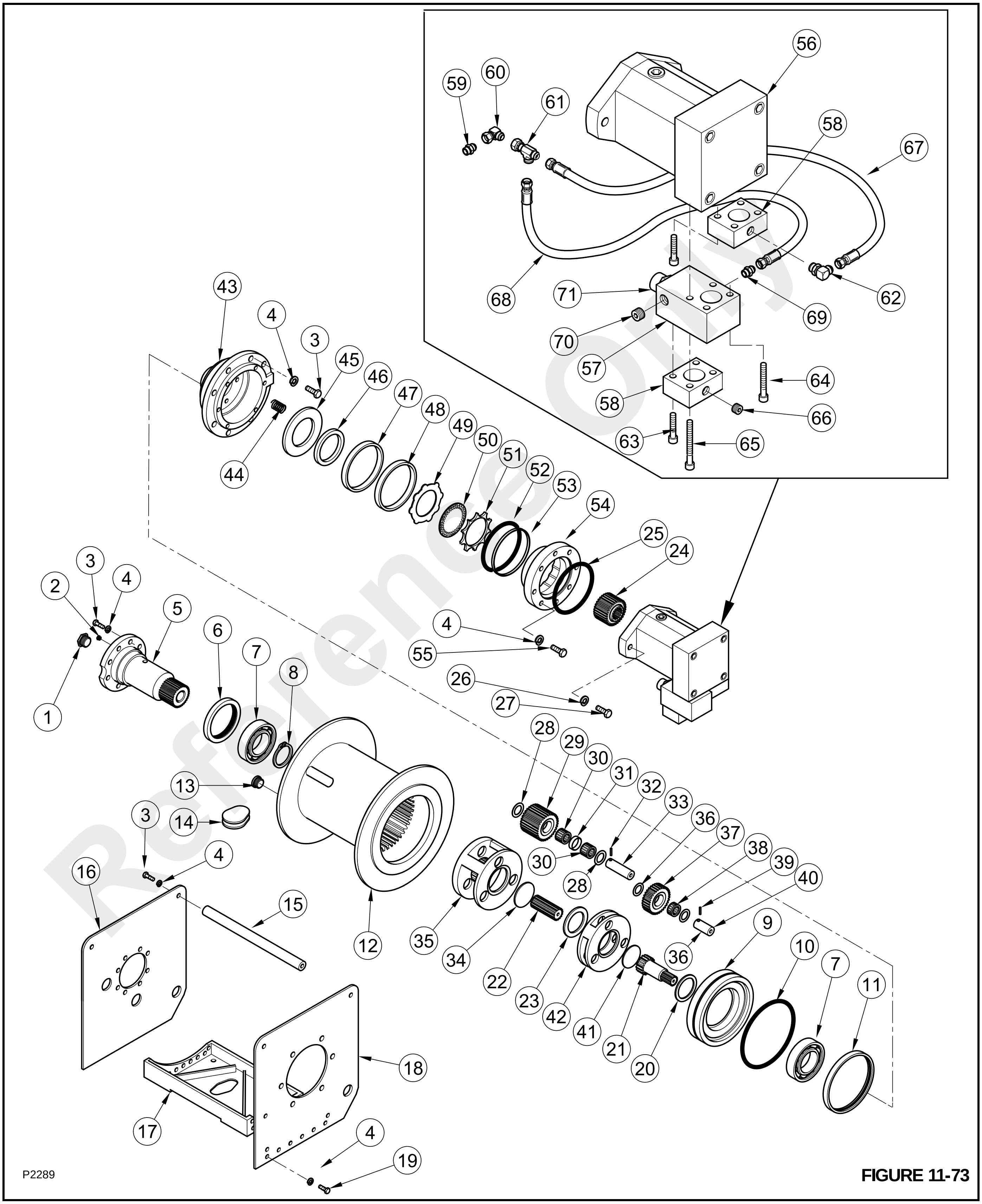
Repair

Removal

1. Remove the wire rope from the hoist drum.

IMPORTANT!
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.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P2289

FIGURE 11-73

Legend for Figure 11-73

1. Sight Gauge
2. Relief Valve
3. Capscrew (22)
4. Lockwasher (36)
5. Bearing Support
6. Oil Seal
7. Ball Bearing (2)
8. Retaining Ring
9. Cable Drum Closure
10. O-Ring
11. Oil Seal
12. Cable Drum
13. O-Ring Plug
14. Cable Wedge
15. Spacer (2)
16. Support Side plate
17. Base
18. Motor Side plate
19. Capscrew (16)
20. Thrust Washer
21. Primary Sun Gear
22. Output Sun Gear
23. Thrust Washer
24. Sprag Clutch Assembly
25. O-Ring
26. Lockwasher (2)
27. Capscrew (2)
28. Thrust Washer (6)
29. Planet Gear (3)
30. Roller Bearing (6)
31. Bearing Spacer (3)
32. Spirol Pin (3)
33. Planet Gear Shaft
34. Output Shaft
35. Output Planet Carrier
36. Bearing Race (6)
37. Planet Gear (3)
38. Roller Bearing (3)
39. Spirol Pin (3)
40. Primary Planet Gear Shaft
41. Primary Spacer
42. Primary Planet Carrier
43. Brake Cylinder
44. Die Spring (12)
45. Pressure Plate
46. Spacer
47. Piston Backup Ring
48. Seal
49. Brake Disc (8)
50. Friction Disc (8)
51. Spring Spacer
52. O-Ring
53. BAckup Ring
54. Motor Support
55. Capscrew (4)
56. Hydraulic Motor
57. Brake Valve Block
58. Manifold (2)
59. Adapter
60. Elbow
61. Tee
62. Elbow
63. HS Capscrew (6)
64. HS Capscrew (2)
65. HS Capscrew (2)
66. Plug
67. Hose Assembly
68. Hose Assembly
69. Adapter
70. Plug
71. Counterbalance Valve Cartridge

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 genuine 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

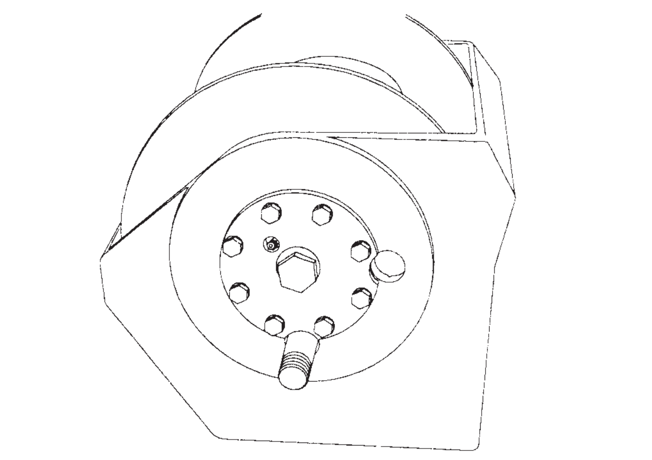
Disassembly

IMPORTANT!
Some illustrations may not depict the exact hoist you are disassembling, but the disassembly procedure are the same. Use Figure 11-73 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,

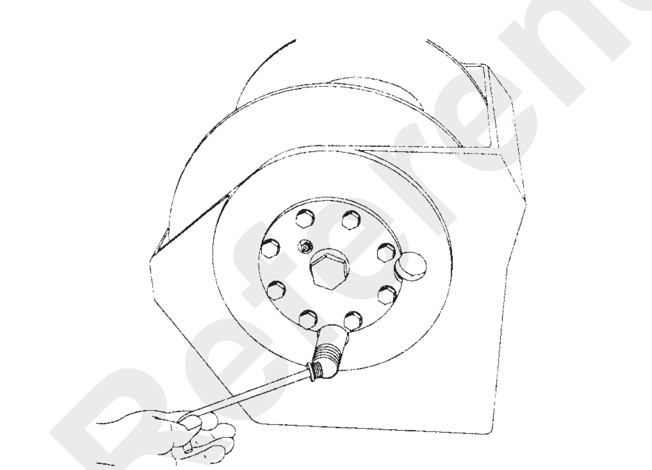
Published 04/07/2015 Control # 569-00

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 11-84). 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 11-74

2. Use a 5/16 inch Allen wrench to remove the drain plug through the pipe (Figure 11-75).

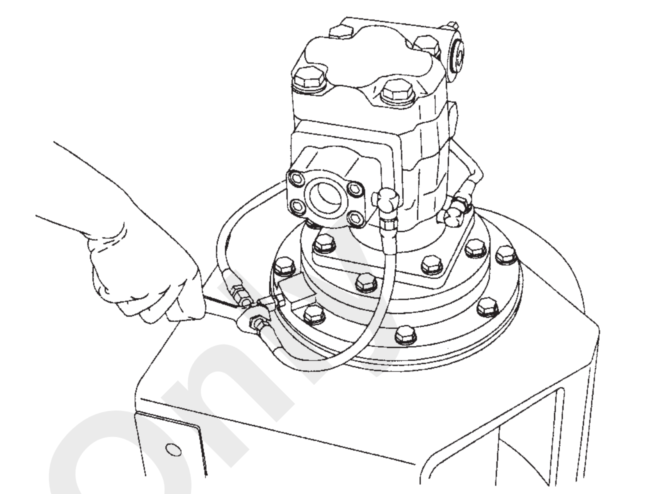


a2212 FIGURE 11-75

IMPORTANT!

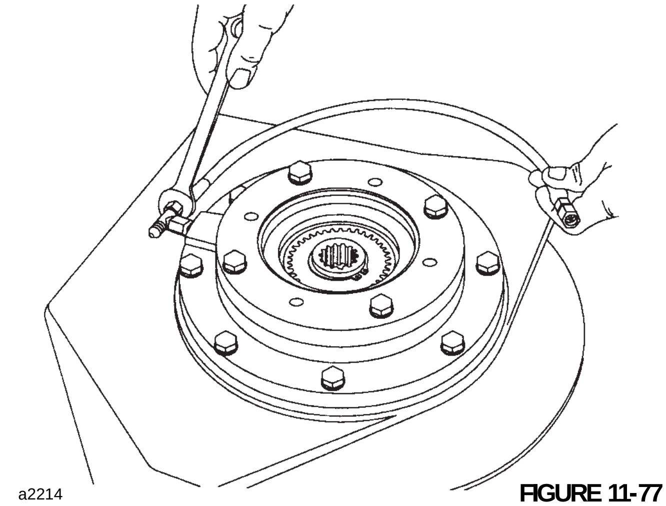
It is not necessary to remove the hoist tension roller subassembly to disassemble the hoist. But if it becomes necessary, see page 11-57 for disassembly procedures.

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 11-76).



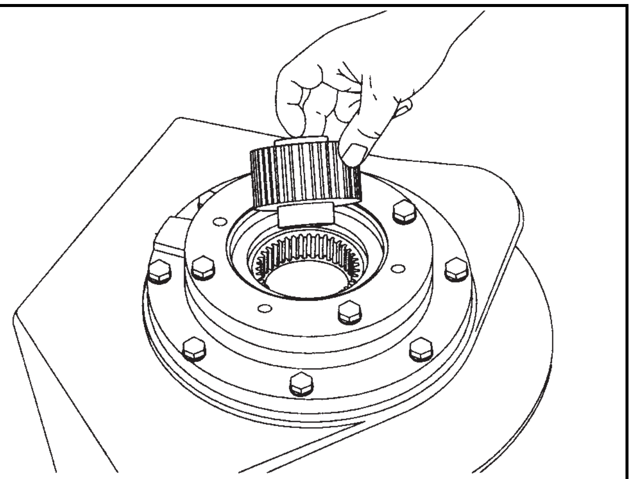
a2213 FIGURE 11-76

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 11-77).



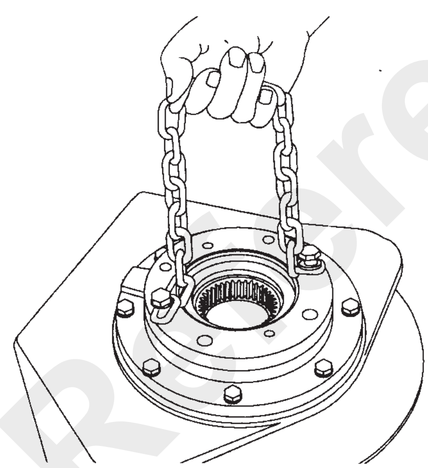
a2214 FIGURE 11-77

6. Remove the brake clutch (Figure 11-78.) assembly from the motor support. Refer to “Brake Clutch Service,” page 11-49 for additional information.



a2215 FIGURE 11-78

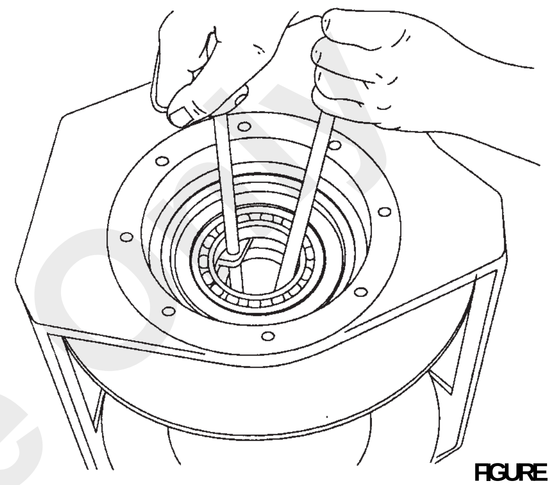
7. Remove the motor support capscrews and install two (2) capscrews and a short piece of chain (Figure 11-79) into the motor mounting bolt holes. Using the chain as a handle, lift the motor support out of the brake cylinder being careful to avoid damaging the sealing surfaces. Remove and discard the O-ring and backup ring from the motor support. Refer to “Motor Support-Brake Cylinder Service,” page 11-45 for additional information.



a2216 FIGURE 11-79

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 11-45 for additional information.

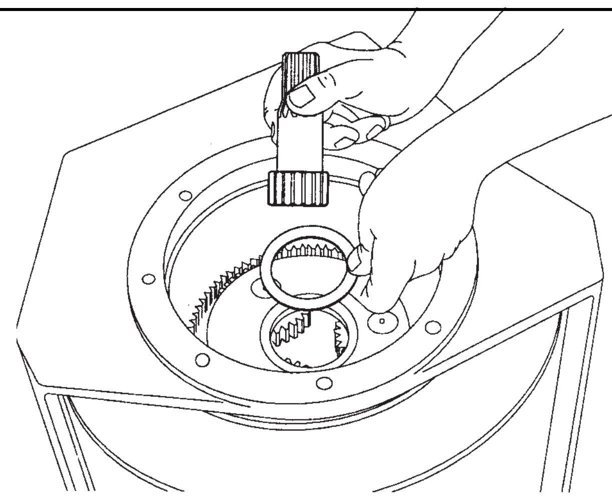
9. Using two heel type pry bars (Figure 11-80) placed between the primary planet carrier and the drum closure, pry upward to remove the drum closure. Remove and discard the O-ring from the outside of the drum closure.



a2217 FIGURE 11-80

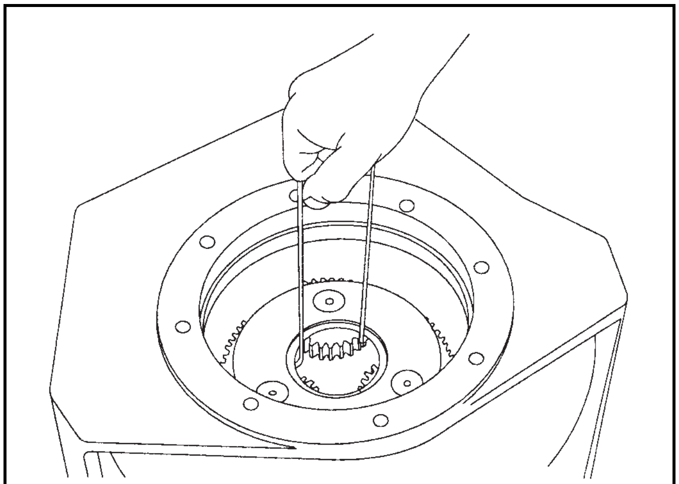
10. Remove the seal and bearing from inside of closure.

11. Remove the primary sun gear and thrust washer (Figure 11-81) from the primary planet carrier.



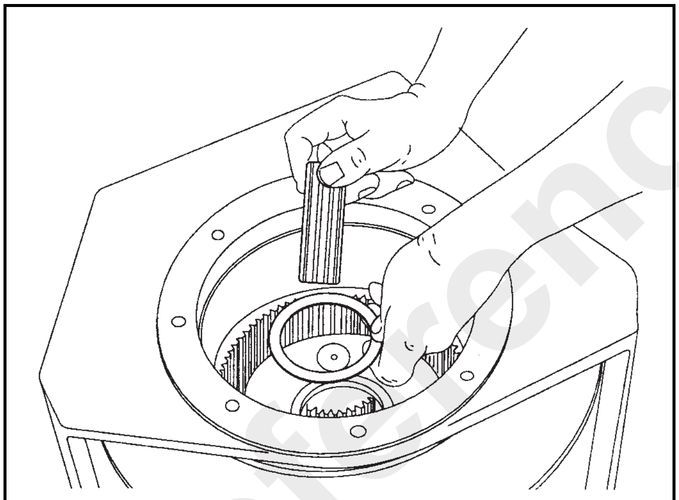
a2218 FIGURE 11-81

12. Remove the primary planet carrier from the drum (Figure 11-82). Refer to “Planet Carrier Service,” page 11-43 for additional information.



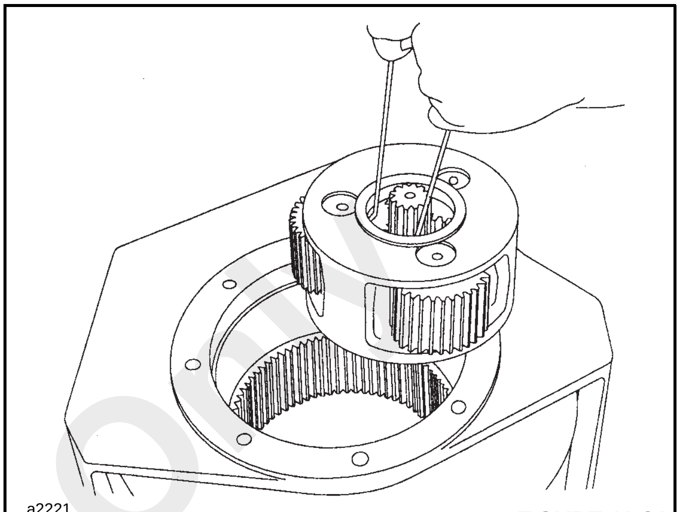
a2219 FIGURE 11-82

13. Remove the output sun gear and thrust washer (Figure 11-83) from the output planet carrier.



a2220 FIGURE 11-83

14. Remove the output planet carrier (Figure 11-84) from the drum. Refer to “Planet Carrier Service” on page 11-43, for additional information.



a2221 FIGURE 11-84

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 out of base onto a work bench and remove seal and bearing from support end.

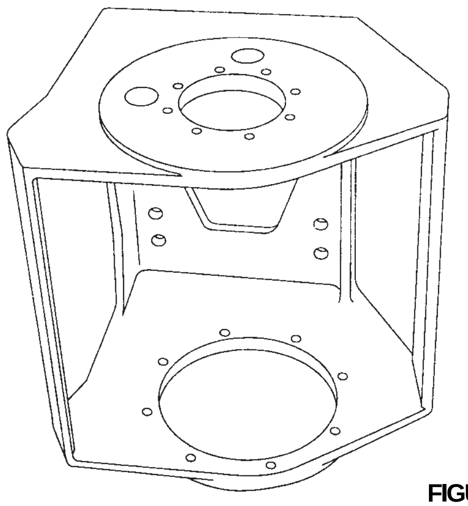
17. Thoroughly clean and inspect drum and base. Check ring gear (machined into inside surface of drum) teeth for nicks, spalling or excessive wear. Replace if wear is greater than 0.4 mm (0.015 in) when compared to unworn area of teeth.

Assembly

NOTICE!

Hoists with a three piece fabricated base use special shoulder capscrews to fasten side plates to the base plate. DO NOT use standard capscrews in their pace.

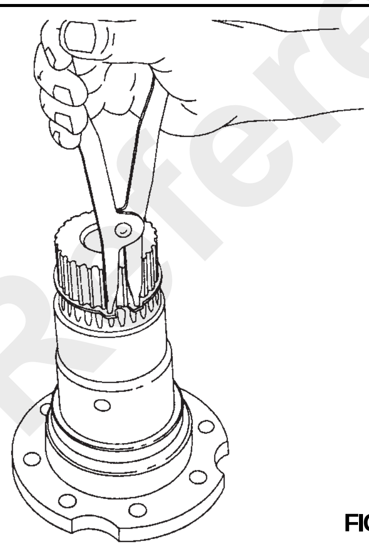
1. Place hoist base on side with bearing support end up (Figure 11-85).



a2222 FIGURE 11-85

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 11-86).

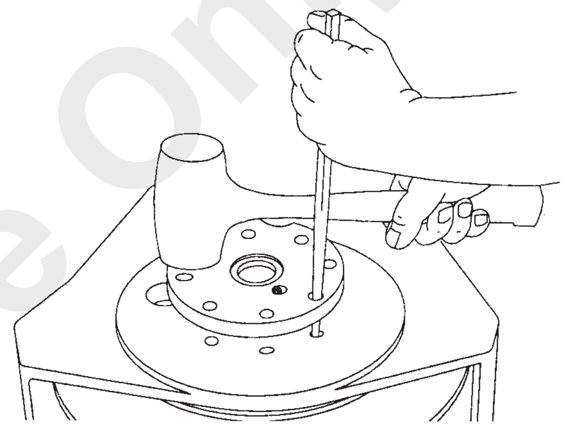


a2223 FIGURE 11-86

NOTICE!
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 11-87). Lubricate the bearing support with petroleum jelly or gear oil and install in base and drum.

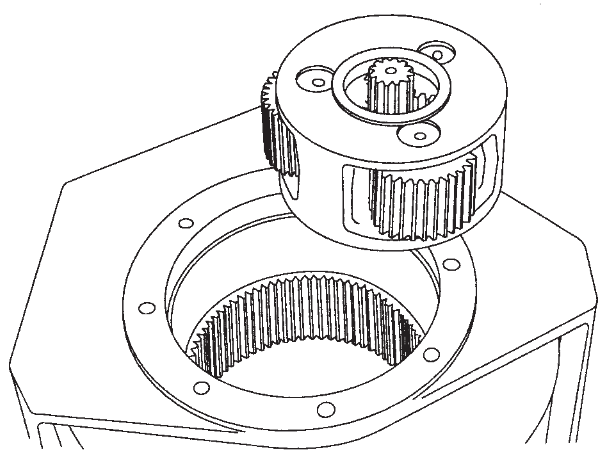
IMPORTANT!
Be sure the vent plug is located above the horizontal center line for the intended application. Oil leakage may occur if vent is positioned incorrectly.



a2224 FIGURE 11-87

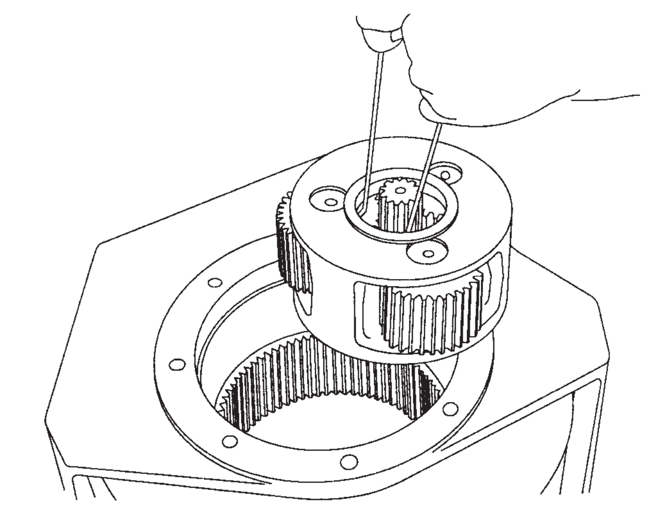
5. Install and tighten the bearing support capscrews to the recommended torque.

6. Stand hoist on bearing support end. Install the output sun gear and thrust washer into output planet carrier (Figure 11-88).



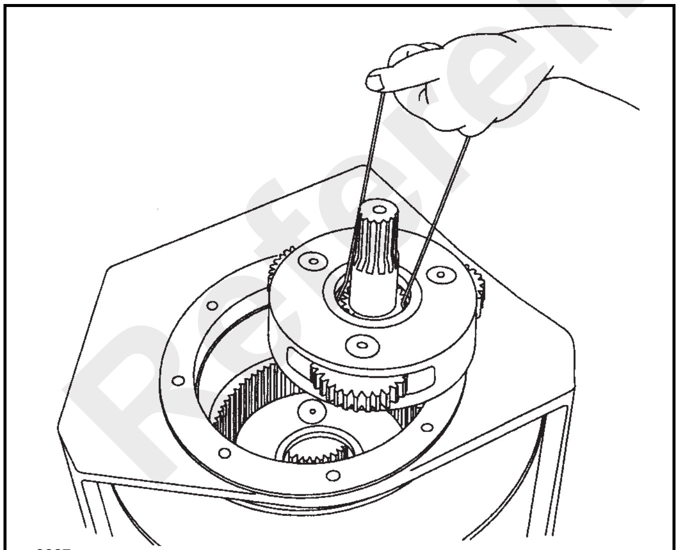
a2225 FIGURE 11-88

7. Install the output planet carrier (Figure 11-89) into the drum while meshing the planet gears with the ring gear and the planet housing with the bearing support.



a2226 **FIGURE 11-89**

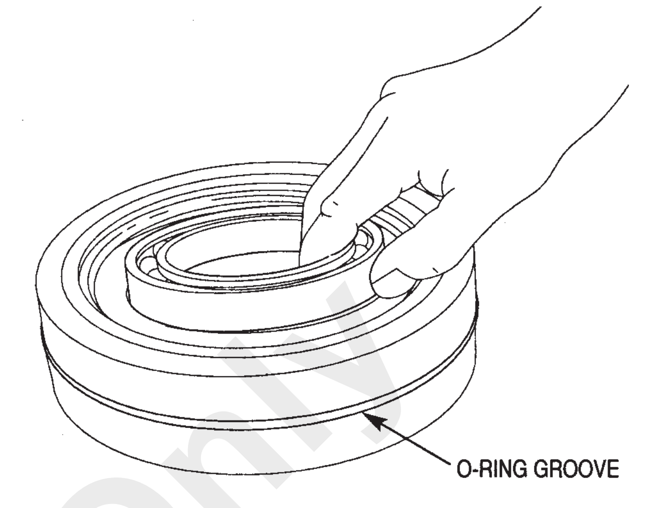
8. Install the primary sun gear and thrust washer into the primary planet carrier.
9. Install the primary planet carrier (Figure 11-90), meshing the planet gears with the ring gear and the planet housing with the output sun gear.



a2227 **FIGURE 11-90**

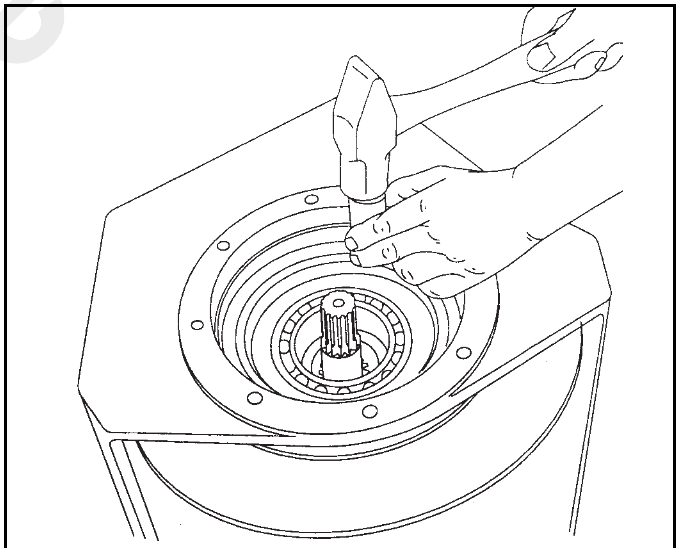
10. Install a new bearing (Figure 11-91) in the drum closure as required. Use sealant on the outside surface of the oil seal. Install with spring side of the seal toward bearing, using a flat plate to avoid distortion.

    Install a new O-ring (Figure 11-91) in the groove on the O.D. of the drum closure.



a2228 **FIGURE 11-91**

11. Lubricate the O-ring and drum opening with petroleum jelly or gear oil and install the drum closure (Figure 11-92) into the drum.

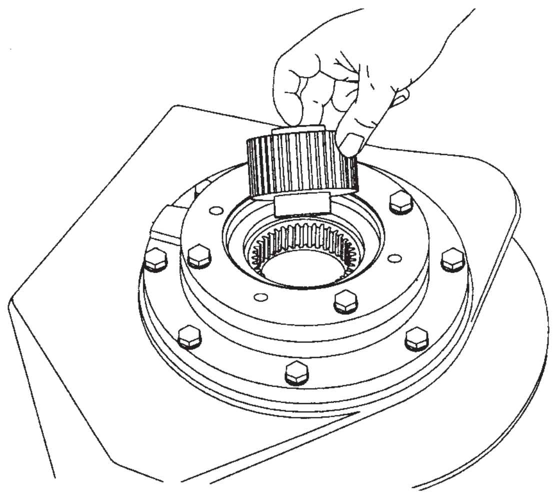


a2229 **FIGURE 11-92**

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 11-93) 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, on page 11-49 for additional information.

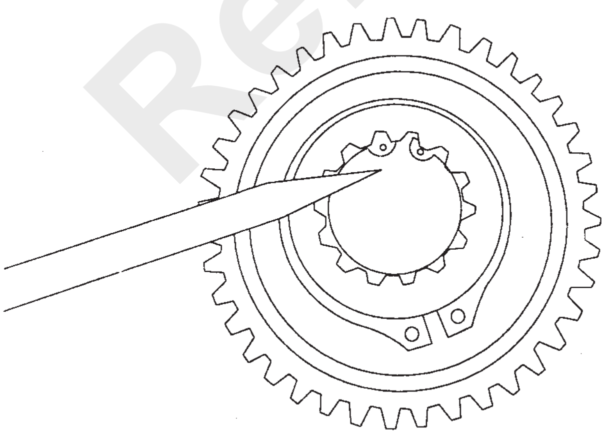


a2230

FIGURE 11-93

WARNING

Be certain the snap ring (Figure 11-94) is seated in the groove in the spline 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.

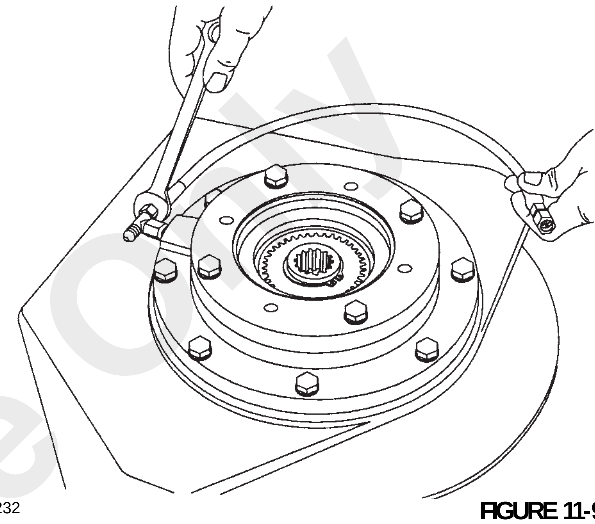


a2231

FIGURE 11-94

14. If the brake discs are misaligned: preventing the installation of the clutch, then with a hand pump, apply 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 11-95)



a2232

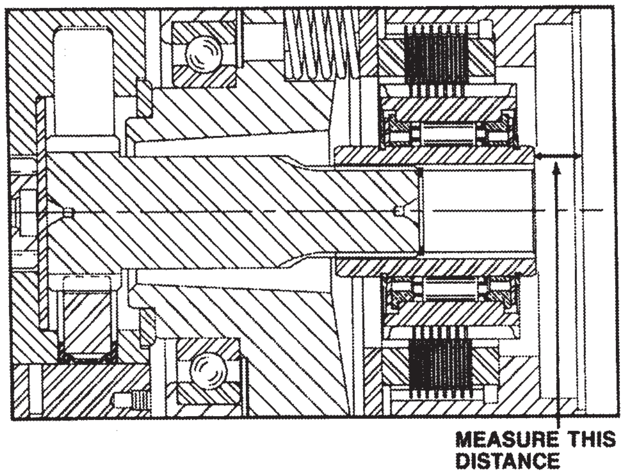
FIGURE 11-95

16. Install a new O-ring on the motor pilot then lubricate with petroleum jelly or gear oil.

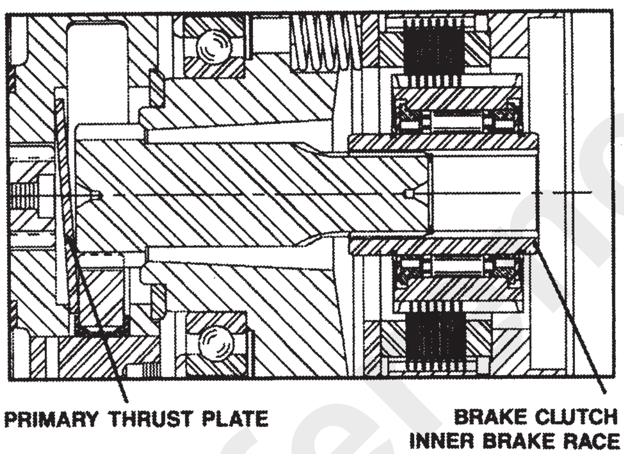
NOTICE!

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 11-96). 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 11-97 and should be checked.



a2233 **FIGURE 11-96**

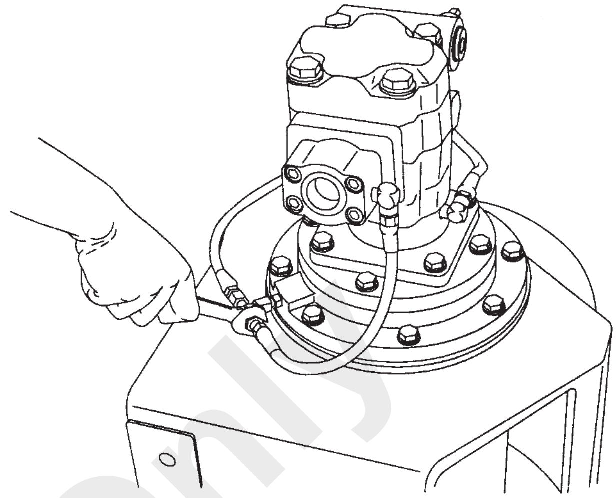


a2234 **FIGURE 11-97**

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 11-98).



a2235 **FIGURE 11-98**

20. After the hoist assembly is complete, check all capscrews and fittings to make certain they have been tightened correctly.

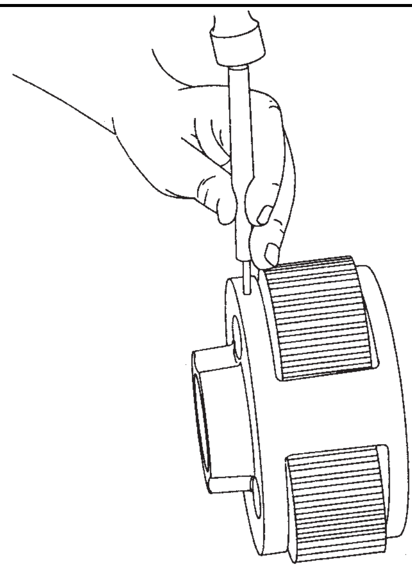
21. Refill the hoist with the recommended oil listed in Section 5, and install the oil level plug.

Planet Carrier Service

Output Planet Carrier

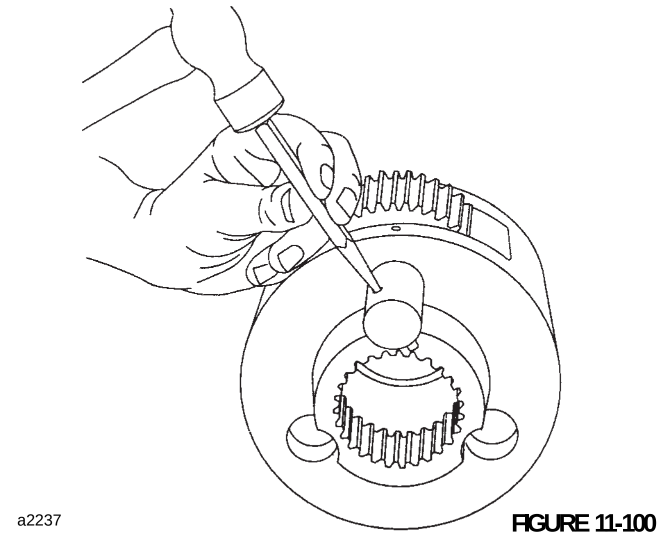
Disassembly

1. Remove the planet gears by driving the roll pins into the center of the planet shafts (Figure 11-99).



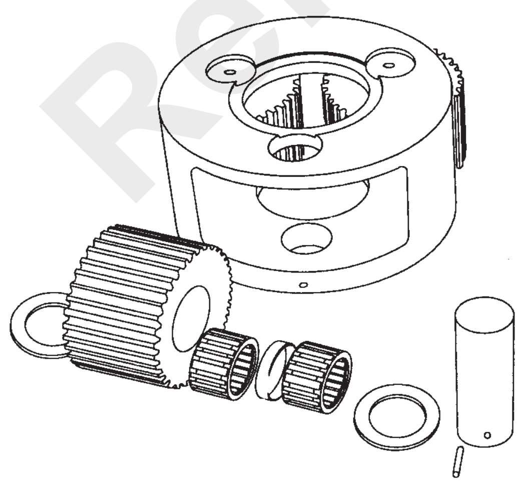
a2236 **FIGURE 11-99**

2. Use a punch (Figure 11-100) to drive the roll pins from the planet shafts. Do not reuse the roll pins.



a2237 FIGURE 11-100

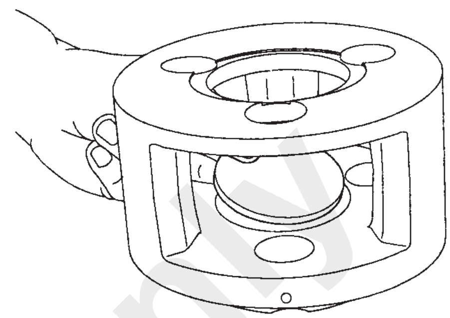
3. Now you can remove the planet shafts, bearings, spacer, thrust washers and gears. Thoroughly clean all parts and inspect for damage and wear. The bearing rollers should not exhibit any irregularities. If the rollers show any sign of spalling, corrosion, discoloration, material displacement or abnormal 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 11-101

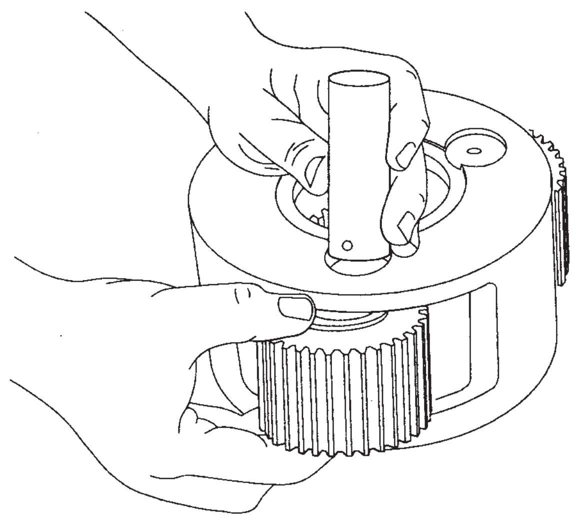
Assembly

1. Place the output planet carrier on workbench with spline coupling side down. Install output thrust plate in center of carrier (Figure 11-102).



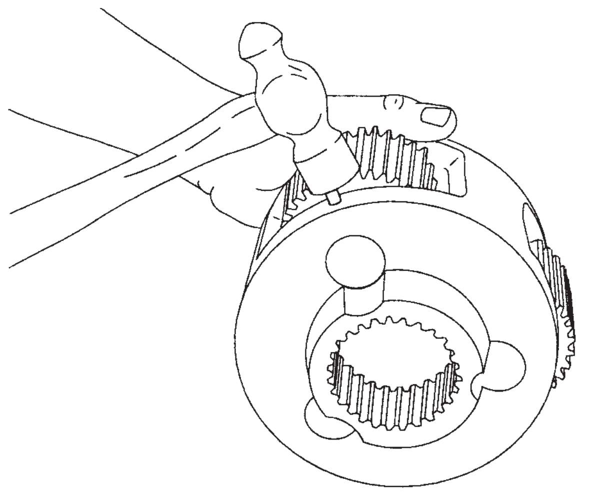
a2239 FIGURE 11-102

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 11-103).



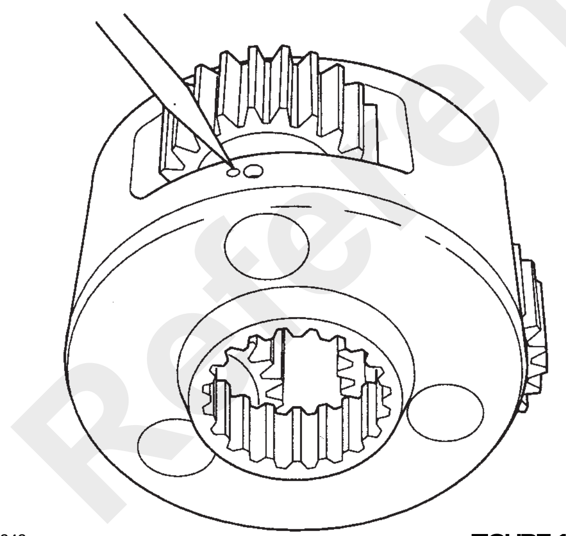
a2240 FIGURE 11-103

3. Carefully align the pin hole in the carrier with the hole in the planet gear shaft (Figure 11-104) 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.



a2241 FIGURE 11-104

4. Note that the roll pin is slightly recessed in the carrier when properly installed. With a center punch (Figure 11-105); 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.



a2242 FIGURE 11-105

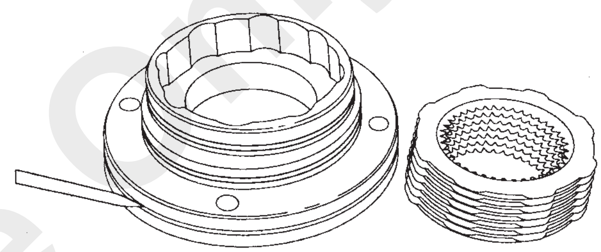
Primary Planet Carrier

1. 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.

Motor Support-Brake

Cylinder Service

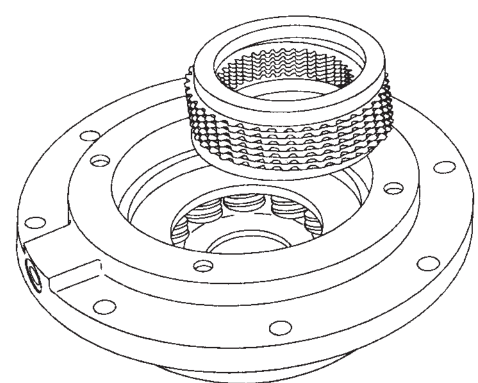
IMPORTANT!
Some of the illustrations show spined brake discs. This brake uses a lobed steel brake separator and motor support as shown in Figure 11-106.



a2243 FIGURE 11-106

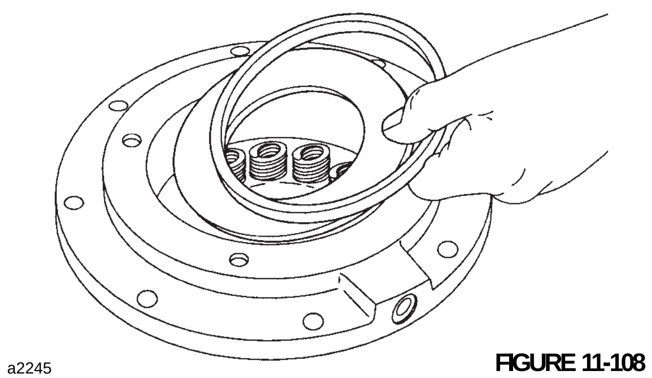
Disassembly

1. Remove spacers, friction brake discs and steel brake discs (Figure 11-107).

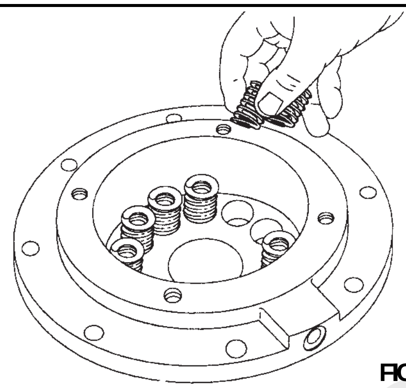


a2244 FIGURE 11-107

2. Remove the piston backup ring and pressure plate (Figure 11-108).

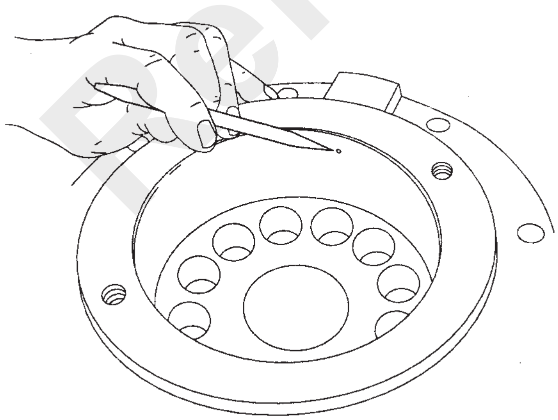

a2245 FIGURE 11-108

3. Remove brake springs (Figure 11-109) and the spring spacer.

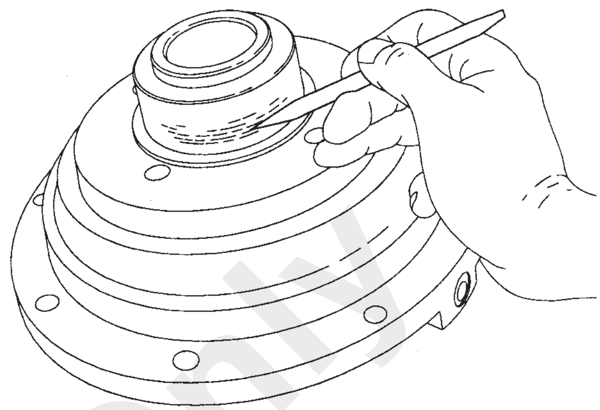

a2246 FIGURE 11-109

Clean and Inspect

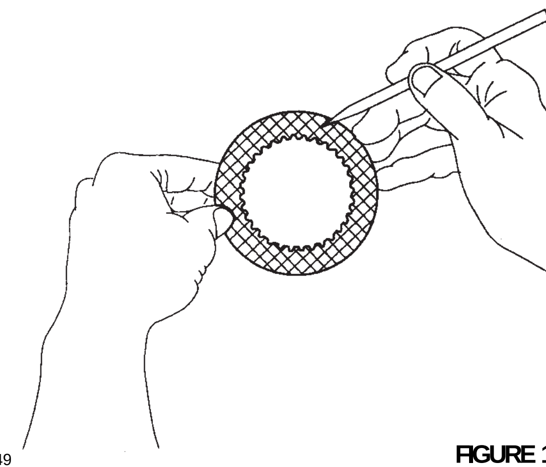
1. Thoroughly clean and inspect all parts at this time. Check brake piston sealing surfaces on the brake cylinder and motor support. Be sure brake release port is free of contamination (Figure 11-110).


a2247 FIGURE 11-110

2. Check oil seal and bearing surfaces on the brake cylinder for damage and wear (Figure 11-111).

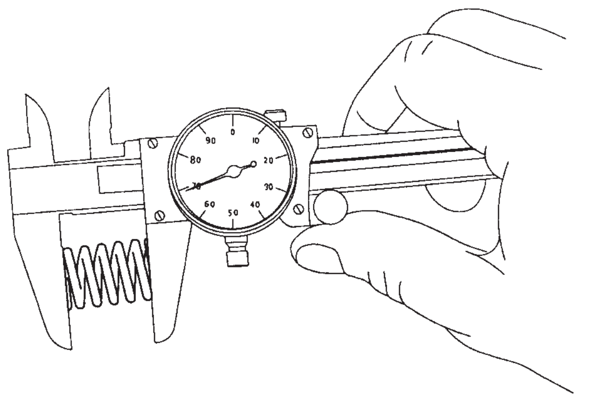

a2248 FIGURE 11-111

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 11-112

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 11-113). 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.

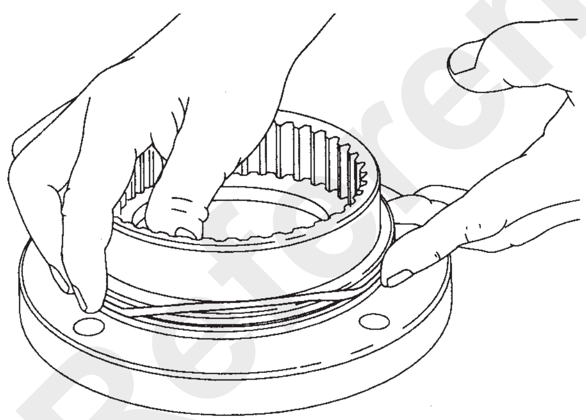


a2250 FIGURE 11-113

NOTICE!
Failure to replace brake springs as a set may result in uneven brake application pressure and repeated brake spring failure.

Assembly

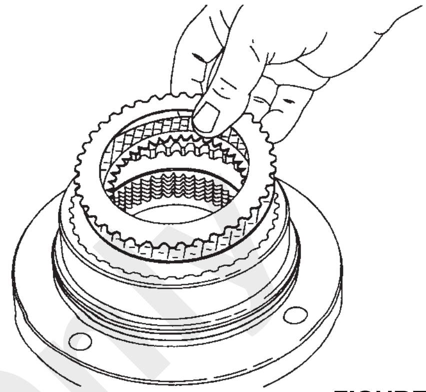
1. Begin assembly by placing the motor support on the workbench with motor mounting surface down. Install new O-ring and brake-up ring (Figure 11-114).



a2251 FIGURE 11-114

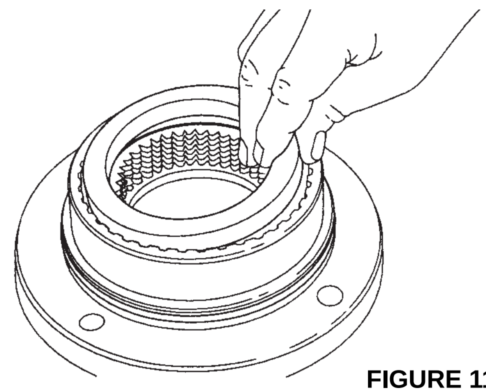
2. Insert first, a steel brake disc followed by a friction disc. Then, alternate steel friction discs until seven (7) friction and eight (8) steel discs have been installed (Figure 11-115). Finish with a steel brake disc on top.

IMPORTANT!
It is good practice to pre-lubricate the discs in a light motor oil prior to assembly.



a2254 FIGURE 11-115

3. Install the brake spacer on top of the last steel brake disc (Figure 11-115).



a2255 FIGURE 11-116

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 11-117). Average gap must measure between 4 mm (0.153 in) maximum and 2 mm (0.80 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.

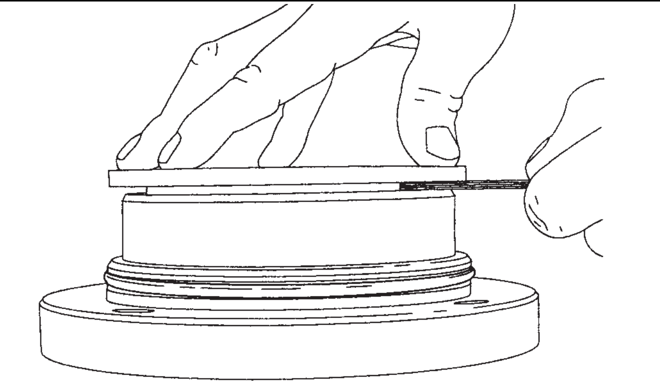


FIGURE 11-117

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 11-118).

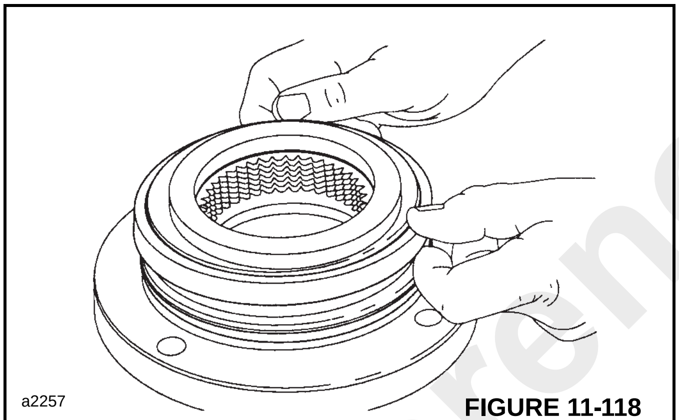


FIGURE 11-118

6. Install the spring spacer and then the brake springs (Figure 11-119).

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.

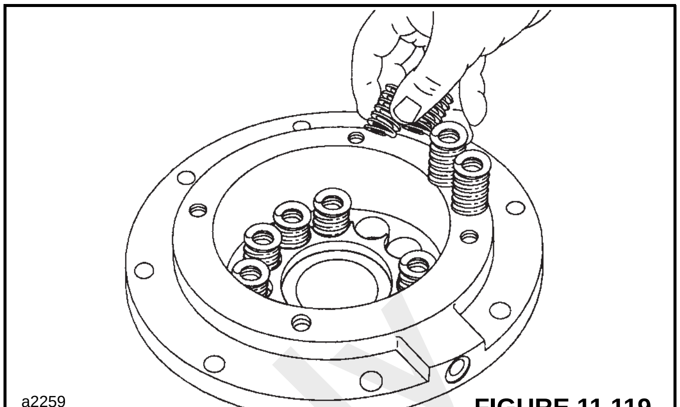


FIGURE 11-119

7. Install the pressure plate into the brake cylinder followed by the piston backup ring (Figure 11-120). 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.

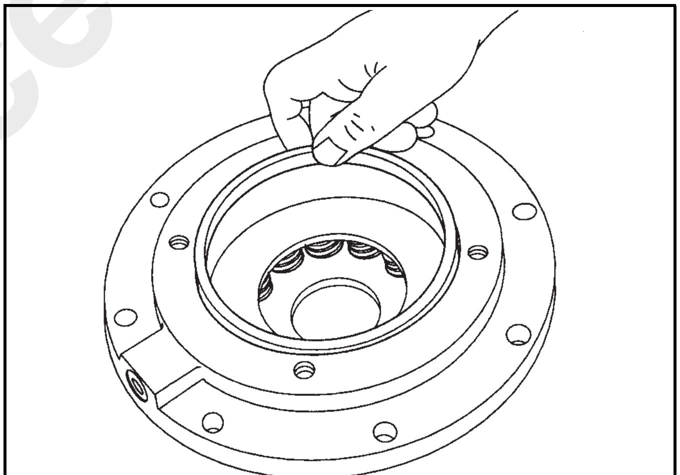


FIGURE 11-120

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 11-121) 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.

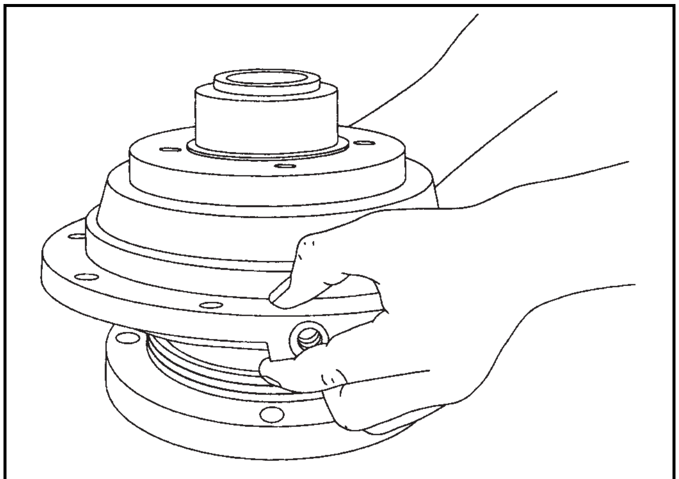


FIGURE 11-121

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 - 13 800 kPa (0 - 2000 psi) pressure gauge and shutoff valve to this fitting (Figure 11-122).

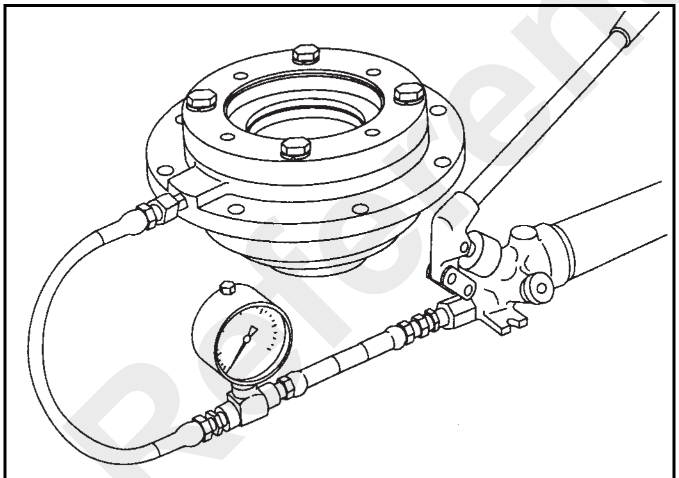


FIGURE 11-122

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 11-123).

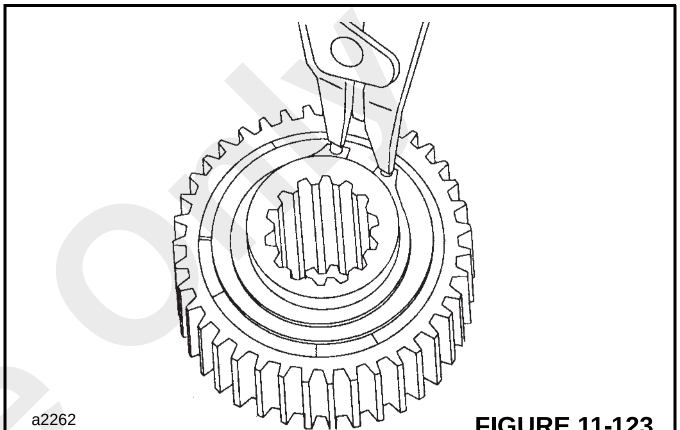


FIGURE 11-123

2. Pull the inner race out (Figure 11-124). Examine the race for scoring, wear, or indentations caused by the sprag cams.

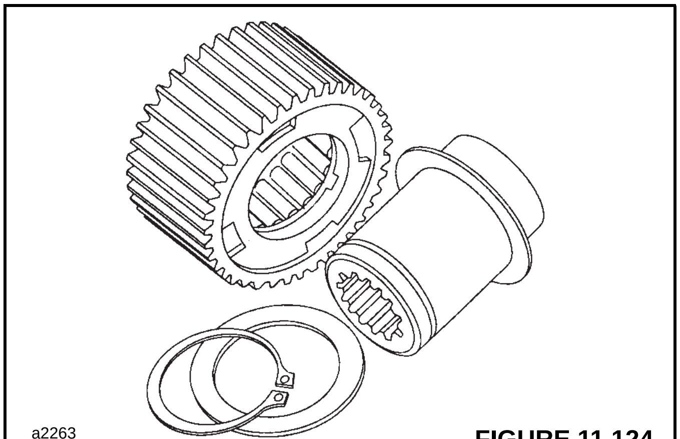
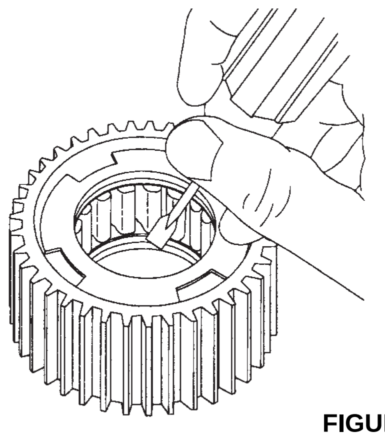


FIGURE 11-124

3. Use a screwdriver and mallet to remove the sprag bushing from one end of the outer race (Figure 11-125). 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.

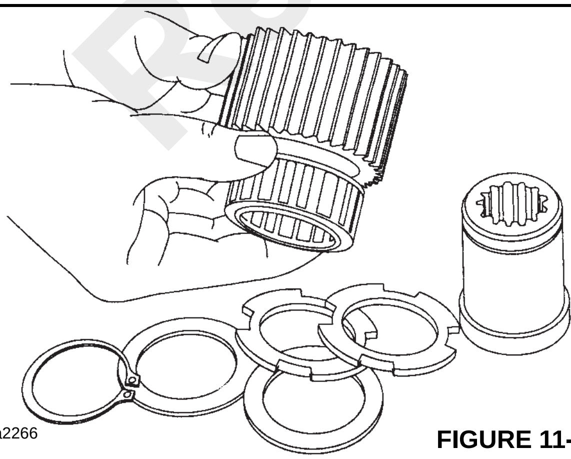


a2264 **FIGURE 11-125**

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.

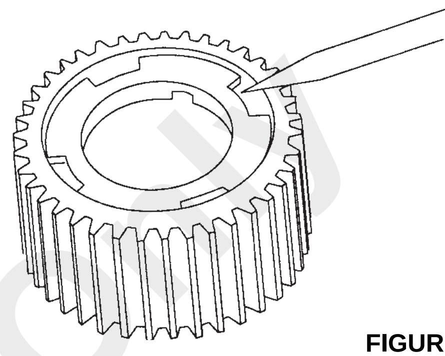
WARNING

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.



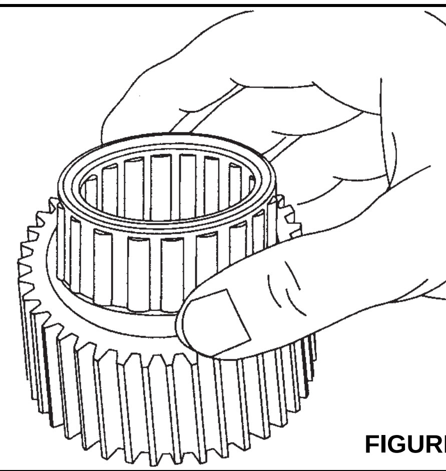
a2266 **FIGURE 11-126**

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 11-127).



a2267 **FIGURE 11-127**

2. Turn the assembly over and install the sprag clutch in the bore of the outer race (Figure 11-128).



a2265 **FIGURE 11-128**

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 11-129). Be sure the snap ring is seated in the snap ring groove.

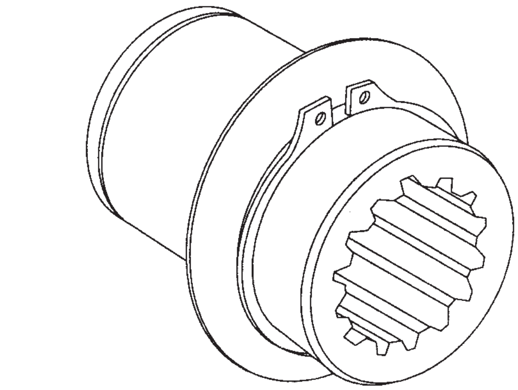


FIGURE 11-129

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.

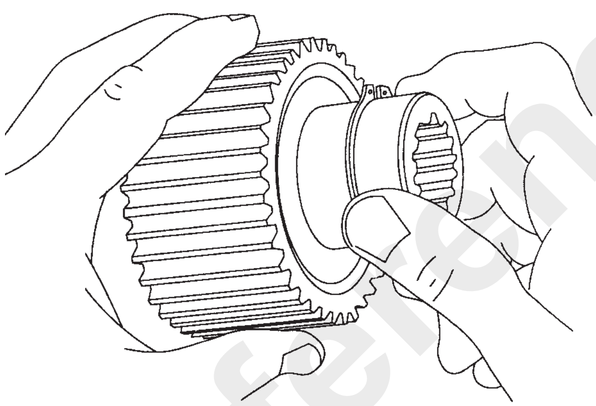


FIGURE 11-130

6. Turn the assembly over with the snap ring down. Install the second retainer and snap ring (Figure 11-131). Make sure the snap ring is properly seated in the groove.

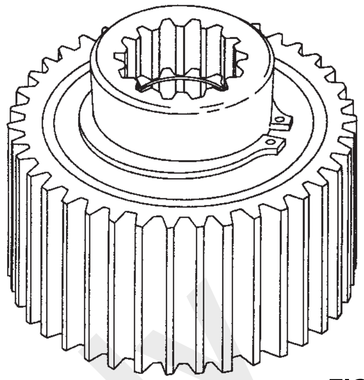


FIGURE 11-131

Figure 11-132 shows a completed clutch assembly.

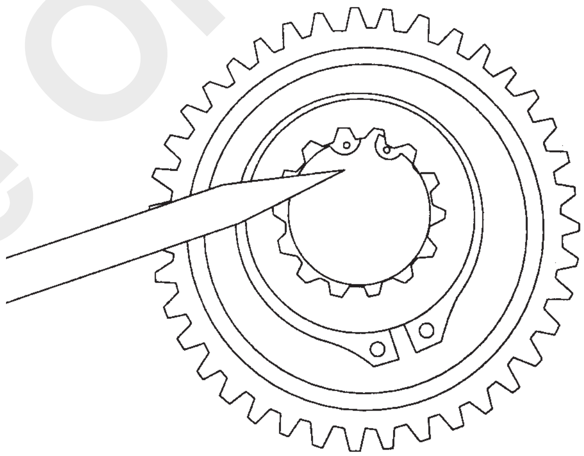


FIGURE 11-132

CAUTION

Be certain the snap ring is seated in the groove in the spline 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.

Troubleshooting

TROUBLE	PROBABLE 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” on page 11-45
	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 11-45.
B - Oil leaks from vent plug.	1. Same as A2. 2. Motor seal may be defective as a result of high system back pressure.	1. Same as A2. 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.
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 Section 5.
D - The hoist runs hot.	1. Excessively worn or damaged internal hoist parts.	1. Disassemble hoist to inspect/ replace worn parts.

TROUBLE	PROBABLE CAUSE	REMEDY
C - 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.
D - 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 purchased from Grove. 2. Replace wire rope.

TULSA HOIST

Drum Rotation Indicator

The drum rotation indicator (DRI) is located on the left side of the hoist and transmits a rotation signal to a solenoid (thumb thumper) located in the hoist control lever at the operator's seat.

The DRI transducer has an integral Last Layer Indicator (LLI) which is programmed to notify the operator when there are three wraps of cable left on the hoist drum.

Removal

1. Loosen the collar on the connector and unplug the DRI cable (1, Figure 11-133).
2. Remove the two retaining screws (2).
3. Remove the DRI unit from the hoist.

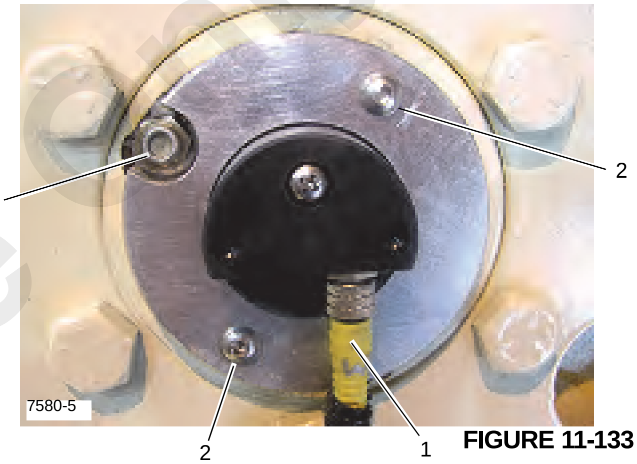


FIGURE 11-133

Installation

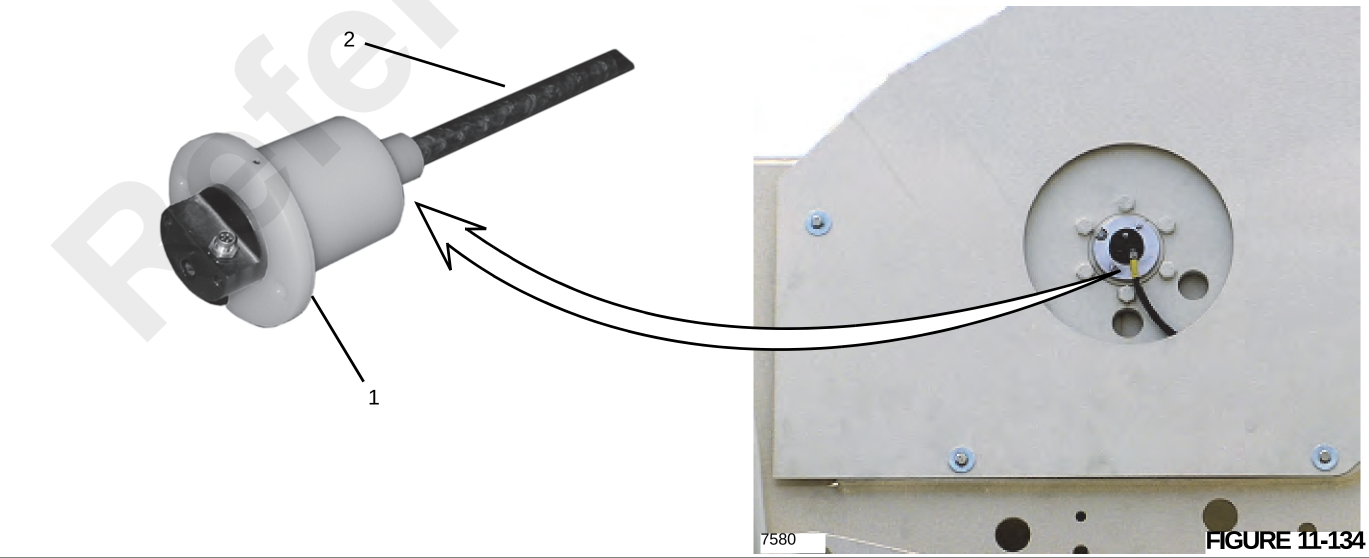


FIGURE 11-134

To install the DRI, use the following procedure:

1. Insert the DRI into the drum. Rotate the DRI (1, Figure 11-134) so that the DRI shaft (2) engages the drive inside the drum.
2. Push the DRI into the drum so that the notch is lined up with the breather (3, Figure 11-133).
3. Secure the DRI with the retaining screws (2, Figure 11-133).
4. Loosen the set screw (1, Figure 11-135) on the side of the DRI flange.
5. Using the spanner wrench holes (2, Figure 11-135) rotate the DRI so that the connector (3) is pointed down.
6. Tighten the set screw (1, Figure 11-135) after the DRI is positioned as desired.
7. Plug in the DRI cable and tighten the collar to secure the connector.

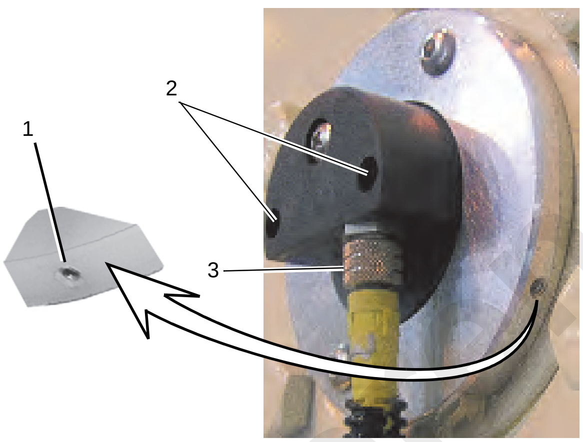


FIGURE 11-135

Programming the Last Layer Indicator

The last layer indicator (LLI) needs to be programmed to alert the operator when the cable is down to the third wrap. To program the LLI you need to:

1. Run the hoist to the third wrap.
2. Remove the programming screw (1, Figure 11-136) on the DRI.
3. Remove power from the LLI by disconnecting the DRI cable (2, Figure 11-136).
4. With a ballpoint pen or small punch, push and hold the learn button (3, Figure 11-136) and return power to the LLI by reconnecting the DRI cable.
5. Release the DRI learn button (2, Figure 11-136).
6. Run the hoist to the start of the second layer.
7. Press and hold the learn button (2, Figure 11-136) for a few seconds and release button.
8. Replace the LLI programming screw.

NOTE: Failure to replace the programming screw (1, Figure 11-136) could effect the operation of the LLI.

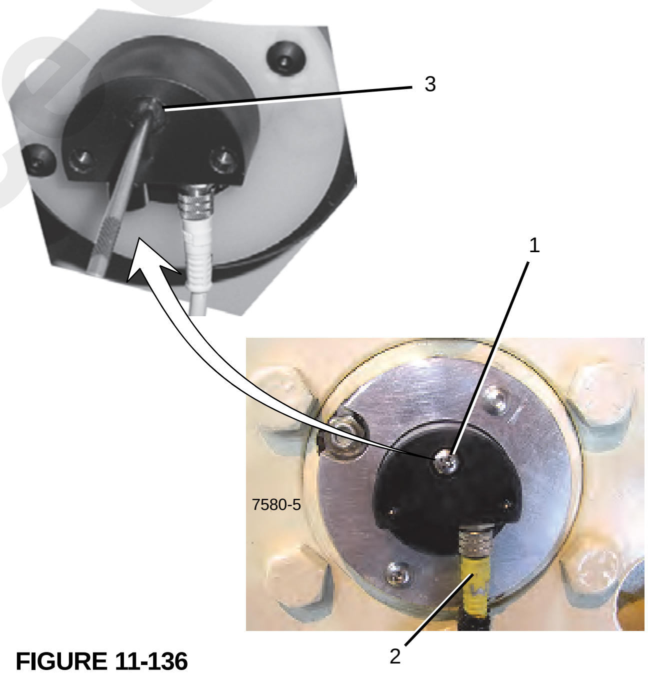


FIGURE 11-136

BEARING, MAST AND RELATED PARTS

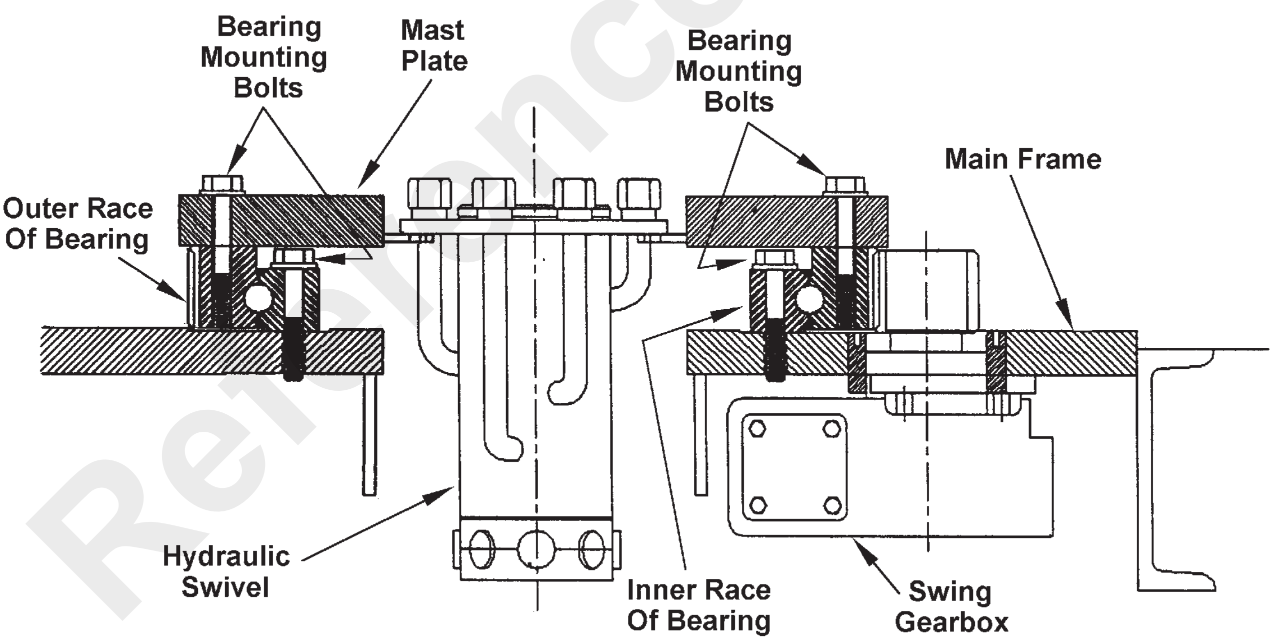
General

The mast is fastened to the main frame of the crane through a bearing. The outer race of the bearing is fastened to the mast and the inner race of the bearing is fastened to the frame. See Figures 11-137 and 11-138.

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.

p0802

FIGURE 11-137



A0490

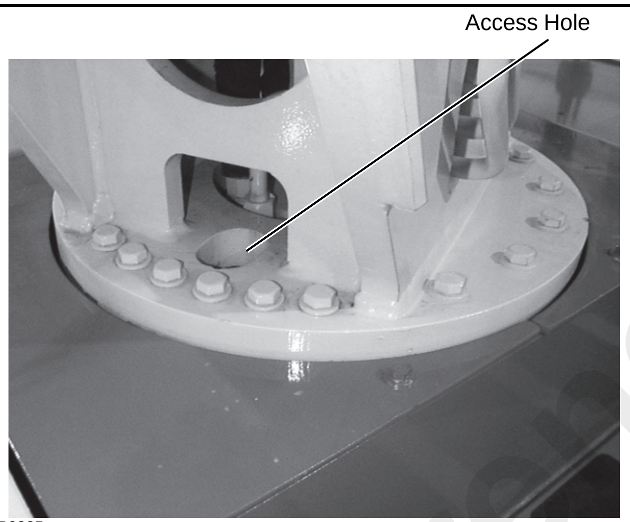
FIGURE 11-138

Mast Bearing

The mast bearing is a ball thrust bearing. The inner race rotates inside the outer race on a row of steel balls.

Apply grease after every 50 hours of operation. 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 11-139) aligns with the grease fitting. Apply grease to the bearing. Rotate the mast through several rotations and then repeat the procedure with the other grease fitting. The old grease will be removed at the bottom of the bearing.



P0325

FIGURE 11-139

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.

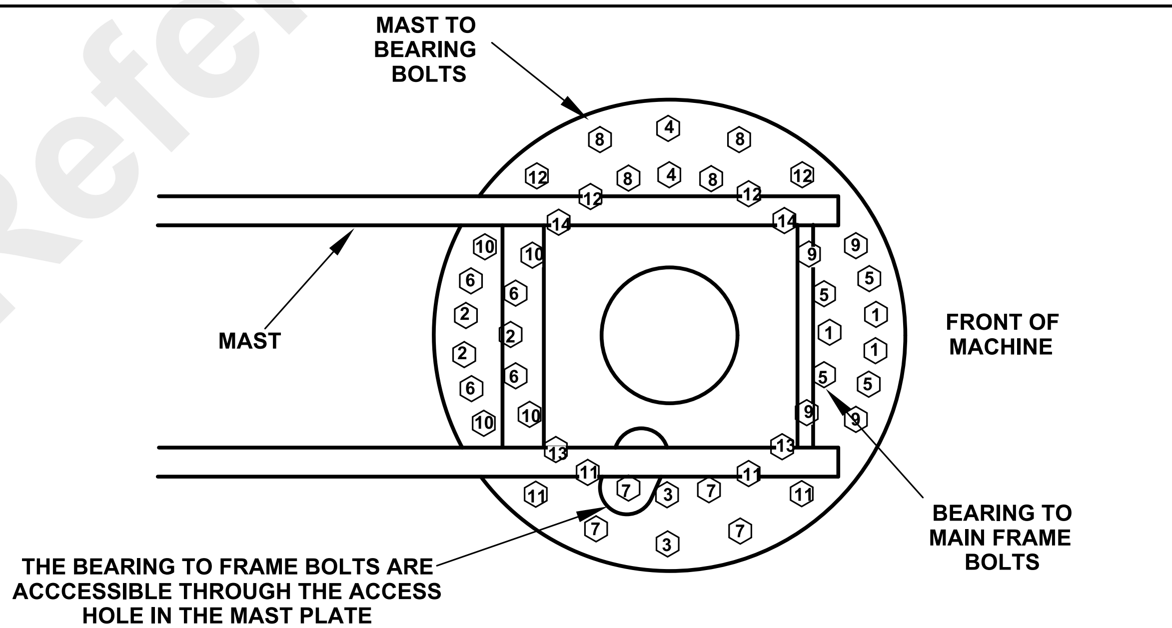
Check the torque on the bolts after the first 50 hours of operation, and then after every 250 hours of operation. Make a record of any loose bolt. If any bolt does not hold to correct torque after the second check, remove and replace the bolt. A loose bolt indicates possible failure of the bolt.

The correct torque on each outside bolt (mast to swing bearing) should be 245 Nm (180 lb-ft). The correct torque on each inside bolt (swing bearing to frame) should be 384 Nm (282 lb-ft).

Use the torque sequence shown in Figure 11-140 when checking the torque on the bolts.

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

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



A0602

FIGURE 11-140

Inspection for Bearing Wear

Because of conservative design parameters, static loading and slow intermittent rotation, there are very few mast bearings that ever see their full design use.

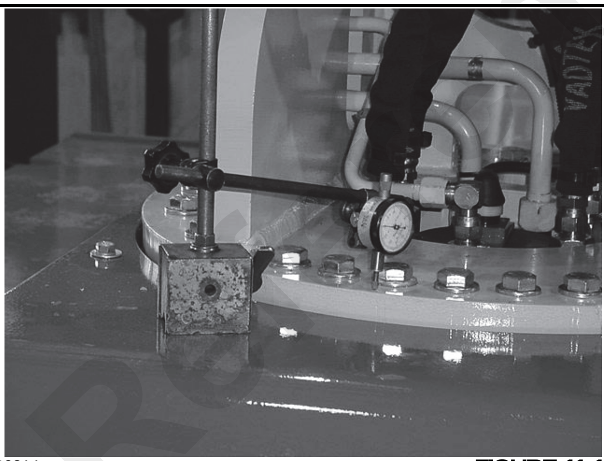
However, the mast does have moving internal parts that are prone to wear if not properly maintained. As the bearing wears, there will be free-play or movement in the bearing.

Some of the symptoms of mast bearing wear are:

- Metal particles in the grease around the seal.
- Increased drive power required.
- Noisy rotation.
- Rough rotation.

If one or more of the above symptoms are evident, the following procedure should be used to check the bearing for excessive wear:

1. On a level, hard packed surface, set the crane up level on its outriggers.
2. Place the boom in forward horizontal position. Fully extend the booms.
3. Place a dial indicator on the swing gearbox cover and mast as shown in Figure 11-141.



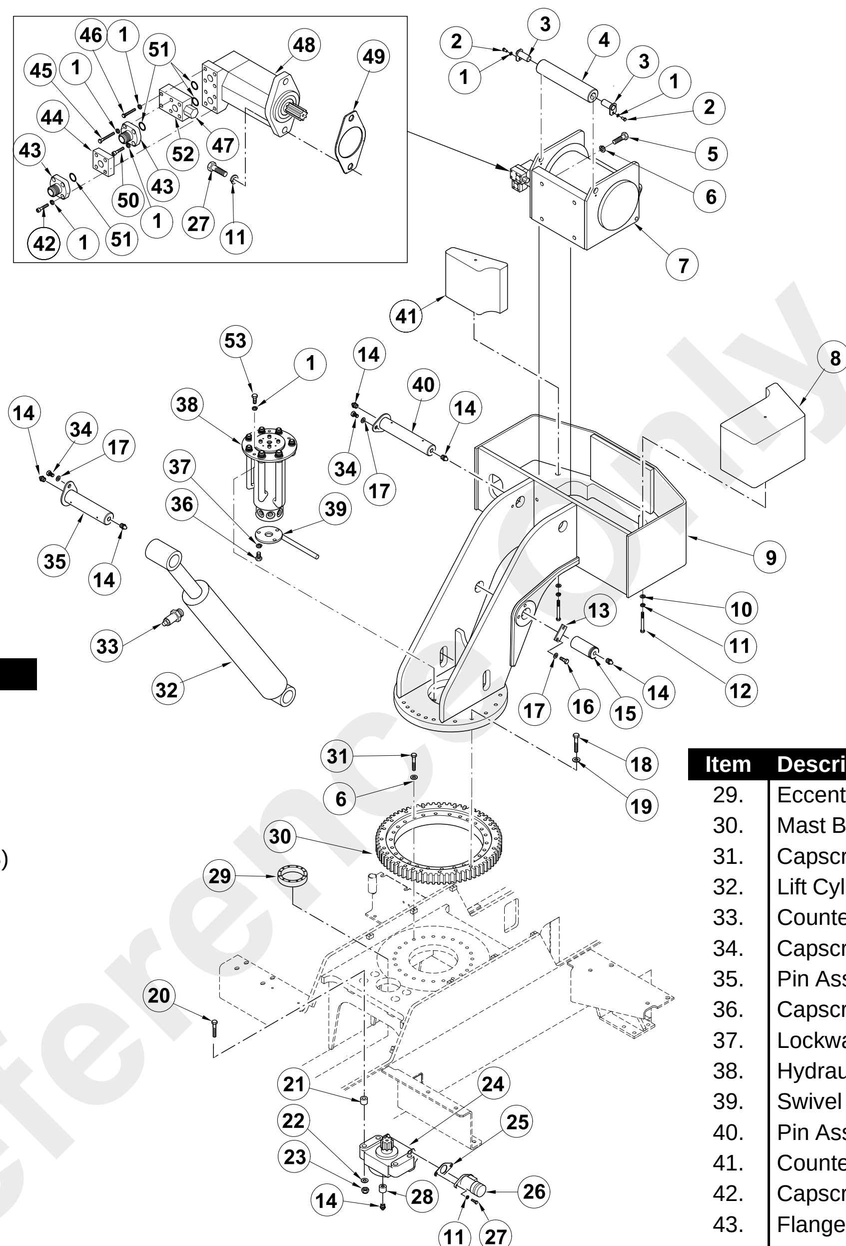
P0814 **FIGURE 11-141**

4. Set the dial indicator to zero.
5. Raise the boom to its full upright position and record the amount of movement on the dial indicator.
6. Rotate the boom 180° and repeat steps 2 thru 5.
7. Average the two readings. The maximum allowable movement is 0.91 mm (0.035 in). The mast bearing must be replaced if the movement is greater than the maximum allowable movement.

Replacing the Mast Bearing

Removal

1. See boom removal and remove the boom from the mast.
2. Disconnect the lift cylinder hoses. Plug/cap the hoses and cylinder ports. Remove the lift cylinder.
3. Put tags on the upper swivel hydraulic hoses and lines with the swivel port to which the hydraulic hose or line connects.
4. Disconnect the hydraulic hoses and lines from the upper swivel ports. Put caps or plugs on the fittings and hydraulic lines and hoses.
5. Remove swivel stop (39, Figure 11-142) from the bottom of hydraulic swivel (38) and support the swivel in place. Remove bolts (53) and washers (1).
6. Connect a hoist capable of handling the weight of the mast. Remove the 22 capscrews (18) and structural washers (19) that fasten mast (9) to mast bearing (30).
7. Remove the mast (9) and place on blocks.
8. Remove the 24 capscrews (31) and structural washers (6) and remove the mast bearing (30).



Item	Description
1.	Lockwasher (15)
2.	Capscrew (2)
3.	Pin Assembly (2)
4.	Rope Deflector Roller
5.	Capscrew (4)
6.	Structural Washer (28)
7.	Main Hoist Assembly
8.	Counterweight
9.	Mast
10.	Flat Washer (2)
11.	Lock Washer (4)
12.	Capscrew (2)
13.	Retainer Bar (2)
14.	Grease Fitting (6)
15.	Pin (2)
16.	Capscrew (4)
17.	Lockwasher (4)
18.	Capscrew (22)
19.	Structural Washer (22)
20.	Capscrew (4)
21.	Spacer (4)
22.	Flat Washer (4)
23.	Nut (4)
24.	Swing Gearbox
25.	Gasket
26.	Swing Motor
27.	Capscrew (4)
28.	Bushing

Item	Description
29.	Eccentric Ring
30.	Mast Bearing
31.	Capscrew (24)
32.	Lift Cylinder
33.	Counterbalance Valve
34.	Capscrew (2)
35.	Pin Assembly
36.	Capscrew (3)
37.	Lockwasher (3)
38.	Hydraulic Swivel
39.	Swivel Stop
40.	Pin Assembly
41.	Counterweight
42.	Capscrew (4)
43.	Flange Adapter (2)
44.	Spacer Block
45.	Capscrew (2)
46.	Capscrew (2)
47.	Counterbalance Valve
48.	Hoist Motor
49.	Gasket
50.	Capscrew (2)
51.	O-ring (4)
52.	Line Mount Body
53.	Capscrew (3)

P0314

FIGURE 11-142

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. Put the mast bearing (30, Figure 11-142) in place on the bearing plate.
3. Install the 24 capscrews (31) and structural washers (6) to fasten the mast bearing (30) to the bearing plate.
4. Figure 11-140 shows the order for tightening the capscrews. Each capscrew must first be tightened to a torque of 384 Nm (282 lb-ft) and then loosened a small amount. Next, tighten the bolts again to a torque of 384 Nm (282 lb-ft).
5. Make sure the top surface of the mast bearing and the bottom surface of the mast base are clean.
6. With a hoist, lower the mast into position over the mast bearing. Install 22 capscrews (18) and structural washers (19).
7. Figure 11-140 shows the order for tightening the bolts. Each bolt must first be tightened to a torque of 245 Nm (180 lb-ft) and then loosened a small amount. Next, tighten the bolts again to a torque of 245 Nm (180 lb-ft).
8. Install swivel stop (39, Figure 11-142) to the hydraulic swivel. Attach swivel to mast base with three capscrews (53) and lockwashers (1).
9. Connect the hydraulic lines and hoses to the hydraulic swivel.
10. Install lift cylinder to mast.
11. Install boom assembly to mast. See Installation earlier in this Section.

Swing Gearbox and Pinion

Maintenance

Gearbox

The swing gearbox has a worm gear set which rotates on taper roller bearings. The gears and bearings are given lubrication by grease in the gearbox. Gaskets inhibit external leakage of the grease.

Keep the gearbox filled with grease. See Section 5, Preventive Maintenance.

Swing Gear/Pinion

The swing pinion and ring gear must be lubricated at regular intervals. See Section 5, Preventive Maintenance for maintenance intervals and instructions.

Adjustments

Checking Backlash

1. Remove the front cover to expose the swing pinion and ring gear.

W0022

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

2. Start the engine and rotate the mast until the high point (marked with a punch-mark on the edge of the mast base plate) is in alignment with the pinion. See Figure 11-143.

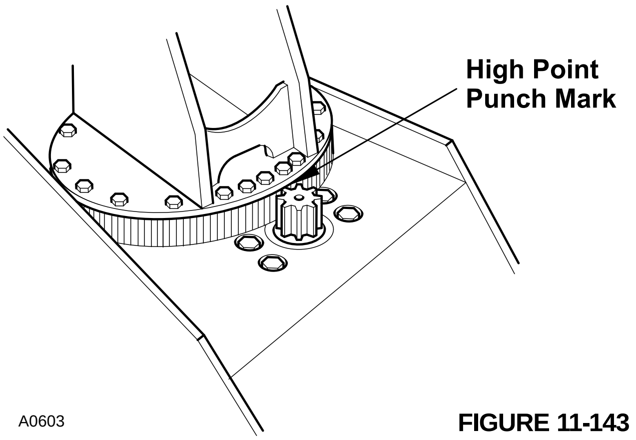


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FIGURE 11-143

3. Using a feeler gauge, check the backlash between the gear and pinion. There should be no clearance between the swing gear tooth and the pinion tooth. If there is any clearance, adjust the backlash.

Adjusting Backlash

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

1. Slightly loosen the four capscrews securing the swing gearbox (Figure 11-144).
2. With a spanner wrench, turn the eccentric ring until the pinion tooth comes in contact with ring gear tooth (zero backlash).
3. Tighten the four capscrews to proper torque.
4. Install the swing pinion cover.

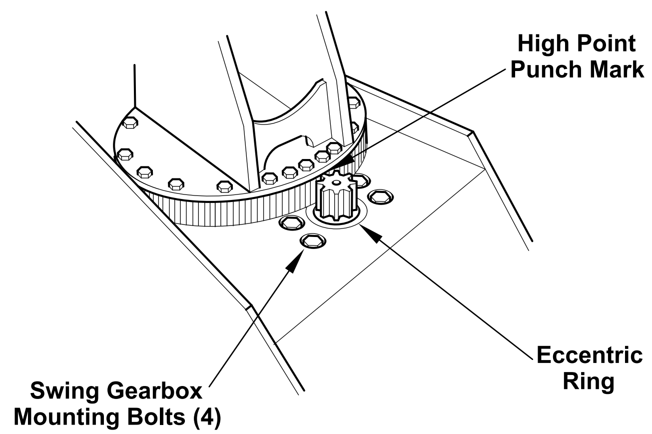


FIGURE 11-144

Swing Gearbox Repair

(Units With S/N 109512-03 and After)

Removal

1. Rotate the boom slightly off center. Then, inhibit the mast from turning, by blocking the boom or attach an overhead crane.
2. Remove the front cover over the swing pinion.
3. Install an eyebolt with 1/2 NF threads into the tapped hole on top of the swing pinion. Attach an overhead crane and chain to the eyebolt.
4. Remove the swing motor (26, Figure 11-142) by removing two capscrews (27) and lockwashers (11). Remove gasket (25).
5. Clear any hoses or obstructions beneath the swing gearbox that would inhibit the gearbox from being lowered to the ground.
6. Remove four nuts (23, Figure 11-142), flat washers (22) and capscrews (20).
7. Using the overhead crane, lower the gearbox to the ground. Be sure to collect the four spacers (21) when the gearbox is lowered. The eccentric ring will be removed with the gearbox.

Disassembly

1. Remove the hydraulic motor.
2. Clean the outside of the gearbox before disassembly.
3. Loosen and remove capscrews (11, Figure 11-145). Remove cover (6) and O-ring (10). Discard the O-ring.
4. Clean as much grease out of the gearbox housing as possible. Properly discard the grease.
5. Remove two socket capscrews (19) and remove motor end cap (22).
6. Remove and discard O-ring (21) and oil seal (2).
7. Remove four capscrews (31) and then remove cap end (20) and shims (26, 29 and 30). Keep the shims together as a set.

NOTE: Tie the shim set together to prevent any shim from being lost.

8. Remove and discard O-ring (21) oil seal (28) from cap end (20).
9. Bend the tabs down on washer (23) to free lock nut (27). Remove lock nut (27), washer (23) and thrust washer (13).
10. Using a suitable puller, remove bevel gear (9). Remove two keys (14).
11. Remove pinion gear shaft (3) along with bearing cone (15) and oil seal (7) out of housing (4). It may be necessary to use a soft mallet to drive the pinion shaft from the housing. At the same time, remove worm gear and shaft (8) by removing it through the end cap opening on the housing. Bearing cone (17) will pull out with worm gear (8). Remove the bearing cones from the worm gear shaft and the pinion shaft. Remove oil seal (7) from the pinion shaft.
12. Remove bearing cone (15) from housing (4).
13. If necessary, using a suitable puller remove any damaged bearing cups from the housing and end caps.

Inspection

Remove breather (34, Figure 11-145) and clean it in a suitable solvent. Clean all other parts. See Section 1. Make careful inspection of all parts, including gears, shafts and bearings.

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

Replace all seals and gaskets.

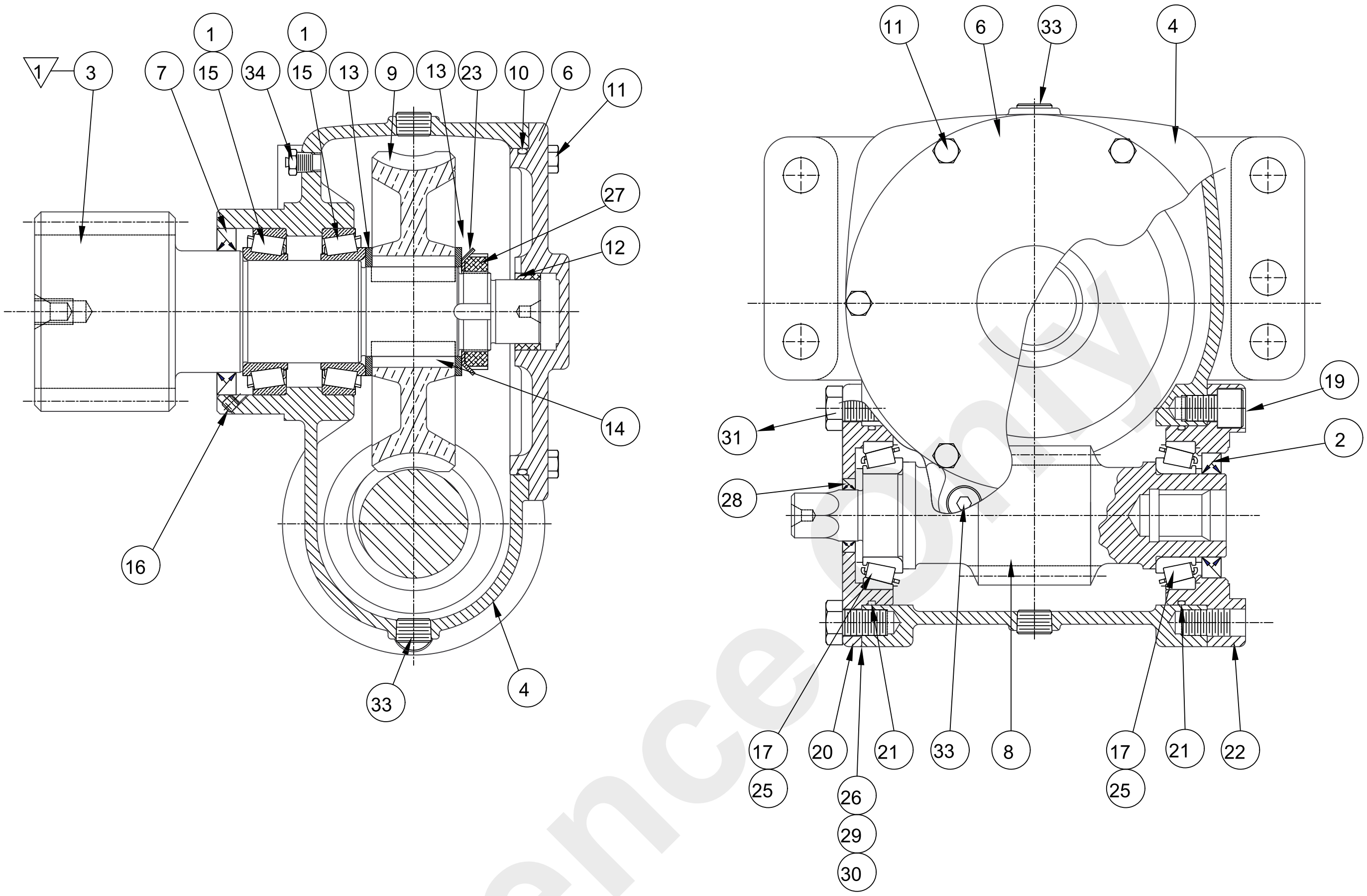
Coat all seals with a Lithium Base, E.P. No. 2 bearing grease.

Assembly

1. If removed, press new bearing cups into housing (18) and end caps (20 and 22)
2. Coat a new oil seal (7) with grease and install it onto pinion gear shaft (3).

NOTE: Before installing any bearing cone, pack it with Lithium Base, E.P. No. 2 bearing grease.

3. Pack bearing cone (15) with grease and install it onto pinion gear shaft (3).
4. Install pinion gear shaft (3) into housing (4). Be sure to seat oil seal (2) into the housing, being careful not to damage it.
5. Pack the other bearing cone (15) with grease and install over pinion gear shaft (3) into housing (4).
6. Insert worm gear and shaft (8) into housing (18).
7. Pack both bearing cones (17) with grease and install them over the ends of the worm gear and shaft into housing (4).
8. Install thrust washer (13) over pinion shaft (3).



Item	Description
1.	Bearing Cup (2)
2.	Oil Seal
3.	Pinion Shaft
4.	Housing
6.	Cover
7.	Oil Seal
8.	Worm Shaft
9.	Worm Gear
10.	O-Ring
11.	Capscrew (6)
12.	Bushing
13.	Thrust Washer (2)

Item	Description
14.	Key (2)
15.	Bearing Cone (2)
16.	Set Screw
17.	Bearing Cone (2)
19.	SH Capscrew
20.	End Cap
21.	O-Ring (2)
22.	Motor End Cap
23.	Lock Washer
25	Bearing Cup (2)
26.	Shim (2)
27.	Lock Nut

Item	Description
28.	Oil Seal
29.	Shim (2)
30.	Shim (2)
31.	Capscrew (4)
33.	Pipe Plug (3)
34.	Breather

a2288

FIGURE 11-145

9. Install two keys (14) into the end of pinion gear shaft (3). Press bevel gear (9) onto pinion gear shaft (3). Align the teeth of the bevel gear with the teeth of the worm gear and shaft.

10. Apply Loctite 243 to the threads of pinion gear shaft (3). Install thrust washer (13), washer (23) and lock nut (27).
11. Tighten lock nut (27) to 68 Nm (50 lb-ft), then loosen the nut and tighten again to a torque of 27.2 - 40.8 Nm (20 - 30 lb-ft). Bend tabs on washer (23) up to lock the nut in place.
12. Install a new oil seal (2) into motor end cover (22). Install a new O-ring (21) onto the motor end cover. Be sure to lubricate both before assembly
13. Install motor end cap (22) to housing (4) and worm shaft (8) using two socket head capscrews (19). Be sure not to damage oil seal (22) and O-ring (21).
14. Install a new oil seal (28) and O-ring (21) to end cap (20).
15. Align the gear teeth of the worm with teeth of the worm gear.
16. If the original bearing cones and cups were installed into the end caps and the worm, the existing shims (26, 29, and 30) may be installed between housing (4) and end cap (20). Install shims and end cap and fasten with four capscrews (31).

    If new bearings were installed, proper bearing preload must be determined before final installation of the end caps.

    a. Install end cap (20) without shims installed.
    b. Using a dial indicator, measure the amount of axial movement on the worm. Proper axial movement must be between -0.025 & +0.05 mm (-0.001 and +0.002 in). Determine the amount of shim spacing needed to acquire the proper axial moment, then install the shims between the housing and the end cap. After the axial movement is set, check the backlash between the worm and worm gear teeth. Backlash should be between 0.127 and 0.177 mm (0.005 and 0.007 in).
17. If bushing (12) was removed, press a new bushing into cover (6).
18. Install a new O-ring (10) into cover (6).
19. Using six capscrews (11), install cover (6) onto housing (4).
20. Install the hydraulic motor.
21. Remove setscrew (16). Fill the gearbox with a Lithium Base, E.P. No. 2 bearing grease through the grease fitting located on the housing. Fill gearbox until grease flows from the setscrew hole.

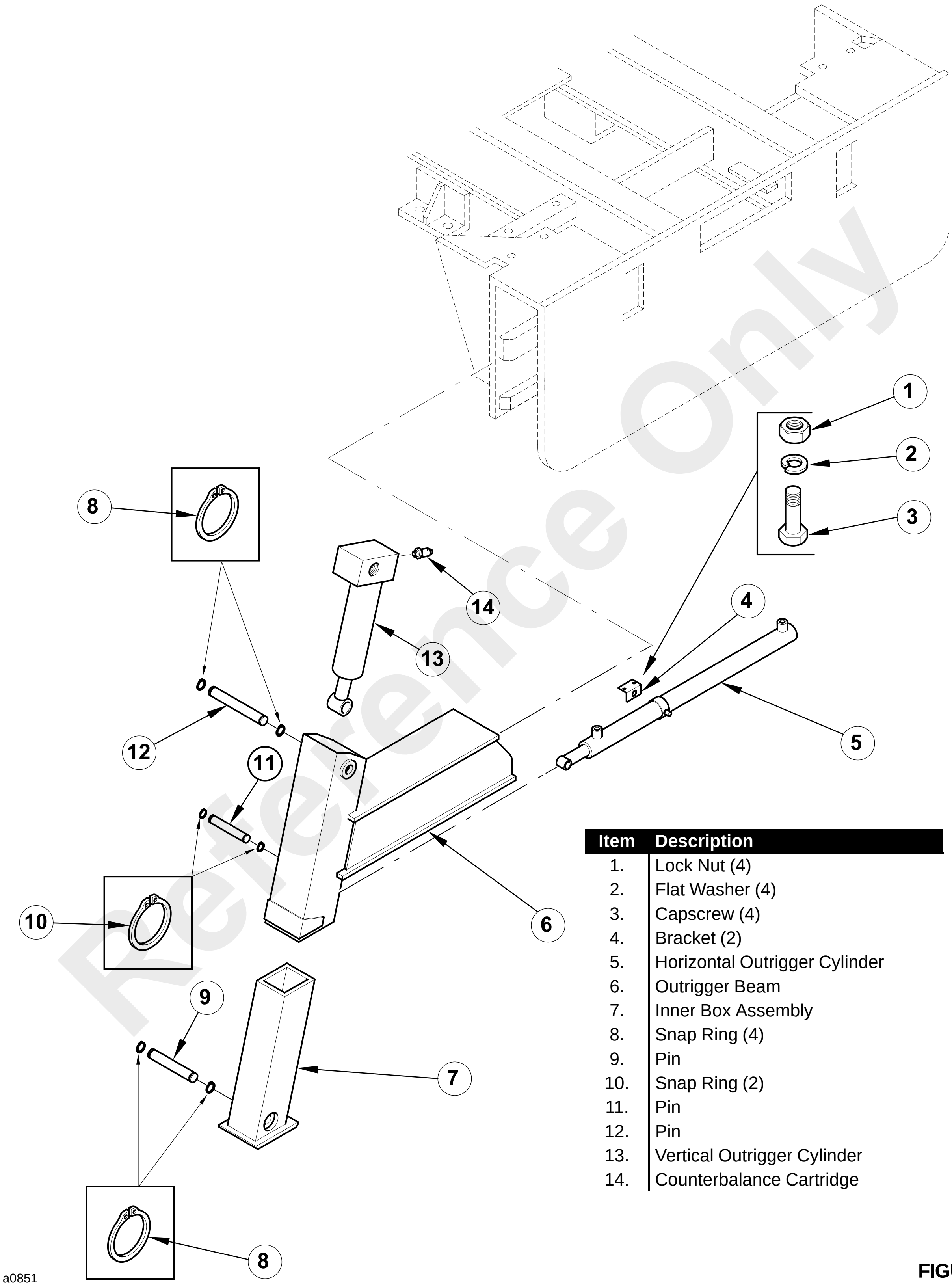
Installation

1. Install an eyebolt with 1/2 NF threads into the tapped hole on top of the swing pinion.
2. Install the eccentric ring onto the gearbox.
3. Using an overhead crane and chain attached to the eye bolt, lift the gearbox into place.
4. Between the gearbox and frame install four spacers (21, Figure 11-142). Fasten the gearbox to the frame with four capscrews (20), flat washers (22) and nuts (23).
5. Place a new gasket (25) between gearbox (24) and swing motor (26). Fasten the swing motor to the gearbox with two capscrews (27) and lockwashers (11).
6. Connect the two hydraulic hoses to the swing motor.
7. Remove the overhead crane and chain. Remove the eyebolt.
8. Adjust the backlash between the pinion gear and ring gear.
9. Coat the teeth of the swing pinion with a gear lubricant. See Section 5.
10. Install the front cover over the swing pinion.
11. Remove blocking from boom.
12. Start the engine and slowly rotate the boom and mast in both directions to remove any air that may have entered the hydraulic circuit.

Outriggers

Removal

1. Engage the parking brake and put chocks at the wheels to inhibit machine movement.
2. Extend the outrigger, remove snap ring (10, Figure 11-146) and drive out pin (11). Disconnect the rod end of the horizontal cylinder (5, Figure 11-146) from the outrigger beam (6). Retract the horizontal cylinder rod.
3. Lower the inner box assembly (7) just far enough to remove the load on the outrigger beam (6).
4. Stop the engine. With the ignition switch in the ON position, actuate the outrigger switches in both directions to release any pressure in the hydraulic circuits. Turn the ignition switch to the OFF position and remove the ignition key.



Item	Description
1.	Lock Nut (4)
2.	Flat Washer (4)
3.	Capscrew (4)
4.	Bracket (2)
5.	Horizontal Outrigger Cylinder
6.	Outrigger Beam
7.	Inner Box Assembly
8.	Snap Ring (4)
9.	Pin
10.	Snap Ring (2)
11.	Pin
12.	Pin
13.	Vertical Outrigger Cylinder
14.	Counterbalance Cartridge

FIGURE 11-146

5. Disconnect the two hydraulic hoses for the vertical outrigger cylinder from the bulkhead fittings attached to the outside of the frame (Figure 11-147). Let the hydraulic oil drain into a suitable container. Plug the hoses.

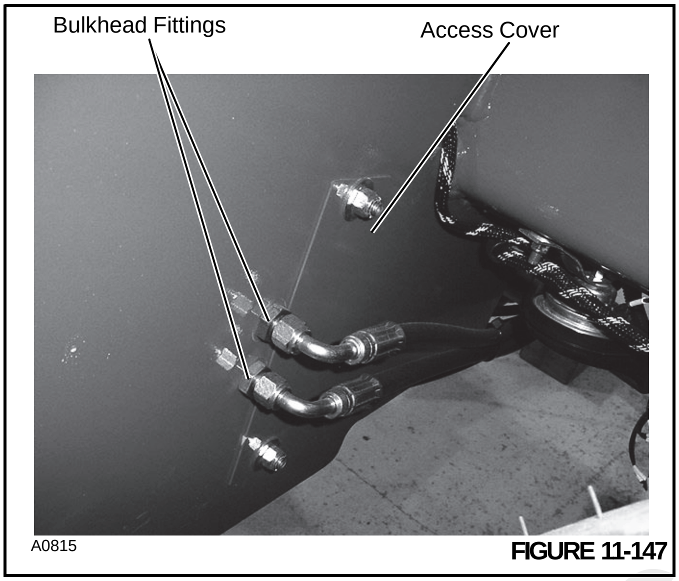


FIGURE 11-147

6. Remove the access cover (Figure 11-147) and from inside the frame housing, disconnect the two vertical outrigger cylinder hoses from the bulkhead fittings.
7. Using a hoist, remove the outrigger assembly from the frame.

Disassembly

1. Disconnect and remove the hydraulic hoses from the elbows at the vertical outrigger cylinder (13, Figure 11-146).
2. Remove the two elbows from the vertical cylinder ports. Remove the counterbalance cartridge (14).
3. Remove a snap ring (8) from either side of pin (12). Drive pin (12) out of the outrigger beam (6).
4. Pull outrigger inner box assembly (7) and vertical outrigger cylinder (13) from outrigger beam (6).
5. Remove a retaining ring (8) from either side of pin (9). Drive out pin (9) from outrigger inner box assembly (7).
6. Remove vertical outrigger cylinder (13).

Assembly

1. Completely clean outrigger beam (6, Figure 11-146) and outrigger inner box (7). Use steam or suitable solvent. Also, clean the slide contact surfaces on the main frame.
2. Lubricate the inside of the outrigger beam box and the outside of the outrigger inner box assembly with STP Oil Treatment, LUBAID NF, or bronze anti-seize compound.
3. Position the vertical outrigger cylinder (13) in the outrigger inner box assembly (7). Align the rod end with the mounting hole and install pin (9) and retaining rings (8).
4. Align the inner box assembly and vertical outrigger cylinder and insert the assembly into the outrigger beam (6). Align cylinder mounting holes and install pin (12) and retaining rings (8).
5. Install counterbalance valve (14) into vertical outrigger cylinder (13). Install the elbows into the ports of the vertical outrigger cylinder.
6. Connect the outrigger hoses to the elbows on the vertical outrigger cylinder.

Installation

1. Lubricate the slide blocks inside the main frame with STP Oil Treatment, LUBAID NF, or bronze anti-seize compound.
2. Insert the outrigger assembly into the main frame far enough to hold it in position.
3. Connect the hoses to the bulkhead fittings on the inside of the main frame. Make sure the hoses are routed in the top center of the outrigger beam and will not be damaged when the outrigger is retracted.
4. Install the access cover and then connect the two hoses to the bulkhead fittings on the outside of the frame.
5. Extend the rod of the outrigger horizontal cylinder and align the mounting holes. Install pin (11, Figure 11-146) and retaining rings (10).
6. Apply a thin layer of STP Oil Treatment, LUBAID NF, or bronze anti-seize compound to the slide block contact surfaces on the outrigger beam.
7. Operate the outrigger and check for correct installation. Stop the engine and check for leakage at the hose connections.

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, Figure 11-148) from harness.
2. Remove switch mounting bracket (2).
3. Remove jam nuts (3) and thread switch (4) out of the mounting bracket.

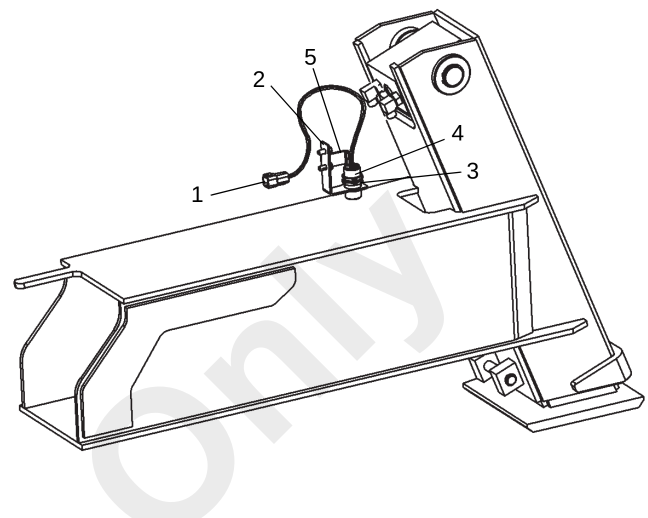


FIGURE 11-148

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 (5) of mounting bracket and LED is pointed away from the bracket.
5. Tighten jam nuts against mounting bracket.
6. Adjust bracket and/or switch to have 3 to 10 mm (.12 to.38 in) gap between end of switch and outrigger beam.
7. Connect switch cable to wire harness.

SECTION 12
SCHEMATICS/WIRING DIAGRAMS

For your convenience, the latest version of schematics available at the time of printing are placed in this section.

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ALPHABETICAL INDEX