GROVE

SERVICE MANUAL

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

5540F/YB5515

Crane Model Number

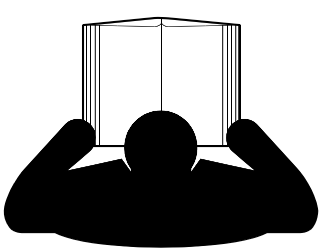
Crane Serial Number

This Manual is Divided into the following Sections:

NOTICE

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

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



DANGER

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

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

Control# 198-04 Published 10-21-2011

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.

1

SECTION 1
INTRODUCTION

TABLE OF CONTENTS

THIS PAGE BLANK

1

SECTION 1
INTRODUCTION

This manual contains information on maintenance, service and repair of the Models 5540F & YB5515 cranes. Major components and systems are included, except service on the engine. This information will be found in the engine manufacturer's service manual.

DIRECTIONAL REFERENCE

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

IDENTIFICATION PLATES

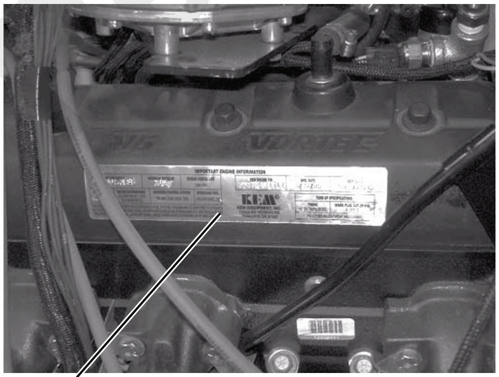
When assistance is required for parts and service, be sure to include the model number and serial number of the crane in the correspondence. Location of serial number plates are shown below.

p0993

Crane S/N Location

FIGURE 1-1

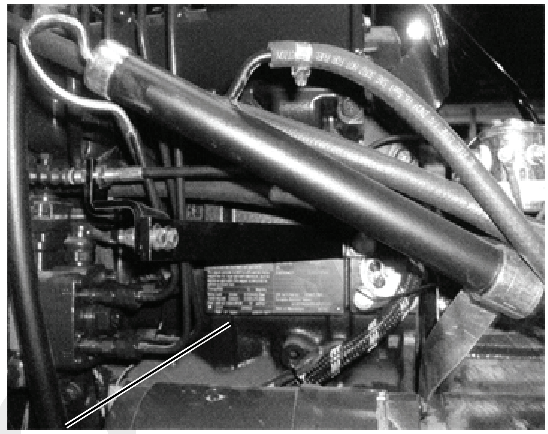
p3077



Gasoline Engine S/N Location

FIGURE 1-2

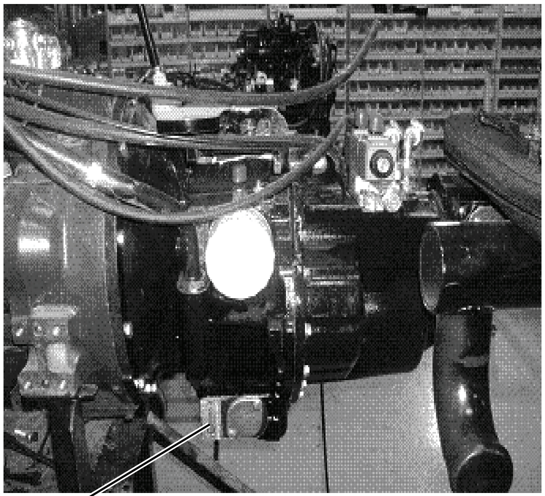
p1878



Diesel Engine S/N Location

FIGURE 1-3

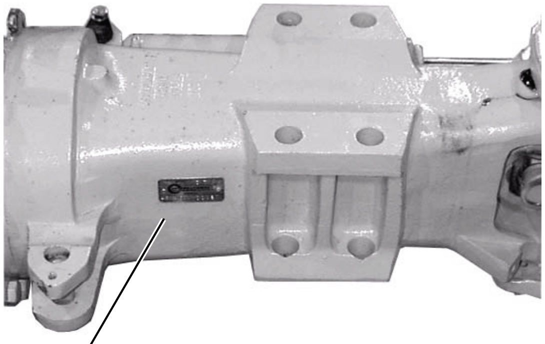
p0076



Transmission S/N Location

FIGURE 1-4

p0074



Front Drive/Steer Axle

FIGURE 1-5

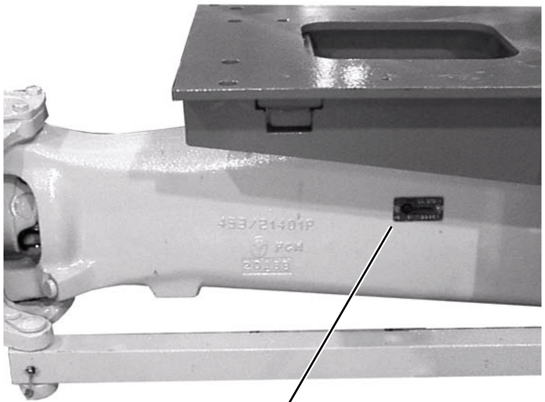


FIGURE 1-6

SPECIFICATIONS

ENGINE

Diesel Engine

Make and Model	Cummins 4B3T.3 – 85 diesel, Tier II
Type of Aspiration	Turbocharged
Horsepower	85 hp @ 2500 rpm
Low Engine Idle Speed	800 rpm
Maximum Engine Speed	2600 rpm

Gasoline/L.P.G. Engine

Make and Model	GM4.3L EFI V6, ZEPA & CARB 2004
Horsepower	110 hp @ 2500 rpm
Low Idle Speed	700 rpm
Maximum Engine Speed	2600 rpm

BOOM

Construction	Telescopic, welded box sections
Number of Sections	Three or Four
Reach	
Three Section	18 ft. 6 in. to 41 ft. (5.65 m to 12.5 m)
Four Section	18 ft. 6 in. to 52 ft. 3 in. (5.65 m to 15.03 m)

MAST ROTATION - 360°

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

ELECTRICAL

Type	12 volts, direct current
Alternator	63 amps
Battery (Two with cold weather start)	90 amp/hr each

FUEL TANK

Capacity	18.5 gal. (70 L)

HYDRAULIC SYSTEM

Primary Pump	4 Section, gear pump
	Main Control ValvesFour-way, open center, pilot operated
Swing Motor	Single section, gerotor-type
Winch 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, crowd, steering and outriggers
Hydraulic Tank	40 gal. (151.4 L) capacity, steel construction with internal baffles

WIRE ROPE

Wire Rope (Main Winch):

Diameter	1/2 in. (13 mm)
Type	6 x 19 EIPS-IWRC
Length	
(Three Section Boom)	240 ft. (73.0 m)
(Four Section Boom)	290 ft. (88.4 m)

Wire Rope (Optional Below Deck Winch):

Diameter	1/4 in. (6 mm)
Length	100 ft (30.5 m)

TORQUE CONVERTER

Model	Borg and Beck S-11
Type	Hydraulic

FRONT AXLE DRIVE

Type	International Transmissions Limited
Model	SD80 - Center Drive Head

REAR AXLE DRIVE

Type	International Transmissions Limited
Model	SD80 - Offset Drive Head

REAR AXLE NON-DRIVE

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

OUTRIGGERS

Type	Hydraulic
Construction	Welded box

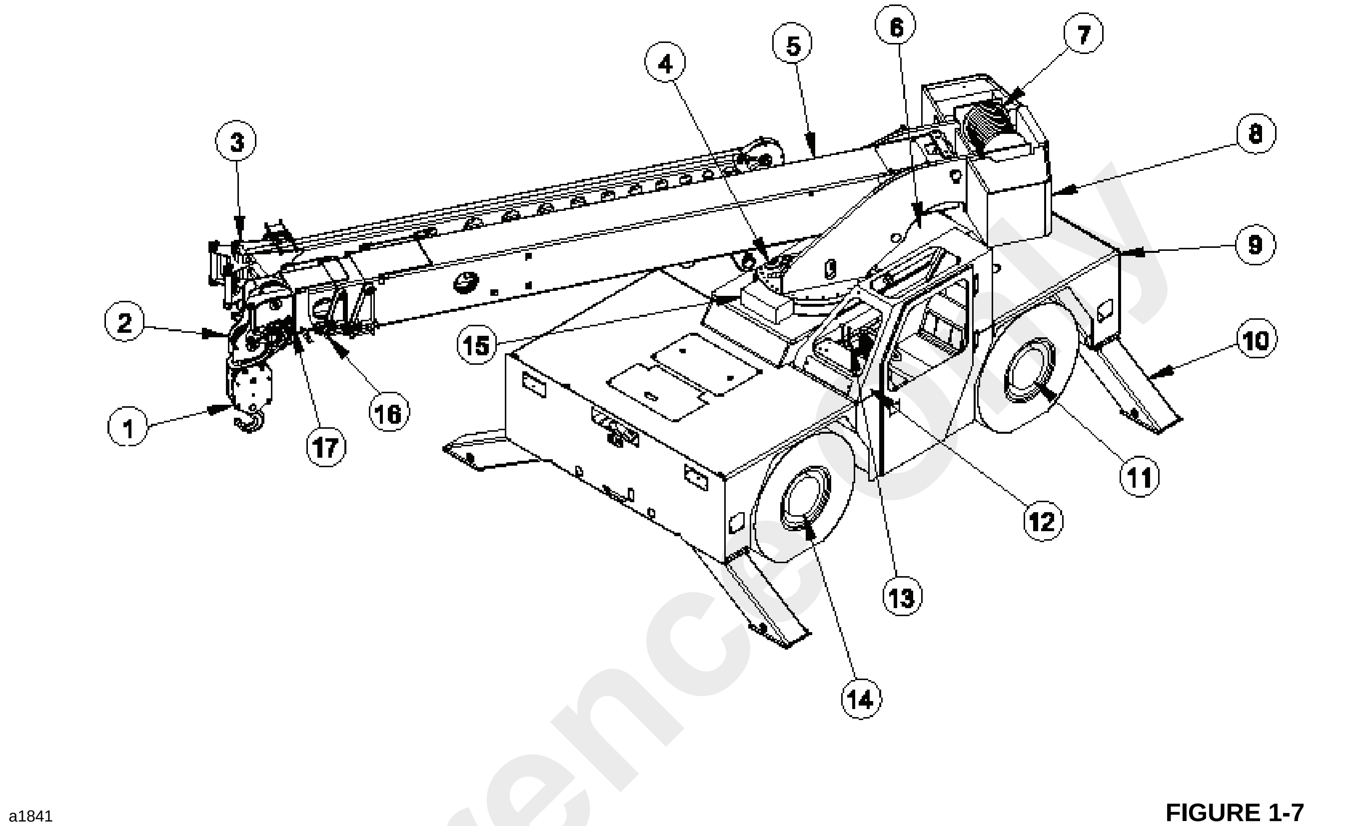


FIGURE 1-7

Item	Description	Item	Description
1	Drop Block	10	Outrigger (4)
2	3rd Boom Section (3 Section Boom) 4th Boom Section (4 Section Boom)	11	Rear Drive Axle (Steerable & Non-Steerable)
3	Optional Boom Extension	12	Enclosed Operator’s Cab (Shown) Optional Cab Guard (Not Shown)
4	Lift Cylinder	13	Main Control Valve Location
5	1st Boom Section	14	Front Steering Drive Axle
6	Engine Compartment	15	Swing Motor and Gearbox Location
7	Main Hoist Assembly	16	2nd Boom Section
8	Mast Assembly	17	3rd Section Boom
9	Main Frame Assembly		

GENERAL MAINTENANCE

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

NOTE: Your safety and that of others is always the number one consideration when working around machines. Safety is a matter of thoroughly understanding the job to be done and the application of good common sense. It is not just a matter of do’s and don’ts. Stay clear of all moving parts.

1. Determine the problem.
2. List possible causes.
3. Devise checks.
4. Conduct checks in a logical order to determine the cause.
5. Consider the remaining service life of components against the cost of parts and labor necessary to replace them.
6. Make the necessary repair.
7. Recheck to ensure that nothing has been overlooked.
8. Functionally test the failed part in its system.

Cleanliness

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

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

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

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

After Cleaning

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

CAUTION

Eye Injury Hazard!

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

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

Removal and Installation

When performing maintenance, do not attempt to manually lift heavy parts when hoisting equipment should be used. Never locate or leave heavy parts in an unstable position. When raising a crane or portion thereof, ensure the crane is blocked securely and the weight is supported by blocks or jack stands rather than by lifting equipment.

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

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

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

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

Disassembly and Assembly

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

Pressing Parts

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

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

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

Locking Devices

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

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

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

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

Wires and Cables

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

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

Shims

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

Hoses and Tubes

⚠ DANGER

High Pressure/Temperature Hazard!

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

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

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

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

Inspection

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

Tighten all connections to recommended torque.

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

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

Replace hoses if any of the following is evident Figure 1-8:

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

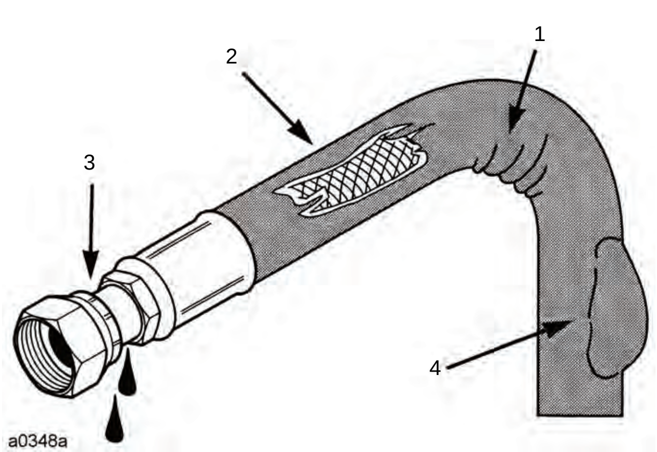


FIGURE 1-8

Installation

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

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

Bearings

Antifriction Bearings

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

Double Row, Tapered Roller

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

Heating Bearings

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

Installation

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

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

Preload

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

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

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

Sleeve Bearings

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

Gaskets

Be sure the holes in the gaskets correspond with the passages in the mating parts. If it is necessary to make gaskets, select material of the proper type and thickness. Be sure to cut holes in the right places. Blank gaskets can cause serious damage.

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

Batteries

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

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

Hydraulic Systems

⚠ DANGER

High Pressure/Temperature Hazard!

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

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

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

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

Cleanliness

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

Keep the System Clean

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

Sealing Elements

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

Hydraulic Lines

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

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

Visual Inspection of Hoses and Fittings

1. Visually inspect hoses and fittings once a month or every 250 hours for the following:

- Leaks at hose fitting or in hose
- Damaged, cut, or abraded cover
- Exposed reinforcement
- Kinked, crushed, flattened, or twisted hose
- Hard, stiff, heat cracked, or charred hose
- Blistered, soft, degraded, or loose cover
- Cracked, damaged, or badly corroded fittings
- Fitting slippage on hose
- Other signs of significant deterioration

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

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

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

If any of these conditions exist, address them appropriately.

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

Table 1-1

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

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

Electrical System

Harnesses, Wires, and Connectors

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

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

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

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

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

Fatigue of Welded Structures

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

Equipment should be periodically inspected for evidence of weld fatigue. The frequency of these inspections should increase with the age of the equipment and the severity of the application.The following are known high stress areas applicable to Grove 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 crossmembers; at the junction of front and rear frame members on truck cranes.
- Turntable bearing connection—where bearing is welded to the crane superstructure or chassis.
- Counterweight support structures.
- Chassis axle and suspension mounting structures.
- Hydraulic cylinder end connections.

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

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

Loctite

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

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

Application of Medium Strength Loctite

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

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

Primer Application

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

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

Adhesive/Sealant Application

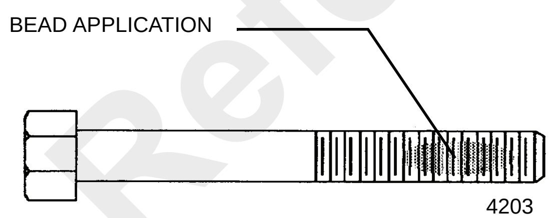


FIGURE 1-9

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 1-9).
2. In a blind hole application, a bead of several drops of adhesive should be applied into the bottom of the hole to be hydraulically forced up during engagement.
3. After application and engagement of mated threads, fixturing will occur within five (5) minutes if primed prior to engagement. Fixturing may take up to 30 minutes on unprimed parts.
4. Time required to achieve full strength is 24 hours. Maximum ultimate strength is achieved using no primer with this specific threadlocking adhesive.

Fasteners and Torque Values

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

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

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

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

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

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

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

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

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

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

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

Torque Wrenches

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

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

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

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

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

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

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

Torque Values

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

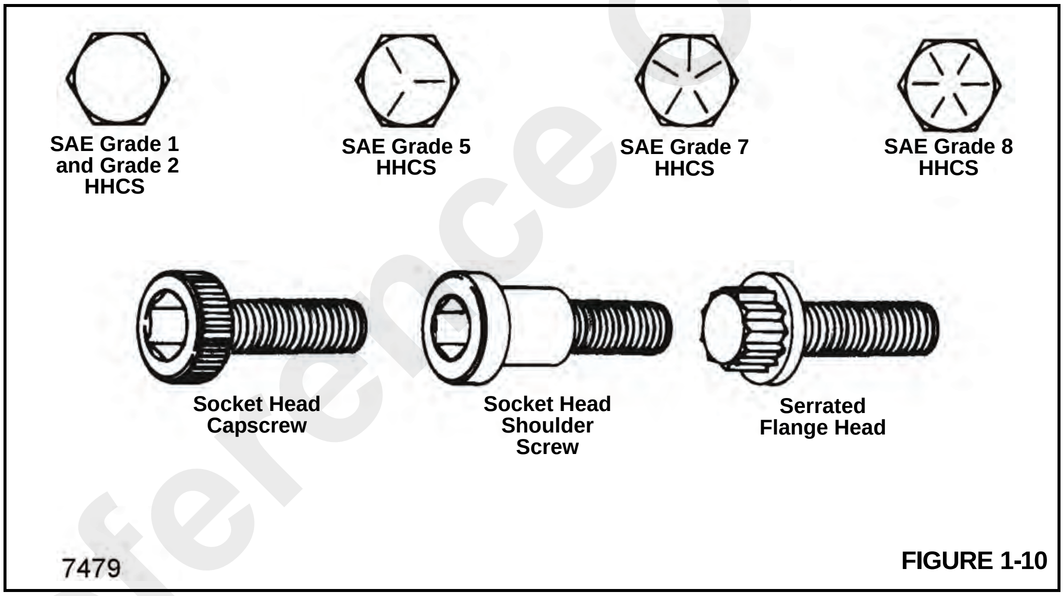


FIGURE 1-10

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

Bolt Diameter - Inches

Torque Values (Pounds-Foot, Maximum/Minimum)

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

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

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

Bolt Diameter - Inches

Torque Values (Pounds-Foot, Maximum/Minimum)

	SAE Grade	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2
Zinc-Flake	**5**	8	15	28	44	66	95	132	229	364	543	785	944	1654
	8	11	22	39	61	94	134	186	323	514	766	1109	1530	2682
Untreated	**5**	10 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)

Grade	M4 0.157	M5 0.197	M6 0.236	M8 0.315	M10 0.394	M12 0.472	M14 0.551	M16 0.630	M18 0.709	M20 0.787	M22 0.866	M24 0.945	M27 1.06	M30 1.18	M33 1.18	M36 1.18
8.8	2.6	5.2	9.0	21.6	42.4	73.1	116	178	250	349	467	600	877	1195	1608	2072
10.9	3.7	7.5	12.5	31.5	62.0	110	170	265	365	520	700	900	1325	1800	2450	3150
12.9	4.3	9.0	15.0	36.0	75.0	128	205	315	435	615	830	1060	1550	2125	2850	3700

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

Bolt Diameter - Metric

Torque Values (Nm, Maximum/Minimum)

Grade	M4 0.157	M5 0.197	M6 0.236	M7 0.276	M8 0.315	M10 0.394	M12 0.472	M14 0.551	M16 0.630	M18 0.709	M20 0.787	M22 0.866	M24 0.945	M27 1.06	M30 1.18
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)

Grade	M8x1 0.157	M10x1 0.197	M10x1.25 0.236	M12x1.5 0.315	M14x1.5 0.394	M16x1.5 0.472	M18x1.5 0.551	M20x1.5 0.630	M22x1.5 0.709	M24x2 0.787	M27x2 0.866	M30x2 0.945	M33x2 1.06	M36x3 1.18
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

Grade	**Bolt Diameter - Metric** **Torque Values** (Nm, Maximum/Minimum)													
	M8x1 0.157	**M10x1 0.197**	**M10x1.25 0.236**	**M12x1.5 0.315**	**M14x1.5 0.394**	**M16x1.5 0.472**	**M18x1.5 0.551**	**M20x1.5 0.630**	**M22x1.5 0.709**	**M24x2 0.787**	**M27x2 0.866**	**M30x2 0.945**	**M33x2 1.06**	**M36x3 1.18**
8.8	29	57	57	100	160	248	345	483	657	836	1225	1661	—	—
	27	53	53	92	147	229	318	446	607	771	1130	1534	—	—
10.9	41	81	81	1140	229	348	491	679	924	1176	1718	2336	—	—
	38	75	75	130	211	322	451	627	853	1085	1587	2157	—	—
12.9	49	96	96	168	268	418	575	816	1111	1410	2063	2800	—	—
	45	90	90	156	246	386	529	754	1025	1302	1904	2590	—	—

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

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

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

WELD STUDS (TABLE 1-10)

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

Table 1-10
Weld Stud Torque Values

T-2-4

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

Hydraulic Fitting

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

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

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

Follow these steps when tightening all fitting connections:

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

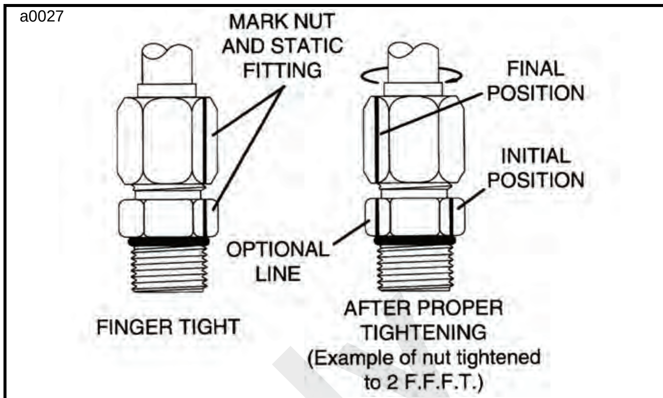


FIGURE 1-11

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

37° Flared Steel Fitting - Tube or Hose to Fitting

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

Table 1-11

T-2-5

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

Adjustable Straight

Table 1-12
Adjustable Straight Thread O-ring

T-2-6

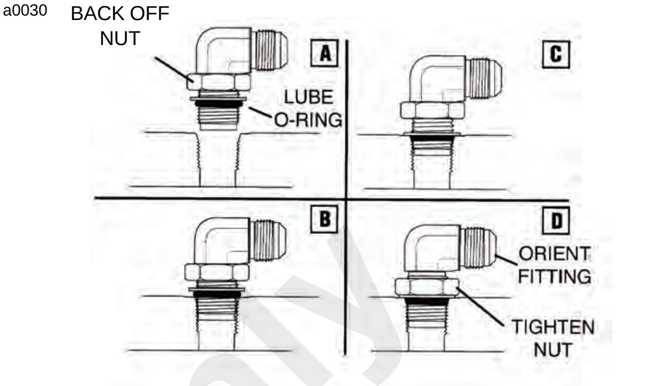
ADJUSTABLE STEEL STR. THREAD O-RING FITTINGS	
SAE SIZE	(F.F.F.T.)
2	1.0 ± 0.25
3	1.0 ± 0.25
4	1.5 ± 0.25
5	1.0 ± 0.25
6	1.5 ± 0.25
8	1.5 ± 0.25
10	1.5 ± 0.25
12	1.5 ± 0.25
14	1.5 ± 0.25
16	1.5 ± 0.25
20	2.0 ± 0.25
24	2.0 ± 0.25
32	2.0 ± 0.25

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

1. Inspect both mating parts for burrs, nicks, scratches, or foreign particles.
2. Lubricate O-ring with a light coat of clean oil (Figure 1-12A).
3. Back off locknut as far as possible (Figure 1-12A).
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 1-12B).
5. To orientate the fitting, unscrew the fitting the required amount, but not more than one full turn (Figure 1-12C).
6. Hold the fitting in the desired position and tighten the nut (Figure 1-12D) following the F.F.F.T. method, See F.F.F.T. METHOD (Flats from Finger Tight) starting with step 4.

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

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

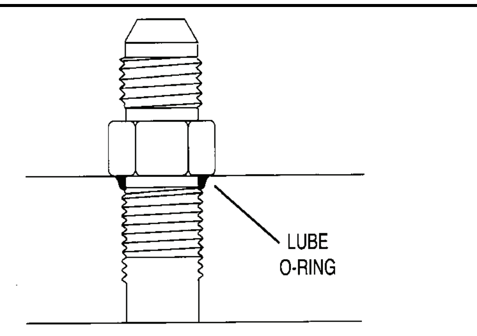


Adjustable Fitting to Port **FIGURE 1-12**

Table 1-13

T-2-7

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



Non-Adjustable Fitting to Port **FIGURE 1-13**

WIRE ROPE

General

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

Environmental Conditions

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

Dynamic Shock Loads

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

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

Lubrication

A wire rope cannot be lubricated sufficiently during manufacture to last it's entire life. Therefore, new lubricant must be added throughout the life of a rope to replace factory lubricant which is used or lost. It is important that lubricant applied as part of a maintenance program shall be compatible with the original lubricant, and to this end, the rope manufacturer should be consulted. Lubricant applied shall be of the type which does not hinder visual inspection. Those sections of rope which are located over sheaves or otherwise hidden during inspection and maintenance procedures require special attention when lubricating rope. The object of rope lubrication is to reduce internal friction and to prevent corrosion.

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

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

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

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

Precautions and Recommendations During Inspection or Replacement

1. Always lock out equipment power when removing or installing wire rope assemblies.
2. Always use safety glasses for eye protection.
3. Wear protective clothing, gloves, and safety shoes as appropriate.
4. Use supports and clamps to prevent uncontrolled movement of wire rope, parts, and equipment.

5. When replacing fixed length cable assemblies (e.g. pendants) having permanently attached end fittings use only pre-assembled lengths of wire rope as supplied from Manitowoc. Do not build lengths from individual components.
6. Replace an entire wire rope assembly. Do not attempt to rework damaged wire rope or wire rope ends.
7. Never electroplate wire rope assemblies.
8. Do not weld any wire rope assembly or component unless welding is recommended by the wire rope manufacturer. Welding spatter shall never be allowed to come in contact with the wire rope or wire rope ends. In addition, be sure that the wire rope is not an electrical path during other welding operations.
9. Wire ropes are manufactured from special steels. If heating a wire rope assembly is absolutely necessary for removal, the entire wire rope assembly shall be discarded.
10. On systems equipped with two or more wire rope assemblies operating as a matched set, they shall be replaced as an entire set.
11. Do not paint or coat wire ropes with any substance except approved lubricants.
12. Measure the rope's diameter across crowns (1) of the strands when determining if rope has become damaged (Figure 1-14).

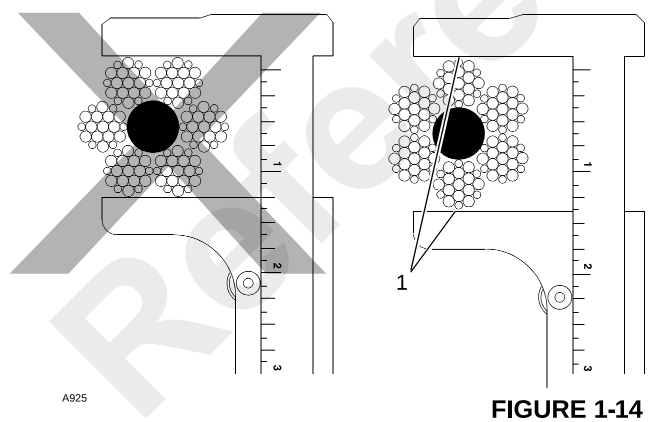


FIGURE 1-14

13. When checking for broken wires (5) Figure 1-15 relax the rope, move it off "pick-up points", and flex it as much as possible. Use a sharp awl to pick and probe between wires and strands, lifting any wire which appears loose or moves excessively. Defect in the rope is in relation to "Lay Length" (2) which is the distance measured along rope in which one strand (3) makes one complete revolution around the core (4).

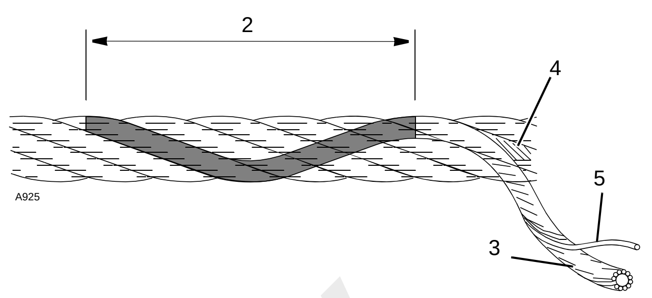


FIGURE 1-15

Wire Rope Inspection (Running Ropes and Pendant Cables)

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

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

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

Keeping Records

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

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

Frequent Inspection

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

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

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

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

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

Periodic Inspection

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

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

Wire Rope Inspection (Boom Extension and Retraction Cables)

Periodic Inspection

It is recommended that a periodic inspection of all boom extension and retraction cables be performed using the following guidelines. This inspection shall cover the entire length of the extension and retraction cables. This inspection should be used to monitor progressive degradation and to discover severe damages necessitating wire rope replacement or equipment repair. Inspection criteria are as follows:

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

Wire Rope Inspection/Replacement (All Wire Rope)

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

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

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

- Wear of one-third the original diameter of outside individual wires. Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than:
  - 1/64 inch for diameters up to and including 5/16 inch.
  - 1/32 inch for diameters 3/8 and 1/2 inch inclusive.
  - 3/64 inch for diameters 9/16 to 3/4 inch inclusive.
  - 1/16 inch for diameters 7/8 to 1 1/8 inches inclusive.
  - 3/32 inch for diameters 1/14 to 1 1/2 inches inclusive.
- In running rope, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
- In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.
- In rotation resistant rope, two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
- Severe corrosion as evidenced by pitting.
- Manitowoc recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
- Manitowoc recommends for cable extended booms, that boom extension cables be replaced every seven (7) years.

Seizing Wire Rope

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

The two preferred methods for seizing wire ropes are:

Method 1

Using a length of soft annealed wire Figure 1-16, place one end in the groove between two strands of the wire rope. Turn the long end of the annealed wire at right angles to the wire and wrap it tightly over the portion in the groove.

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

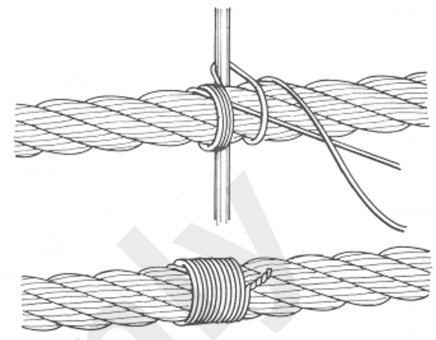


FIGURE 1-16

Method 2

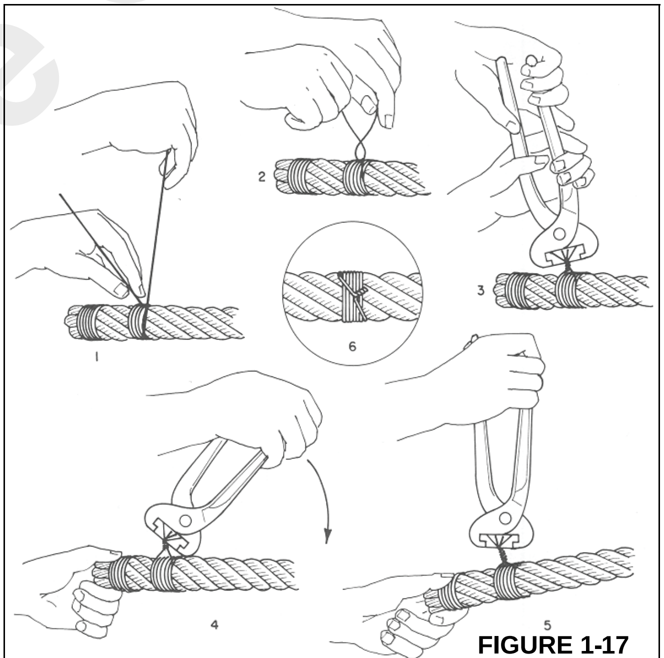


FIGURE 1-17

Wind a length of soft annealed wire Figure 1-17 around the wire rope at least seven times. The two ends should be twisted together in the center of the seizing. Tighten the seizing by alternately prying and twisting. Cut off both ends of the wire and pound the twist flat against the rope.

NOTE: Non-preformed wire rope (1) Figure 1-18 should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).

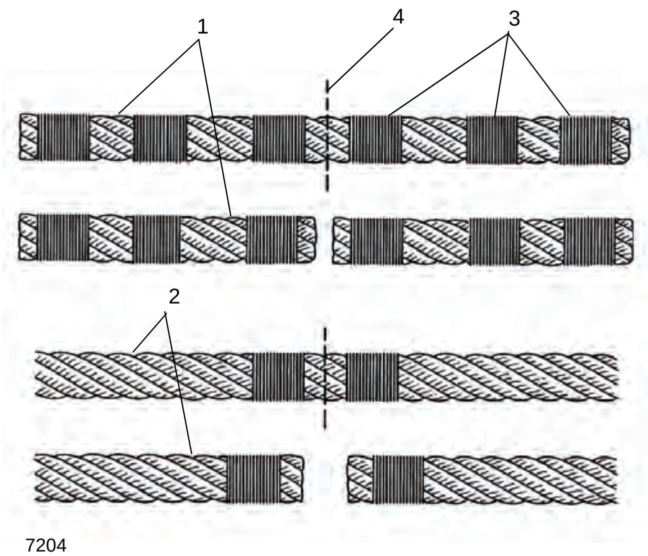


FIGURE 1-18

Installing Flex-X 35 Wire Rope

CAUTION

Any cutting of this specific wire rope is not recommended. If FLEX-X 35 wire rope must be cut for any reason, it is necessary to follow the following instructions. Also, unlike other types of wire rope, the ends on this wire rope must be welded.

1. Unload properly and relieve any twists. Pull the rope off the shipping reel or unroll it from a shipping coil. (If done improperly, you may kink the rope, which will result in permanent damage to the rope.) Then, lay the rope on the ground in direct line with the boom. This helps release any twist in the rope.
2. Pull the rope over the point sheave and attach the end to the hoist drum. Be sure not to remove the welded end.
3. Wind rope onto drum slowly and carefully. At this point, it isn't necessary to provide additional load other than the weight of the rope being pulled across the ground.
4. Spool first layer tightly. It is essential on smooth-faced drums that the first layer is spooled with wraps tight and close together since the first layer forms the foundation for succeeding layers. If need be, use a rubber, lead or brass mallet (but never a steel hammer) to tap the rope into place.
5. Spool multiple layers with sufficient tension. It's very important to apply a tensioning load to the ropes during the rope breaking-in process. (If not, the lower layers may be loose enough that the upper layers become wedged into the lower layers under load, which can seriously damage the rope.) The tensioning load should range from 1 to 2% of the rope's minimum breaking force.
6. For ropes in multi-part systems: Reeve the traveling block and boom tip sheaves so the rope spacing is maximized and the traveling (hook) block hangs straight and level to help assure block stability.
7. Breaking in new Flex-X 35—After installation, properly break in the rope, which allows the rope's component parts to adjust themselves to the operating conditions:

   With the boom fully raised and fully extended, attach a light load at the hook and raise it a few inches off the ground. Allow to stand for several minutes. Then cycle the load between the full "up" and "down" positions several times. Observe the drum winding and rope travel for any potential problems.

   After making the lifts with a light load, increase the load and cycle it up and down a few times. This procedure will train the rope and help assure smooth operation during its useful life.

   Ideally, you should run these loads with reeving that lets you place the loads on the block with all rope off the drum except the last three wraps. If this is not possible, alternate methods must be used to assure proper tensioning of the rope on the drum.

Procedures for Cutting and Preparing Flex-X 35

Flex-X 35 is a special wire rope that must be handled differently than any other rope manufactured. One characteristic that makes this rope special is that the outer strands are not preformed. It is because of this that the following procedures for cutting and preparing Flex-X 35 must be followed:

1. The welded ends prepared by the manufacturer are not to be removed.
2. Before cutting the rope, make three separate bands with seizing strand on each side of where the cut is to be made (total of six bands for each cut). Each band is to have a minimum length of one and one half times the rope diameter. The two bands closest to the cut should be located at a distance equal to one rope diameter away from the cut. The four remaining bands should be evenly spaced at a distance equal to three rope diameters.
   a. If a welder is available, the cut should be made with an abrasive saw. Immediately after the cut, both ends of the rope are to be cap welded so that all inner and outer strands are welded together, preventing any movement between them.

NOTE: The outer strands must not be able to move with respect to the inner strands. The weld must not exceed the diameter of the rope.

b. If a welder is not available, the cut is to be made with an acetylene torch. The cut is to be made in such a way that both ends of the rope are completely fused so that all inner and outer strands are bonded together, preventing any movement between strands.

NOTE: The outer strands must not be allowed to move with respect to the inner strands. The fused end must not exceed the diameter of the rope.

3. Once the cuts have been completed, the seizing bands are to be left in place.

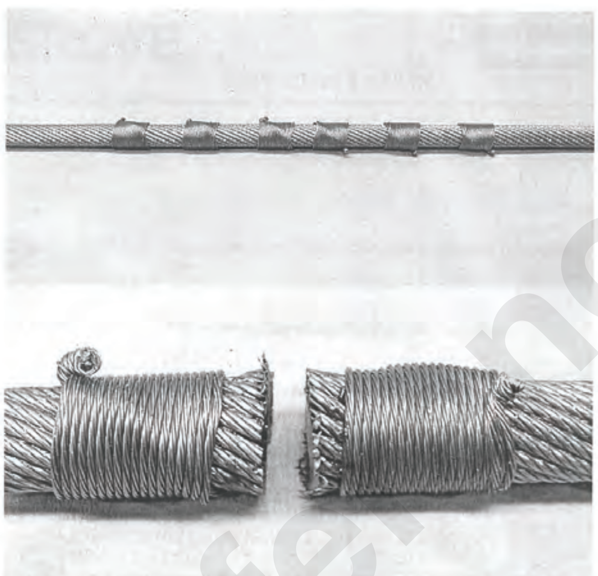


FIGURE 1-19

O-RING, SEAL AND ELASTIC NUT REPLACEMENT

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

HYDRAULIC PRESSURE TESTING

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

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

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

THIS PAGE BLANK

Published 10-21-2010, Control# 198-04

SECTION 2
SAFETY PRACTICES

TABLE OF CONTENTS

2

THIS PAGE BLANK

SECTION 2
SAFETY PRACTICES

INTRODUCTION

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

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

SIGNAL WORDS

This 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.

IMPORTANT

The information in this manual does not replace any safety rules and laws used in your area. Before operating the crane, learn the rules and laws for your area. Make sure the 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.

Personal Considerations

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

Equipment Considerations

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

General Considerations

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

Operational Considerations

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

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

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

TABLE OF CONTENTS

3

THIS PAGE BLANK

SECTION 3
ELECTRIC SYSTEM

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 (two with diesel engine cold start) 12 volt battery.

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

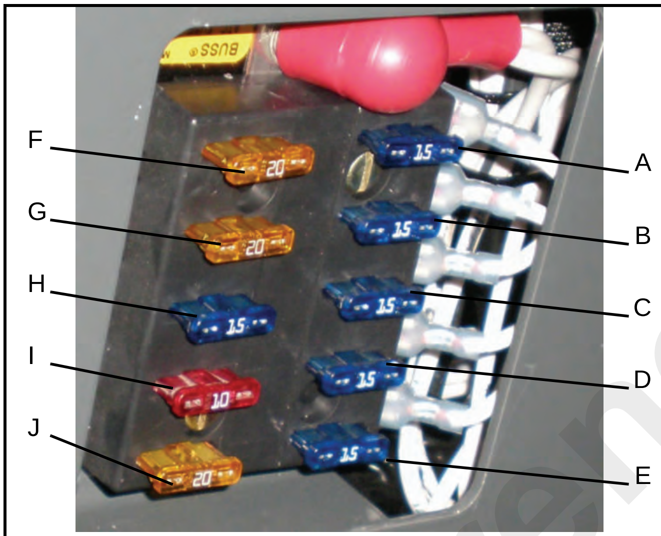
Wire Harnesses

Four wire harnesses connect the electrical system components:

- Dash Wire Harness
- Main Frame Wire Harness
- Engine Wire Harness (Diesel)
- Engine Wire Harness (Gasoline/Dual Fuel)

Fuses

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



7227 **FIGURE 3-1**

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

Table 3-2
Fuse Ratings

FUSE	RATING	FUNCTION CIRCUIT
A	15 amp	Heater/Defroster, Strobe Light, Gauges
B	15 amp	Windshield Wiper
C	15 amp	Horn, Parking Brake, Cold Start
D	15 amp	Winch Control, 4 Wheel Steer
E	15 amp	Brake Lights, fuel shut-off (diesel engine) or spark ignition coil (gasoline engine), alternator
F	20 amp	Anti-Two Blocking, LM2
G	20 amp	Warning Lights, Turn Signal Lights, and Flasher, Auto Lockout
H	15 amp	Park Brakes
I	10 amp	Steering Circuit
J	20 amp	Head and Tail Lights, Dash Lights, Boom Lights

CHARGING SYSTEM

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

Alternator and Voltage Regulator

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

Batteries

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

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

Voltmeter

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

Pressure Switch

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

Special Precautions

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

Battery Maintenance and Charging

Battery

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

Charging the Battery

WARNING

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

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

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

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

NOTE: *When two batteries are used, as in the case when diesel engine cold start is installed, keep both batteries fully charged. Charging one of the* *batteries and leaving the other at low charge can cause damage to the fully charged battery. A weak battery in the system puts an overload on the electrical system.*

STARTING CIRCUIT

The starting circuit for a **diesel engine** includes the battery, starter motor and solenoid, auxiliary start solenoid, starter relay, park brake switch, and the ignition switch.

The starting circuit for a **gasoline or dual fuel engine** includes the battery, starter motor and solenoid, engine ICU park brake switch, and ignition switch.

General Inspections

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

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

Starting Circuit Check

NOTE: *If the starter will not 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 parking brake is engaged. Personal injury is possible.

---

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

Gasoline or Dual Fuel Engines

1. Place the ignition switch in the OFF position and place the travel select lever in neutral.
2. Refer to 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 was indicated, go to step 4.

4. Turn the ignition switch to the START position and check voltage at the start terminal. If no voltage, replace the switch. Go to step 5 if voltage is indicated.

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 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. If voltage is indicated at the relay wire 21A, go to step 6.

6. 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 neutral start 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 3-3
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

The gauges are 12 volt components. Power is available to the gauges through a 15 amp fuse when the ignition switch is in the ON position.

Fuel Gauge

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

Engine Oil Pressure Gauge

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

Engine Temperature Gauge

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

Voltmeter

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

Normally, when the engine is stopped (ignition switch in the ON position) or when the engine is running at low idle, the voltmeter will indicate 11-14 volts. When the engine is running above low idle, the voltmeter will normally indicate 14-16 volts. More than 16 volts indicates an overcharging condition Table 3-4.

Hour Meter

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

Table 3-4: Voltage Level Conditions

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

WIRE HARNESSES

Engine Wire Harness

The engine wire harnesses Figure 3-2 and Figure 3-3 supply electrical current from the battery to the charging circuit, starting circuit, and senders attached to the engine. It also supplies the current to the main frame wire harness.

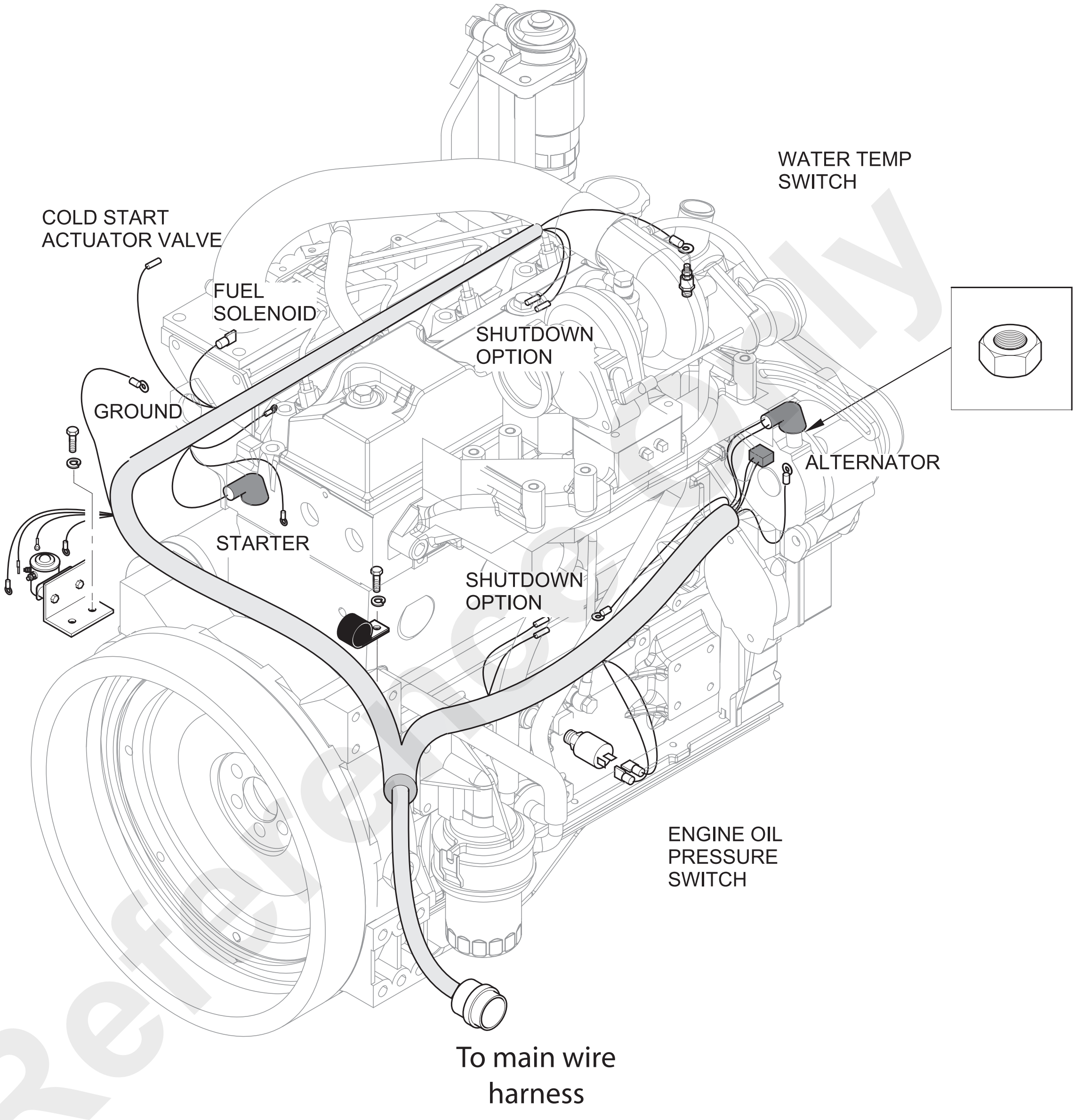
Main Frame Wire Harness

The main frame wire harness Figure 3-4 supplies electrical current to operate the electrical components attached to the main frame. It also connects to the instrument panel and engine wire harnesses.

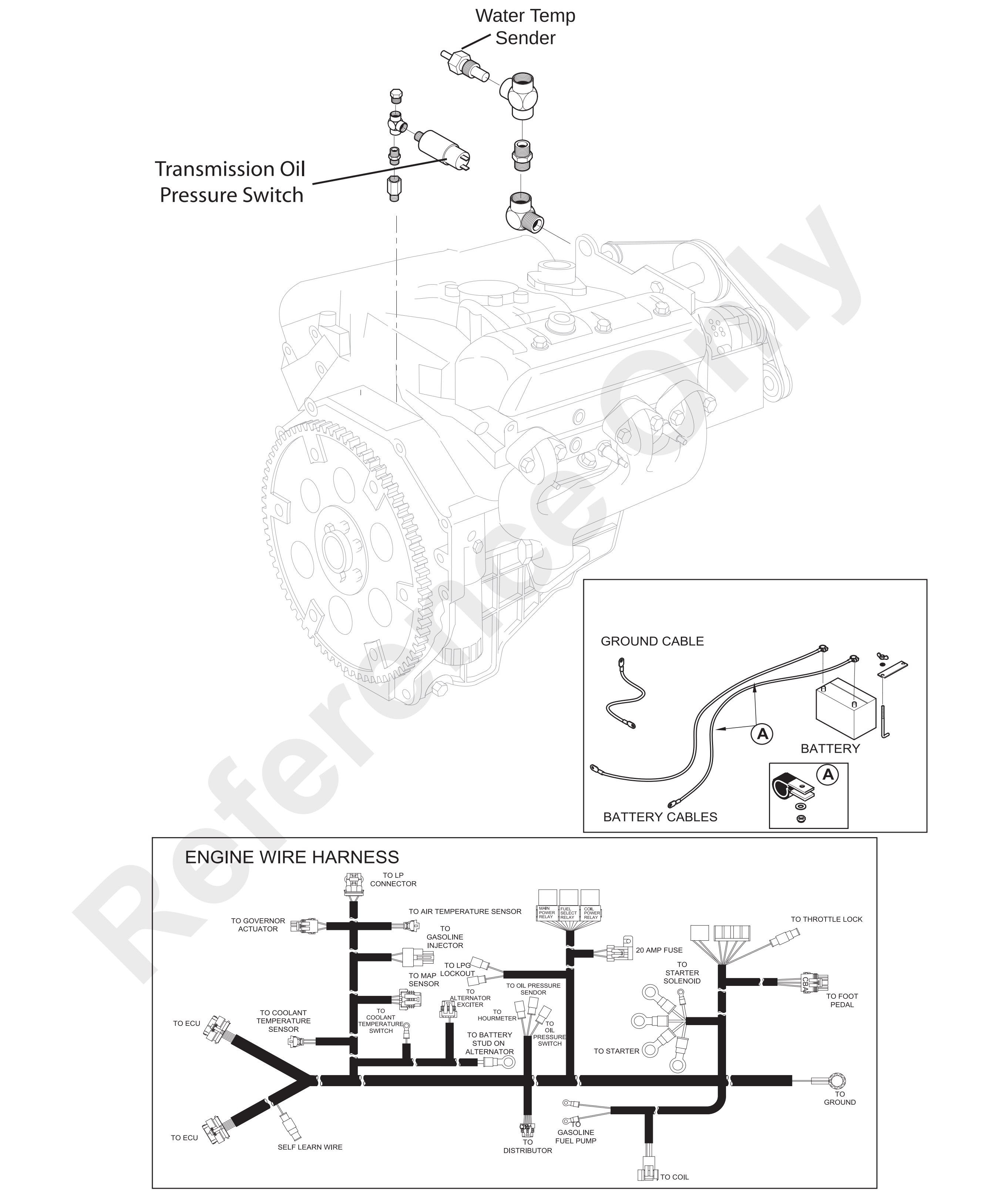
Instrument Panel Wire Harness

The instrument panel wire harness Figure 3-5 supplies electrical current to the gauges, lights and switches in the instrument panel. It connects to the main frame wire harness.

NOTE: *For wire harness wiring diagrams, see Schematics/ Wiring Diagrams.*



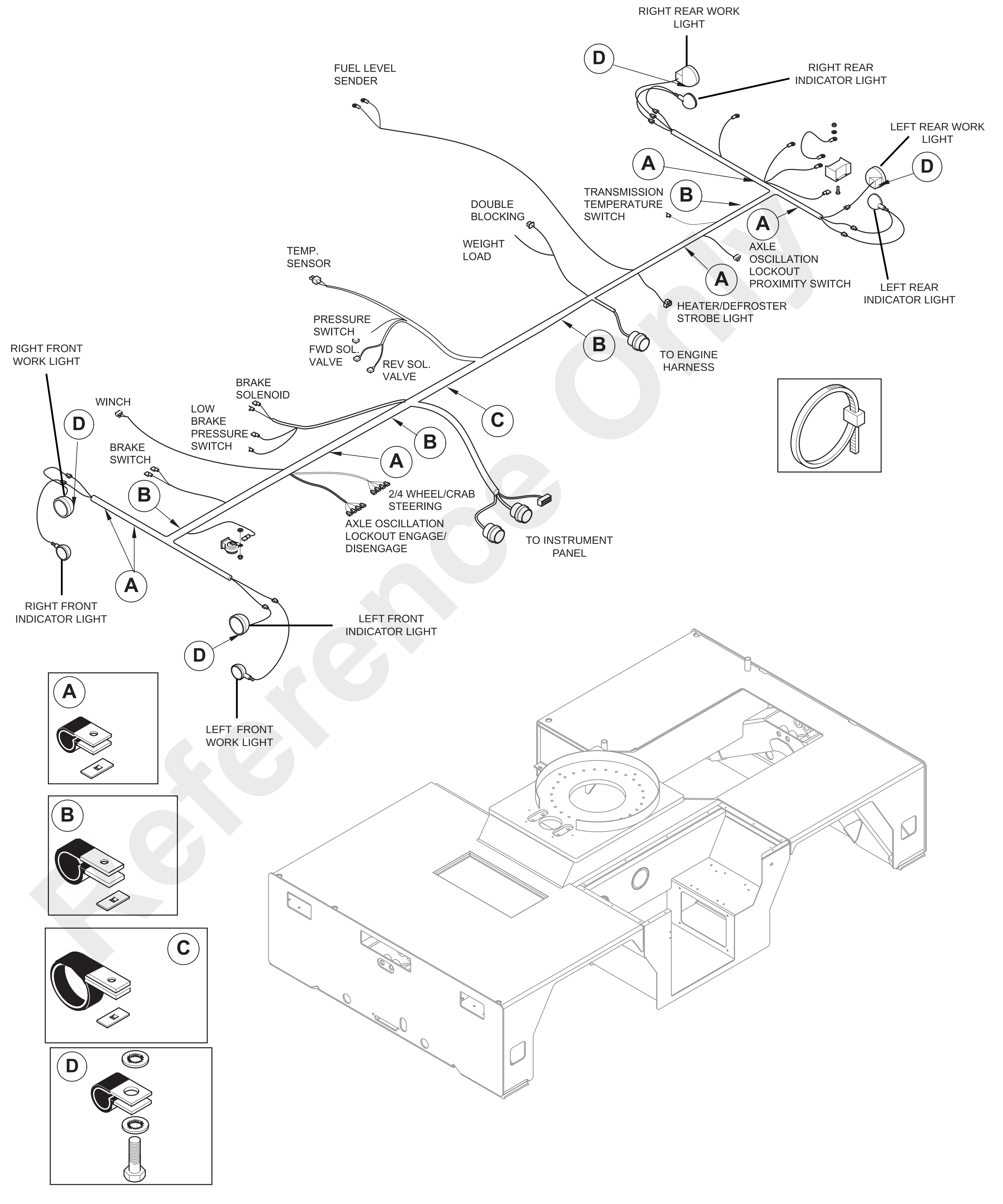
a1634 Engine Wire Harness - Diesel Engine **FIGURE 3-2**



a1633

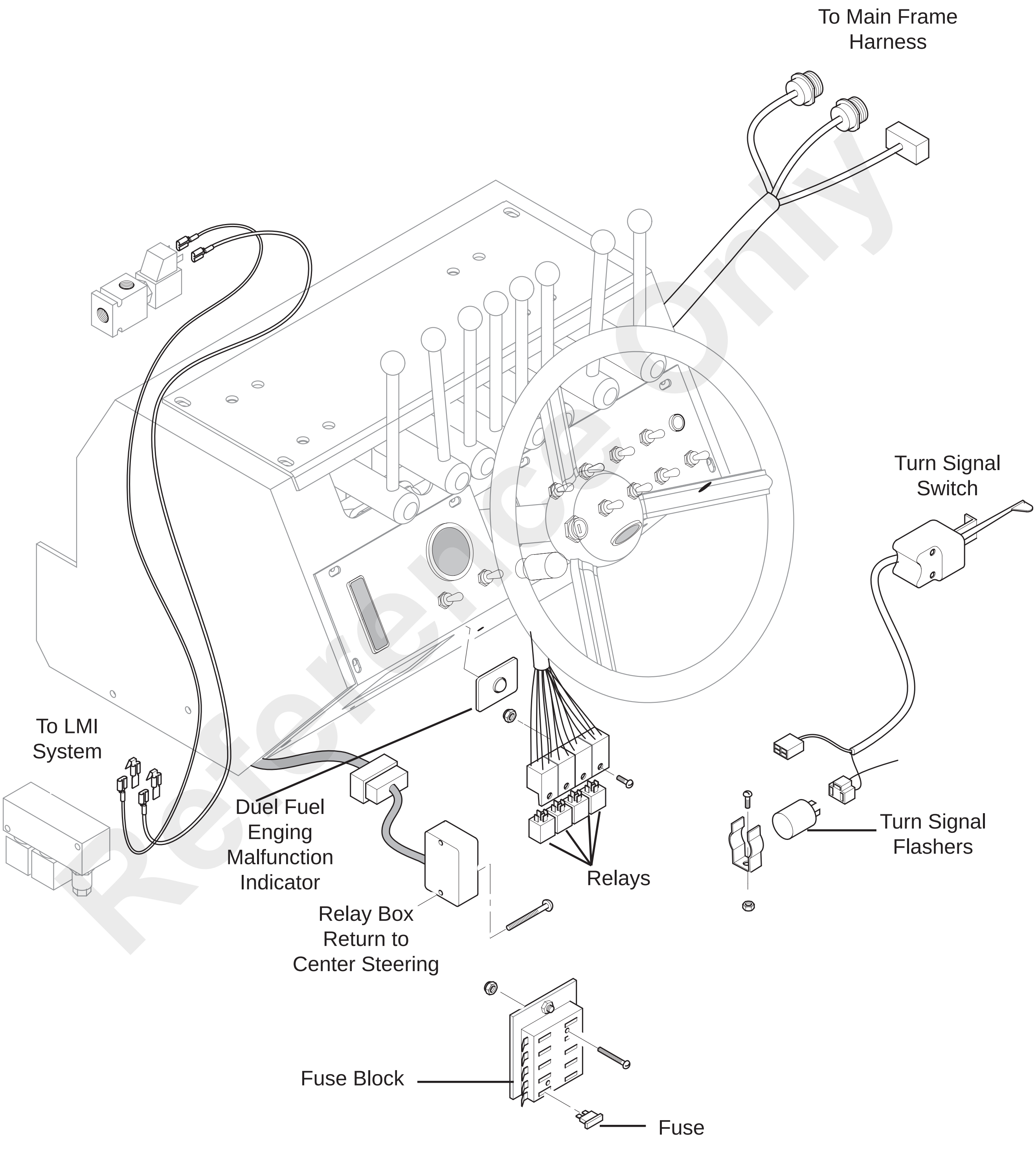
Engine Wire Harness - Gasoline/Dual Fuel (Current)

FIGURE 3-3



Main Frame Harness

FIGURE 3-4



a1636 Instrument Panel Wire Harnesses **FIGURE 3-5**

ACCESSORY CIRCUITS

Anti-Double Blocking System (Figure 3-6)

General

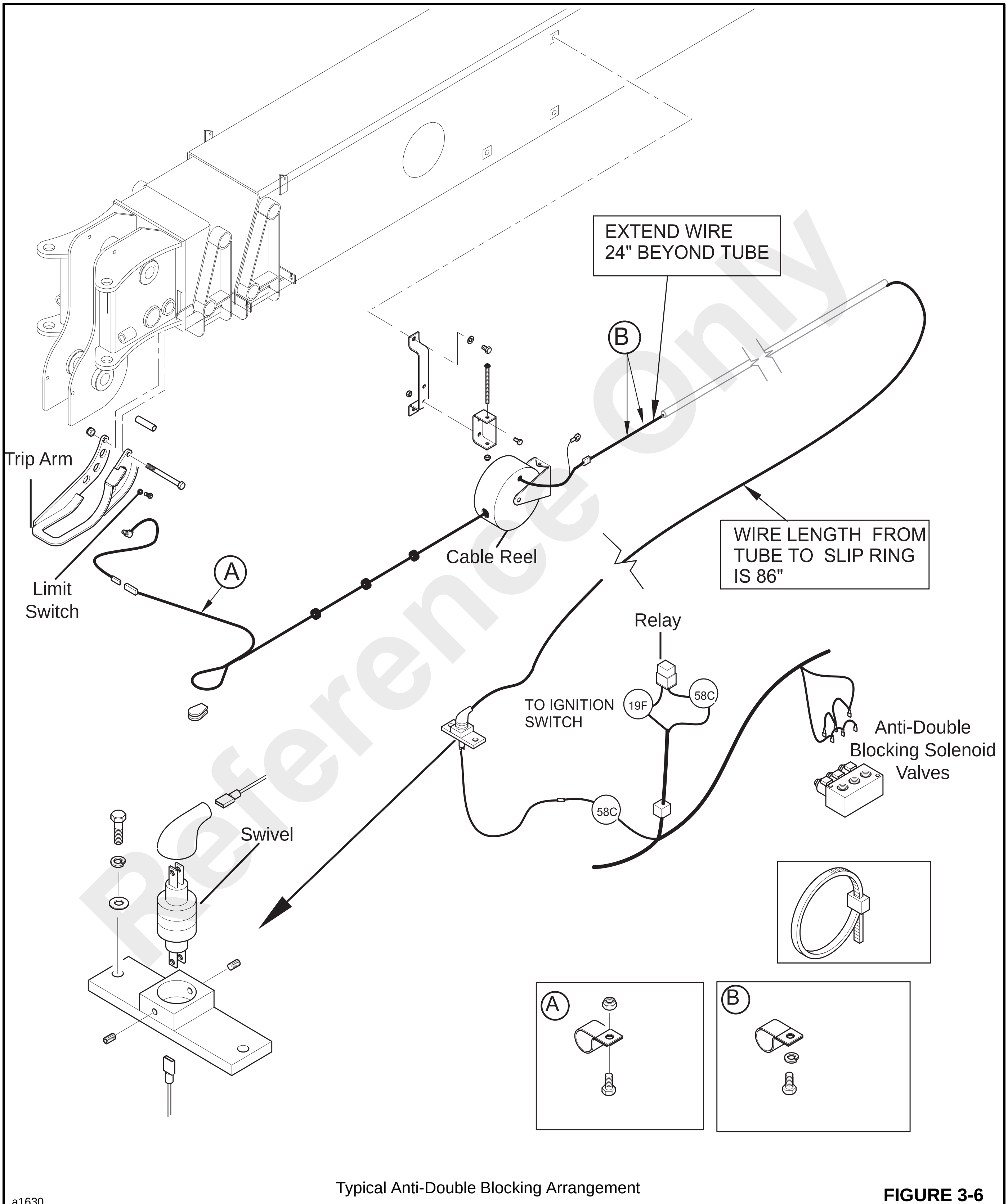
This mechanism inhibits the hook block from being pulled into the boom head during extension of the booms and during winch operation. When the hook block actuates the limit switch on the boom head, oil flow to the crowd cylinder, lift cylinder and winch motor is stopped. A horn is activated to give a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

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, crowd and winch circuits.

Electric Swivel

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



Typical Anti-Double Blocking Arrangement

FIGURE 3-6

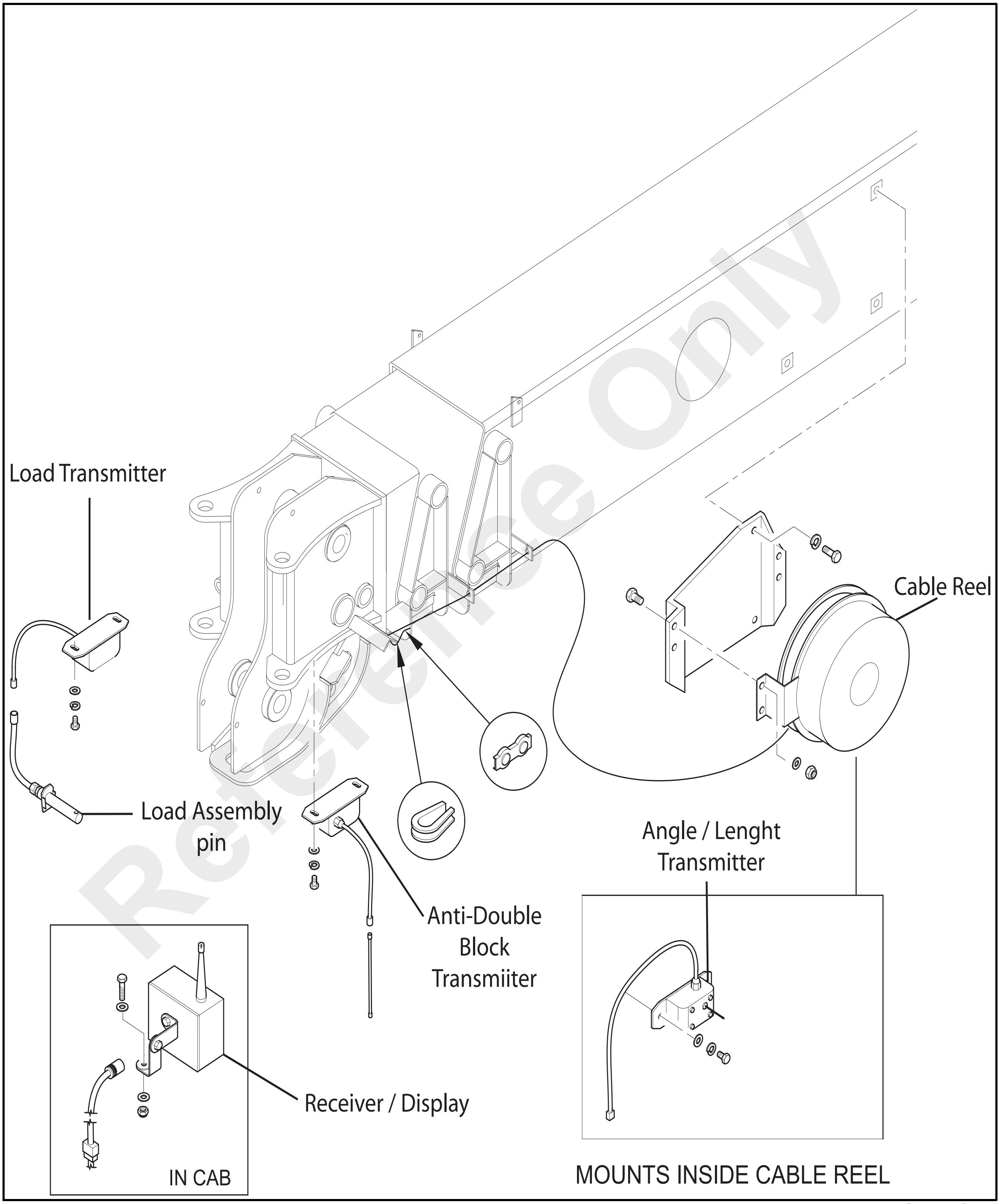
Load Moment Indicator (LMI) System (Figure 3-1)

Description

The load moment indicator (LMI) is a length, load, angle, radius, lifting capacity and anti-double block indicator. A display in the cab provides information to assist the operator in operating the crane. The system can be set with limits by the operator to warn of approach into undesired areas of angle, length or height.

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

See wiring diagram in *Schematics/Wiring Diagrams*.



a1309

LMI System Arrangement

FIGURE 3-1

Optional Engine Shutdown

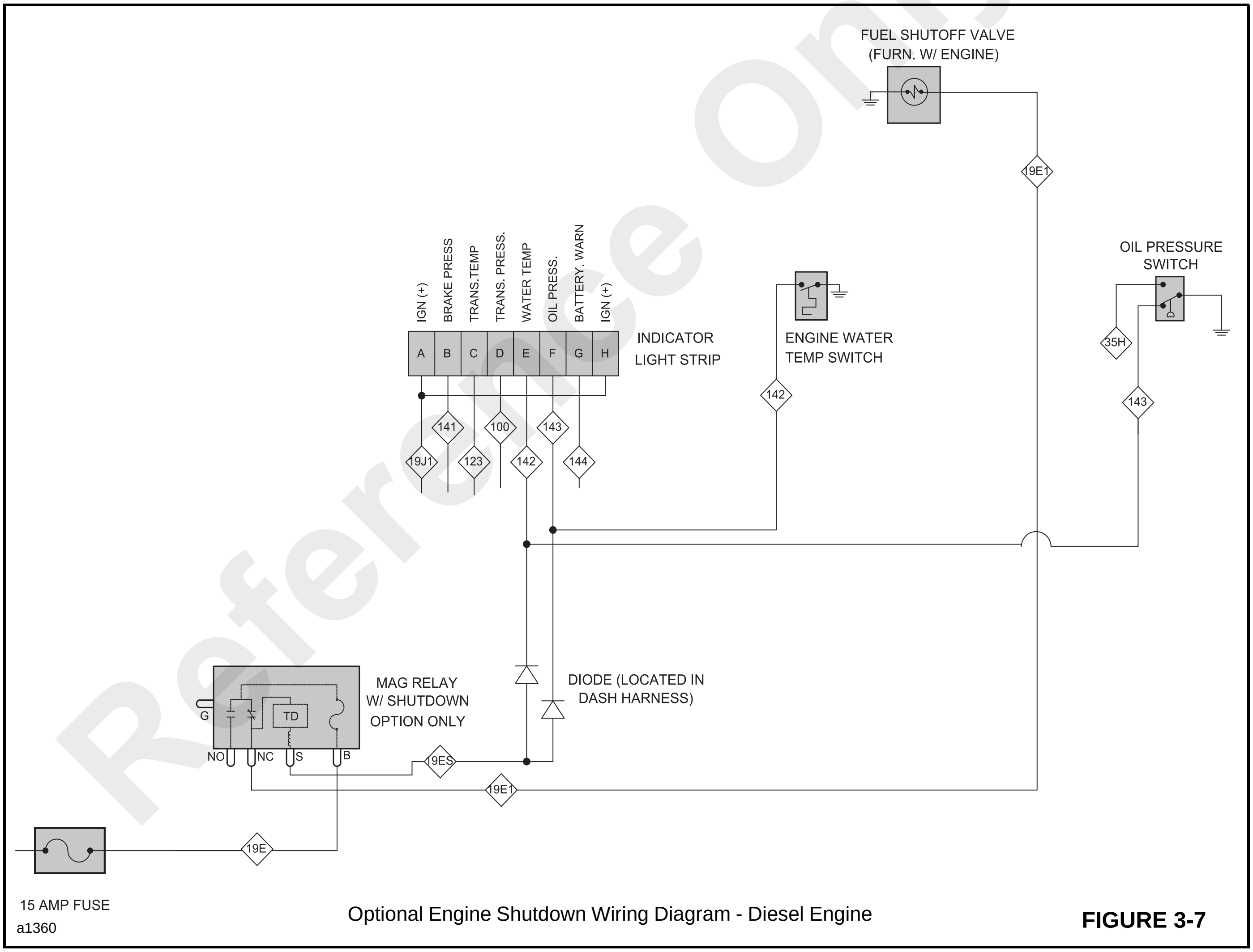
General Description

Units with a diesel engine can be furnished with an automatic engine shutdown, to protect the engine when the engine oil pressure is too low or the engine water temperature is too high. The electrical circuit (Figure 3-7) includes a mag relay switch located behind the cab dash panel, two diodes in the instrument panel wire harness, the warning indicator light strip under the dash panel, the engine water temperature and oil pressure senders, and the fuel shut off valve.

Circuit Function

When the engine oil pressure drops below a safe operating pressure or the water temperature rises above a safe operating temperature, the sending unit sends a signal to the indicator light though either wire 142 or 143, illuminating the light. It also, sends a signal to the mag relay switch under the dash panel. Both senders are connected to the “S” terminal of the relay through wire 19ES. To prevent current from one sender (oil pressure), illuminating the other indicator light (water temperature) the circuit has two diodes installed, which allow current to travel in one direction only. The relay is activated and cuts current from the “NC” terminal to the fuel shut off valve, closing the valve and shutting off the engine.

3



Optional Engine Shutdown Wiring Diagram - Diesel Engine

FIGURE 3-7

Heater

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

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

TROUBLESHOOTING

Finding a problem in the electrical system is not difficult if you know basic electricity and understand the arrangement of the electrical system. Use the wiring diagrams in *Schematics/Wiring Diagrams* 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 3-5
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 stat or 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.	**1.** Loose or worn alternator belt.	**1.** Adjust or replace belt.
	2. Bad alternator.	**2.** Replace or repair.
	3. Bad battery.	**3.** Replace battery.
	4. Low electrolyte level.	**4.** Add distilled water.
	5. Short circuit in system.	**5.** Check and repair.
	6. Worn alternator.	**6.** Test, replace or repair alternator.
	7. Malfunctioning voltage regulator.	**7.** Replace the voltage regulator.
	8. Low engine speed.	**8.** Run engine at higher speed.

Problem	Possible Cause	Solution
Alternator Noise.	**1.** Badly worn belt.	**1.** Replace belt and adjust.
	2. Pulleys out of alignment.	**2.** Align fan and alternator pulleys.
	3. Loose pulley.	**3.** Check for broken key or worn keyway, if used.Tighten pulley nut.
	4. Worn bearings.	**4.** Replace or repair alternator.
	5. Short in rectifier diodes.	**5.** Replace or repair alternator.
Starter motor does not turn.	**1.** Open circuit, dirty or loose connections.	**1.** Clean and tighten connections at battery and starter. Check wiring and connections between ignition switch and starter solenoid.
	2. Bad starter relay (diesel engines only).	**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. Parking brake not engaged.	**6.** Engage parking brake.
	7. Bad neutral start relay.	**7.** Replace relay.
Motor runs in only one direction.	**1.** Defective solenoid or stuck solenoid.	**1.** Jar solenoid to free contacts. Check by applying 12 volts to coil terminal (should hear an audible click when energized). Replace solenoid.
	2. Defective control switch.	**2.** Check and replace if necessary.
Motor runs extremely hot.	**1.** Long period of operation.	**1.** Cooling-off periods are essential to prevent overheating.
	2. Insufficient battery power.	**2.** Check battery terminal voltage under load. If 10 volts or less, replace the battery.
	3. Bad connection.	**3.** Check battery cables for corrosion, clean and grease.
Motor runs but with insufficient power, or with slow line speed.	**1.** Insufficient battery power.	**1.** Check battery terminal voltage under load. If 10 volts or less, replace the battery.
	2. Bad connection.	**2.** Check battery cables for corrosion, clean and grease.
Motor runs but drum does not rotate.	**1.** Clutch not engaged.	**1.** Engage clutch.
	2. Clutch engaged.	**2.** Disassemble the winch to determine cause and repair.

Problem	Possible Cause	Solution
Motor will not operate.	**1.** Defective solenoid or stuck solenoid.	**1.** Jar solenoid to free contacts Check by applying 12 volts to coil terminal (should hear an audible click when energized). Replace solenoid.
	2. Defective control switch	**2.** Check and replace if necessary.
	3. Defective motor.	**3.** If solenoids operate, check voltage at armature post. Replace motor if defective.
	4. Loose connections.	**4.** Tighten connections on bottom side of hood and on motor.

THIS PAGE BLANK

SECTION 4
HYDRAULIC SYSTEM

TABLE OF CONTENTS

4

THIS PAGE BLANK

SECTION 4
HYDRAULIC SYSTEM

TECHNICAL DATA

Hydraulic Pressures:

Hoist and Boom (Lift) Circuits	3500 ±50 psi (24,132 ±345 kPa)
Telescope and Outrigger Circuits	3500 ±50 psi (24,132 ±345 kPa)
Swing Circuit	2000 ±50 psi (13,790 ±345 kPa)
Steering Circuit	2500 ±50 psi (17,237 ±345 kPa)

Rated Pump Output at 2600 rpm:

Section 1	24 gpm (91 lpm)
Section 2	22.8 gpm (86.3 lpm)
Section 3	13.2 gpm (49.9 lpm)
Section 4	13.2 gpm (49.9 lpm)

GENERAL DESCRIPTION

General

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

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

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

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

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

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

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

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

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

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.

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

Hydraulic System

There are four hydraulic systems on this machine. Information on the hydraulic system for the transmission, brakes, and steering is found in Sections 5, 7and 8 respectively. Only the main hydraulic system is included in this section. The main hydraulic system gives hydraulic power to:

- The swing motor
- The boom cylinders; lift and telescope
- The front and rear outrigger cylinders
- The main winch motor

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

TROUBLESHOOTING

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

Troubleshooting Aids

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

- 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).
- Learn if the problem is common to all circuits or is found in one or two circuits.
- Make a visual inspection. Look for a restriction in the linkages, low level of hydraulic oil, bent tubes, collapsed or ballooned hoses, leakage around the hydraulic components, etc.

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

Remember:

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

Again, use the schematic. Find which components are in the circuit or circuits. What component can cause the problem with these symptoms? Make a list of the possible causes. Start at the source of the flow in that circuit. If the problem is in all circuits, start at the pump. Know the direction of oil flow through each circuit.

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

If the problem is 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

Table 4-1
General Hydraulic System Troubleshooting

Problem	Possible Cause	Remedy
Noise (above normal).	Air in system.	With engine at low rpm, operate all control functions several times to return the air to atmosphere through the tank breather.
	Low oil supply.	Add recommended oil.
	Restriction in pump inlet line.	Remove and clean inlet line to pump.
	Dirty oil.	Change oil and filters. See Preventative Maintenance, Chapter 5.
	Loose clamps, vibration of hydraulic lines.	Check and tighten.
	Dirt or foreign material in a relief valve.	Clean or replace the relief valve.
	Broken control valve spool.	Replace the control valve section.
	Pump bearings worn.	Replace the bearings or pump.
Slow operating speeds (All functions).	Low engine rpm.	Increase engine rpm.
	Air leak in pump inlet line.	Tighten pump inlet line. Replace O-ring in inlet flange.
	Air in oil (foam in tank).	Check oil level, look for leaks in the system.
	Leakage in the load sense relief valve.	Remove and clean or replace the relief valve.
	Improper load sense relief valve setting.	Replace the relief valve.
	Leakage in hydraulic swivel.	Replace seals on swivel shaft.
	Control valve not fully actuated.	Check spool travel.
	Improper primary pump.	Check and adjust pump pressure settings. See Main Control Valve.
	Faulty pump.	Overhaul or replace pump.
No movement when system is first started.	Low oil level.	Check and add oil.
	Air or restriction in inlet line to pump pressure.	Check and tighten inlet line. Clear restriction.
	Cold oil or wrong weight of oil.	Use correct oil, follow normal warming procedure.
Loss of movement during operation.	Low oil level.	Check and add oil.
	Vacuum in hydraulic tank.	Clean tank filler/breather cap.
	Restriction or leakage in the relief valve.	Clean or replace the relief valve.
	Broken hydraulic line.	Replace.
	Bad seal in hydraulic swivel.	Replace seals.
	Broken gear or shaft in pump.	Overhaul or replace.

Problem	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 Preventative Maintenance, Chapter 5.
	Oil too light.	Use correct oil.
	Low oil level.	Check and add oil.
	Dirty oil.	Change oil and filters. See Preventative Maintenance, Chapter 5.
Foam in hydraulic oil tank.	Leak in system.	Check O-ring on pump inlet. Check for leak in system and correct.
	Wrong type of oil.	Use correct oil.
	Low oil level.	Check and add oil.
	Bad seal in pump, motor or cylinder.	Overhaul or replace.
Short life of pump bearings, shafts, etc.	Dirt in oil.	Change oil and filter more frequently.
	Wrong type of oil.	Use correct oil.
Pump leakage (external).	Bad seal on pump shaft.	Replace shaft seal.
	Bad seals between pump sections (Swing & Steering).	Replace seals.
Difficult to engage valve spools.	Dirt or foreign material between spool and valve bore.	Remove and clean valve spool valve and bore.
	Broken spring (spool return).	Replace spring.
	Distortion or damage to valve spool.	Replace valve section.

Table 4-2
Lift Circuit Troubleshooting

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

Problem	Possible Cause	Remedy
Boom moves slowly downward when control valve is in NEUTRAL position.	Internal leakage in cylinder.	Replace piston seals.
	Leakage in holding valve.	Replace holding valve. DO NOT ADJUST.
	Faulty controller.	Repair or replace.
	Broken centering spring in control valve section.	Replace broken spring.

Table 4-3
Telescope (Crowd) Circuit Troubleshooting

Problem	Possible Cause	Remedy
Cylinder will not extend the boom under load.	Restriction in boom sections.	Clean and apply lubricant to boom slides. See Preventative Maintenance, Chapter 5.
	Load too heavy.	Reduce load.
	Faulty pump.	Overhaul or replace.
	Leakage in hydraulic swivel.	Replace seals in the swivel.
	Load sense relief valve malfunction.	Check load sense relief pressure.
	Dirt or restriction in main relief.	Disassemble the relief valve and clean.
Boom extends, but will not retract.	Restriction in hose to the control valve.	Check and correct.
	Malfunction in the holding valve.	Replace the holding valve. DO NOT ADJUST
Boom retracts but will not extend	Malfunction in anti-double blocking electrical system.	See Electric System.
	Bad cartridge in anti-double blocking solenoid valve.	Replace the cartridge
	Restriction in pilot control line to control valve.	Check and correct.
	Faulty controller.	Repair or replace control valve.
Boom slow at extending.	Restriction in boom sections.	Clean and lubricate boom slides. See Preventative Maintenance, Chapter 5.

4

Table 4-4
Outrigger Circuit Troubleshooting

Problem	Possible Cause	Remedy
No movement all cylinders	Dirt in relief valve keeping the valve off the valve seat.	Clean the relief valve.
	Relief valve setting too low.	Check and adjust the relief valve setting.
	Faulty pump section.	Overhaul or replace the pump.
Slow movement all outriggers.	Low engine rpm.	Increase engine speed.
	Leakage in relief valve.	Clean or replace the relief valve.
Slow movement, one cylinder.	Internal leakage in the cylinder	Replace piston seals.
Outrigger lowers but will not raise.	Faulty lock valve in base of the cylinder	Replace counterbalance valve.
Outrigger cylinder does not hold under load.	Leakage in counterbalance valve in base of cylinder.	Clean or replace counterbalance valve.
	Internal leakage in cylinder.	Replace piston seals.
Outriggers only on one side.	Faulty control valve section.	Repair or replace valve section.
	Faulty selector valve.	Replace selector valve.
	Restriction or dirt between the O/R valve spool and housing.	Remove and clean the outrigger valve spool.

Table 4-5
Main Winch Circuit Troubleshooting

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

Problem	Possible Cause	Remedy
Hook block lowers, but will not raise.	Malfunction in anti-double blocking electrical system.	See Electric System, Chapter 3.
	Bad cartridge in anti-double blocking solenoid valve.	Faulty controller.
	Faulty controller.	Repair or replace.
	Restriction in pilot control line to control valve.	Locate and correct.

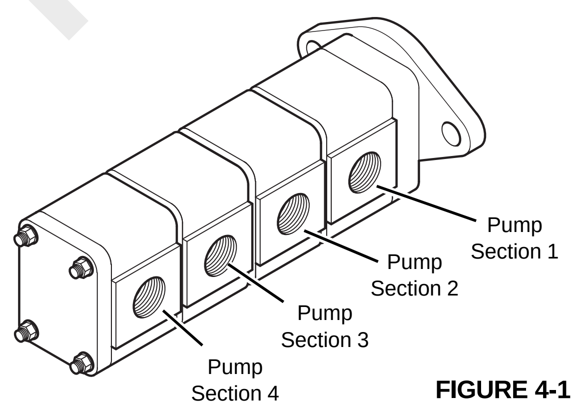
Table 4-6
Swing Circuit Troubleshooting

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

SUCTION, PRESSURE AND RETURN CIRCUITS

General

The main hydraulic pump is a gear pump with four sections Figure 4-1. Oil is available to the inlet of the pump from the hydraulic tank. The first pump section (nearest to the transmission) moves the hydraulic oil to the P3 port of the main control valve. Here the oil is available to operate the main winch. Hydraulic oil returning from the winch motor passes through the control valve, the return filter and then into the hydraulic oil tank.



a1619 **FIGURE 4-1**

The second pump section moves hydraulic oil to the P2 port of the main control valve. At this valve, the oil is available to operate the lift and crowd and outrigger cylinder functions. Hydraulic oil which returns from these functions is sent through the return filter, then back to tank.

The third pump section moves hydraulic oil to the P1 port of the control valve. Oil is available to operate the swing function. Hydraulic oil which returns from this functions is sent through the return filter, then back to tank.

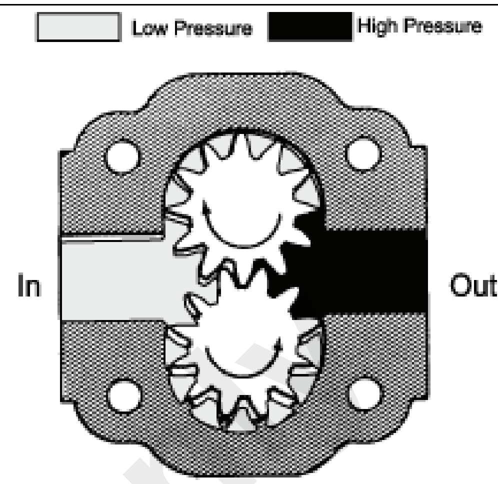
The fourth pump section moves hydraulic through to the steering orbitrol and the accumulator charging valve, through a priority flow control valve. Return oil from the steering orbitrol returns to tank through the return filter.

Hydraulic Pump

The drive gears of the four gear sets are turned by the drive shaft connected to the transmission. When the gears turn, oil from the inlet side of the hydraulic pump is moved around the outside of the gears to the outlet side of the pump.

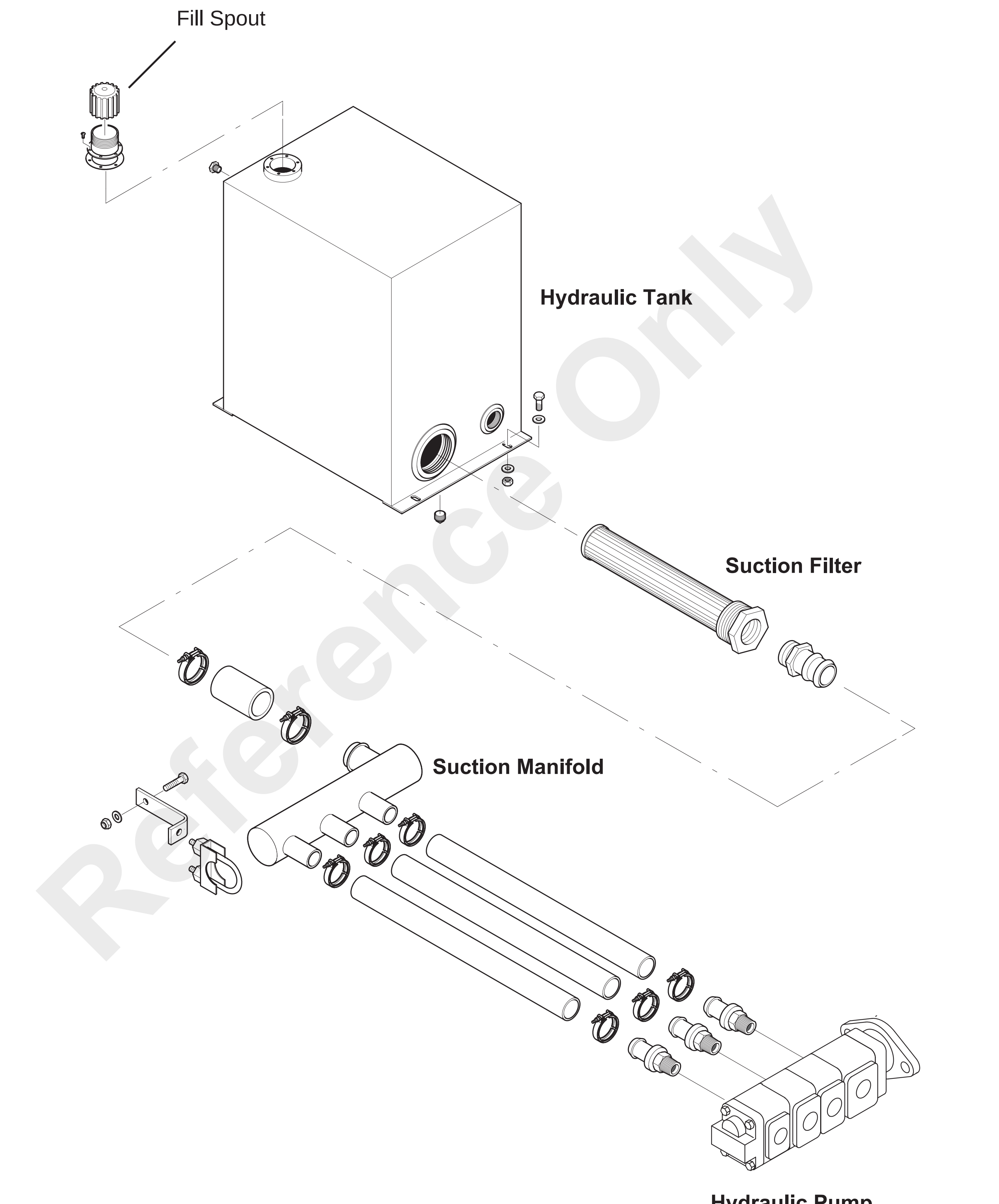
The inlet side of the hydraulic pump is under low pressure Figure 4-2. The outlet side is normally under high pressure. Pressure from the outlet side of the pump pushes the pressure plates against the gears to inhibit leakage or bypass in the hydraulic pump.

Lubrication of internal components is provided through passages in the hydraulic pump body and grooves in the pressure plates. A lip seal on the shaft and o-rings between the sections prevent external leakage in the pump.



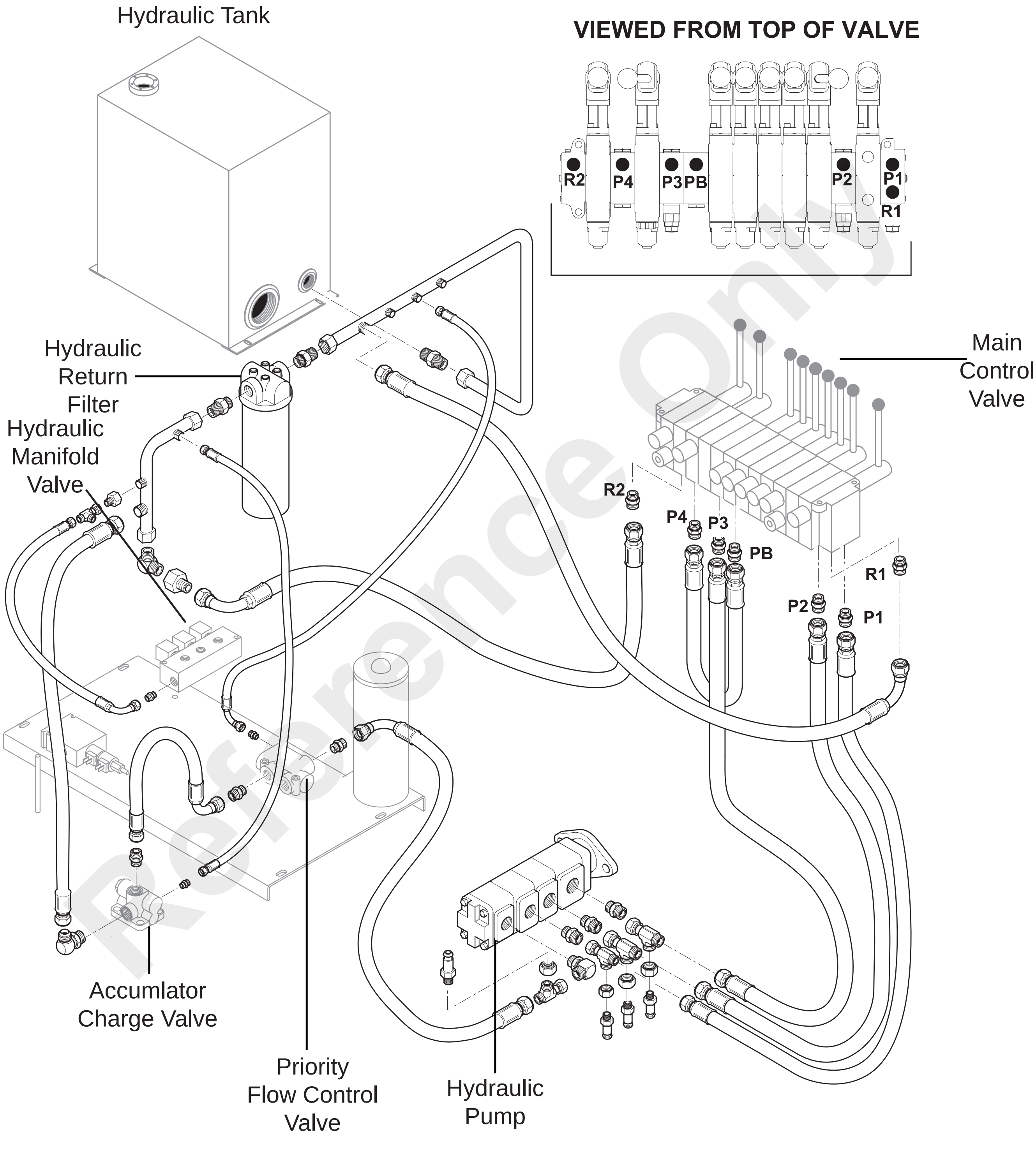
a0389

FIGURE 4-2



Suction Circuits

FIGURE 4-3



a1564

Suction Circuits

Test - Pump Output

To check the output of the hydraulic pump, use a 100 gpm (379 lpm) flowmeter. Follow the instructions in the flowmeter manual. For rated output, see page 4-1.

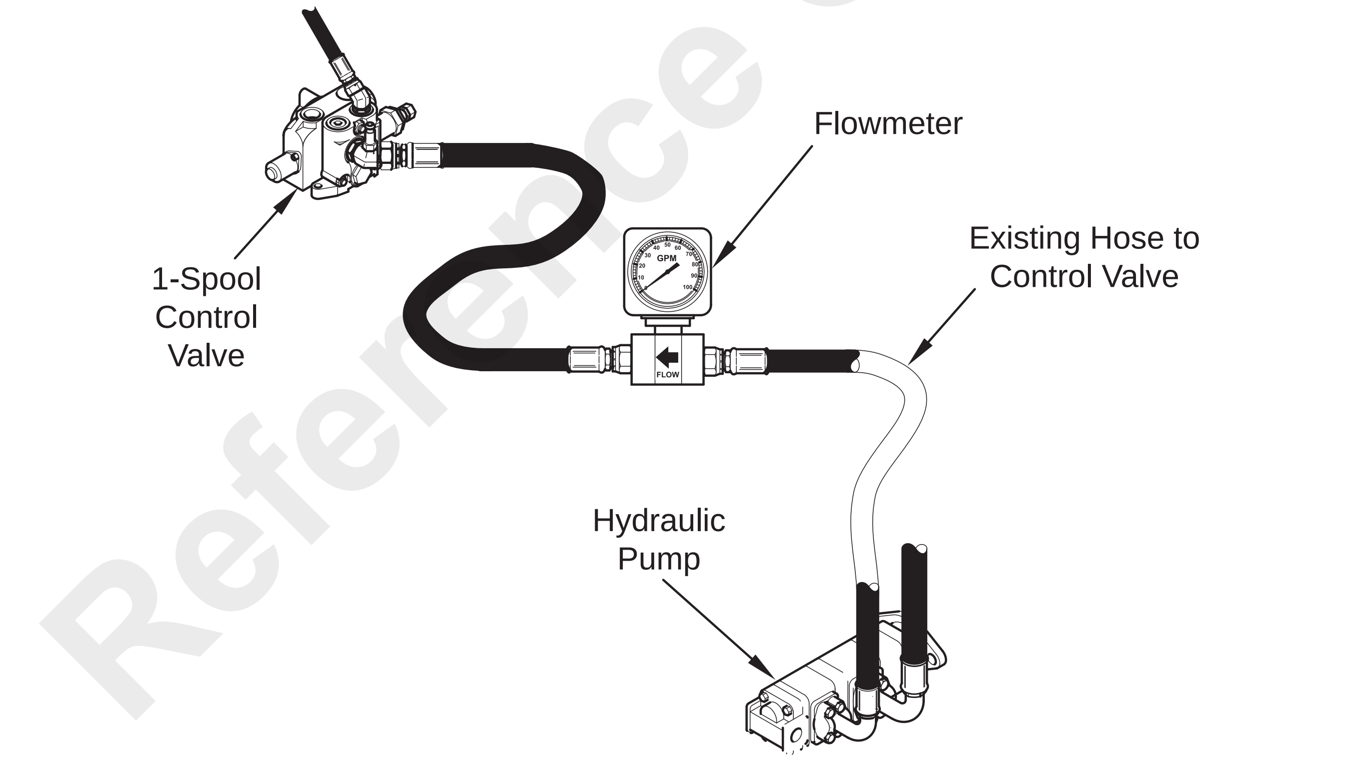
NOTE: All flow tests must be taken when the temperature of the hydraulic oil is 120 - 130° F (45 - 54° C).

To check the efficiency of the pump, use the following procedure:

1. Connect a flowmeter between the pump and control valve Figure 4-5 according to the instructions in the flowmeter manual. Make sure the needle valve on the flowmeter is fully open.
2. Start the engine and run at maximum rpm. Wait until the oil reaches the operating temperature.
3. Slowly close the needle valve of the flowmeter until the pressure for the circuit being supplied by the pump section being tested.
4. Read the amount of flow on the flowmeter. Record the flow reading and the engine rpm.
5. Fully open the flowmeter needle valve.
6. Accelerate the engine until the engine speed matches the speed recorded in step 4. Read the amount of flow on the flowmeter. Record this reading.
7. Compare the results to find the efficiency of the pump.

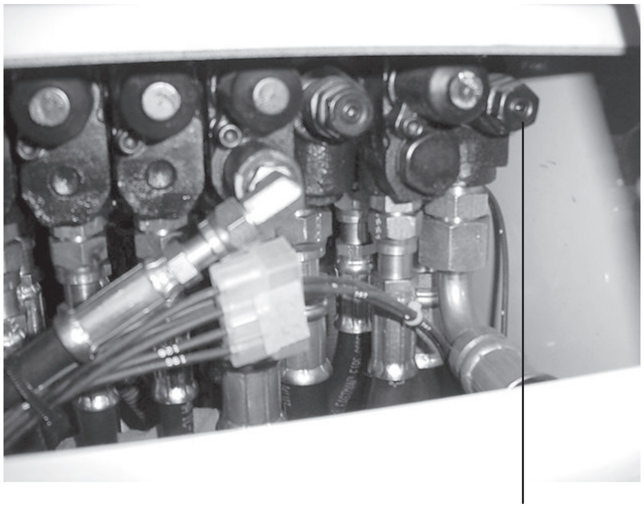
$$\text{Percent of Pump Efficiency} = \frac{\text{Flow at X psi} \; (X) \times 100}{\text{Flow at 0 psi (0 kPa)}}$$

8. If the pump is less than 80% efficient, repair or replacement is necessary.

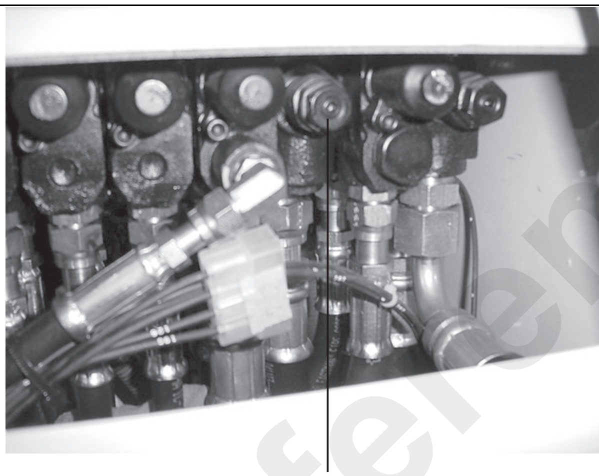


a0391 Flowmeter Installation, Typical **FIGURE 4-5**

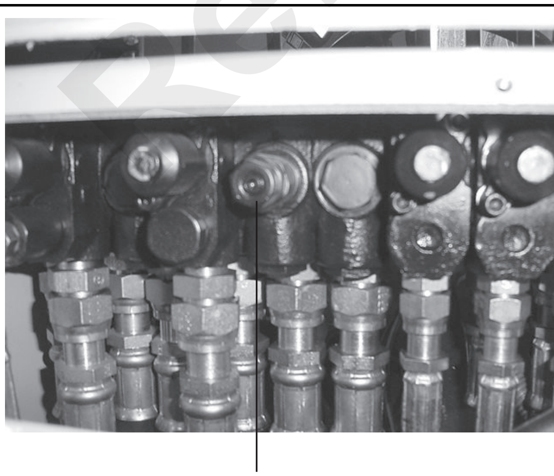
Main Relief Valves



p0709 Swing Main Relief Valve Location **FIGURE 4-6**



Telescope/Outrigger Main relief Valve Location
p0710 **FIGURE 4-7**



Winch Hoist/Boom Lift Main Relief Valve Location
p0706 **FIGURE 4-8**

Each pump section has a main relief valve to protect the hydraulic circuits fed by the section. Pump sections 1, 2 and 3 are in the inlet and mid-inlet sections of the main control valve. See Figure 4-6, Figure 4-7 and Figure 4-8.

The relief valve for the fourth section is located in the priority flow control valve.

The purpose of the main relief valve is to control maximum pressure in the hydraulic pump circuit. Pressure in the system increases as resistance to the flow of hydraulic oil increases. The hydraulic pump operates constantly and will continue to push more hydraulic oil into the system. When the flow of the hydraulic oil is stopped at any point in the system, pressure increases very rapidly. The relief valve opens and lets the hydraulic oil from the hydraulic pump return to the hydraulic tank when the pressure reaches the maximum set limit of the relief valve.

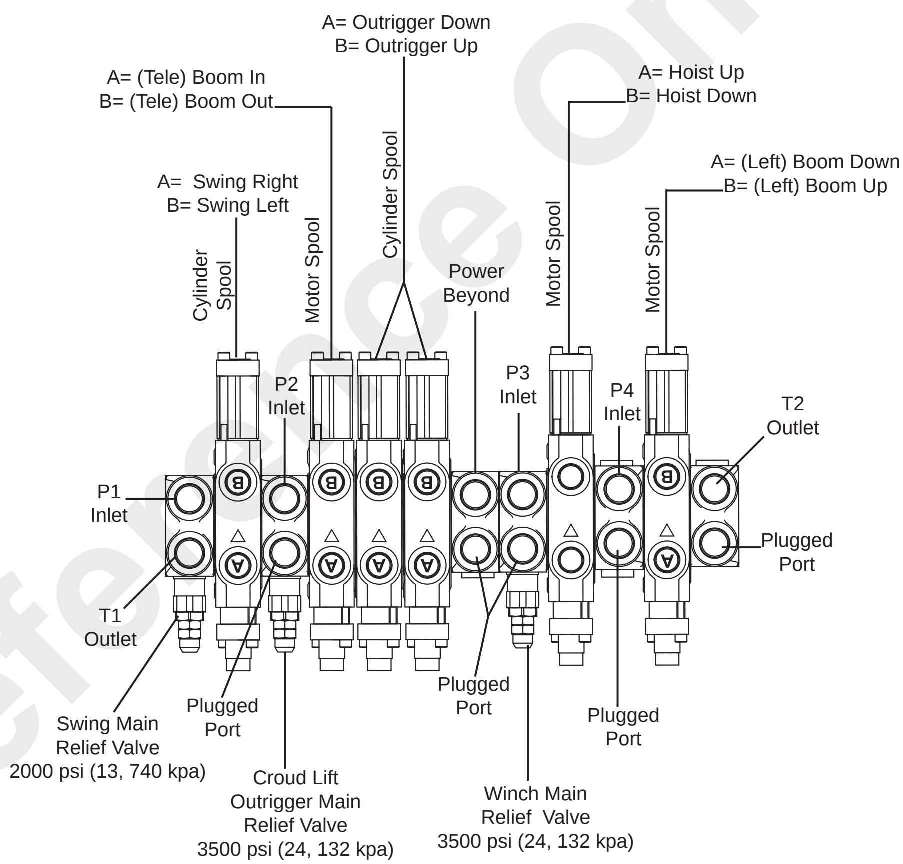
Remember, pressure in a hydraulic system is applied to every component in contact with the hydraulic oil. For example, pressure will increase when a cylinder rod reaches the end of its stroke. This pressure will have an affect on every component between the cylinder and the hydraulic pump. Without a relief valve in the circuit, the high pressure can easily break the hydraulic pump, a hydraulic line or other component in that circuit.

Main Control Valve

Technical Data

Spool type	Sliding, double action, cylinder
Hoist, Crowd and Lift Circuits and outriggers Main Relief Valves	See Figure 4-9
Swing Circuit Main Relief Valve	See Figure 4-9
Spool travel (from neutral)	5/16 inch (7,87 mm)
Port pressurized (3-Spool Control Valve):	
Handle In - Spool out	A-Port
Handle out - Spool in	B-Port

Valve Identification



Main Control Valve Identification

FIGURE 4-9

Valve Description

The main control valve bank consists of one single valve assembly, Figure 10-9. The valve assembly if mounted in the front of the cab on the dash. The control valve is a multi-section, open-center, three position, four-way directional control valve equipped with self-centering valve spools.

The control valve consists five inlet sections with three relief valves, one outlet section, and four or six parallel working sections and two single working sections. The swing and outrigger working sections are a cylinder spool section and all others are motor spool sections.

Motor spool sections allow oil to return to the hydraulic tank when the valve spool in the centered or neutral position. **Cylinder spool** sections block the oil from returning to the hydraulic tank when the valve spool is in the centered or neutral position.

Parallel Valve Spool Description

A parallel spool is a solid-core spool designed to route oil from the work circuit back to tank.

In a valve assembly that has all parallel valve spools, if two are shifted at the same time, the spool closest to the valve inlet will block the open-center passage and prevent supply oil from reaching the other spools downstream. If the first spool is shifted to only partially block the center passage, the oil will enter the work circuit which offers the least resistance. Oil always flows the path of least resistance. When two parallel spools are shifted at the same time, the function which offers the least resistance will move first. When the resistance in that circuit increases above that of the circuit, the second function will operate. In affect, with a parallel spool arrangement, only one function is workable at a time.

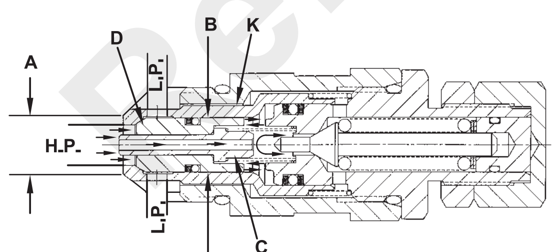
Main Relief And Port Relief Valves

The main relief valves for the main system are located in the inlet sections of the main control valve. The relief valve is in communication with the center or high pressure passage of the control valve and will open to release excess oil to tank when the pressure in the center passage exceeds the pressure setting of the main relief valve.

The purpose of the main relief valve is to control maximum pressure in the pumping circuits and to control any pressure surges or spikes caused by a sudden load on the system.

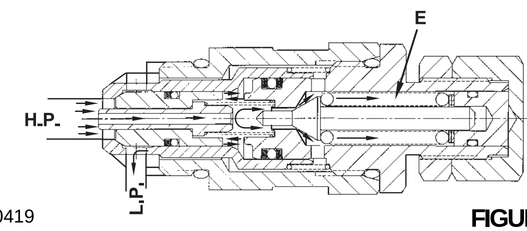
Since pressure applied to any point in the circuit is applied equally through the circuit, a pressure surge at a motor or cylinder is felt all the way back to the pump.

A relief valve is in communication between the high pressure port “HP” Figure 4-10 and the low pressure area “LP”. Oil is admitted through the hole in poppet “C” and because of a differential area between diameters “A” and “B”, relief valve poppet “D” and check valve poppet “K” are tightly sealed.



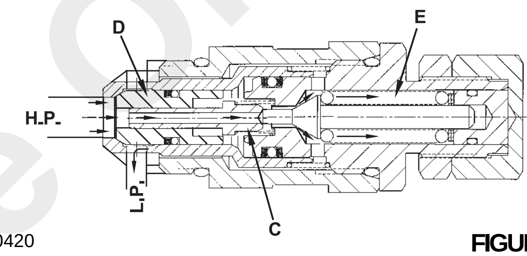
a0418 **FIGURE 4-10**

The oil pressure in the high pressure port “HP” Figure 4-11 has reached the setting of the pilot poppet spring force and unseats pilot poppet “E” and oil flows around the poppet, through the cross drilled holes and to the low pressure area “LP”.



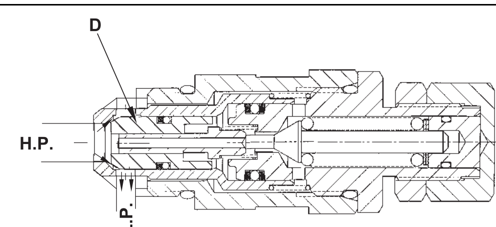
a0419 **FIGURE 4-11**

The loss of oil behind poppet “C” Figure 4-12 affected by the opening of pilot poppet “E” causes poppet “C” to move back and seat against pilot poppet “E”. This shuts off the oil flow to the area behind relief valve poppet “D” and causes a low pressure area internally.



a0420 **FIGURE 4-12**

The imbalance of pressure on the inside as compared to that of the high pressure port “HP” forces the relief valve poppet “D” Figure 4-13 to open and relieve the oil directly to the low pressure chamber “LP” in the valve. Oil then flows back to the hydraulic oil tank.



a0421 **FIGURE 4-13**

Main Relief Valve Pressure Test Procedure

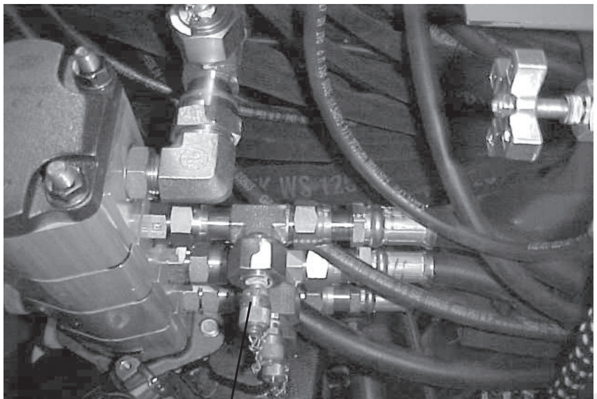
NOTE: The hydraulic oil must be at operating temperature (120° - 130° F (45° - 54° C).

Swing Circuit Main Relief Valve Setting Test

1. With the engine shut off and parking brake engaged, install a 0 - 5000 psi (0 - 345 bar) pressure gauge to the test connection on the pressure side of the swing section of the hydraulic pump (Figure 4-14).
2. Disconnect both hoses at the swing motor. Plug the hoses and cap the fittings on the motor.
3. Start the engine and accelerate it to full rpm.

4. Actuate the swing control and observe the pressure gauge attached to the pump outlet. The relief valve should open at 2000 ± 50 psi (138 ± 3.5 bar). Release the control lever after the reading is obtained.
5. If the pressure reading is correct, stop the engine and remove the pressure gauge. Connect the two hoses to the swing motor.
6. If the pressure reading is incorrect, adjust the pressure setting for the swing circuit relief valve.

p1636



Swing Circuit Test Relief Valve Test Connection

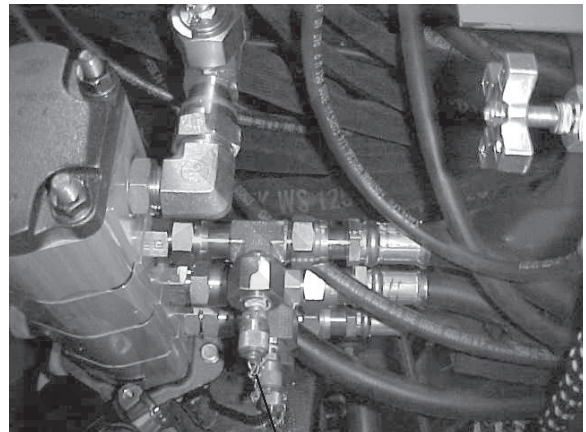
FIGURE 4-14

Boom Lift/Telescope/Outrigger Circuit Main Relief Valve Test

The boom lift circuit, telescope circuit and outrigger circuits are protected by the same relief valve. To test the relief valve it is recommended that the boom lift circuit be used for testing purposes.

1. With the engine shut off and the parking brake engaged, connect a 0 -5000 psi (0 - 345 bar) to the test connection on the pressure side of the telescope/outrigger section of the hydraulic pump (Figure 4-15).
2. Start the engine and accelerate it to full rpm.
3. Actuate the boom lift control to fully lower the boom. Hold the control in position and observe the pressure gauge attached to the pump outlet. The relief valve should open at 3500 ± 50 psi (241 ± 3.5 bar). Release the control lever after the reading is obtained.
4. If the pressure reading is correct, stop the engine and remove the pressure gauge.
5. If the pressure reading is incorrect, adjust the pressure setting for the boom lift, telescope/outrigger circuit relief valve.

p1636



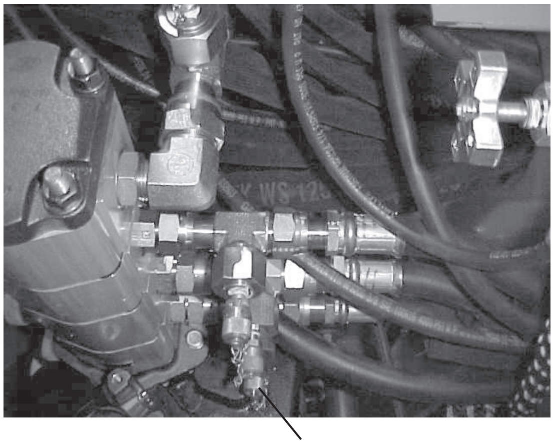
Boom Lift/Telescope/Outrigger Circuit Relief Valve Test Connection

FIGURE 4-15

Winch Hoist Circuit Main Relief Valve Test

1. With the engine shut off and the parking brake engaged, connect a 0 - 5000 psi (0 - 345 bar) to the test connection on the pressure side of the winch hoist/boom lift section of the hydraulic pump (Figure 4-16).
2. Disconnect the hoist brake line between the brake valve and the hoist brake housing. Cap and plug the openings.
3. Start the engine and accelerate it to full rpm.
4. Actuate the boom lift control to fully lower the booms. Hold the control in position and observe the pressure gauge attached to the pump outlet. The relief valve should open at 3500 ± 50 psi (241 ± 3.5 bar). Release the control lever after the reading is obtained.
5. If the pressure reading is correct, stop the engine and remove the pressure gauge.
6. If the pressure reading is incorrect, adjust the pressure setting for the winch hoist circuit relief valve.
7. Reconnect the brake line.

p1636



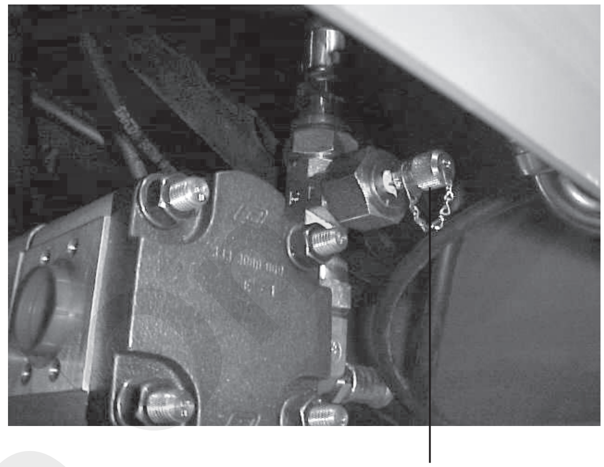
Winch Hoist/Boom Lift Circuit Main Relief Valve Test Connection

FIGURE 4-16

Steering Circuit Relief Valve Test

1. With the engine shut off and the parking brake engaged, connect a 0 - 5000 psi (0 - 345 bar) to the test connection on the pressure side of the steering section of the hydraulic pump (Figure 4-17).
2. Start the engine and accelerate it to full rpm.
3. Place the steering select switch in 2 wheel steering mode.
4. Turn the steering wheel in either direction until the front wheels are at their maximum steerable position. Hold the steering wheel in position and observe the pressure gauge attached to the pump outlet. The relief valve should open at 2500 ± 50 psi (172 ± 3.5 bar). Release the steering wheel after the reading is obtained.
5. If the pressure reading is correct, stop the engine and remove the pressure gauge.
6. If the pressure reading is incorrect, the priority flow control valve must be replaced. The relief valve portion of the valve is nonadjustable.

p1637



Steering Circuit Main Relief Valve Test Connection

FIGURE 4-17

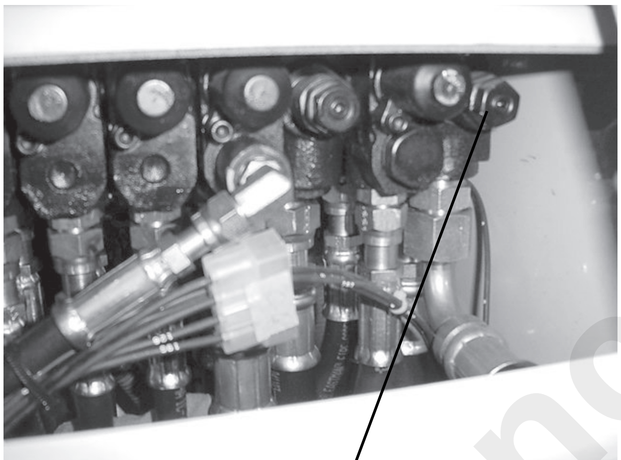
Adjusting Main Relief Valve Pressure Settings

NOTE: It is necessary to climb under the crane to perform pressure setting testing. Be sure engine is shut off and the ignition key is removed (unless noted), parking brake is engaged and chock blocks are in place before climbing under the crane.

Swing Circuit Main Relief Valve Adjusting Procedure

1. With the engine shut off and parking brake engaged, install a 0 - 5000 psi (0 - 345 bar) pressure gauge to the test connection on the pressure side of the swing section of the hydraulic pump (Figure 4-14).
2. Disconnect both hoses at the swing motor. Plug the hoses and cap the fittings on the motor.
3. Remove the access panel in front of the cab control panel to gain access to the main control valve (Figure 4-18).

p1647



Swing Main Relief Valve Location

FIGURE 4-18

4. Loosen the jam nut on the swing main relief valve (Figure 4-18).
5. Start the engine and accelerate it full rpm.
6. Actuate the swing control and observe the pressure gauge attached to the pump outlet.
7. Turn the relief valve adjusting screw until a pressure reading of 2000 ± 50 psi (138 ± 3.5 bar) is obtained. Turning the adjusting screw clockwise will increase the pressure; turning the adjusting screw counterclockwise will decrease the pressure.
8. Release the control lever. Tighten the jam nut on the relief valve. Actuate the lever again and check the pressure reading. If correct stop the engine and remove the pressure gauge. If incorrect, readjust the pressure setting until correct.
9. Remove the plugs and caps and connect the hoses to the swing motor.

Boom Lift/Telescope/Outrigger Circuit Main Relief Valve Adjusting Procedure

1. With the engine shut off and the parking brake engaged, connect a 0 - 5000 psi (0 - 345 bar) to the test connection on the pressure side of the boom lift/ telescope/outrigger section of the hydraulic pump (Figure 4-15).
2. Remove the access panel in front of the cab control panel to gain access to the main control valve (Figure 4-19).

p1647

Boom Lift/Telescope/Outrigger Main relief Valve Location

FIGURE 4-19

3. Loosen the jam nut on the telescope/outrigger main relief valve (Figure 4-19).
4. Start the engine and accelerate it full rpm.
5. Actuate the boom lift control to fully lower the boom. Hold the control in this position and observe the pressure gauge attached to the pump outlet.
6. Turn the relief valve adjusting screw until a pressure reading of 3500 ± 50 psi (241 ± 3.5 bar) is obtained. Turning the adjusting screw clockwise will increase the pressure; turning the adjusting screw counterclockwise will decrease the pressure.
7. Release the control lever. Tighten the jam nut on the relief valve. Actuate the lever again and check the pressure reading. If correct stop the engine and remove the pressure gauge. If incorrect, readjust the pressure setting until correct.

Winch Hoist/Circuit Main Relief Valve Adjusting Procedure

1. With the engine shut off and the parking brake engaged, connect a 0 - 5000 psi (0 - 345 bar) to the test connection on the pressure side of the winch hoist section of the hydraulic pump (Figure 4-15).

2. Remove the access panel in front of the cab control panel to gain access to the main control valve (Figure 4-20).

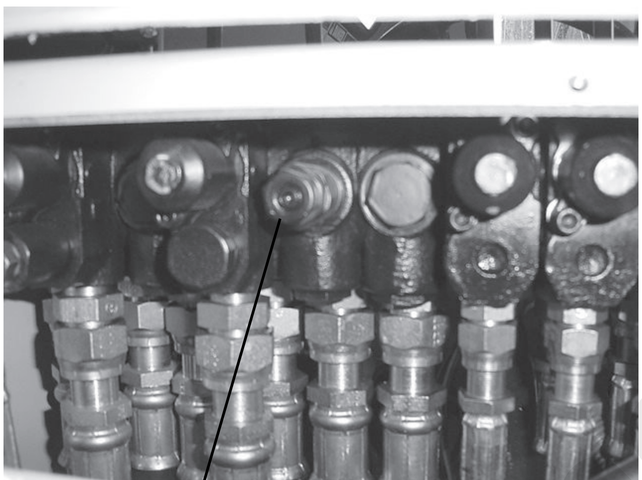


FIGURE 4-20

3. Loosen the jam nut on the winch hoist/boom lift main relief valve (Figure 4-20).

4. Disconnect the hoist brake line between the hoist brake valve and hoist brake. Cap and plug all openings.

5. Start the engine and accelerate it full rpm.

6. Actuate the winch hoist control to raise the cable assembly Hold the control in position and observe the pressure gauge attached to the pump outlet.

7. Turn the relief valve adjusting screw until a pressure reading of 3500 ± 50 psi (241 ± 3.5 bar) is obtained. Turning the adjusting screw clockwise will increase the pressure; turning the adjusting screw counterclockwise will decrease the pressure.

8. Release the control lever. Tighten the jam nut on the relief valve. Actuate the lever again and check the pressure reading. If correct stop the engine and remove the pressure gauge. If incorrect, readjust the pressure setting until correct.

9. Reconnect the hoist brake line.

LIFT CIRCUIT

General

The lift hydraulic circuit (Figures 10-21 through 10-23) includes the lift cylinders, two holding valves, Ports 3 and 4 in the hydraulic swivel, an anti-double block cutout solenoid valve, the valve section of the control valve, 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 inhibit movement of the lift cylinders.

Raising the Booms

Pulling the handle spool IN connects the supply from the pump to part B in the control valve (Figure 4-21). Oil leaves Port B of the control valve section and passes through Port 3 of the hydraulic swivel and enters the base end of the lift cylinder through the holding valve. In this direction, the oil flows freely through the holding valve and into the base end of the cylinder. The cylinder rod starts to extend, pushing oil ahead of the piston out the rod end port. The oil returns through Port 4 of the hydraulic swivel to Port A of the control valve section. From here, the oil is routed to the tank passage of the control valve assembly and returns through the return filter to the hydraulic oil tank.

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

Lowering the Booms

Pushing the handle spool OUT sends oil in the opposite direction and causes the cylinder to retract Figure 4-22. 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

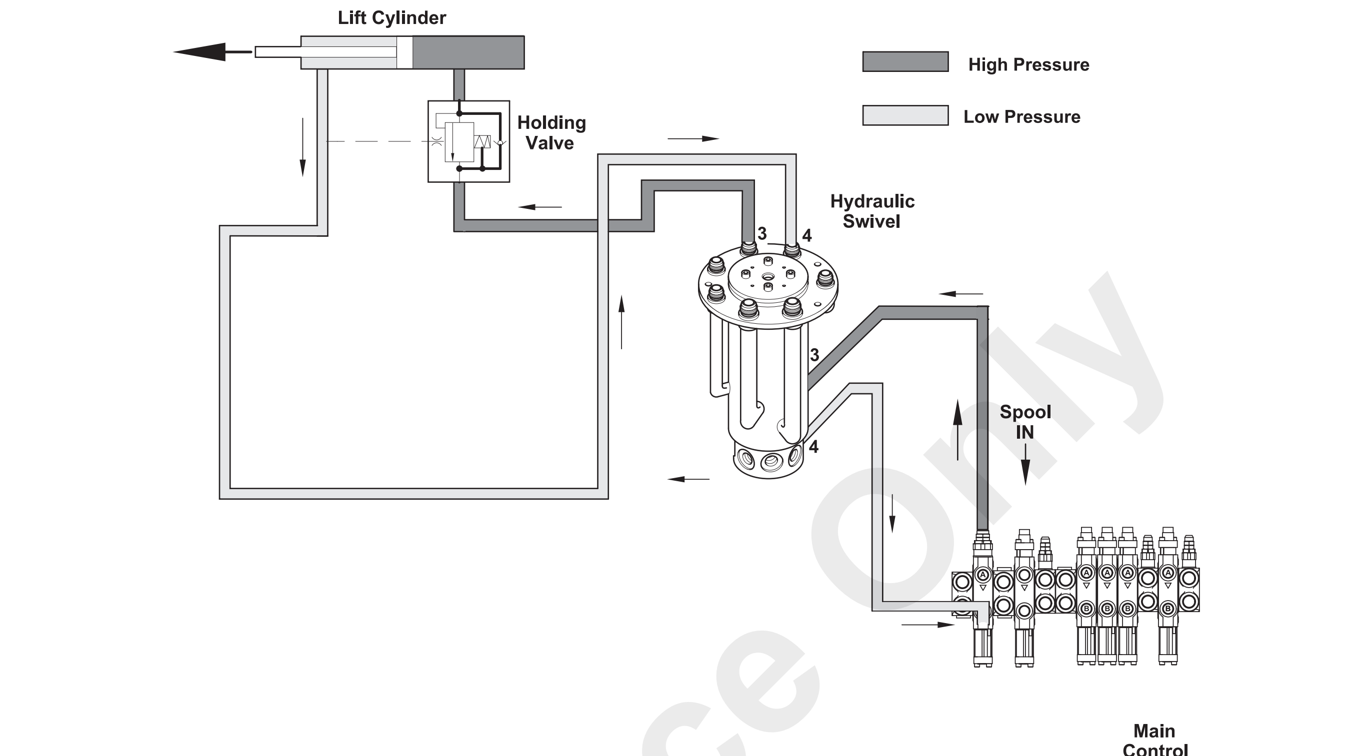
Do not adjust the holding valve setting. The valve is adjusted by the manufacturer.

Lift Cylinder Leakage Check

If internal leakage of the cylinder is suspected, check for leakage as follows:

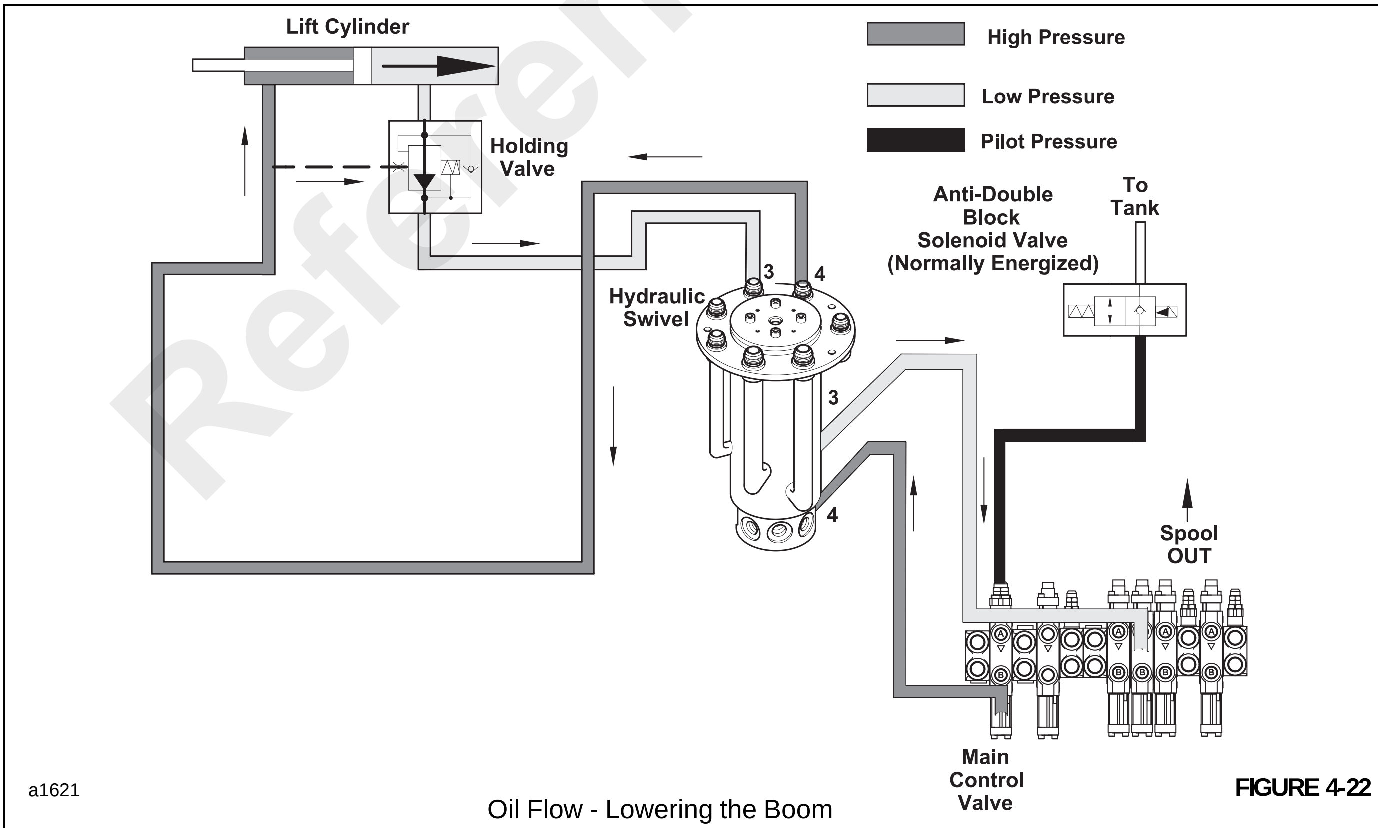
1. Remove the suspected cylinder from the machine See Hydraulic Cylinders in this section.
2. Mount the cylinder in a suitable cylinder stand.
3. Connect a portable hydraulic system to the cylinder base end.
4. Apply pressure to extend the cylinder rod.
5. Check the amount of leakage from the rod port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

4



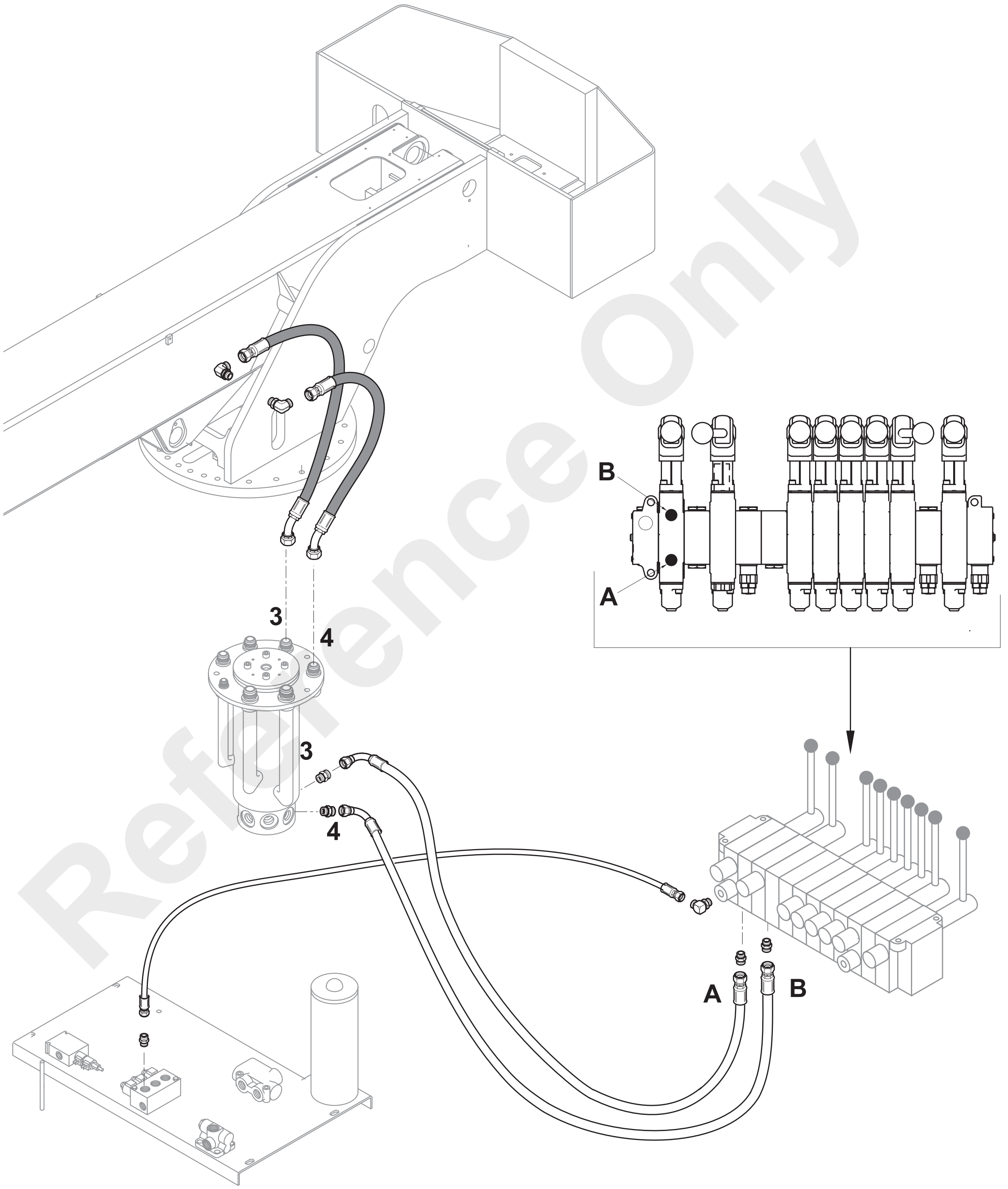
Oil Flow - Rasing the Boom

FIGURE 4-21



Oil Flow - Lowering the Boom

FIGURE 4-22



Lift Circuit Hydraulic Lines

FIGURE 4-23

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 4-24. Grooves and ports in the shaft align with ports in the housing. Seals between the grooves of the shaft inhibit leakage between the passages. The seals fit tightly against the housing. The housing rotates with the mast and the shaft is stationary.

Functions

The 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 (main winch) 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 (main winch) 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 raised. When lowering 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 lowered. When raising 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 extended. When retracting the boom the hydraulic oil under low pressure flows through this port.

Port No. 6

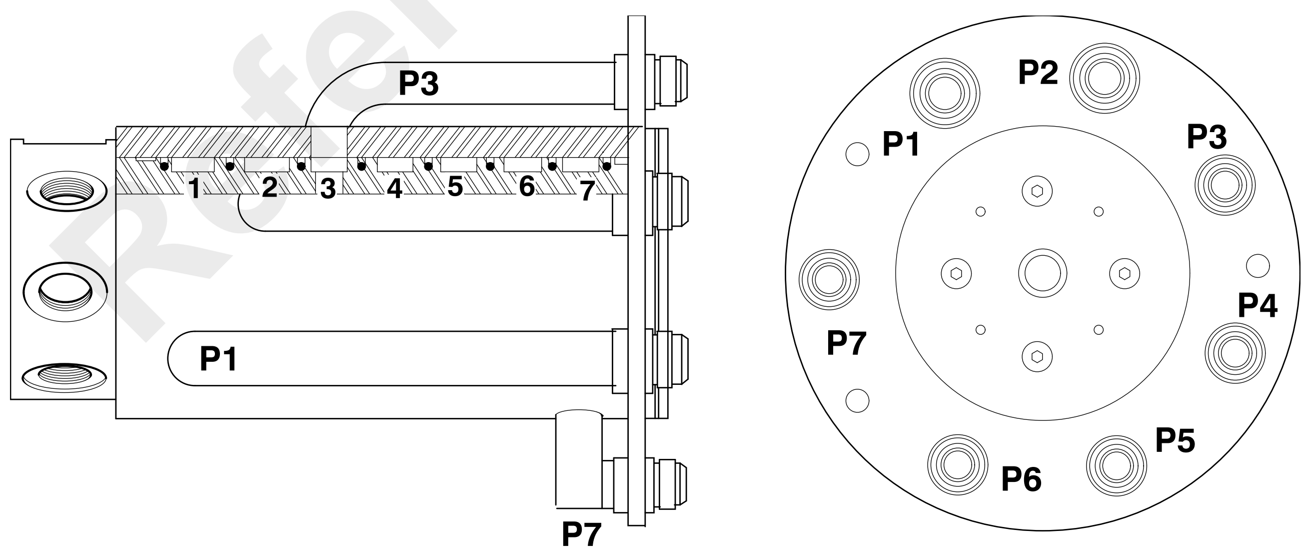
Hydraulic oil under pressure flows through this port when the boom is being retracted. When extending the boom the hydraulic oil under low pressure flows through this port.

Port No. 7

Hydraulic oil under low pressure flows through this port from the winch 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.



a0466

Hydraulic Swivel Port Arrangement, Typical

FIGURE 4-24

CROWD CIRCUIT

General

The crowd circuit includes the crowd cylinder, a holding valve, ports 5 and 6 of the hydraulic swivel, an anti-double block cutout solenoid valve, a section of the main control valve, and the hydraulic lines.

Oil Flow

Crowd Out

Pushing the handle spool OUT connects the supply from the pump to cylinder port A of the control valve section Figure 4-25. Oil leaves Port A and is routed through the hydraulic swivel port 6 to the base end of the cylinder.

In the extending direction, oil flows freely through the holding valve and into the base end of the cylinders. The cylinders extend and push oil ahead of the piston through the rod end port of the cylinders. 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 crowd 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 winch before he can extend the boom.

Crowd In

Pulling the handle spool IN routes oil out of valve port B and through the port 5 of the hydraulic swivel to the rod port of the hydraulic cylinders Figure 4-26. 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 cylinders. When the pressure is high enough to open the holding valve, the cylinder retracts. See Holding Valve.

Oil from the rod end of the cylinders return 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.

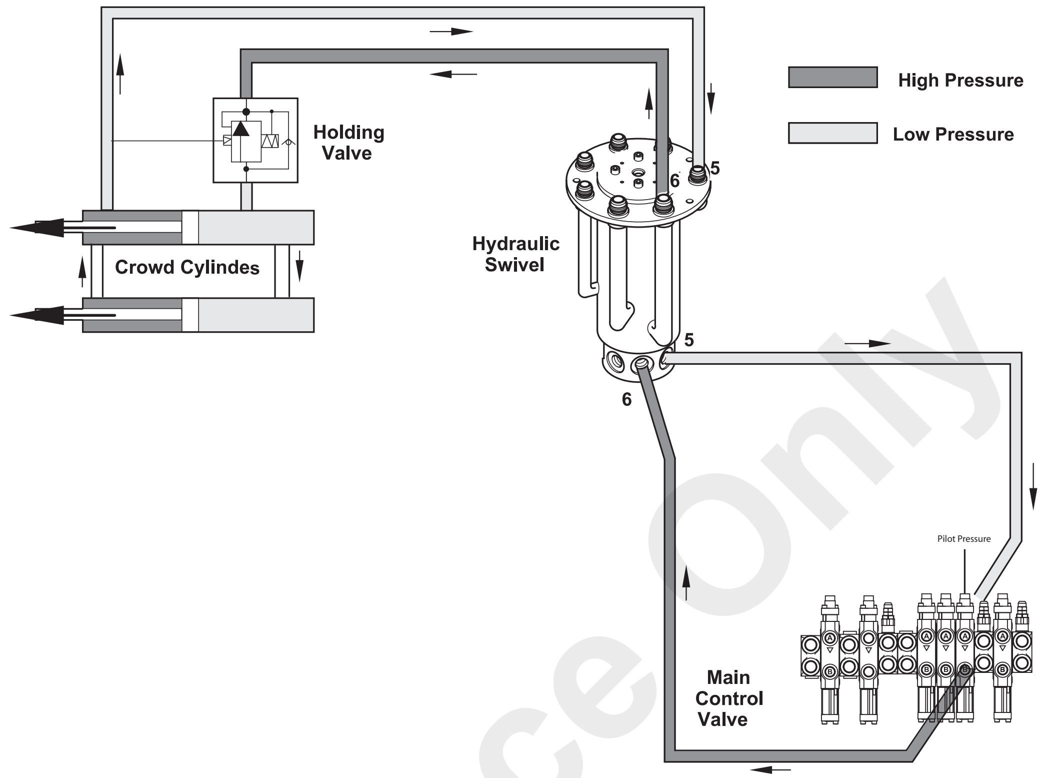
Pilot pressure from the rod side of the piston opens the holding valve. If the cylinder starts to retract faster than the pump can fill the cylinder, there will be a decrease in the pilot pressure. The holding valve will close and interrupt the flow of oil from the cylinder. The holding valve will interrupt 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

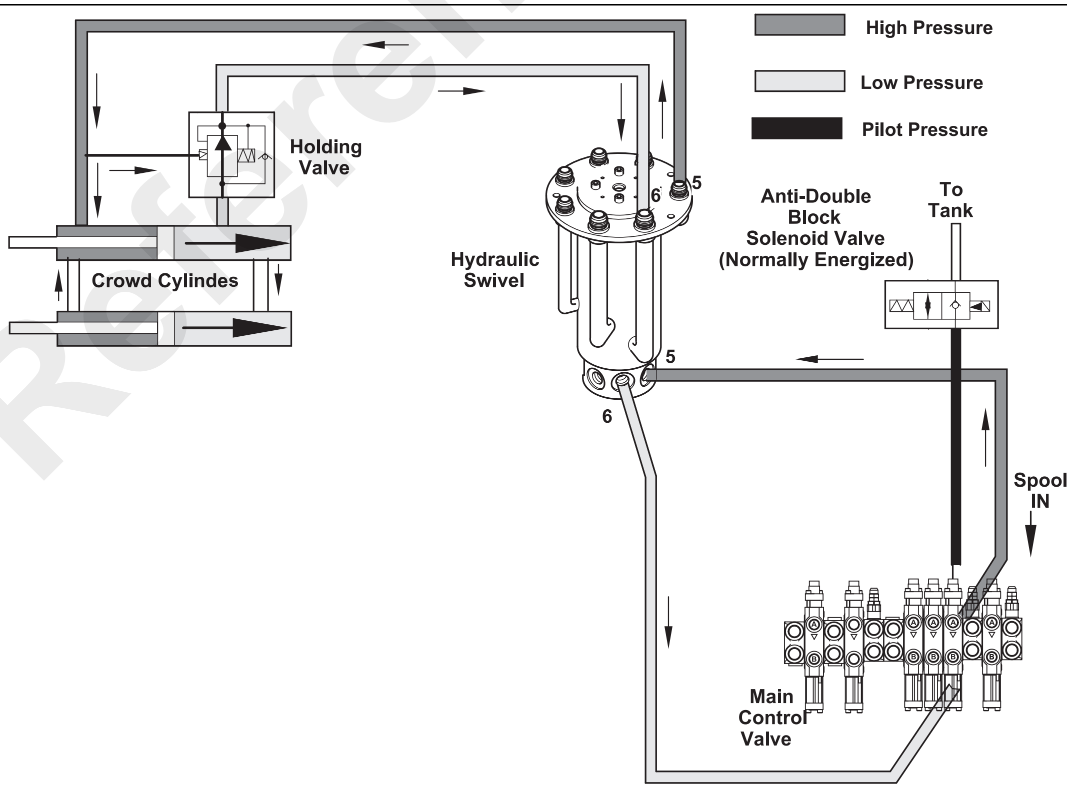
Do not adjust the holding valve setting. The valve is adjusted by the manufacturer.

4



Oil Flow - Crowd Out

FIGURE 4-25



Oil Flow - Crowd Out

FIGURE 4-26

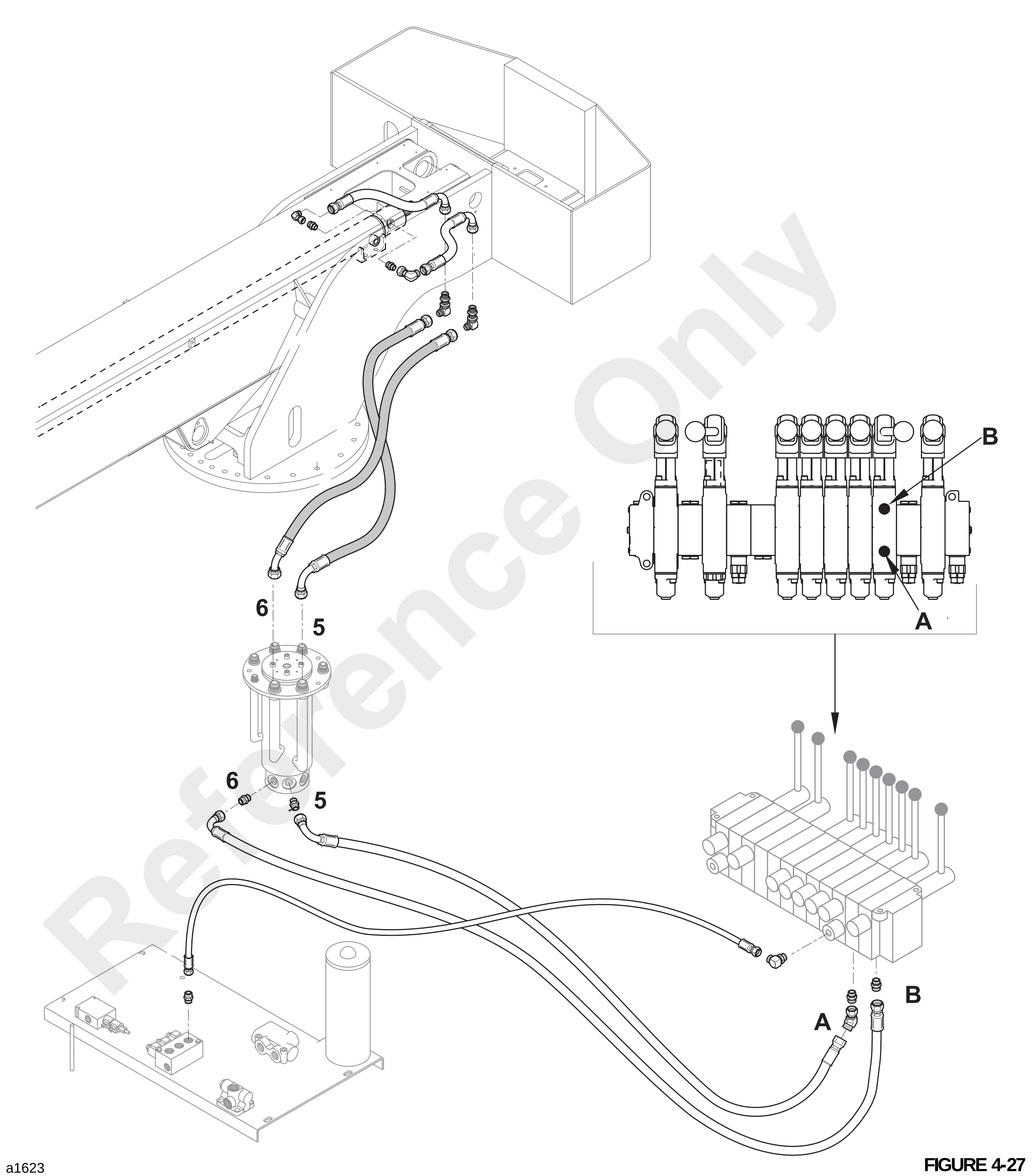


FIGURE 4-27

Crowd Cylinders Leakage Test

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

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 4-27 which connects to the rod port of the crowd 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 Hydraulic Swivel information in this section.

MAIN WINCH CIRCUIT

General

The main winch circuit includes the winch motor, a brake, a brake holding valve, ports 1 and 2 of the hydraulic swivel, an anti-double block solenoid valve, the spool section of the control valve and the hydraulic lines.

Oil Flow

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

Winch Up

Pulling the handle spool IN routes oil from the front pump to port B of the spool in the control valve Figure 4-28. From here the oil is routed through swivel port 1 to the brake holding valve. In this direction, the oil flows freely through the brake holding valve to the winch motor.

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

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

The oil turns the motor and returns through swivel port 2 to the control valve. From here, the oil is sent back through the filter to the hydraulic tank.

Winch Down

Pushing the handle spool OUT sends oil from cylinder port A of the spool in the control valve though swivel port 2 to the winch motor Figure 4-29. 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 winch brake to disengage. The oil then returns through swivel port 1 to the control valve and back to the tank.

Drain Line

A drain line is connected to the winch 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.

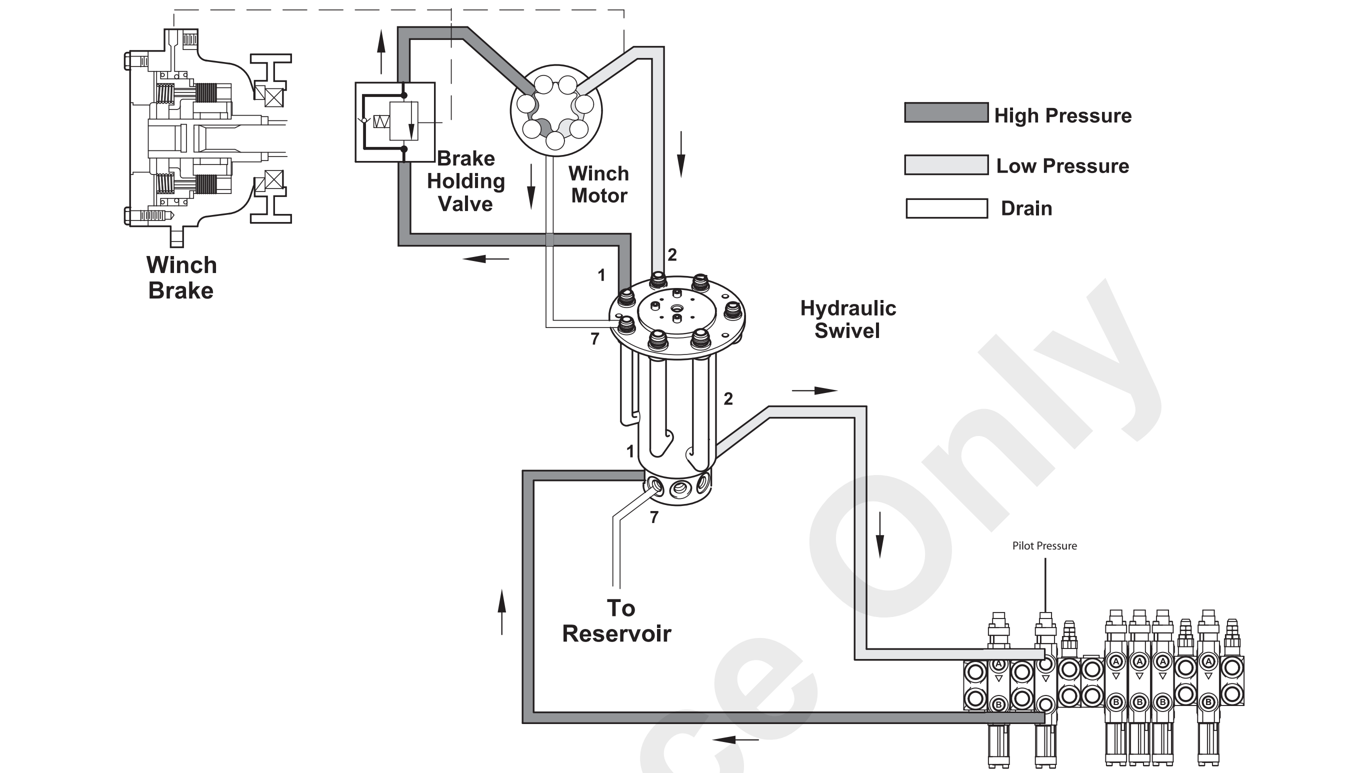
Engine speed is important for smooth operation. At low engine speed, normally there will not be enough oil from the pump to keep the motor turning. As a result, the load will move down in a movement that is not regular.

WARNING

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

Hydraulic Swivel

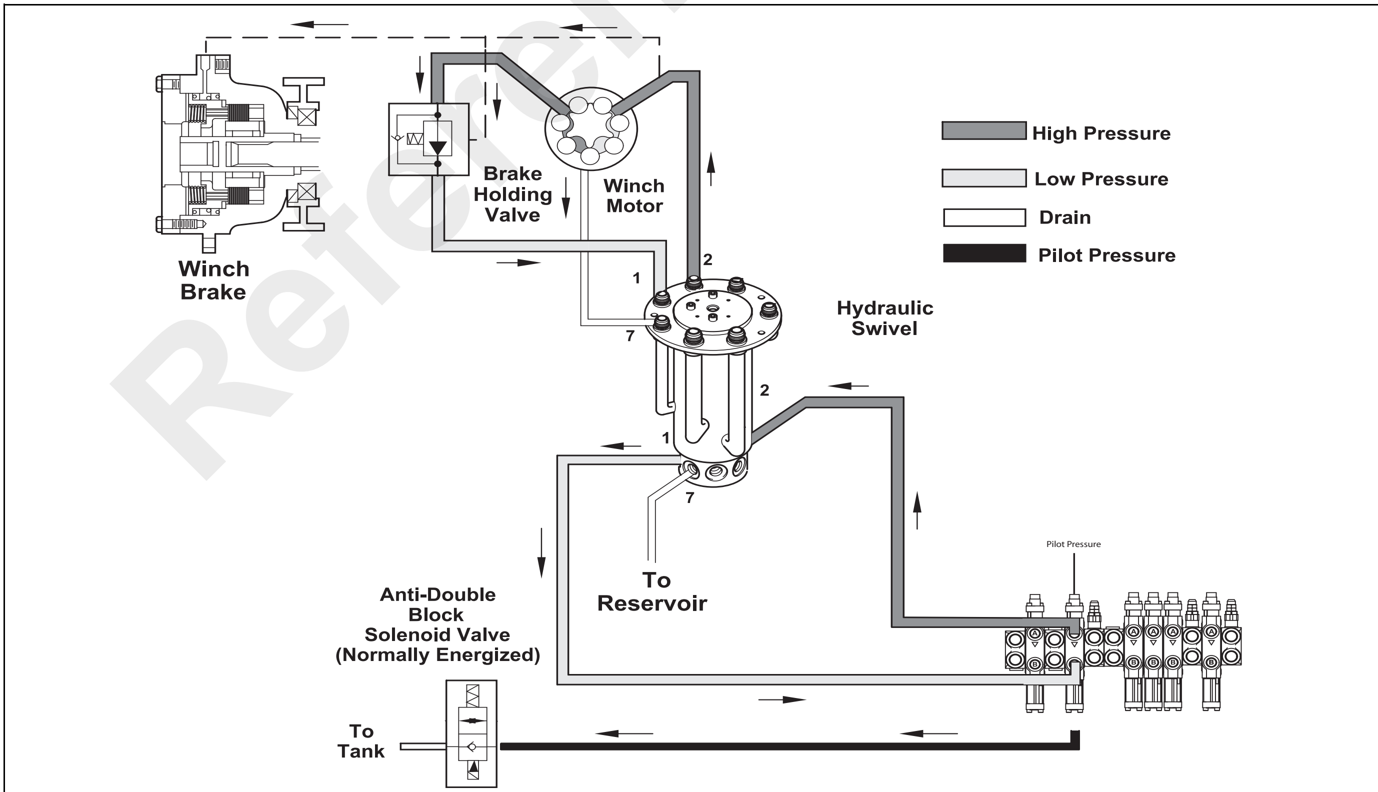
See Hydraulic Swivel information in this section.



a1626

Oil Flow - Winch Up

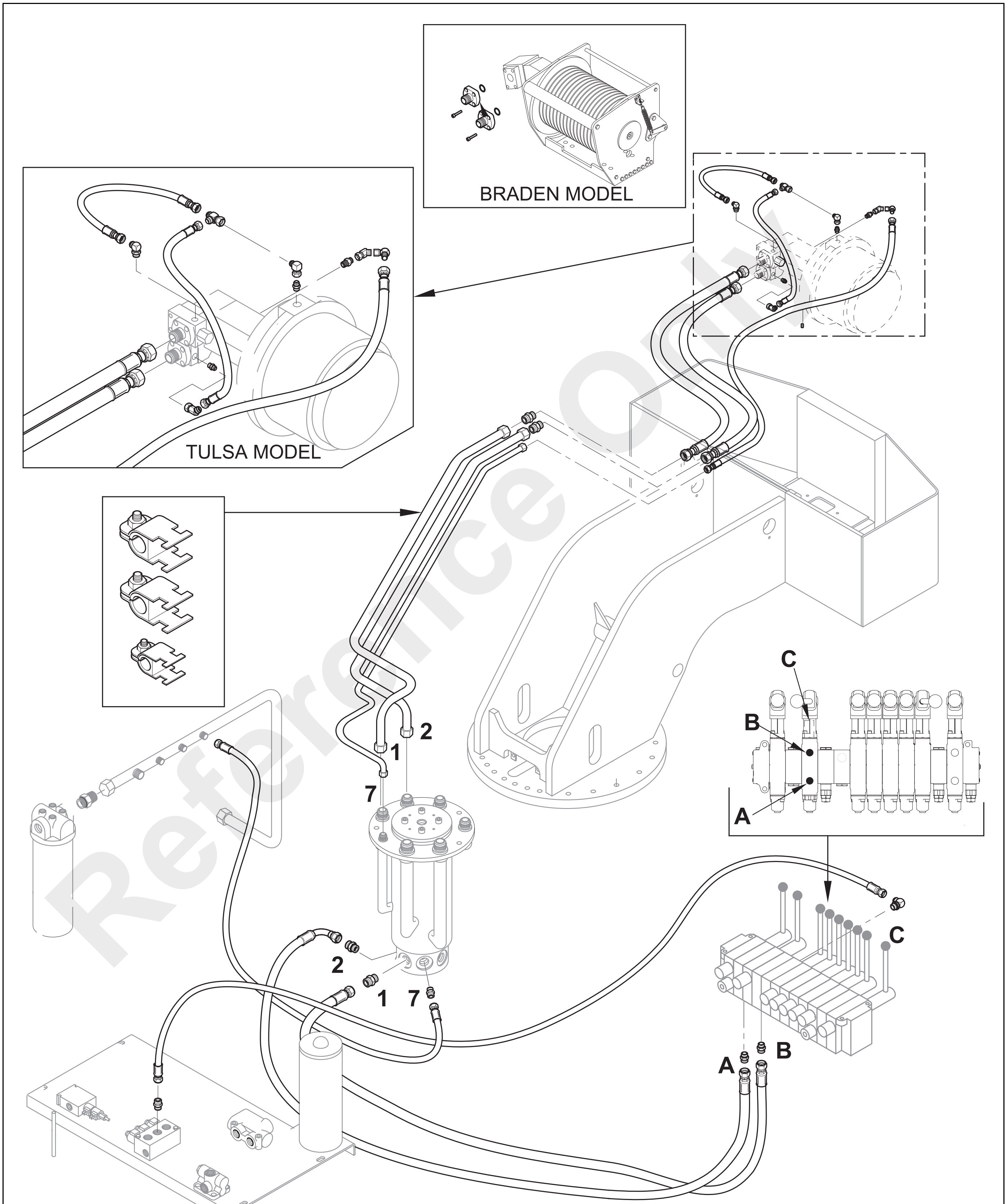
FIGURE 4-28



a1627

Oil Flow - Winch Down

FIGURE 4-29



Winch Circuit Hydraulic Lines

FIGURE 4-30

SWING CIRCUIT

General

The swing motor is controlled by a spool in the control valve Figure 4-31. In the neutral position, oil is held in the circuit and the motor is prevented from turning. The gear/pinion is protected by a main relief valve set at 2400 psi (16 547 kPa) in both swing directions.

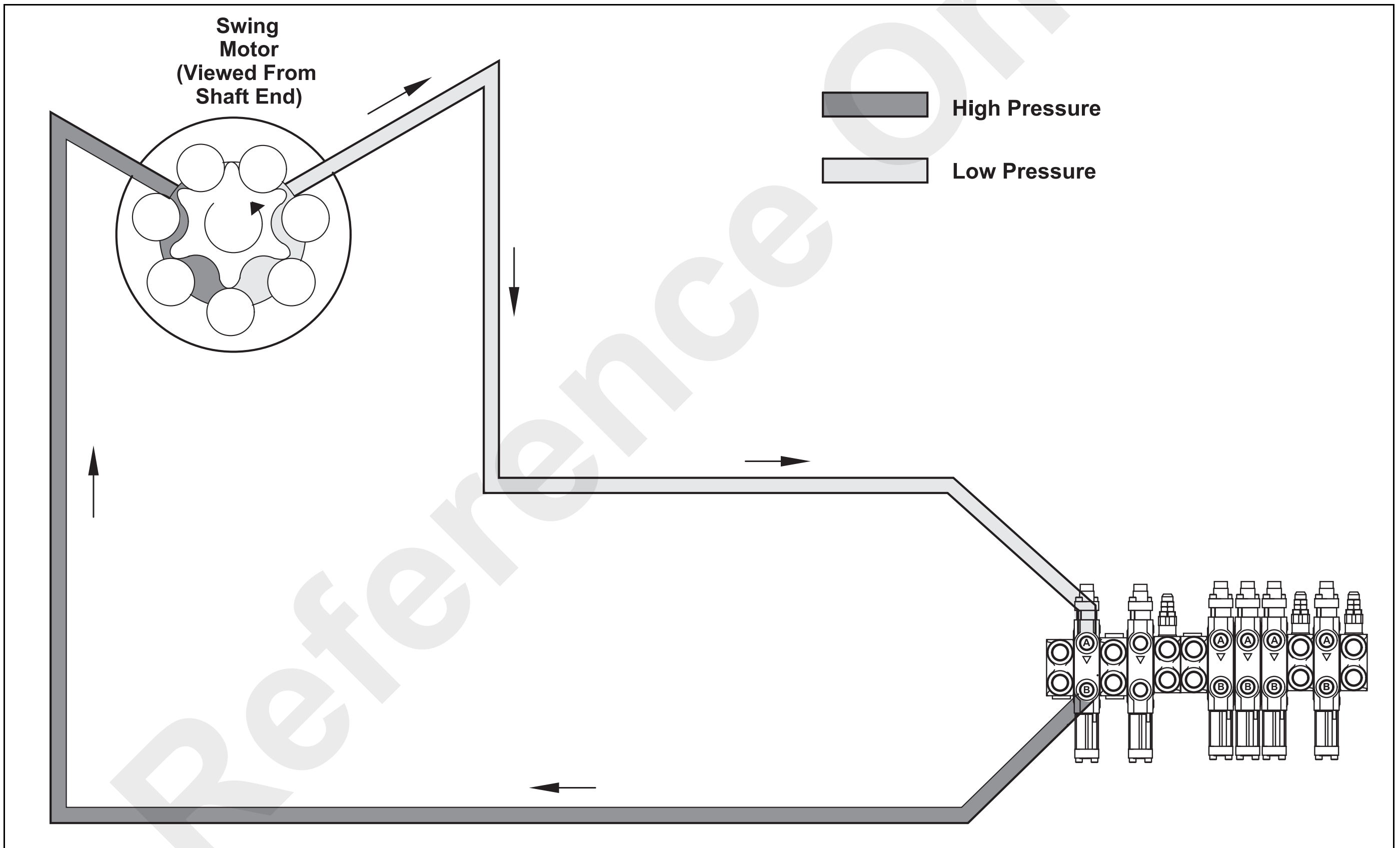
Oil Flow

Swing Right

Pushing the handle spool OUT sends oil through motor port B 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 A port and sent back to tank through the return filter.

Swing Left

Pulling the handle spool IN sends oil through motor port A 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 B port and is sent back to the tank through the return filter.



Oil Flow - Swing Right

FIGURE 4-31

ANTI-DOUBLE BLOCKING SYSTEM

General

The anti-double block circuit protects the hoist, telescope and lift circuits from damage in the event that the hoist block comes in contact with the boom head causing a double blocking situation. The anti-double block system includes an anti-double block mechanism Figure 4-32 at the end of the boom head, a valve block with three normally closed solenoids Figure 4-33, and a check valve in the main control valve sections for lift, telescope and hoist functions.

p1622

Anti-Double Block Bracket

p1873

FIGURE 4-32

Anti-Double Blocking Solenoids

Valve Location

p1874

FIGURE 4-33

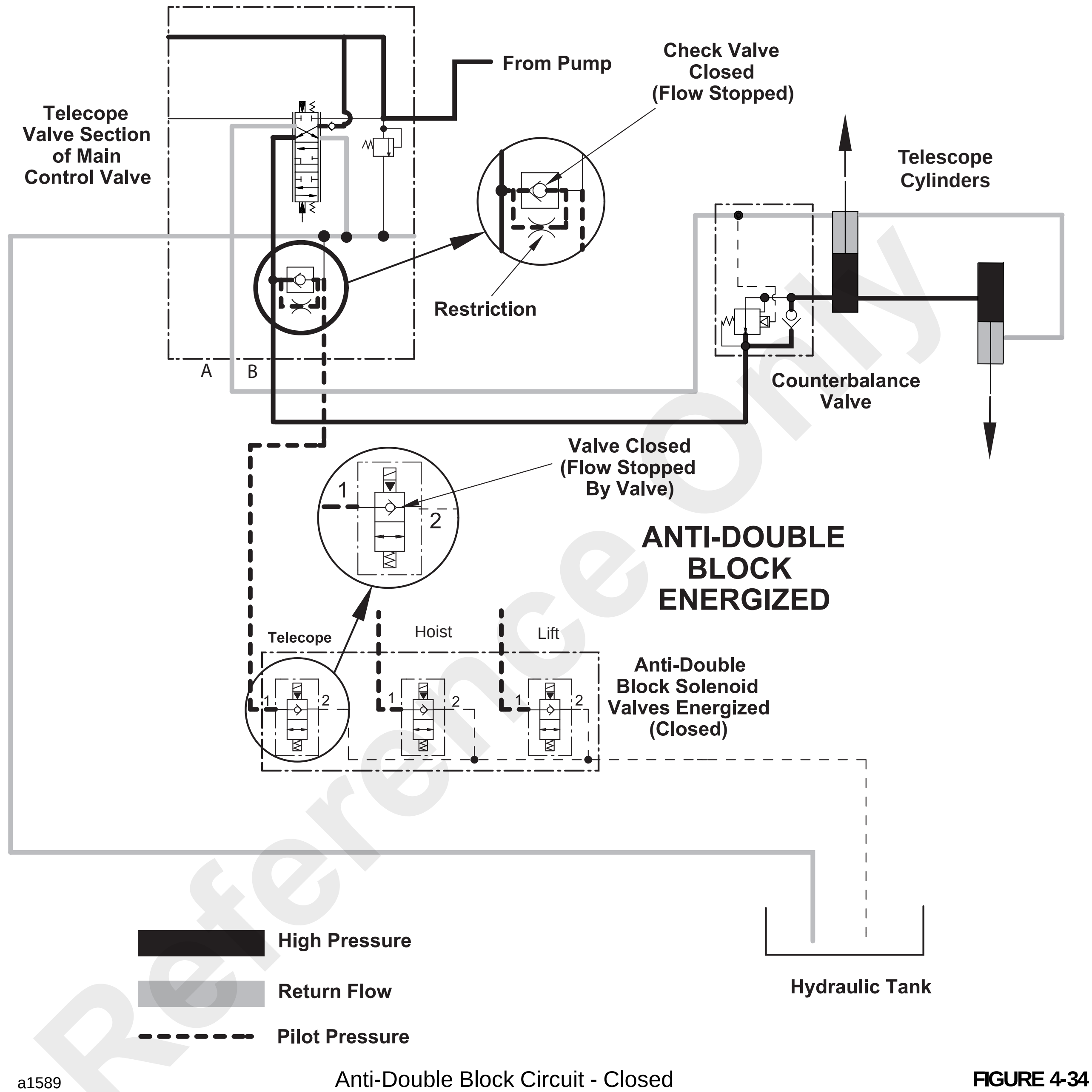
System Function

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

During normal operation the solenoid valves are in the closed (energized) position Figure 4-34. 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.

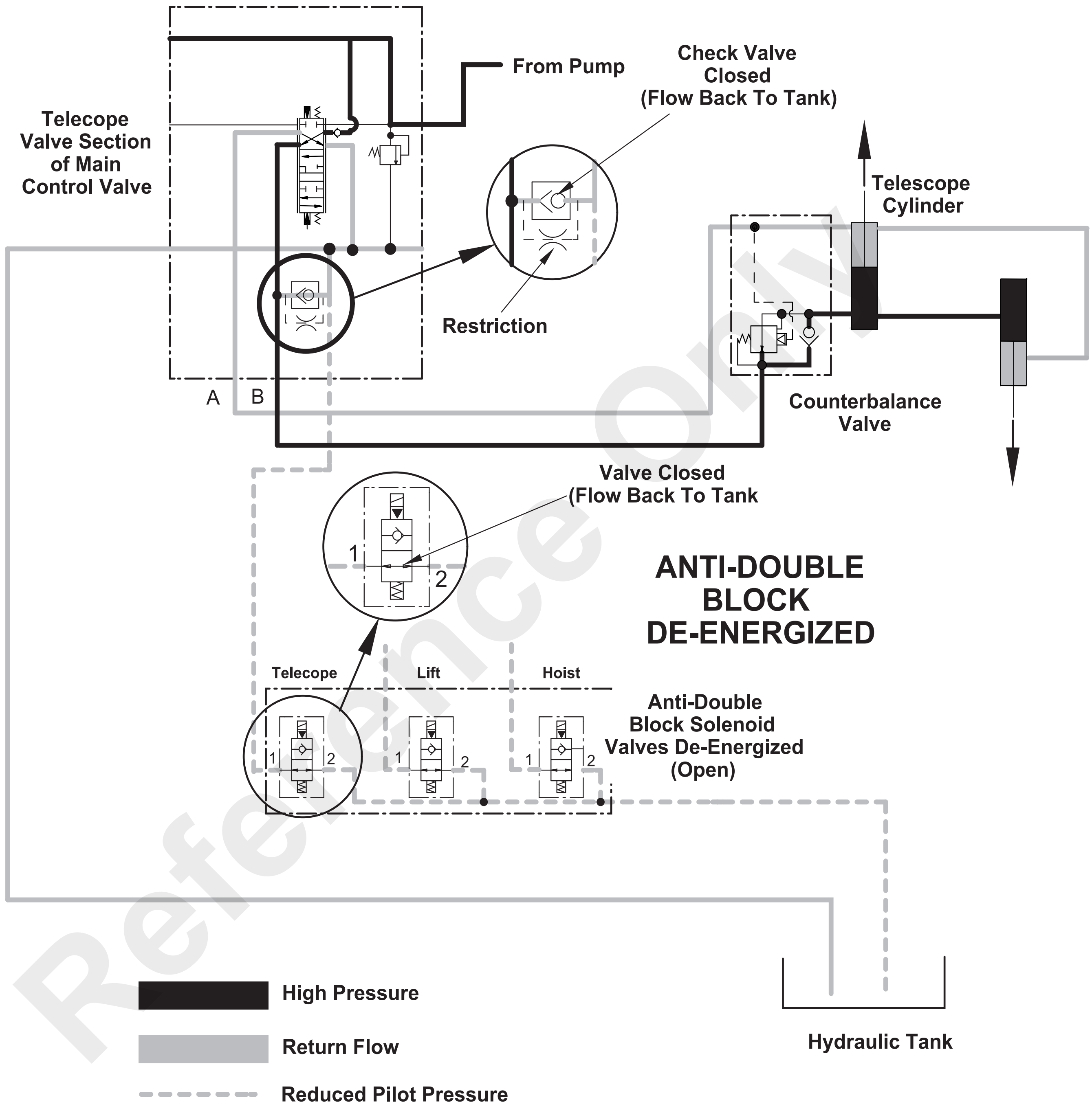
When the hoist block comes in contact with the anti-double blocking bracket at the end of the boom head, the bracket raises and actuates a switch. This switch, when actuated, removes the electrical signal to the three solenoid valves opening them Figure 4-35. With the solenoid valves open, oil supply 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 opens, hydraulic oil which would normally flow to the lift cylinder, telescopic cylinder or hoist motor through port A or port B 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 or port B to the function.



Anti-Double Block Circuit - Closed

FIGURE 4-34



a1590

Anti-Double Block Circuit - Open

FIGURE 4-35

OUTRIGGER CIRCUIT

General

Two outrigger hydraulic systems are available on the crane:

- Standard outrigger controls.
- Optional independently controlled outriggers.

Standard Outrigger Hydraulic System

The standard outrigger hydraulic system (Figure 4-36) includes the four outriggers cylinders with holding valves, two sections of the main control valve and the hydraulic lines.

Optional Independently Controlled Outrigger Hydraulic System

The optional independently controlled outrigger hydraulic system (Figure 4-37) includes the four outrigger cylinders with holding valves, four sections of the main control valve and the hydraulic lines.

Oil Flow

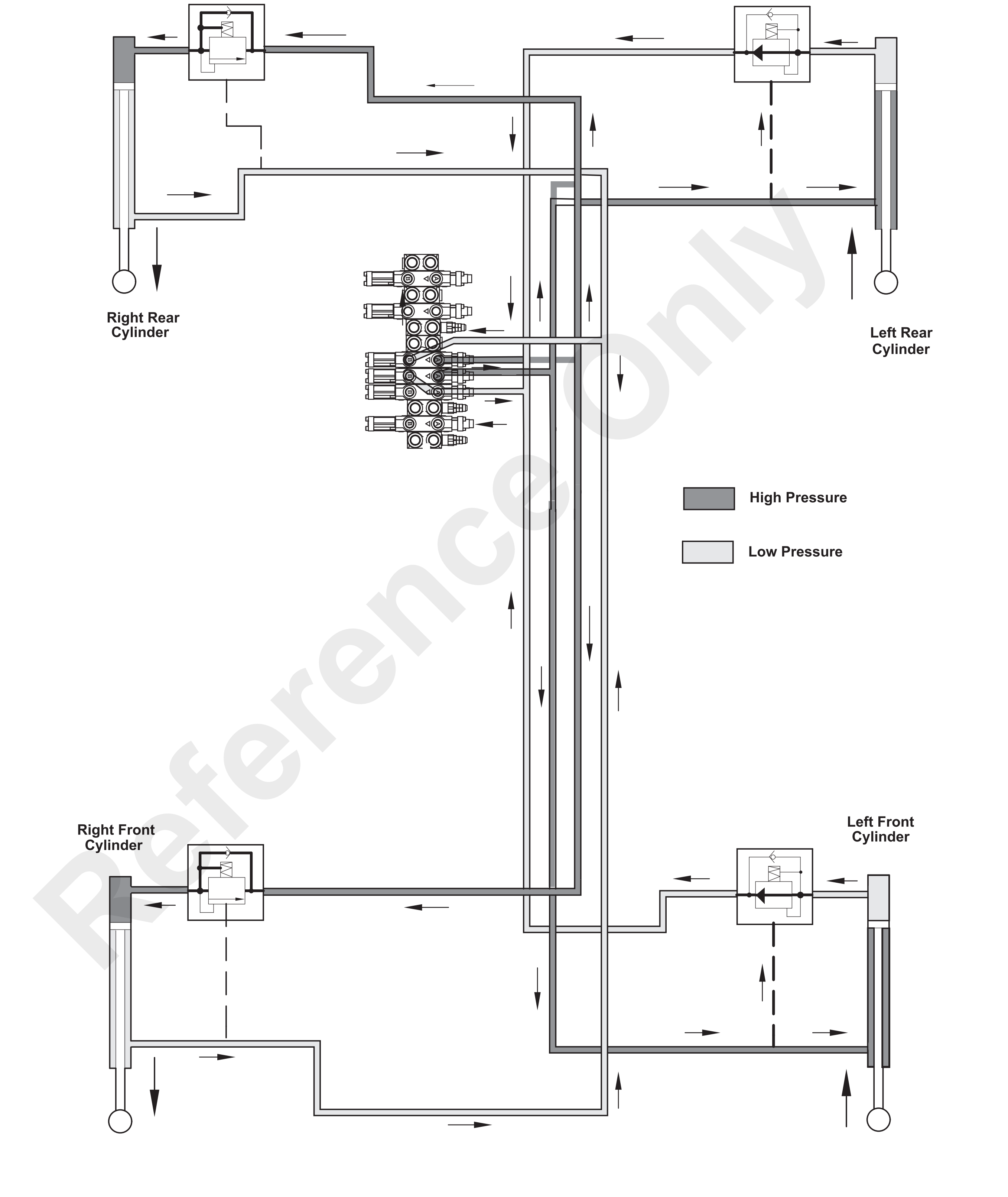
Outrigger Down

Pushing the handle (pushing the valve spool IN), routes oil out of the valve port A (Figure 4-38 and Figure 4-39) to the base end of the hydraulic cylinder.

In the down 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 to port B of the control valve. From here, the oil is routed into the tank passage and returns through the main filter to the hydraulic tank.

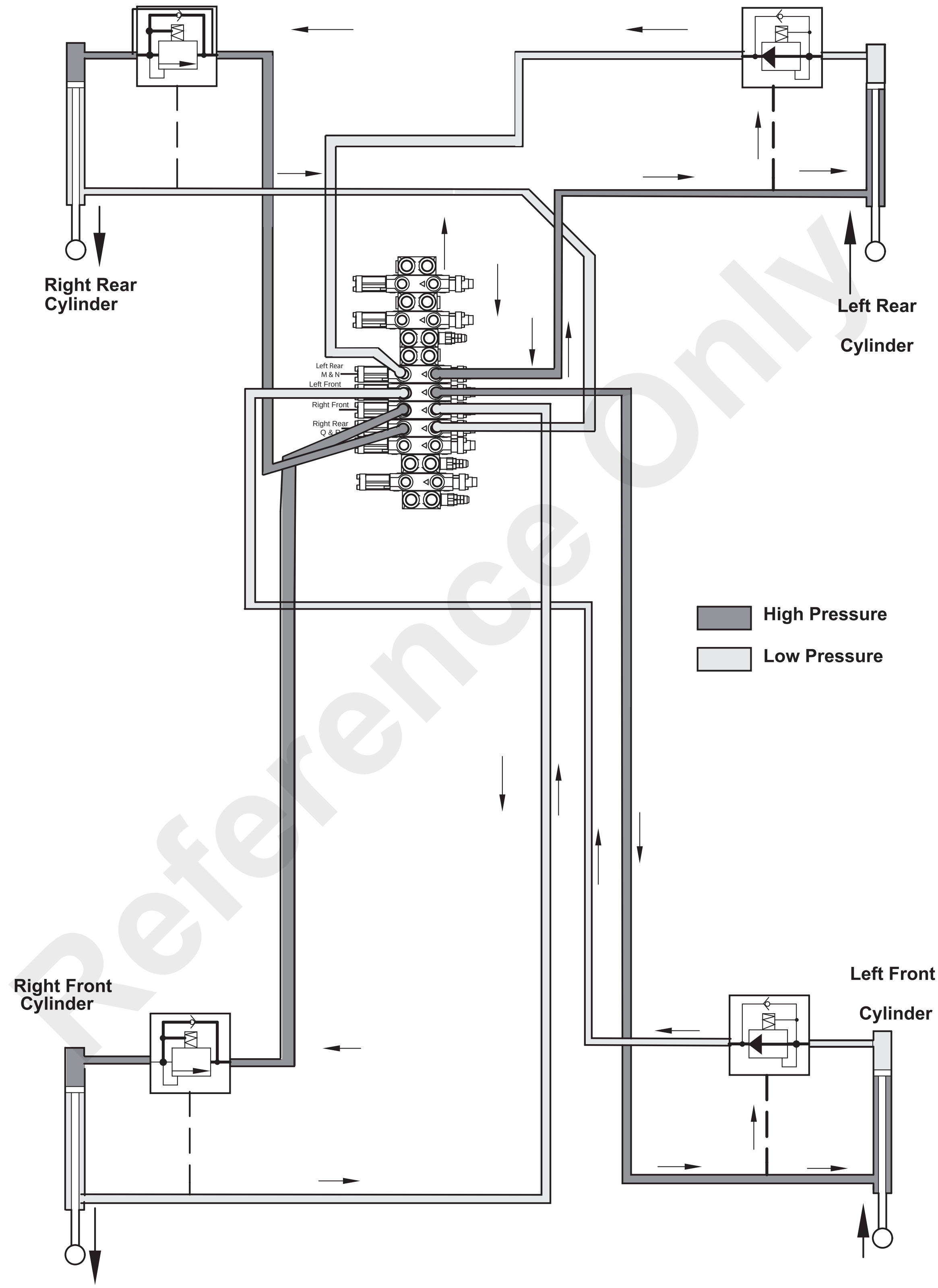
Outrigger In

Pulling the handle (pulling the valve spool OUT), routes oil out of the valve port B (Figure 4-38 and Figure 4-39) to the rod end of 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 Load Holding Valve. Oil from the rod end of the cylinder returns to port A of the control valve. From here, the oil is routed into the tank passage and returns through the main filer to the hydraulic tank.



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

FIGURE 4-36



a0406

Oil Flow - Vertical Outrigger Extend and Retract
(Optional Independently Controlled Outriggers

FIGURE 4-37

Load Holding Valves

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

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

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

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

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

Outrigger Cylinder Leakage Check

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

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

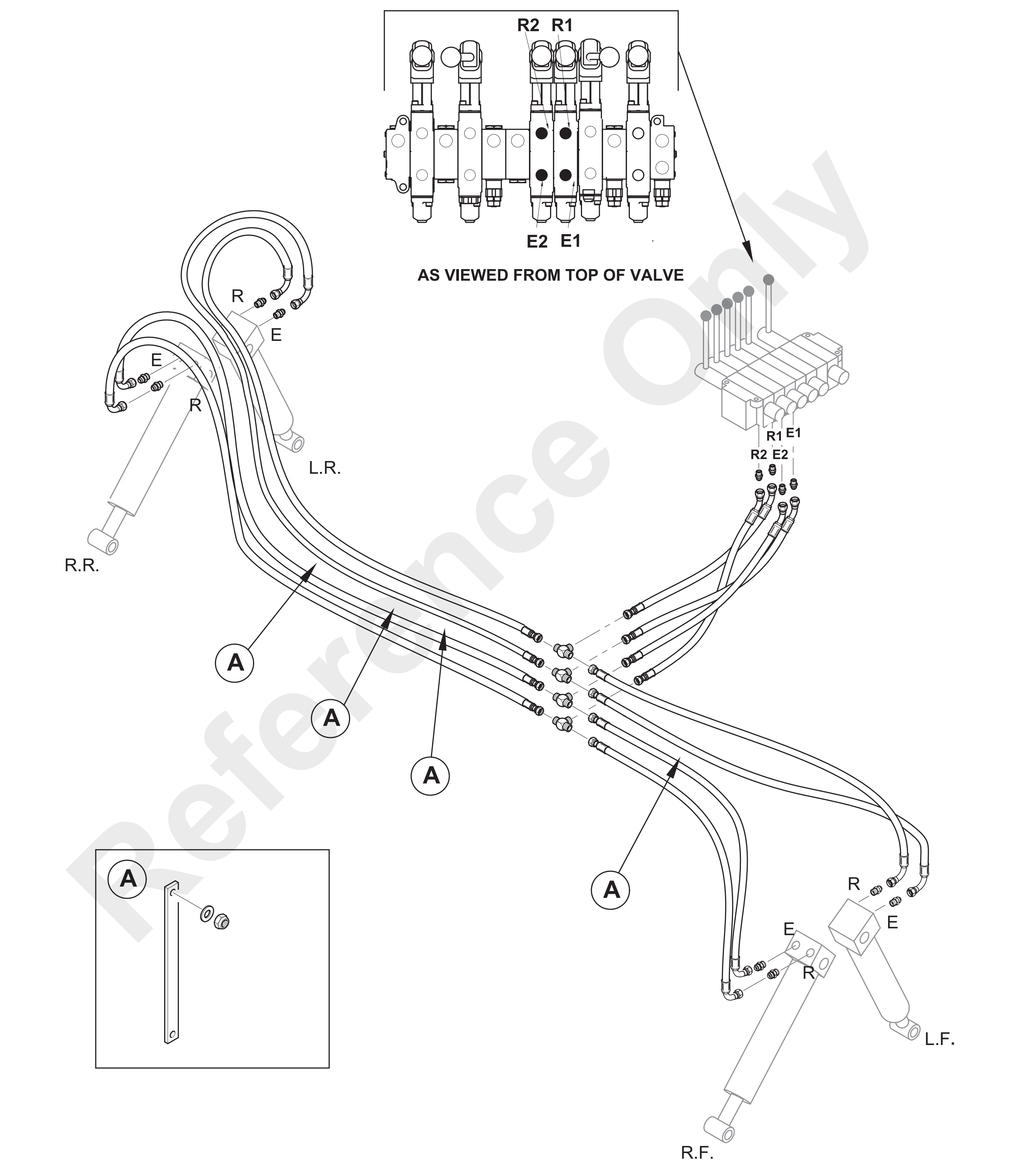
AXLE LOCKOUT CIRCUIT

General

The axle lockout hydraulic system (Figure 4-40) includes the accumulator charging valve, the axle lockout solenoid valve, two axle lockout hydraulic cylinders, an the hydraulic lines.

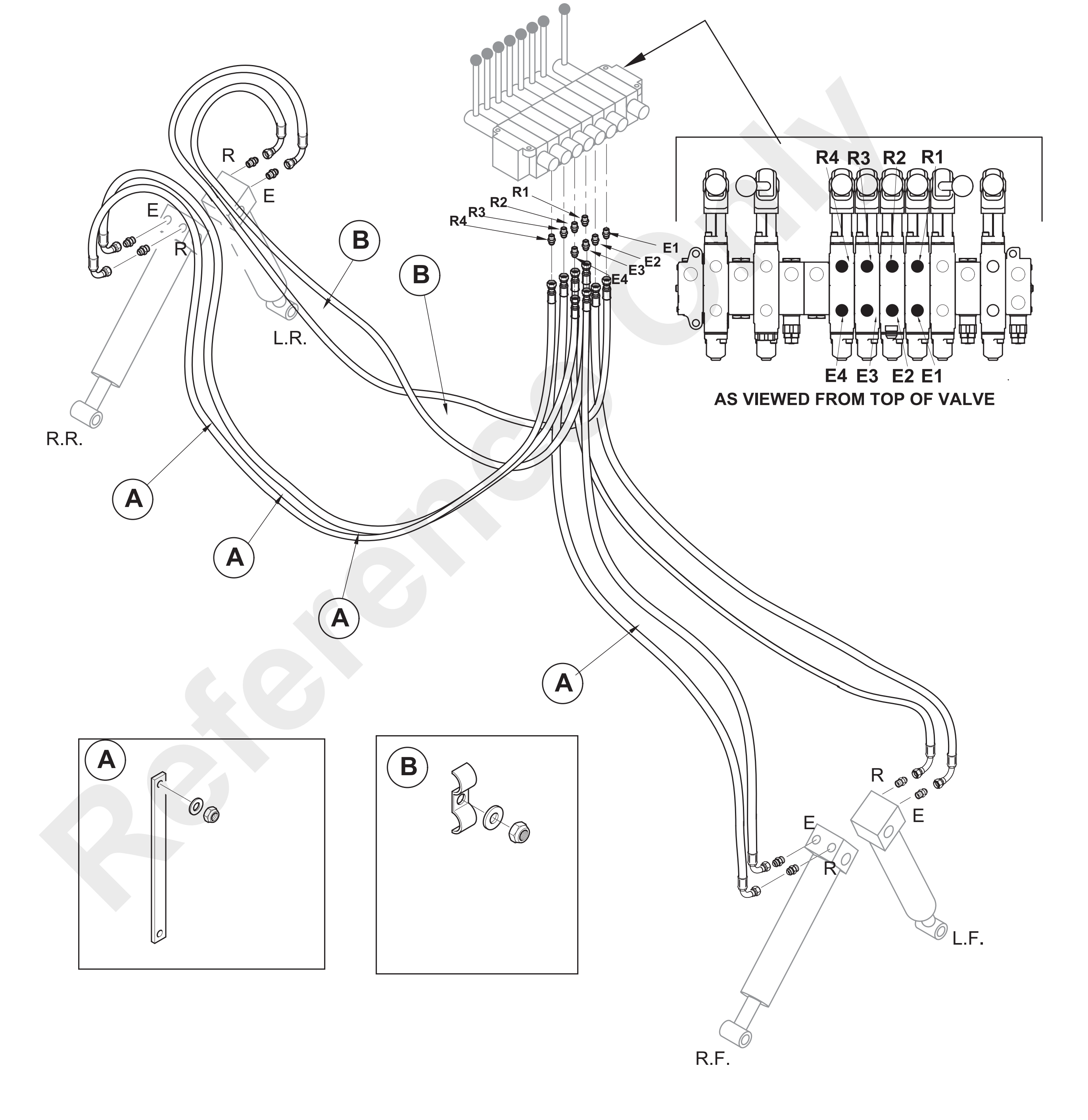
Oil Flow

Oil flow from the accumulator charge valve flows to the axle lockout solenoid valve. With the axle lockout disengaged solenoid energized, the solenoid spool is shifted to allow oil to flow from the barrel end of one cylinder to the rod end of the other as one side of the axle is forced up by traveling over uneven terrain. The system is not pressurized and oil is moved from one cylinder to the other as the action of the axle moving the cylinders. When the axle lockout engaged solenoid is energized, the solenoid spool shifts to block oil movement from one cylinder to the other providing a hydraulic lock holding the axle rigid.



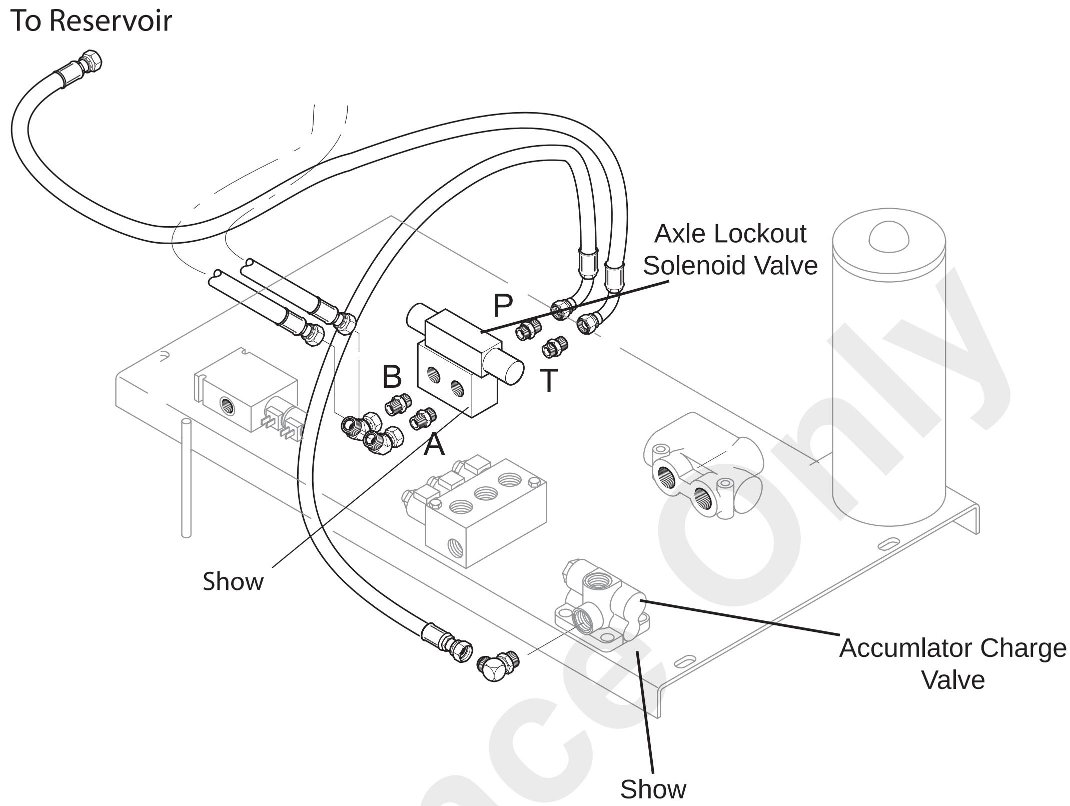
Outrigger Hydraulic Lines (Standard Outriggers)

FIGURE 4-38



Outrigger and Hydraulic Lines (Optional Independent Outriggers)

FIGURE 4-39



a0407

Oil Flow - Axle Oscillation Lockout (Axle Locked)

FIGURE 4-40

COMPONENT REPAIR

Hydraulic Pump Repair

Removal

1. Drain the oil from the hydraulic tank.
2. Disconnect the inlet and outlet lines from the pump. Place caps on the lines and plugs in the open ports of the pump to keep dirt out of the system.

CAUTION

The pump is heavy. Use a sling and overhead crane or a support to hold the pump in position while removing the mounting hardware.

---

3. Remove the pump mounting bolts and lockwashers. Remove the pump from the transmission,.
4. Take the pump to a clean work area or disassembly.

Disassembly

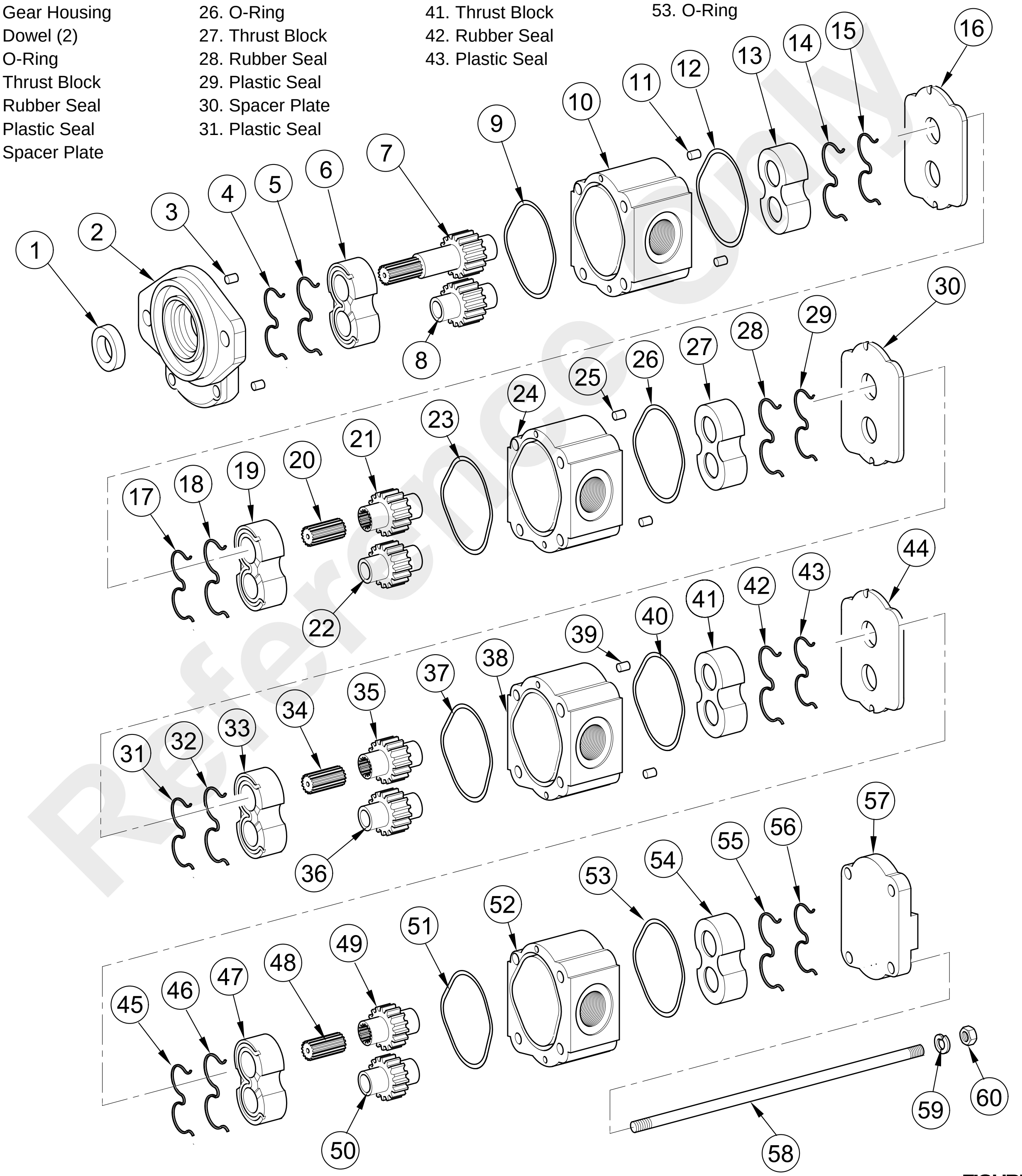
CAUTION

Seals are the only recommended service parts for this pump because it is economically unfeasible to repair the pump; service parts and labor to install the parts will often exceed a new pump cost. Also, replacing one or more components of the pump will affect volumetric efficiency. Once a pump is broken in the components wear patterns match the components' wear patterns producing a "customized" fit. Changing components will affect the "custom" fit.

NOTE: Before disassembling the pump, ensure that the pump, bench and tools are thoroughly clean.

1. Lightly mark the shaft end cover **2** Figure 4-41, gear housings (**10**, **24**, **38** and **52**) and port end cover **57** to ensure proper assembly.
2. Clamp the shaft end cover **2**, with shaft pointing down, in a vice.
3. Remove mounting lockwashers **59** and nuts **60**.
4. Remove port end cover **57**.
5. Remove gear housing **52**. Tap the housing with a soft hammer, if necessary.
6. Since the metal components are not replaceable there is no need to disassemble the gear housings **52**, **38**, and **24**, except for removing the seals. Remove plastic seals **45** and **56**, rubber seals **46** and **55** and o-rings **51** and **53**.
7. Remove connecting shaft **48**.
8. Remove spacer plate **44**.
9. Remove gear housing **38**. Tap the housing with a soft hammer, if necessary.
10. Remove plastic seals **31** and **43**, rubber seals **32** and **42** and o-rings **37** and **40**.
11. Remove connecting shaft **34**.
12. Remove spacer plate **30**.
13. Remove gear housing **24**. Tap the housing with a soft hammer, if necessary.
14. Remove plastic seals **17** and **29**, rubber seals **18** and **28** and o-rings **23** and **25**.
15. Remove connecting shaft **20**.
16. Remove spacer plate **16**.
17. Remove gear housing **10**. Tap the housing with a soft hammer, if necessary. Gears **7** and **8**, thrust block **6** and seals **4** and **5** will remain with shaft end cover **2**.
18. Remove thrust block **13** from gear housing **10**.
19. Remove plastic seal **15**, rubber seal **14** and o-rings **9** and **12**.
20. Push up on drive gear **7** to remove it from shaft end cover **2**. Remove driven gear **8**.
21. Remove thrust block **6**. Remove plastic seal **4** and rubber seal **5**.
22. Remove the four studs **58**.
23. Remove shaft end cover **2** from the vice. Using a flat head screw driver, remove lip seal **1** from shaft end cover **2**.

1. Lip Seal
2. End Cover
3. Dowel (2)
4. Plastic Seal
5. Rubber Seal
6. Thrust Block
7. Drive Gear
8. Driven Gear
9. O-Ring
10. Gear Housing
11. Dowel (2)
12. O-Ring
13. Thrust Block
14. Rubber Seal
15. Plastic Seal
16. Spacer Plate
17. Plastic Seal
18. Rubber Seal
19. Thrust Block
20. Connecting Shaft
21. Gear
22. Gear
23. O-Ring
24. Gear Housing
25. Dowel (2)
26. O-Ring
27. Thrust Block
28. Rubber Seal
29. Plastic Seal
30. Spacer Plate
31. Plastic Seal
32. Rubber Sea
33. Thrust Block
34. Connecting Shaft
35. Gear
36. Gear
37. O-Ring
38. Gear Housing
39. Dowel (2)
40. O-Ring
41. Thrust Block
42. Rubber Seal
43. Plastic Seal
44. Spacer Plate
45. Plastic Seal
46. Rubber Seal
47. Thrust Block
48. Connecting Shaft
49. Gear
50. Gear
51. O-Ring
52. Gear Housing
53. O-Ring
54. Thrust Block
55. Rubber Seal
56. Plastic Seal
57. End Cover
58. Stud (4)
59. Lockwasher (4)
60. Nut (4)



Hydraulic Pump

FIGURE 4-41

Assembly

1. Push lip seal **1** Figure 4-41 squarely into the recess of shaft end cover **2**. Lip seal garter spring faces in toward unit.
2. Clamp the end cover plate in a suitable vice.
3. Install a new rubber seal **5** and plastic seal **4** into groove on thrust block **6**.

NOTE: Use a light coat of grease in all seal grooves to hold seals in position.

4. Install o-rings **9** and **12** into grooves on gear housing **10**.
5. Position gear housing **10** on shaft end cover **2**, being sure the light marking made in step of disassembly are aligned. Be sure o-ring **9** stays in its groove. If necessary, use a soft hammer to tap the housing onto the shaft end cover.
6. Install thrust block **6** into gear housing **10** with the seals facing the shaft end cover. The middle of the “3” shaped seals must point to the LOW PRESSURE (inlet) side of the pump.
7. Install drive gear **7** and driven gear **8**. Make sure to cover the spines of the gear with a protective sleeve, such as mylar, to protect the lip seal from being damaged by the splines. When the drive gear shoulder meets the lip seal a firm push should overcome the resistance allowing the gear to rest on the thrust block.
8. Install thrust block **13** into gear housing **10**.
9. Install rubber seal **14** and plastic seal **15** into groove of thrust block **13**.
10. Install spacer plate **16** over gear housing **10**.
11. Install connecting shaft **20** into drive gear **7**.
12. Install rubber seals **18** and **28** and plastic seals **17** and **29** into grooves of thrust blocks **19** and **27**. Install o-rings **22** and **26** into grooves on gear housing **24**.
13. Install assembled gear housing **24** onto spacer plate **10**, being sure the light marking made in step of disassembly are aligned. Be sure seals and o-ring remain in their respective grooves. If necessary, use a soft hammer to tap the housing onto the spacer plate.
14. Install spacer plate **30**.
15. Install connecting shaft **34** into gear **21**.
16. Install rubber seals **32** and **42** and plastic seals **31** and **43** into grooves of thrust blocks **33** and **41**. Install o-rings **37** and **40** into grooves on gear housing **38**.
17. Install assembled gear housing **38** onto spacer plate **30**, being sure the light marking made in step of disassembly are aligned. Be sure seals and o-ring remain in their respective grooves. If necessary, use a soft hammer to tap the housing onto the spacer plate.
18. Install spacer plate **44**.
19. Install connecting shaft **48** into gear **21**.
20. Install rubber seals **46** and **55** and plastic seals (**45** and **56** into grooves of thrust blocks **47** and **54**. Install o-rings **51** and **53** into grooves on gear housing **52**.
21. Install assembled gear housing **52** onto spacer plate **30**, being sure the light marking made in step of disassembly are aligned. Be sure seals and o-ring remain in their respective grooves. If necessary, use a soft hammer to tap the housing onto the spacer plate.
22. Install port end cover **57** over gear housing **52**.
23. Install studs **58**, lockwashers **59** and nuts **60**. Tighten the nuts to a torque of 1000 in-lb. (113 Nm).

Installation

1. Slide the drive coupling over the spline shaft of the pump.
2. Using a hoist and sling or support, position the pump and new gasket over the spline shaft of the transmission.
3. Install two bolts and lockwashers and tighten.
4. Connect the inlet and outlet lines to the pump.
5. Fill the hydraulic tank with recommended hydraulic oil.
6. Start the engine and let in run for several minute. Then, actuate each hydraulic function to release any air in the hydraulic circuits.
7. Check oil level in the hydraulic tank and fill if necessary.

Main Control Valves

General

The main control valves are 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 or both. A thorough cleaning of the valve and replacement of seals will generally remedy a leaking problem. Extreme care must be taken when disassembling and assembling valves 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 and relieve all hydraulic pressure in lines and hoses connected to the valve.
2. Thoroughly clean the outside of the valve and surrounding tube lines.
3. Disconnect, mark for assembly and plug all lines and hoses attached to the valve assembly.
4. Remove t he four bolts, washers, lockwashers and nuts securing the valve mounting plate to the dash.
5. Loosen and remove the four bolts, washers, lockwashers and nuts securing the valve assembly to the mounting plate. Remove the valve and take to clean work area.

Disassembly

Complete Valve Assembly

NOTE: Although the following procedures are for disassembling the three-spool main control valve, the procedures may be used for disassembling the one-spool main control valve.

1. Place the valve assembly on the work bench with the outlet section facing up.
2. Remove the three nuts from the studs at the outlet section **16** Figure 4-42.
3. Lift off the outlet section **16** from the studs.

CAUTION

Be careful when separating the valve sections. The three spool sections have spring-loaded load check assemblies. The spring could fly out of the valve section when the section is removed.

---

4. Lift off boom lift spool section **8**.
5. Lift off mid-inlet section **15**.
6. Lift off winch spool section **8**.
7. Lift off mid-inlet sections **14** and **13**.
8. Lift of outrigger spool section **9**.
9. Lift off the telescope spool section **8**.
10. Lift off mid-inlet section **6**.
11. Lift off swing spool section **5**.
12. Remove the tie rods **17** from the outlet section **2**.
13. Remove and discard all o-rings **3** from the valve sections.

Spool Valve Sections

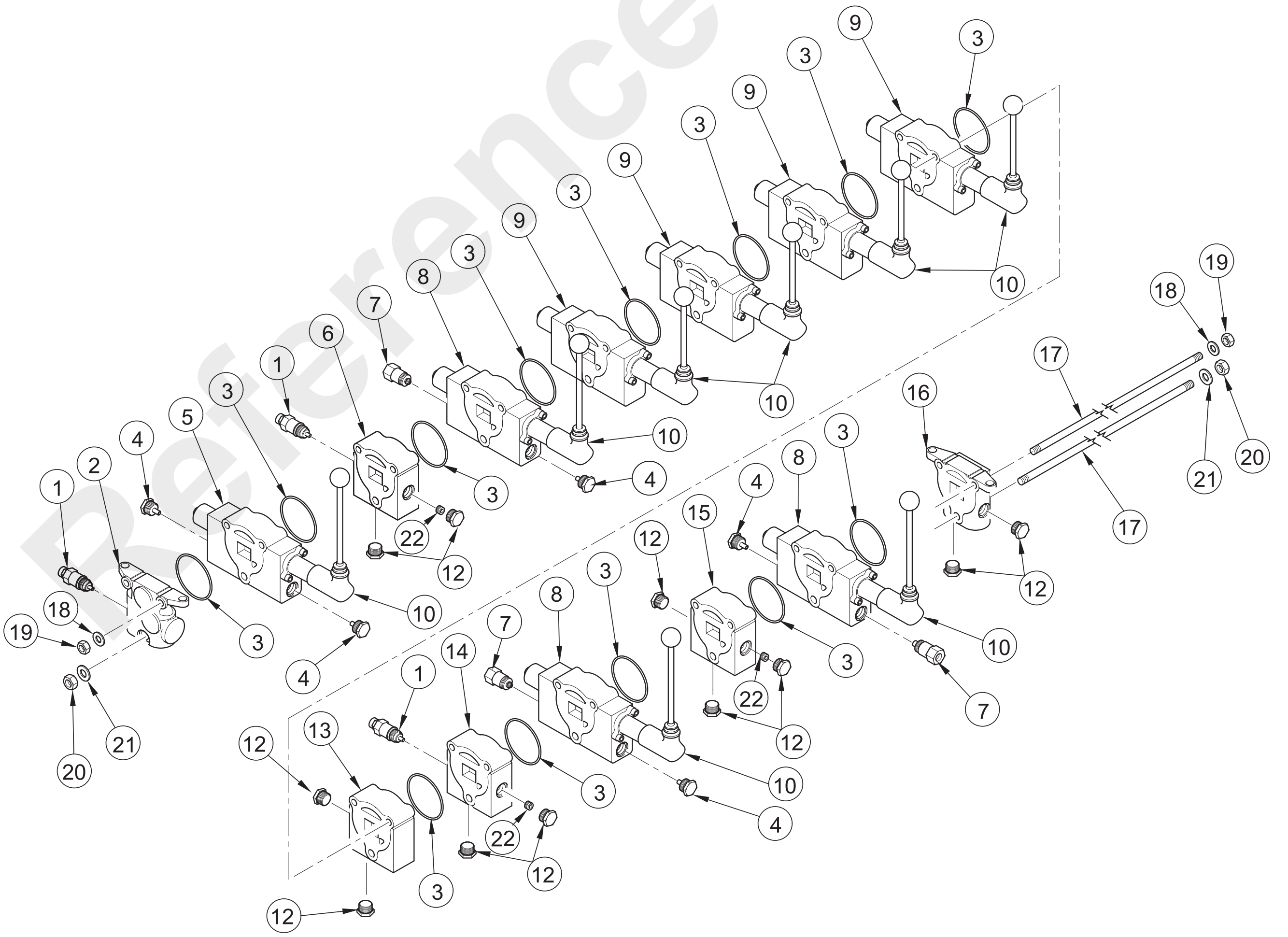
1. Remove the load check spring **4** Figure 4-43 and load check poppet 3.
2. Remove the handle assembly from the spool valve section.
3. Remove the seal plate **7** and remove and discard the wiper seal **6** and o-ring **5**.
4. Loosen and remove the two hex socket cap screws **16**. Remove the seal plate **11** and cap **15**.
5. Slowly loosen screw **14**. The screw is under spring pressure be sure to hold the spring seats **12** and spring 13 when removing screw **14**.
6. Remove spring seats **12**, spring **12** and screw **14**.
7. Remove and discard o-ring **9** and wiper seal **10**.

Assembly

Spool Valve Sections

1. If the valve spool was removed from the valve housing, apply a good grade of petroleum jelly to the spool and then insert the spool into the housing.
2. Coat all seals with a light coat of hydraulic oil, then install o-ring **9** Figure 4-43, wiper seal **10**.
3. Install one of the spring seats **12** over the valve spool. Install spring **13** and the other spring seat **12**. Install screw **14** and tighten to a torque of 7 lb-ftl (9.52 Nm).
4. Locate cap **15** and seal plate **11** over the spring assembly and secure to the valve housing with two hex socket capscrews **16**. Tighten to a torque of 7 lb-ft (9.52 Nm).

1. Main Relief Valve
2. Inlet Valve Section
3. O-Ring
4. Shut Off Plug
5. Swing Valve Spool Section
6. Mid-Inlet Section
7. Anti-Void Assembly
8. Telescope, Winch and Boom Lift Valve Spool Sections
9. Outrigger Valve Spool Sections
10. Handle Assemblies
11. N/A
12. Plug Assembly
13. Mid-Inlet Section
14. Mid-Inlet Section
15. Mid-Inlet Section
16. Outlet Valve Section
17. Tie Rods
18. Washers
19. Nuts
20. Nuts
21. Washers
22. Plug



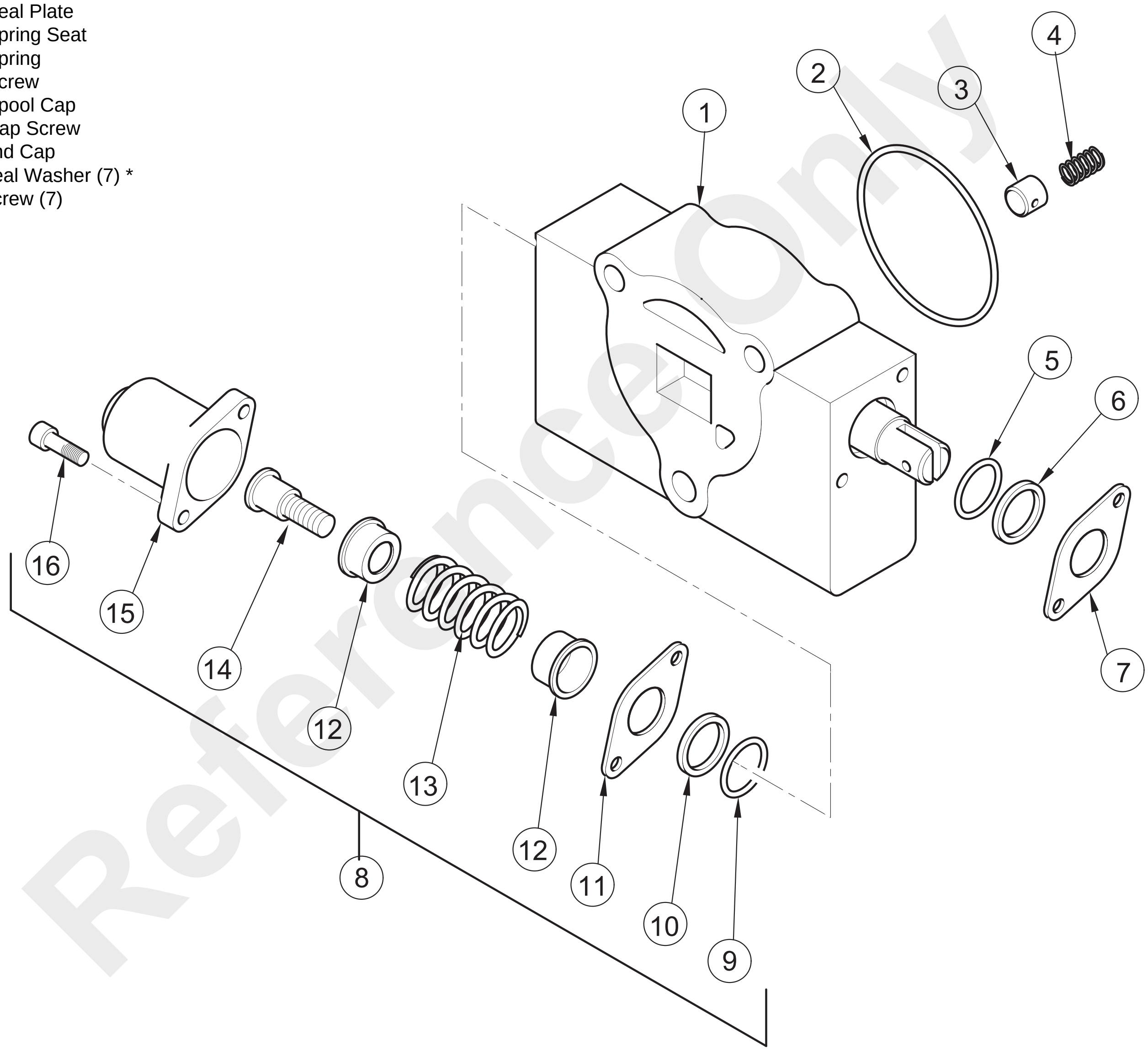
a1618

Main Control Valve

FIGURE 4-42

4

1. Spool and Housing
2. O-Ring
3. Load Check Poppet
4. Load Check Spring
5. O-Ring
6. Wiper Seal
7. Seal Plate
8. End Mechanism Kit
9. O-Ring
10. Wiper Seal
11. Seal Plate
12. Spring Seat
13. Spring
14. Screw
15. Spool Cap
16. Cap Screw
17. End Cap
18. Seal Washer (7) *
19. Screw (7)

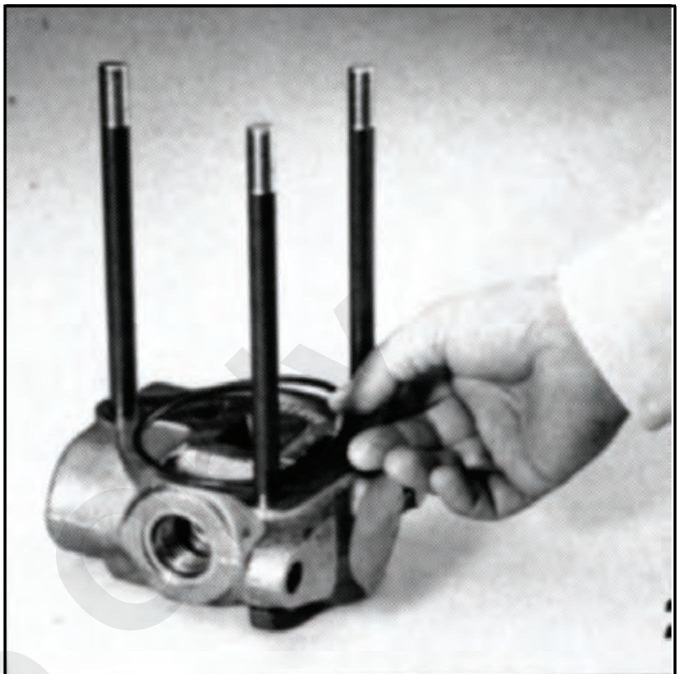


Spool Valve Section

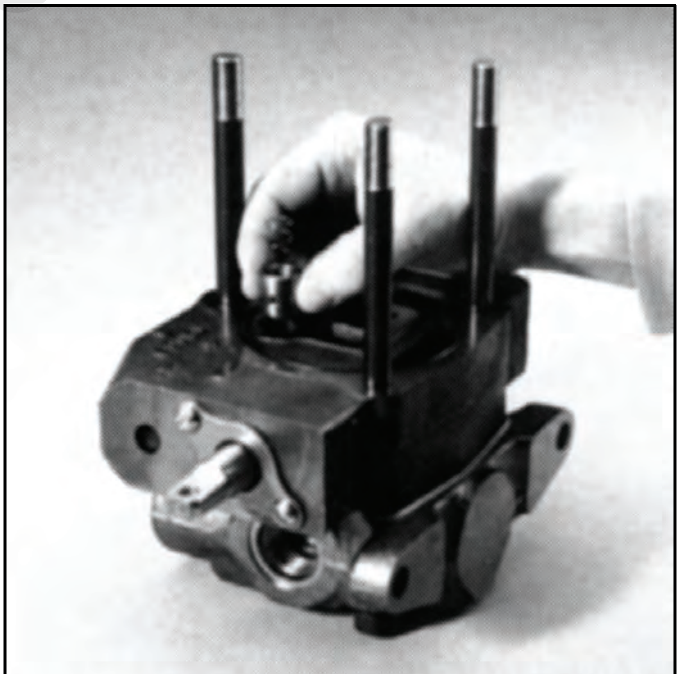
FIGURE 4-43

Complete Valve Assembly

1. Layout the valve components on a clean, flat working surface.
2. Assemble tie rod nuts and washers to one end of each tie rod **17** Figure 4-42. Insert the tie rods through the tie rod holes of inlet section **2**. Lay the inlet section with the tie rods facing up.
3. Place o-ring **3** in position on the face of the inlet section Figure 4-44.
4. Place the swing pool section 5 Figure 4-42, o-ring side up, on the inlet section 16. Position the o-ring 2 Figure 4-43 and insert load check poppet 3 and spring 4 into load check cavity Figure 4-45. Be sure the nose of the check poppet is facing down.
5. Position mid-inlet section 6 Figure 4-42 in place.
6. Repeat step 4 above for the telescope spool section 8.
7. Repeat step 4 above for the outrigger spool sections 9.
8. Position mid-inlet sections 13 and 14 with new o-rings 3 in place.
9. Repeat step 4 above for the winch spool section 8.
10. Position mid-inlet section 15 in place.
11. Repeat step 2 above for the boom lift spool section 8.
12. Position outlet section **16** on the last spool section and hand tighten the tie rod nuts.
13. Position the valve assembly with the mounting pads of the end sections on the flat surface. To obtain proper alignment of the end sections relative to the spool sections, apply downward pressure. Snug tie rod nuts to about 10 lb-ft (13,6 Nm). Final torque on the two 1/2 inch nuts is 14 lb-ft (19 Nm); final torque on the 9/16 inch nut is 33 lb-ft (45 Nm).



p0160 FIGURE 4-44

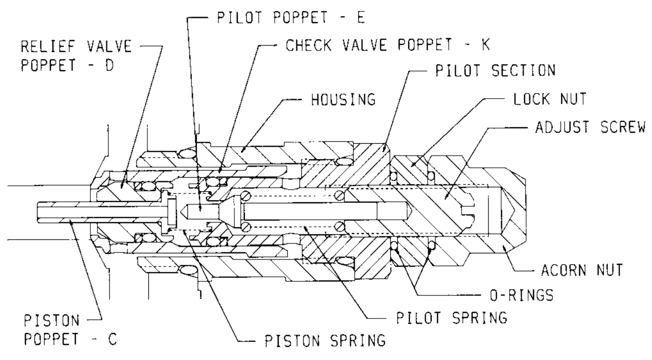


p0161 FIGURE 4-45

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 Figure 4-46, relief valve poppet and the check valve.

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.



a0972 FIGURE 4-46

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.

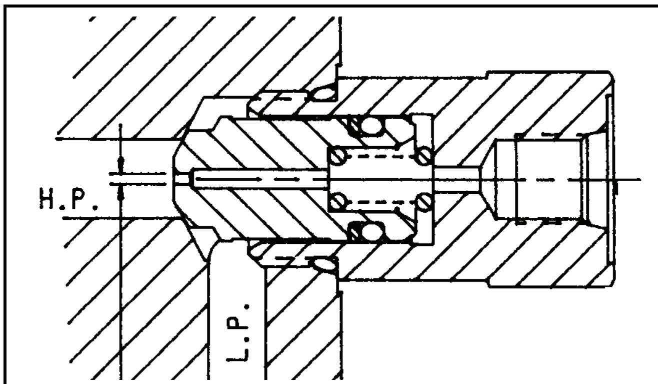
If the relief valve still does not function properly, replace the relief valve.

Relief Valve Troubleshooting

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

Anti-Void Assembly

Trouble resulting in a malfunctioning anti-void valve Figure 4-47 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 Anti-Void Valve FIGURE 4-47

Installation

1. Position the valve assembly on the mounting plate and secure with three bolts, washers and nuts.
2. Connect the hydraulic lines to the control valve.
3. Start the engine and release the air captured in the hydraulic lines, by operating each hydraulic function several times in each direction.
4. Check for leaks and fill the hydraulic reservoir if required.

Swing Motor

Removal

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

CAUTION

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

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

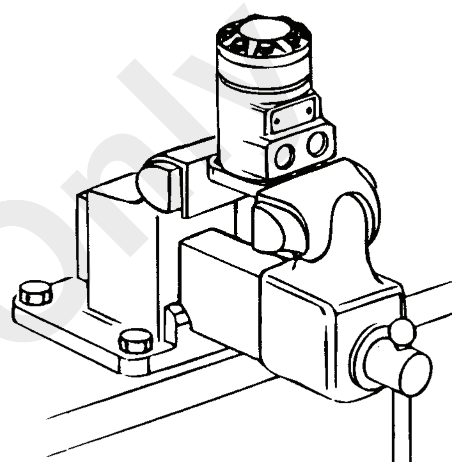
Disassembly

CAUTION

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

1. Place the motor in a vice and clamp across the edges of the flange Figure 4-48 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.

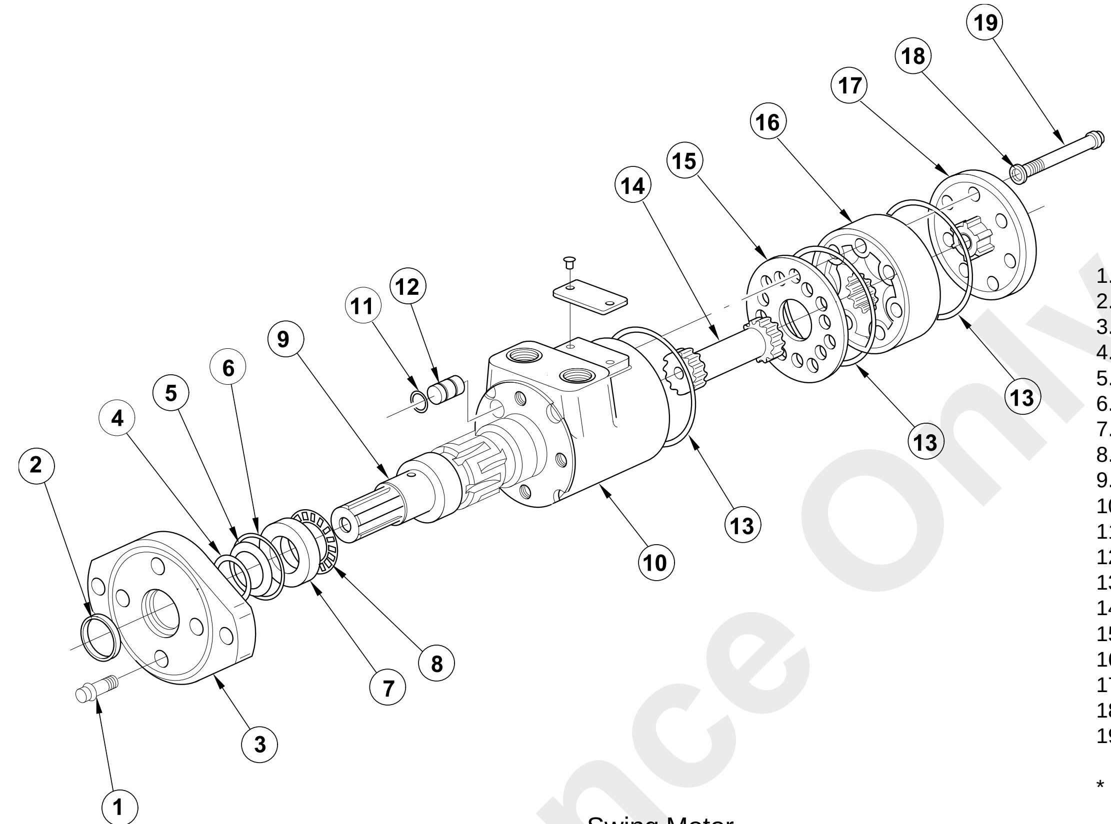


a0763

FIGURE 4-48

2. Remove seven capscrews **19** Figure 4-49 and seal washers **18**.
3. Remove end cap **17**. Remove and discard seal **13** from the end cap.
4. Remove gerotor **16**. Remove and discard seal **13** from the gerotor.
5. Remove drive shaft **14**.
6. Remove spacer plate **15**.
7. Remove seal **13** from housing **10**.
8. Remove output shaft **9** from housing **10**.
9. Remove needle thrust bearing **8** from shaft or housing.
10. Reposition the motor in the vice. Clamp across ports Figure 4-50. DO NOT clamp on housing. Excessive clamping pressure on side of housing causes distortion.

4



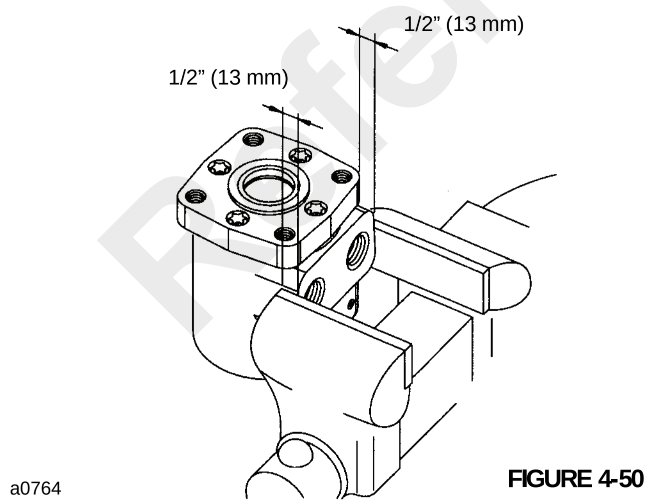
1. Screw (4)
2. Exclusion Seal
3. Mounting Flange
4. Backup Ring *
5. Shaft Pressure Seal *
6. Seal *
7. Bearing Race
8. Thrust Needle Bearing
9. Output Shaft
10. Housing
11. O-Ring
12. Plug
13. Seal (3) *
14. Drive Shaft
15. Spacer Plate
16. Gerotor Set
17. End Cap
18. Seal Washer (7) *
19. Screw (7)

* Included In Seal Kit

a0949

Swing Motor

FIGURE 4-49



a0764

FIGURE 4-50

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

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

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

When heated, Loctite partially melts. This reduces the torque required to remove screw. Use a small flame propane torch to heat a small area of the housing where the screws enter. Figure 4-51. **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.

12. Carefully remove flange **3** Figure 4-49 from housing **10**.

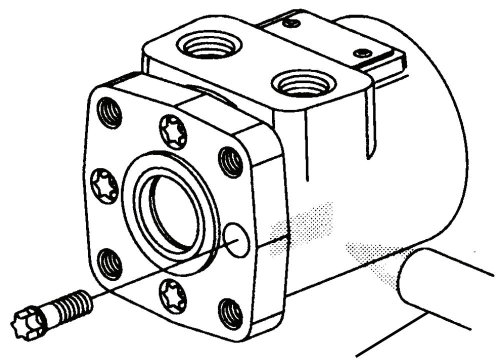


FIGURE 4-51

13. Exclusion seal **2**, backup ring **4**, shaft pressure seal **5** and seal **6** will come off with flange **3**. Use the seal removal tool to remove the exclusion and pressure seals Figure 4-52 and Figure 4-53.

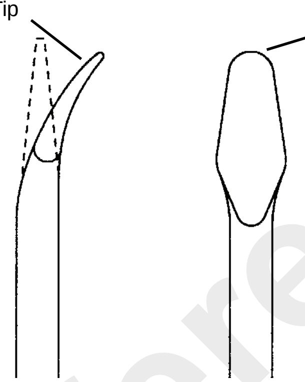


FIGURE 4-52

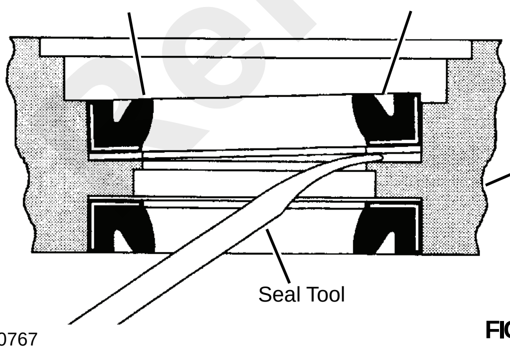


FIGURE 4-53

14. A metal plug **12** Figure 4-49, 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 0.187 inch (5 mm) 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 4-49 was removed, lubricate the new o-ring **11** and install on the plug. The plug has two o-ring grooves, but requires only one o-ring in the groove closest to the end of the plug. Push the plug into the housing **10** until it is flush with the housing. Be careful not to damage the o-ring.

2. Lubricate output shaft **9** with hydraulic oil and install the shaft into housing **10**.

CAUTION

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

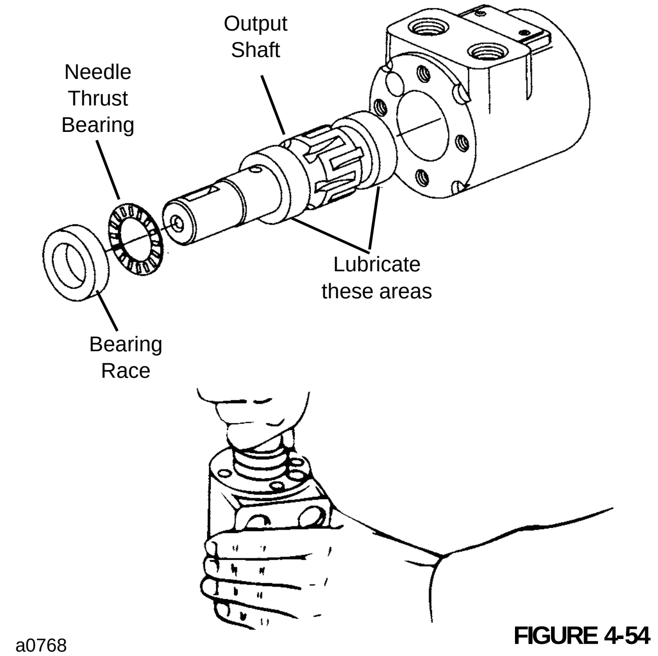


FIGURE 4-54

3. Install needle thrust bearing **8**, then bearing race **7** on shaft **9**. Pull shaft partially out of housing. Push all three parts in housing **10** together Figure 4-54. 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 4-49 in flange **3** with the lips of the seal facing out Figure 4-55. Carefully press the exclusion seal in place.

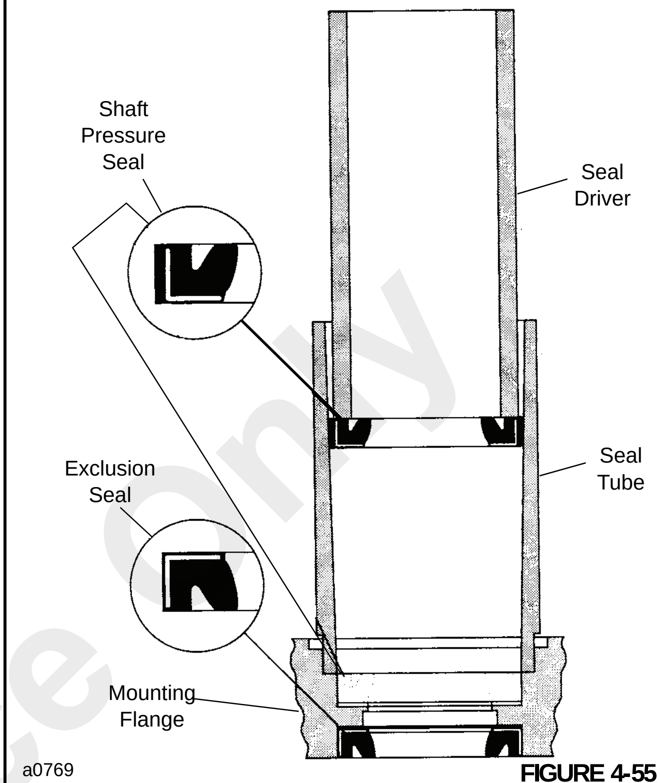


FIGURE 4-55

6. Install shaft pressure seal **5** in flange **3** with lips of seal face up using a suitable driver Figure 4-55. 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 4-49 into groove in flange **3**.

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

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

9. Apply 3 or 4 drops of Loctite sealant at the top of the threads for each of the four holes in the housing Figure 4-56. 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.

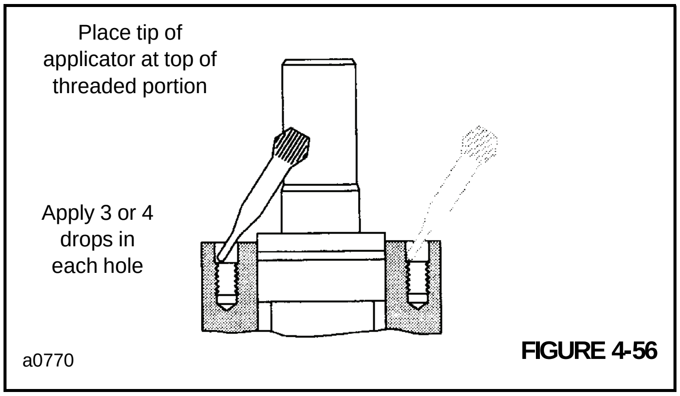


FIGURE 4-56

10. Before installing the flange and seal assembly over shaft **9** Figure 4-49, place a protective sleeve or bullet over the shaft. Then lubricate the space between exclusion seal **2** and pressure seal **5**, as well as the lips of both seals Figure 4-57.

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

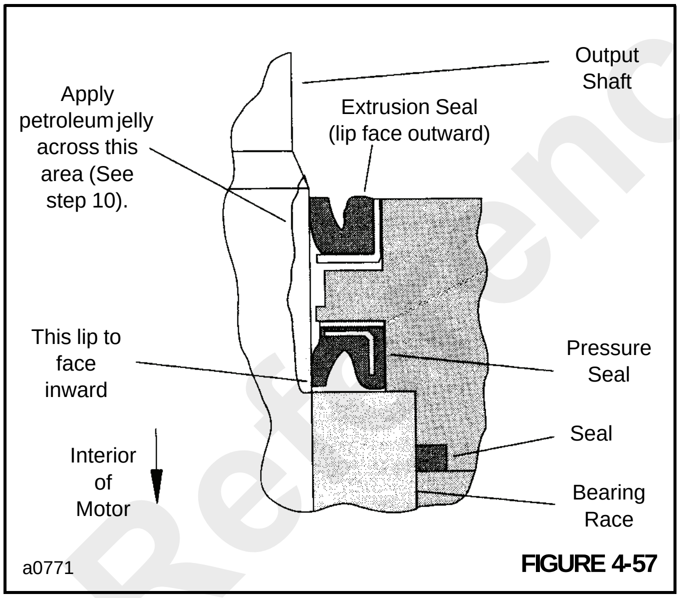


FIGURE 4-57

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 250 lb-in. (28 Nm). 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 4-49 in the housing groove. Avoid twisting the seal.

Timing Procedure

15. Install drive shaft **14** Figure 4-49. Use a felt tip pen to mark one drive tooth. Align this mark with the timing dot on the output shaft Figure 4-58.

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

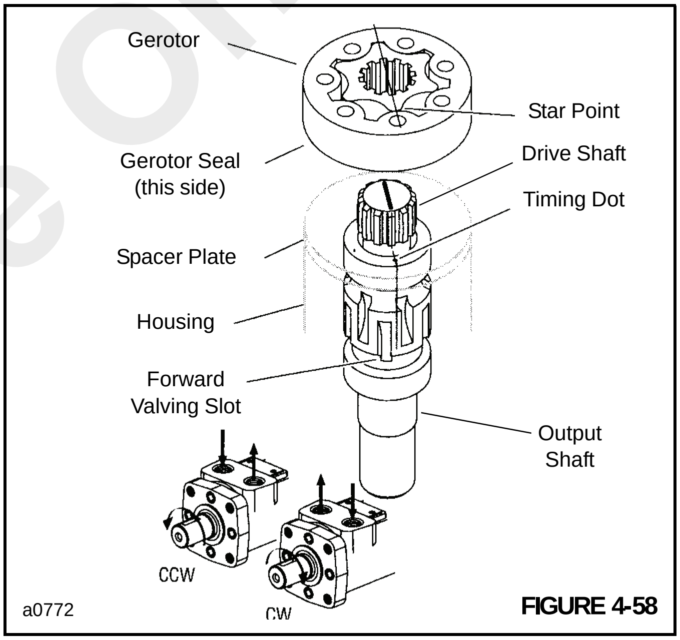


FIGURE 4-58

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 4-58.
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 40 lb-in. (7.4 Nm). Make sure the seal washers are properly seated. Then, tighten the capscrews to a torque of 235-250 lb-in. (27-29 Nm) in the sequence shown Figure 4-59.

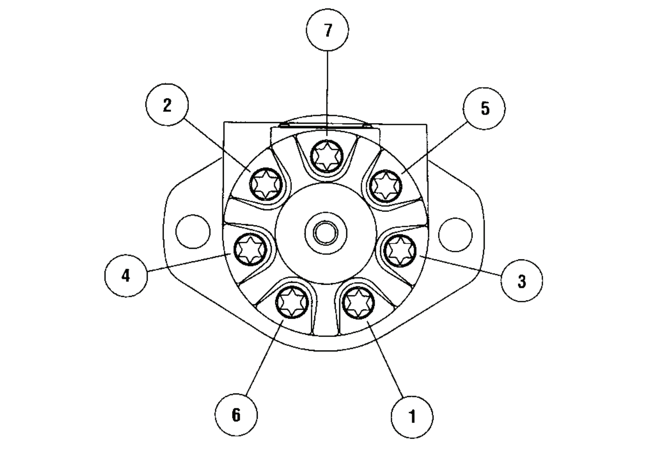


FIGURE 4-59

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.

Winch Motor

Removal

1. Shut off the engine, set the parking brake.
2. Before disconnecting the hydraulic lines, clean the port area of the winch motor thoroughly. Disconnect the hydraulic lines from the winch 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 winch. Remove the winch motor and gasket. Discard the gasket.
4. Remove hoses, fittings, the adapter flanges, spacer block and line mount body Figure 4-60 from the pump. Discard all o-rings. The Tulsa model is shown, but the Braden model is similar.

Disassembly

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

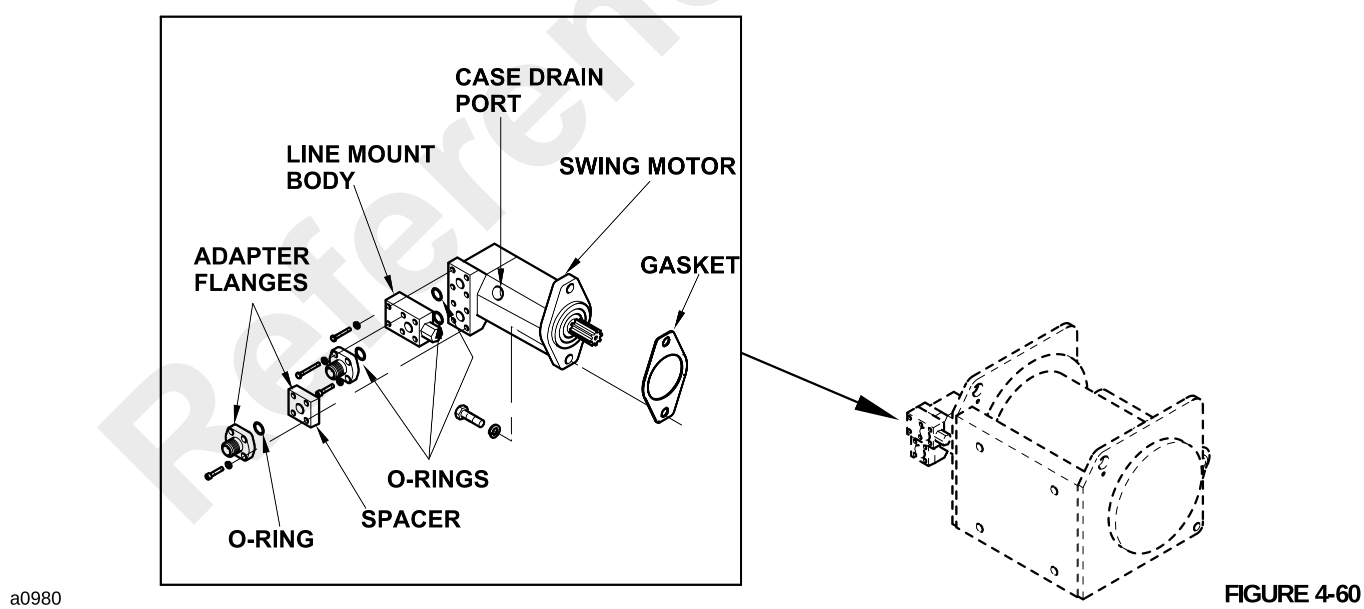


FIGURE 4-60

Installation

1. Install the line mount body Figure 4-60, spacer and adapter flanges to the winch motor. Be sure to use new o-ring seals.
2. Install the winch motor and new gasket to the winch using two capscrews and lockwashers.

CAUTION

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

3. Fill the winch motor with hydraulic fluid through the case drain port Figure 4-60 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 winch through several cycles to remove any air in the system. Check for hydraulic leaks.

Hydraulic Swivel

Removal

CAUTION

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

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

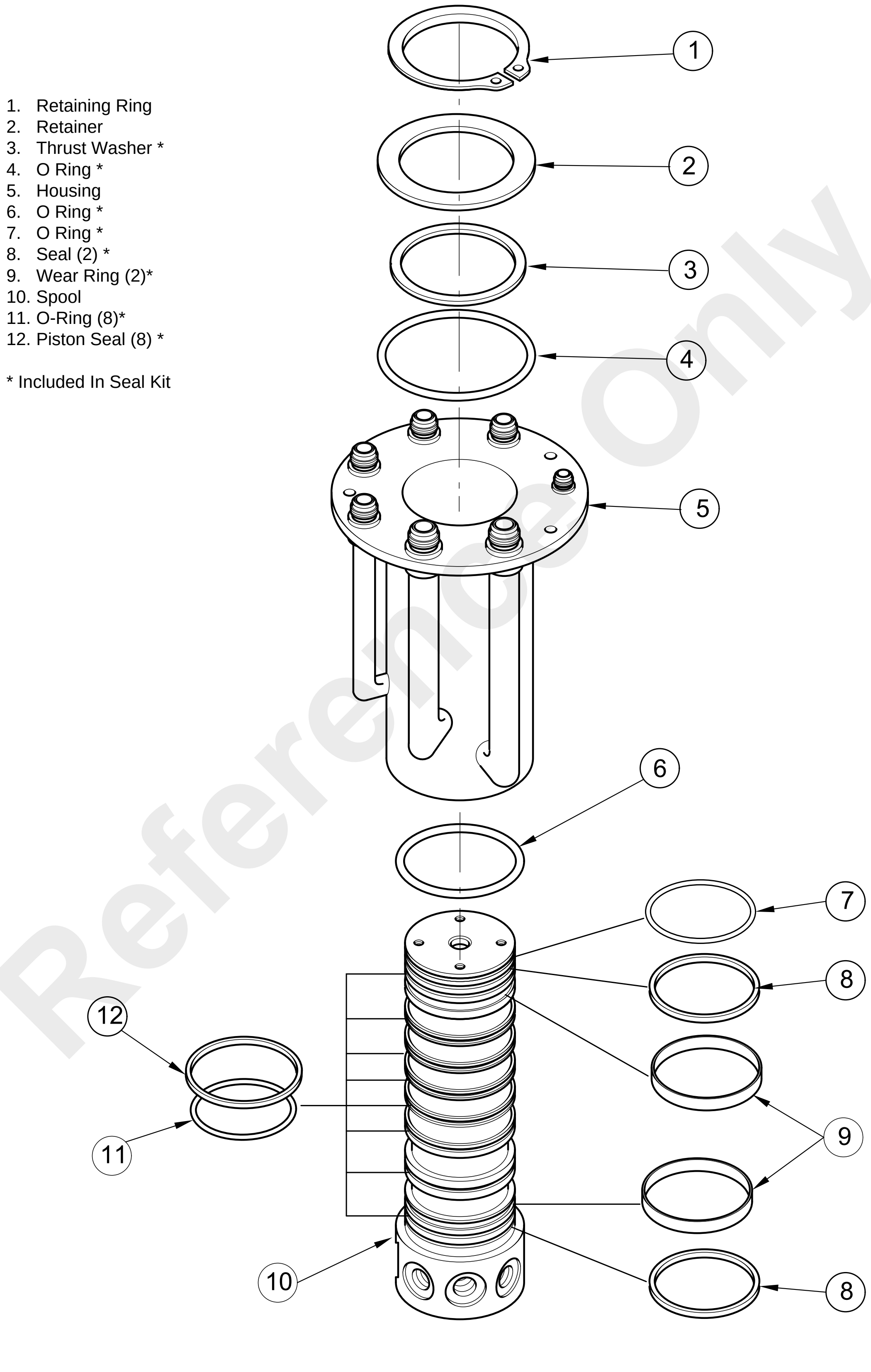

1. Retaining Ring
2. Retainer
3. Thrust Washer *
4. O Ring *
5. Housing
6. O Ring *
7. O Ring *
8. Seal (2) *
9. Wear Ring (2)*
10. Spool
11. O-Ring (8)*
12. Piston Seal (8) *
* Included In Seal Kit
1
2
3
4
5
6
7
8
9
10
11
12
8
a1562

FIGURE 4-61

Disassembly

1. Remove retaining ring **1** Figure 4-61 and retainer **2**. Remove and discard thrust washer **3** and o-ring **4**.

2. Carefully pull the swivel spool **10** from swivel housing **5**. If the swivel can not be pulled from the swivel, hit the top of the swivel shaft with a soft hammer.

3. Remove and discard o-ring **6** and all seals and wear rings from spool **10**.

Inspection

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

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

Install new seals, wear rings and thrust washers.

Assembly

NOTE: The hard rubber piston seal **11** Figure 4-61 must be warm before installation. Heat the seal with a trouble lamp. Do not apply lubricant to the loader before installation.

1. Place the spool on the work bench in the vertical position.

2. Walk one seal **8** down each groove until it reaches the last groove. Then slide seal down the spool until it seats in groove on the spool.

CAUTION

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

3. Install an o-ring **11** into each of the eight grooves on the spool.

4. Install one heated piston seal **12** over each o-ring.

5. Install the two wear rings **9** into their appropriate grooves.

6. Install o-ring **7** into its groove.

7. Place the swivel housing **5** on the work bench with the bottom of housing facing up. Lubricate the lower 1/4 of the swivel bore with hydraulic fluid.

8. Place o-ring **6** on the end of the swivel housing **5** and then insert the assembled spool into the housing until it is seated. Be careful not to pinch or cut o-ring (6).

9. Turn the swivel over and install thrust washer **3** and o-ring **4**. Install retaining ring **2** and secure with retaining ring **1**.

Test

Pressure test the hydraulic swivel to 5000 psi (34 475 kPa).

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

Installation

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

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

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

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

5. Connect the hydraulic lines to the upper ports.

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

CAUTION

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

Hydraulic Cylinders

Removal

NOTE: The following removal instructions are general and should be modified to suit the cylinder being removed. Crowd cylinder removal instructions will be found in Section 9. Steering cylinder removal instructions can be found in Steering System Section 8.

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

Disassembly

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

Steering cylinder repair instructions can be found in Steering System Section 8.

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

Inspection

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

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

Look for damage to the chrome surface of the rod. The rod must be smooth and straight. A bent rod indicates possible loss of strength in the rod and replacement is necessary. If the chrome surface has damage, completely remove the old chrome and apply new chrome 0.001 inch (0,03 mm) thick.

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

Assembly

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

Test

1. Fill the cylinder with clean hydraulic oil. To test the piston seal rings, continue to push oil into the rod end after the

cylinder has hit bottom. Test to pressure indicated Table 4-7 in both directions as directed in steps 2 through 5.

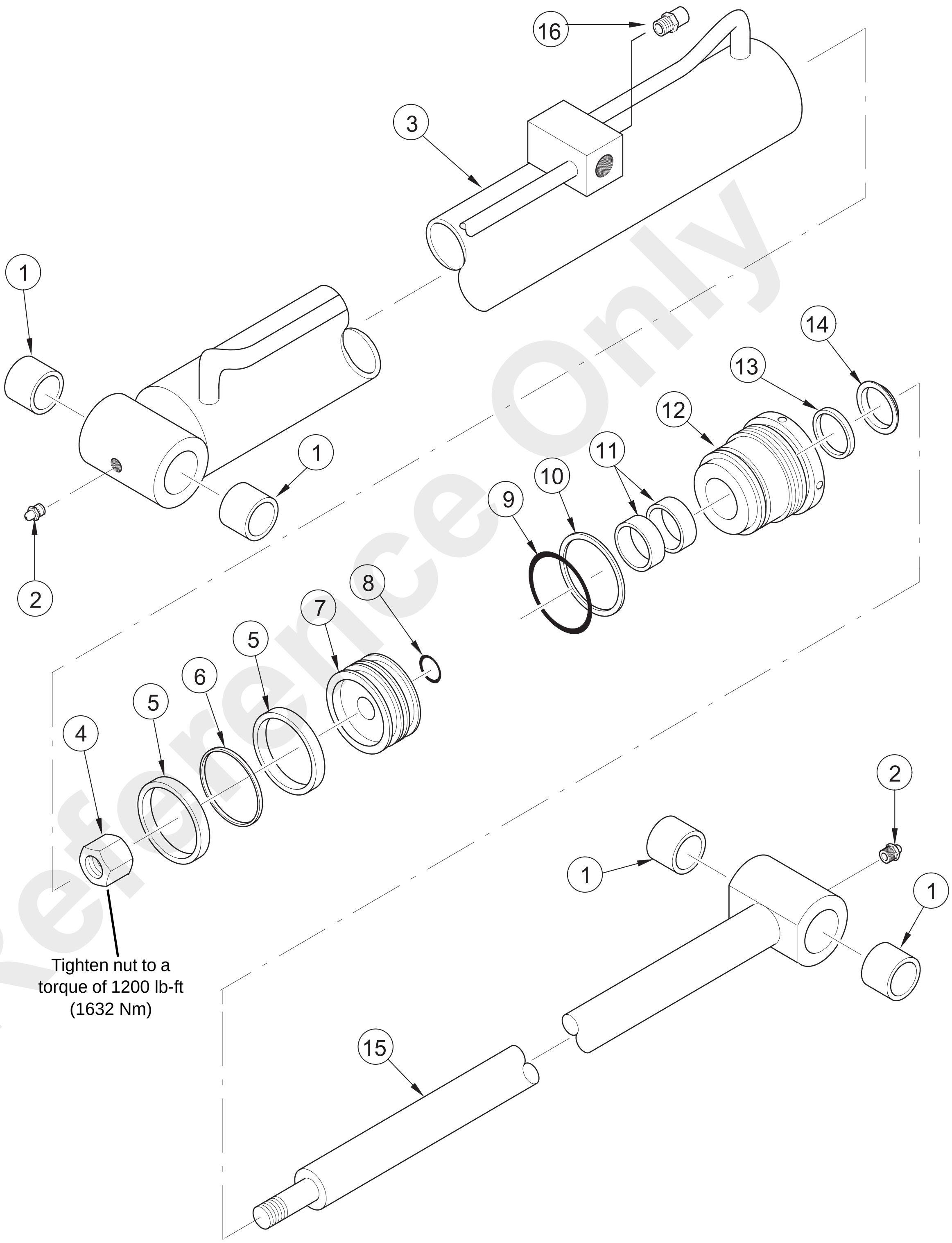
Table 4-7: Cylinder Test Pressures

CYLINDER	TEST PRESSURE
Lift	4500 psi (31 005 kPa)
Crowd	4500 psi (31 005 kPa)
Outrigger	4500 psi (31 005 kPa)
Axle Lockout	2500 psi (17 225 kPa)

2. Move the cylinder rod through two complete strokes at 800 psi (5510 kPa) to remove air from the cylinder. Look for external leaks. If the pressure difference between cylinder ports is more than 100 psi (689 kPa) 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 800 psi (5510 kPa), 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 4-7 to the rod port. Hold this pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No internal or external leakage is permitted.
5. Fully extend the cylinder rod. Keep the rod port open. Apply test pressure Table 4-7 to the base port. Hold this pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No internal or external leakage is permitted.
6. Put plugs in the cylinder ports to keep out dirt during installation.

Installation

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



1. Bushing (4)
2. Grease Fitting
3. Cylinder Tube
4. Piston Nut
5. Wear Ring (2) *
6. Piston Seal *
7. Piston
8. O-Ring *
9. O-Ring *
10. Back Up Ring *
11. Wear Ring *
12. Gland Head
13. Rod Seal *
14. Rod Wiper *
15. Cylinder Rod
16. Counterbalance Valve Cartridge
17. Rod Wiper*
18. Cylinder Rod
19. Plug
20. Fitting

* = Seal Kit Parts

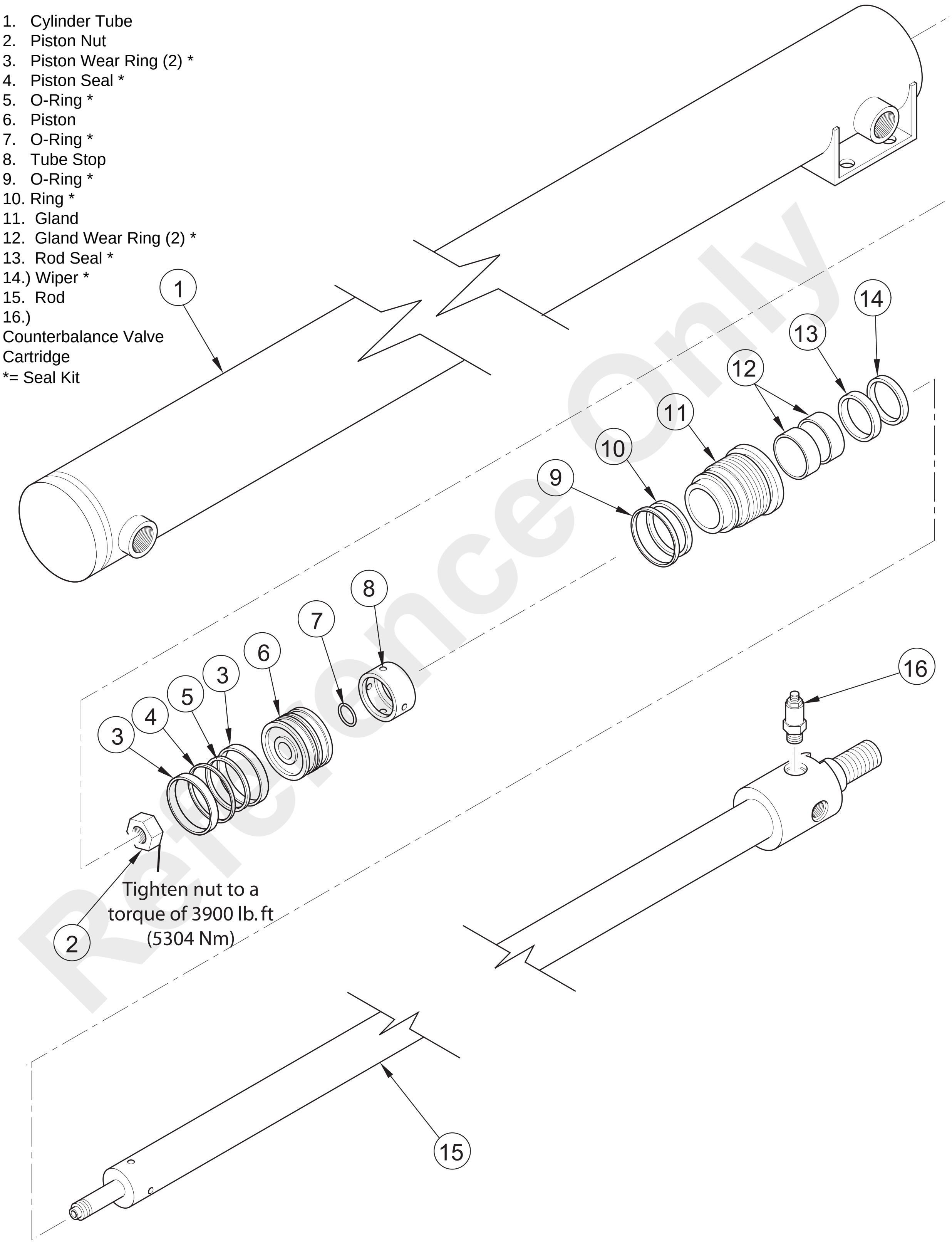
a0432

Lift Cylinder

FIGURE 4-62

1. Cylinder Tube
2. Piston Nut
3. Piston Wear Ring (2) *
4. Piston Seal *
5. O-Ring *
6. Piston
7. O-Ring *
8. Tube Stop
9. O-Ring *
10. Ring *
11. Gland
12. Gland Wear Ring (2) *
13. Rod Seal *
14.) Wiper *
15. Rod
16.) Counterbalance Valve Cartridge

*= Seal Kit



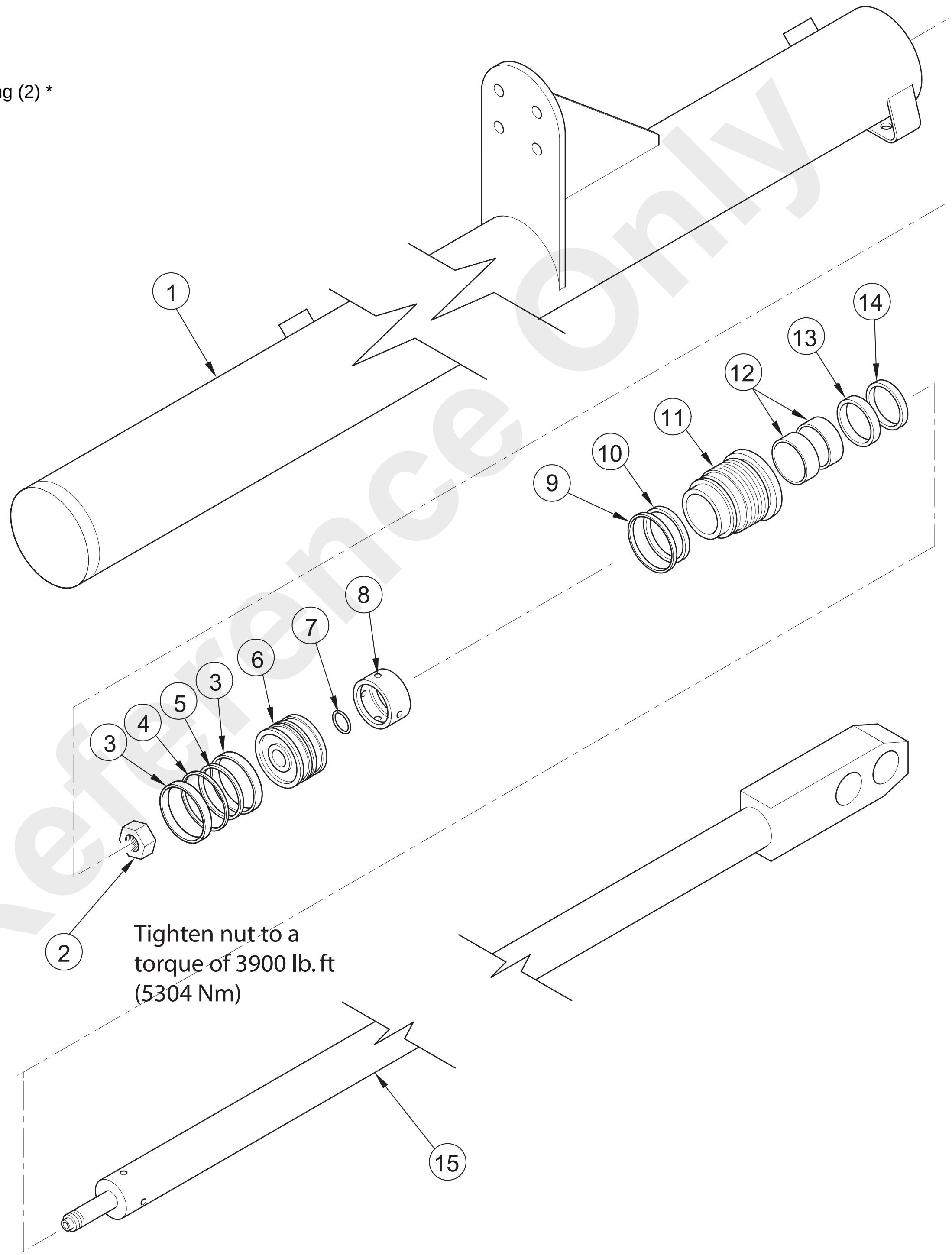
a0434

Upper Crowd Cylinder

FIGURE 4-63

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

* = Seal Kit Parts



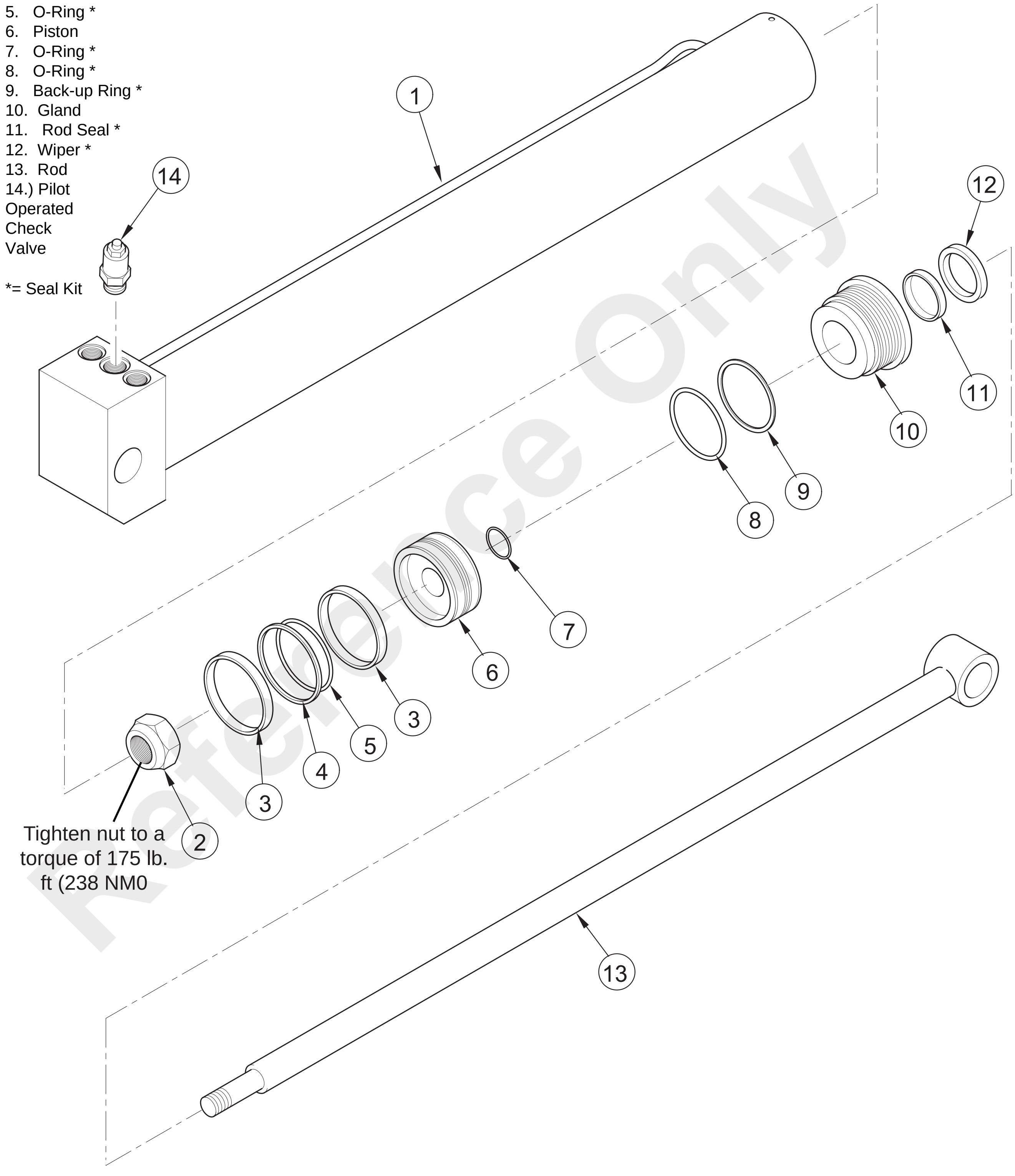
a0440

Lower Crowd Cylinder

FIGURE 4-64

1. Cylinder Tube
2. Piston Nut
3. Piston Wear Ring (2) *
4. Piston Seal *
5. O-Ring *
6. Piston
7. O-Ring *
8. O-Ring *
9. Back-up Ring *
10. Gland
11. Rod Seal *
12. Wiper *
13. Rod
14.) Pilot Operated Check Valve

*= Seal Kit



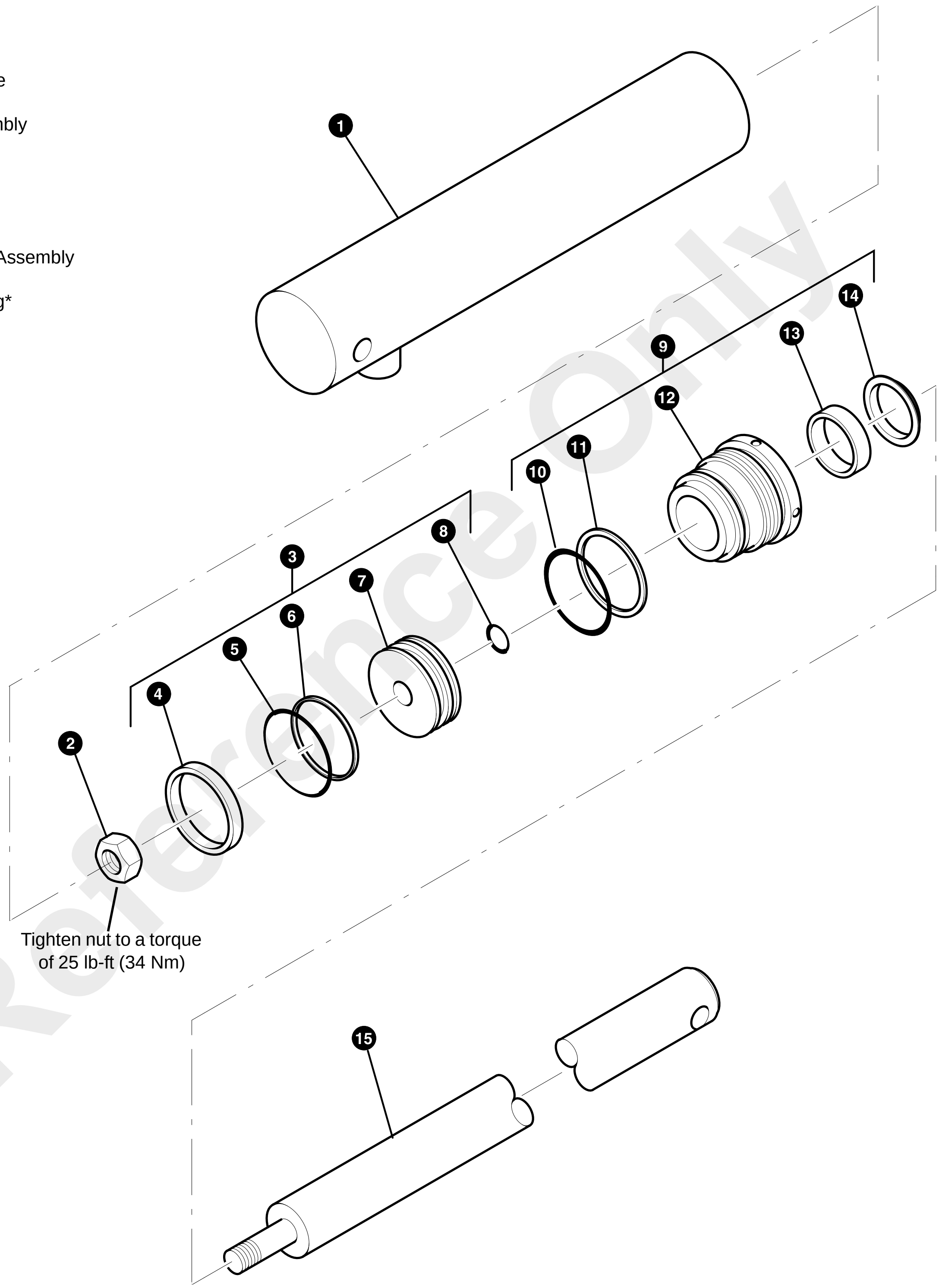
a0437

Outrigger Cylinder

FIGURE 4-65

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

*= Seal Kit



a0439

Axle Oscillation Lockout Cylinder

FIGURE 4-66

SECTION 5
PREVENTATIVE MAINTENANCE

TABLE OF CONTENTS

5

SECTION 5
PREVENTATIVE MAINTENANCE

INTRODUCTION

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

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

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

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

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

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

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

Spark Arresting Mufflers

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

Safety List

Inspect the following safety equipment daily:

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

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

COVERS - Keep all protective covers in place.

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

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

LUBRICANTS

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

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

MAINTENANCE RECORDS

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

SPECIAL MAINTENANCE

Delivery Inspection

Fuel Tank

- Fill with correct fuel.

Engine

- check oil in crankcase
- On diesel engines remove water from fuel filters and sediment bowl.

Cooling system

- Check coolant level. Fill if level is low.

Hydraulic Tank

- Check oil level. Fill if level is low.

Drive Axles

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

5

Winch Gearbox

- Check oil level. Fill if level is low.

Tires

- Check for correct air pressure.

Wire rope cable clamps and connections

- Check for loose or missing parts.

Anti-Double Blocking System

- Check that the system is working properly.

Controls

- Check that all controls are working properly.

After First 50 Hours of Operation (New Cranes)

Engine

- Change the engine oil and filter.

Transmission

- Change the transmission oil filter.

Swing Gearbox

- Check and tighten mounting bolts.

Hoist Gearbox

- Check and tighten mounting bolts.

Swing Gear Pinion and Swing Gear

- Lubricate.

Grease Fittings

- Apply grease to all grease fittings.

Boom Slides

- Lubricate.

Wheel Mounting Nuts

- Check Torque.

Cranes Not In Regular Use

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

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

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

PREVENTIVE MAINTENANCE

Maintenance Schedule and Checklist

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

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 250 hour (monthly) maintenance interval, perform all the tasks required for daily, 50 hour and 100 hour maintenance.

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

5

Service Check	Daily before operation	50 Hours Weekly	100 Hours Two Weeks	250 Hours Monthly	500 Hours Three Months	1000 Hours Six Months	2000 Hours Yearly
Check axle wheel hub lubricant level (4)					x		
Check axle housing lubricant level (2)					x		
Check winch gearbox and brake lubricant level					x		
Lubricate the outrigger slides					x		
Add grease to swing gearbox					x		
Replace fuel filter elements (diesel)					x		
Inspect the parking brake pads					x		
Inspect tires for damage					x		
Add rust inhibitor to engine cooling system					x		
Replace the air cleaner element *					x		
Clean and adjust spark plug gap (gasoline engine)					x		
Check swing gear to pinion backlash						x	
Replace the transmission oil and filter						x	
Replace the axle wheel hub lubricant						x	
Replace the axle housing lubricant						x	
Replace the winch gearbox lubricant						x	
Replace the hydraulic oil						x	
Replace the hydraulic oil filter						x	
Replace the L.P.G. inline filter						x	
Replace the in-line fuel filters (gasoline)						x	
Replace PVC valve (gasoline engine)						x	
Clean PVC hoses, tubes, and fittings (gasoline engine)						x	
Replace spark plugs (gasoline engine)						x	
Replace the engine coolant							x
Inspect the crane structure and booms for damage							x
Test the Load Management Indicator (LMI)							x
-optional							x

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

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

Lubrication Points

Apply grease to the following fitting after the first 20 hours of operation, thereafter every 50 hours of operation, whichever occurs first. Use a Lithium Base, E.P. No. 2 bearing grease or equivalent. Apply enough grease to remove the old grease.

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

Booms and Main Frame

Location	QTY
Mast Bearing (see Figure 5-1)	2
Boom Pivot (see Figure 5-2)	2
Boom Head Sheaves and Pivot (see Figure 5-3)	2
Lift Cylinder Pivots (see Figure 5-5)	2

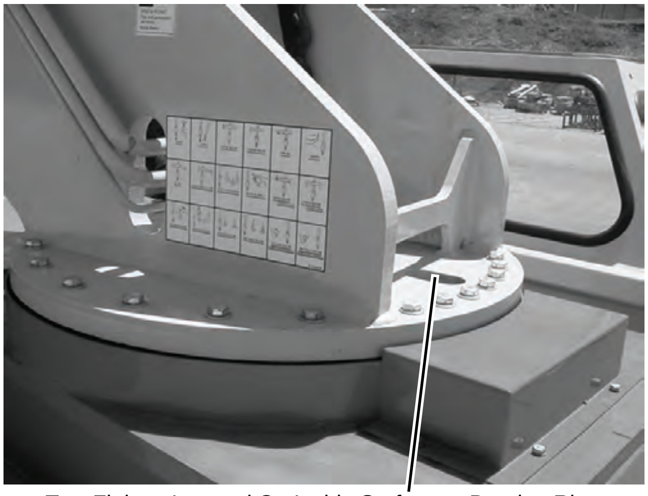
Drive Train

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

Optional Equipment and Accessories

Location	QTY
Drop Block (see Figure 5-15)	2
Jib Boom Head Sheave (see Figure 5-16)	1
Jib Boom Deflector Sheave (see Figure 5-17)	1

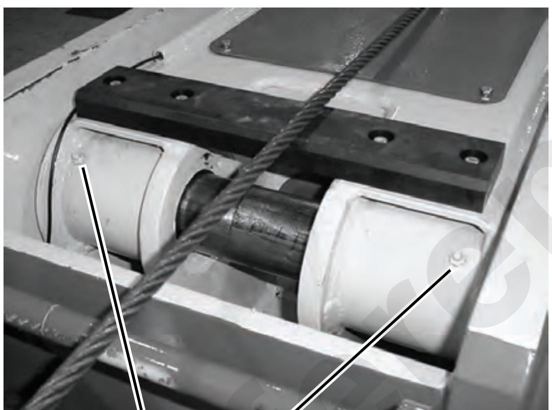
p1638



Two Fittings Located On Inside Surface or Bearing Ring

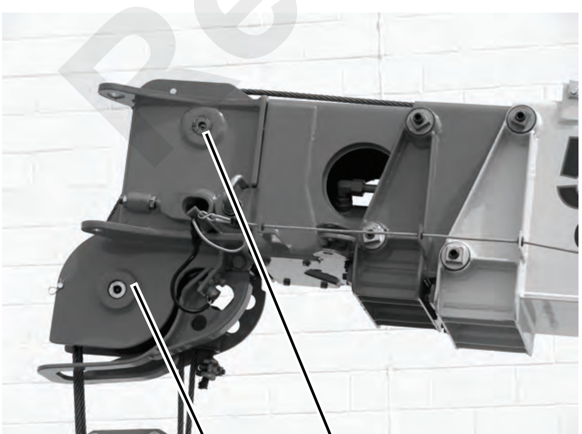
Mast Bearing Lubrication Point **FIGURE 5-1**

p1663



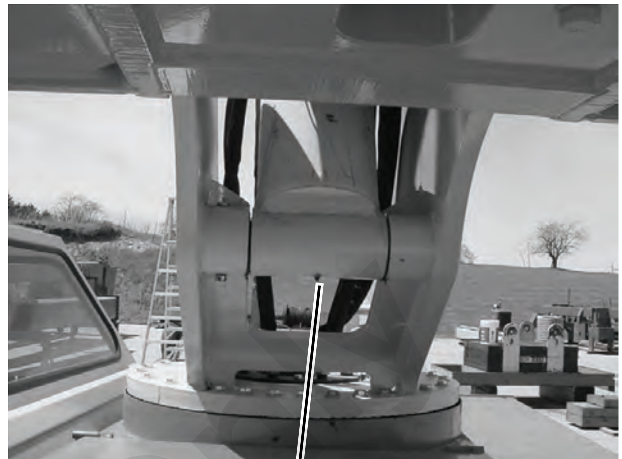
Boom Pivot Lubrication Points **FIGURE 5-2**

p1622



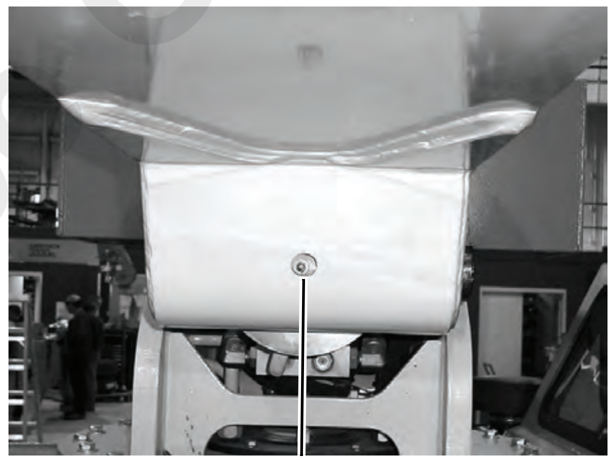
Boom Head Sheaves and Pivot Lube Points **FIGURE 5-3**

p1639



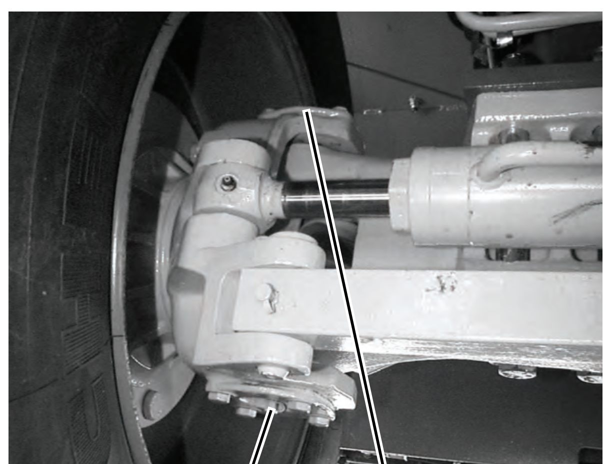
Lift Cylinder Pivots Lube Points (Base End) **FIGURE 5-4**

p1664



Lift Cylinder Pivots Lube Point (Rod End) **FIGURE 5-5**

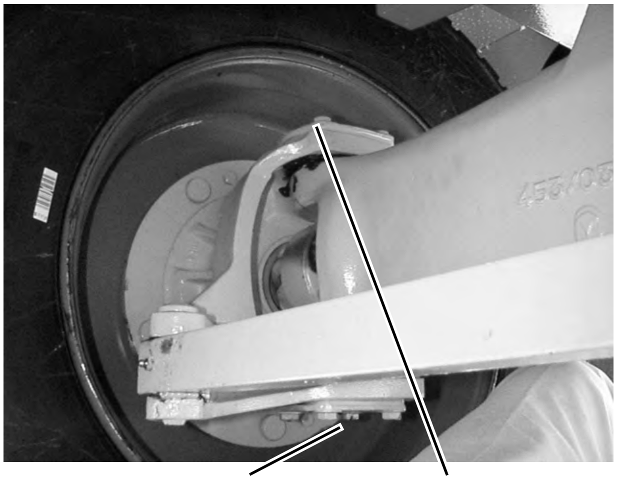
p0417



Steering Knuckle Lube Points (Front Axle) **FIGURE 5-6**

Manitowoc Crane Care

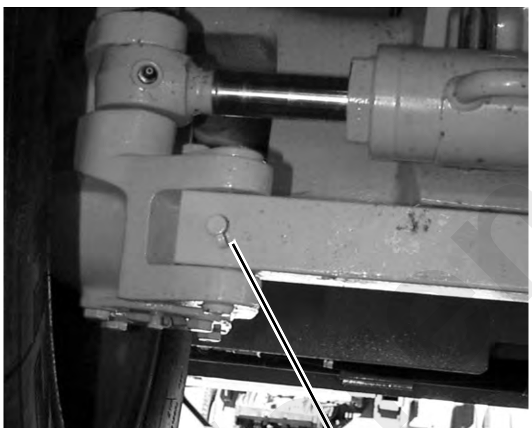
p0421



Steering Knuckle Lube Points (Rear Axle)

FIGURE 5-7

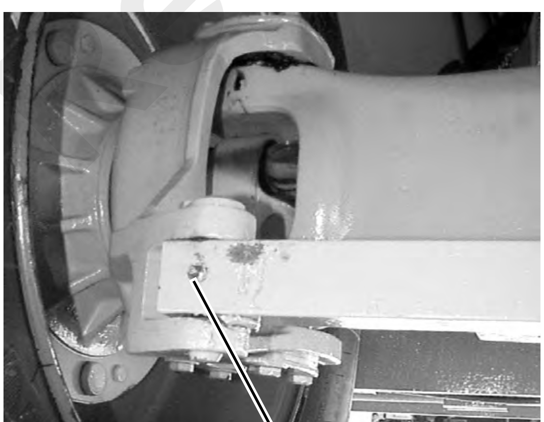
p0419



Steering Link Lube Points (Front Axle)

FIGURE 5-8

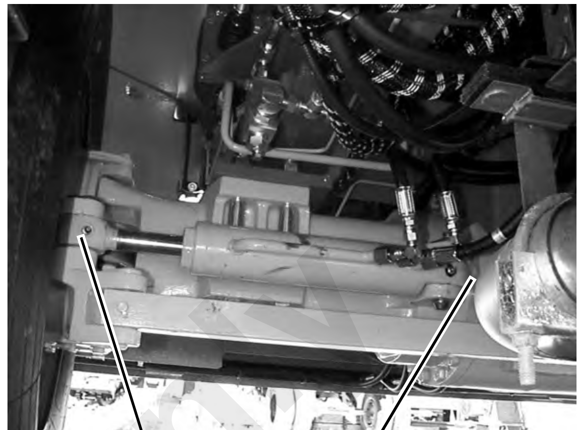
p0422



Steering Link Lube Points (Rear Axle)

FIGURE 5-9

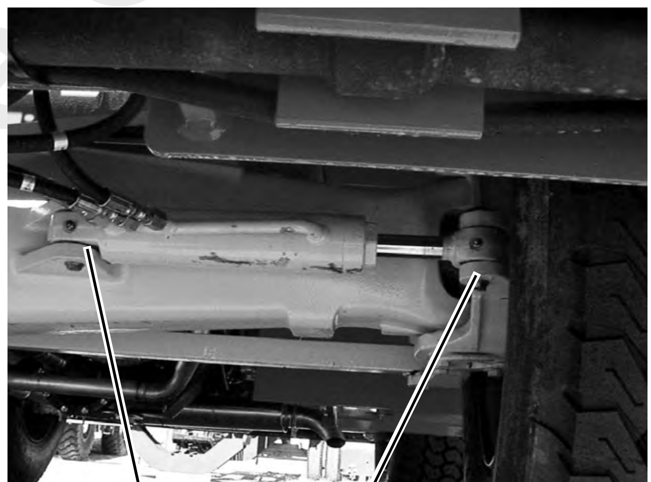
p0418



Steering Cylinder Pivot Ends Lube Points (Front Axle)

FIGURE 5-10

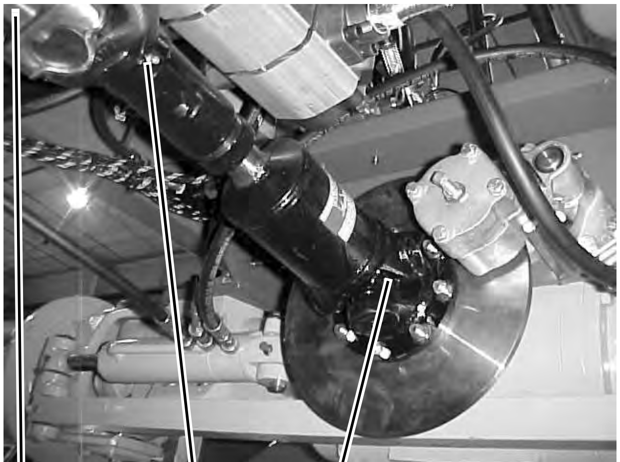
p0420



Steering Cylinder Pivots Ends Lube Points (Rear Axle)

FIGURE 5-11

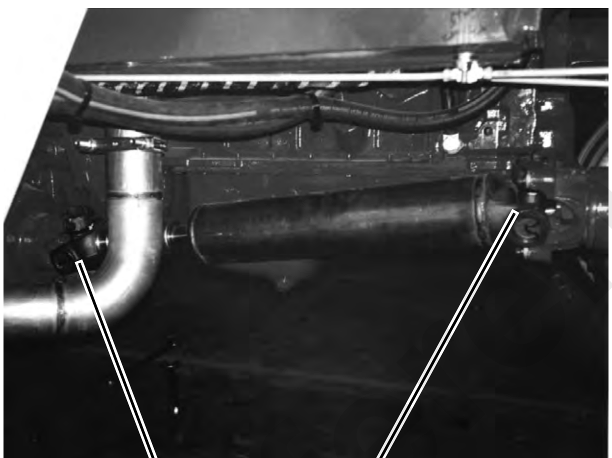
p1643



Drive Shaft Lube Points (Front Axle)

FIGURE 5-12

p0401



Drive Shaft Lube Points (Rear Axle-Typical)

FIGURE 5-13

p0423

Rear Axle Pivot Lube Point

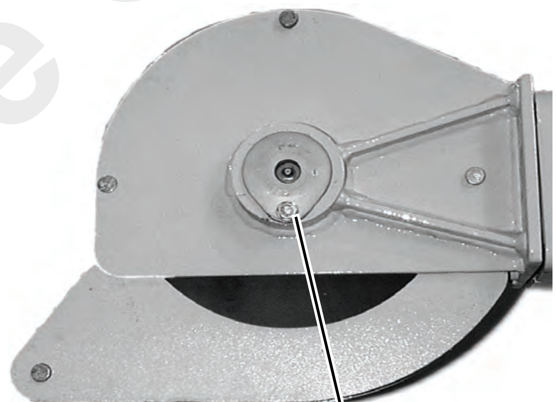
FIGURE 5-14

p0391

Drop Block Lube Point

FIGURE 5-15

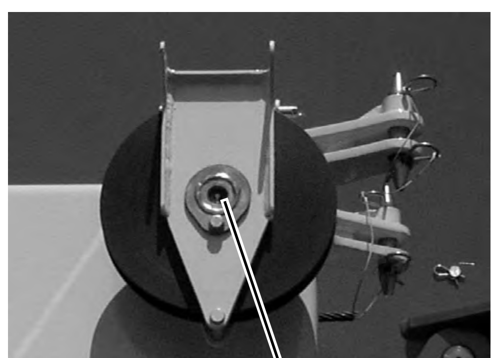
p0315



Jib Head Sheave Lube Point (Typical)

FIGURE 5-16

p0392



Jib Boom Deflector Sheave Lube Point

FIGURE 5-17

SCHEDULED MAINTENANCE

Daily (Walk-around) Inspection

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.

Inspections

Inspect The Anti-Double Blocking System

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

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

Lower the hoist block and the alarm will stop.

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

Inspect The Wire Rope

Each day before beginning operation, visually inspect the wire rope for damage. See “50 Hours of Operation (Weekly)” on page 5-13, for examples of damage that can be visually inspected for. If any damage is found, do not operate the crane. The wire rope must be replaced with a new rope before operation can resume.

Inspect Reeving, Clamps and Connections

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

WARNING

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

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

Inspect the Lifting Hook

WARNING

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

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

Inspect All Safety Devices

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

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

Check Controls Operation

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

Component/System Checks

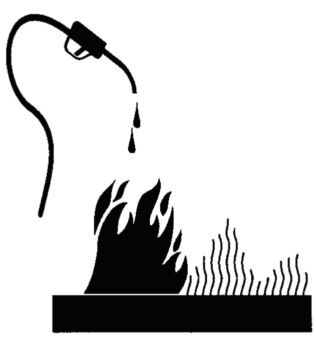
Check Fuel Level

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

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



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

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

Check the Engine Crankcase Oil Level

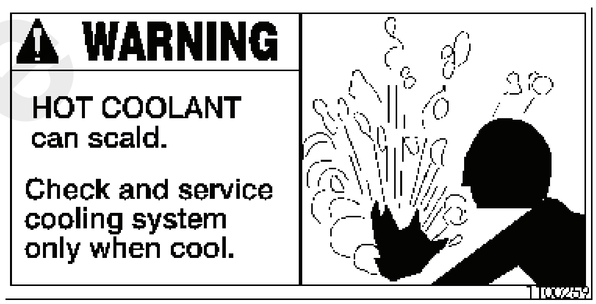
1. Level the crane, engage the parking brake and shut off the engine.
2. Lift the engine compartment cover and support in place using the furnished prop rod.
3. Remove the engine oil dipstick and check oil level. Oil should be visible within the crosshatched mark area on the dipstick.
4. If the oil is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

Check the Transmission Oil Level

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

FIGURE 5-18

Check Engine Coolant Level



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

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

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

p1651

Overflow Bottle

FIGURE 5-19

Drain Water from Engine Fuel Filter (Diesel Engine)

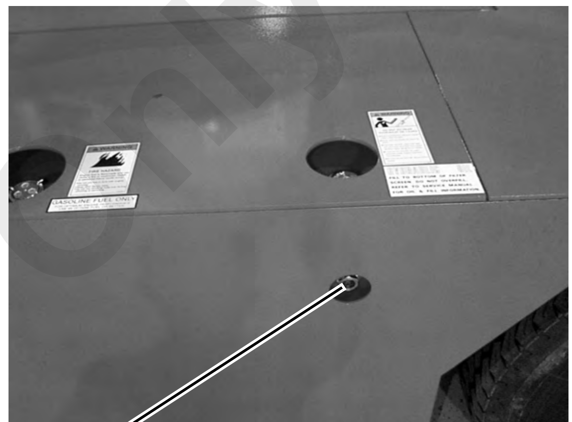
1. Shut off the engine and engage the parking brake.
2. See the engine manual furnished with the crane and follow the water draining instructions.

Check Hydraulic Oil Level

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

1. Be sure the boom is fully retracted and lowered and the outriggers are retracted and up.
2. Level the crane, engage the parking brake and shut off the engine.
3. Visually check the oil level on the hydraulic oil level sight gauge (Figure 5-20). The hydraulic oil should be 3 mm (0.125 in) from the top of the sight gauge. If low, fill tank with clean recommended hydraulic oil.

p0396



Hydraulic Oil Sight Gauge

FIGURE 5-20

Check the Air Cleaner Restriction Indicator

The air cleaner is equipped with a filter restriction indicator (Figure 5-21). The air cleaner element needs cleaning or replacing if the indicator's colored piston has popped out and is visible when the engine is running at high idle.

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

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

5

FIGURE 5-21

Remove the Element

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

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

Inspect the Element

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

Clean the Element

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

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

1. Clean the filter element with compressed air. Use compressed air with 30 psi (205 Nm) maximum pressure at the nozzle.
2. Direct the air inside the element and then move the nozzle up and down while rotating the element.

Install the Element

1. Install the safety element over the stud in the housing and slide it all the way in.
2. Install and tighten the wing nut. Hand tighten it only. Install the element over the stud in the housing and slide it all the way in.
3. Make sure the gasket is seating evenly. If you don't feel the gasket is seating evenly for a perfect seal, you won't have protection. Recheck to see if the sealing surface in the housing is clean, or if the element is the right model number. If may be too short for the housing. Install and tighten the wing nut. Hand tighten only.
4. Install the air cleaner housing cover and the wing nut.
5. Reset the air cleaner restriction indicator by pushing in the reset button (Figure 5-33).
6. If a cleaned air cleaner element was installed, start the engine and run at high idle. If the air cleaner restriction indicator's colored piston pops out and is visible again, shut down the engine and replace the air cleaner element with a new element.

Check Tire Pressure

Check the air pressure in the crane's four tires. Correct pressure is 120 psi (828 kPa).

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

Squeeze the dust cup (Figure 5-22) to remove any accumulation of dust or debris.

p0398

Dust Cup

FIGURE 5-22

Wire Rope Inspection

All wire ropes wear out eventually and lose work capability throughout their service life. That's why period 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 dealer. 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 5-23 are present.
2. **Sheaves** - Inspect sheaves for damage and/or wear. The sheave grooves must be smooth and a little larger than the wire rope. Use a sheave gauge to check the size of the sheave groove. Rough edges, narrow or worn grooves will cause damage to the wire rope. Replace any worn or damaged sheaves.

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

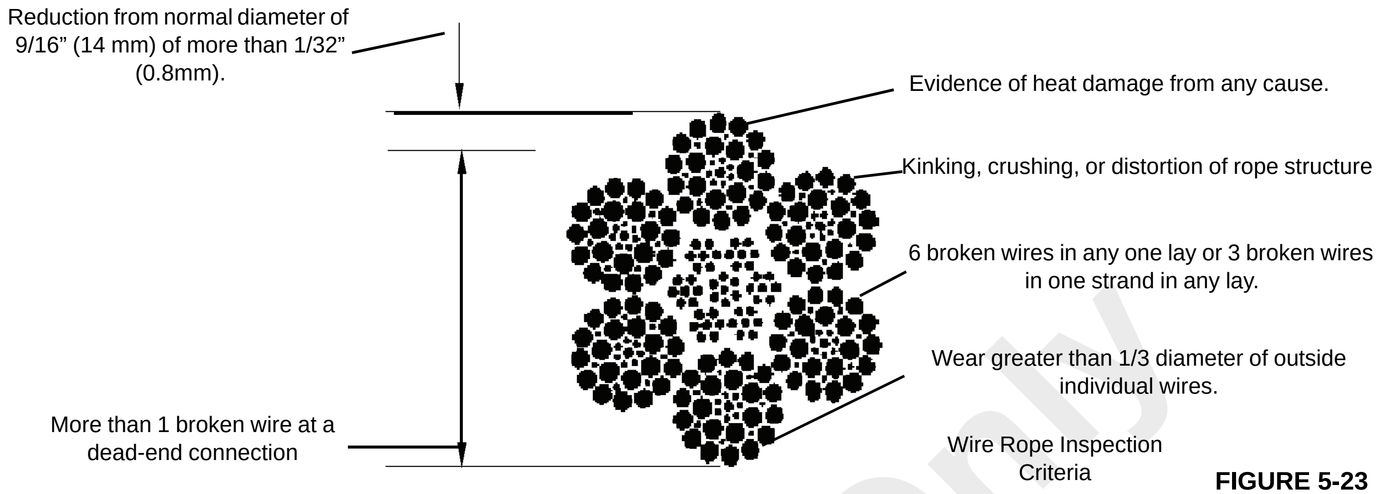


FIGURE 5-23

Grease Fittings

Lubricate all points indicated under the heading “Lubrication Points”.

Lubricate Parking Brake

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

p1643

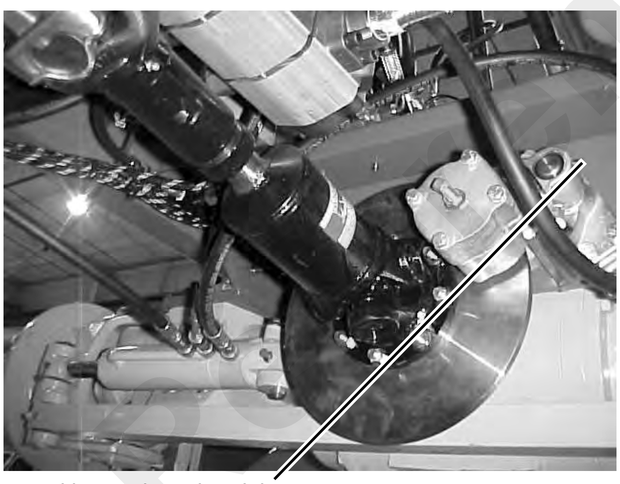
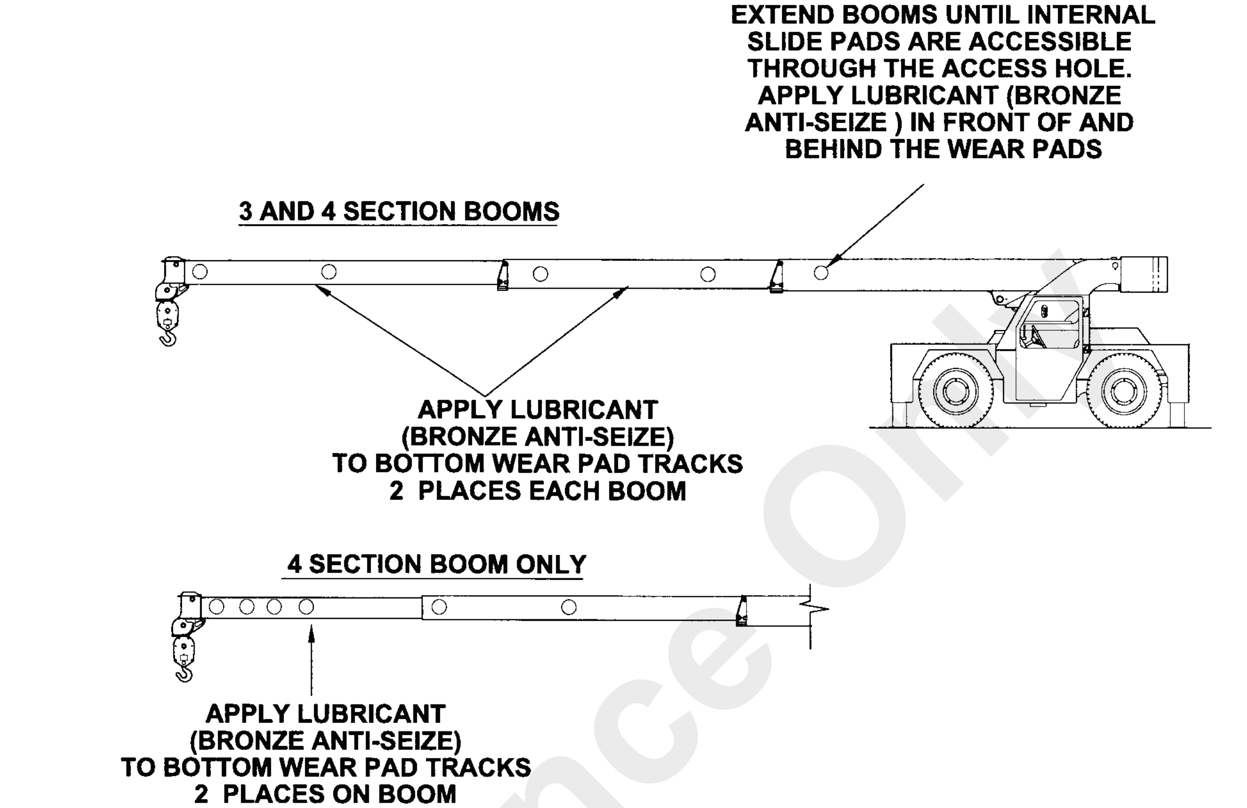


FIGURE 5-24

Lubricate The Boom Slides

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



Boom Slide Lubrication

FIGURE 5-25

5

100 Hours of Operation (Two Weeks)

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.

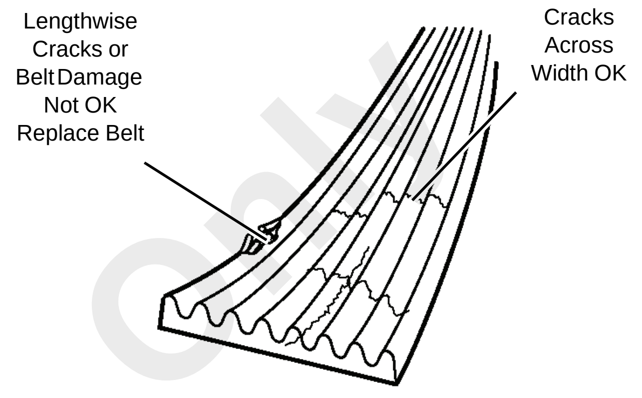
For additional engine maintenance guidelines, see the engine manual furnished with this crane.

Inspect the Fan Belts

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

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

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



Ribbed Belt Inspection-General

FIGURE 5-26

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

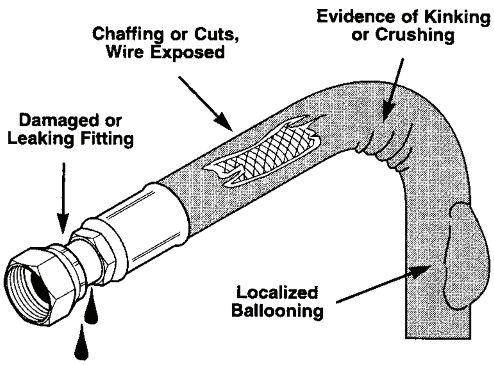
Check Wheel Nut Torque

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

250 Hours of Operation (Monthly)

Inspect the Hydraulic Hoses

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



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

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

Clean Battery and Cables

1. Remove the battery compartment cover.

p1652

Battery Location

FIGURE 5-27

2. Tighten all battery hardware to keep the battery securely in place.
3. Disconnect the battery cables.
4. Sprinkle the batteries with baking soda to neutralize the acid. Rinse with water. Be careful not to get water inside the battery.
5. Coat the battery posts with petroleum jelly and reinstall the battery cables.
6. Install the battery box cover.

Clean the Radiator

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

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

Lubricate the Wire Rope

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

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

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

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

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

Lubricate the Swing Gear and Pinion

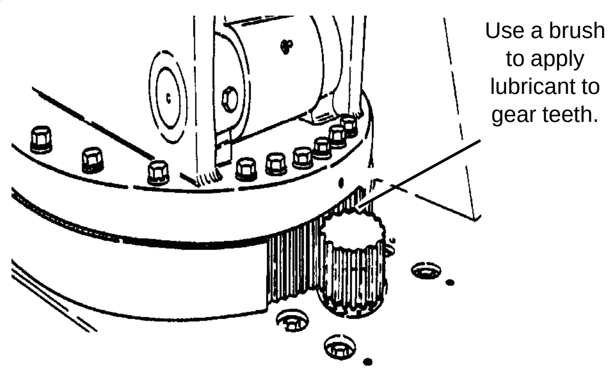
1. Engage the parking brake and shut off the engine.
2. Remove the guard covering the swing pinion.

w0022

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

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

a0097



Swing Gear and Pinion Lubrication **FIGURE 5-28**

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

Replace the Crankcase Oil and Filter

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

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

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

NOTE: Hot oils can cause personal injury.

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

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

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

Torque Critical Bolts

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

Hoist Winch Gearbox Mounting Bolts

Torque the 3/4" mounting bolts (4) to 280 lb-ft (380 Nm). See Figure 5-29.

p1644

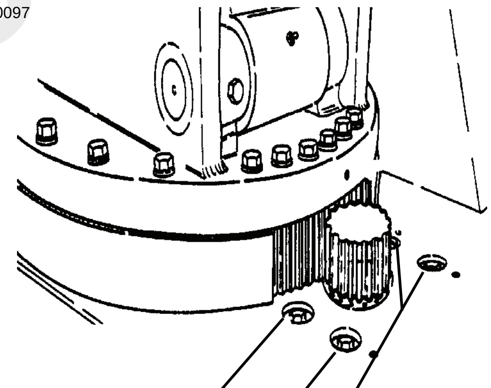
Hoist Winch Gearbox Mounting Bolts - 4

FIGURE 5-29

Swing Gearbox Mounting Bolts

Torque the 3/4" gearbox mounting bolts (4) to 200 lb-ft (272 Nm). See Figure 5-30. If the bolts are loose, check gear backlash.

a0097



Swing Gearbox Mounting Bolts

FIGURE 5-30

Mast Mounting Bolts

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

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

The correct torque on each outside bolt (mast to swing bearing) should be 158 lb-ft (215 Nm). The correct torque on each inside bolt (swing bearing to frame) should be 282 lb-ft (381 Nm).

Use the torque sequence shown in Figure 11-124 when checking the torque on the bolts.

NOTE: Use only special Grade 8 for replacement of the mast bolts. Order the bolts from your dealer, see your parts manual.

5

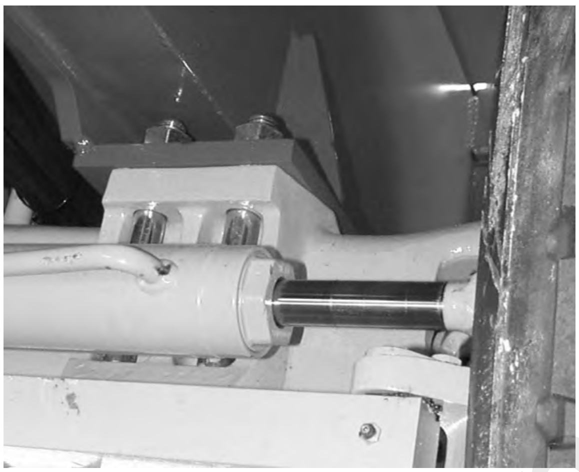
NOTE: If a broken bolt is found, replace the bolt and also replace the bolt on each side of the broken bolt.

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

Front Axle Mounting Bolts

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

p0424



Front Axle Mounting Bolts

FIGURE 5-31

500 Hours of Operation (3 Months)

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.

Inspect the Tires

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

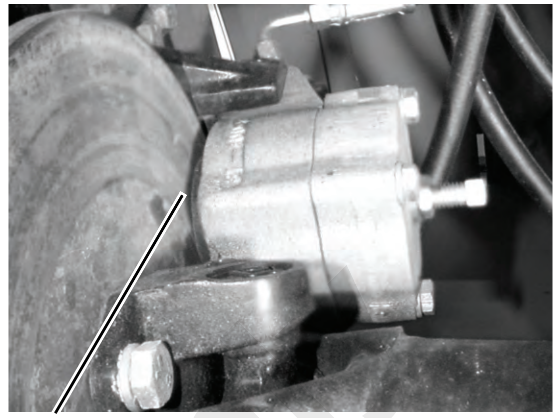
Inspect Parking Brake Pads

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

Inspect the thickness of the brake pads (Figure 5-32). Replace the brake pads if they are 0.028 inches (0.71 mm) thick or less.

Check the surface condition of the brake disc. Replace the disc if badly warped, pitted or out of tolerance.

p0329



Parking Brake Pads

FIGURE 5-32

Replace Fuel Filter (Diesel Engine)

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

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

Replace Air Cleaner Element

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

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

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

7. Install the new element over the stud in the housing and slide it all the way in.
8. Make sure the gasket is seating evenly. If you don't feel the gasket is seating evenly for a perfect seal, you won't have protection. Recheck to see if the sealing surface in the housing is clean, or if the element is not the right model number. If may be too short for the housing.
9. Install the air cleaner housing cover and the wing nut. Only hand tighten the wing nut.
10. Reset the air cleaner restriction indicator by pushing in the reset button (Figure 5-33).

p0411

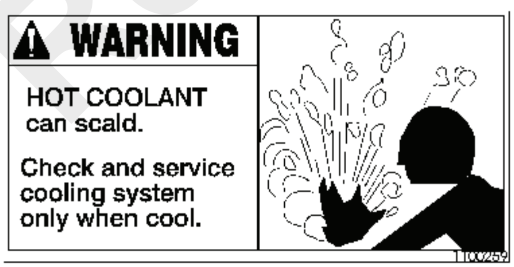
Resetting the Indicator Button-Typical

FIGURE 5-33

Spark Plug Gap (Gasoline Engine)

Thoroughly clean the spark plugs, including the threads. Check the electrode gap with a 0.030 inch (0.76 mm) feeler gauge. If not correct, reset the gap.

Add Rust Inhibitor to Engine Cooling System

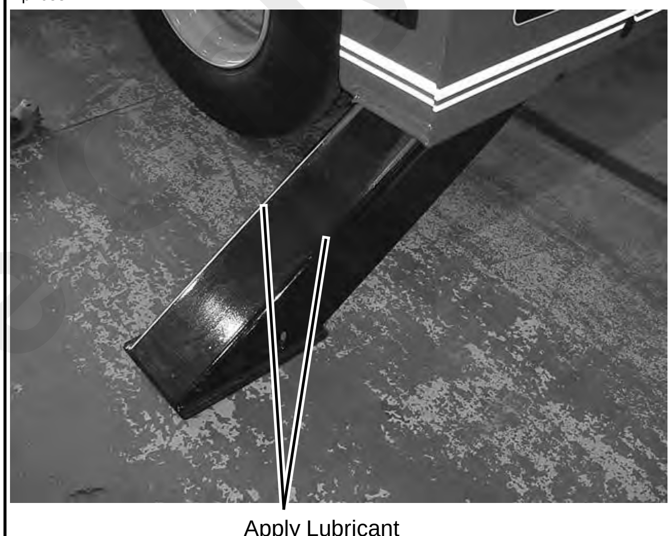


For maximum protection of the engine cooling system, add a corrosive inhibitor to the radiator. When the engine is cold, remove the radiator cap and pour the inhibitor in the radiator reservoir, following manufacturer's instructions.

Lubricate the Outrigger Slides

1. Lower the outriggers.
2. Clean the tops of the outriggers with a suitable solvent.
3. Apply Mobil EP grease, or equivalent, to the areas shown in Figure 5-34. Do not over lubricate. Raise and lower the outriggers several times to spread the grease.

p1658



Outrigger Lubricant

FIGURE 5-34

Add Grease to the Swing Gearbox

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

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

p0438

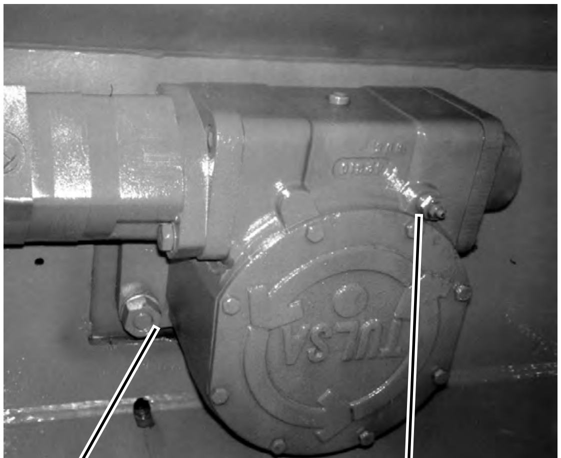


FIGURE 5-35

1. Engage the parking brake and shut off the engine. Remove the ignition key.
2. Clean the grease fitting and check plug (Figure 5-35).
3. Remove the check plug.
4. Apply Lithium Base, E.P. No. 2 bearing grease to the fitting. Fill gear box until grease exits the check plug hole. Install the check plug.

Check Axle Housing Lubricant Level

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

1. Clean around the axle housing fill/check plug (Figure 5-36 and Figure 5-37) and remove the plug.

p0429

FIGURE 5-36

p0430

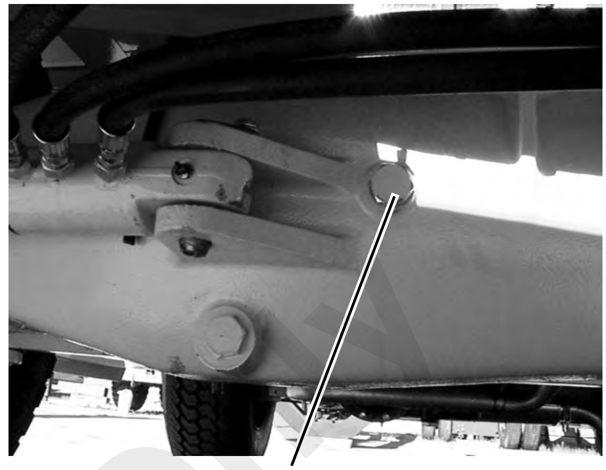


FIGURE 5-37

2. Check the lubricant level, which should be even with the bottom of the fill/check hole.
3. If necessary, add Mobil Fluid 424 to fill the housings until oil is level with the bottom of the fill/check hole.

Check Wheel Hub Lubricant Level

1. Using the outriggers, raise the tires slightly off of the ground.
2. Place the transmission in neutral and release the parking brake.
3. Turn one of wheel hubs until the fill/check plug is horizontal with the ground (Figure 5-38).

p1385

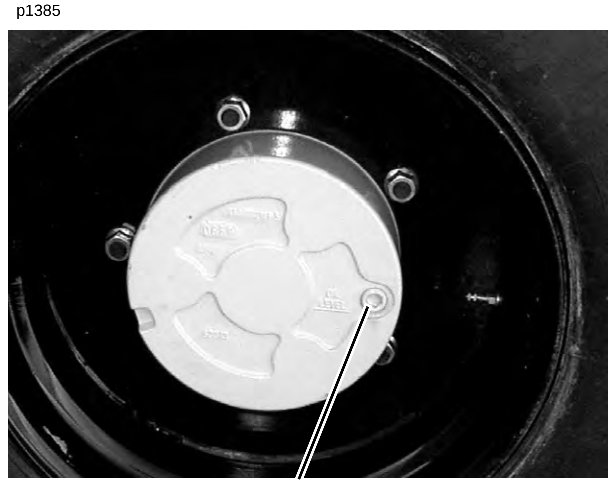


FIGURE 5-38

4. Clean around the plug and then remove it.
5. Check the lubricant level, which should be even with the bottom the hole.

6. If necessary, add Mobil Fluid 424 to fill the hub to the recommended level.
7. Repeat Steps 1 through 4 for the other wheel hubs.

Check Winch Gearbox and Brake Lubricant Levels

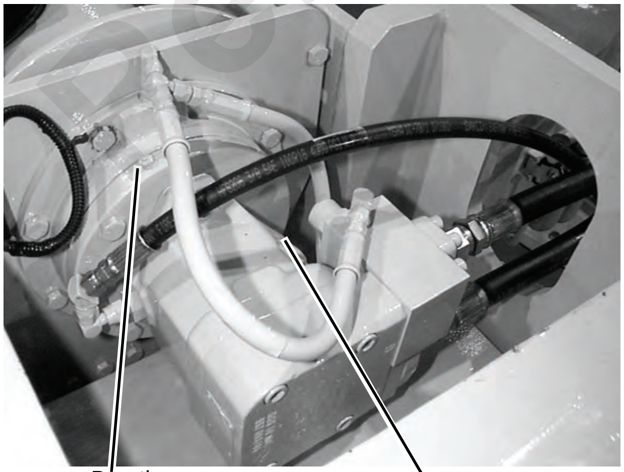
1. Lower the boom to its lowest position.
2. Engage the parking brake and shut off the engine.
3. Clean around the gearbox fill/check plug (Figure 5-40) and then remove the plug.
4. Check the lubricant level, which should be to the bottom of the fill/check hole.
5. If necessary, add SAE 90 EP gear lube to gearbox until it reaches the bottom of the fill/check plug hole.
6. Clean around the area of the brake breather and check plug (Figure 5-39). Remove the check plug.

p0412

Brake Breather

FIGURE 5-39

p1250



Breather

Check Plug Location

Fill/Check Plug

FIGURE 5-40

7. Check the lubricant level which should be level with the bottom of the check plug hole.

WARNING

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

---

8. If necessary, add SAE 20-20W motor oil through breather hole until oil is level with the bottom of the check plug hole.
9. Install the breather and check plug

1000 Hours of Operation (6 Months)

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

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

Replace the Transmission Oil and Filter

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

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

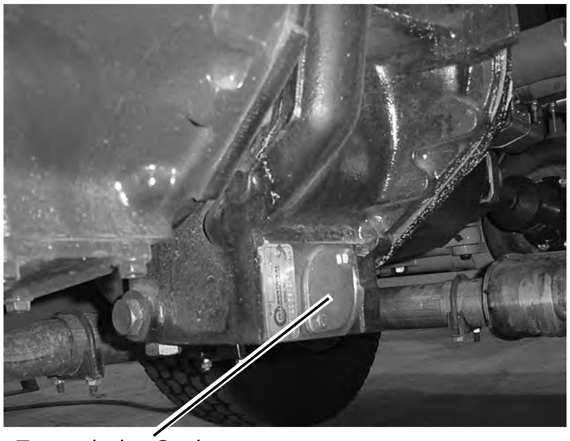
NOTE: When the strainer is loosened/removed, oil will gush out. Keep to one side when you remove the strainer.

2. Place a suitable container under the strainer (Figure 5-41). Remove the strainer and gasket and drain the oil into the container. Discard the gasket.

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 5-42). Drain any oil left in the transmission into the container. Install the drain plug.

p1653



Transmission Strainer

FIGURE 5-41

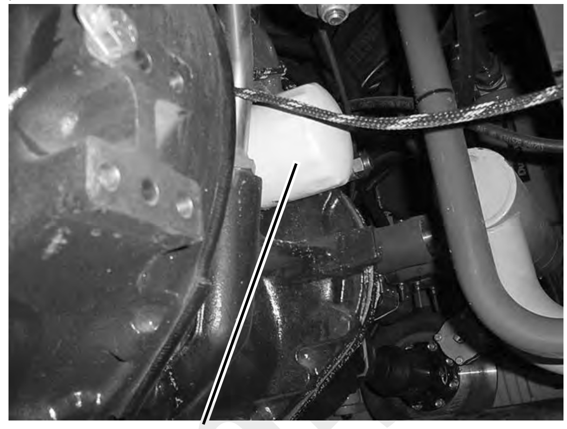
p1654

Transmission Drain Plug

FIGURE 5-42

4. Clean the strainer in a suitable solvent.
5. Install the cleaned strainer and new gasket. Tighten the strainer mounting bolts to a torque of 7.4 lb-ft (10 Nm).
6. Remove the transmission oil filter by unscrewing it from the transmission housing (Figure 5-43). Properly discard the filter.
7. Coat the seal of the new filter with clean transmission oil.
8. Screw on the transmission filter until it touches the filter head. Then, turn the filter another 3/4 of a turn minimum to seat the seal.

p1655



Transmission Oil Filter

FIGURE 5-43

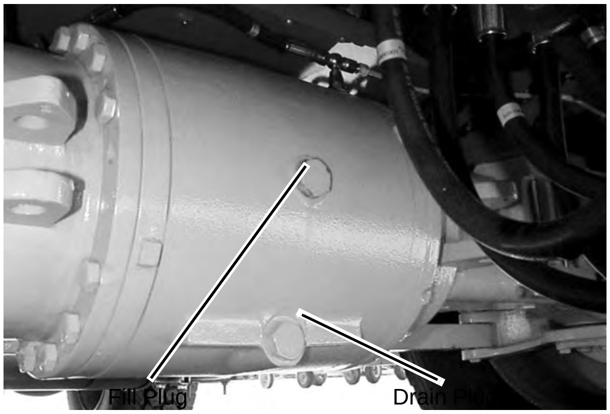
9. Fill the transmission with Mobil ATF 210, or equivalent, transmission fluid to the upper mark on the dipstick (approximately 3.43 gallons [13 liters]).
10. Start the engine and let it run at idle speed for a period not exceeding five minutes. This allows the oil to fill the transmission filter, torque converter and hoses.
11. Stop the engine, wait approximately one minute and then check oil level. If low, add oil to the upper mark on the transmission dipstick. **DO NOT OVERFILL.**

Replace the Axle Housing Lubricant

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

1. Clean around the fill plug in the axle housing (Figure 5-44 and Figure 5-45). Remove the plug.
2. Place a container under the axle housing drain plug (Figure 5-44 and Figure 5-45). Remove the drain plug and drain the fluid into the container. Install the drain plug.
3. Clean the front axle breather (Figure 5-46) with a suitable solvent. If the breather is removed, be sure that the hole in the breather tube is facing toward the axle hub (toward the right).

p0429

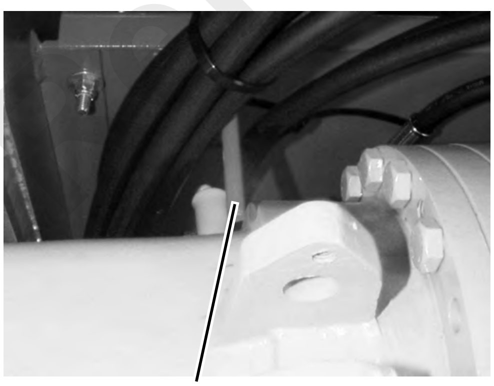


Axle Housing Drain and Fill Plugs (Front Axle) **FIGURE 5-44**

p0430

Axle Housing Drain and Fill Plugs (Rear Axle) **FIGURE 5-45**

p0431



Axle Housing Breather (Front Axle) **FIGURE 5-46**

4. Fill the axle housing with recommended lubricant through the fill plug hole. Fill until the oil reaches the bottom of the fill hole.
5. Install the fill plug.

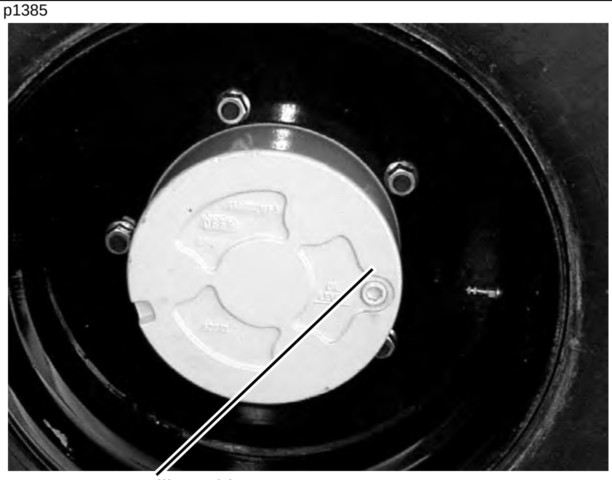
Replace Axle Wheel Hub Lubricant

p1385

Drain Plug Location **FIGURE 5-47**

1. Using the outriggers, raise the tires slightly off of the ground.
2. Place the transmission in neutral and release the parking brake.
3. Turn one of the axle wheel hubs until the drain plug is located at the bottom of the wheel hub (Figure 5-47).
4. Clean around the drain plug and then remove it. Drain the wheel hub oil into a suitable container.

p1385



Fill Position **FIGURE 5-48**

5. Turn the wheel hub until the drain hole is horizontal (Figure 5-48).
6. Fill the wheel hub with the recommended lubricant through the fill hole until the oil reaches the bottom of the hole.
7. Install the plug.
8. Repeat the above procedure for the other three wheel hubs.

5

Replace the Winch Gearbox and Brake Lubricant

Winch 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 in the hole in the side of the mounting bracket.

p0412

Plug Locations **FIGURE 5-49**

3. Clean around the gearbox breather and the fill/check plug hole. Remove the gearbox breather (Figure 5-49) and clean it in a suitable solvent. After it is cleaned, install the breather.
4. Clean around the fill/check plug (Figure 5-49) and remove the plug.
5. Place a suitable container under the drain plug.
6. Screw a 1 inch pipe nipple into the hole in the mounting bracket (Figure 5-49). Using a ratchet wrench with an extension and a 3/8” hex wrench attached, remove the drain plug through the pipe nipple. Allow the fluid to drain into the container. Examine the oil for signs of significant metal particles. If any particles are found, the gearbox may require disassembly and repair.
7. Install the drain plug and remove the nipple.
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.

Replace the Hydraulic Oil

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

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

To change the hydraulic oil:

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

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

4. Level the crane, engage the parking brake, shut off the engine and remove the ignition key.
5. Place a suitable container under the hydraulic tank drain ports (Figure 5-50).

p0426

Hydraulic Tank Drain Ports **FIGURE 5-50**

p0426

Tank Hoses and Suction Strainer **FIGURE 5-51**

6. When the tank is empty, disconnect the two hydraulic lines from the rear of the hydraulic oil tank (Figure 5-51). Remove the suction strainer from the suction port and clean it in a suitable solvent.
7. Clean the inside of the hydraulic tank and remove any sediment.
8. Install the fill strainer, suction strainer, suction hose and return line to the hydraulic tank.
9. Replace the hydraulic oil filter. See “Replace the Hydraulic Oil Filter.”
10. Fill the hydraulic tank with Mobil Fluid 424 hydraulic oil to the level sight glass.
11. After the tank is filled, start the engine and operate each function until all the cylinders and lines are filled.
12. Fully retract and lower the boom and retract the outriggers. Check the hydraulic oil level. Oil must be to the level sight glass. Add hydraulic oil if necessary.
13. Visually check for leaks.

Replace the Hydraulic Oil Filter

p0432

Hydraulic Filter

FIGURE 5-52

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

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

2. Locate the hydraulic oil filter under the machine (Figure 5-52).
3. Remove the filter:
   - **a.** Using a filter wrench, turn the filter counterclockwise to loosen and remove the filter. Properly discard the removed filter.
   - **b.** Clean the mounting surface on the filter head for the filter.
4. Install the filter:
   - **a.** Apply a small amount of clean hydraulic oil to the gasket of the new hydraulic filter. Install the filter. Install the filter to the filter head by turning it clockwise until the filter gasket makes contact. Then, tighten the filter 1/2 to 3/4 turn to achieve a tight seal.
   - **b.** Start the engine and check for leaks around the filter.

Replace L.P.G. Inline Filter

WARNING

Before disconnecting any L.P.G. lines and fittings, be sure the gas supply is shut off at the tank. L.P.G. gas is explosive and can cause serious personal injury or death.

WARNING

Keep flames from the surrounding area when disconnecting L.P.G. lines. L.P.G. gas is explosive and can cause serious personal injury or death.

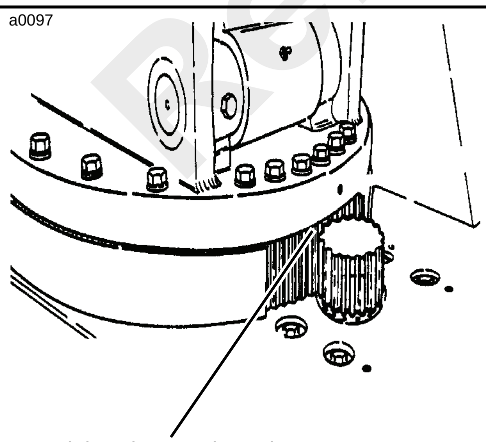
Shut off the L.P.G. supply at the tank and slowly loosen the hose at the bottom of inline swivel until all gas has escaped. Then, disconnect the hose and remove the inline filter. Install a new filter and attach the hose. Open the L.P.G. supply and check for leaks, using a soap and water solution. Bubbles will appear if leaks are present. Do not operate the crane with gas leaks. Tighten any loose connections.

Check Swing Gear/Pinion Backlash

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

Rotating gears can cause injury. Keep hand clear of rotating pinion and gear while the mast is rotating. Start the engine and rotate the mast until the high point on the swing gear is in alignment with the pinion. The high point is punch-marked on the mast plate (Figure 5-53).

2. Using a feeler gauge, check the backlash between the gear and pinion. There should be no clearance between the swing gear tooth and the pinion tooth. If there is any clearance, adjust the backlash. See Section 9, Structurals.



Swing Gear Backlash Check **FIGURE 5-53**

Replace the Spark Plugs (Gasoline Engine)

Disconnect one spark plug wire at a time and then replace the old spark plug with a new plug. Correct spark plug as AC 41-932 spark plug. The spark plug gap should be 0.030 inches (0.76 mm). Connect the spark plug wire and then remove the next wire.

Replacing the In-line Fuel Filter (Dual Fuel Engine)

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

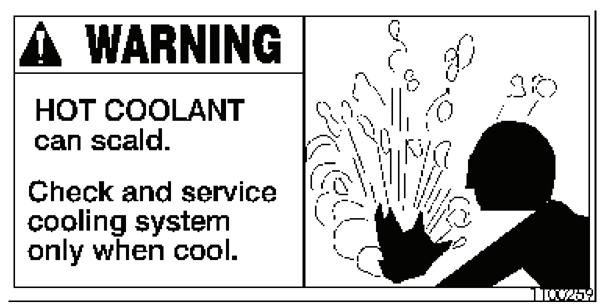
1. Engage the parking brake and shut off the engine.
2. Disconnect the two clamps and remove the filter.
3. Install a new filter between the hoses and secure it in place with the two clamps.

2000 Hours of Operation (Yearly)

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.

Replacing the Engine Coolant



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

Inspect the Crane Structure and Booms for Damage

Thoroughly inspect the crane structure and booms for the following:

1. Inspect for loose mounting hardware. Tighten any loose hardware.
2. Inspect for cracked or broken welds. Do not operate the crane if a critical weld is cracked or broken until the weld is repaired. Contact your Grove distributor or Manitowoc Crane Care.
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 Load Moment Indicator (Optional)

See the Load Moment Indicator manual furnished with this crane and test the indicator according to instructions in the manual.

MISCELLANEOUS MAINTENANCE

Batteries/Charging System

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

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

Checking the Charging System

Check the voltmeter reading on the instrument panel. Normal voltmeter readers 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 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.

Charging the Battery

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

Before using a battery charger, an attempt can be made to recharge the battery using the engine alternator by first jump starting the crane (See Jump Starting, in Section 3) and letting the engine run.

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

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

Replacing the Battery

NOTE: The fluid in electric storage batteries contains sulfuric acid, which is **POISON** and can cause **SEVERE CHEMICAL BURNS.** Avoid all contact of fluid with eyes, skin or clothing. Use proper protective gear when handling batteries. **DO NOT** tip any battery beyond a 45° angle in any direction. If fluid contact does occur, follow the First Aid suggestions that follows.

Battery Electrolyte First Aid

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

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

NOTE: In case of internal contact, **DO NOT** give fluids that would induce vomiting.

Remove the battery very carefully to avoid spillage of battery fluid. Properly dispose of the battery.

Fuel System

Fuel Storage

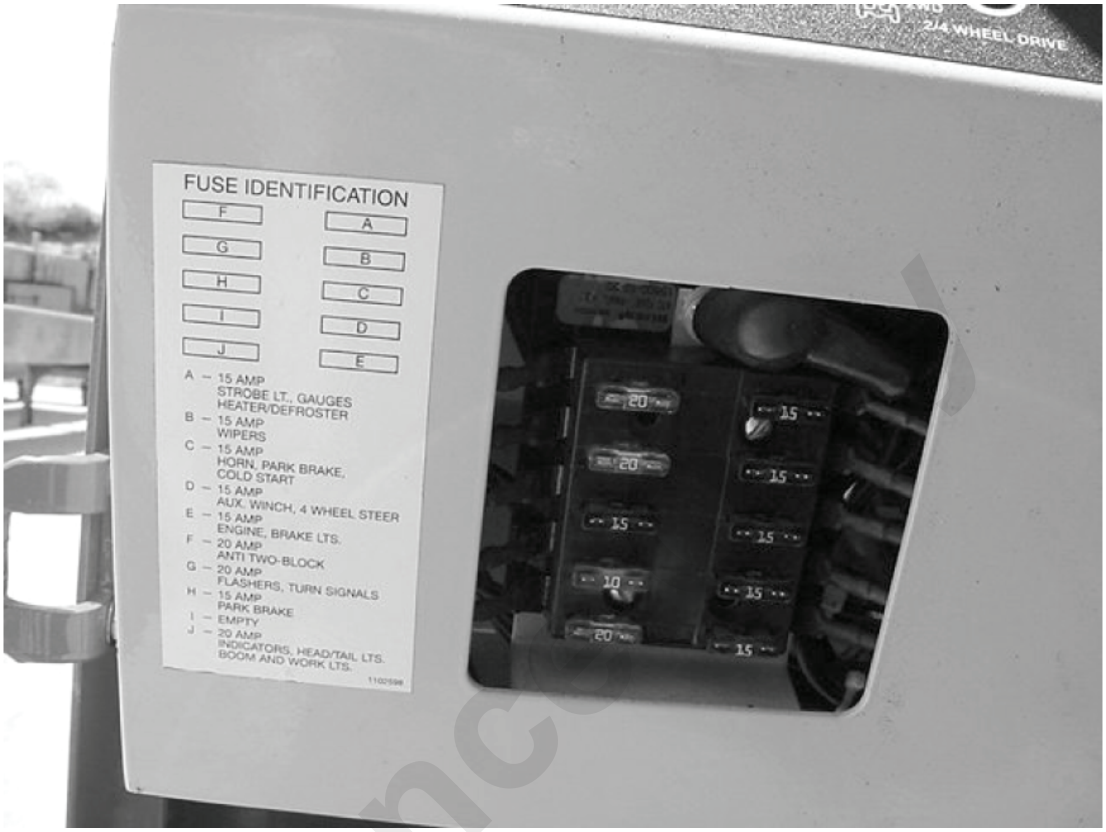
Storage of fuel for an extended period causes accumulation of sediment, dirt, water and other foreign materials in the fuel. Many engine problems are caused by dirty fuel and long storage periods.

Keep fuel in an outside location. Use a shelter to keep the fuel as cool as possible. The water from condensation must be removed at regular intervals from the storage tank.

Fuse Replacement

Ten fuses are located on a fuse block in the instrument panel (Figure 5-54).

p1645



Fuse Cover Location

FIGURE 5-54

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, cased 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 primered and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

NOTE: Unit must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged 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.

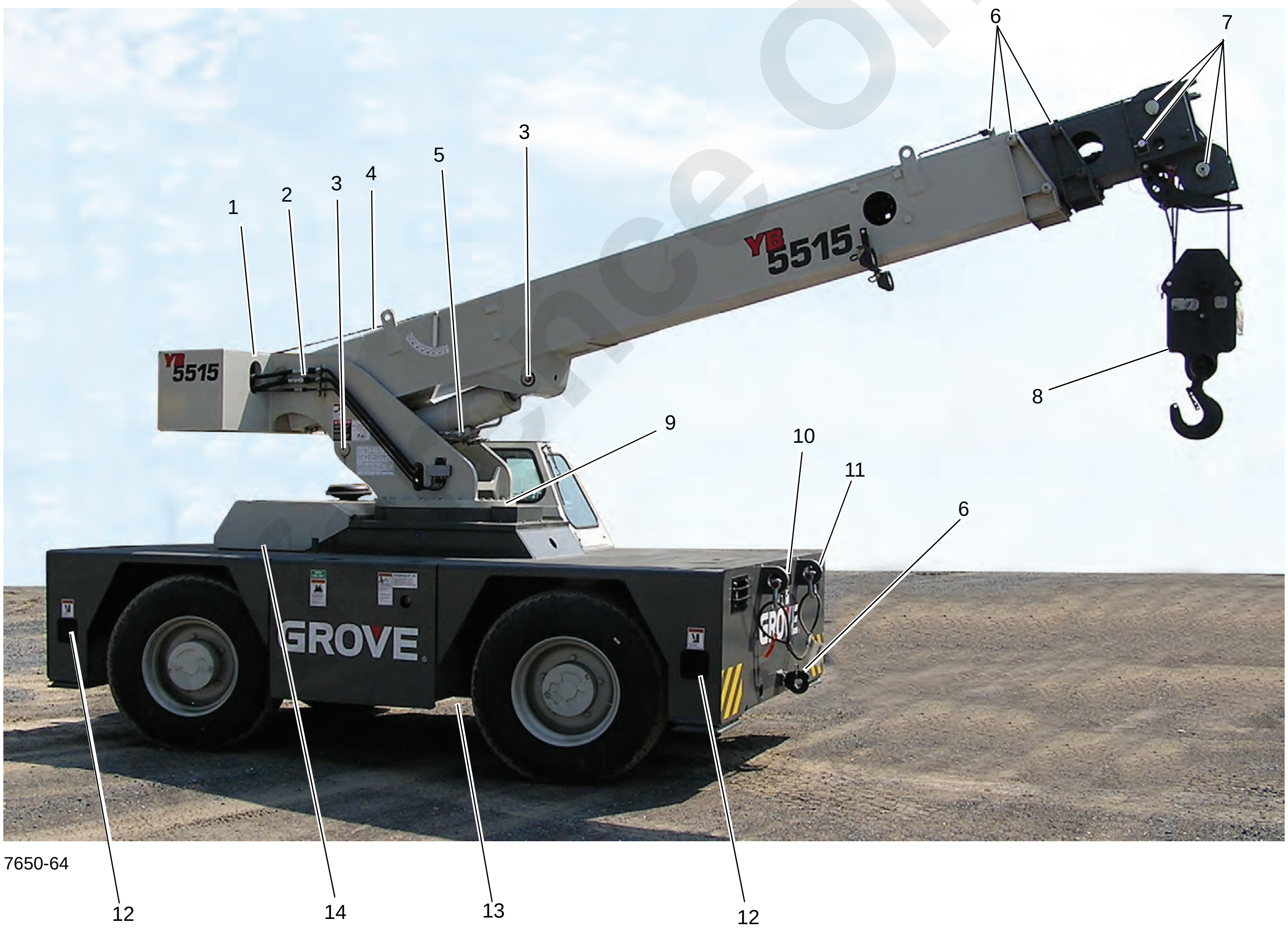
Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

Refer to Figure 5-55

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; Valves, hose end and fittings, Swivel, pumps, axles, drivelines, transmission, slew ring fasteners and all interior surfaces of the frame.

- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose 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.



7650-64

FIGURE 5-55

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

Item	Description
9	Turntable Bearing Fasteners
10	O/R Pins, Clips
11	Hook block Tiedown Cable
12	O/R Hose Connections
13	Entire underside of unit
14	Powertrain Hardware inside compartment
15	Boom Extension Pins, Clips - Option
16	Boom Extension Hanger Hardware - Option

SECTION 6
ENGINE AND ENGINE SYSTEMS

TABLE OF CONTENTS

6

THIS PAGE BLANK

SECTION 6
ENGINE AND ENGINE SYSTEMS

GENERAL

These instructions are written for worldwide use. In territories where legal requirements govern engine smoke emissions, noise, safety factors, etc., then all instructions, data and dimensions given must be applied in such a way that, after maintaining or repairing the engine, it does not contravene regulations when in use.

NOTE: These instructions cover only the routine maintenance of the engine. See the engine manual furnished with the crane for engine diagnosis, repair and component replacement.

ENGINE TYPES

Two and four wheel drive units use a Cummins 4B3.3 turbo-charged diesel engine.

ENGINE PERFORMANCE

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

ENGINE RPM

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

GOVERNOR

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

NOTE: On units with a diesel engine, restrictions or wrong adjustment of the throttle linkage can be a possible cause of wrong engine rpm. Make sure the throttle linkage moves the engine throttle lever through a full stroke. If necessary, disconnect the throttle linkage and move the throttle by hand. Check the engine speed with the throttle linkage disconnected and compare results.

ENGINE CRANKCASE SYSTEM

The engine crankcase system must be well lubricated to inhibit damage to the engine. The correct type of oil must be used, as well as proper maintenance at regular intervals. For correct intervals, see Preventative Maintenance, page 1.

Crankcase Oil Data

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

Diesel Engine

Oil Performance Recommendations

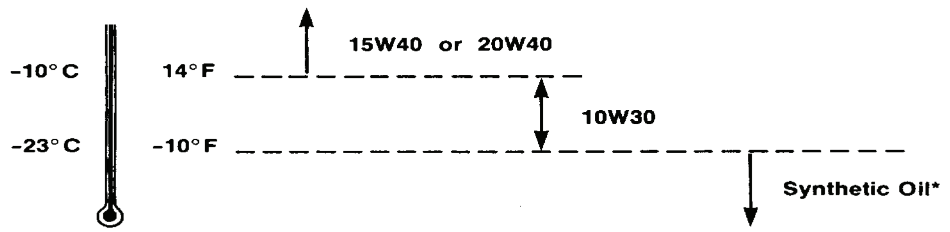
CC/SF for use in naturally aspirated engines and in engines that operate in light duty service including standby and emergency operation (equivalent to MIL-L-2104B).

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

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

Oil Viscosity Recommendations

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



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

Arctic Operation

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

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

Table 6-1: Arctic Oil Recommendations

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

ENGINE COOLING SYSTEM

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

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

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

Coolant Requirements

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

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

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

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

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

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

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

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

NOTE: If you use water without a corrosion inhibitor, rust will form and plug the small holes in the head gasket. These holes are orifices and their size is critical. Do not enlarge the size of the orifices. To do so will disturb the coolant flow and will not solve any overheating problem. If you use water without a corrosion inhibitor for even a short period, the cup plugs will rust through, allowing coolant leakage.

An incorrect or malfunctioning radiator cap can result in the loss of coolant and engine running hot. Any sudden loss of coolant from a heavily loaded engine can result in severe damage to the pistons and cylinder bore.

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

Radiator Cap and Overflow Bottle

The cooling system is designed to use a radiator cap to prevent the boiling of lubricant. The radiator cap is set to open at 7 psi. (50 kPa). When it does open it allows coolant to be expelled into the overflow bottle and as soon as the engine cools the overflow fluid is sucked back into the radiator. An incorrect radiator cap can result in a great loss of coolant and the engine running hot.

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

Thermostat

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

ENGINE ELECTRICAL SYSTEM

The engine electrical system, the charging and starting circuits, as well as the sending units, are described in this section.

ENGINE FUEL SYSTEM

Diesel Engine Fuel System Description

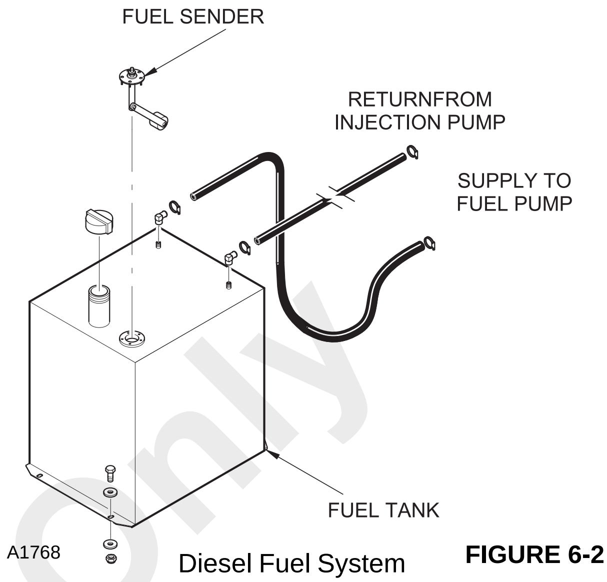
The diesel engine fuel system is a closed-loop fuel system which includes a fuel tank, an engine fuel filter, an engine fuel pump and the fuel lines.

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

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

Fuel Tank

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



Diesel Fuel System **FIGURE 6-2**

Fuel Level Sender and Gauge

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

Fuel Pump

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

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

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

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

Fuel Filter

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

Fuel Injection Pump

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

Fuel Injectors

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

QSB Engine Electronic Controlled Fuel System Units

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

Types of Fuel to Use

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

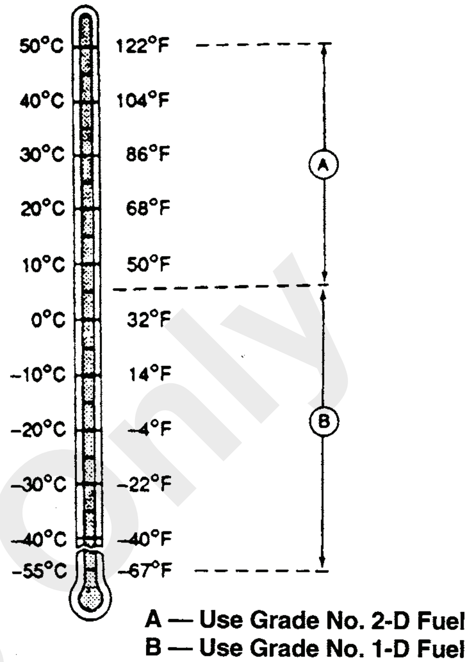
WARNING

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

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

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

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



a0321

FIGURE 6-3

NOTE: If engine is operating at temperatures 0 -40° to -70° F (-40° to -57° C), Grade DF-A arctic fuel is recommended. Also consult the engine distributor for special lubricants and starting aids.

Cetane number should be a minimum of 40 to assure satisfactory starting and overall performance. At low temperatures and/or high altitudes, minimum cetane number of 45 is recommended.

NOTE: Excessive white smoke at start up could be a result of low cetane fuel.

Use low sulfur content fuel with a cloud point of at least 10° F (6° C) below the lowest expected air temperature at time of starting. The cloud point is temperature at which wax crystals begin to form in diesel fuel.

NOTE: When using diesel fuel with a sulfur content above 0.5%, the engine oil change interval must be reduced by 50%. DO NOT use a fuel with more than 1% sulfur.

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.

ENGINE AIR INTAKE SYSTEM

Air for combustion is pulled through an air filter by the engine. Dust and foreign materials are removed from the air by the air filter.

Replace or clean the air filter at the intervals given in Section 5, Preventative Maintenance, Section 5. Make sure all clamps on the intake tube and filter are tight. If dust or foreign materials enter the engine, permanent damage can be caused to the engine.

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

ENGINE EXHAUST SYSTEM

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

w0002

FIGURE 6-4

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

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

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

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

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

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

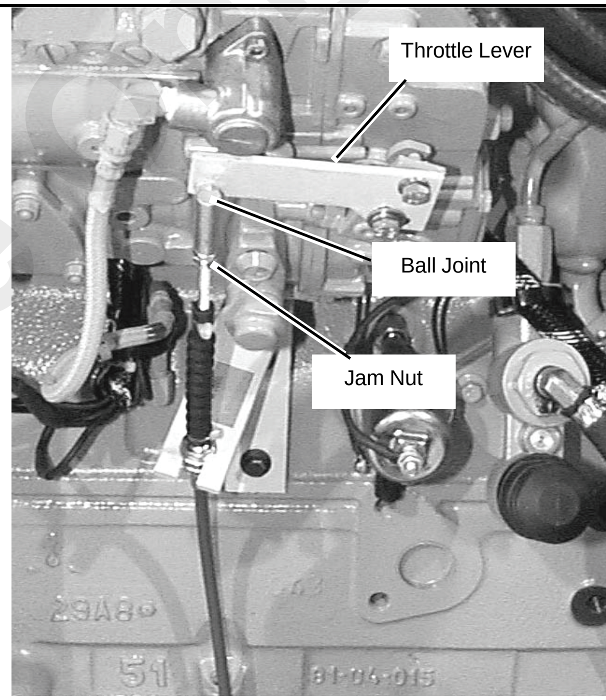
Check the complete exhaust system for broken, damaged, missing or mispositioned parts, open seams, holes, loose connections and other deterioration which could cause exhaust fumes to seep into the operator's compartment. Any damaged areas must be corrected.

CHECKS AND ADJUSTMENTS

Throttle Linkage Adjustment

Adjustment of the throttle linkage is made by adjusting the travel distance of the throttle cable.

1. Remove the ball joint Figure 6-5 from the throttle control lever.



p0096

FIGURE 6-5

2. Loosen the jam nut and turn the ball joint clockwise to increase throttle speed and counterclockwise to decrease throttle speed.
3. Connect the balljoint to the throttle lever and then tighten the jam nut.

NOTE: Maximum speed on both the diesel and gasoline engines is 2500 rpm. Main hydraulic pump damage could occur from a higher rpm setting. Never set engine speed higher than 2500 rpm.

Table 6-2: Engine Troubleshooting Chart

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

REMOVAL AND INSTALLATION

Removal

WARNING

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

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

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

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

Installation

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

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

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

DUAL FUEL ENGINE AND ENGINE SYSTEMS

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 Types

Both the two wheel drive and four wheel drive machines use a GM 4.3L dual fuel engine.

Engine Performance

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

Engine RPM

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

Governor

The governor is preset at the factory and is very unlikely that it should ever have to be adjusted. If adjustment is required for any reason, refer to Adjustment in this section.

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.

The lubricating oil recommendation is based upon engine design, type of service and the atmospheric temperature prevailing. High quality oils are required to ensure maximum performance, long engine life, and minimum cost of operation.

The recommended oil to be used in the GMC V-6 Gasoline Engine must have the following classifications.

API, SAE ASTM ClassificationSG/CD, SF/CC

Do not use SD or SC API classification oils. These oils do not provide adequate protection against oil oxidation, high temperature oil deposits, rust and corrosion.

Recommended SAE Viscosity Grades.	
5W20	+20° to -25° F
10W30	+104° to -15° F
15W40	+122° to +14° F
20W40	+122° to +25° F
10W	+40° to -25° F
20W	+75° to +32° F
30W	+104° to +45° F
40W	+122° to +60° F

Engine Cooling System

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

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 V-belt from the crankcase 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. The antifreeze must have an ethylene glycol (ethanediol) base. Use a low silicone antifreeze that conforms to one of the standards below, or which contains no more than 0.1% anhydrous alkali metasilicate.

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

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

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

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

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

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

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

CAUTION

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

Radiator Cap and Overflow Bottle

The cooling system is designed to use a radiator cap to prevent the boiling of lubricant. The radiator cap is set to open at 7 psi. (50 kPa). When it does open it allows coolant to be expelled into the overflow bottle and as soon as the engine cools the overflow fluid is sucked back into the radiator. An incorrect radiator cap can result in a great loss of coolant and the engine running hot.

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

Thermostat

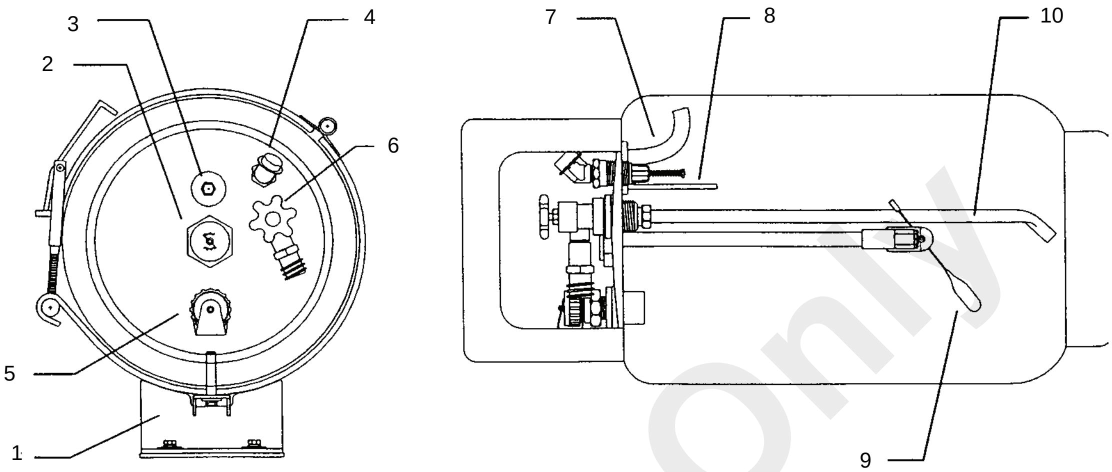
A malfunctioning thermostat can result in the engine running hot or cold. If it becomes necessary to replace the thermostat refer to the engine manual furnished with the crane.

Engine Electrical System

The engine electrical system, the charging and starting systems, as well as the sending units, are described in Section 11.

ENGINE FUEL SYSTEMS

Fuel Injected Dual Fuel System



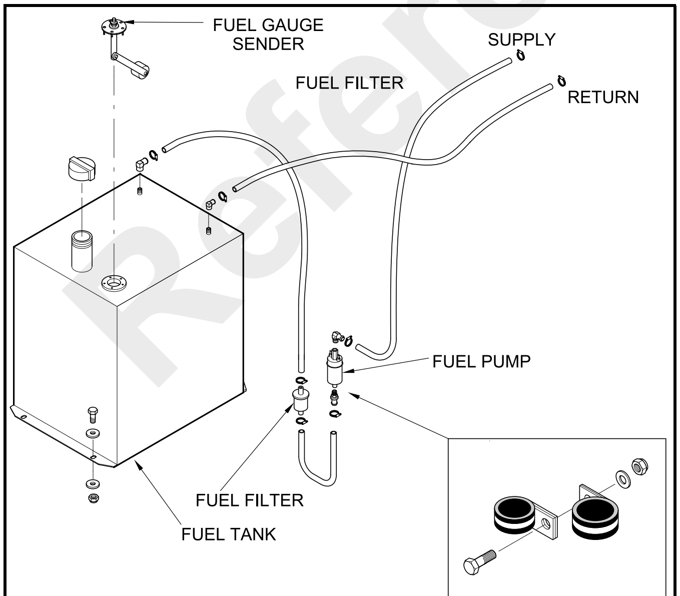
a0959

LPG Tank

FIGURE 6-6

Gasoline Portion

The gasoline fuel portion of this dual fuel system Figure 6-7 is a closed-loop system which includes a fuel tank, an in-line fuel pump, a filter installed between the fuel pump and the engine. A relay switches between Liquid Propane Gas (LPG) and Gasoline when the dual fuel switch is actuated in the operator's cab.



a2184

Dual Fuel Gasoline System

FIGURE 6-7

Liquid Propane Gas (LPG) Portion

The LPG portion of the dual fuel system includes an LPG tank, a bulkhead connection, a hydrostatic relief valve, an in-line filter, a primary vaporizer unit, a secondary vaporizer unit and a throttle body. A relay switches between Liquid Propane Gas (LPG) and Gasoline when the dual fuel switch is actuated in the operator's cab.

LPG Tank

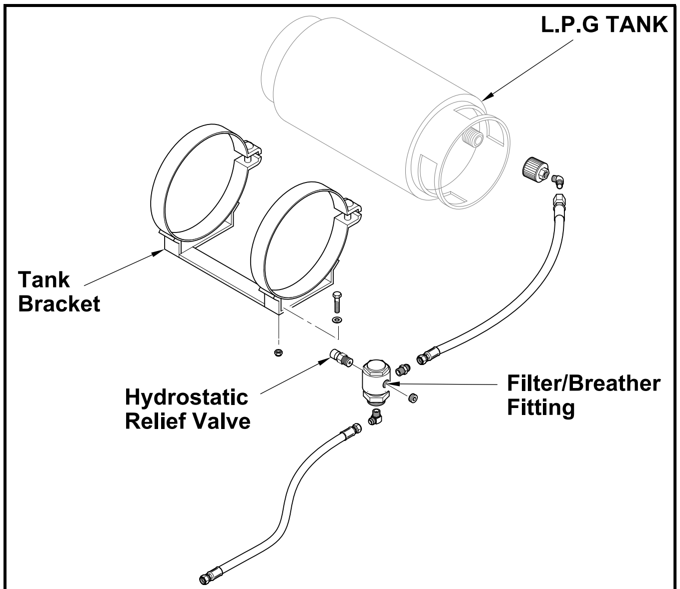
See Figure 6-6 for description of LPG tank.

In-line Filter

A 20 micron filter Figure 6-8 is installed in the LPG line to the engine. This filter must be replaced yearly.

Hydrostatic Relief Valve

The hydrostatic relief valve Figure 6-8 protects the LPG fuel system from a pressure buildup above 375 psi (2585 kPa). If the pressure in the system becomes greater than the setting of the relief valve, the relief valve opens and releases gas to the atmosphere until the pressure drops below the relief valve setting, at which time the relief valve closes.



Hydrostatic Relief Valve and In-Line Filter

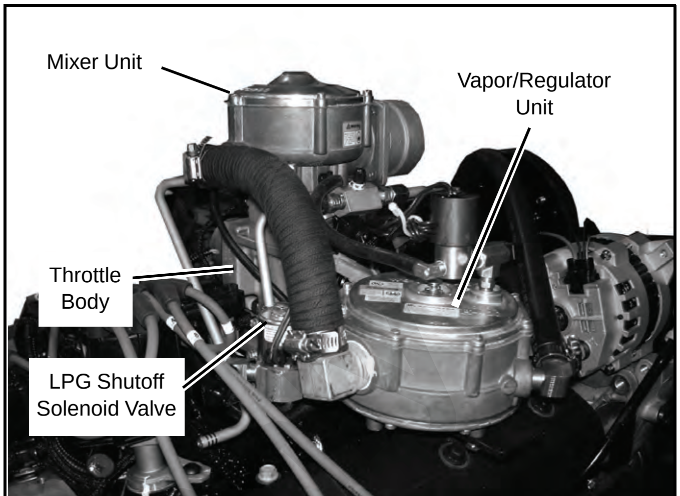
a2128

FIGURE 6-8

Vaporizer/Regulator Unit

The vaporizer/regulator unit Figure 6-9 receives liquid propane at tank pressure and reduces the pressure in two stages to slightly less than atmospheric pressure. When the engine is cranking or running, a partial vacuum is created in the fuel line to the throttle body which opens the regulator allowing fuel flow to the mixer assembly.

In the process of reducing the pressure from upwards of 180 psi (1241 kPa) in the LPG tank to atmospheric pressure, the liquid propane expands to become a vapor, causing refrigeration. To compensate for this and to assist in vaporization, water from the engine cooling system circulates through the heat exchanger of the vaporizer/regulator unit. The regulator seals off fuel flow when the engine stops.



p3028

FIGURE 6-9

Mixer Unit

The mixer unit Figure 6-9 adjusts the correct amount of fuel and air for proper engine operation.

The air/fuel mixture is adjusted at the factory for proper engine operation.

Throttle Body

The throttle body Figure 6-9 houses and operates two fuel injectors; one for gasoline and one for LPG.

Fuel Tank

The fuel tank is located on the right side of the crane's frame. 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 of the tank.

Fuel Level Sender and Gauge

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

Fuel Pump

The fuel injection pump is located between the fuel tank and the engine. As long as the dual fuel switch in the cab is set to "Gasoline," the fuel pump will pump fuel to the engine when the ignition switch is turned to the ON position and while the engine is running. When the dual fuel switch is set to the LPG position, the pump is shut off.

Types of Fuel to Use

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

Anti-Knock Index Number (AKI) -- 87 or 89
Research Octane Number (RON) -- 90

CAUTION

The use of gasoline with a lower octane than 87 AKI (91 RON) octane will result in serious damage to the engine. Engine damage resulting from use of low octane gasoline is considered misuse of the engine and will void the engine warranty and the Grove warranty.

Gasoline Containing Alcohol

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

The GMC gasoline engine may be operated using gasoline blended with no more than 10% Ethanol meeting the octane specifications. **DO NOT** use any gasoline which contains **METHANOL.**

Engine Air Intake System

Air for combustion is pulled through an air filter by the air pump on the engine. Dust and foreign materials are removed from the air by the air filter.

Replace or clean the air filter at the intervals given Preventive Maintenance Section of the operator's manual. 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.

CAUTION

Never run the engine without an air filter installed.

Engine Exhaust System

w0002

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

FIGURE 6-10

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.

Period 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 miss-positioned 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.

Electronic Fuel Injection System

General

Over the past 30 years, increasing regulations have made electronic engine controls a cost-effective solution for reducing emissions and improving fuel economy and performance in passenger cars and trucks. Positive side effects from the addition of electronics, include better acceleration, improved cold start and hot start behavior and improved power output. Many of the components that have had extensive development and testing in passenger car applications (e.g., fuel injectors, pumps, regulators, sensors, etc.) are used directly on the industrial gasoline engine installed in the Modes 5540F & YB5515 crane. When these components are applied correctly, along with an electronic control unit (ECU) designed specifically for industrial applications, the result is a system which meets the immediate needs of regulatory agencies.

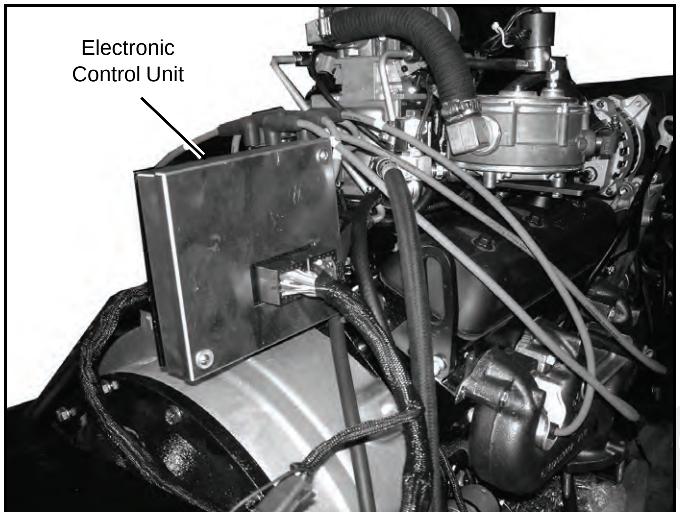
The fuel injection system used on this Grove crane utilizes high volume, state-of-the-art automotive components and an ECU and throttle designed for industrial applications. The system is very simple when compared with current automotive complexity. The system fulfills the requirements of the industrial engine user, by combining flexible fuel control, electronic speed control and ignition control in the same microprocessor.

Injection Strategy

The type of fuel injection used on this YB crane is classified as Throttle Body Injection (TBI). This type of injection, also known as single point injection, operates fuel injector(s) located upstream of the intake manifold.

Control Unit

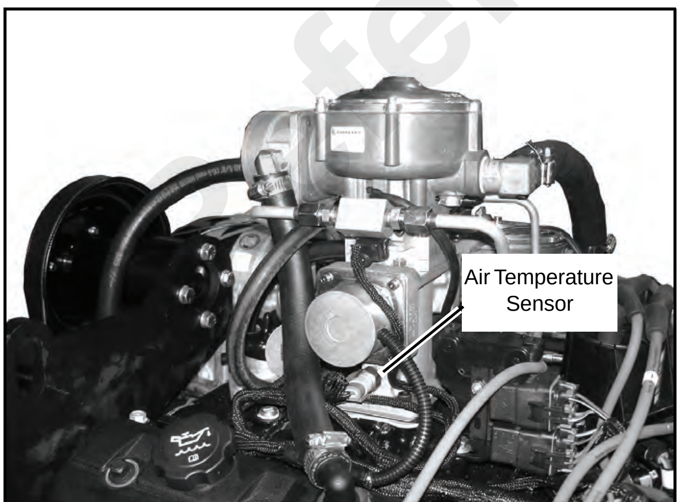
1. The **Electronic Control Unit (ECU)** Figure 6-11 is a simple programmable computer that controls air/fuel mixtures, spark advance curves and provides electronic governor control based upon engine and environment information received from the fuel injection system sensors. The ECU constantly reads the inputs and calculates the time the injectors are turned on, tells them when to turn on, calculates ignition advance and tells the ignition system when to fire each spark plug.



p3029 **FIGURE 6-11**

Sensors

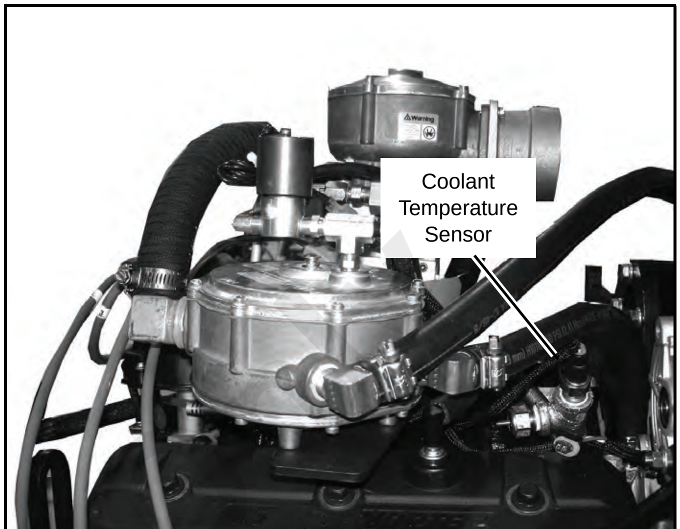
Several sensors are used in the fuel injection system to provide the ECU with vital operating information.



p3032 **FIGURE 6-12**

1. Air Temperature Sensor Figure 6-12

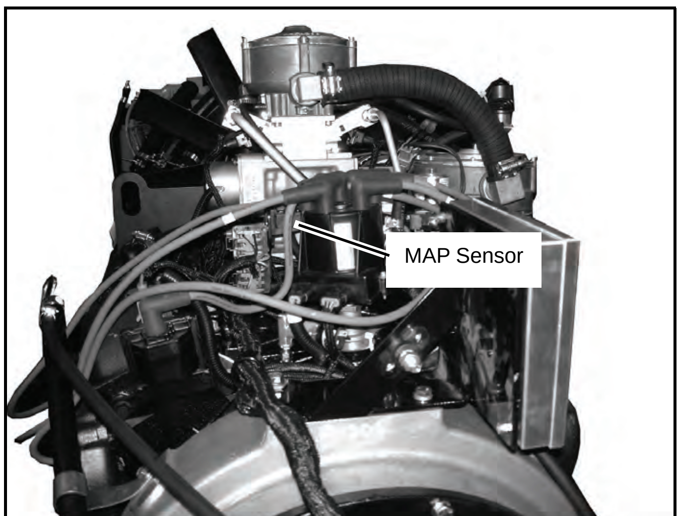
   This sensor is used to measure the air temperature in the intake system. The information obtained is used to change the air/fuel ratio (mixture) to compensate for different ambient air temperatures.



p3031 **FIGURE 6-13**

2. Coolant Temperature Sensor Figure 6-13

   Used to measure the engine coolant temperature, the ETS provides information for cold or hot correction of the injection volume and ignition timing. It is also used to provide gain correction to the governor control during cold start.



p3030 **FIGURE 6-14**

3. MAP Sensor

   The Manifold Absolute Pressure (MAP) sensor Figure 6-14 provides the ECM with a signal proportional to engine load. This is used in determining injection volume, acceleration compensation, ignition timing and governor control.

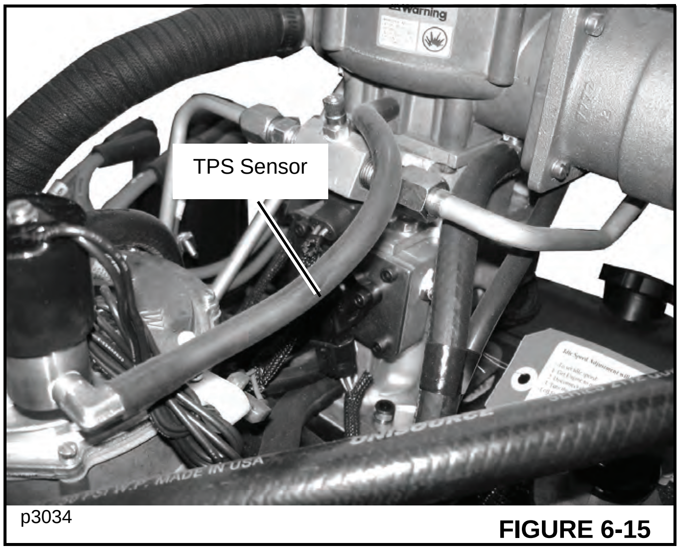


FIGURE 6-15

4. Throttle Position Sensor Figure 6-15

The Throttle Position Sensor (TPS) signal is used to provide an indirect indication of engine load. It may also be used for governor feedback control. This sensor is located in the throttle body.

A potentiometer in the accelerator pedal Figure 6-16 regulates the speed of the engine and is connected to the throttle position sensor by an electrical wire assembly.

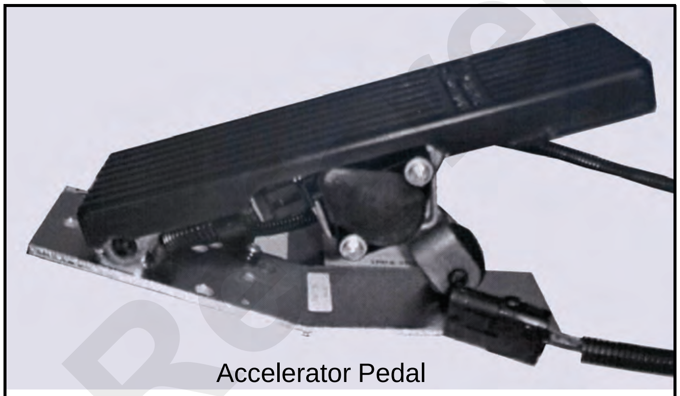


FIGURE 6-16

5. Oxygen (O2) Sensor

This sensor is installed in the engine exhaust and is used to control exhaust gas emissions.

Fuel Injection Components

1. Coarse Fuel Filter Figure 6-17

Located between the fuel tank and the fuel pump, this 40 micron filter protects the fuel pump from contaminants in the fuel supply.

2. Fuel Pump Figure 6-17

The fuel pump is located between the coarse filter and the fine fuel filter and is operated by the crane's electrical system. It is a high pressure pump and its pressure must be maintained at a constant pressure to feed the fuel injectors and allow air/fuel ratio control.

3. Fine Fuel Filter Figure 6-17

Located between the fuel pump and the engine, this 10 micron filter protects the fuel injectors from contaminates that are either too small to be filtered by the coarse fuel filter or are released by the fuel pump.

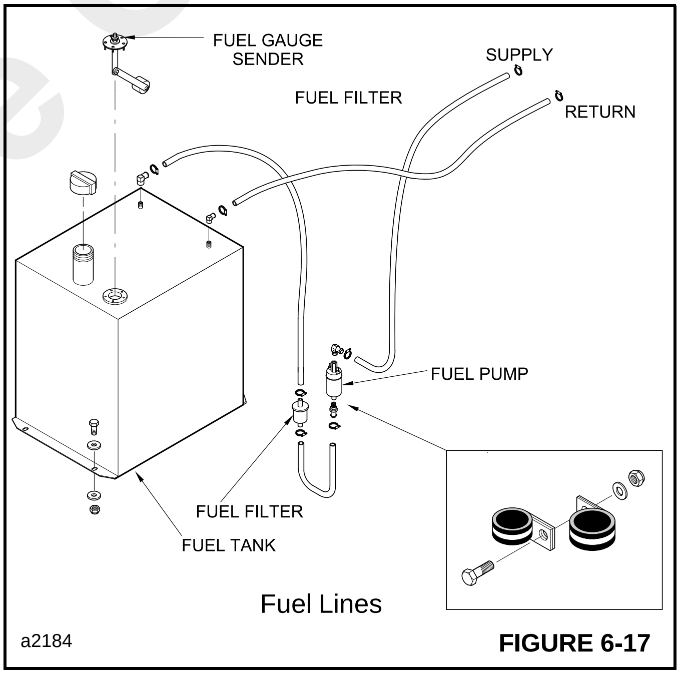
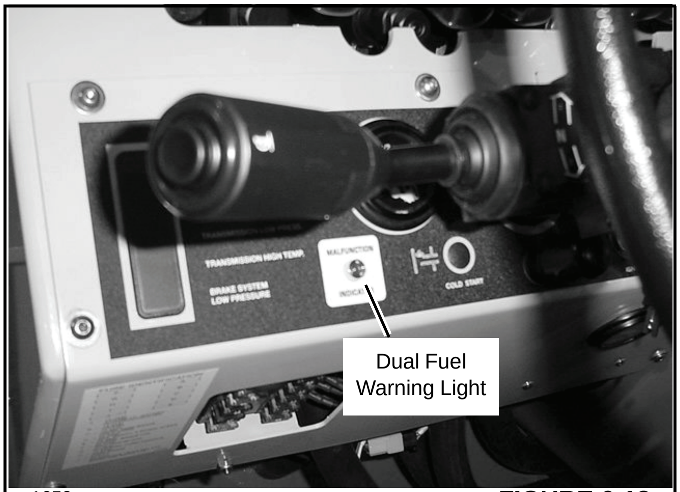


FIGURE 6-17

4. Fuel Injectors

One fuel injectors is used in the fuel injection system. It injects gasoline only.



p1659 FIGURE 6-18

Dual Fuel Engine Warning Light

This light is for operator inspection upon powering the system with the ignition switch. This light displays error codes, if present, when the ignition switch is turned on, engine off. The codes are conveyed by flashing the light in such a manner that the first numeral flashed, a pause, and then the second number if the code flashed.

The light will flash a code 12 every time the ignition switch is moved to the ON position; this indicates the system is in the diagnostic mode. When a code has been set, the code will be indicated after the code 12 is flashed. For instance, if a code 24 has been set, the light will flash one time, pause, flash two times, after which it will flash two times and then four times, indicating the code 24. If multiple codes are set they will be displayed in numerical order, not in order of occurrence.

Refer to Table 6-3 for error codes and error code diagnostics

.

Table 6-3: Error Codes

Error Codes	Error Description
12-	Diagnostic mode indicator
13-	Oxygen sensor error
14-	Engine coolant tempera -- high
15-	Engine coolant temperature -- low
21-	Throttle position sensor error
22-	Throttle body actuator not responding
23-	Inlet air temperature sensor -- low
24-	Inlet air temperature sensor -- high
25-	Electronic ignition control error
31-	Drive by wire error
32-	System voltage low
41-	Manifold absolute pressure sensor error
43-	Fuel Injector fault
51-	EPROM fault
52-	Analog to digital converter fault
61-	LP solenoid relay fault
62-	Fuel pump relay fault
63-	Dual fuel relay fault
64-	Ignition power relay output fault

NOTE: For electrical connections, pin numbers, etc., refer to wiring diagrams.

Error Code Diagnostics

Code 12: Code 12 is special code signifying the beginning or end of the error codes.

Code 13: Code 13 indicates the oxygen (O2) sensor has not warmed up or is stuck rich, lean or neutral for a period of time. Other fuel system issues can cause this; for example, incorrect fuel pressure, or a leak in the MAP sensor hose.

To verify the oxygen sensor wiring:

1. Verify fuses are intact.
2. Disconnect the oxygen sensor connector, and turn the ignition power on.
3. Measure the voltage across the oxygen harness connector pins A (-) and B (+). This should read near 0.45 volts.
4. If not turn off the power.
5. Disconnect the ECM.
6. Check the connections shown below:

Harness O2 Sensor Check

Meter Mode	From	To	Desired Result	If Defective
Ohms	ECM10	Harness O2 A	<1 Ohm	Wire is open
Ohms	ECM10	Harness O2 B	Open	Wire is shorted
Ohms	ECM20	Harness O2 A	< 1 Ohm	This wire is open
Ohms	ECM 20	Harness O2 B	Open	Wire is shorted

7. Turn on the ignition

 7.1 Measure the voltage across the harness oxygen sensor connector pins C (+) and D (-). This should read near battery voltage. If not perform the following measurements:

Harness O2 Heater Check

Meter Mode	From	To	Desired Result	If Defective
Voltage	Ground	Harness O2 C	10 - 14 volts	O2 wire is open
Voltage	Battery +	Harness O2 C	< 1 volt	O2 wire is open
Voltage	Ground	Harness O2 C	< 1 volt	O2 wire is open
Voltage	Battery +	Harness O2 C	10 - 14 volts	O2 wire is open

 7.2 If battery voltage is present in step 7.1, measure resistance between the 2 white wires on the O2 sensor. There should be between 1.5 to 3.52 ohms at room temperature. If the heater is open or shorted, replace the sensor. A warm sensor will read higher resistance than a cold sensor. If no wires are open or shorted. Verify the rest of the fueling system is operating properly. If everything else checks out, replace the oxygen sensor.

Code 14: The engine coolant reads too high. It is possible to receive this code if the engine is severely overheated above 280° F (138° C).

Code 15: The engine coolant reads too low. This may occur if the temperature is below 30° F (-1° C), or if the coolant temperature sensor is unplugged.

To verify coolant temperature wiring:

1. Disconnect the coolant temperature sensor (CTS) and measure the resistance of the coolant temperature sensor. This will vary depending on the sensor's temperature. The resistance should be within 5% of that listed below. If the sensor differs, replace the sensor.

CTS/IAT Resistance

Degrees F (C)	CTS Resistance (Ohms)	IAT Resistance (Ohms)
-22 (-30)	52594	51791
5 (-20)	21371	21044
32 (0)	9399	12073
68 (20)	3511	3457
77 (25)	2795	2752
86 (3)	2240	2205
95 (35)	1806	1778
104 (40)	1465	1443
140 (60)	671	660
167 (75)	395	398
176 (80)	334	329
194 (90)	242	238
203 (95)	207	204
212 (100)	178	175
248 (120)	100.9	99

2. Turn ignition power ON.
   - 2.1 Measure the voltage between the CTS sensor pin A (WHT/BK) and ground. This should read near 5 volts. If it does not proceed to step 2.1.1.
     - 2.1.1 Turn off the ignition power and disconnect the ECM.
     - 2.1.2 Measure the resistance from ECM pin 9 to CTS pin A. It should read less then 1 ohm. If it does not repair the wire.
     - 2.1.3 Measure the resistance from the ECM connector pin 10 to sensor pin B (BK/YL). It should read less then 1 ohm. If it does not, repair the wire.
   - 2.2 If no sensor or wiring problems are found, replace the ECM.

Code 21: The throttle position sensor (TPS) is reading incorrectly. Make sure the throttle position sensor is plugged in.

To verify the throttle position sensor and wiring:

1. Disconnect the throttle position sensor from the harness.
   - 1.1 Measure the resistance between TPS pins A and B. This should read 2.5 - 7.5 ohms. If it is outside this range, replace the sensor.
   - 1.2 Measure the resistance from pin A to pin C while slowly, manually move the throttle plate. The resistance should increase smoothly without dips or spikes. If it is not smooth replace the sensor.
2. Turn the ignition power ON. Measure voltage from harness to TPS connector pins A (-) and B (+). This should measure 4.75 to 5.25 volts. If not proceed with step 2-1.
   - 2.1 Perform the following measurements:
   - 2.2 Turn the ignition power OFF. Disconnect the ECM from the wiring harness. Disconnect the MAP sensor

and drive-by-wire pot (if it is used and easy to disconnect). Perform the measurements below:

TPS Wiring Troubleshooting

Meter Mode	From	To	Desired Result	If Defective
Ohms	ECM Harness 10	TPS A	< 1 Ohm	Ground wire is open
Ohms	ECM Harness 40	TPS B	< 1 Ohm	5 volt wire is open
Ohms	ECM Harness 8	TPS C	< 1 Ohm	TPS signal wire is open
Ohms	ECM Harness 10	ECM Harness 40	Open or < 1000 Ohms if DBW pot	5 volt wire is shorted to ground
Ohms	ECM Harness 10	ECM Harness 8	Open	TPS signal shorted to ground
Ohms	ECM Harness 40	ECM Harness 8	Open	TPS signal shorted to +5 volts

If all other TPS tests check out, reconnect all sensors. Measure the voltage from TPS pin C to ground while manually opening the throttle plate. The voltage should read >0.5 volts at closed throttle and < 4.5 volts at wide open throttle and move smoothly between closed ad open throttle. If the voltage has “dead spots” or spikes, replace the TPS sensor. If the voltage is within the range and moves smoothly, replace the ECM.

Code 22: The throttle body actuator is not responding; the fault is either caused by a short circuit or the actuator is unplugged.

Code 23: The inlet air temperature reads too low. This may occur if the temperature is below -40° F (-40° C), or if the IAT sensor is unplugged

Code 24: The air inlet temperature (IAT) reads too high. While unlikely, if this sensor is above 270° F (132° C) this code will be sent.

To verify the inlet air temperature sensor wiring:

1. Disconnect the inlet air temperature sender (IAT) and measure the resistance. This will vary depending on the sensors temperature. The resistance should be within 5% of that listed in the table under Code 15. If the sensor differs, replace the sensor.
2. Turn the ignition power ON and disconnect the IAT sensor.
   - 2.1 Measure the voltage between IAT sensor pin A (purple) and ground. This should read near 5 volts. If it does not proceed to step 2.1.1.
     - 2.1.1 Turn off the ignition power and disconnect the ECM
     - 2.1.2 Measure resistance from ECM pin 19 to IAT harness pin A. It should read less than 1 ohm. If it does not, repair the wire.
     - 2.1.3 Measure resistance from ECM connector pin 10 to IAT sensor pin B (BK/YL). It should read less than 1 ohm. If it does not repair the wire.
   - 2.2 If no sensor or wire problems are found, replace the ECM.

Code 31: Drive-by-wire (DBW) error (wire from foot throttle to TPS), the drive-by-wire voltage is too low or too high. This code can be set in some systems if the drive-by-wire pot is set to one extreme or the other. First set the pot at least 1/8 of a turn from either end. If the error code is gone, there is no problem.

To verify the DBW sensor and wiring:

1. Turn ignition power ON. Measure voltage from harness DBW ground wire (BK/YL) and supply (harness wire RD/BL). This should measure 4.75 - 5.25 volts. If not proceed to step 1.1.
   - 1.1 Turn off the ignition power, disconnect the DBW sensor from the harness, if possible, and disconnect the ECM.
   - 1.2 Measure the resistance between DBW control ground (harness wire BK/YL) and supply (harness wire RD/BL). This should read close to the pots resistance (in the range of 1 k ohms to 10 k ohms), however if it reads open or shorted the unit is defective.
   - 1.3 Measure the resistance from the pots ground lead to the output lead (harness GN/YL). The resistance should start low when the pot is turned to the low side and increase smoothly as the pot is turned to the high side. If the resistance does not smoothly increment or has discontinuity, replace the DBW device.

Turn ignition power OFF. Disconnect the ECM from the wire harness. Disconnect the MAP sensor and TPS. Perform the following measurements:

DBW Wiring Troubleshooting

Meter Mode	From	To	Desired Result	If Defective
Ohms	ECM Harness 10	DBW GND (BK/YL)	< 1 Ohm	Ground wire is open
Ohms	ECM Harness 40	DBW +5 (RD/BU)	< 1 Ohm	5 volt wire is open
Ohms	ECM Harness 8	DBW output (GN/YL)	< 1 Ohm	DBW signal wire is open
Ohms	ECM Harness 10	ECM Harness 40	Open or < 1000 Ohms if DBW pot	5 volt wire is shorted to ground
Ohms	ECM Harness 10	ECM Harness 18	Open	TPS signal shorted to ground
Ohms	ECM Harness 40	ECM Harness 18	Open	TPS signal shorted to +5 volts

1.4 If all other DBW tests check out, reconnect all sensors. Measure the voltage from DBW output to ground while manually opening the foot throttle control. The voltage should move smoothly between low and high speed. If the voltage has “dead spots” or spikes, replace the DBW device. If the voltage is within the range and moves smooth, replace the ECM.

Code 32: System voltage too low.

This indicates the ECM is receiving a low battery voltage measurement. Verify the battery voltage measures above 10 volts while the engine is running.

1. Measure the system (battery voltage) during normal operation. If it below 12.5 volts the charging system should be diagnoses. Normal running battery voltage should read approximately 13 - 14.5 volts. If the battery voltage is low, the charging system or machine wiring should be diagnosed.
2. Turn ignition power OFF, then disconnect the ECM. Turn ignition power ON. Measure the voltage between pins ground (25 or 35) and switched power (11), and then the battery voltage. The two readings should be with 0.5 volts unless the machine draws current for other functions. If any wires show considerable voltage drop the wire should be inspected for damage or poor connections.
   - 2.1 Measure the voltage between battery ground (-) and ECM pin 25. This voltage should be near 0.
   - 2.2 Measure the voltage between battery ground (-) and ECM pin 35. The voltage should be near 0.
   - 2.3 With ignition power still ON, measure voltage between ECM pin 11 and battery positive (+). This voltage should be near 0.

Code 41: MAP sensor system error.

The MAP sensor code can be set: if the map output wire is grounded to +5 volts, or if the MAP pressure does not change between key on and engine run time. Verify:

1. MAP sensor is plugged in.
2. Vacuum hose to MAP sensor is connected properly with no leaks.
3. Disconnect MAP sensor electrical connector. Turn ignition power ON. Measure the voltage from pins A (BK/YL) to C (RD/BU). This should read 4.75 - 5.25 volts. If it is outside of this range proceed with step 3.1.
   - 3.1 Perform the following measurements:

3.2 Turn ignition power OFF. Disconnect the ECM from the wire harness. Disconnect the TPS sensor and drive-by-wire pot. Perform the following measurements.

MAP Wiring Troubleshooting

Meter Mode	From	To	Desired Result	If Defective
Ohms	ECM Harness 10	MAP A	< 1 Ohm	Ground wire is open
Ohms	ECM Harness 40	MAP C	< 1 Ohm	5 volt wire is open
Ohms	ECM Harness 8	TPS C	< 1 Ohm	TPS signal wire is open
Ohms	ECM Harness 10	ECM Harness 40	Open or <1000 Ohms if DBW pot	5 volt wire is shorted to ground
Ohms	ECM Harness 10	ECM Harness 7	Open	MAP signal shorted to ground
Ohms	ECM Harness 40	ECM Harness 7	Open	MAP signal shorted to +5 volts

4. If all MAP tests check out, reconnect all sensors and turn ignition power on. Measure the voltage from MAP pin B to ground while manually applying vacuum to the vacuum fitting on the MAP sensor. The voltage will depend on the vacuum, but should read 0.1 volt under high vacuum to 4.7 - 5.0 volts at atmospheric pressure and sea level. If the voltage is within the range, replace ECM.

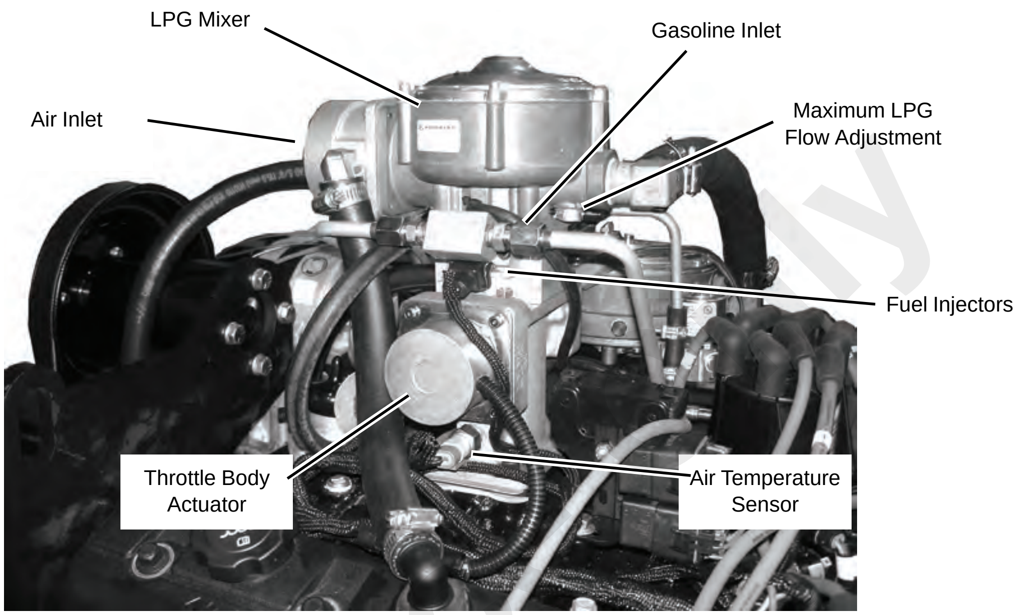
Code 43: Fuel Injector Error.

The fuel injector circuit is not responding properly. The circuit has an open, short, or lost power from the power relay. If the injector shows a true fault, it is unlikely the engine would run on gasoline. The injector could be turned on all the time and therefore it would squirt gasoline continuously when the ignition relay is active. This would tend to flood the engine; however, it may run depending on loading and other conditions. Verify fuel injector fault.

1. Verify the ignition relay is operating properly as described under Code 64. The ignition relay provides power to the fuel injector.
2. Disconnect the fuel injector. Connect a volt meter between ground and injector pin A (RD/BK). Switch the ignition from off to ON. Verify 12 volts is present at pin 87 of the ignition coil during 2 second initial prime period. If voltage is not present, continue with step 2.1.
   2.1 Connect a voltmeter between ground and pin 87 of the ignition coil and fuel injector relay. Switch the ignition power from off to ON. Verify 12 volts is present at pin 87 during 2 second initial prime period. If voltage is present, proceed with step 2.1.1.
      2.1.1 Recheck the ignition power relay as describes under Code 64.
   2.2 Turn OFF the ignition power. Measure resistance from relay pin 87 (RD/BK of the ignition coil and fuel injector relay) and injector pin A (RD/BK). This should measure less than 1 ohm. If the measurement is greater repair the wire.
3. With the ignition power OFF, measure the resistance of the fuel injector. The resistance of a room temperature injector should read 1 -2 ohms. Replace the injector if the resistance is considerably outside this range.
4. Disconnect the ECM from the harness. Measure the resistance of the ECM harness pin 4 and injector connector pin B. This should read less than 1 ohm. If it is greater replace the wire.
5. Measure the resistance from ECM harness pin 25 and injector connector pin B. This should read 0. If it shows any continuity repair a short to ground.
6. Measure the resistance from ECM pin 1 (switched battery voltage) and injector connector pin B. This should read 0. If it shows any continuity repair am short to battery voltage.
7. If no short is found and the injector squirts fuel during the initial prime period, replace the ECM.
8. If no short is found and the injector does not squirt fuel during the initial prime period, but the engine runs normally (without flooding), investigate for battery voltage and charging system malfunctions. Otherwise replace the ECM.

Basic Dual Fuel System Troubleshooting Guide

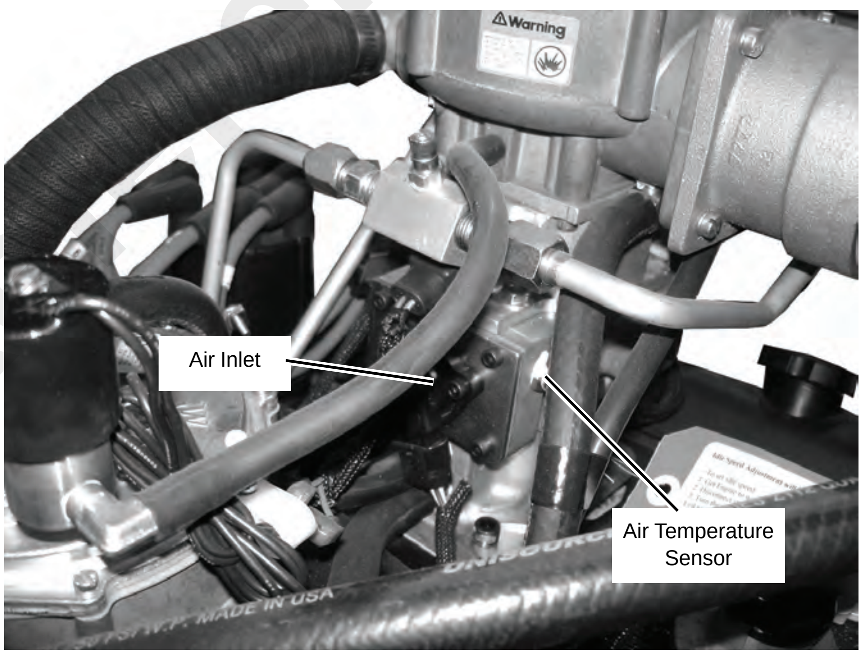
NOTE: The following figures show items referenced in the dual fuel troubleshooting guide.



Dual Fuel System

p3032

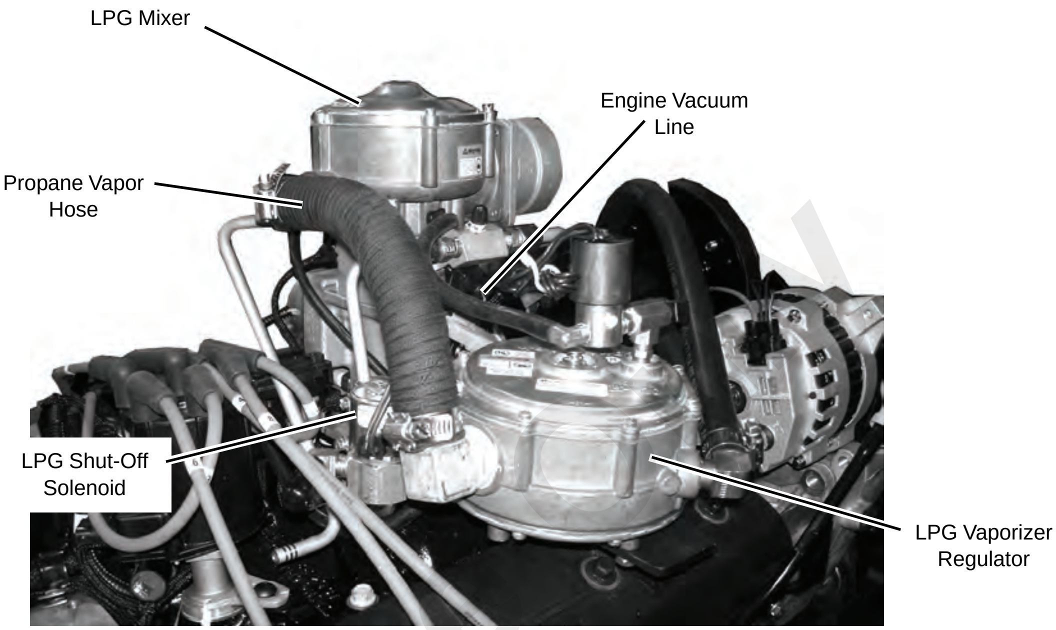
FIGURE 6-19



Dual Fuel System

p3034

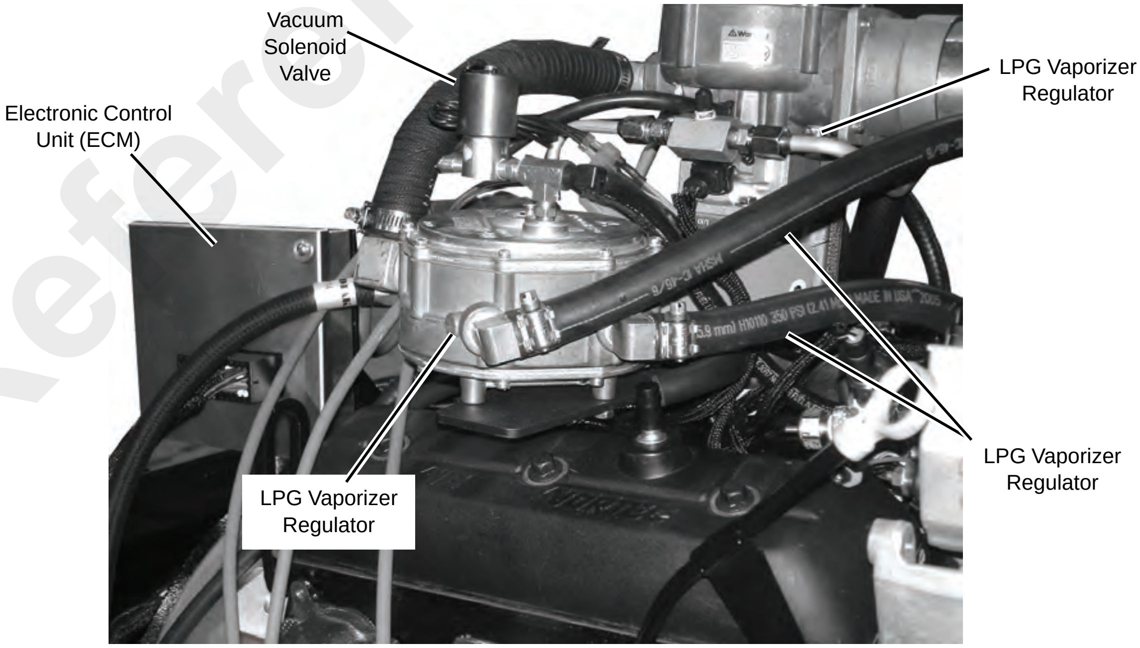
FIGURE 6-20



LPG Fuel System

p3033

FIGURE 6-21



LPG Fuel System

p3035

FIGURE 6-22

The following is a guide to the most common engine performance complaints. The guide is to be used to diagnose problems that are due to worn out components and/or basic adjustments in the fueling system.

CONDITION: Engine will not start (Gasoline)

Verify each item below:	Remedy for each item:
Fuel tank level.	Add fuel.
Check fuel pump. Cycle ignition switch ON/OFF, fuel pump should run for 2 seconds.	Check wiring and fuse/ relay.
Use a pressure gauge connected to the fuel port. Verify the fuel pressure reads between 40-50 psi (276-310 kPa).	Check and replace fuel filter. Check and replace fuel pressure regulator. Check and replace fuel pump.
Fuel injector is spraying.	Check fuel injector wiring.
Fuel injector is not leaking.	Replace injector o-ring or injector.
Spark plugs are not fouled or wet.	Disconnect the fuel injectors connectors for 15 seconds while cranking to unflood the engine.

CONDITION: Engine runs too rich on gasoline

Verify each item below:	Remedy for each item:
Check for vacuum leaks to the MAP sensor.	Replace the hose.
Restricted fuel return line.	Replace the fuel line.
LPG shut-off valve does not close.	Shut off LPG tank valve and then replace or clean the LPG shut-off valve.
Check fuel pressure. Should be between 40-50 psi (276 - 310 kPa) at the fuel port.	Replace pressure regulator.
Check for a bad MAP sensor.	Replace with a new MAP sensor.
Check for a bad IAT, ECT sensor.	Replace with a new sensor.
Check for exhaust leaks before the O2 sensor.	Repair leaks in the exhaust system.
Check for excessive smoke while running.	Check and replace fouled spark plugs.

CONDITION: Engine runs lean or misfires on gasoline

Verify each item below:	Remedy for each item:
Visually inspect fuel filters for restriction.	Replace fuel filter.
Use a pressure gauge connected to the fuel port. Verify the fuel pressure reads between 40-50 psi (276-310 kPa).	Replace pressure regulator.
Check for clogged fuel injectors.	Clean or replace fuel injectors
Visually inspect MAP sensor hose for breaks.	Replace the hose.
Check for a bad MAP sensor.	Replace with a new MAP sensor.
Check for a bad IAT, ECT sensor.	Replace with a new IAT sensor.
Check for intake manifold air leaks.	Repair leaks in the intake system.

CONDITION: Engine runs lean or misfires on LPG

Verify each item below:	Remedy for each item:
LPG filter is not contaminated and use air pressure to verify restriction.	Replace LPG filter.
Check for clogged fuel lines.	Clean fuel lines.
LPG pressure regulator/ vaporizer is not frozen or icing.	Check for air leaks, purge air from coolant hoses, add coolant.
Visually inspect vacuum hoses for breaks.	Repair as necessary.
Verify timing with a timing light.	Adjust distributor timing.
Verify that the air filter for the vaporizer is not clogged.	Replace air filter.
Vaporizer primer button becomes hard to depress when the fuel is present.	Replace or clean the LPG fuel lock-off.

CONDITION: Engine runs too rich on LPG

Verify each item below:	Remedy for each item:
Verify that there are no leaks into the vacuum port on the LPG mixer.	Replace or repair the hose.
Check for clogged air filter.	Repair or replace.
Check for exhaust leaks before the O2 sensor.	Repair air leaks in the exhaust system.
Verify that the O2 sensor is working properly.	See Error Code 13.
Verify idle air screw is adjusted at idle. Fuel trim valve will have a 50% duty cycle.	Turn the adjustment screw counterclockwise to lean out the air/fuel mixture.
Check for faulty LPG vaporizer.	Replace if LPG vapor pressure is not greater that Atmospheric pressure - " W.C.

CONDITION: Engine will not start on LPG

Verify each item below:	Remedy for each item:
Check fuel shut-off valve. Cycle ignition switch ON/ OFF, fuel shut-off valve should click off after 2 seconds.	Check for obstructions in fuel line. Check wiring and fuse/ relay.
Clogged LPG filter.	Close liquid fuel tank valve. Repair or replace LPG filter. Open liquid fuel tank valve and check for leaks.
Check for stuck open vacuum valve.	Clean valve. Check wiring.
Check for clogged small air filter on top of the vaporizer.	Clean or replace air filter and orifice jet.
Check for carburetor malfunction.	Check diaphragm for hoe and damage. Repair or replace.

Checks and Adjustments

Spark Plug Gap

Check, clean and adjust the spark plugs every 3 months, or after every 500 hours of operation, whichever occurs first, or more often if required.

Thoroughly, clean the spark plugs, including the threads. Check the electrode gap with a feeler gauge. There will be a small amount of friction as you move the feeler gauge between the electrodes, if adjusted correctly. Bend only the side of the electrode to set the gap.

Past Production Units	0.035 in (0,90 mm)
Current Production Units	0.030 in (0,0762 mm)

Engine Timing

The engine timing should be checked and set as follows:

1. Connect the timing light to the No. 1 spark plug wire (front cylinder).
2. Start the engine and let it run at idle.
3. Check the timing on the crankshaft pulley, in relation to the pointer on the timing cover.
4. Timing should be:

   Past Production Units.......... 11° BTDC ± 1°

   Current Production Units.......10° BTDC ± 1°
5. If timing needs to be adjusted. Loosen the distributor hold down clamp screw and turn the distributor clockwise or counterclockwise to adjust the timing.
6. After adjusting the timing, tighten the distributor clamp screw, turn the engine off and remove the timing light.

TROUBLESHOOTING

Problem	Possible Cause	Solution
Engine will not start.	**1.** Improper starting procedure.	**1.** Review starting procedure in Operator's Manual.
	2. No fuel.	**2.** Check fuel gauge. Switch to LPG or gasoline.
	3. Crankcase oil too heavy (cold weather starting).	**3.** Use oil with proper viscosity.
	4. Clogged fuel filter.	**4.** Replace the filter.
	5. Loose battery connections.	**5.** Check and tighten connections.
	6. Weak or discharged battery.	**6.** Check battery. Recharge.
	7. Blown fuse in fuel injection system.	**7.** Check and replace fuse.
	8. Lost ECU power.	**8.** Check for voltage between 14 ga. red wire at the start and ground wire at the engine.
	9. Faulty ignition relay.	**9.** Turn the ignition key to the ON position and listen for a click in the ignition relay. No click, replace the relay.
	10. Loose connections to distributor.	**10.** Check and tighten.
	11. Faulty fuel pump.	**11.** Fuel pump should run for several seconds when ignition key is on (gasoline mode).
	12. Loose connections to distributor.	**12.** Check and tighten.
	13. Loose connections to ignition coil.	**13.** Check and tighten.
	14. Loose connections to fuel injectors.	**14.** Check and tighten.
	15. Loose or broken connection in wire harness to ECU.	**15.** Check and tighten.
Rough/Unstable idle.	**1.** Low fuel level.	**1.** Check fuel level.
	2. Loose or damaged rubber vacuum hoses.	**2.** Check, connect or replace.
	3. Faulty spark plugs or wires.	**3.** Check and replace.
	4. High fuel return pressure.	**4.** Less than 5 psi (34 kPa) is OK.
	5. Disconnected engine temperature sensor.	**5.** Check and connect.
	6. Incorrect engine timing.	**6.** Check engine timing and adjust.
Poor acceleration.	**1.** Air filter plugged.	**1.** Replace.
	2. Plugged fuel filter.	**2.** Replace if plugged or marginal.
	3. Incorrect engine timing.	**3.** Check engine timing and adjust.

Problem	Possible Cause	Solution
Engine knocking.	**1.** Incorrect engine timing. **2.** Fuel contamination or low octane fuel. **3.** Engine overheating.	**1.** Check engine timing and adjust. **2.** Drain and replace fuel (minimum 87 octane). **3.** Check thermostat. Replace if necessary. Check for low coolant level. Add coolant if necessary.
High engine idle.	**1.** Leakage in intake manifold. **2.** Incorrect engine timing.	**1.** Check and repair. **2.** Check engine timing and adjust.
Engine running excessively rich in gasoline mode (sooty black smoke).	**1.** Incorrect fuel return pressure. **2.** Faulty engine temperature sensor. **3.** Faulty air temperature sensor. **4.** Faulty injector.	**1.** Less than 5 psi (34 kPa) is OK. **2.** Check and replace. **3.** Replace. **4.** Replace.
Engine running excessively rich in LPG mode (sooty black smoke).	**1.** Dirty or clogged air cleaner. **2.** Loose LPG hose connection to the vaporizer unit.	**1.** Check and replace **2.** Check and repair.
Below normal engine temperature.	**1.** Defective thermostat. **2.** Defective temperature gauge or sender.	**1.** Remove and check thermostat. **2.** Check gauge, sendor and all connections.
Lack of power.	**1.** Engine overload. **2.** Intake air restriction. **3.** Clogged fuel filter. **4.** Overheated engine. **5.** Faulty engine.	**1.** Reduce the load. **2.** Service air cleaner. **3.** Replace fuel filter. **4.** Refer to Engine Operator's Manual. Check for plugged radiator/oil cooler fins. Check thermostat and coolant level. **5.** Repair engine.

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

11. Remove the air cleaner and intake hose(s).

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

12. Disconnect the fuel lines from the fuel tank. Plug or cap the lines to prevent leakage. On dual fuel engines, close the L.P. tank and disconnect L.P. hose from the filterlock on the engine.

13. Disconnect the drive shaft(s) from the transmission. See Section 6.

14. Disconnect the exhaust pipe from the exhaust manifold of the engine.

15. Drain the hydraulic tank.

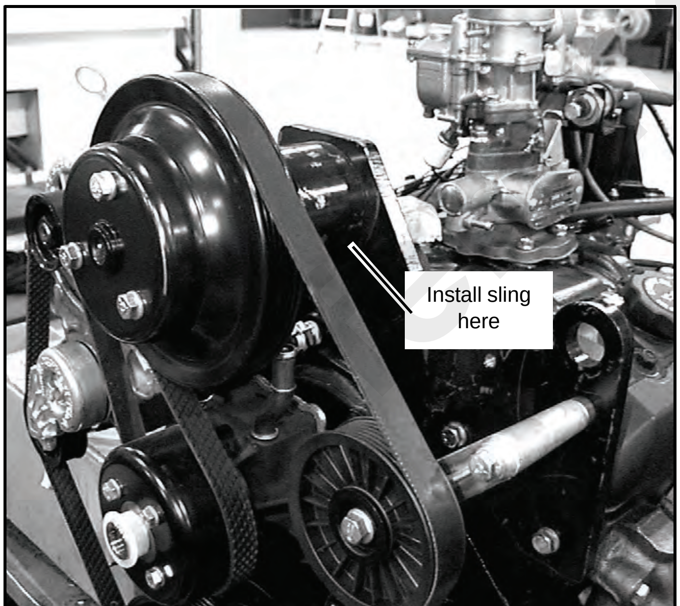
16. Disconnect the hydraulic hoses from the four sections of the hydraulic pump.

17. Disconnect the suction hose from the hydraulic tank and the hydraulic pump suction manifold.

18. Disconnect the throttle linkage from the engine.

19. Disconnect the engine ground cable from the engine or the engine flywheel.

20. Remove the rear axle.



p0106 **FIGURE 6-23**

- **a.** Support the gasoline engine by placing a sling under the high fan mounting bracket Figure 6-23 and attach it to a hoist. Use the hoist to support the engine while the rear axle is being removed.
- **b.** Loosen and remove the wheel lug nuts and remove both rear wheels.
- **c.** Disconnect and plug the hydraulic hoses at the steering cylinders.
- **d.** Disconnect and cap and plug the brake hoses from the axle.
- **e.** Support the axle on a trolley jack.
- **f.** Remove the front engine mounting hardware.
- **g.** With the engine and rear axle both supported, remove the eight bolts and flat washers securing the engine/axle mounting bracket to the chassis.
- **h.** Lower and remove the axle clear of the chassis.

21. Remove the rear engine support mounting bolts, washers, rubber mounts and nuts.

22. Using a trolly jack, raise the transmission so it can be removed out the rear of the chassis.

23. Using the hoist, slowly pull the engine and transmission forward enough to attach a sling around the torque converter housing. At the same time, check that all items are free for engine removal. Attach a pull jack to the sling and hoist.

24. 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.

25. If a new engine is to be installed, remove all parts from the old engine not provided with the new engine and install them on the new engine.

Installation

1. Attach a hoist to the engine the same way removal was accomplished.

2. Lift the engine into place over the chassis. Tilt the engine at about a 30° angle to insert the engine into the chassis. Lower the engine into the chassis and set the transmission on a trolley jack. Remove the sling and pull jack.

3. Move the engine and transmission into the chassis until the rear mounting bolts, washers, rubber mounts and nuts can be installed and tightened.

4. Install the rear axle.

- **a.** Locate the rear axle under its mounting location. Raise the axle and mounting bracket into position and install the eight mounting bolts and flat washers.
- **b.** Install the front engine mounting hardware.
- **c.** Connect the brake lines to the axle.
- **d.** Connect the hydraulic hoses to the steering cylinders.

5. Connect the suction hose to the hydraulic tank and the hydraulic pump suction manifold.

6. Connect the hydraulic hoses to the four sections of the hydraulic pump.
7. Fill the hydraulic tank.
8. Connect the engine ground cable to the engine.
9. If equipped, install the cold start kit.
10. Connect the throttle linkage to the engine.
11. Connect the exhaust pipe to the engine manifold. If a gasket is used, install a new gasket.
12. Connect the drive shaft(s) to the engine.
13. Connect the fuel lines to the fuel tank. On dual fuel engine, connect the L.P. hose to the filterlock on the engine.
14. Install the air cleaner and intake hoses. Make sure all hoses are connected.
15. Install the radiator in place on the chassis.
16. Connect the transmission cooling lines to the radiator. Connect the upper and lower radiator hoses.
17. Connect the hot water heater hoses to the engine.
18. Fill the radiator with recommended coolant.
19. Connect the transmission wire harness to the instrument panel wire harness.
20. Connect the transmission high temperature switch lead to the switch.
21. Connect the engine wire harness to the frame wire harness.
22. Install the engine cover and rear deck cover plate.
23. Connect the battery cables to the battery.
24. Check complete installation to be sure all components are installed and secure.
25. Fill the engine and transmission with recommended oil.
26. Start the engine. Continue to add transmission fluid until transmission cooling lines are full. Add fluid as needed to fill the cooling system.
27. Adjust the throttle control, if necessary.
28. Bleed air from steering circuits by turning the rear wheels several times in both directions.
29. Stop the engine and check for leaks. Tighten fittings if necessary.
30. Bleed air from the brake lines. Refer to Brake System, Section 9

THIS PAGE BLANK.

SECTION 7
TRANSMISSION AND TORQUE CONVERTER

TABLE OF CONTENTS

7

SECTION 7
TRANSMISSION AND TORQUE CONVERTER

TECHNICAL DATA

General Technical Data

Description	Combined torque converter, reverser, and gearbox unit with synchromesh manual gear selection			
Designation	SS720 (2 wheel drive) SS740 (4 wheel drive)			
Weight (dry)	(375 Ib)170 kg	(441 Ib) 200 kg		
Number of Teeth				
Transfer Gear	19 17			
Layshaft	3638			
SS740 4WD Dropgears	26/32	24/34	26/33	23/34
4WD Disconnect				
Clutch Type (Spring ON)				
Clutch Type (Pressure ON)				
Permanent Engage (No Clutch)				
SS700 Dropgears				
Overall Ratio (Stamped on Serial Plate)	17/38 Low Ratio	19/36 Std Ratio		
26/32	1:1.816	1:1.1539		
24/34	1:1.578	1:1.337		
26/33	1:1.761	1:1.493		
27/31	1:1.947	1:1.650		
23/34	1:1.512	1:1.282		
Gear Ratios:	Std Ratio	Low Ratio		
1st	5.56:1	6.55:1		
2nd	3.45:1	4.06:1		
3rd	1.83:1	1.89:1		
4th	1.00:1	1.00:1		
Torque Converter				
Torque Converter Dia.	(12.2 in) 310 mm			
Converter Identification Torque I	04/600580	04/600581		
Multiplication at Stall	2.52:13.01:1			
Minimum Engine Rev/Min at Converter Stall	Refer to Machine Performance Data.			
Converter Pressures (in neutral):	PSI	kPa		
Converter IN at 122° F (50° C)				
1000 rpm/min	22 – 36	*152-248*		
2000 rpm/min	77 – 97	*531-669*		
Converter IN at 212° F (100° C)				
1000 rpm/min	7-19	*48-131*		
2000 rpm/min	59-71	407-490		
Converter OUT at 122° F (50° C)				
1000 rpm/min	12-23	83-159		
2000 rpm/min	43-58	297-400		
Converter OUT at 212° F (100° C)				
1000 rpm/min	4.0-9.0	28-62		
2000 rpm/min	30-42	207-290		

7

Converter Inlet Relief Valve Pressure (Max.)	95	
Lubrication Pressures (in neutral)	PSI	kPa
At 122° F (50° C)		
1000 rpm/min	4.0-13	28-90
2000 rpm/min	26 – 35	172-241
At 212° F (100° C)		
1000 rpm/min	1.0-4.0	7-28
2000 rpm/min	19-30	131-207
*Mainline Pressure (in neutral)	PSI	kPa
At 122° F (50° C)		
1000 rpm/min	159-188	*1096-1296*
2000 rpm/min	188-226	*1296-1558*
At 212° F (100° C)		
1000 rpm/min	148-177	*1020-1220*
2000 rpm/min	165-203	*1138-1400*

Clutch Pressure (forward and reverse)

Clutch pressures should be the same as Mainline Pressure to within (10 PSI) (69 kPa).

Clutch Pressure (to disconnect 4-wheel drive)

Clutch pressures should be the same as Mainline Pressure to within (10 PSI) (69 kPa).

Flow Rates (in neutral)	GPM	*LPM*
Cooler at 122° F (50° C)		
1000 rpm/min	2.0 – 2.9	1.7-2.4
2000 rpm/min	3.6-5.3	3.0-4.4
Cooler at 212° F (100° C)		
1000 rpm/min	1.1-2.2	1.1-1.8
2000 rpm/min	3.8-4.6	3.2-3.8
Pump at 122° F (50° C)		
1000 rpm/min	3.0-4.1	2.5-3.4
2000 rpm/min	6.7-8.8	*5.3-7.3*

NOTE: *For new gearboxes (i.e. under 100 hours of service) or gearboxes that have been fully repaired, the pressures will be slightly higher than those listed (10 -15 psi; 70 -100 kPa).*

Clutch Solenoid Technical Data

Type	4 way, 3 position, directional control
Operating Flow	9.85 gpm (40 L/min)
Operating Pressure	145 psi (1000 kPa)
Leakage (maximum	.14 in/min @ 104° F, 145 psi (50 cc/min @ 40° C, 1000 kPa)
Coil Operating Voltage	+12V DC nominal (10.8V – 13.2V)
Pull-in Voltage	+10.5V (max.) @ 77° F (25° C) air (after energized for 10 minutes and off for 10 seconds)
Dropout Voltage	+1.5V (min.) at 68° F (20° C) air
Peak Voltage	+ 26V DC for 5 minutes at 32° F (0° C)
Coil Resistance	4.9 ohms ± 5% @ 68° F (20° C)

DESCRIPTION OF OPERATION

General

The transmission consists of a torque converter, hydraulic reverser unit and integral manual four speed gearbox.

Torque Converter

The torque converter is the hydraulic link between the engine and the drive train. There are three main components in the torque converter:

1. A turbine
2. An impeller (pump)
3. 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.

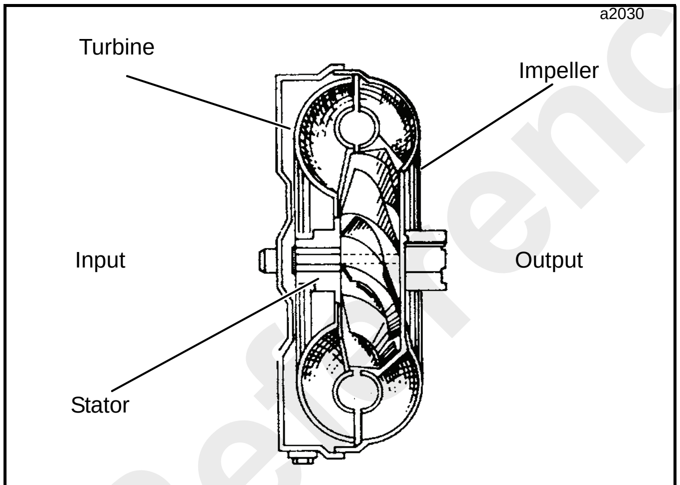


FIGURE 7-1

The **turbine** is opposite the impeller and is connected by splines to the input shaft of the 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 7-2 and Figure 7-3 shows the arrangement of the system.

NOTE: Normal operating temperature is 180° - 190° F (82° - 88° C). 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 180° - 190° F (82° - 88° C). 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 reverser unit **A** has a pair of hydraulically operated clutches giving forward - neutral - reverse drive. Oil pressure is provided by a crescent type pump **B** driven at engine speed by the drive lugs of the torque converter **C**. The oil passage is controlled by the pressure maintaining valve **D**, and clutch selection is achieved by means of an electric solenoid valve **E**.

Drive is transferred from the reverser unit by helical gears to the mainshaft **F**, which carries the 3rd/4th synchromesh unit **G**, and to the layshaft **H**, which carries the 1st/2nd synchromesh unit **J**. The synchromesh units are of the “Blocking Pin” type. See description of the Synchromesh Unit, page 7-7.

Drive is transmitted finally via the output shaft **K** to the rear axle. If 4 wheel drive is selected, the front wheels are also driven via 4 wheel drive output yoke **L**. A full description of 2/4-wheel drive clutch operation is given in Hydraulic 2/4-Wheel Drive Unit Operation.

Driveshaft **T** is permanently driven by the engine and runs through the hollow forward/reverse unit shaft to the back of the gearbox. The shaft **T** drives a gearbox mounted main hydraulic pump (if fitted).

Oil is drawn from the gearbox sump via strainer **P** by pump **B**. Pressurised oil from the pump is fed through an internal passage via the filter **Q** to the pressure maintaining valve **D**, which maintains pressure to the solenoid valve **E** for forward/reverse clutch selection. Excess oil from the maintaining valve flows back through casing cross drillings to the torque converter **S**. Oil enters the converter between the converter hub and the stator support, and leaves between the stator and the input shaft. Pressure in the converter is controlled by a regulating valve **C** which dumps excess oil from the converter line back to the sump.

Torque converter relief valve **V** acts as a safety valve should the system pressure suddenly rise above normal, protecting the torque converter from being damaged.

Oil from the torque converter flows out of the transmission to the external oil cooler **Z**, returning at the rear of the transmission unit to pass through the centre of the input shaft **A3** for clutch lubrication. Oil then returns to the sump.

Lubrication oil is also provided via a pump drain line to the forward/reverse front shaft bearing **A4**. The drain from pressure maintaining valve **D** also provides lubrication for idler gear bearing **F**.

Solenoid Valve Operation

Pressurised oil at the solenoid valve **E** is used to control the forward/reverse clutches **A1** and **A2**.

Forward:

In the diagram, electrical solenoid **E1** is energized by the forward/reverse control lever in the cab. Pressurised oil is diverted to the forward clutch **A1** and forward is selected. A restrictor orifice in the feed to the solenoid valve modulates the pressure to the clutch to smooth engagement. At the same time oil from reverse clutch **A2** is diverted back to the sump via solenoid valve **E**.

Reverse:

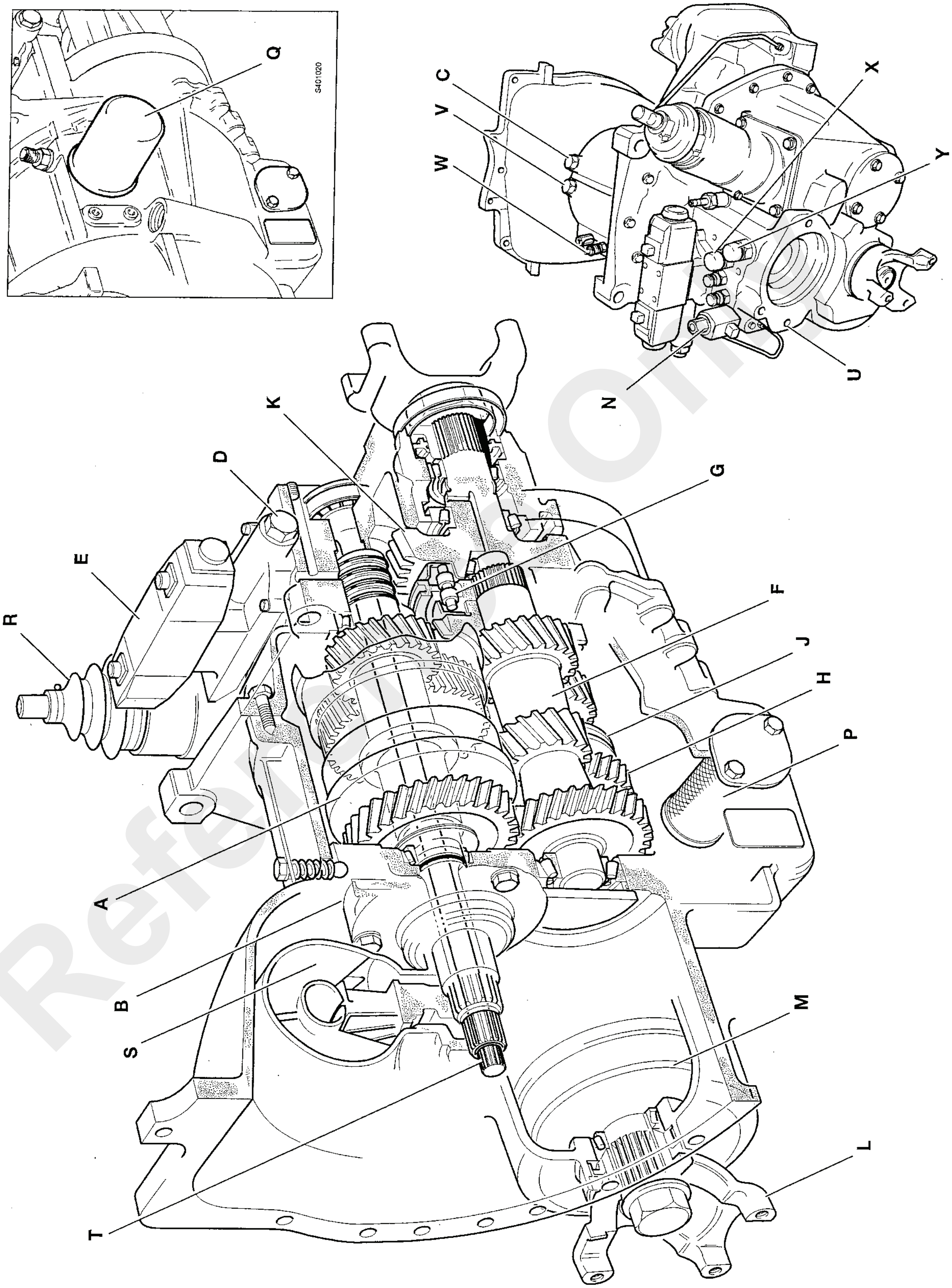
When reverse is selected electrical solenoid **E2** is energized and pressurised oil is diverted to the reverse clutch **A2**. At the same time oil from clutch **A1** is diverted back to the sump.

Neutral:

When neutral is selected (via the control lever or the transmission dump button), the flow of the pressurised oil is blocked at the solenoid valve. No solenoids are energized and no clutches engaged.

For a further detailed description refer also to Reverser Clutch.

The 2/4-wheel drive clutch **M** is controlled by solenoid valve **N**. A full description of 2/4-wheel drive clutch operation is given in Hydraulic 2/4-Wheel Drive Unit Operation.



A388431

FIGURE 7-2

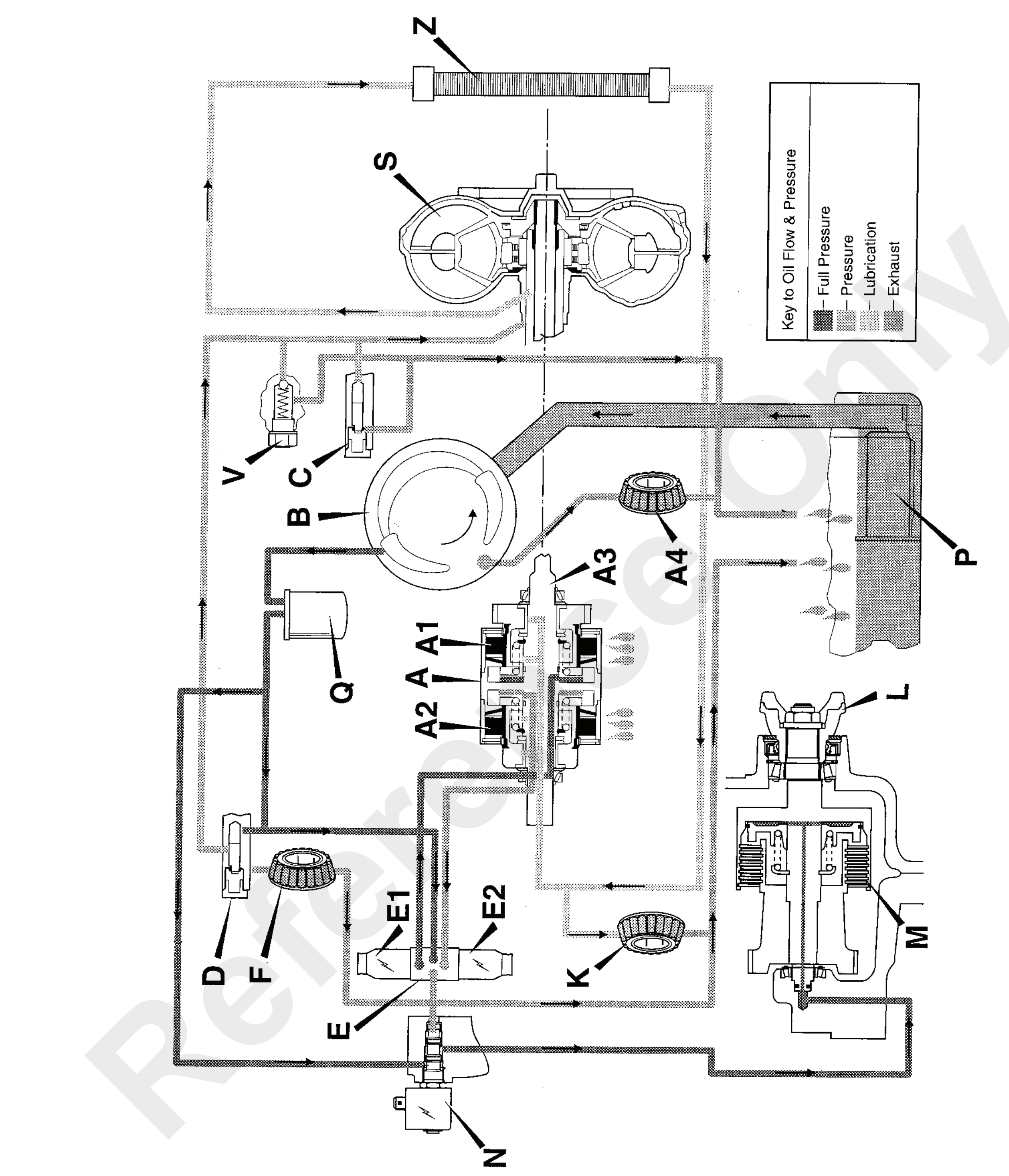

Z
S
Key to Oil Flow & Pressure
Full Pressure
Pressure
Lubrication
Exhaust
V
C
B
P
A3
A4
A1
A
A2
Q
L
M
E1
E2
K
D
F
E
N
A396520

FIGURE 7-3

Synchromesh Unit

Description

The transmission is equipped with “Blocking Pin” synchromesh units, comprising of the following parts:

a. **SYNCHRO HUB (A).** Controls the operation of the synchromesh unit and gear selection, the selector fork engaging into the outer groove. Internal dog teeth link the selected gear to the drive shaft. Through the synchro hub center are two sets of holes for the blocker pins **(C)** and the split energizer pins **(D),** spaced alternately.

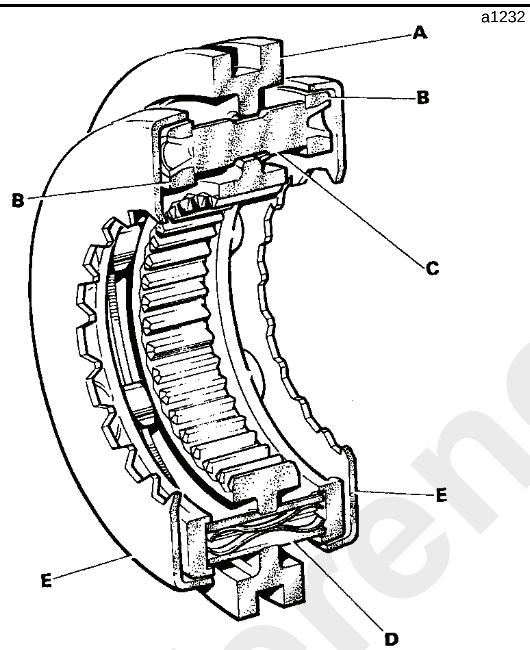


FIGURE 7-4

b. **SYNCHRO RINGS (B).** They are rigidly joined by the blocker pins, with the split energizer pins held, in counterbores, between the two synchro rings.

c. **BLOCKER PINS (C).** These pins have a narrow neck in the center, against which the synchro hub transmits radial drive during gear changes. The edges of the blocker pin neck and their mating synchro hub holes are designed so that, as the radial loads are reduced, the synchro hub can slide over the shoulder of the blocker pin.

d. **SPLIT ENERGIZER PINS (D)**. These pins take the initial axial load of the synchro hub on the shoulder of the split energizer pin neck. As the axial load reaches approximately 90 lb. (40.8 kg) the internal springs allow the split energizer pin to collapse and the synchro hub to move axially.

e. **SYNCHRO CUPS (E).** These take the frictional drive from the synchro ring on their inner faces. The synchro cups are splined to drive their respective gears while synchronization is taking place.

Operation

Figure 7-5 shows the gearbox with the first gear engaged. Synchro ring **B** is in contact with synchro cup **E** and the synchro hub dog teeth are linking first gear to the shaft gear. In this position the split energizer pins **D** are “collapsed.”

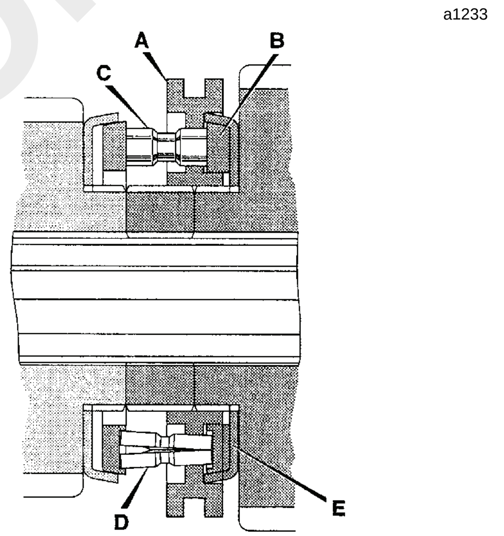


FIGURE 7-5

When selecting second gear the synchro hub **A** slides along the split energizer pins until the pin recess and synchro hub flange are in line. At this point, the split energizer pins open and the synchro rings are moved by the synchro hub pushing on the split energizer pin shoulder.

Initial contact between the synchro ring and the synchro cup starts to synchronize the speed of the shaft and second gear. The rotational force of the synchro ring is taken by the blocker pin against the edge of the synchro hub hole as shown in Figure 7-6.

7

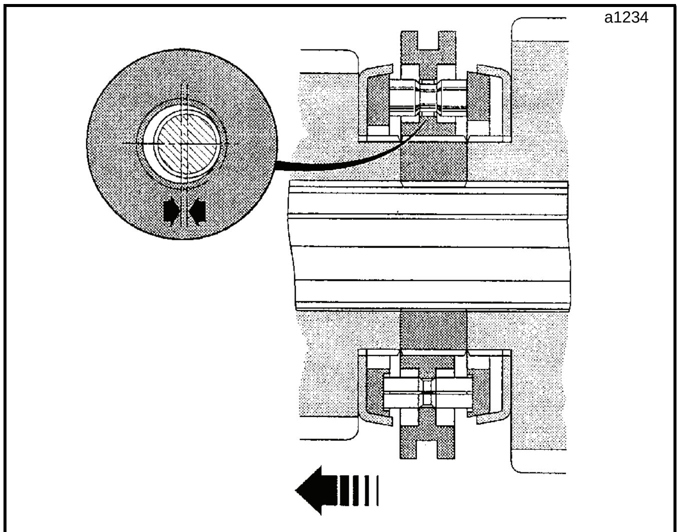


FIGURE 7-6

As the axial load on the synchro hub increases, the split energizer pin "collapses" and the conical faces of the blocking pin and synchro hub hole come into contact, as shown in Figure 7-7.

Further increases in the axial loads increases the frictional grip of the synchro ring and the synchro cup, causing the shaft and gear speeds to synchronize.

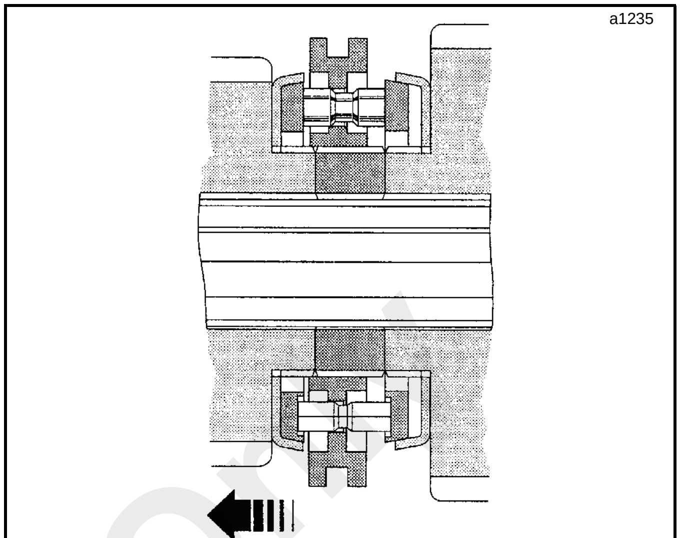


FIGURE 7-7

As the speeds are synchronized the radial load on the blocker pin and synchro hub is reduced. This allows the synchro hub to slide freely along the blocker pin and engage its dog teeth with second gear, as shown in Figure 7-8.

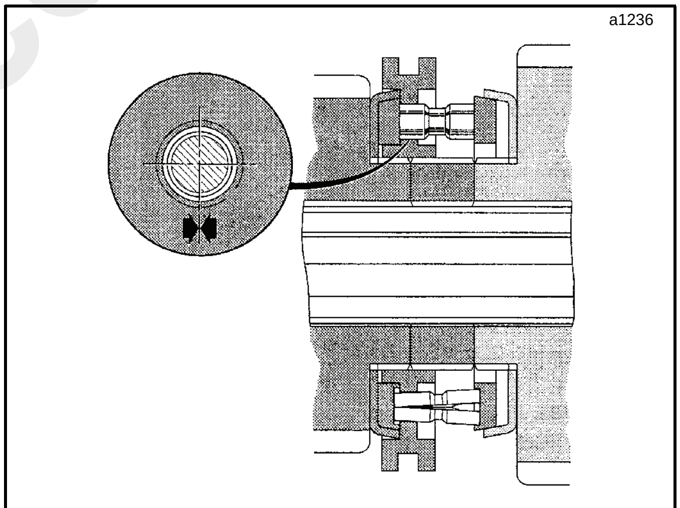


FIGURE 7-8

Reverser Clutch

The reverser clutch unit **1**(See Figure 7-9) transfers drive from the input shaft **A3** to either gear **G1** or gear **G2** depending on which of the two clutches (**A1** or **A2**) is engaged, giving forward or reverse drive. When neither clutch is engaged, neutral is selected.

The clutches are of the wet, multi-plate type.

The clutch housings and input shaft are a one piece assembly **A3**. The assembly is permanently driven by the engine via the torque converter. Clutch counter plates **3** are also permanently driven via meshing teeth inside the clutch housings. Clutch friction plates **4** are meshed with the gear/ plate carriers, (**G1** and **G2**).

In the diagram, clutch **A1** is engaged. The counter plates **3** and friction plates **4** are pressed together by hydraulically actuated piston **5**. Drive is then transmitted from the input shaft to the gear **G1**. Clutch **A2** is disengaged and no drive is transmitted to gear/plate carrier **G2**. The gear is also free to rotate on the input shaft assembly.

Actuation of the hydraulic pistons **10** and **5** is controlled via three position solenoid valve **E**. When neutral is selected, solenoids **E1** and **E2** are deactivated and the flow of pressurised oil to the clutches is blocked. Springs **8** and **9** move the pistons away from the clutch plates and oil from both pistons is vented to the sump. When either forward or reverse is selected, the solenoid valve **E** diverts pressurised oil via cross drillings inside the input shaft **A3** to the appropriate clutch (piston **10** or **5**) in the unit. Pressure from the other clutch is vented to the sump via the solenoid valve spool. Oil is prevented from leaking by seals **6** on the pistons and ring seals **7** on the input shaft **A3**.

The valve **E** is shown using symbols.

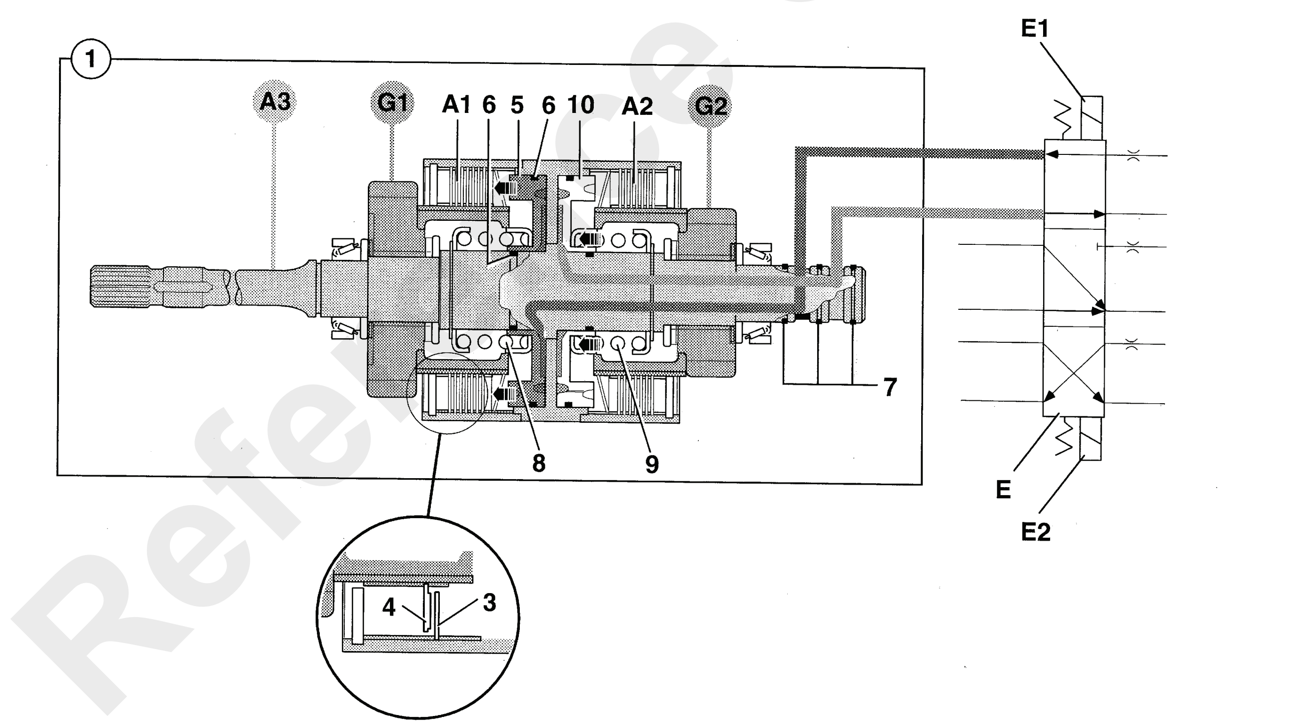


FIGURE 7-9

Hydraulic 2/4-Wheel Drive Unit - Spring ON/Pressure OFF

4-Wheel Drive Operation (See Figure 7-10)

This clutch is of the 'Spring-ON (4WD)/Pressure-OFF (2WD)' type. The clutch is engaged and disengaged by introducing or dumping pressurised oil behind piston **C** via a solenoid valve **A**. The solenoid valve is operated by a switch in the cab.

When the switch is in the 4-wheel drive position, solenoid valve **A** is de-energized. With the solenoid **A1** de-energized, the valve spool moves under the force of the spring **A2**. The oil supply to the piston **C** is blocked, (shown at port **3**). At the same time oil vents from the back of piston **C** to the sump via ports **1** and **2**.

Because there is no pressure behind piston **C**, the clutch friction/counter plates of clutch pack **B** are forced together by disc springs **D**, thus driving the output yoke **E**.

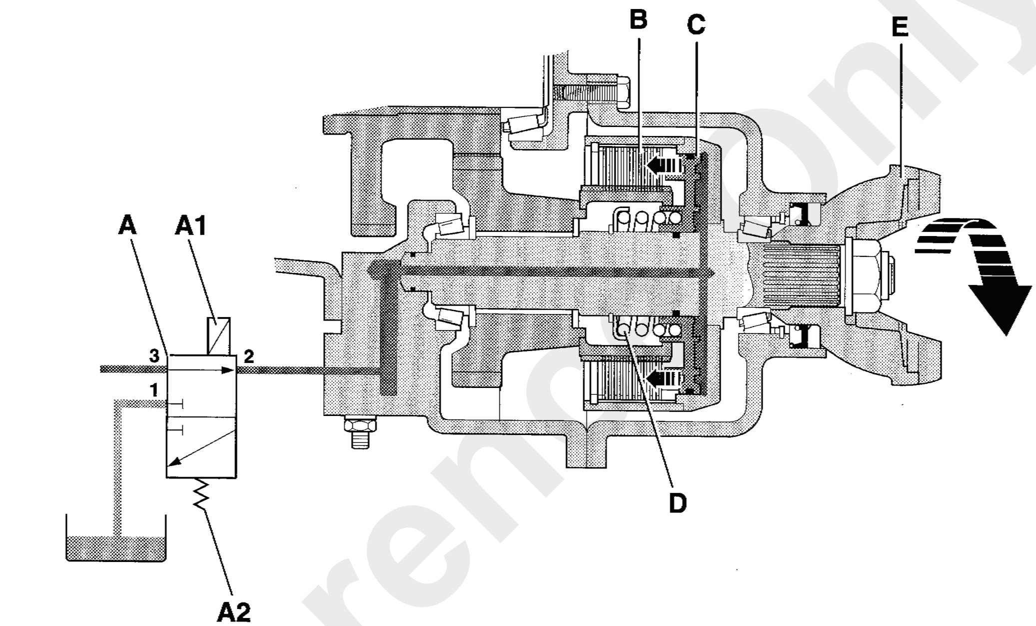


FIGURE 7-10

2 Wheel Drive Operation (See Figure 7-11)

When the switch is in the 2-wheel drive position, solenoid valve **A** is energized. The energized solenoid **A1** causes the valve spool to move and form a connection between ports **3** and **2**.

Pressurised oil is directed to piston **C** via ports **3** and **2**. The piston moves actuating sleeve **F** and then pressure plate **G** against the force of springs **D**, thus releasing the spring force on the clutch friction/counter plates of clutch pack **B**.

Because there is no spring force, the friction/counter plates of clutch pack **B** now freely rotate on the output shaft, thus disengaging drive to the front axle.

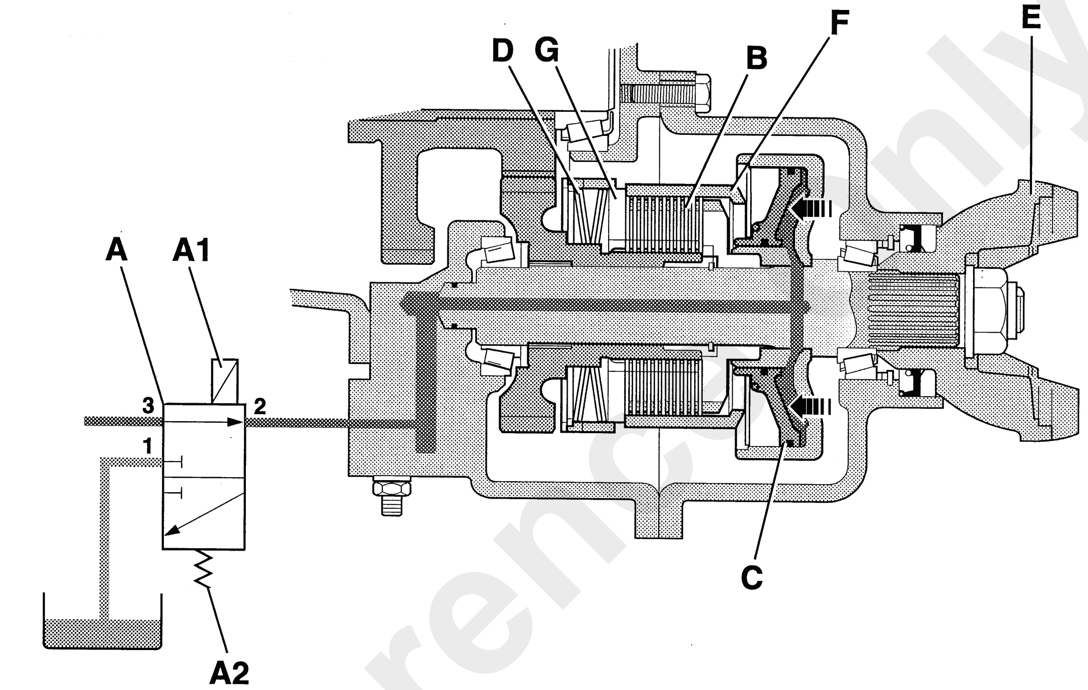


FIGURE 7-11

Hydraulic 2/4-Wheel Drive Unit - Pressure ON/Spring OFF

4-Wheel Drive Operation (See Figure 7-12)

This clutch is of the 'Pressure-ON (4WD)/Spring-OFF (2WD)' type. The clutch is engaged and disengaged by introducing or dumping pressurised oil behind piston **C** via a solenoid valve **A**. The solenoid valve is operated by a switch in the cab.

When the switch is in the 4-wheel drive position, solenoid valve **A** is energized. The energized solenoid **A1** causes the valve spool to move and form a connection between ports **3** and **2**.

Pressurised oil is directed to piston **C** via ports **3** and **2**. The piston moves, against spring **D**, to press the friction/counter plates of clutch pack **B** together, thus driving the output yoke **E**.

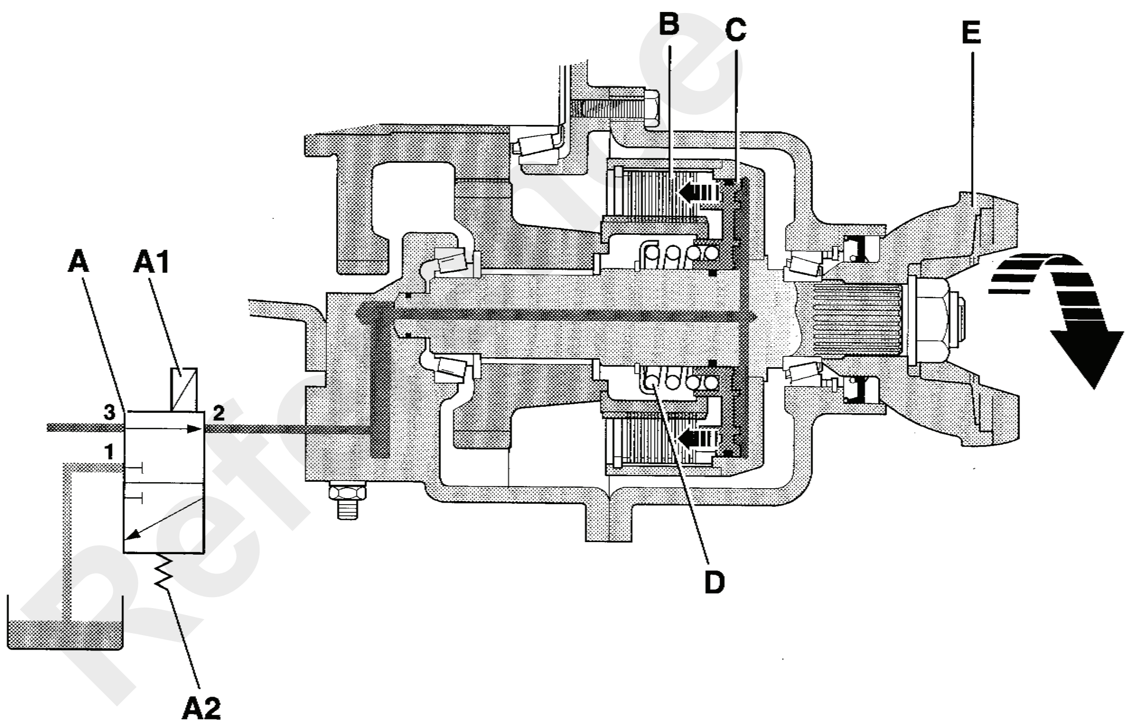


FIGURE 7-12

Hydraulic 2/4-Wheel Drive Unit - Pressure ON/Spring OFF (cont'd)

2-Wheel Drive Operation (See Figure 7-13)

When the switch is in the 2-wheel drive position, solenoid valve **A** is de-energized. With the solenoid **A1** de-energized, the valve spool moves under the force of the spring **A2**. The oil supply to the piston **C** is blocked (shown at port **3**). At the same time oil vents from the back of piston **C** to the sump via ports **1** and **2**.

Because there is no pressure behind piston **C**, the friction/counter plates of clutch pack **B** now freely rotate on the output shaft, thus disengaging drive to the front axle.

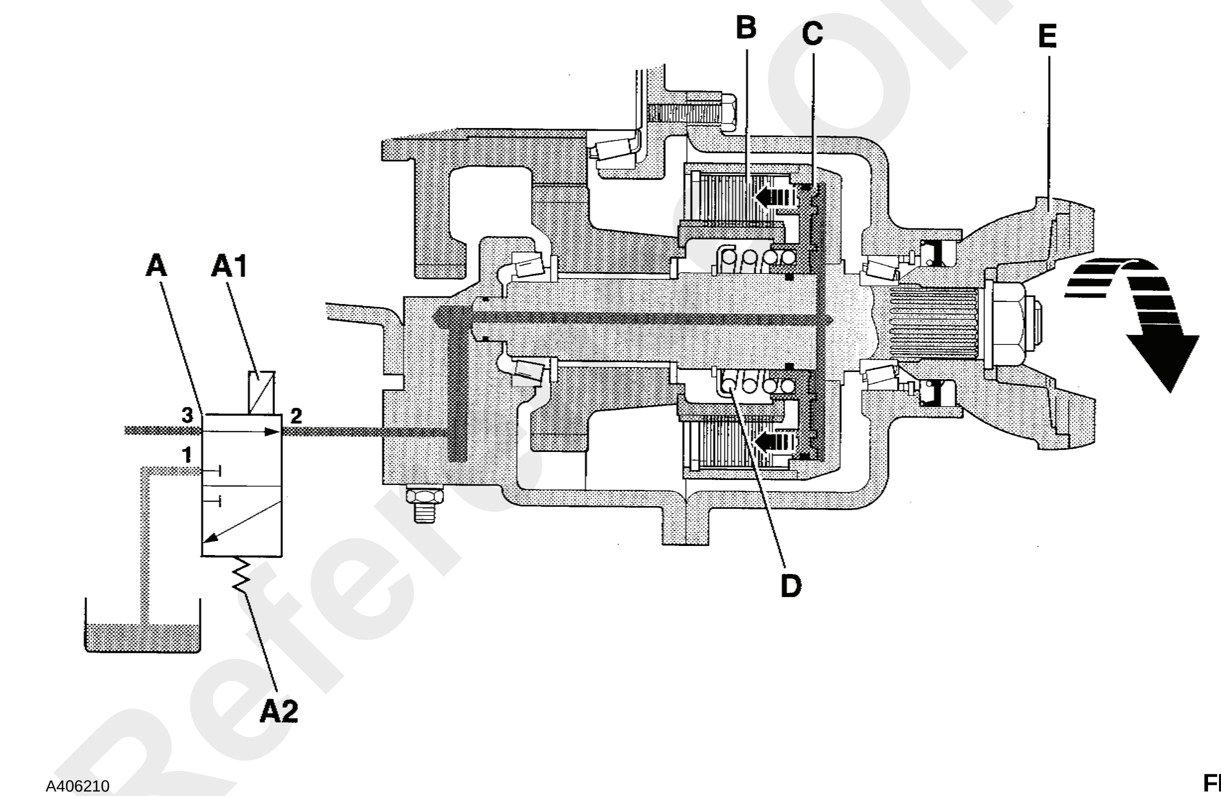


FIGURE 7-13

TROUBLESHOOTING

General Troubleshooting

Before carrying out the checks listed, the machine, if possible, should be operated to determine the problem area(s) and to bring the system to its normal working temperature.

Ensure that the correct quantity and grade of oil is being used and that there are no obvious leaks.

- **a.** If the transmission is noisy, start at check 1.
- **b.** If the transmission is overheating, start at check 4.
- **c.** If the transmission will not pull, start at check 12.
- **d.** If there is no drive in one or both directions, start at check 17.
- **e.** If the transmission is jumping out of gear, start at check 29.
- **f.** If the transmission is sticking in gear, start with check 39.
- **g.** If ratios are “crash changing,” start at check 41.

	CHECK		ACTION
1.	Is there noise when selecting direction?	YES	Check 3.
		NO	Check 2.
2.	Is there noise when running with direction selector in neutral and ratio selector is in first?	YES	Check 9.
		NO	Check 19.
3.	Is there air in the hydraulic system?	YES	Continue running to expel air.
		NO	Check 4.
4.	Is the fluid level correct?	YES	Check 5.
		NO	Check level only when machine is cold and top off as required.
5.	Are the oil passages restricted?	YES	Clear the restriction.
		NO	Check 6.
6.	Is the suction strainer restricted?	YES	Remove and clean strainer.
		NO	Check 7.
7.	Is pump pressure as specified?	YES	Check 9.
		NO	Check clutch pressure maintenance valve is free to operate.
8.	When flow testing pump, is output low?	YES	Replace pump.
		NO	Check converter sprag clutch for wear and slip.
9.	Does the noise continue when direction selector is in forward or reverse?	YES	Check 10.
		NO	Check 11.
10.	Is transmission misaligned?	YES	Replace mountings and check position.
		NO	Check “Converter Out” pressure and flow.
11.	Are the pump bushings worn?	YES	Replace pump.
		NO	Check converter for wear or cooler for restriction to flow.
12.	Is the transmission not pulling in one direction?	YES	Check 16.
		NO	Check 13.
13.	Is transmission not pulling in both Forward and Reverse?	YES	Stall test machine, Check 14.
		NO	Check 16.
14.	Is “Converter In” pressure as specified?	YES	Check 15.
		NO	Inspect converter relief valve for damage. Check cooler bypass valve pressure setting.
15.	Is pump being driven by converter?	YES	Check pump pressure.
		NO	Replace damaged parts.

CHECK		ACTION
16. Are clutch sealing rings damaged?	YES	Install pressure gauge into clutch feed lines to monitor pressure.
	NO	Check clutch plates for damage.
17. Is there drive is one direction only?	YES	Check 19.
	NO	Check 18.
18. Is the start switch in the run position and supplying current to neutral start relay?	YES	Check 19.
	NO	Rectify.
19. Is the fault only when the transmission is hot?	YES	Disassemble solenoid and check components.
	NO	Check relay and wiring.
20. Is the noise a growl, hum or grinding?	YES	Check gears for damage or wear.
	NO	Check 22.
21. Is the noise a hiss, thump or bumping?	YES	Check bearings for damage or wear.
	NO	Check 22.
22. Is the noise a squeal?	YES	Check free running gears or seizure.
	NO	Check 23.
23. Is the noise present in neutral or in gear?	NEUTRAL	Check 24.
	GEAR	Check 27.
24. Is the countershaft or bearings worn or damaged?	YES	Replace damaged parts.
	NO	Check 25.
25. Is there excessive backlash in the gears?	YES	Adjust by checking shaft end float.
	NO	Check 26.
26. Is the mainshaft pilot bearing worn?	YES	Replace.
	NO	Check gear teeth or scuffing.
27. Is the mainshaft rear bearing worn?	YES	Replace.
	NO	Check 28.
28. Are the sliding gear teeth worn or damaged?	YES	Replace gears.
	NO	Check 29.
29. Are the selector forks loose?	YES	Tighten screws.
	NO	Check 30.
30. Are the selector fork pads or grooves in gears worn?	YES	Replace worn parts.
	NO	Check 31.
31. Are the dog gear teeth worn?	YES	Replace.
	NO	Check 32.
32. Are the selector rod detent springs broken?	YES	Replace.
	NO	Check 33.
33. Are the selector rods worn or damaged?	YES	Replace.
	NO	Check 34.

CHECK		ACTION
34. Are the selector fork pads out of position?	YES	Reposition or replace (check interlock).
	NO	Check 35
35. Is there excessive end float in gears or shafts?	YES	Adjust.
	NO	Check thrust washers and mating surfaces.
36. Is the synchronizer bronze worn?	YES	Replace synchronizer pack.
	NO	Check 37
37. Are steel chips embedded in the bronze?	YES	Continue using, chips will either embed below the surface or will be dislodged.
	NO	Check 38
38. Are the synchronizer components damaged?	YES	Replace.
	NO	Check free running gears for seizure or damage.
39. Are the sliding gears tight on the splines?	YES	Loosen or replace.
	NO	Check 40
40. Are chips wedged between splines of shaft or gears?	YES	Remove chips.
	NO	Ensure that clutch is disengaging.
41. Are steel chips embedded in bronze?	YES	Continue using, chip will either embed below the surface or will be dislodged.
	NO	Check 42
42. Are the synchronizer spring pins damaged?	YES	Replace Synchronizer.
	NO	Check 43
43. Is the synchronizer bronze worn?	YES	Renew synchronizer.
	NO	Check blocker pins.

Hydraulic 2/4-Wheel Drive Unit (Spring ON/ Pressure OFF)

2wd Cannot Be Engaged

In normal operation the 2/4-wheel drive clutch is spring loaded and therefore engaged to give 4-wheel drive. The clutch must be pressurised to give 2-wheel drive. Before starting the more detailed fault finding procedures - eliminate the obvious:

1. Check that the transmission oil level is correct.
2. Check that the fuse for the 2/4WD circuit is intact.
3. Check that the 4-wheel drive external pipework is not damaged.
4. Check that all the electrical connections are clean and secure.
5. Check that the mainline pressure is correct, see Low Mainline Pressure.
6. Check that the pump flow rate is correct.

If the fault is not rectified after eliminating the obvious, check the following

Possible Cause	Remedy
7. Low mainline pressure (Minimum pressure required to disengage 2/4WD clutch is 8.6 bar; 125 psi).	**7.** Identify if the fault is related to the 2/4WD disconnect:
	a. Disconnect the external pipework to the 2/4WD clutch. Cap and plug open orifices.
	b. Check the mainline pressure - if the pressure is correct, the fault must be within the 2/4WD (see step 8). If the reading is still low check the transmission in the normal manner.
8. Low mainline pressure (due to 2/4WD clutch):	**8.** Rectify fault:
a. 2/4WD solenoid spool sticking.	**a.** Strip, clean and re-assemble solenoid valve, renew valve if required.
b. 2/4WD solenoid permanently energized.	**b.** Check the 2/4WD relay and select switch, replace as necessary.
c. 2/4WD solenoid spool O-ring failed.	**c.** Renew O-ring.
d. Clutch shaft sealing rings leaking.	**d.** Renew clutch shaft sealing rings.
e. Excessive clutch shaft end float.	**e.** Rectify fault, renew parts as required, reset end float (should not exceed 0.03 mm; 0.001 in)
f. Clutch piston O-ring failed.	**f.** Replace clutch piston O-ring.
9. Defective 2/4WD clutch:	**9.** Rectify fault:
a. Worn pressure (counter) plate	**a.** Inspect pressure (counter) plate, renew as required.
b. Worn actuating sleeve.	**b.** Measure length of actuating sleeve and renew as required, sleeve length should be 2.390 in (60.70 mm).
c. Incorrect clutch pack end float	**c.** Measure clutch pack end float, should be 0.030 - 0.059 in (0.75 -1.5 mm). Correct as required

4WD CANNOT BE ENGAGED

No pressure is required to engage 4WD (spring loaded). Check that the front wheel drive train is intact (i.e. propshaft and axle). Also check that the solenoid spool is not sticking (in the 2WD position). Finally check the 2/4-wheel drive switch and relays

Hydraulic 2/4-Wheel Drive Unit (Pressure ON/Spring OFF)

4wd Cannot Be Engaged

In normal operation the 2/4-wheel drive clutch is spring loaded off and therefore disengaged to give 2-wheel drive. The clutch must be pressurised to give 4-wheel drive. Before starting the more detailed fault finding procedures eliminate the obvious:

1. Check that the transmission oil level is correct.
2. Check that the fuse for the 2/4WD circuit is intact.
3. Check that the 4-wheel drive external pipework is not damaged and that the drive train is intact.
4. Check that all the electrical connections are clean and secure. Also check that the solenoid spool is not sticking (in the 2WD position).
5. Check that the mainline pressure is correct, see Low Mainline Pressure.
6. Check that the pump flow rate is correct.

If the fault is not rectified after eliminating the obvious, check the following:

Possible Cause	Remedy
7. Low mainline pressure	**7.** Identify if the fault is related to the 2/4WD disconnect: **a.** Disconnect the external pipework to the 2/4WD clutch. Cap and plug open orifices. **b.** Check the mainline pressure - if the pressure is correct, the fault must be within the 2/4WD (see step 8). If the reading is still low check the transmission in the normal manner.
8. Low mainline pressure (due to 2/4WD clutch): **a.** 2/4WD solenoid spool sticking. **b.** 2/4WD solenoid spool O-ring failed. **c.** Clutch shaft sealing rings leaking. **d.** Excessive clutch shaft end float. **e.** Clutch piston O-ring failed.	**8.** Rectify fault: **a.** Strip, clean and re-assemble solenoid valve, renew valve if required. **b.** Renew O-ring. **c.** Renew clutch shaft sealing rings. **d.** Rectify fault, renew parts as required, reset end float (should not exceed 0.001 in (0.03 mm)) **e.** Replace clutch piston O-ring.
9. Defective 2/4WD clutch: **a.** Worn friction/counter plates **b.** Mechanical failure of 4WD unit **c.** Incorrect clutch pack end float.	**9.** Rectify fault: **a.** Inspect friction/counter plates, renew as required. **b.** Strip and inspect 4WD unit. Check that the electrical and hydraulic circuits are functioning correctly. **c.** Measure clutch pack end float (should be 0.002 to 0.004 in (0.04 to 0.09 mm)). Correct as required.

2wd Cannot Be Engaged

No pressure is required to engage 2WD (spring loaded). Check that the solenoid spool is not sticking (in the 4WD position), then see below.

Possible Cause	Remedy
10. Incorrect type of solenoid valve fitted	**10.** Check solenoid

Possible Cause	Remedy
11. Non-return valve faulty.	**11.** Check the non-return valve
12. 2/4WD solenoid permanently energized	**12.** Check the 2/4WD relay and select switch, replace as necessary.

Water Contamination

Troubleshooting

Carefully inspect the gearbox oil for signs of water contamination. Contaminated oil will contain water droplets or be visibly emulsified. Water droplets may be visible on the dipstick or inside the filler tube. For oil analysis purposes, the maximum permissible water content of the oil is 0.10%.

If the transmission oil has been contaminated with water, faults or damage to the gearbox may be apparent as a result. Before remedying, thoroughly investigate and rectify the cause of the water contamination.

	Possible Cause	Remedy
1.	Water ingress during filling/topping up.	Carry out flushing procedure. Refill with the recommended grade of oil.
2.	Missing/incorrect dipstick, damaged filler tube.	Renew missing/incorrect/damaged components. Carry out flushing procedure. Refill with the recommended grade of oil.
3.	Machine operated in deep water.	Carry out flushing procedure. Refill with the recommended grade of oil.
4.	Gearbox casings damaged.	Inspect, renew damaged components. Carry out flushing procedure. Refill with the recommended grade of oil.
5.	Gearbox oil circuit pipes/hoses damaged.	Inspect, renew damaged components. Carry out flushing procedure. Refill with the recommended grade of oil.
6.	Oil cooler failure. (Water cooled machine installations).	Inspect, renew damaged components. Carry out cooler test procedure. Carry out flushing procedure. Refill with the recommended grade of oil.

Gearbox faults caused typically by water contamination and other factors related to the transmission oil:

Fault	Possible Cause	Remedy
1. Pressurization of gearbox casing - Dipstick blows out/oil leaking from dipstick tube.	Water in oil combined with heat from torque converter causes steam. Gearbox over filled with oil.	Replace/renew dipstick. Carry out flushing procedure. Refill with the recommended grade of oil. Drain the oil level to the correct level, see **Check Oil Level**, Section 3.
2. Clutch Failure - Friction Lining Separation	Water ingress. Overheating.	Renew friction plates. Carry out flushing procedure. Refill with the recommended grade of oil.See **Fault Finding - Synchro Shuttle Gearbox - Hydraulics**.
3. Badly worn/noisy bearings.	Water ingress. Insufficient lubrication.	Fit new bearings. Carry out flushing procedure. Refill with the recommended grade of oil.

If the transmission cooler circuit becomes contaminated due to the ingress of water, stop the engine immediately. Drain the oil from the transmission sump and external cooler circuit into a suitable container.

CAUTION

The oil could be hot, avoid contact with the skin to prevent scalds.

Inspection

Inspect the transmission generally for visible means of water entry into the system.

Disconnect the transmission cooler circuit and clean thoroughly. The transmission cooler is a possible source of water contamination and should be tested for possible failure as follows:

Cooler Test Procedure

1. Remove the cooler from its mounting.
2. Drain remaining oil/water from the cooler.
3. Connect an air supply to the transmission oil inlet connection and plug and seal the outlet.
4. Submerge the cooler in a tank of water and apply air pressure to test for leakage. If bubbles are visible the integrity of the cooler has broken down and the cooler should be scrapped.

NOTE: Air test pressure should not exceed 6 bar (90 psi).

5. If the cooler is not damaged, it should be cleaned and dried ready for reassembly onto the transmission.

After refilling the transmission with new oil, and the engine and transmission have returned to normal working temperature, the operator should periodically stall the torque converter for up to 5 second intervals to remove trapped water. To stall the torque converter, carry out the following procedure:

Stalling the Torque Converter

1. Apply the foot brake firmly. If necessary, set the machine against a fixed obstruction.
2. Select 4th speed forward and open the throttle fully.

CAUTION

DO NOT stall the converter for more than 10 seconds maximum. If contamination is severe (oil still visibly emulsified) repeat the drain/fill procedure before returning the machine to service.

Flushing Procedure

1. Reconnect the hoses to the cooler. Ensure the joints are clean and leakproof.
2. Renew the oil filter.
3. Refill the transmission circuit with the recommended grade of oil.
4. Start the engine and continue running for several minutes to reach normal operating temperature.
5. Stall the torque converter for 5 seconds.
6. Continue running the engine for 5 minutes.
7. Repeat the torque converter stall for 5 seconds.
8. Continue this procedure for a period for up to 30 minutes, if possible during machine operation.
9. Drain the oil and fit a new filter. Test the oil for contamination.
10. Refill the transmission circuit with the recommended grade of oil.

NOTE: If the oil drained at step 9 is clean and free from water contamination - return the transmission to service. If not, repeat flush and fill procedure.

General Procedure

Between 50 and 100 hours operating time after cooler failure, drain the transmission cooler circuit and refill with the recommended grade of oil and renew the oil filter.

Oil should no longer show evidence of water contamination. Further sampling should be carried out if in doubt.

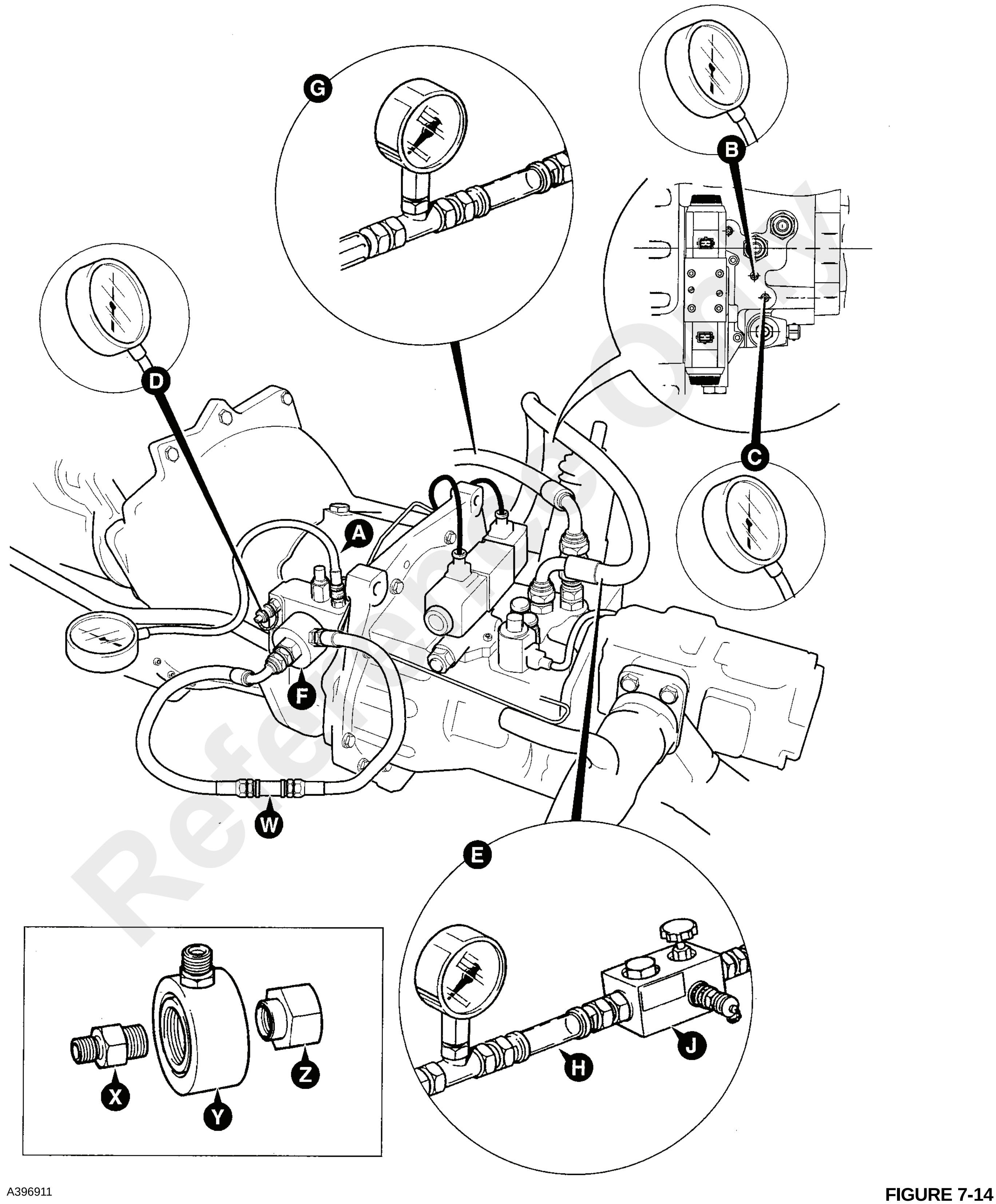


FIGURE 7-14

Pressure and Flow Tests

Before completing any of the transmission pressure/flow tests, make sure that the oil level is correct and at normal operating temperature.

Test points have been introduced which can be left in place after testing. Remove blanking plugs as required and fit the test points. If the test points are to be left in place use Loctite 242 on the threads when fitting. Torque to 21 ft. lb (28 Nm).

WARNING

Fine jets of hydraulic oil at high pressure can penetrate the skin. Do not use your fingers to check for hydraulic oil leaks. Do not put your face close to suspected leaks. Hold a piece of cardboard close to suspected leaks and then inspect the cardboard for signs of hydraulic oil. If hydraulic oil penetrates your skin, get medical help immediately.

Take care when disconnecting hydraulic hoses and fittings as the oil will be HOT.

DO NOT go underneath the machine with the engine running. Switch off the engine, apply the parking brake and chock both sides of all wheels before going underneath the machine.

Test Points

A. Mainline pressure

B. Forward clutch pressure

C. Reverse clutch pressure

D. Converter inlet/converter relief valve pressure

E. Converter outlet pressure

F. Pump flow (remove filter and fit adapters)

G. Lubrication pressure

H. Cooler flow (flowmeter in line from transmission to cooler)

I. Load Valve

If testing the complete transmission, the following procedures are listed in a logical sequence and should therefore be completed in the same sequence. Also, refer to the fault finding procedures at the end of the transmission section for reference to specific tests.

Mainline Pressure

1. Stop engine, connect a 0-300 psi (0-2068 kPa) pressure gauge to test connector **A**.
2. Start engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will show the Mainline Pressure which should be as shown in Technical Data, page 7-1.
3. Repeat step 2 and note gauge readings with engine running at 2000 rpm.
4. Stop engine and remove test gauge.

If the mainline pressure is low, refer to the fault 'Low Mainline Pressure' for a list of possible reasons. A high reading could indicate a faulty pressure maintenance valve.

Clutch Pressure (Forward Clutch Given in Example)

1. Stop engine, connect a 0-300 psi (0-2068 kPa) pressure gauge to test connector **B** (item **C** for reverse clutch).
2. Start engine and run at 1000 rpm. With parking brake and footbrake firmly applied, select **Forward**, the pressure gauge will show the **Clutch Pressure** which should be as shown in Technical Data, page 7-1**.**

NOTE: Note: If the mainline pressure is in the lower part of the tolerance band (see Technical Data, page 7-1), then the forward and reverse clutch pressures should also be in the lower part of the tolerance band and vice versa.

3. Repeat step 2 and note gauge readings with engine running at 2000 rpm.
4. Stop engine and remove test gauge

If the clutch pressure is low, the clutch could be leaking. A leaking clutch is easier to detect when the engine is running at idle. With the engine at idling speed, check the mainline pressure and then check the clutch pressure as described above, if the clutch pressure is 1.7 bar (25 psi) less than the mainline pressure, then the clutch is probably leaking. Refer to the fault 'Low Clutch Pressure' before dismantling the clutch.

A high reading could indicate a faulty pressure maintaining valve.

Pump Flow

1. Stop engine, remove transmission filter, and screw adapter **X** on to the threaded spigot. Fit test adapter **Y** and secure with adapter **Z**. Connect flowmeter **W**.
2. Start engine and run at 1000 rpm. With the transmission in neutral the flowmeter will show the Pump Flow which should be as shown in Technical Data, page 7-1.
3. Repeat step 2 and note gauge readings with engine running at 2000 rpm.
4. Stop engine and remove test adapters, refit filter.

If the pump flow is low, refer to the fault **Low Pump Flow**.

Converter Out Pressure/Oil Cooler Flow Rate

1. Stop engine, connect a 0-145 psi (0-1000 kPa) pressure gauge and flowmeter (see note) into the converter out line as shown at **E** and **H** respectively.

NOTE: The flowmeter must have a low back pressure, otherwise an incorrect reading will be obtained.

2. Run the engine at 1000 rpm with transmission in neutral. The pressure gauge indicates the Converter Out Pressure and the flowmeter indicates the Oil Cooler Flow Rate, both readings should be as specified in Technical Data, page 7-1.
3. Repeat step 2 and note gauge readings with engine running at 2000 rpm.
4. Stop engine, remove test gauges and refit hoses to original position.

If the pressure is low, refer to the fault **Low Converter Out Pressure** for a list of possible reasons. A high pressure together with low flow could be caused by a blocked oil cooler.

Converter In Pressure

1. Stop engine, connect a 0-145 psi (0-1000 kPa) pressure gauge to test point **D**.
2. Start the engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will show Converter In Pressure which should be as shown in Technical Data, page 7-1. A high or low reading could indicate a faulty converter relief valve, or a problem with the pump.
3. Remove pressure test gauge

Converter Relief (Safety) Valve Pressure

1. Connect a 0-145 psi (0-1000 kPa) pressure gauge to test point **D**.
2. Fit a load valve **J** into the converter out line.

CAUTION

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 be incurred.

DO NOT allow the pressure to exceed 7.6 bar (110 psi) or damage to the converter seals will be caused.

3. Start the engine and run at 1000 rpm. With the transmission in neutral, slowly screw down the load valve **J** while observing the gauge reading which should rise to the Converter Relief (Safety) Valve setting as specified in Technical Data, page 7-1.
4. If the reading is higher than specified then the converter relief valve is faulty. A low reading indicates a leaking pump seal or a faulty converter relief valve.
5. Stop engine, remove test gauges and refit hoses to original position.

Lubrication Pressure

1. Stop engine, connect a suitable pressure gauge into the return line from the oil cooler to the transmission as shown at **G**.
2. Start the engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will indicate the Lubrication Pressure which should be as specified in Technical Data, page 7-1.
3. Repeat step 2 and note gauge readings with engine running at 2000 rpm.
4. Stop engine and remove pressure gauge

Torque Converter Stall Test

NOTE: Before completing the torque converter stall test, make sure that the mainline and clutch pressures are correct. If the pressures are incorrect, the clutches could slip, causing premature wear of the clutch friction plates.

Also, make sure that the machine neutral circuit pressure (including steer circuit) is correct 200 psi (1379 KPa) maximum.

1. Ensure that the engine and transmission are at normal working temperature. Run engine at maximum speed and check the No Load Speed (High Idle Speed). See Engine Technical Data for correct figure; adjust if necessary.
2. Apply parking brake and footbrake firmly, select 4th Speed Forward and open throttle fully. Engine speed should be as specified at Torque Converter Stall in Transmission Technical Data. Select Reverse and repeat test.

DO NOT stall the converter for longer than 30 seconds or the transmission fluid will overheat.

3. If engine speeds are higher than the stated figures check the transmission for clutch slippage or internal leakage.
If engine speeds are below the stated figures either the engine is losing power and should be serviced/ overhauled or the torque converter reaction member clutch is slipping.

NOTE 1: The engine can also be checked by doing a stall test and 'blowing off the main relief valve simultaneously. The speed should be as stated in Technical Data ('Engine Rev/Min at Converter Stall + MRV Operating).

NOTE 2: Maximum Governed Speed is a datum figure only. It cannot be adjusted or checked with the engine installed in the machine.

Sump Oil Strainer Procedure (See Figure 7-15) (after Transmission Overhaul)

If the transmission is not thoroughly cleaned during overhaul, any particles below 200 micron (0.2 mm) can pass through the existing suction strainer and into the transmission pump before being caught in the pressure filter. This can result in transmission pump failure and the transmission may have contamination related problems (scoring of bearings and clutch housing).

It is recommended that a special 75 micron (0.075 mm) service suction filter is temporarily fitted after a transmission overhaul to clean the system and prevent further damage.

The following procedure should be adopted:

1. During the overhaul, the transmission should be cleaned as thoroughly as possible.
2. If a significant amount of particles and oil debris is present, then it is recommended that the oil cooler and pipework are cleaned or replaced.
3. Fill the transmission with clean, correct specification oil.
4. The transmission should be overfilled for initial start-up.
5. Disconnect the oil cooler feeder pipe at **E** and run the engine at idle.
6. Drain the excess oil into a suitable container which will prevent contaminated oil being pumped into the oil cooler or transmission. The transmission must be kept full at all times.
7. Reconnect the oil cooler at **E**. Run the machine to working temperature and carry out functional tests.
8. Remove the connection or plug from the suction strainer and drain the system.

NOTE: Drain through the strainer, not the drain plug and DO NOT re-use this oil as it will be contaminated.

9. Remove and clean the service suction strainer with its magnet. Retain for future use.
10. Fit the production suction strainer, tightening bolts **F** to 5.2-7.3 lb ft (7-10 Nm).
11. Fit a new pressure filter **C**.

NOTE: The pressure filter should be changed again after 100 hours running.

12. Refill the system with clean and correct specification oil.

7

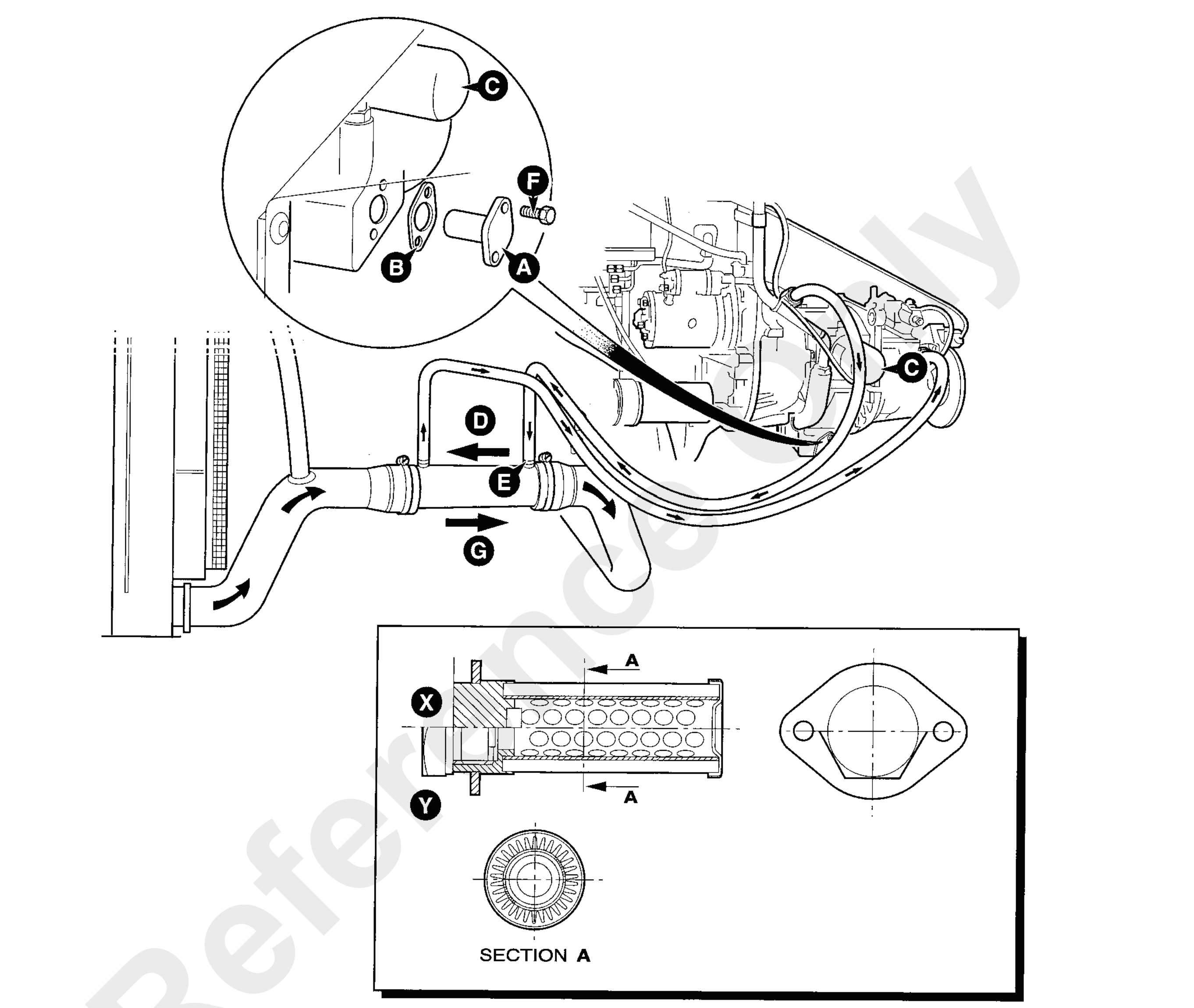


FIGURE 7-15

Component Key:	
A	Suction strainer (892/00970)
B	Gasket
C	Pressure Filter
D	Hot Oil
E	Oil Cooler Feed Pipe
F	Bolt (2 off)
G	Cold Water

TRANSMISSION REPAIR

Servicing the Torque Converter

Removal

Remove the complete power unit. See Engine and Engine Systems, page 6-1

1. Fasten the engine to an engine stand.
2. Using an overhead crane and chains, support the weight of the transmission and remove the twelve capscrews and lockwashers securing the transmission to the engine flywheel housing.

CAUTION

The transmission weighs approximately 400 lb (181 kg) dry. Use adequate hoist and chains. Personal injury could occur from improper lifting of the transmission.

3. Remove the transmission 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.
4. The torque converter assembly is fastened to the engine flywheel through a drive plate. Remove the drive plate mounting screws and remove the torque converter and drive plate.
5. Remove the bolts securing torque converter to drive plate. Remove drive plate and its reinforcement.
6. Replace the complete torque converter. The parts are not serviced separately. Replace drive if it is distorted or damaged.

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.*

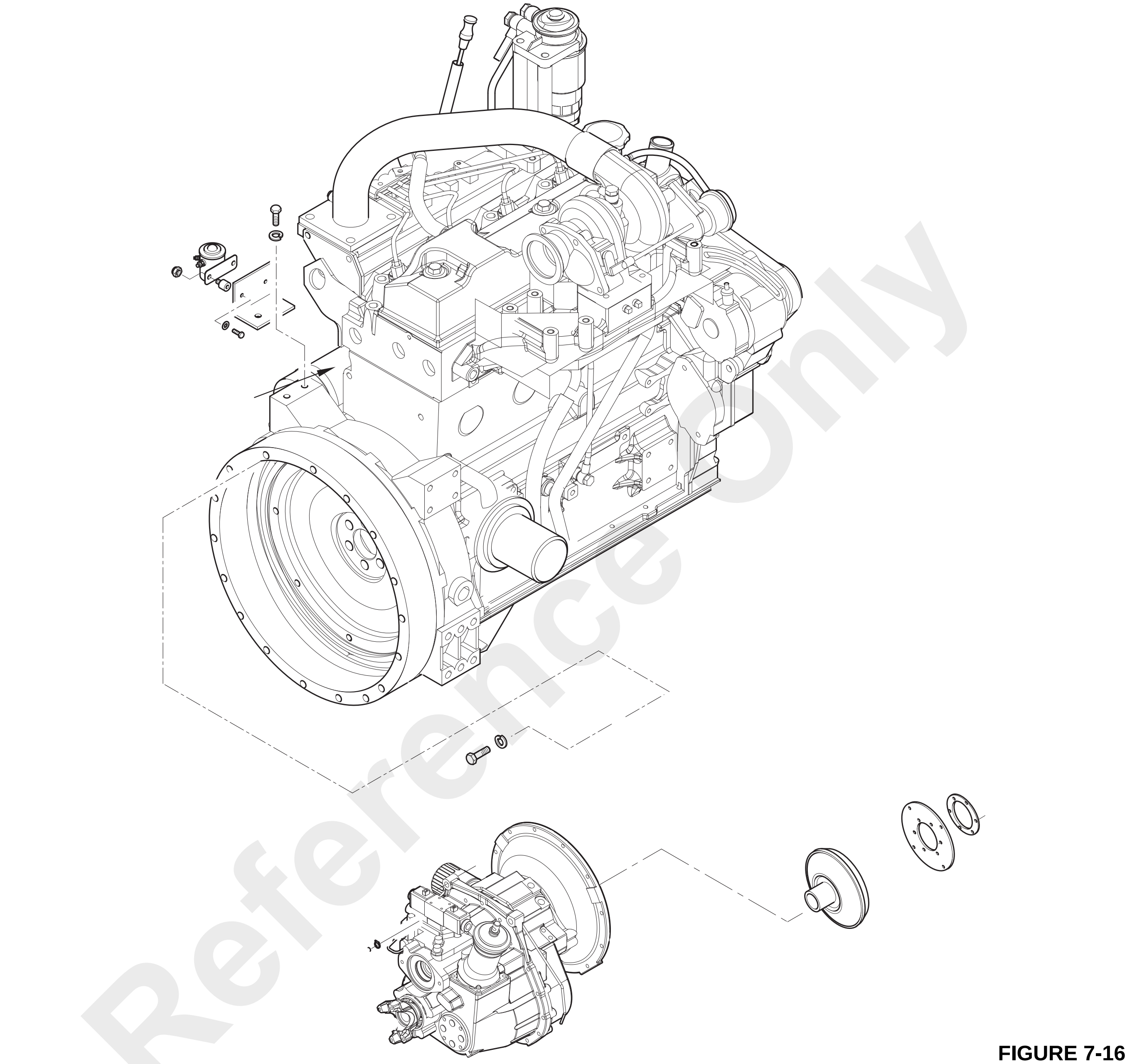


FIGURE 7-16

Installation

NOTE: *It is recommended, when installing the torque converter, that the alignment tool procedure be used. The alignment tool is available from your Grove distributor or Manitowoc Crane Care under part number 1902662. If the tool can not be obtained, use the optional procedure, Installing Without Alignment Tool.*

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 reinforcing plate (**1** Figure 7-17) onto the torque converter.

a1240

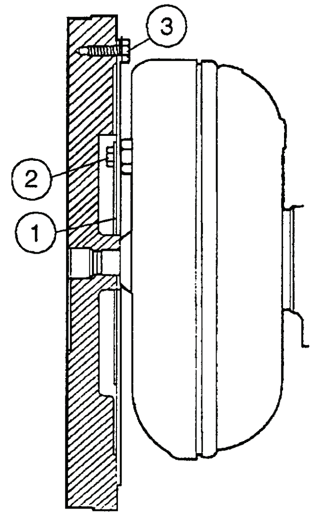


FIGURE 7-17

2. Place the torque converter alignment tool **A** (Figure 7-18) over the torque converter shaft, 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.

a1294

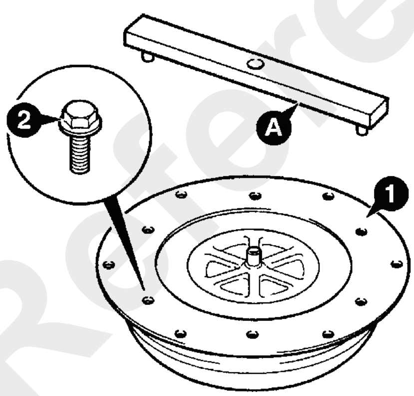


FIGURE 7-18

3. Apply Loctite 242 to the threads of bolts **2** and install four of the bolts, attaching the drive plate to the torque converter. Tighten the bolts to 62 lb-ft (84 Nm). Remove the alignment tool and install the remaining two bolts. Tighten to a torque of 62 lb-ft (84 Nm).

4. Locate the torque converter and drive plate assembly on the flywheel. Apply Loctite 242 to bolt **3** and install the bolts to attach the drive plate to the flywheel. Check the converter run-out as shown in **B** of Figure 7-19, which should not exceed 0.015 inches (0.33 mm). Adjust as necessary.

a1239

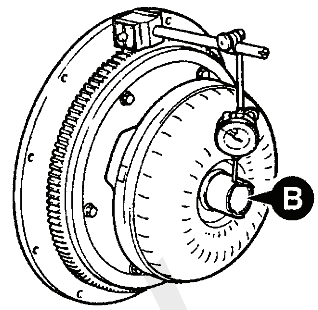


FIGURE 7-19

5. Tighten the drive plate mounting bolts **3** to a torque of 14 lb-ft (10 Nm).

Installing without Alignment Tool (Optional)

1. Assemble the drive plate and reinforcing plate (**1**, Figure 7-17) to the torque converter using bolts **2**. Apply Loctite 242 to the bolts and only finger tighten at this time.

2. Install the torque converter and drive plate assembly to the engine flywheel, fasten with mounting bolts **3**. Check the alignment of the torque converter to the flywheel using a dial indicator held in position against the converter hub (Figure 7-20). The torque converter must be centered on the flywheel within 0.015 in (0.33 mm). When correct, mark the position of the flywheel and drive plate, then remove the drive plate and annulus from the flywheel.

Centering Check p-centering

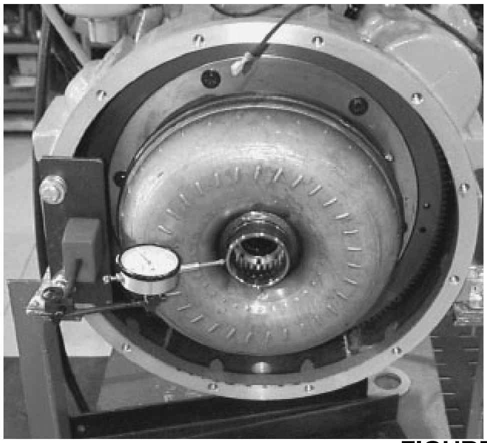


FIGURE 7-20

3. Tighten bolts to a torque of 62 lb-ft (84 Nm).

4. Install the torque converter and drive to the engine flywheel, aligning the drive plate with the alignment marks. Recheck centering on the flywheel. Coat the threads of bolts with Loctite 242 and install them. Tighten the bolts to a torque of 14 lb-ft (19 Nm).

Installing Transmission

1. Clean and lubricate the splines of the transmission input shaft. Install the transmission to the converter, ensuring that the dogs on the converter oil seal shaft engage with the recesses on the transmission input. Take care not to damage the oil seal.
2. Install twelve bolts and lockwashers. Tighten bolts to a torque of 23 lb-ft (31 Nm).
3. Install the power unit into the crane. See Engine and Engine Systems, Chapter 6.
4. Connect all removed hydraulic lines, electrical harnesses, cables, etc.
5. Fill the transmission with recommended oil. See Preventative Maintenance, Chapter 5.

Servicing the Transmission

Removal

1. Remove complete power unit. See Engine and Engine Systems, Chapter 6.
2. Fasten engine to an engine stand.
3. Drain the transmission. See Preventative Maintenance, Chapter 5.

CAUTION

The transmission weighs approximately 400 lb (181 kg) 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 and lockwashers that fasten the transmission housing 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. Remove the torque converter.

Transmission Gearbox Repair

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 572° F (300° C) 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 572° F (300° C) (e.g. engine fire) must be treated using the following safety procedure. Make sure that heavy duty gloves and safety glasses are worn:

1. Ensure that components have cooled then remove and place materials into plastic bags.
2. Thoroughly wash contaminated area with a 10% calcium hydroxide or other suitable alkali solution, if necessary use wire wool to remove burnt remains.
3. Thoroughly wash contaminated area with detergent and water.
4. Contain all removed material, gloves etc., used in this operation in sealed plastic bags and dispose of in accordance with Local Regulations.

NOTE: DO NOT BURN FLUORO-ELASTOMERIC MATERIALS. If contamination of skin or eyes occurs, wash the affected area with a continuous supply of clean water or with calcium hydroxide solution for 15 - 60 minutes. Get medical attention immediately.

Dismantling

Cleanliness is of the utmost importance when servicing the gearbox. All precautions to prevent any ingress of dirt, grit etc. must be taken. To this end wash the exterior of the gearbox assembly as follows:

Make sure that all open ports and orifices are effectively plugged. Remove any deposits of dirt, grit and oil from the outer casings using a suitable degreaser and water. Dry the casings.

NOTE: Paragraph numbers correspond with numbers in illustrations.

If not already removed, remove hydraulic pump from gear box.

1. Remove the circlip (**1**, Figure 7-21) and then withdraw the pump driveshaft **1a** together with its bearing **1b**.
2. Remove and discard the shaft sealing ring.

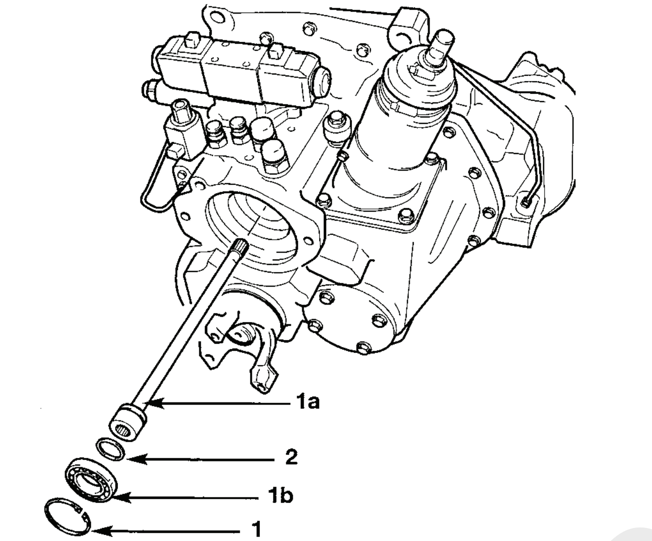


FIGURE 7-21

3. Drain the oil from the casing by removing the suction strainer **3a**. Remove and discard the oil filter **3b** (See Figure 7-22).

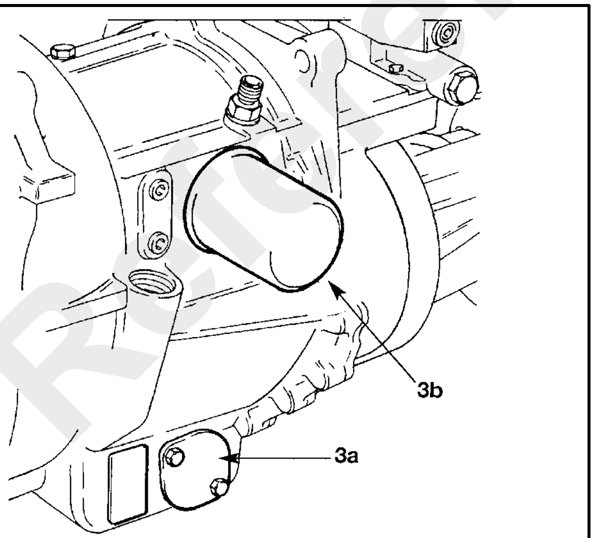


FIGURE 7-22

4. If the gearbox is fitted with a 2/4-wheel drive unit **B**, remove it. See Hydraulic 2/4-Wheel Drive Unit - Disassembly for the correct procedures (See Figure 7-23).

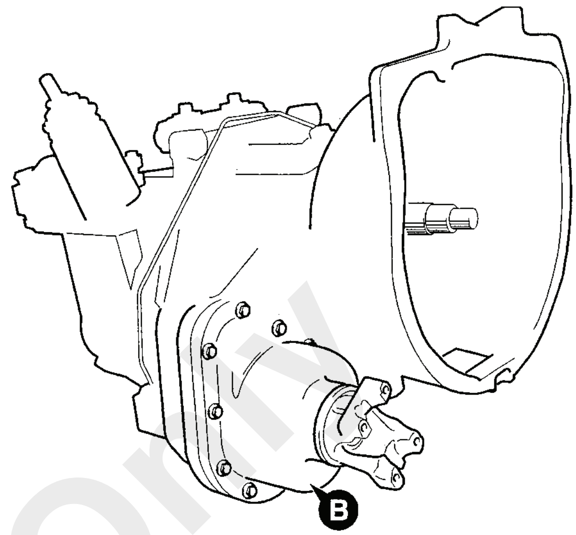


FIGURE 7-23

5. Unscrew bolts (Figure 7-24) and withdraw pump **7**.
6. Remove and discard pump sealing ring **6**.
7. Separate pump **7** components. Note that the pump components are held together with a security screw at the rear of the assembly.
8. Remove and discard oil seal **8** from pump housing.

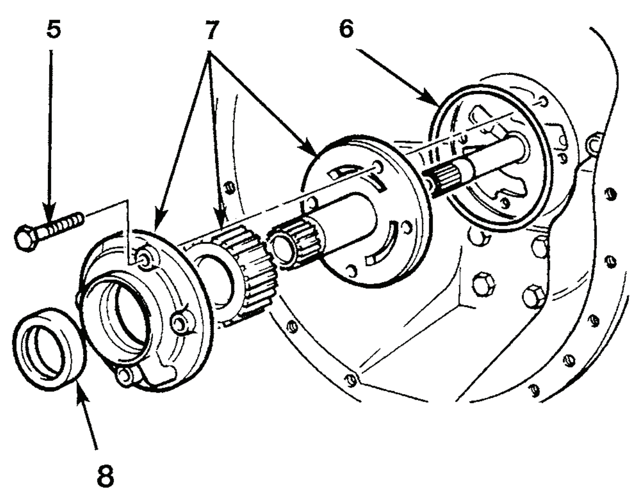


FIGURE 7-24

Position transmission vertically, standing on the face of the torque converter housing.

9. Unscrew capscrews and remove solenoid control valve. (**9**, Figure 7-25) Note the O-rings fitted around ports on the mating face of solenoid valve body

NOTE: See **Solenoid Valve** for solenoid valve disassembly and assembly procedures

10. On 4-wheel drive transmissions remove the 4-wheel drive hydraulic pipe and control valve **10a**.

11. Undo the 4 bolts and remove the gear lever turret. Remove the baffle plate beneath if fitted. If necessary the turret assembly can be disassembled as follows:

NOTE: The procedure below is for a double turret as shown (Figure 7-26). If dismantling a single turret follow steps a, e and f only (Steps b, c and d are not applicable to single turrets)**.**

a. Slacken worm drive clips and remove rubber boot.

b. Using a suitable press or clamp, carefully press the top lever **11a** down to compress spring **11b**, just enough to release pressure on circlip **11c**.

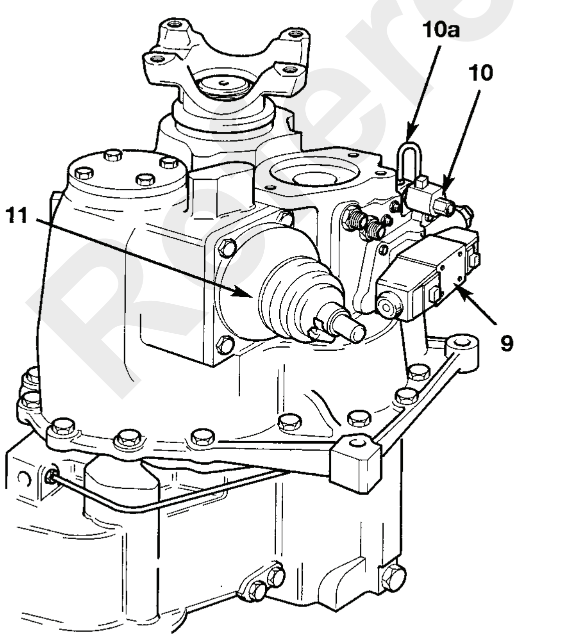
NOTE: BEWARE of spring pressure acting on nylon seat when circlip is removed

c. Remove circlip **11c**.

d. Slowly release the pressure from the top lever **11a** and remove it, together with bushing **11d**, washer **11e** and spring **11b**.

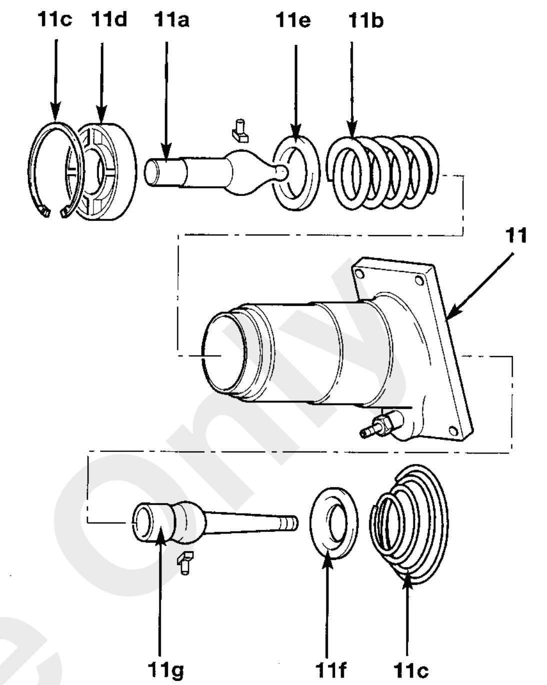
e. Rotate spring **11c** so as to disengage from the retaining tabs inside the turret **11**. Be aware that the spring may suddenly disengage while still under pressure. Repeat this operation until all the coils are disengaged and the spring can be removed.

f. Remove retainer **11f** and bottom lever **11g**.



A387950

FIGURE 7-25

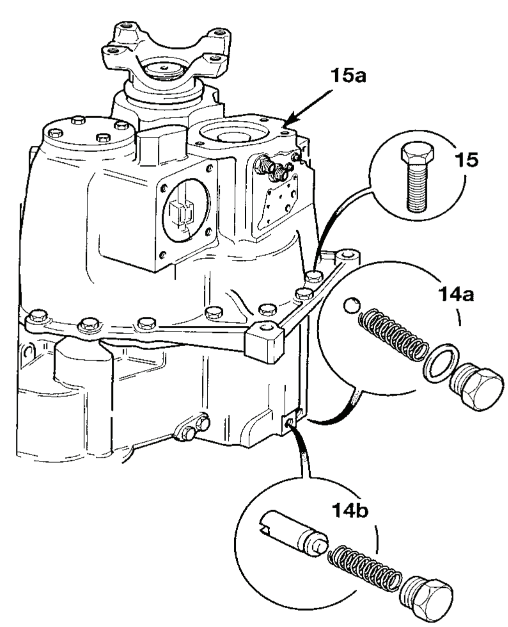


A388211

FIGURE 7-26

12. Unscrew plug **12** (Figure 7-27) and withdraw pressure maintenance valve spool and spring.

13. Unscrew four bolts and remove pressure maintenance valve body **13**. Remove and discard gasket.



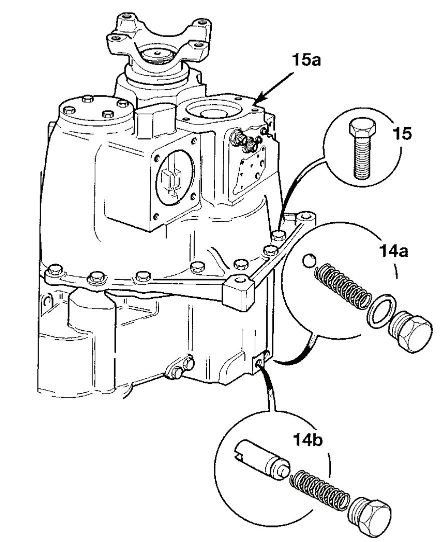
A387970

FIGURE 7-27

Manitowoc Crane Care

14. Remove the torque converter pressure relief valve ball and spring assembly **14a** (Figure 7-28). Remove the torque converter pressure regulating valve spool and spring assembly **14b**.

15. Unscrew bolts **15** and lift off output end casing **15a**. Be sure to retrieve bearing outer cups from inside the casing. Keep the cups together with their associated bearing.



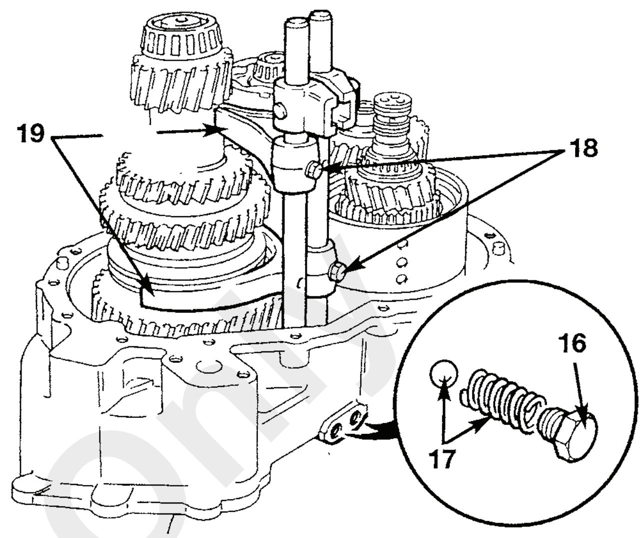
A387970 **FIGURE 7-28**

16. Unscrew selector detent plugs **16** (Figure 7-29).

17. Remove selector detent balls and springs **7**.

18. Unscrew selector fork retaining screws **18** and lift out selector rods.

19. Note that the selector forks **19** are not interchangeable. Mark the forks to ensure they are replaced correctly. Remove selector forks.

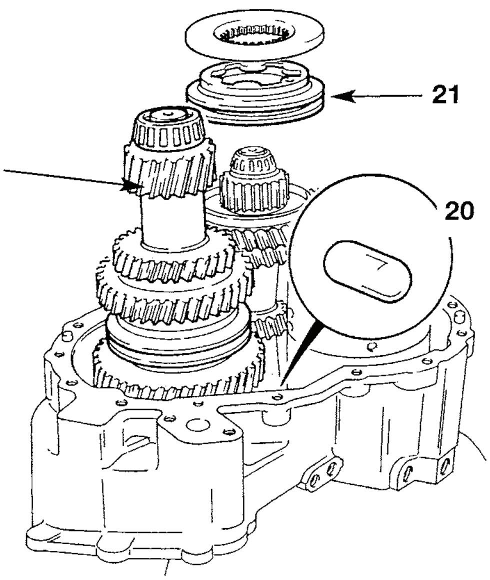


221080 **FIGURE 7-29**

20. Push out the interlock plunger **20** (Figure 7-30) on disassembly.

21. Lift off 3rd/4th synchro-hub **21**. Note the positions for refitting with mating cups.

22. Lift out layshaft assembly **22**.



A395460 **FIGURE 7-30**

23. Remove idler gear upper thrust washers and bearing **23** (Figure 7-31). Keep the thrust washers and bearing together.

24. Tilt mainshaft **L** to one side and lift off idler gear **24** together with its needle roller bearing **24a**.

7

25. Remove idler gear lower thrust washers and bearing **25**. Keep the thrust washers and bearing together.

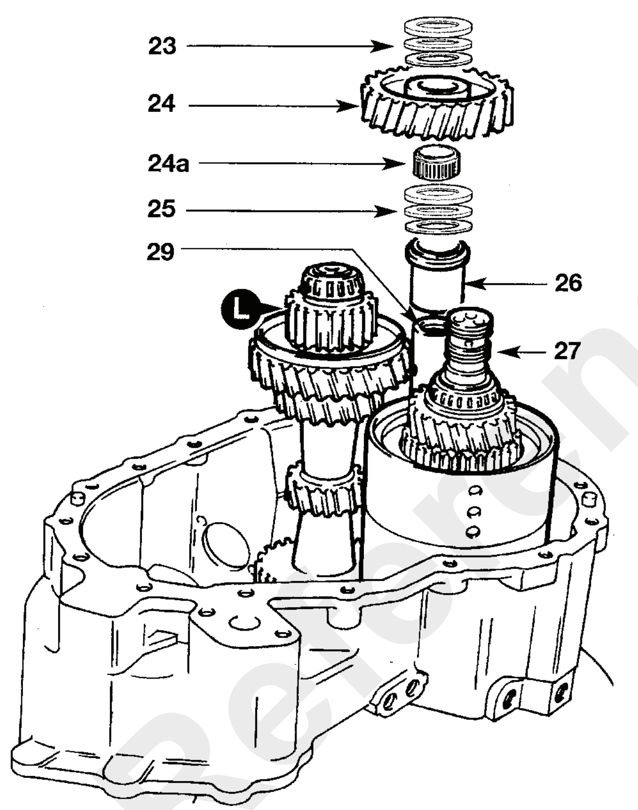
26. Lift off idler gear spacer **26**.

27. Tilt mainshaft **L** to one side and lift out the reverser assembly **27**. Discard the piston rings seals.

NOTE: See Reverser Unit for reverser unit disassembly **8** and assembly procedures.

28. Remove mainshaft **L**.

29. The idler gear spindle is a press fit in the casing. Use a suitable puller screwed into the 1/2 in B.S.P. hole in the end of the spindle for extraction. Note that the spindle should only be removed if it is damaged and is required to be replaced.



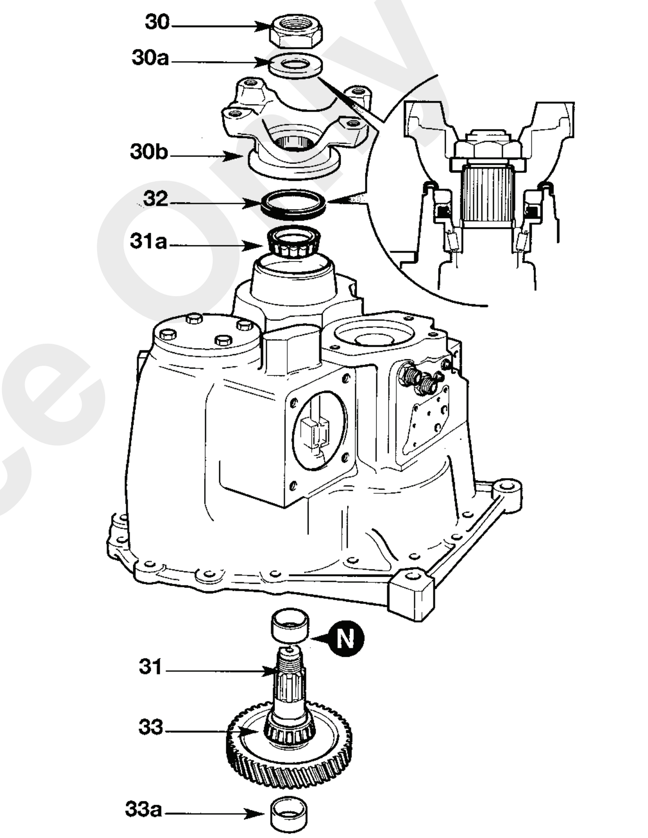
S407370 FIGURE 7-31

30. Unstake the nut **30** (Figure 7-32). While holding the output yoke, unscrew output shaft nut and remove the washer **30a** beneath. Support output shaft from beneath and lift off the yoke **30b**.

31. Withdraw output shaft assembly **31** and lift out outer bearing **31a**. Remove spacer **N** and retain for assembly.

32. Pry out oil seal **32** and discard.

33. Using a suitable puller, withdraw output shaft inner bearing **33**. Remove the mainshaft bearing outer cup **33a** from the center of the output shaft transfer gear.



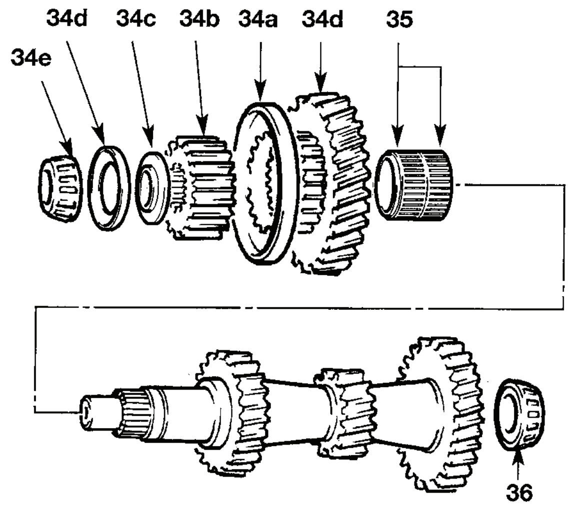
A388000 FIGURE 7-32

Mainshaft

34. Using suitable puller, pull off 3rd gear together with synchro cup **34a**, (Figure 7-33) gear **34b**, spacer washer **34c**, oil retention washer **34d** and bearing **34e**. Keep the synchro hubs and cups in their original relationship.

35. Remove needle roller bearings **35**.

36. Remove bearing **36** from converter end of mainshaft using press a suitable.



S388160 **FIGURE 7-33**

Layshaft

37. Remove the bearing **37** (Figure 7-34). Remove 4WD transfer gear **37b** and bearing **37a** from layshaft. On 2WD machines a spacer is fitted in place of the transfer gear.

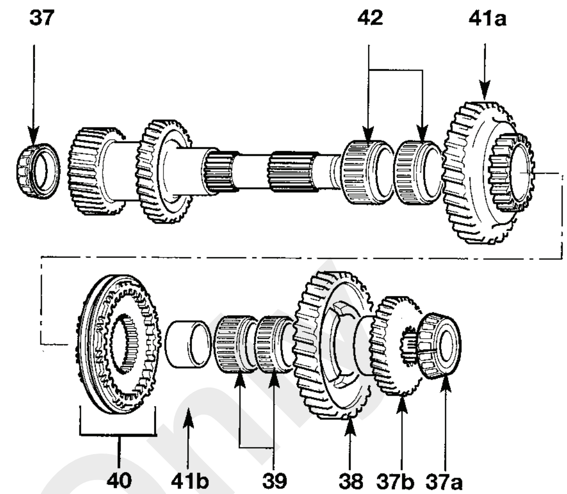
38. Liftoff 1st gear **38**.

39. Remove 1st gear needle roller bearings **39**.

40. Note that the 1st/2nd synchro unit **40** is of a different design to the 3rd/4th gear unit. There are components which may be lost during removal unless care is taken. Hold the unit together with the synchro cones on each side and lift off. Keep the synchro cones, rings and hubs in their original relationship.

41. Use a press to push off 2nd gear **41a**, synchro assembly **40** and 1st gear needle roller track ring **41b**.

42. Remove 2nd gear needle roller bearings **42**.

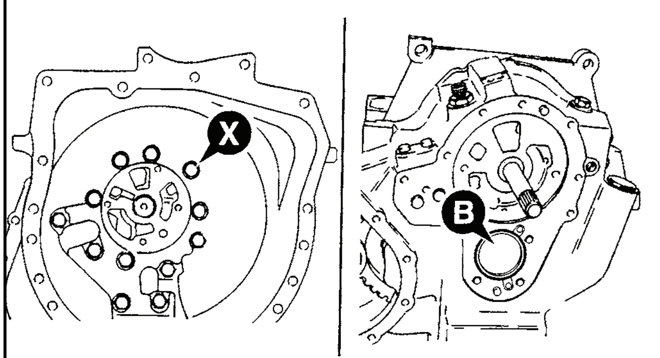


A395470 **FIGURE 7-34**

Setting Ring Removal

The mainshaft and layshaft end float is controlled by a threaded 'setting ring' screwed into the casing.

To enable access to the mainshaft setting ring the torque converter housing must be removed. Undo the 12 fixing bolts **X** (Figure 7-35) and remove the housing. The setting ring is located at position **B**.



S388330 **FIGURE 7-35**

To enable access to the layshaft setting ring the bearing cover must be removed. Undo the 4 fixing bolts **Y**, (Figure 7-36) remove the cover and discard the gasket beneath. The setting ring is located at position **C**.

If the bearings or shaft are to be renewed the associated setting ring must be removed and discarded as follows:

7

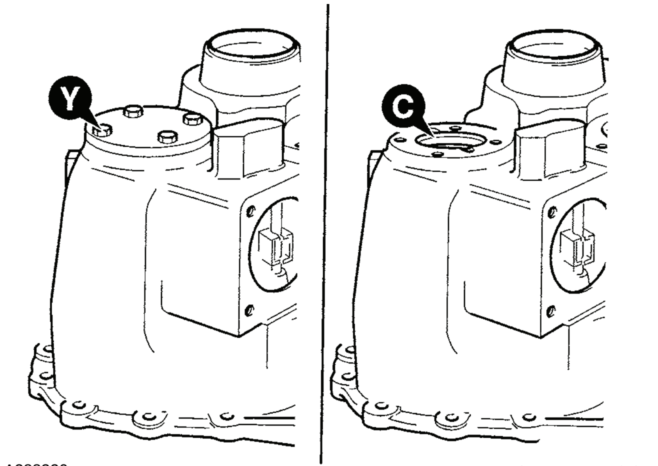


FIGURE 7-36

1. Carefully pry out the staked section of the ring **Z** (Figure 7-37) clear of the casing.
2. Unscrew and discard the ring.
3. Be sure to remove any shards of metal that may have fallen into the casing.

NOTE: Once removed, the setting rings must not be re-used. Discard the ring and obtain a new one. Note that the mainshaft and layshaft setting rings are not interchangeable

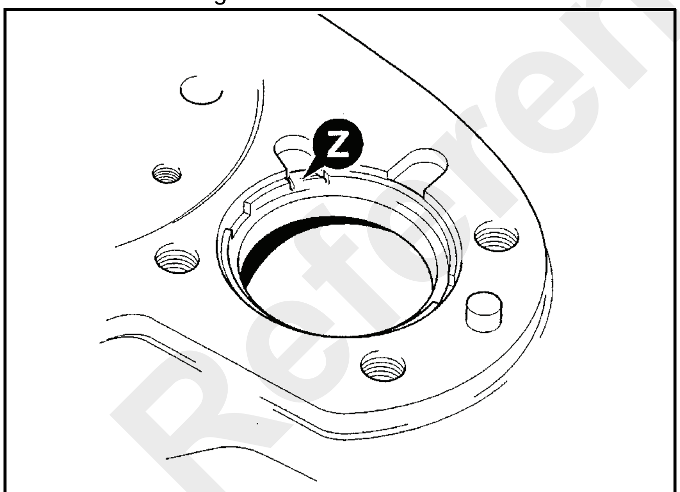


FIGURE 7-37

Inspection

Before assembling the gearbox make sure that a thorough inspection of all components is carried out. Remember that although a failed component may be easy to identify, the cause of that failure may be less easy to trace. It is also possible that a failed component may have caused damage to other areas of the gearbox.

1. Carefully remove all traces of gasket compound from components as follows:
   - **a.** Front and rear casing mating faces.
   - **b.** Front casing and torque converter housing mating faces.
2. Clean the inside of the casings using a suitable degreasing agent.
3. Carefully inspect all gears, bearings and shafts for signs of excessive wear or damage. If wear or damage is evident, components must be renewed.
4. Make sure that all oil way cross drillings in the casings, shafts and gears are clear and free from debris. Blocked oil ways are a common cause of bearing failure. Use an air line to blow through cross drillings.

NOTE: If failure of the reverser unit or hydraulic 2/4-wheel drive unit is suspected, see the relevant disassembly and assembly procedure in this section.

1st/2nd Gear Synchromesh Unit

The 1st/2nd gear synchro unit must be checked for wear before assembly as follows:(See Figure 7-38 thru Figure 7-40)

1. Before dismantling the unit be aware that on reassembly, the components must be kept in their original relationships.
2. Disassemble the unit by removing the cones and rings **A1**, **A2** and **B1**, **B2**. Push off the sleeve **C** taking care to retrieve the sets of balls **D**, poppets **E** and springs **F**.
3. Inspect the mating faces of cones and rings. The wear indicator grooves **X** must still be visible. As a further check, locate the cones and rings together (as shown at **Y**) and measure the clearance between them using feeler gauges. The clearance should be between 0.02 in and 0.7 in for both **A** and **B** pairs. If either is out side these limits then the complete synchro unit must be renewed.

4. Inspect the teeth on all cones and rings for excessive wear or damage. If wear or damage is evident the unit must be renewed.

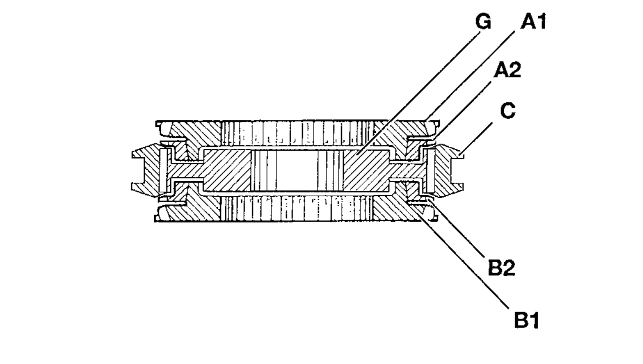


FIGURE 7-38

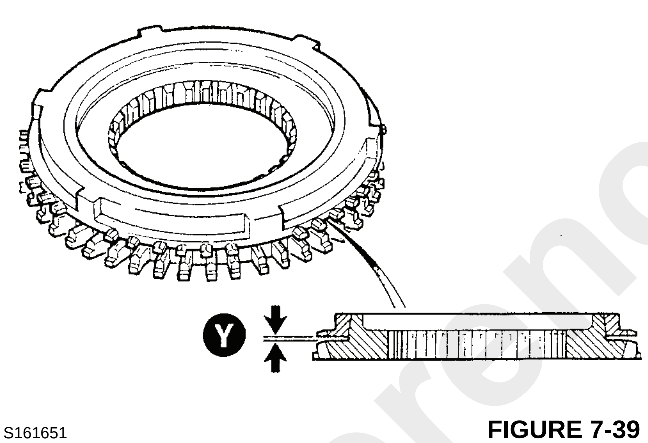


FIGURE 7-39

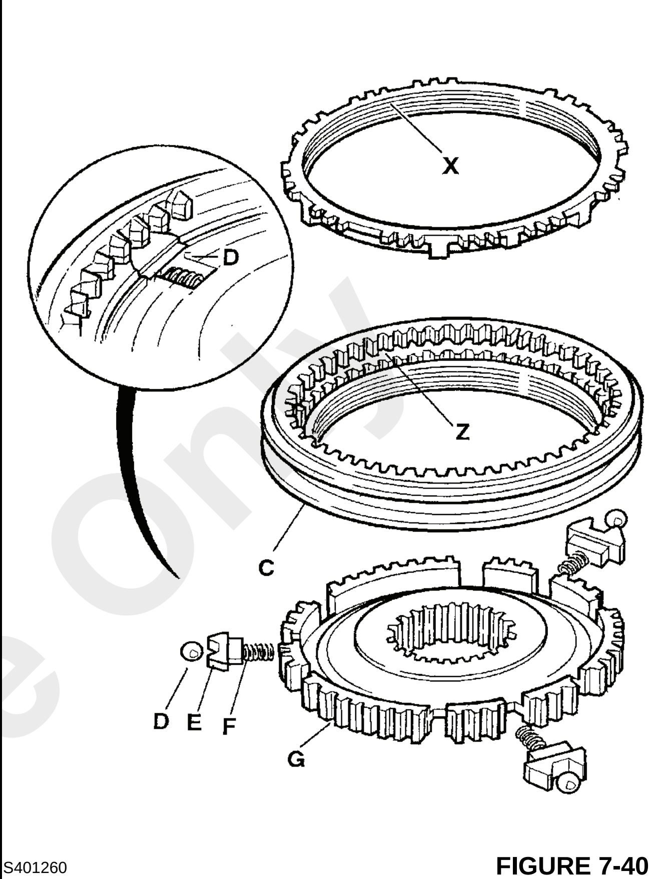


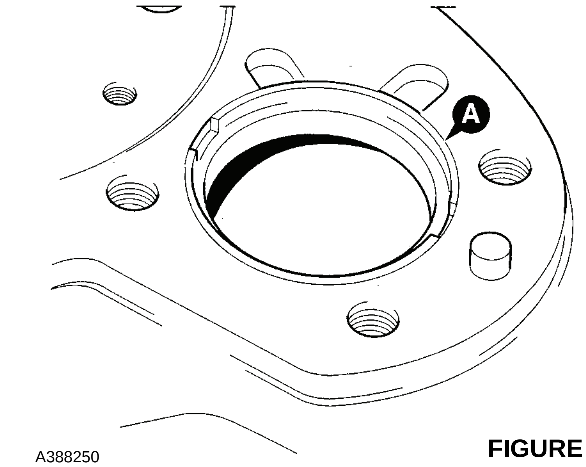
FIGURE 7-40

Assembly

Bearing Setting Rings

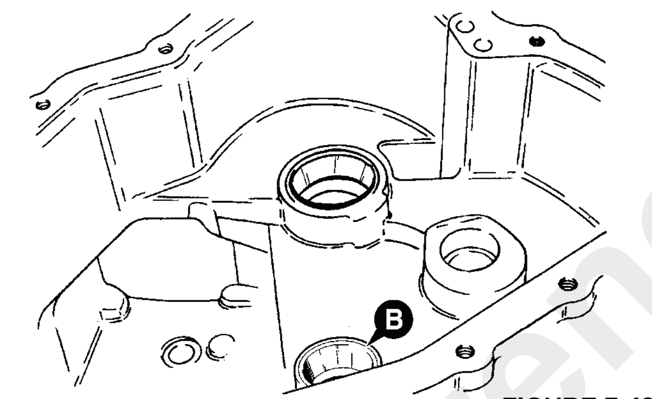
If the bearing outer cups and setting rings have been removed, fit new rings so that they are flush with the outer face of case as shown at **A** (Figure 7-41). Press in the outer bearing cups from the inside of the casing as shown at **B** (Figure 7-42). Push in the cup until it is up against the setting ring.

7



A388250

FIGURE 7-41



S407550

FIGURE 7-42

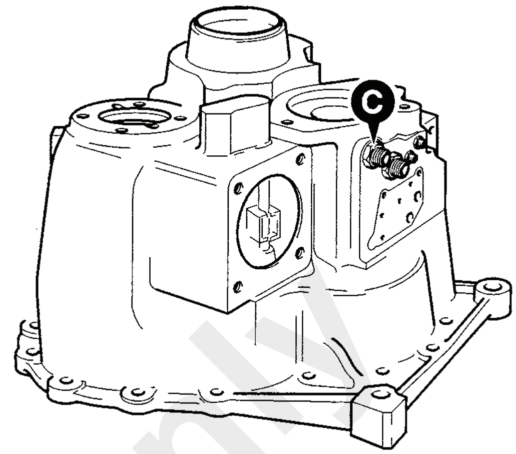
Casings

If the gearbox casings are to be renewed, be sure to fit blanking plugs and adaptors as required. Inspect the original casings and identify the blanking plug and adaptor positions. Transfer the plugs and adaptors to the new casings. Apply Loctite 242 to the threads.

Note that new plugs may be supplied with a sealant 'patch', in which case sealant need not be applied. Torque plugs to 18.4 - 20 Ib ft (25 - 28 Nm).

Before fitting adapter **C** (Figure 7-43), be sure to fit the orifice restrictor inside the port.

If the torque converter housing has been removed, temporarily replace it. The gearbox can again be positioned standing on the face of the housing ready for assembly.

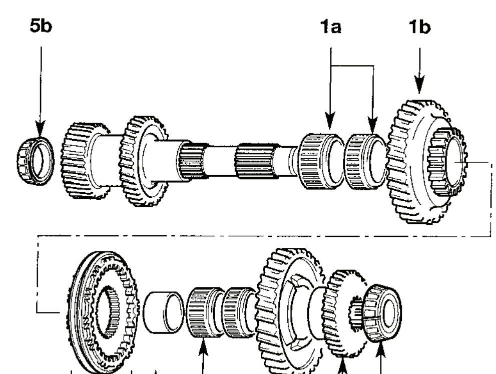


A388420

FIGURE 7-43

Layshaft

1. Smear bearing surface of shaft with Mobil HP222 Grease and fit needle roller bearings **1a** (wider bearing first), followed by 2nd gear **1b**.
2. Fit the synchro assembly **2**, then press fit the bearing track **3a**.
3. Slide 1st gear needle roller bearings **3b** over the track. Smear bearings with oil. Fit 1st gear **3c** over needle roller bearings.
4. Assemble 4WD transfer gear **4** over splines. On 2WD machines slide spacer over splines.
5. Press bearing **5a** and **5b** onto the assembled layshaft. Smear the bearings with Mobil HP222 Grease.



A395470

FIGURE 7-44

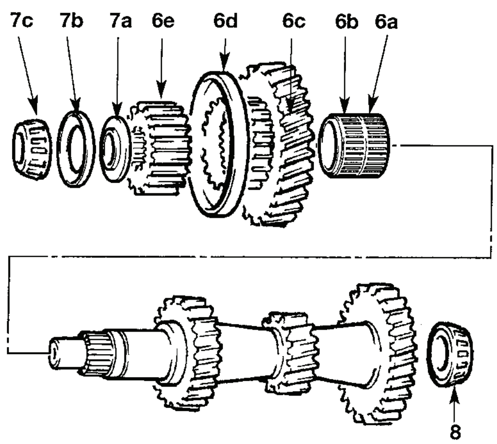
Mainshaft

6. Coat bearing surface of mainshaft with Mobil HP222 Grease. Install the needle roller bearings **6a** and **6b**

(Figure 7-45). Assemble 3rd gear **6c** and synchro-cup **6d**. Fit synchro gear **6e**.

7. Install spacer washer **7a** and oil retention washer **7b** with bevel towards bearings. Press bearing **7c** onto shaft and smear with Mobil HP222 Grease.

8. Press bearing **8** onto assembled mainshaft and coat bearing with Mobil HP222 Grease.



S388160

FIGURE 7-45

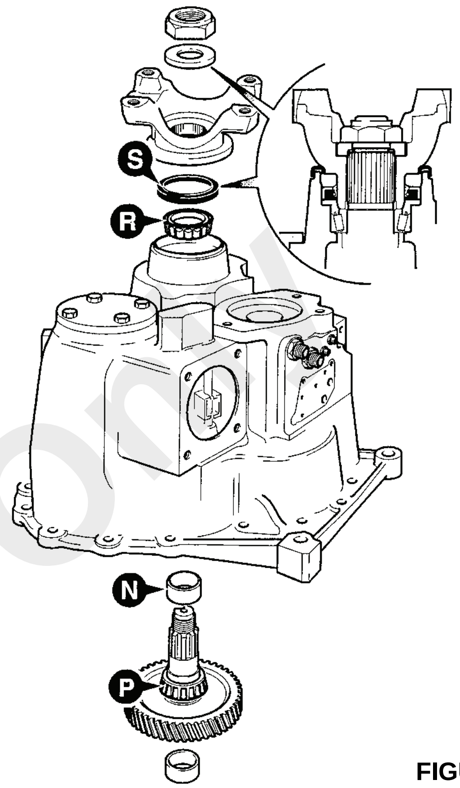
9. Transfer Gear/Output Shaft (See Figure 7-46)

NOTE: Make sure that the layshaft bearing outer cup is fitted to the rear casing before fitting the transfer gear/output shaft.

   a. Liberally coat output shaft inner bearing with Mobil HP222 Grease before fitting inner bearing **P**.

   b. Install the service solid spacer **N** 0.54 in (13.70 mm) over output shaft and assemble into casing.

   c. Lightly oil output shaft outer bearing and cup **R** and fit to output shaft, do not fit oil seal **S** at this stage



A388000

FIGURE 7-46

10. Install special tool sleeve **A** (Figure 7-47) which temporarily replaces the output yoke and secure with special tool nut **B**, torque to 36.9 lb ft (50 Nm).

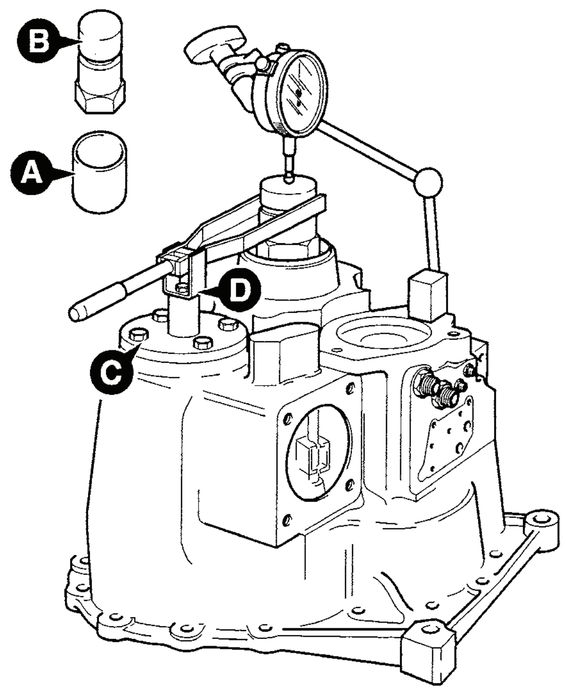
NOTE: Check for end float while tightening nut **B**, if there is no end float check:

The bearing cups are pushed fully into the casing.

The correct bearings are fitted, check parts catalogue.

The solid spacer **N** is 0.54 in.

   a. Ensure that the layshaft setting ring is slightly below layshaft cover facing on the rear case. Fit special tool support pillar **C** (892/01076) so that the fork end engages in special tool nut **B**, tighten bolt **D**.



A396650

FIGURE 7-47

11. Fit dial test indicator **E**.

a. Set torque wrench **F** to 26 lb ft (35 Nm) and measure the end float while rotating the output shaft.

b. To select the right size spacer, subtract the end float obtained at step **11b** from the solid spacer (13.70 mm). Also subtract 0.120 mm to allow for theoretical bearing tolerance and pre load. If there is no spacer of this size, fit the next smallest spacer.

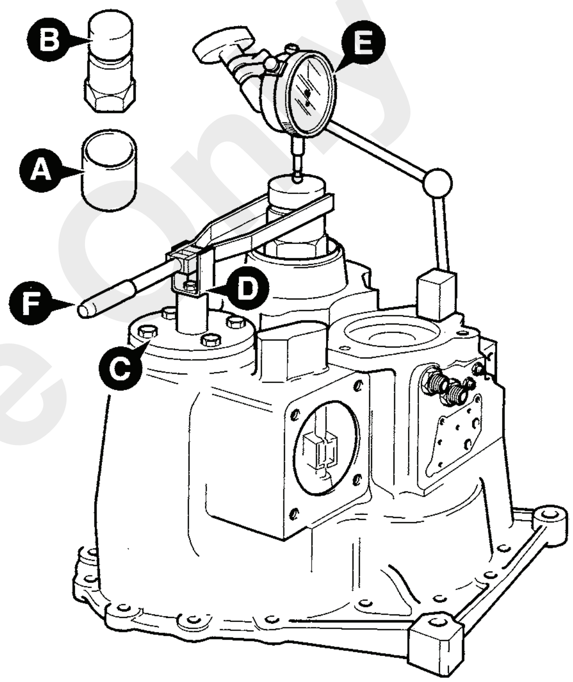
Example:

Service spacer	13.70
Subtract end float	00.41
Total	**<u>13.29</u>**
Subtract tolerance & preload	<u>00.12</u>
Result	**13.17**
Use next smallest spacer i.e.	**13.15**

c. Remove special nut **B** and sleeve **A**. Remove rear bearing and 13.70 mm spacer. Fit correct size spacer (Do no fit the oil seal at this stage). Take care to avoid damaging the outer bearing.

d. Install sleeve **A** and initially tighten nut **B** to 36.9 lb ft (50 Nm). Check there is no end float and rolling torque less than 1.0 Ib ft (1.5 Nm). If the rolling torque exceeds 1.0 Ib ft (1.5 Nm) check that the output shaft has been assembled correctly.

e. If the rolling torque measured is too high, install the next larger size spacer. If there is end float, install the next smaller size spacer.



A396650

FIGURE 7-48

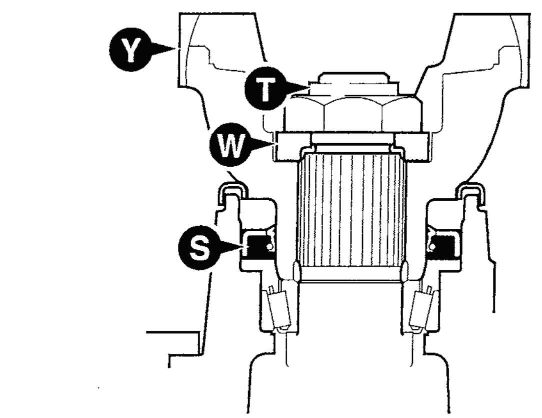
12. Remove nut **B** (Figure 7-48) and sleeve **A**. Install new oil seal **S** (Figure 7-49), grease between seal lips before fitting. Note that the seal does not fix to the back of the housing - use service tool to locate the seal. Fit the output yoke **Y**.

a. Install the stepped washer **W** the correct way with the plain face uppermost as shown.

b. Install NEW retaining nut **T** and progressively torque to 221 Ib ft (300 Nm). Provided the correct size spacer has been selected, the rolling torque should be 1.5 Ib ft (2.0 Nm) when nut **T** is fully tightened.

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, carefully stake nut **T** into slot using a square-ended staking tool.

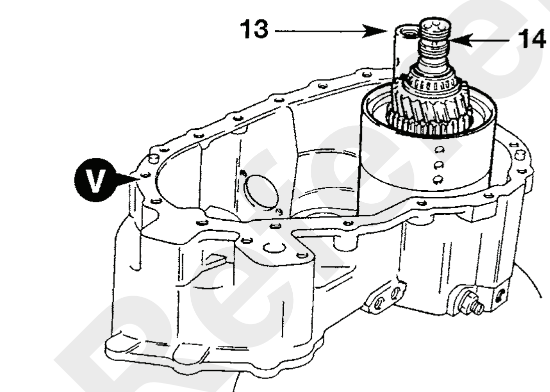


A38180 **FIGURE 7-49**

13. Press idler gear spindle **13** (Figure 7-50) into front casing.

NOTE: Before proceeding further, make sure that the **13** shaft front bearing outer cups are correctly located inside the casing **V**.

14. Grease forward/reverse shaft front bearing **14**, then carefully lower the reverser unit into casing. Install the shaft sealing rings and coat with grease. See Reverser Unit, Piston Ring Seals - Fitting Procedure.



2211800 **FIGURE 7-50**

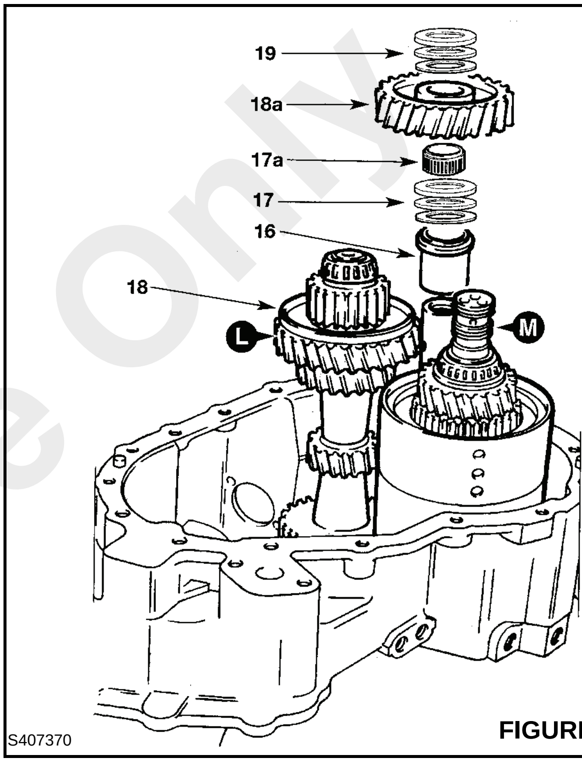
15. Coat mainshaft output end bearing with Mobil HP222 Grease and place mainshaft **L** (Figure 7-51) in position, alongside the reverser unit assembly M**.**

16. Install idler gear spacer **16**.

17. Install thrust washers and bearing assembly **17**. Lubricate and fit the needle roller bearing **17a**.

18. Install synchro cone to 3rd gear **18** (mainshaft **L**). Fit the idler gear **18a** to the spindle while tilting mainshaft **L** to one side.

19. Fit thrust washers and bearing assembly **19**.



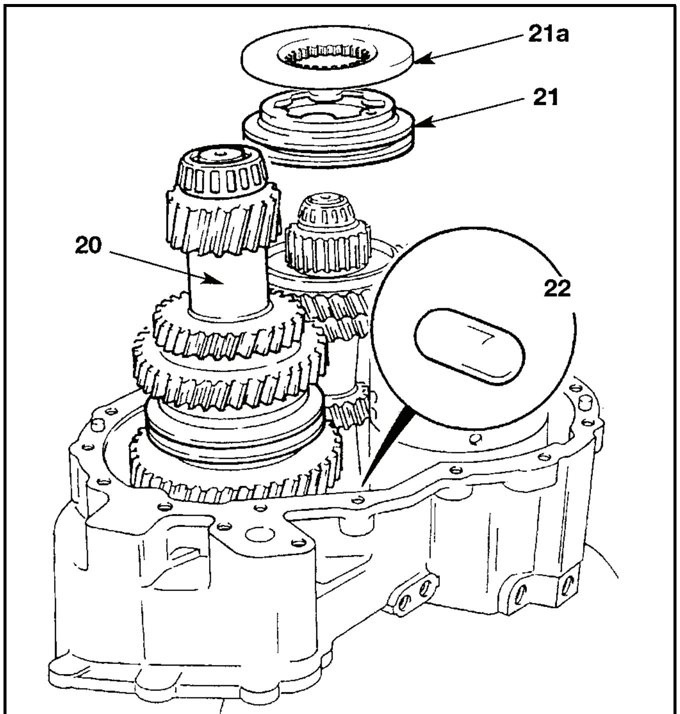
S407370 **FIGURE 7-51**

20. Coat front end bearing **20** (Figure 7-52) of layshaft with Mobil HP222 Grease, and carefully lower layshaft into position.

21. If re-using synchro assembly **21** install the parts in their original positions.

22. Using a suitable wire support locate interlock plunger **22** into its bore. A coat of grease will hold the plunger in position. If required, access is; available via a V4 BSP side drilling.

7



221090 FIGURE 7-52

23. Install selector forks **23** (Figure 7-53) into position.

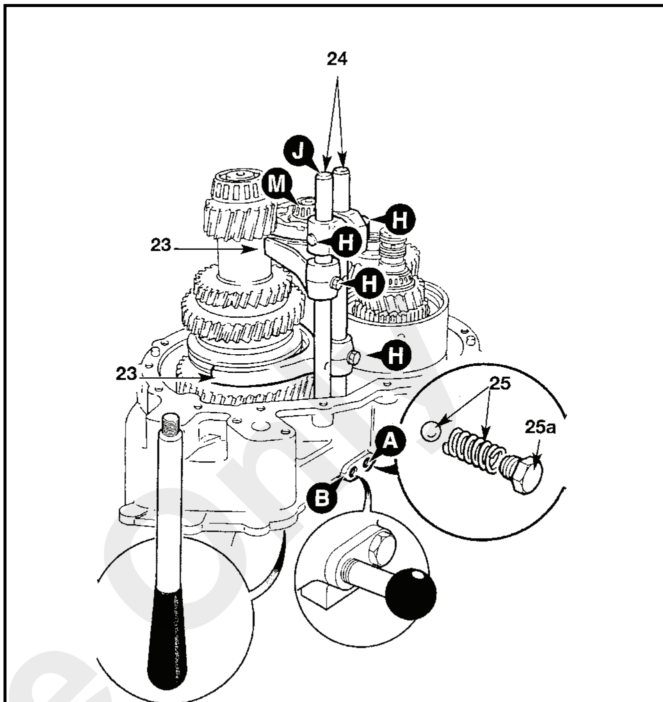
24. Slide selector rods **24** into position, taking care not to dislodge the interlock plunger. Apply Loctite 242 to selector fork retaining screws **H**, and tighten to 26 lb ft (35 Nm).

25. Install 1st gear selector detent ball and spring at position **A**. Apply Loctite 242 to the detent plug **25a**, screw in and tighten.

26. Temporarily install the 3rd and 4th gear selector detent assembly at position **B**, do not apply sealant to the plug at this time.

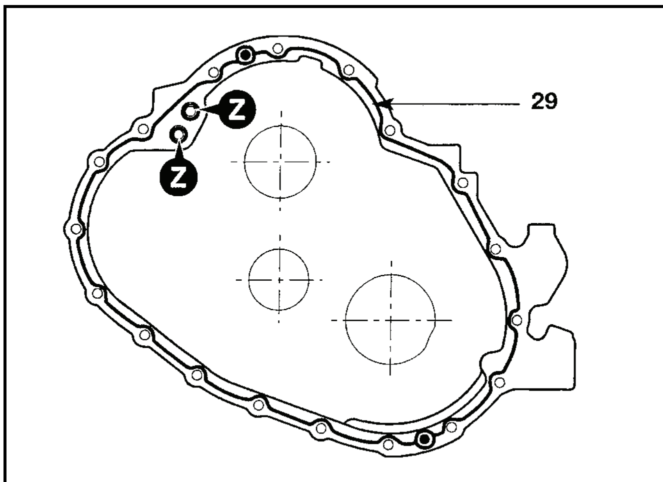
27. Check that each gear engages fully, and that the interlock plunger prevents simultaneous engagement of 2 ratios.

28. Remove the 3rd and 4th gear selector detent assembly from position **B**. Lift the selector rod **J** to select 4th gear. With 4th gear selected, temporarily lock the rod in position by screwing in service tool 892/01077 at **B**. Temporarily fit service tool 892/01078 to the torque converter end of mainshaft **M**. If the tool is not available a suitable M8 bolt approximately (4 in) long can be used.



S395500 FIGURE 7-53

29. Apply a bead of Loctite 574 Multi gasket (Figure 7-54) to mating face of casing. Insert O-rings. Smear grease onto forward/reverse shaft ring seals, and apply Mobil HP222 Grease to bearings prior to fitting the output end casing.

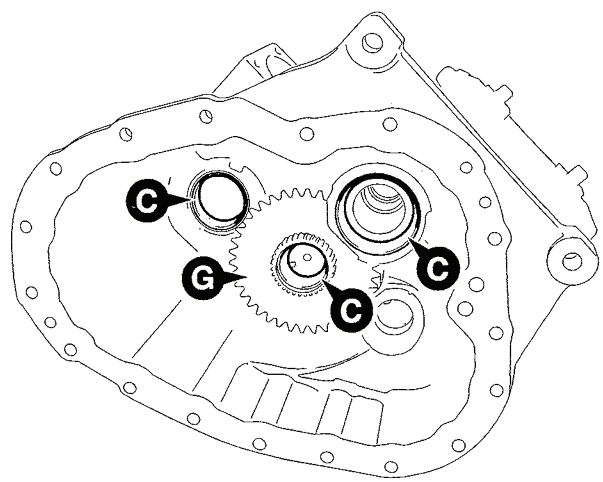


A388010 FIGURE 7-54

NOTE: Make sure that the forward/reverse shaft ring seals are in good condition before fitting the output end casing.

30. Make sure that the 3 bearing outer cups **C**, (Figure 7-55) are correctly located; note that 2 cups locate inside the casing and 1 locates in the centre of the output shaft transfer gear **G**. Carefully lower rear casing into position. Note that the reverser unit shaft engages with the casing

first, followed by 3rd/4th gear selector rod. To ensure that the mainshaft locates with the output shaft it will be necessary to push on tool **T** to keep the shaft correctly aligned. Rotate the output shaft **S** back and forth to engage the gears on the layshaft. Do not use excessive force when fitting the casing.



A395340

FIGURE 7-55

31. Apply Loctite 242 to bolts **31**, (Figure 7-56) and torque to 42 lb ft (57 Nm).

32. Remove service tool at position **B**. Install the detent ball and spring. Apply Loctite 242 to selector detent plug, install and tighten.

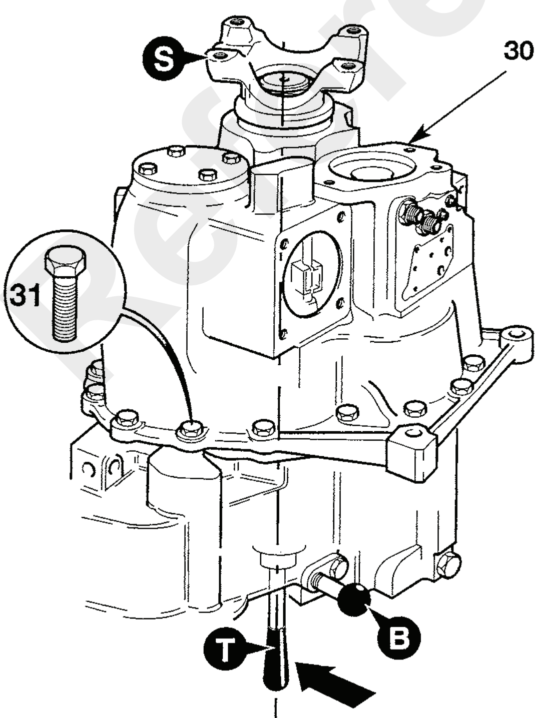


FIGURE 7-56

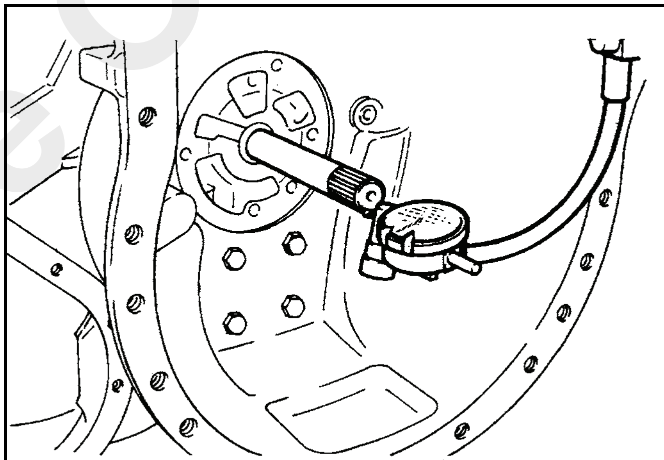
33. End Float Checking - Reverser Unit (Figure 7-57)

Measure end float of forward/reverse shaft which should be 0.0004 to 0.006 in (0.01 to 0.16 mm).

NOTE: Rotate shaft while measuring to seat bearings fully. Position pointer of dial test indicator (DTI) on the chamfer of the shaft, not the end face. This will ensure a constant reading is given.

The forward/reverse shaft and its associated components are manufactured using a 'Set-right' system. Provided components are assembled correctly, the end float will be within the limits given above.

If there is no float, or too much end float, separate the casings and check that the bearings inner and outer cups are fitted correctly. If the forward/reverse shaft and clutch assemblies have been dismantled check that the assembly has been carried out correctly.



s221201

FIGURE 7-57

34. End Float Setting - Mainshaft (See Figure 7-55 and Figure 7-56)

If the mainshaft, output shaft and/or associated bearings have been renewed, the shaft end float must be reset.

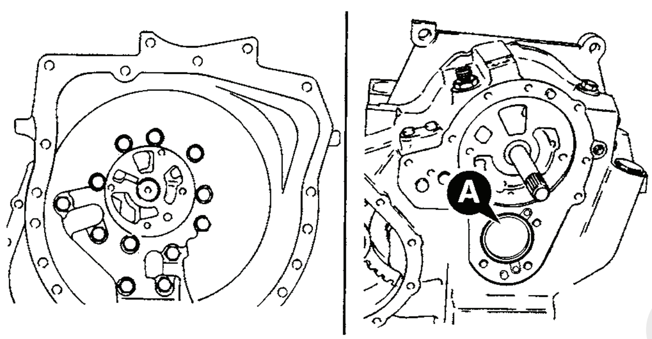
a. Remove the torque converter housing and position the gearbox to gain access to setting ring **A**.

b. Using service tool 892/01079 tighten the setting ring to 18.4 Ib ft (25 Nm) whilst at the same time rotating the shaft via the output yoke (a gear must be engaged). Do not over tighten the ring. Overtightening will damage the bearings.

c. Undo the ring a small amount to obtain a shaft end float of 0.001 to 0.003 in (0.03 to 0.08 mm). To measure the end float screw in a bolt at the threaded hole in the end of the shaft. Set up a DTI with the probe on the chamfer of the shaft. Zero the DTI. Rotate the shaft and at the same time pull up on the bolt, noting the reading on the DTI. Screw the ring in or out until the end float is correct.

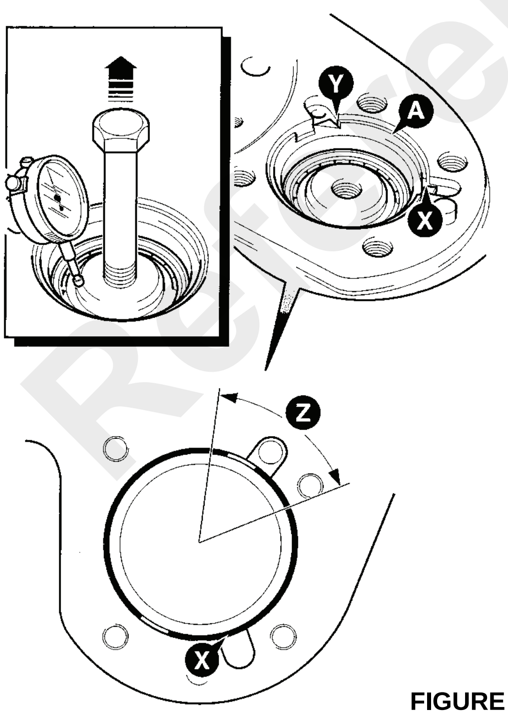
d. When the correct setting has been obtained, stake the setting ring to the casing as shown at **Y** (see the note below). Note that once staked the setting ring can not be used again. If the ring is disturbed it must be discarded and a new one used to re-set the end float.

NOTE: If the slots in the setting ring fall close (within zone **Z**) to the staking position **Y**, stake at position **X** instead. In this event the ring must also be folded on one side at position **Y**, fold on the side furthest away from the slot in the ring. This is important as the ring will otherwise restrict the flow of lubrication oil.



s338330

FIGURE 7-58



a396640

FIGURE 7-59

35. End Float Setting - Layshaft (See Figure 7-60 and Figure 7-61)

If the layshaft and/or its bearings have been renewed, the shaft end float must be reset.

a. Install the torque converter housing and stand the gearbox on the housing.

b. Tighten the setting ring **A** to 18.4 lb ft (25 Nm) while at the same time rotating the shaft via the output yoke (a gear must be engaged). Do not over tighten the ring. Overtightening will damage the bearings.

c. Loosen the ring a small amount to obtain a shaft end float of 0.001 to 0.003 in (0.03 to 0.08 mm). To measure the end float screw in a bolt at the threaded hole in the end of the shaft. Set up a DTI with the probe on the chamfer of the shaft. Zero the DTI. Rotate the shaft and at the same time pull up on the bolt, noting the reading on the DTI. Screw the ring in or out until the end float is correct.

d. When the correct setting has been obtained, stake the setting ring to the casing as shown at the two positions **Y** (see the note below). Note that once staked the setting ring can not be used again. If the ring is disturbed it must be discarded and a new one used to re-set the end float.

NOTE: If the slots in the setting ring fall close (within zone **Z**) to the staking positions **Y**, stake at position **X** instead. In this event the ring must also be folded on one side at the two positions **Y**, fold on the side furthest away from the slot in the ring. This is important as the ring will otherwise restrict the flow of lubrication oil.

e. Using a new gasket, refit the layshaft bearing cover. Apply Loctite 242 to the fixing bolts and tighten to 42 lb ft (56 Nm).

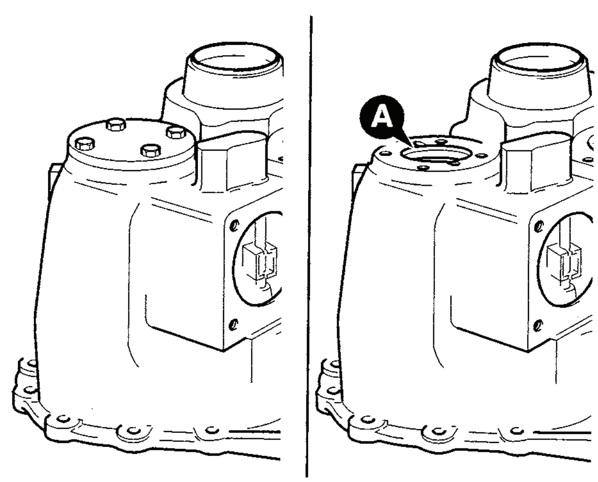
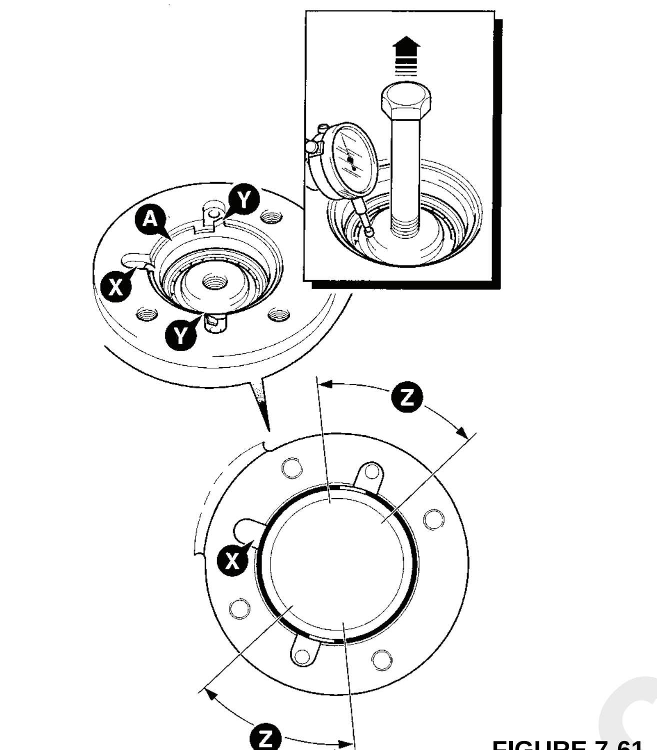
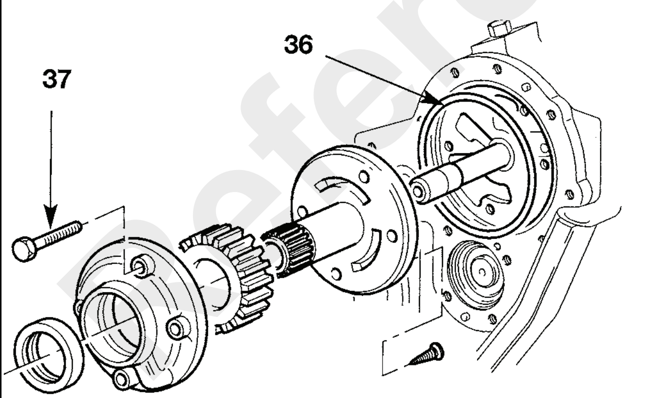


FIGURE 7-60



a396630 FIGURE 7-61

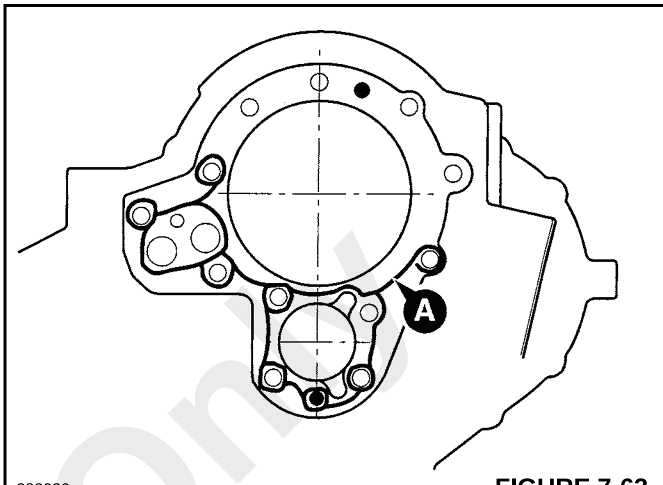
36. Place new pump sealing ring **36** (Figure 7-62) in position. Make sure that the charge pump drain hole is clear before fitting a new oil seal to the pump housing.



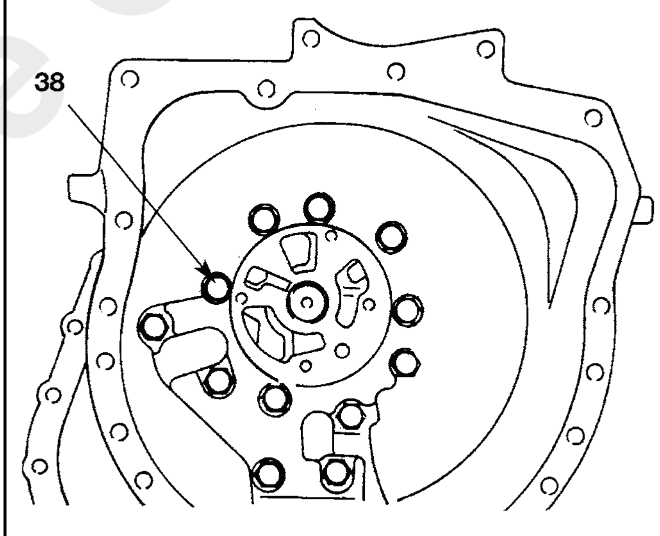
a388140 FIGURE 7-62

37. Install pump taking care to align mounting holes. Apply Loctite 242 to bolts **37** and, using new sealing washers, tighten to 31 lb ft (28 Nm) Apply a bead of Loctite 574 Multi gasket to the mating face of the gearbox cover as shown at **A**. Refit the torque converter housing. Apply Loctite 242 to the 12 bolts and tighten to 42 lb ft (56 Nm).

38. Apply a bead of Loctite 574 Multi gasket to the mating face of the gearbox cover as shown at **A** (Figure 7-63). Install the torque converter housing. Apply Loctite 242 to the 12 bolts and tighten to 42 lb ft (56 Nm).



a388020 FIGURE 7-63



221260 FIGURE 7-64

39. Install torque converter pressure relief valve assembly **39a** (Figure 7-65). Install the valve ball and spring. Ensure that larger diameter of spring is located securely over the spigot on the plug. Use a new sealing washer, apply Loctite 242 to the plug, then tighten. Install the torque converter pressure regulating valve assembly **39b**; Fit the spool and spring. Apply Loctite 242 to the plug, then tighten.

40. Using a new gasket **40** mount pressure maintenance valve onto casing. Apply Loctite 242 to bolts and tighten to 7.4 lb ft (10 Nm).

NOTE: To avoid contamination of sealant printed on gasket face keep in protective wrapper until needed.

7

41. Assemble pressure maintenance valve spool **41** and spring into adaptor block. Apply Loctite 242 to plug, fit and tighten. **Do not overtighten** as damage to the aluminium housing could result.

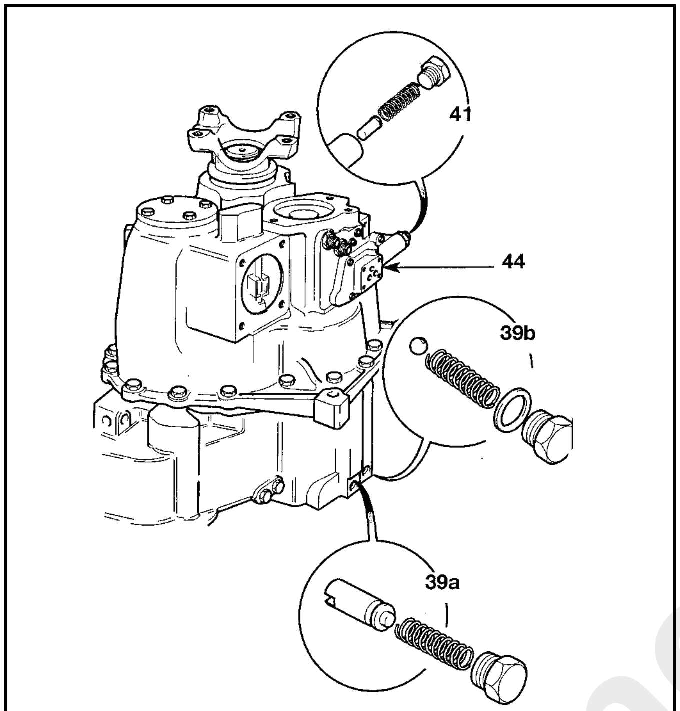


FIGURE 7-65

42. Install new O-rings around ports on mating face of solenoid valve **42**. Mount solenoid valve onto pressure maintenance valve, ensuring that port **P1** aligns with metering orifice in the pressure maintenance valve body. Apply Loctite 242 to capscrews and tighten to 3.7 lb ft (5 Nm).

43. Fit the 4-wheel drive solenoid valve. Fit the hydraulic pipe **43a**.

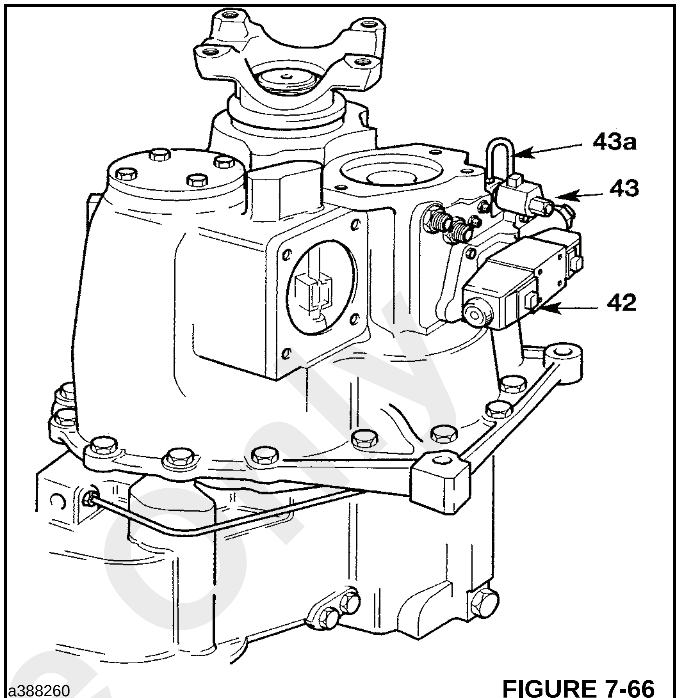


FIGURE 7-66

44. If the gear lever turret assembly has been dismantled, apply grease liberally to the working surfaces before assembling. Assembly is the reverse of the procedure detailed in Gearbox - Dismantling, Step 11, but note the following:

- **a.** Be sure to locate the slots in the levers **A** (Figure 7-67) with the pegs **B** in the housing **E**.
- **b.** After fitting spring **C**, rotate it so that the end of the bottom coil butts with the spigot **D** in the housing **E**.

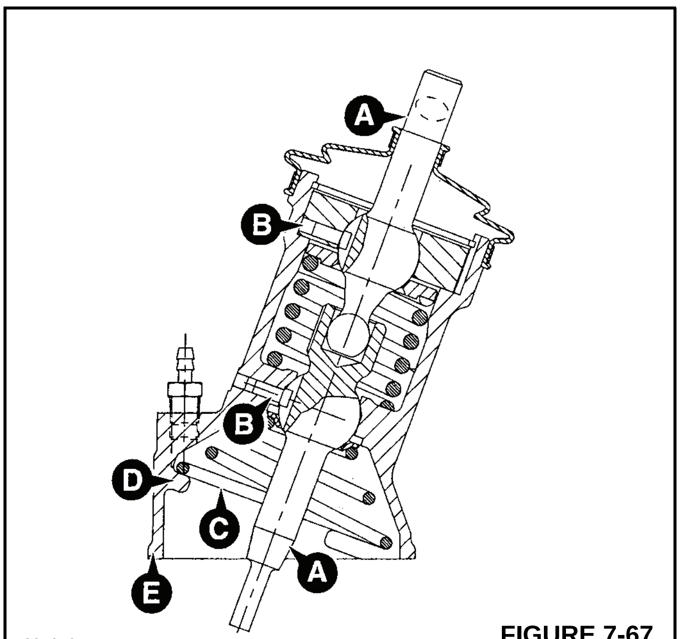
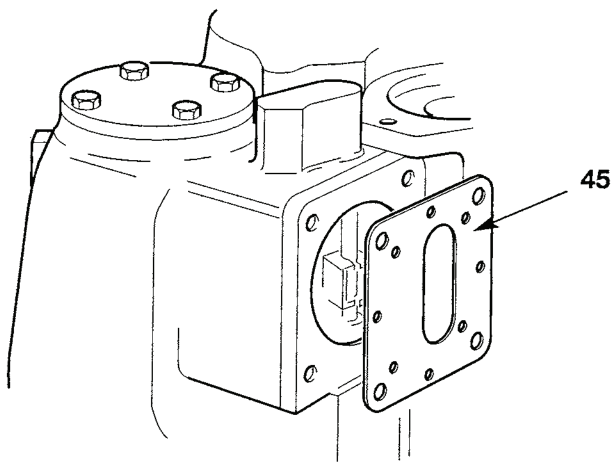


FIGURE 7-67

45. Locate a new gasket (not shown) on the casing followed by the gear lever turret baffle plate (Figure 7-68). Make sure the plate is the correct way round.



a388270 **FIGURE 7-68**

46. Locate a second gasket and then fit the turret assembly **46** (Figure 7-69). Apply Loctite 242 to mounting bolts and tighten to 42 lb ft (56 Nm). Check for gear selection.

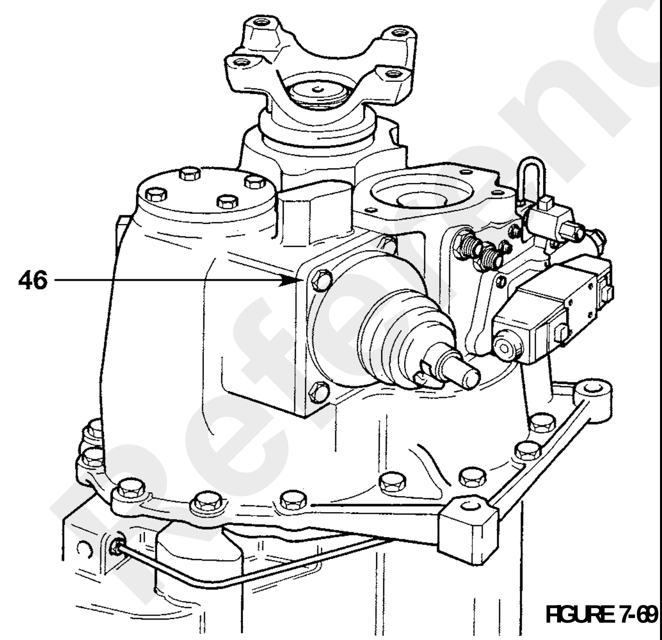


FIGURE 7-69

NOTE: It is recommended that a 75 micron (0.075mm) service suction strainer (892/00970) is fitted to clean the system after a major overhaul.

Remove the service strainer and fit a production strainer after the first 100 hours operation. Renew the oil.

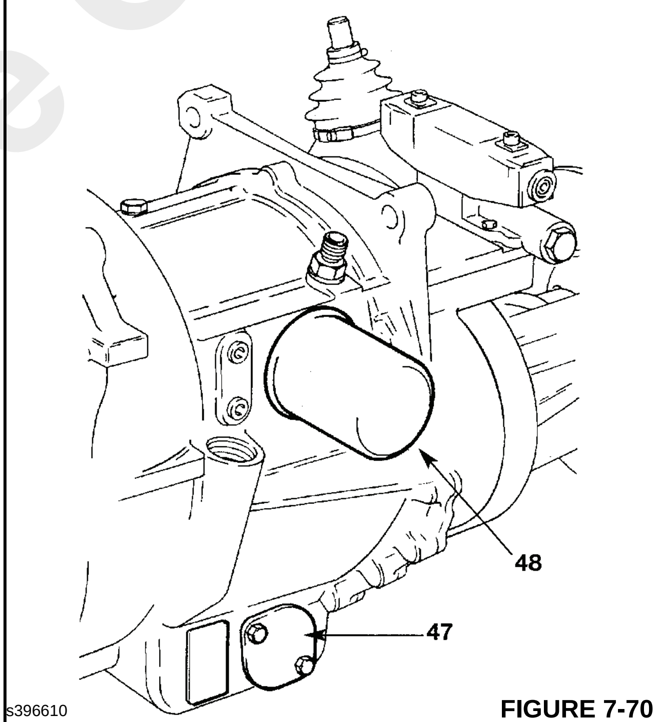
47. Using a new gasket, install suction strainer **47** (Figure 7-70). Apply Loctite 242 to bolts and tighten to 7 lb ft (10 Nm).

48. Install a new filter **48**.

49. Install dipstick/oil filler tube (not shown) as follows:

- **a.** Fit nut to tube followed by seal.
- **b.** Insert tube fully down bore in casing. Engage nut and tighten down loosely onto seal.
- **c.** Tighten nut fully after tube has been correctly phased.

See Hydraulic 2/4-Wheel Drive Unit for 4WD clutch disassembly and assembly procedures.



s396610 **FIGURE 7-70**

50. Fit a new sealing ring **50a** (Figure 7-71) to the pump drive shaft. Insert the pump drive shaft followed by bearing **50b** and circlip **50c**.

51. Carefully locate the splined shaft of the pump into the gearbox. Apply Loctite 242 to the threads of the two fixing bolts and secure the pump flange to the gearbox mounting face.

7

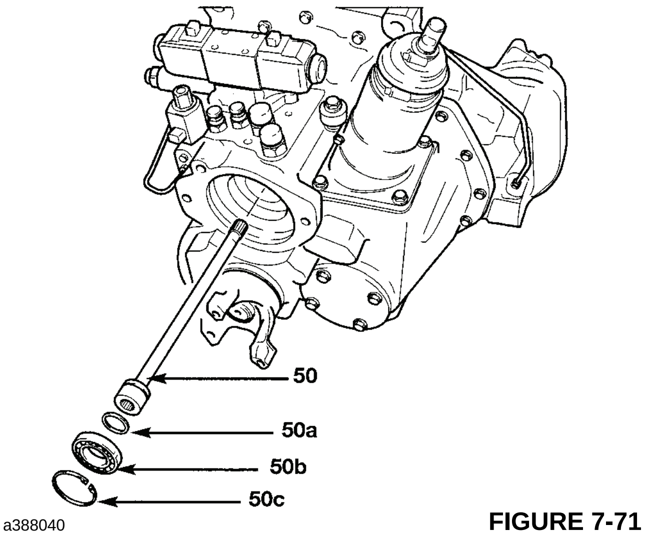


FIGURE 7-71

Solenoid Valve Disassembly and Assembly

The numerical sequence shown on the illustration is intended as a guide to dismantling.

NOTE: It is not normally recommended to remove the spool **12**, Figure 7-72 from the valve body. None of the component parts of the CETOPS valve assembly can be renewed individually. The extent of permissible servicing is cleaning and the consequential renewal of O-ring seals. If damage to any component or distortion of the spool is evident the complete valve assembly must be renewed.

Great care should be taken when disassembling and assembling the valve to avoid the following:

- Contamination
- Damage to spools
- Damage to seal grooves

Any of the above may result in possible problems with the operation of the valve.

For assembly the sequence should be reversed.

For clarity, only one solenoid has been numbered in the dismantling sequence.

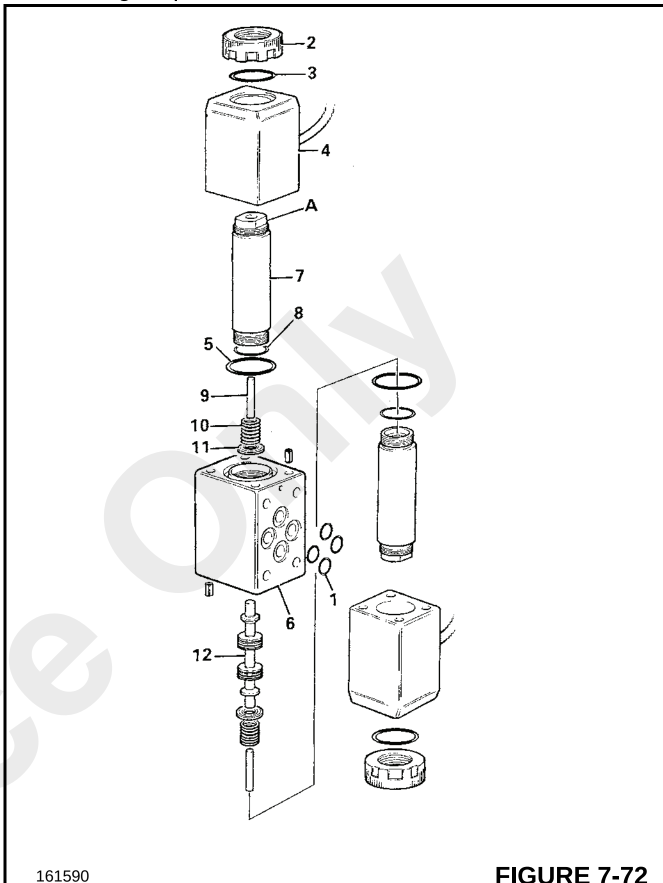


FIGURE 7-72

Dismantling

1. Remove the surface mounted O-rings **1**.
2. Unscrew the knurled nut **2** and remove O-ring **3**, withdraw the solenoid **4** and O-ring **5**.
3. Hold the solenoid valve body **6** in a vice, using the spanner flats **A**, remove spindle **7** and O-ring **8**.
4. Pull out actuating pin **9**, spring **10**, spring retainer **11** and spool **12**.
5. Dismantle the opposite solenoid in the same sequence as described above.
6. Inspect the spool and spool bore for signs of wear, nicks scratches etc**.**

Assembly

1. Renew all O-rings.
2. Lightly lubricate all parts with clean transmission fluid before assembling.
3. Check that the flying leads are secure and that the connectors are intact.

4. Apply a small quantity of Loctite 242 to the threads in the knurled nut **2** before fitting.

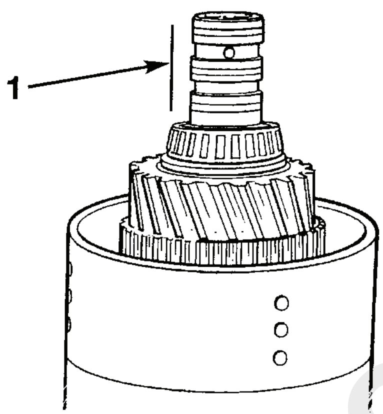
Torque Settings

Item	lb ft	Nm
2	8-10	10-15

Disassembly (Figure 7-73)

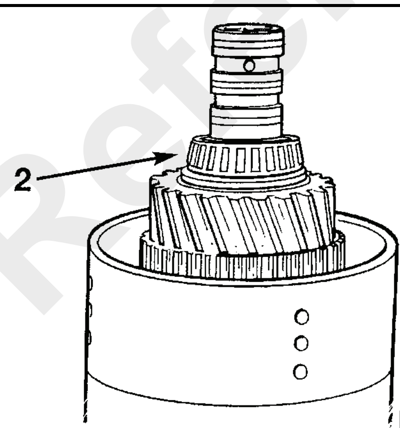
1. Carefully remove piston ring seals.

NOTE: If the piston ring seals are excessively worn then check for burrs or damage on the shaft grooves. If necessary remove burrs with a fine grade abrasion paper and oil.



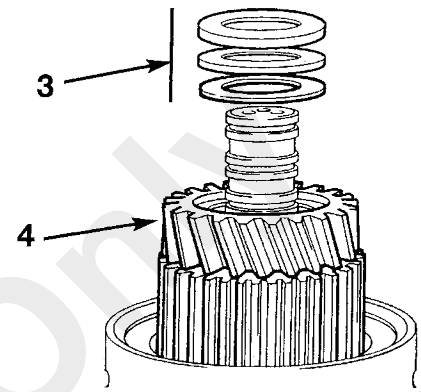
s232720 **FIGURE 7-73**

2. Remove the taper bearing (**2**, Figure 7-74) using pullers.



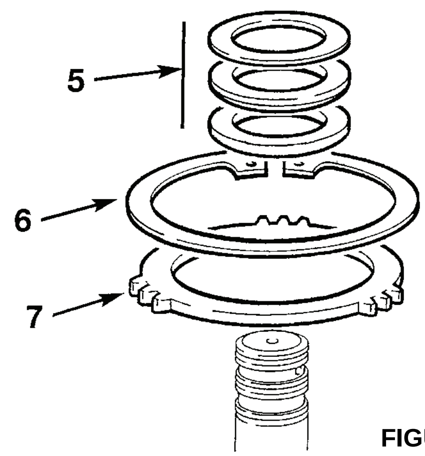
s232720 **FIGURE 7-74**

3. Remove the thrust bearing and thrust washers (**3**, Figure 7-75).
4. Withdraw the gear and splined hub assembly **4** with the needle roller bearing and spacer. Note the position of the spacer to ensure it is installed correctly on reassembly.



s407220 **FIGURE 7-75**

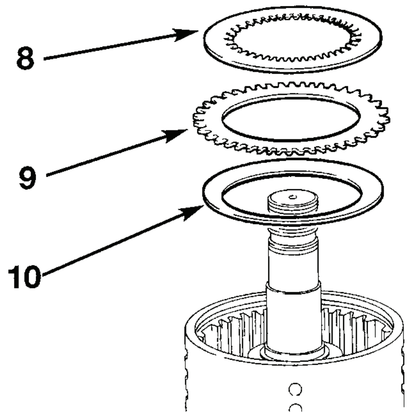
5. Remove thrust bearing and thrust washers (**5**, Figure 7-76).
6. Remove the clutch friction/counter plates retaining circlip **6**.
7. Remove pressure (end) plate **7**.



s407250 **FIGURE 7-76**

8. Remove the clutch friction/counter plates (**8**, Figure 7-77). Keep them together in sets, DO NOT mix the plates with those from other clutches.
9. Remove last counter plate **9**.
10. Remove the disc spring **10**.

7

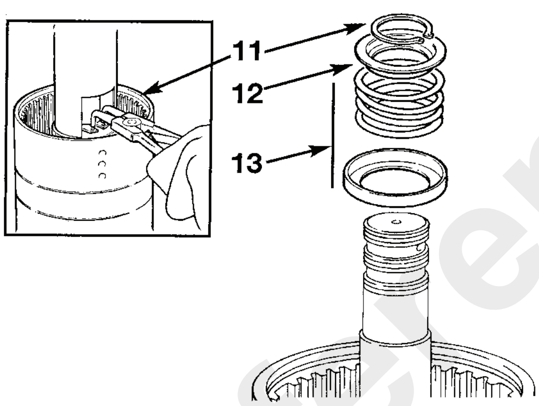


s232741 **FIGURE 7-77**

11. Position clutch assembly in press (Figure 7-78) to compress piston spring **13** then remove circlip **11**.

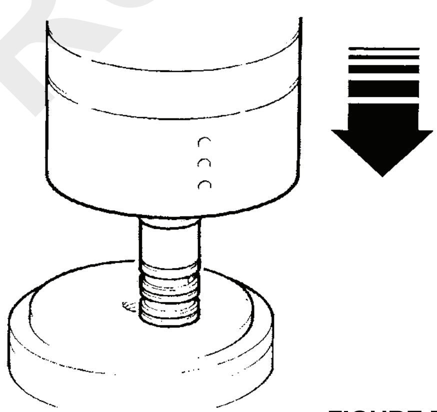
12. Lift off spring retaining plate **12**.

13. Remove spring and oil baffle **13**.



s407190 **FIGURE 7-78**

14. Knock the clutch shaft on a piece of aluminum (or wood) to remove the piston.(See Figure 7-79)

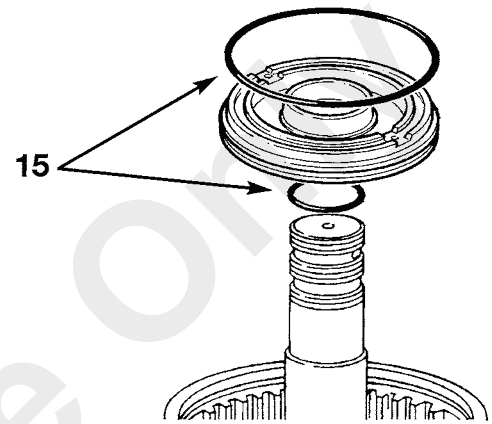


s145010 **FIGURE 7-79**

NOTE: If the piston does not loosen when the clutch shaft is knocked on aluminum, then hand pump air down the shaft oil inlet hole.

15. Remove and discard piston and shaft O-rings (Figure 7-80)

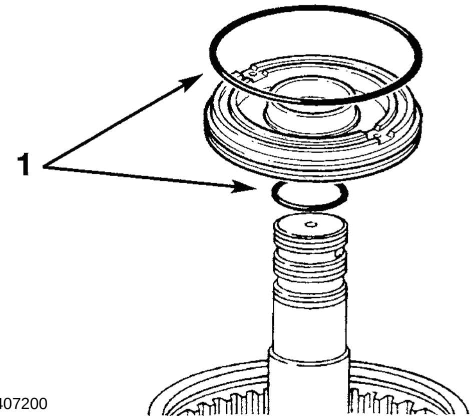
16. Repeat steps 2 thru 15 to disassemble the opposite clutch. Note that a spacer is not fitted on the opposite (Forward) clutch. Refer to step 4.



s407200 **FIGURE 7-80**

Assembly

1. Install new O-rings (**1**, Figure 7-81) onto the piston and shaft, lubricate with oil then press piston fully into bore of clutch housing.

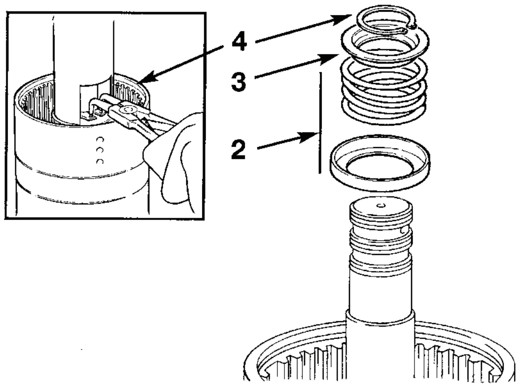


s407200 **FIGURE 7-81**

2. Install the oil baffle and piston spring (**2**, Figure 7-82), make sure the spring seats in the piston.

3. Install the spring retaining plate **3**.

4. Compress spring **2** and secure with circlip **4**.



s407190

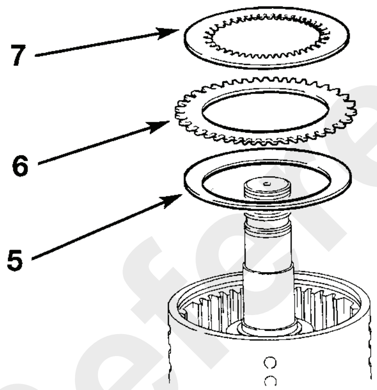
FIGURE 7-82

5. Install the disc spring assembly. (**5**, Figure 7-83). Install the assembly so that the outer diameter curves away from the clutch piston.

6. Firstly, install one counter plate **6**.

7. Install one friction plate **7** followed by one steel counter plate.

8. Continue installing alternating friction and plain steel plates, finishing with a friction plate **7**.

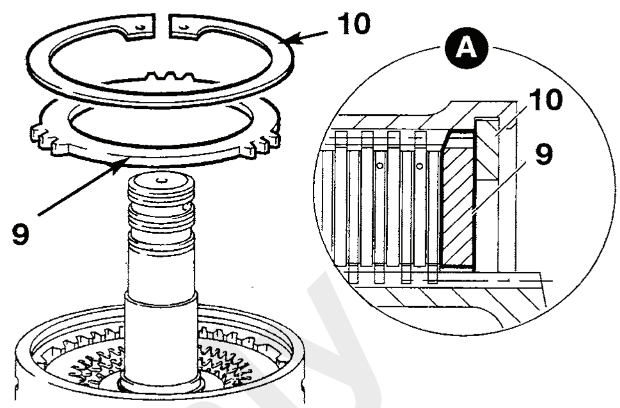


s232741

FIGURE 7-83

9. Install the pressure (end) plate (**9**, Figure 7-84). Make sure that the chamfered face is fitted facing the clutch pack as shown at **A**. Make sure that the prongs on the pressure plate DO NOT locate in the large grooves in the hub (the ones with drilled holes).

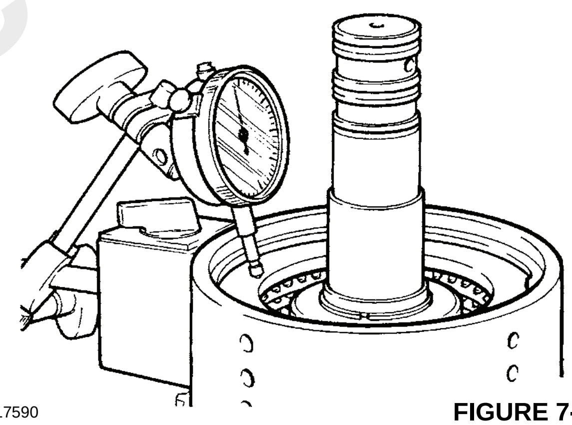
10. Install the clutch friction/counter plates retaining circlip **10**. Using an air line blow air down the shaft oil inlet hole and check the piston and clutch pack is free to operate smoothly.



A402700

FIGURE 7-84

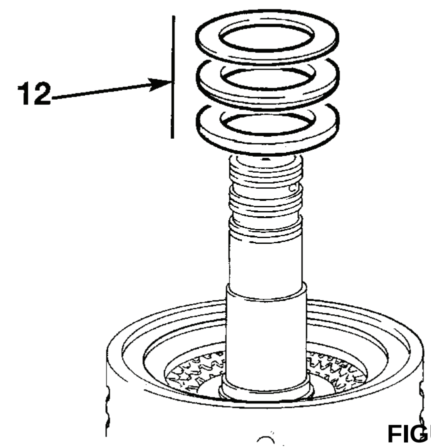
11. Using a dial test indicator, as shown (Figure 7-85), measure the end float of the pressure (end) plate, which should be 0.126 to 0.173 in (3.2 to 4.4 mm). Install shim between the retaining circlip and pressure (end) plate to correct end float inaccuracies.



S217590

FIGURE 7-85

12. Install thrust bearing and thrust washers.



S407240

FIGURE 7-86

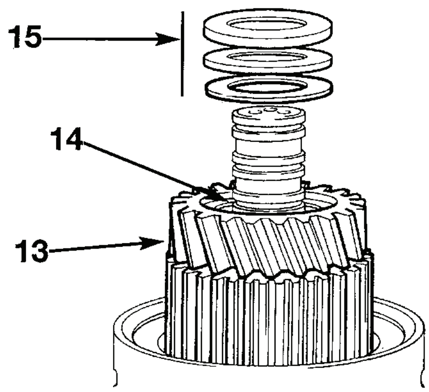
13. Install gear and splined hub assembly (**13**, Figure 7-87).

NOTE: Prior to fitting gear, align teeth of clutch plates using a thin rod (screwdriver).

14. Install the spacer **14** followed by the needle roller bearing.

NOTE: Ensure that the spacer is fitted first.

15. Install thrust bearing and thrust washers **15**.



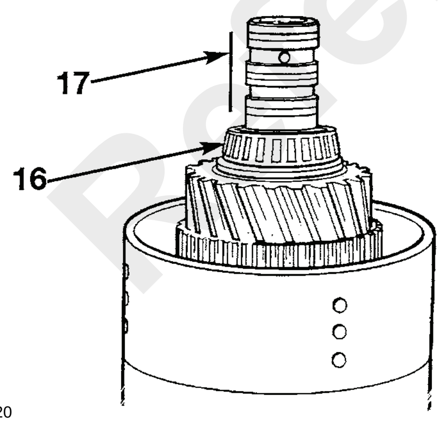
S407220

FIGURE 7-87

16. Coat the clutch end bearing (**16**, Figure 7-88) with Mobil HP222 Grease and press the bearing onto shaft.

17. Install piston ring seals **17**, refer to Piston Ring Seals - Fitting Procedure.

18. Repeat steps 1 thru 16 for the opposite clutch. Note that a spacer is not installed on the opposite (Forward) clutch. Refer to step 14.

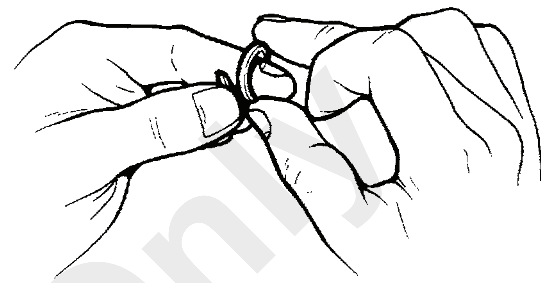


S232720

FIGURE 7-88

Piston Ring Seals - Fitting Procedure

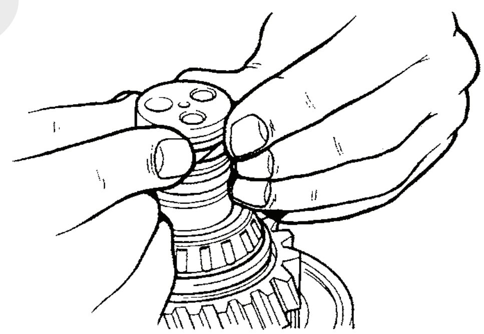
1. Wind the PTFE piston ring seal around your finger as shown (Figure 7-89), so that the seal forms a 'coil'.



157250

FIGURE 7-89

2. Coat the seal with grease and then fit the seal to the shaft. (Figure 7-90)



S152260

FIGURE 7-90

Make sure that the seal sits below or flush with the outer diameter of the shaft. If necessary, use finger pressure as shown to make the seal flush with the shaft.

CAUTION

If the seal is not set below or flush with the outer diameter of the shaft, then the seal will 'cut' when the shaft is fitted to its mating component.

Hydraulic 2/4-Wheel Drive Unit Disassembly and Assembly (Pressure ON/Spring OFF Type)

NOTE: Before disassembling the unit drain the gearbox oil. To aid working on this item, use the output yoke as a stand.

Dismantling, see Figure 7-91

1. Hold the yoke **E** using service tool 892/00812 and remove bolt **F**. Remove the yoke. Carefully remove and discard oil seal **M**. Be sure not to damage the seal housing.
2. Remove bolts **D**. Lift off the 4WD casing **P**. Lift out the 4WD unit from the gearbox.
3. Remove bearing **1**, only if to be renewed.
4. Remove seal ring **2**. Note, If the piston ring seal is damaged or excessively worn then check for burrs or damage on the shaft groove. If necessary remove burrs with a fine grade abrasion paper and oil.
5. Using a puller remove the 4WD output gear **5**, together with its bearing **3**, needle roller bearings **6** and thrust washer **4**. Remove thrust washer **7**. (Note that thrust washers **4** and **7** are not interchangeable).
6. Remove circlip **8** and shim(s) **9** if fitted. Retain any shims as a set for assembly.
7. Remove pressure plate **10**, the clutch pack friction plates **11** and counter plates **12**.

NOTE: If only the clutch pack was to be removed, the job is now complete.

8. Using a suitable press and an adaptor similar to **Y**, compress spring **15** and remove circlip **13**.
9. Remove spring retainer plate **14**, spring **15** and oil baffle **15a**.
10. Withdraw piston **16** then remove and discard O-rings **17** and **18**.

NOTE: The piston housing cannot be separated from the shaft, as on the other types of 2/4WD units.

Inspection

Perform a visual inspection of the friction and counter plates.

Counter plates - light scoring/polishing is permissible, plates that are not 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 not flat, have friction material damage or scoring must be replaced with a new set.

Do not mix old, new and worn plates.

Two different suppliers of the thinner friction plates 0.062 to 0.067 in (1.6 to 1.7 mm) approximately have been used (identified as brown or green), do not mix the different plates in the same clutch pack.

Inspect the mating faces of the gearbox and 4WD casings for damage.

Assembly

If only the clutch pack has been removed, begin at step 4.

1. Grease the shaft, fit new O-rings **17** and **18** then locate piston **16** over the shaft and into the housing.
2. Locate oil baffle **15a**, spring **15** into the piston and position the retainer plate **14** over the spring.
3. Using a press and adaptor **Y**, compress spring **15** and fit circlip **13**.
4. Build up the clutch pack, installing friction plates **11** and counter plates **12** alternately, starting with a counter plate and ending with a friction plate.
5. Install pressure plate **10**, shim(s) **9** and circlip **8**. Using an air line blow air down the shaft oil inlet hole and check the piston and clutch pack is free to operate smoothly.
6. Measure the clutch pack end float using two screwdrivers as shown at **B**. End float should be between 0.04 to 0.09 in (1.0 mm to 2.3 mm). Adjust as necessary, by adding or removing shims **9**.
7. Fit thrust washer **7**, 4WD gear **5**, needle roller bearings **6** and thrust washer **4**.
8. Press bearing **3** squarely onto the shaft to seat on thrust washer **4**, taking care not to exert any force on the housing i.e. rest the unit on the opposite shaft end, not the housing.
9. Fit new seal **2**.
10. If required, press a new bearing **1** into position, taking care not to exert any force on the housing (see Step 8).
11. Fit the 2/4WD unit to the gearbox.
12. Apply a thin bead of Loctite 574 Multi gasket to the 4WD mating face of the gearbox front case. Fit the case **P**, apply Loctite 242 to bolts **D** and progressively torque to 46 Ib ft (56 Nm).
13. The 2/4WD unit and its associated components are manufactured using a 'set-right' system. Provided that components have been assembled correctly, the shaft end float will be 0.0004 to 0.006 in (0.01 to 0.16 mm). Rotate the shaft by hand and ensure that it runs smoothly. Pull the shaft up and down to detect any excessive end float. If there is excessive end float or the shaft runts roughly, dismantle the unit and check for correct assembly.

7

14. Fit a new oil seal **M**, fit the output yoke **E**, and flanged bolt **F**. Torque the bolt to 291 lb ft (395 Nm).

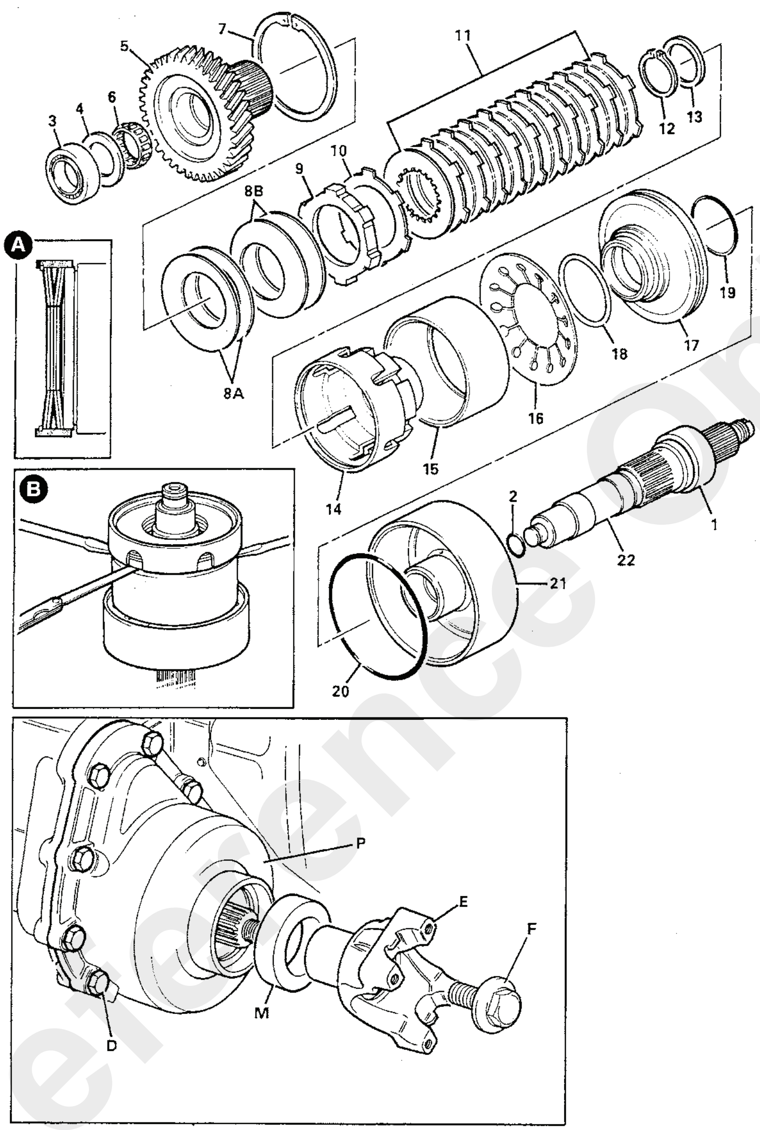


FIGURE 7-91

Hydraulic 2/4-Wheel Drive Unit Disassembly and Assembly (Spring ON/Pressure OFF Type)

NOTE: Before disassembling the unit drain the gearbox oil.

Disassembly, see Figure 7-92

1. Hold the yoke **E** and remove bolt **F**. Remove the yoke. Carefully remove and discard oil seal **M**. Be sure not to damage the seal housing.
2. Remove bolts **D**. Lift off the 4WD casing **P**. Lift out the 4WD unit from the gearbox.
3. Remove bearing **1**, only if to be renewed.
4. Remove seal ring **2**.

NOTE: If the piston ring seal is damaged or excessively worn then check for burrs or damage on the shaft groove. If necessary remove burrs with a fine grade abrasion paper and oil.

5. Pull off the 4WD output gear **5**, together with its bearing **3**, needle roller bearing **6** and thrust washer **4**.
6. Using a suitable press, compress disc springs **8A**, **8B** and remove the circlip **7**.

CAUTION

There is approximately (6000 lbf) 26700 N clamping force acting on the springs.

7. Remove disc springs **8A**, **8B**, pressure plate **9**, shim(s) **10** (keep the shim(s) separate from the counter plates), and clutch pack friction plates and counter plates **11**.
8. Remove the clutch drum retaining circlip **12** and support washer **13**.
9. Remove clutch drum **14** and actuating sleeve **15**.
10. Remove disc spring **16**.
11. Remove the piston **17** and its spring steel ring **18**.
12. Remove and discard piston O-rings **19** and **20**.
13. Remove the piston housing **21** only if necessary, the housing is a press fit on shaft **22**.

Inspection

Perform a visual inspection of the friction and counter plates.

Counter plates - light scoring/polishing is permissible, plates that are not 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 not flat, have friction material damage or scoring must be replaced with a new set.

Do not mix old, new and worn plates.

Two different suppliers of the thinner friction plates 0.062 to 0.067 in (1.6 to 1.7 mm) approximately have been used (identified as brown or green), do not mix the different plates in the same clutch pack.

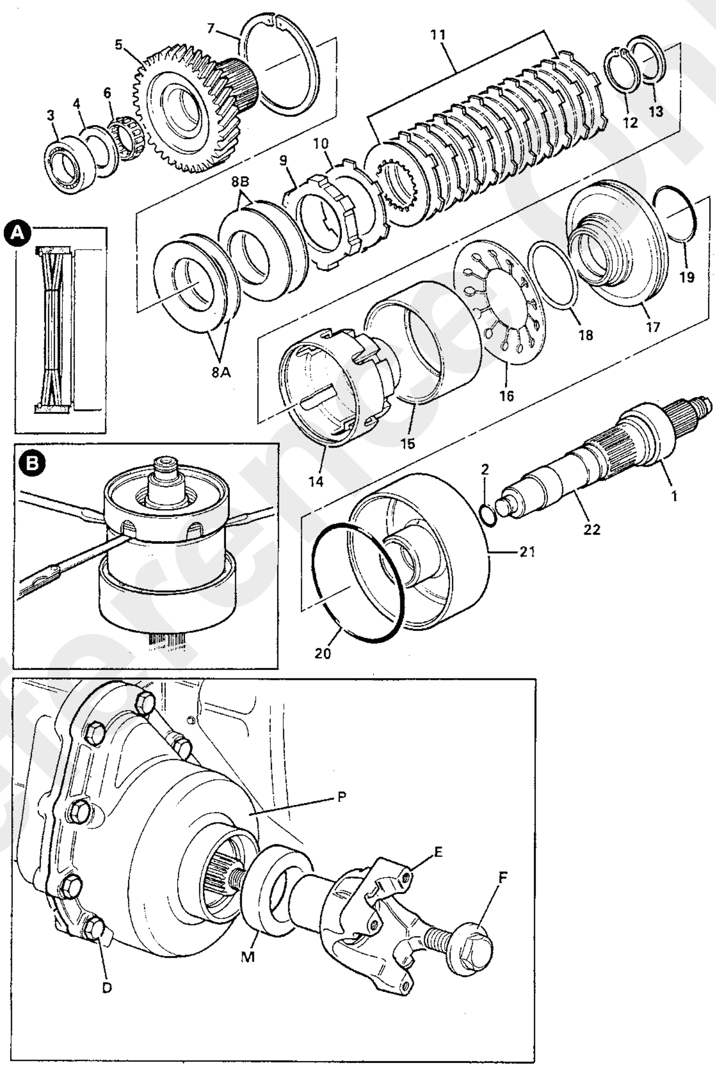
Assembly

NOTE: Use the pressure test adaptor and clamp assembly (see Service tools, Section 1) to 'bench test' the clutch. Bench testing will ensure the clutch operates correctly prior to re-assembling and installing in the machine. Refer to Pressure Testing.

1. Grease the shaft **22** then install the piston housing **21** by pressing the shaft squarely into the housing (make sure the housing is securely supported on the centre boss).
2. Install new O-rings **19** and **20** to piston **17**, locate the piston into housing **21**. Install spring steel ring **18** ensuring that it seats firmly in its groove.
3. Place the disc spring **16** into the housing **21**.
4. Position the actuating sleeve **15** onto the disc spring **16**.
5. Install the clutch drum **14** in the housing. Install support washer **13** and drum securing circlip **12**.
6. Build up the clutch pack **11**, installing friction plates and counter plates alternately, starting with a counter plate and finishing with a friction plate. Use the 4WD output gear **5** to align the clutch plate splines.
7. Install shim(s) **10** and pressure plate **9**.
8. Place the first two disc springs **8B** with their convex sides uppermost, onto the clutch pack. (There are four disc springs, which are identical). Place the other two disc springs **8A**, with their convex sides down, onto the first two - refer to inset **A**.
9. Using a suitable press, compress the disc springs **8A** and **8B**, fit circlip **7**.
10. Use levers to remove free play, as shown at **B**. Measure the gap between pressure plate **9** and actuating sleeve **15**, The gap should be 0.030 - 0.059 in (0.75 - 1.5 mm). If necessary install new shim **10** to achieve the correct gap. (Shim **10** can be a combination of a single counter plate, shim (thinner than the counter plate) or both counter plate and shim). Check that the clutch pack splines are still aligned - see step **6**.
11. Install the 4WD output gear **5** and its needle roller bearing **6**. Check the operation of the clutch using service tool 993/59300, see Pressure Testing.

7

12. Install thrust washer **4** and bearing **3**.
13. Fit sealing ring **2** and bearing **1**.
14. Fit the 2/4WD unit to the gearbox.
15. Apply a thin bead of Loctite 574 Multi gasket to the 4WD mating face of the gearbox front case. Fit the case **P**, apply Loctite 242 to bolts **D** and progressively torque to 46 lb ft (56 Nm).
16. The 2/4WD unit and its associated components are manufactured using a 'setright' system. Provided that components have been assembled correctly, the shaft end float will be 0.0004 to 0.006 in (0.01 to 0.16 mm). Rotate the shaft by hand and ensure that it runs smoothly. Pull the shaft up and down to detect any excessive end float. If there is excessive end float or the shaft runts roughly, dismantle the unit and check for correct assembly.
17. Install a new oil seal **M**, fit the output yoke **E**, and flanged bolt **F**. Torque the bolt to 291 lb ft (395 Nm).



s396880

FIGURE 7-92

Manitowoc Crane Care

Hydraulic 2/4-Wheel Drive Unit Pressure Testing (Spring ON/Pressure OFF Type)

1. Assemble the 2/4-wheel drive unit, as described in Assembly, see Figure 7-93.
2. Check the clutch pack end float and adjust as required, see Assembly.
3. Using special tool 993/59300, insert the adaptor **A** into the oil gallery in the end of the 2/4-wheel drive unit shaft as shown. Hold the adaptor in position with clamp **B**.
4. Use a hand pump to pressurize the clutch assembly until gear, item **5** can be turned by hand. Note the pressure gauge reading - DO NOT EXCEED 200 psi (13.8 bar).
5. If the pressure gauge reading is between 125 - 135 psi (8.6 - 9.3 bar) then the clutch is operating correctly and can be fitted into the gearbox.
6. If however the pressure gauge reading is above 135 psi (9.3 bar) then check the unit for assembly defects, especially the clutch pack end float (the shim may not be to the correct thickness). Re-test after checking for (and rectifying) assembly defects.

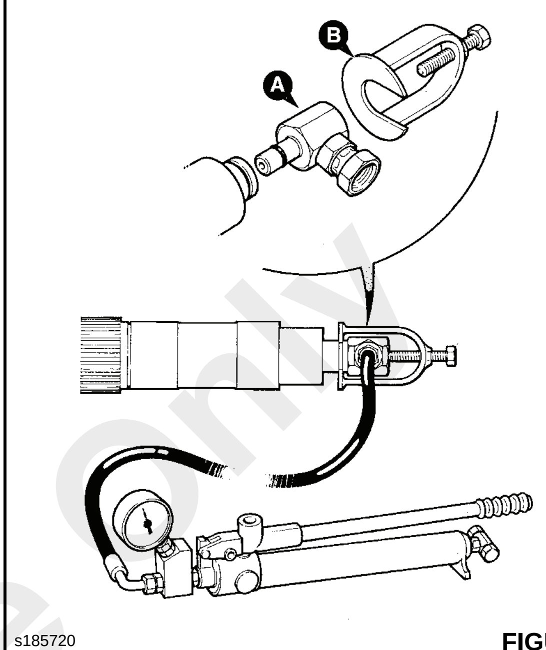


FIGURE 7-93

7

SECTION 8
AXLES/DRIVE SHAFTS/WHEELS AND TIRES

TABLE OF CONTENTS

8

THIS PAGE BLANK

SECTION 8
AXLES/DRIVE SHAFTS/WHEELS AND TIRES

DESCRIPTION

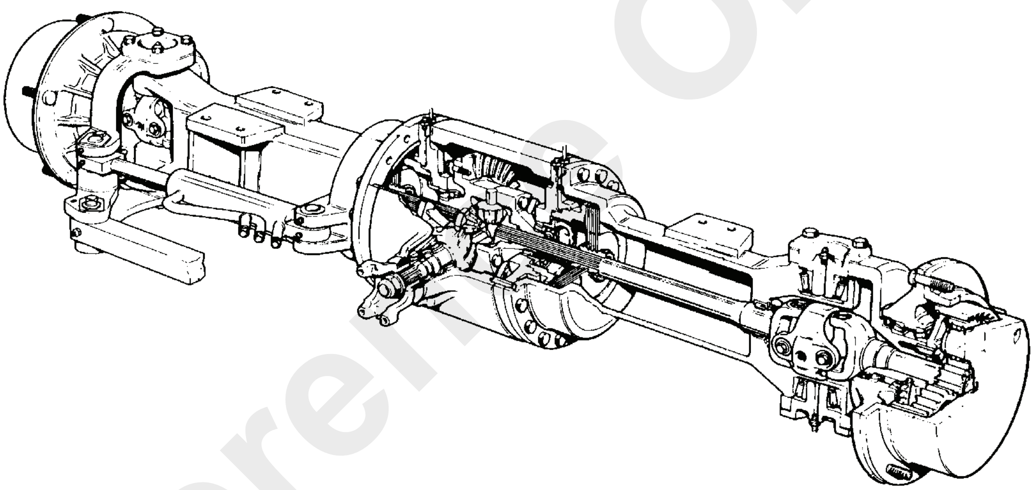
Front Axle

The front axle Figure 8-1 is a rigid-mounted drive axle, attached to the frame of the crane by eight bolts, washers and nuts. The axle includes a 3 piece spiral bevel input, two reduction drive hubs and inboard brakes.

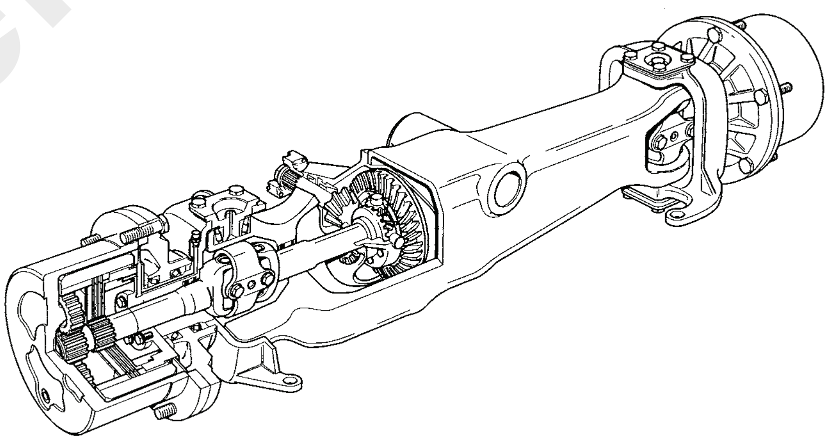
Rear Axle

The crane may be equipped with either a rear drive axle or rear non-drive axle. Figure 8-2 shows only the drive axle.

The axle is pin mounted to the frame of crane, allowing it to pivot in both directions. When the axle is equipped with axle lockouts, the axle will pivot 4° in either direction when the locks are not engaged. With oscillation locks engaged, the axle will pivot 1-1/2° in both directions. On units with no axle lockouts the axle will pivot 1-1/2° in both directions. The drive axle includes spiral bevel input, two reduction drive hubs and brakes in the drive hubs. The non-drive axle does not have a 3 piece spiral input.



F Front Drive Axle **FIGURE 8-1**



a0166 Rear Drive Axle **FIGURE 8-2**

8

TECHNICAL DATA

Front Drive Axle

Type	3piecespiralbevelinputwithepicyclichubreduction and inboard braking
Installation	Rigid pad mount
Number of steering cylinders	2
Weight (dry, with no steering cylinders and without wheels)	926 lb. (420 kg) approximate
Half (Axle) shaft braking/type	5 plate (each half shaft). Standard retraction type.
Input type	1480 half yoke
Toe-in	0°
Caster angle	0°
Camber angle	1°
King pin inclination	0°
Hub reduction	5.4:1
Overall ratio	13.7:1
Crownwheel and pinion ratio	2.538:1
Number of teeth:	
Crownwheel	33
Pinion	13

Rear Drive Axle

Type	Spiral bevel input with epicyclic hub reduction
Installation	Pin mount
Number of steering cylinders	2
Weight (dry, with no steering cylinders and without wheels)	992 lb. (450 kg) approximate
Hub brakes	3 plate (each hub) standard retraction type.
Input type	1480 half yoke
Oscillation (Both Directions)	4° (Oscillation lockouts installed but not engaged)
	1-1/2° (Oscillation lockouts installed and engaged or no axle lockouts.
Toe-in	0°
Caster angle	0°
Camber angle	1°
King pin inclination	0°
Hub reduction	5.4:1
Overall ratio	24.975:1
Crownwheel and pinion ratio	4.625:1
Number of teeth:	
Crownwheel	37
Pinion	8

Rear Non-Drive Axle

Type	Spiral bevel input with epicyclic hub reduction
Installation	Pin mount
Number of steering cylinders	2
Weight (dry, with no steering cylinders and without wheels)	931 lb. (424 kg) approximate
Hub brakes	3 plate (each hub) standard retraction type.
Input type	1480 half yoke
Oscillation (Both Directions)	4° (Oscillation lockouts not engaged) 1-1/2° (Oscillation lockouts engaged)
Toe-in	0°
Caster angle	0°
Camber angle	1°
King pin inclination	0°
Hub reduction	5.4:1

8

FRONT DRIVE AXLE REPAIR

Removal

WARNING

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

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

1. Loosen the wheel lug nuts then raise and support the machine on axle stands or blocks positioned under the chassis frame. Remove the wheels.
2. Disconnect the drive shaft from the axle by removing the eight bolts, lockwashers and nuts securing the drive shaft to the parking brake disc plate.
3. Disconnect parking brake hydraulic line from the parking brake. Plug and cap hose and fitting.
4. Disconnect and plug the hydraulic hoses to the steering cylinders.
5. Disconnect the brake lines the front axle.
6. Support the axle on a trolly jack.
7. Loosen and remove the eight mounting bolts and nuts.
8. Remove the axle from the machine.

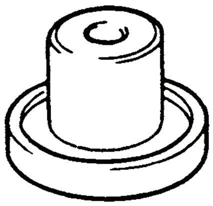
Installation

1. Place the axle on a trolly jack.
2. Position the axle and trolly jack under the machine frame.
3. Install the eight bolts and nuts with the nuts on top of the axle. Tighten the bolts to a torque of 575 lb-ft (782 Nm).
4. Connect the brake line or hose to the axle.
5. Connect the hydraulic hoses to the steering cylinder.
6. Connect the hydraulic line to the parking brake .
7. Connect the front drive shaft to the parking brake disc plate using eight bolts, lockwashers and nuts.
8. Bleed the air from both service and parking brake system. See Section 7.
9. Bleed the air from the steering circuit. See Section 8.
10. Install the wheels to the axle. Lower the machine. Torque the lug nuts to 500 lb-ft (680 Nm).

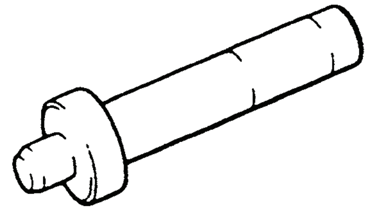
Special Tools

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

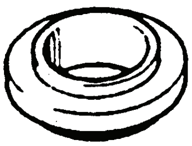
The tools illustrated on the next page are available from your Grove dealer.


a0167

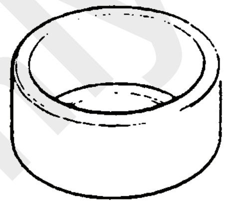
Driver - Crownwheel Bearing and Differential Bearing Cones


a0174

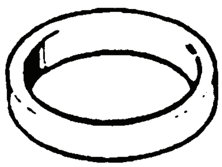
Bearing Pad Driver


a0168

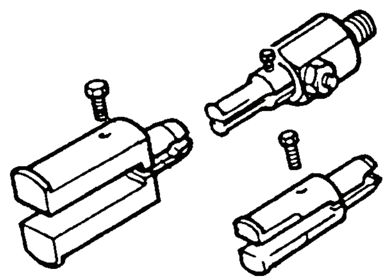
Adapter - Steer/Drive Axle Pinion Bearing Cone


a0171

Measuring Cup - Pinion Head Bearing


a0169

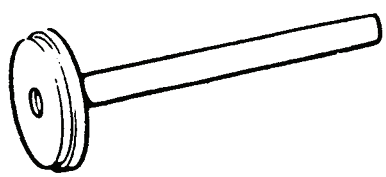
Spacer - Pinion Bearing Pre-load


a0172

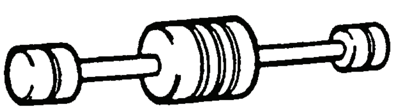
Adapter - Impulse Extractor
Small - 17 to 25 mm
Medium - 25 to 45 mm
Large 45 to 80 mm


ı0173

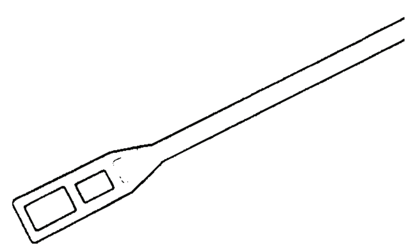
17 mm A/F x 3/4 in. square drive


a0175

Driver - Pinion Head Bearing Cup


a0179

Impulse Extractor Set for Hub Bearing Seals


a0180

Drive Coupling Spanner for Axle York Couplings

FIGURE 8-3

8

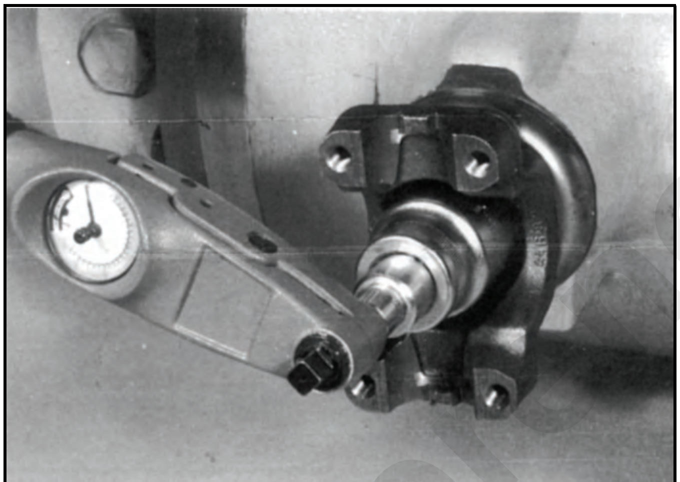
Replacing The Pinion Oil Seal

WARNING

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

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

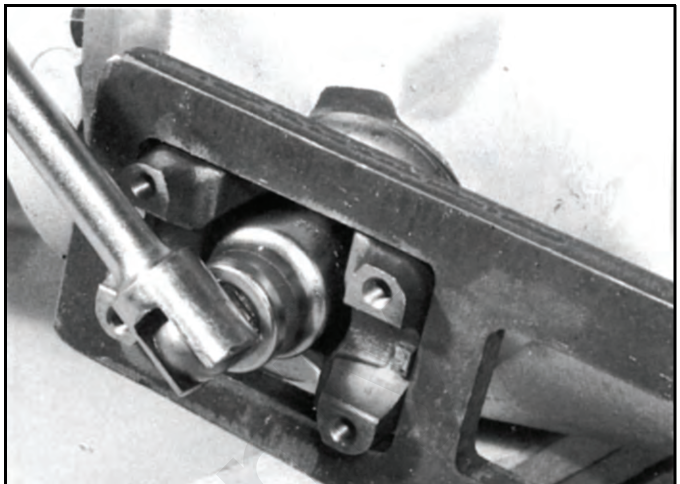
1. Remove the wheel and tires and disconnect the axle drive shaft. Measure the axle rolling torque and record the reading Figure 8-4.



p0078 **FIGURE 8-4**

2. Mark the position of the coupling yoke on the splined shaft. Using the drive coupling spanner, remove the coupling yoke Figure 8-5 together with its stake nut and washer.

NOTE: On later axles, the stake nut and washer are combined. The separate nut and washer should be discarded and replaced with the new combined nut and washer.



p0079 **FIGURE 8-5**

3. Remove the seal Figure 8-6 and install a new one. Pack the lips of the new seal with grease before installing.

p0080 **FIGURE 8-6**

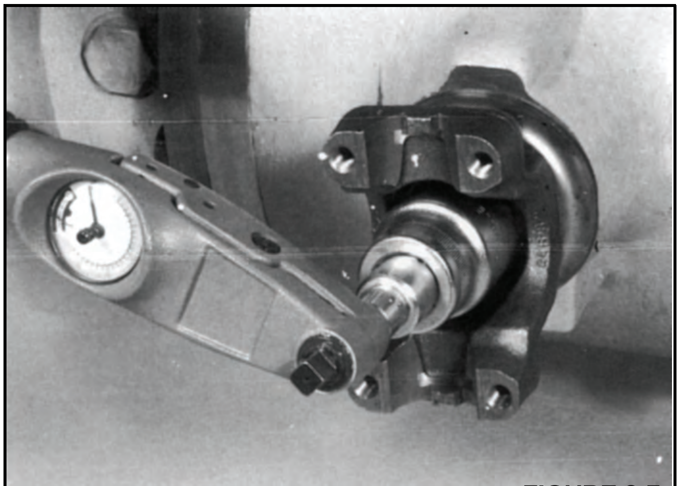
NOTE: Take care not to damage the housing when removing the old oil seal.

4. Align the locating marks on the yoke and the splined shaft. Install the coupling yoke and a new combined stake nut and washer.

5. Using the drive coupling spanner Figure 8-5, tighten the nut to a torque of 184 lb-ft (250 Nm).

6. Measure the rolling axle torque Figure 8-7. The reading should be the 0.37 to 0.74 lb-ft (0.5 to 1 Nm) more than that recorded in Step 1.

   If necessary, progressively tighten the nut to achieve the correct rolling torque.



p0081 **FIGURE 8-7**

CAUTION

If the rolling torque value (new pinion seal installed) exceeded the reading in Step 1 by 0.74 lb-ft (1 Nm) or more, then the collapsible spacer mounted on the axle pinion MUST be replaced.

7. Stake the nut using a square ended staking tool.

Axle Hub Repair

Disassembly

NOTE: The axle does not have to be removed to disassemble the axle hub.

1. Drain the oil from the axle hub.

2. Remove screws **24** Figure 8-8.

3. Using a soft-faced mallet, tap the planet gear carrier **18** to “crack” the joint between the carrier and the bearing carrier **8**. The pry the planet gear carrier from the bearing carrier. Remove and discard O-ring **23**.

4. Remove a planet gear **19** only if it is defective. A planet gear can only be replaced as an assembly, which consists of the pinion, a bearing and two “L” shaped retaining rings. To remove a planet gear, first remove the retaining ring **4**, then pull off the planet gear.

5. The drive shaft thrust pad **17** is drilled and taped M6 for removal purposes. Remove the drive shaft thrust pad from planet gear carrier.

6. Remove the external retaining ring **22** and sun gear **20**.

7. Remove the Verbus Ripp bolts **16**. These bolts are very tight and care must be taken not to distort the bolt heads. Use as short of an extension as possible. Discard the Verbus Ripp bolts.

8. Using two metric bolts jack the annulus assembly **12, 13 & 14** off bearing carrier **8**.

NOTE: Be sure annulus ring position is marked for reassembly.

NOTE: Fretting between the hub swivel and annulus carrier mating surfaces might be evident. This condition is normal, do not attempt to repair.

If the hub swivel and annulus carrier are to be replaced, they must be replaced as a pair not individually.

9. Remove internal retaining ring **14** to separate the annulus ring **12** from the annulus carrier **13**.

10. Pull off bearing carrier **8** together with the outer wheel bearing cone **10** and cup **11**. Remove combination seal **9**. Remove the inner bearing cup **7** from the inboard side of the carrier.

11. Pull off inner wheel bearing **6**.

NOTE: Earlier type axles may have an o-ring and wear ring installed in place of combination seal **9**. These parts should be discarded.

12. On later units, remove and discard combination seal **9**.

13. Disconnect the track rod and steering cylinder from the axle steering knuckles.

NOTE: If the track rod is removed completely, identify R.H. and L.H. ends to ensure correct assembly.

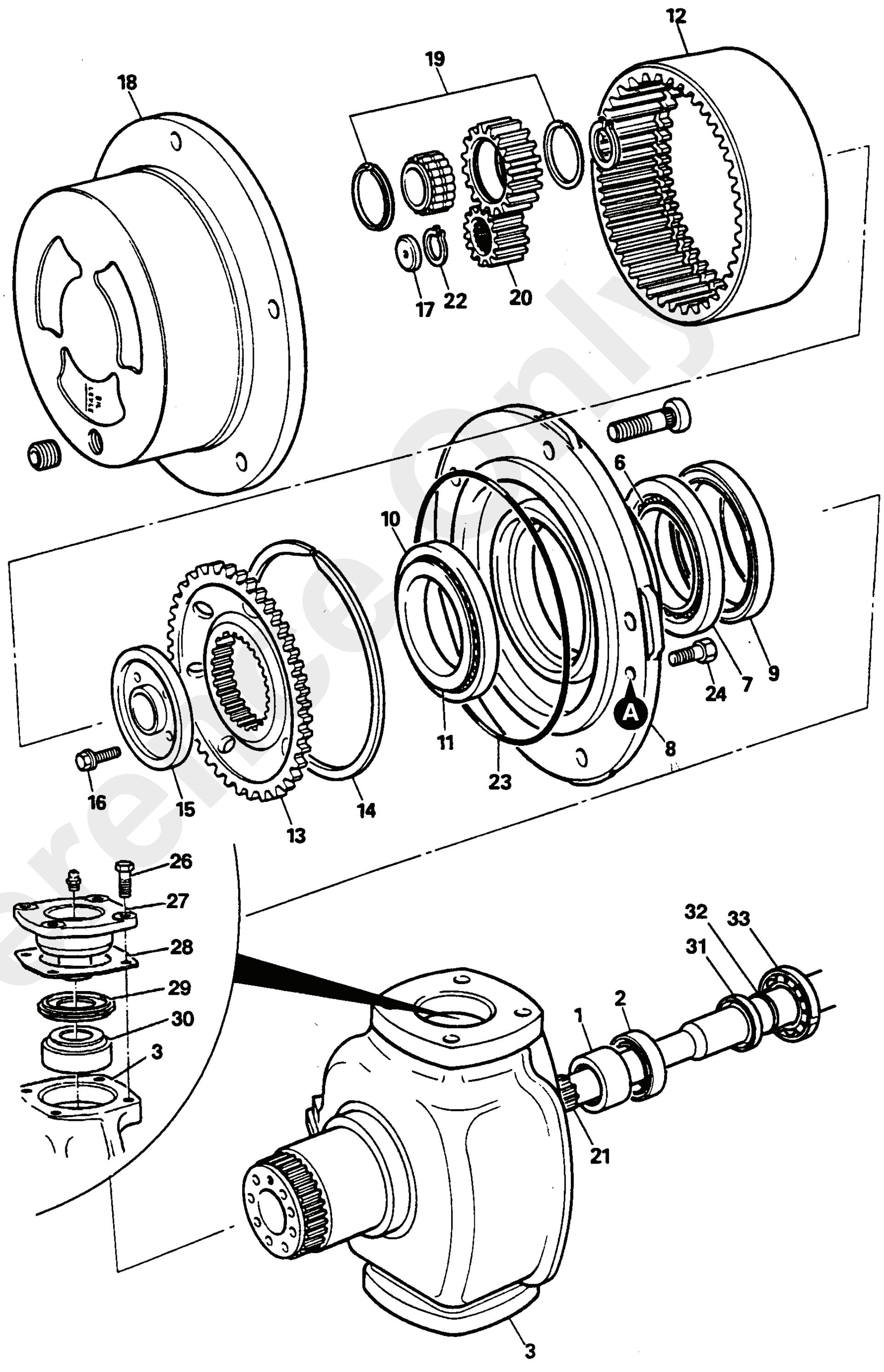
NOTE: The top and bottom trunnions are very similar (bottom trunnion not shown), the only difference being that shims **28** are installed to the top trunnion only.

14. Mark the position of the top and bottom trunnions **27**, remove bolts **26** and remove the trunnions. Retain shims **28** with top trunnion. Remove hub swivel **3**.

NOTE: Trunnions may be removed easily and without damage to the shims by pumping grease through the grease fitting.

15. Remove top and bottom trunnion seals **29** and bearings **30**.

1. Bearing
2. Oil Seal
3. Hub Swivel
4. Snap Ring
6. Wheel Bearing Cone
7. Wheel Bearing Cup
8. Bearing Carrier
9. Combination Seal
10. Wheel Bearing Cone
11. Wheel Bearing Cup
12. Annulus Ring
13. Brake Carrier
14. Retaining Ring
15. Retainer Plate
16. Verbus Ripp Bolts (4)
17. Thrust Pad
18. Planetary Gear Carrier
19. Planet Gear Assembly (3)
20. Sun Gear
21. Drive Shaft
22. Snap Ring (3)
23. O-Ring
24. Capscrew (2)
26. Trunnion Bolts (8)
27. Trunnion (2)
28. Shim
29. Seal (2)
30. Bearing (2)
31. Oil Seal
32. Retaining Ring
33. Bearing



a0181

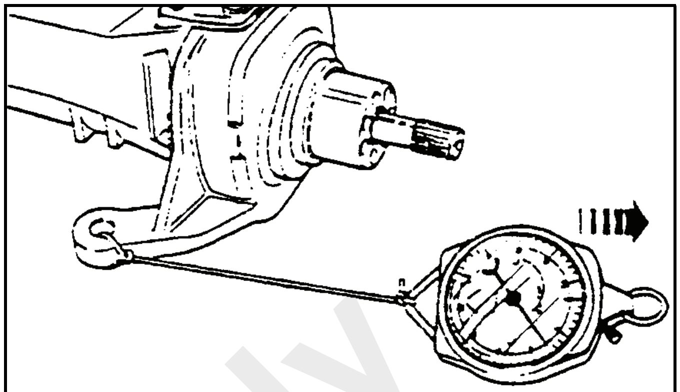
FIGURE 8-8

16. Remove drive shaft **21** from the axle casing.
17. Pry out drive shaft inner oil seal **2**.
18. Using a bearing puller, remove bearing **1**.
19. Pry out drive shaft inner seal **31B.**
20. Remove retaining ring **32**.
21. Using a bearing puller, remove bearing **33**.
22. If there has been a component failure, remove all traces of debris and clean the magnetic drain plug.

Assembly

NOTE: The top and bottom trunnions are very similar (bottom trunnion not shown), the only difference being that shims **28** are installed to the top trunnion only.

1. Tap the drive shaft inner bearing **33** Figure 8-8 into position in the hub swivel drive shaft bore. Secure with retaining ring **32**.
2. Install a new oil seal **31** Pack grease between lips of the seal.
3. Install drive shaft **21**, taking care to locate inner end into the splines of the differential gears.
4. Tap drive shaft outer bearing **1** into position in the hub swivel.
5. Install new oil seal **2**. Pack grease between the lips of the seal.
6. Press new top and bottom oil seals **29** into position followed by bearings **30**. Grease bearings and oil seal before installing in axle.
7. Locate hub swivel **3** and install bottom trunnion **27**. Apply Loctite 242 to the threads of the bottom trunnion bolts **26** and then tighten to a torque of 42 lb-ft (56 Nm). Install top trunnion **27** with normal 0.10 in. (0.25 mm) shim **28** and leave top trunnion bolts **26** finger tight).
8. Attach a spring balance Figure 8-9 to track rod swivel and turn the swivel. Tighten the top trunnion bolts **26** to eliminate end float but without bearing pre-load, i.e. no increase in spring balance reading.



a0182 **FIGURE 8-9**

9. Measure the gap at the top trunnion and subtract 1 mm (0.040 inches) to give shim thickness (bearing pre-load). For example:

   Gap = 1,55 mm (0.061 inches)

   less = 1,00 mm (0.040 inches)

   Shim = 0,55 mm (0.021 inches)

NOTE: If the gap measures 1 mm (0.040 inches), then no shim is required.

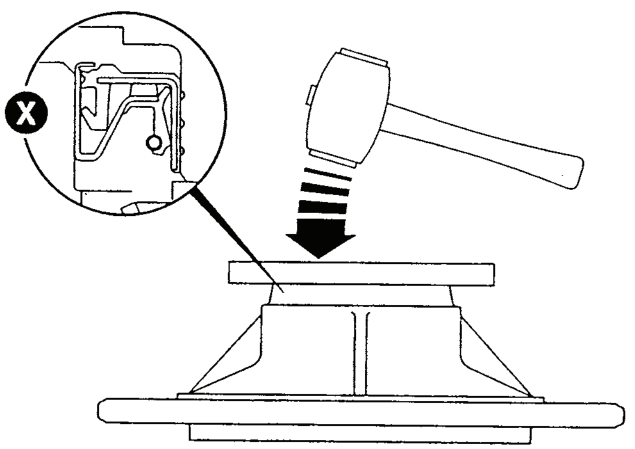
NOTE: If after installing the shims, the bearing pre-load is not attainable, install new bearings.

10. Reinstall the top trunnion. Apply Loctite 242 to the top trunnion bolt threads, install and tighten to a torque of 42 lb-ft (56 Nm).

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

11. Connect the track rod and steering cylinder to the axle steering knuckle. Tighten the track rod nut to a torque of 100 lb-ft (135 Nm), then continue to tighten to next castellation and insert the pin.
12. Lightly oil the inner wheel bearing **6** and its cup **17**. Then install them into bearing carrier **8**.
13. Install a new combination seal **9** into the bearing carrier **8**.

    Do not lubricate before installing. Drive the seal squarely into the bearing carrier **8** until the locating lip is flush, as shown in **X** Figure 8-10.



a0496 **FIGURE 8-10**

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

14. Install the cup of outer wheel bearing **10** Figure 8-8 into the bearing carrier **8**. Grease the bore of the combination seal **9** and the surface of the stub.

15. Install the bearing carrier **8** onto hub swivel **3**.

16. Lightly oil the bearing race of outer wheel bearing **11**. Install the bearing onto the axle arm. Rotate the carrier **8** (and therefore the bearing) during installation.

17. Assemble annulus ring **12** to annulus carrier **13**. Secure with retaining ring **14**.

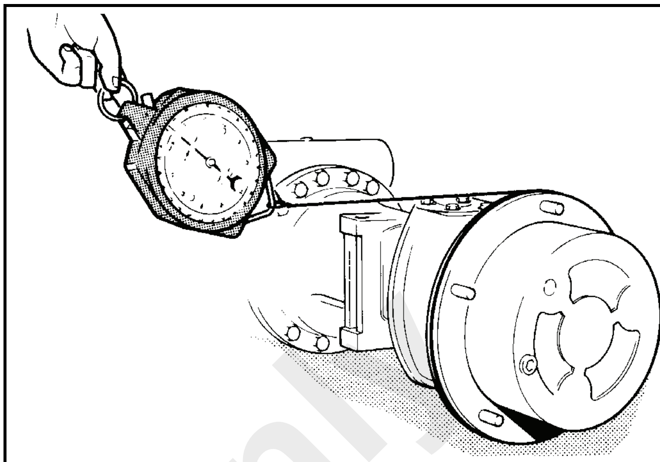
18. Install the annulus assembly in the same angular position as removal (see Note before step 9 on page 8-7) using new Verbus Ripp bolts **16**. Do not fully tighten the bolts but allow the bearing carrier to rock slightly.

CAUTION

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

19. Check the bearing carrier rolling force:

- **a.** Use a spring balance and cord wrapped around the planet carrier bolts Figure 8-11. Pull the spring balance so that the hub rotates. Do this several times to set the seal and then record the reading.
- **b.** Remove the planet gear carrier **18** Figure 8-8 and tighten the new Verbus Ripp bolts **16** to 122 lb-ft (166 Nm).



a0186 **FIGURE 8-11**

- **c.** Repeat steps 19 and 19A and record the reading.
- **d.** To get the rolling force, subtract the seal drag rolling force (Step 19 A) from reading obtained at step 19C. The result should be 3 to 34 lb. (1.4 to 15.3 kg).

  If the resulting force is outside these limits check that seal **19** is installed correctly and/or replace bearings (**6** and **11**).

NOTE: A high rolling force reading may indicate that the oil seal was damaged during installation.

20. Press the drive shaft thrust pad **17** (chamfered side down) into the recess in planet gear carrier **18**.

21. Install new planet gears **19** in place of any that were removed (see Step 4 in Disassembly). Secure with retaining ring **4** .

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

22. Slide sun gear **20** onto the drive shaft and secure with retaining ring **22**.

23. Install a new o-ring **23**.

24. Install planet gear carrier **18** onto bearing carrier **8** turning it slightly to engage the gear teeth and aligning the two tapped holes **A** Figure 8-8 in the planet gear carrier. (The tapped holes are diametrically opposite one another). Ensure that the gear carrier butts fully against the bearing carrier.

NOTE: Do not strike the center of planet gear carrier **18** when installed, as this may dislodge drive shaft thrust pad **17**.

25. Install screws **24** and tighten to a torque of 41.3 lb-ft (56 Nm).

26. Fill the axle hub with oil. See Preventative Maintenance, Chapter 5.

Drive Head Repair

The following procedures can only be carried out with the axle removed from the machine. See “Removal”, on page 8-4.

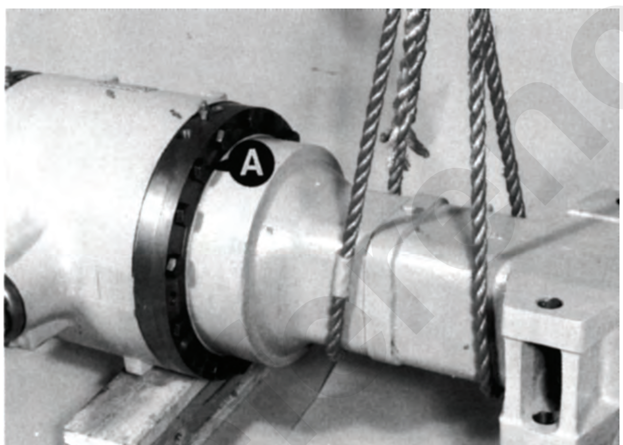
It will be necessary to provide a suitable stand to support the axle after removal.

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

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

Disassembly

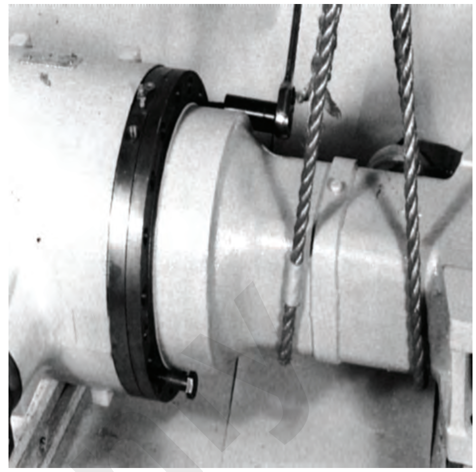
1. Before disassembling the axle, drain the oil from the axle into a suitable container.
2. Remove the steerig cylinders and track rod.
3. Remove both axle arms.
   a. Support the axle arm and remove bolts **A** Figure 8-12.



a0187

FIGURE 8-12

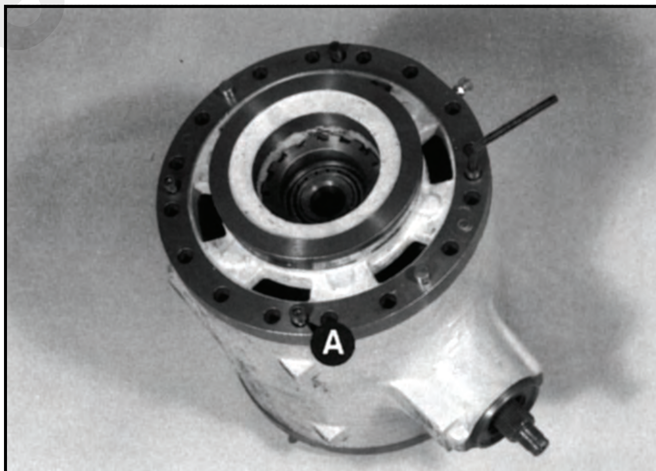
   b. Jack the axle arm off of the drive head, using the drive head securing bolts Figure 8-13. Remove all traces of gasket material from the mating surfaces.



a0188

FIGURE 8-13

4. Remove the drive shaft coupling. See Replacing the Pinion Oil Seal on page 8-6.
5. Position the drive head as shown in Figure 8-14, with the crownwheel at the top. Remove capscrews **A**.

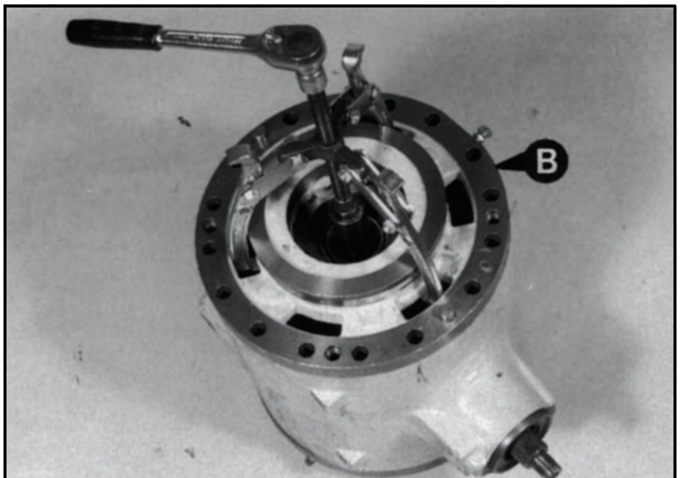


a0189

FIGURE 8-14

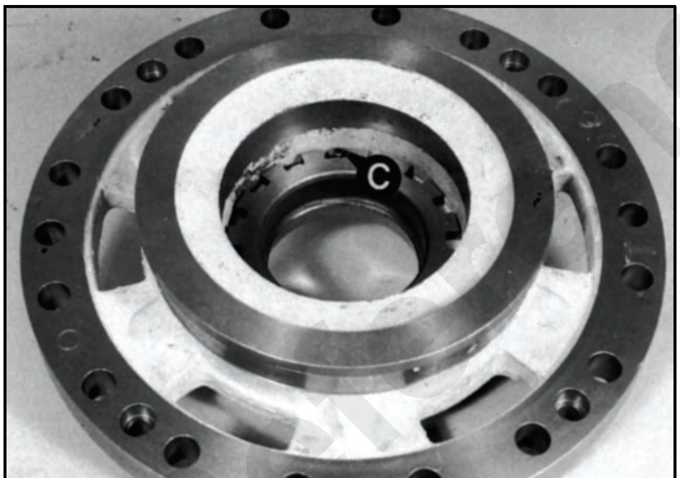
6. Match - mark the brake piston housing **B** Figure 8-15 and the drive head. Pull off the brake piston housing.

8



a0190 **FIGURE 8-15**

7. Drive out the differential side nut locking pin **C** Figure 8-16, to allow readjustment upon assembly. Remove the other brake piston housing only if damaged, but remove its locking pin **C** regardless (to allow side load adjustment upon assembly).



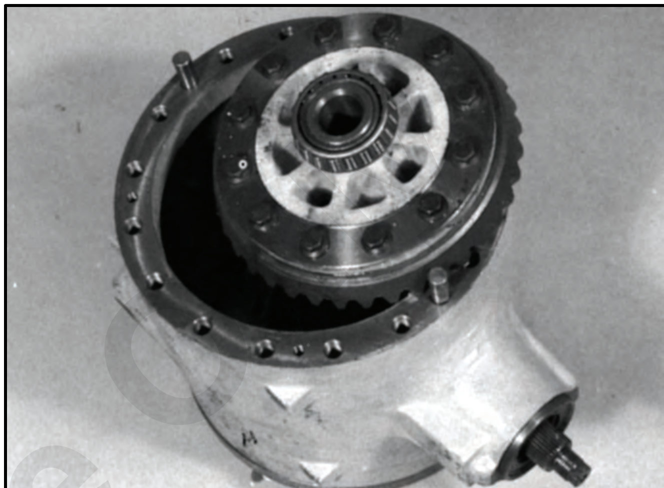
a0191 **FIGURE 8-16**

CAUTION

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

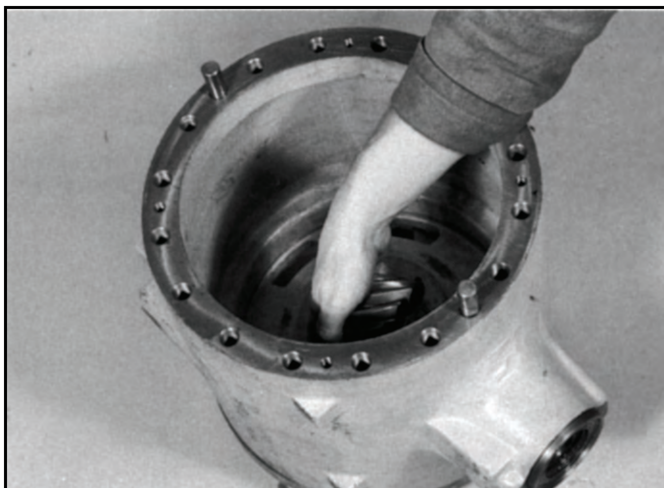
8. Lift out the crownwheel/differential assembly Figure 8-17.

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



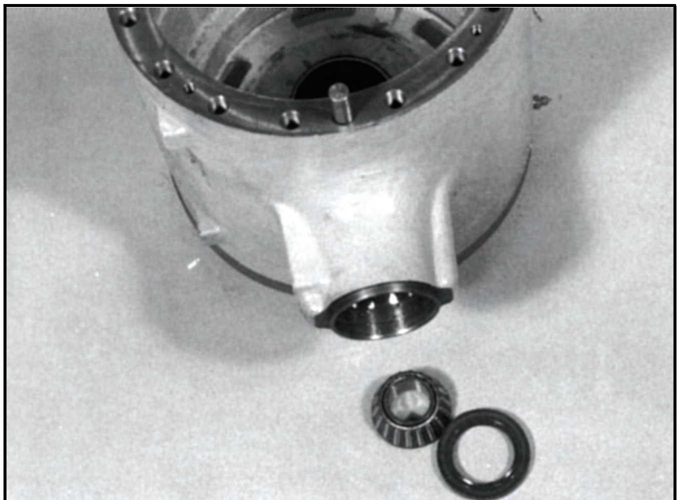
a0192 **FIGURE 8-17**

9. Using a soft hammer, hit the pinion end shaft until the piston is free from its front bearing. Remove the pinion Figure 8-18.



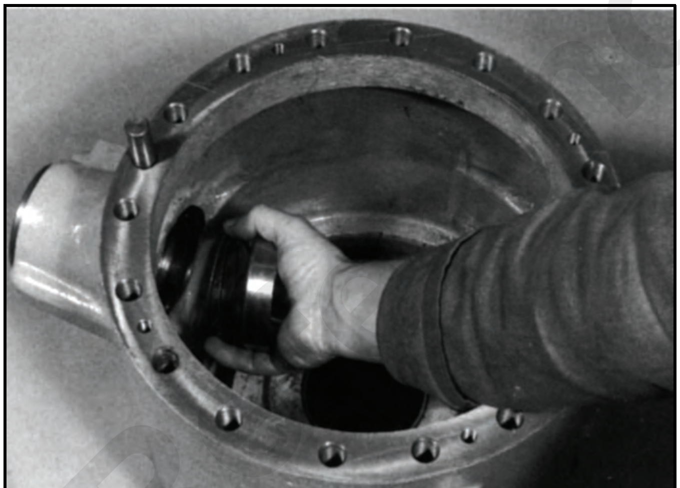
a0193 **FIGURE 8-18**

10. Remove the pinion seal and outer bearing cone Figure 8-19.



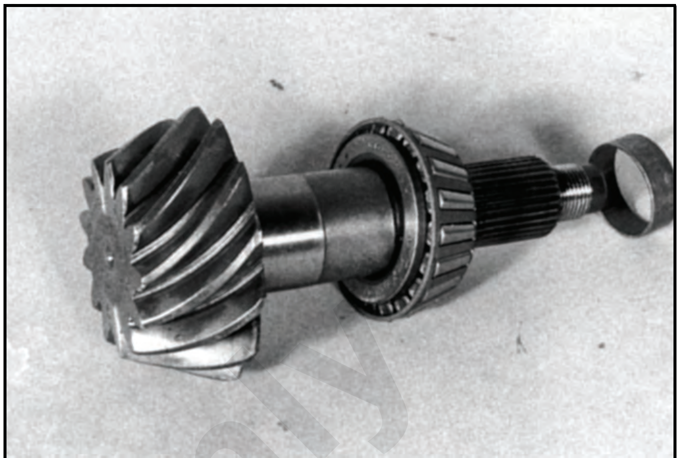
a0194 **FIGURE 8-19**

11. If necessary, drive out the pinion inner bearing cup and shims Figure 8-20. Discard the shims. Repeat for the outer bearing cup, if required. There are no shims for the outer bearing cup.



a0195 **FIGURE 8-20**

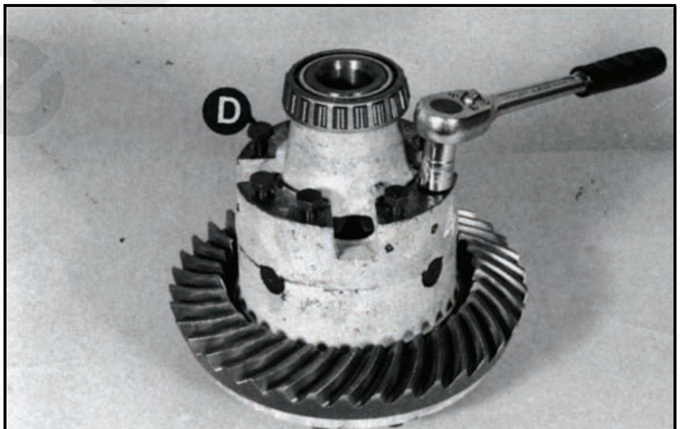
12. Remove and discard the pinion collapsible spacer Figure 8-21. Pull of the bearing cone.



a0196 **FIGURE 8-21**

13. To dismantle the differential assembly:

a. Remove bolts **D** Figure 8-22.



a0197 **FIGURE 8-22**

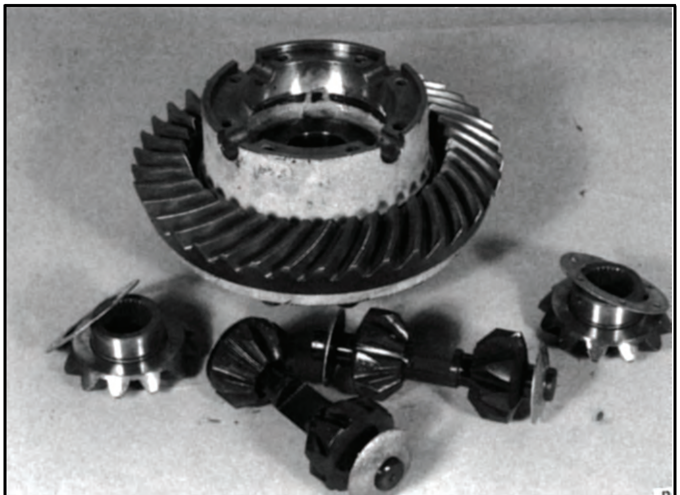
b. Lift off the top half housing Figure 8-23.

a0198 **FIGURE 8-23**

8

c. Remove the differential gears and spherical washers Figure 8-24. Pull off both differential bearing cones.

If required, remove the crownwheel to differential case half retaining bolts and remove the crownwheel.



a0199 **FIGURE 8-24**

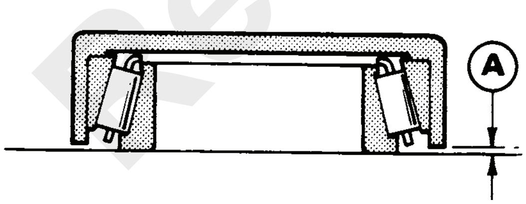
Assembly

Pinion Depth Setting Procedure

Determine the pinion depth setting as follows:

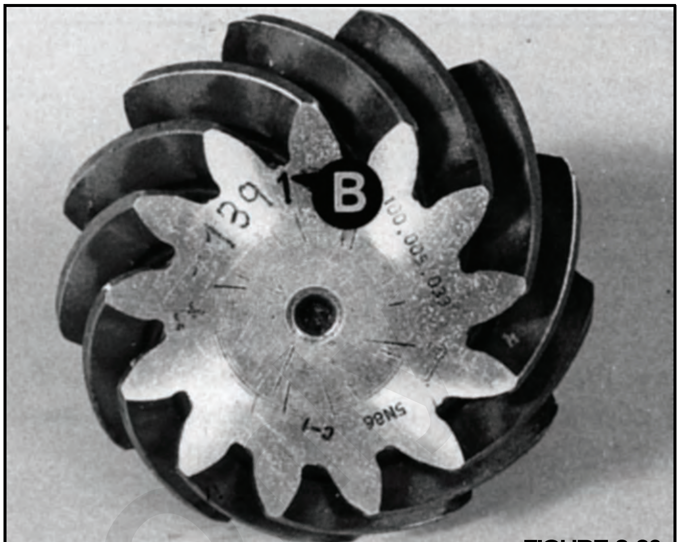
NOTE: See page 8-15 for general guidance on crownwheel and pinion adjustment.

1. Assemble the pinion inner bearing and its cup on a flat surface.
2. Place the pinion bearing measuring cup over the bearing assembly Figure 8-25. Measure gap A. Add tool depth of 30,1 mm. (1.18 inches) to gap A to give bearing depth.

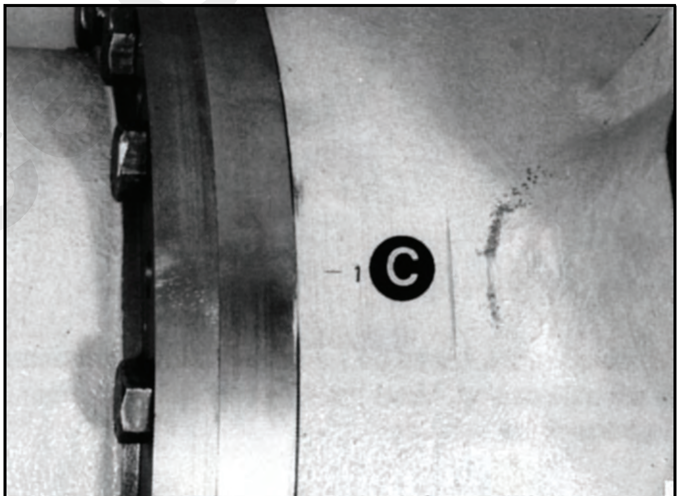


a0201 **FIGURE 8-25**

3. Find the mounting distance value **B** Figure 8-26 on the pinion and deviation **C** Figure 8-27 on the drive head housing. Both units are in millimeters. To convert millimeters to inches, multiply millimeters by 0.03937.



a0202 **FIGURE 8-26**



a0203 **FIGURE 8-27**

4. If dimension **B** is positive, add it to the bearing depth. If dimension **B** is negative, subtract it from the bearing depth. See example Crownwheel and Pinion Adjustment on page 8-15.
5. If dimension **C** is positive, subtract it from the total. If dimension **C** is negative, add it to the total. See example Crownwheel and Pinion Adjustment on page 8-15.
6. Subtract the result from the standard value of 31,19 mm (1.23 inches) to give the required shim thickness. See example Crownwheel and Pinion Adjustment on page 8-15.

Example:

Dimensions in Millimeters

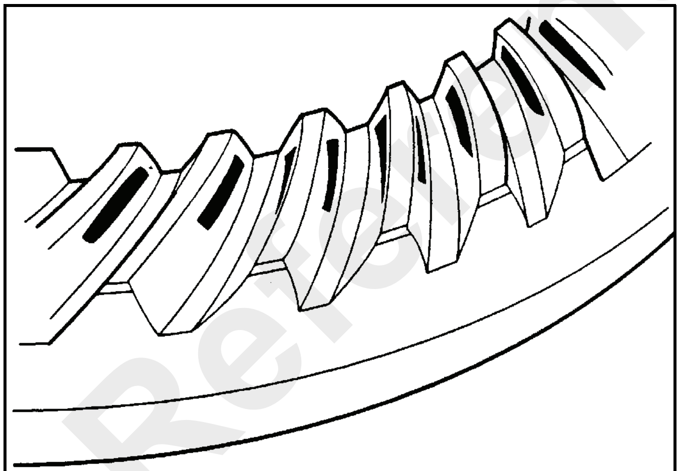
Dimension A	0.25
Add to depth	+30.01
Total	**30.26**
Add dimension B, if positive. (Subtract if negative)	+0.01
Total	**30.27**
Add dimension C if negative. Subtract if positive	(+) -0.01
Total	**30.28**
Standard Value	31.19
Less Calculated total from above	-30.28
Shim Thickness	**0.91**

Crownwheel and Pinion Adjustment

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

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

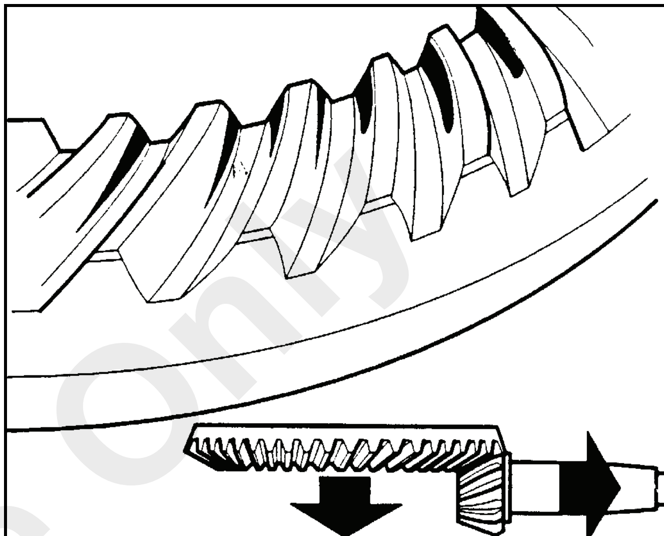
Correct teeth marking Figure 8-28



a0204 **FIGURE 8-28**

Pinion too deeply in mesh Figure 8-29

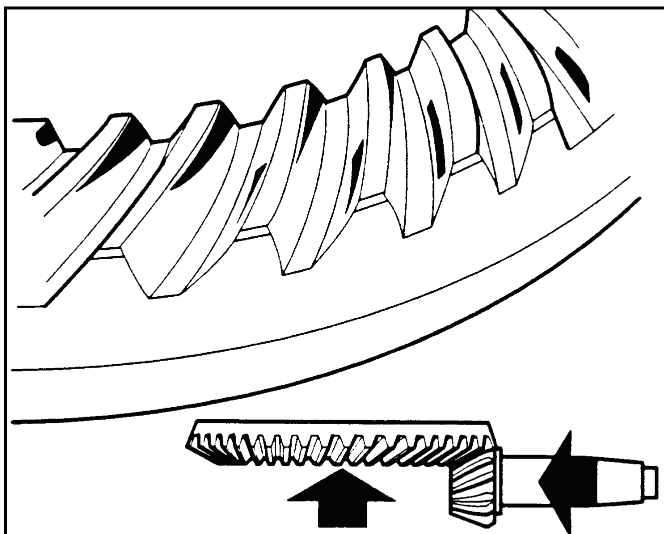
Decrease the shim thickness between the pinion inner bearing cup and the axle casing. Move the crown wheel towards the pinion to correct the backlash.



a0205 **FIGURE 8-29**

Pinion too far out of mesh Figure 8-30.

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



a0206 **FIGURE 8-30**

Assembly Procedures

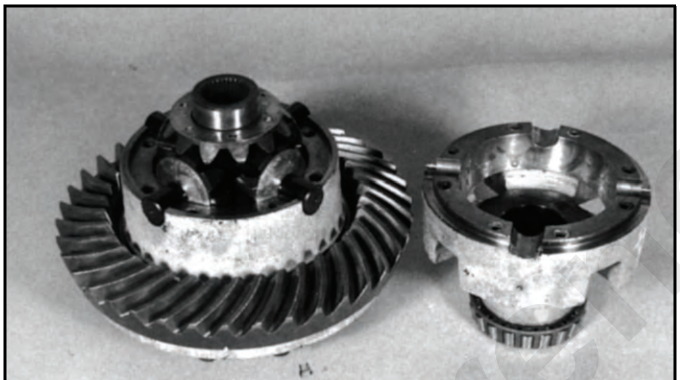
NOTE: The crownwheel and pinion are matched and should be replaced as a set, if either one is damaged or excessively worn.

The two differential case halves are also matched, as are the differential side gears and planet gears. Do not use unmatched case halves or gears.

NOTE: Make sure all bearings are lightly oiled before installing and setting. Make sure to rotate bearings while setting.

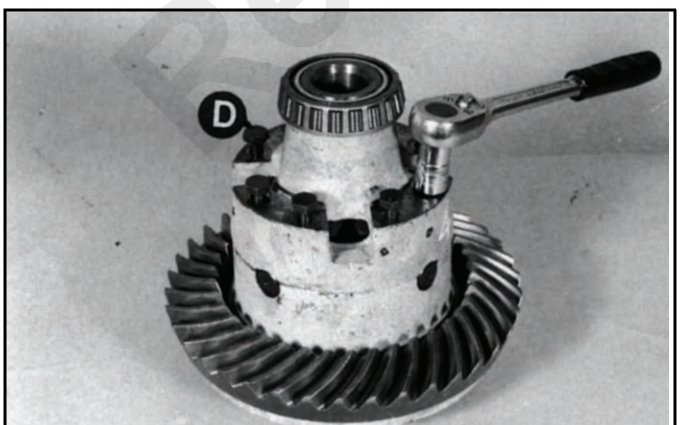
1. If required, install the crownwheel to the differential case half. Tighten the crownwheel retaining bolts to a torque of 122 lb-ft (166 Nm).

Assemble the differential gears and their spherical washers into the bottom half housing Figure 8-31. Install the differential bearing cones.



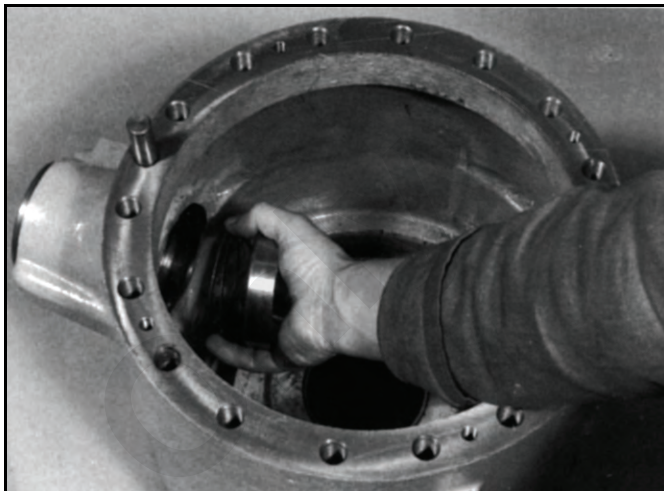
a0198 **FIGURE 8-31**

2. Position the top half housing onto the differential, aligning the match mark letters. Apply Loctite 242 to the threads of bolts **D** Figure 8-32. Install the bolts and tighten to a torque of 42 lb-ft (56 Nm). Check the gears for free rotation.



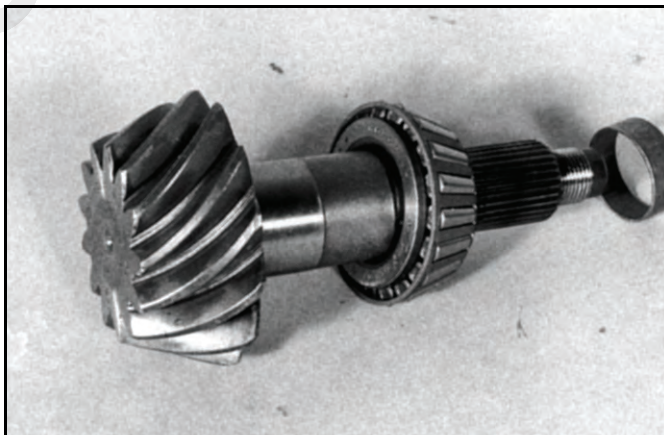
a0197 **FIGURE 8-32**

3. Install the pinion bearing cup Figure 8-33, together with the required thickness of shims to give correct pinion depth (see Pinion Depth on page 8-14). To ensure that cup is installed square, use a suitable puller assembly. Do not use a hammer. Install the outer bearing cup.



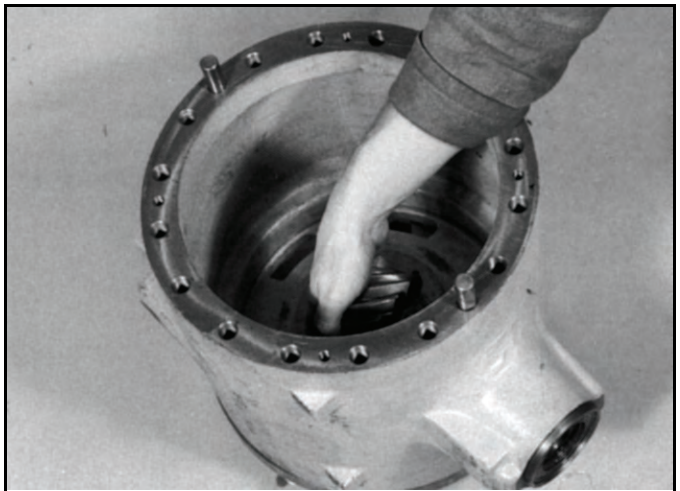
a0195 **FIGURE 8-33**

4. Install the pinion inner bearing cone Figure 8-34 and a new collapsible spacer.



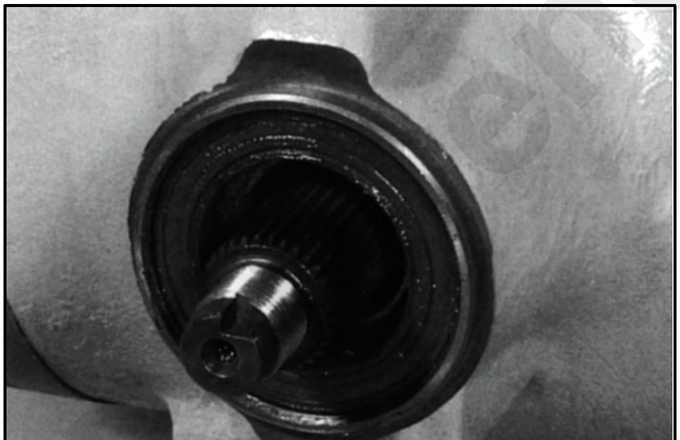
a0196 **FIGURE 8-34**

5. Insert the pinion into its bore Figure 8-35. Before inserting, ensure that the pinion matches the crownwheel. The code numbers etched on the pinion end face and the crownwheel perimeter should be the same.



a0193 **FIGURE 8-35**

6. Install the outer bearing cone Figure 8-36 and the seal. Pack grease between the lips of the seal before installing.

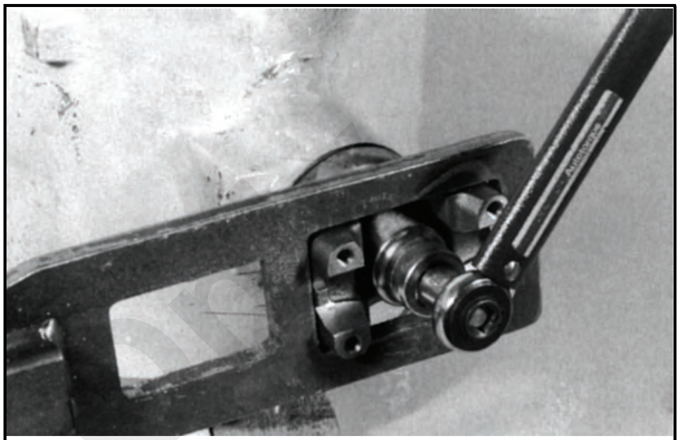


a0207 **FIGURE 8-36**

7. Install the drive coupling yoke and secure it with a new stake nut and washer.

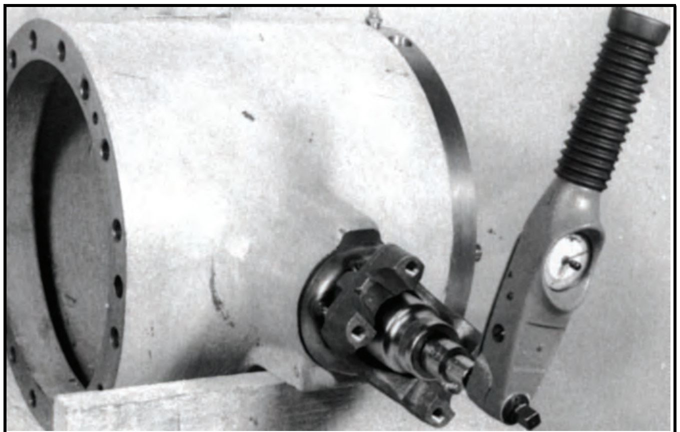
   Hold the yoke Figure 8-37 with the drive coupling spanner. Tighten the stake nut until end float is almost zero, then check the seal drag torque. It should be between 3.5 to 8.9 lb-in. (0,40 to 1,0 Nm).

   Continue to tighten the stake nut to achieve the correct rolling torque as described in Step 8. If the nut is overtightened, the collapsible spacer must be replaced.



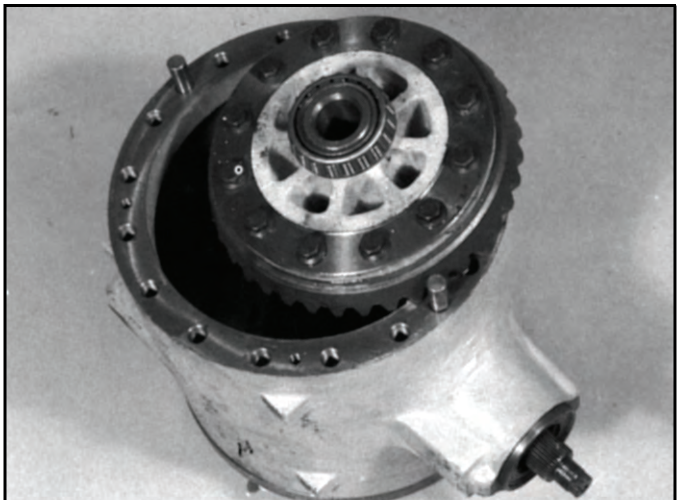
a0208 **FIGURE 8-37**

8. Measure the rolling torque Figure 8-38, which should be 1.3 to 2.1 lb-ft (1.7 to 2.8 Nm) excluding seal drag. When the torque is correct, stake the nut to the pinion shaft using a square-ended staking tool.



a0210 **FIGURE 8-38**

9. If both brake piston housings were removed, install one at the opposite end of the crownwheel Figure 8-39, using the procedure in Step 10. Then install the crownwheel/ differential assembly into the drive head.

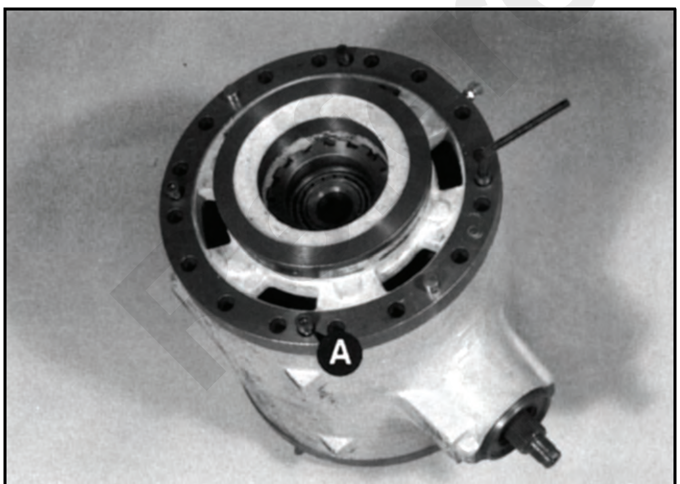


a0192 **FIGURE 8-39**

10. Apply Loctite 275 to the drive head mating face. Install the brake piston housing. Ensure that the match marks made during disassembly are aligned. Install capscrews **A** Figure 8-40 (see Important) and tighten to a torque of 42 lb-ft (56 Nm). Torque applies to both piston housings.

NOTE: If the old capscrews are to be used, clean the threads with a wire brush and then coat the threads with Loctite 242. Install and tighten to a torque of 42 lb-ft (56 Nm).

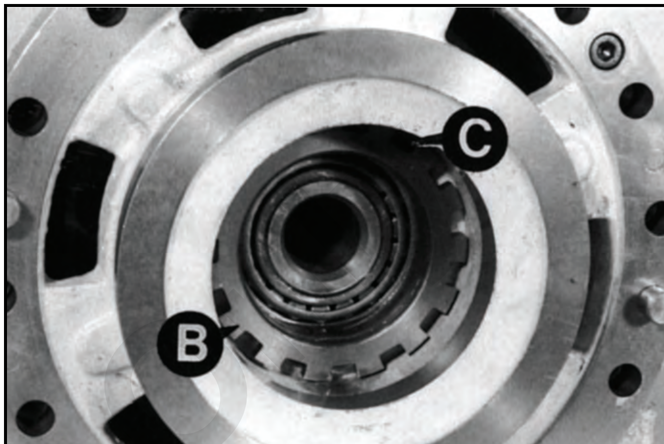
New capscrews are encapsulated and do not require cleaning or manually coating with sealant.



a0189 **FIGURE 8-40**

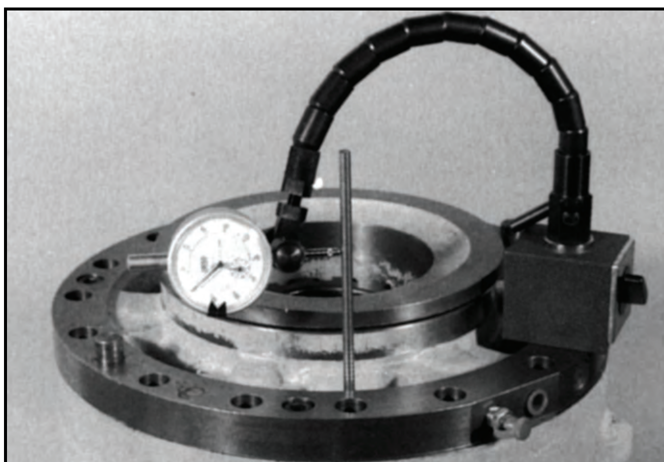
11. Adjust differential side nuts **B** Figure 8-42 to give a bearing pre-load of 1.0 to 1.84 lb-ft (1,36 to 2,5 Nm).

Measure the pre-load by taking another rolling torque reading and subtracting the torque value measured at Step 8. The difference is the bearing pre-load.



a0211 **FIGURE 8-41**

12. Measure the crownwheel backlash, which should be 0.005 to 0.008 in. (0,13 to 0,2 mm) Figure 8-42. Adjust the differential side nuts by equal amounts when altering backlash. When backlash and pre-load are both correct, install the side nut locking pins **C** Figure 8-41. Verify crownwheel, pinion and pre-load are set properly. See Crownwheel and Pinion Adjustment on page 8-15.



a0209 **FIGURE 8-42**

REAR AXLES REPAIR

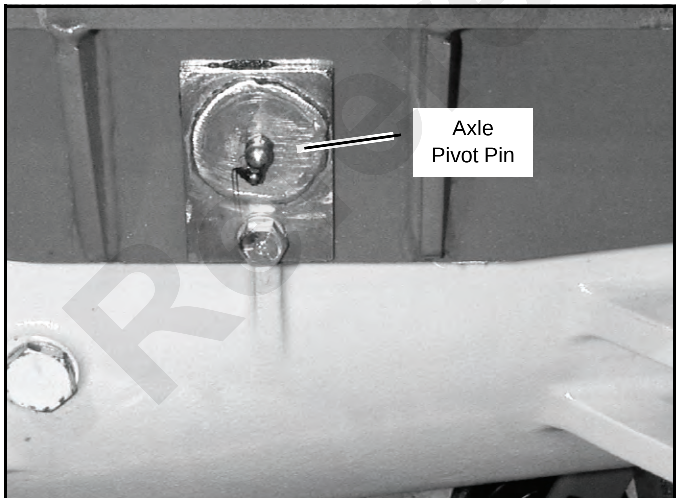
Removal

WARNING

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

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

1. Loosen the wheel lug nuts and raise and support the machine on axle stands or blocks positioned under the chassis frame. Remove the wheels.
2. Disconnect the drive shaft from the axle by removing four bolts and lockwashers.
3. Disconnect and plug the hydraulic hoses to the steering cylinder.
4. Disconnect, cap and plug the brake hoses from the axle.
5. Support the axle on a trolley jack.
6. Remove the bolt and lockwasher Figure 8-43 securing the axle pivot pin. Remove the axle pivot pin.



p0082 **FIGURE 8-43**

7. Lower the axle clear of the mounting bracket and remove it from the machine.

Installation

1. Place the axle on a trolley jack and position it under the machine frame.
2. Raise axle and position it in the mounting frame.
3. Install the axle pivot pin.
4. Coat the threads of the pin retaining bolt with Loctite 242 and then secure the axle pivot pin with the bolt and lockwasher.
5. Grease the axle pivot pin through two grease fittings.
6. Connect the brake lines and the steering lines to the axle.
7. Bleed the air from the brake system. See Section 7.
8. Bleed the air from the steering circuit. See Section 8.

Service Tools

To completely the disassemble and assemble the rear axle, special tools are required. Unless you have the tools illustrated Figure 8-3, DO NOT service the axle.

Replacing the Pinion Oil Seal

The procedure for replacing the pinion or seal on the rear drive axle is the same as the front drive axle. Refer to page 8-6 for replacement procedures.

Axle Hub Repair

Disassembly Figure 8-45

WARNING

A raised and badly supported 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. Disconnect the track rod and steering cylinders.

NOTE: If the track rod is removed completely, identify R.H. and L.H. ends to ensure correct assembly.

2. Drain all oil from the hub.
3. Remove screws **33** Figure 8-45.
4. Pry off planet gear carrier **27** at the pry points. Remove and discard o-ring **32**.

5. Remove planet gears **28** only if defective. Note that gears can only be removed as assemblies, which consist of the gear, the bearing and two “L” shaped retaining rings. To remove the planet gear, remove the external retaining ring **29**.
6. Pull off the planet gear **28**.
7. The drive shaft thrust pad **26** is drilled and tapped M6 for removal purpose. Remove the thrust pad from gear carrier **27**.
8. Remove retaining ring **31** to allow sun gear assembly (30) to be slid off the drive shaft **42**.
9. Remove retaining ring **25** to allow the brake pack assembly to be slid off the drive shaft **42**.
10. Remove brake pressure plate **24**, counter plates **23** and friction plates **22**.

NOTE: If the brake pack is to be reused, note the position of the plates before removing.

11. Examine the friction plates. Wear limit of the friction plates is to the depth of the crosshatching Figure 8-44. Check all plates for flatness and damage. (Some scoring of the counter plates is normal.) Completely replace the brake pack if it is worn or damaged. Do not replace individual plates.

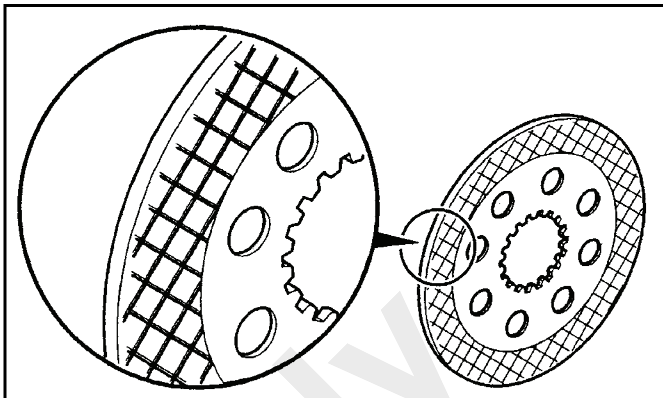


FIGURE 8-44

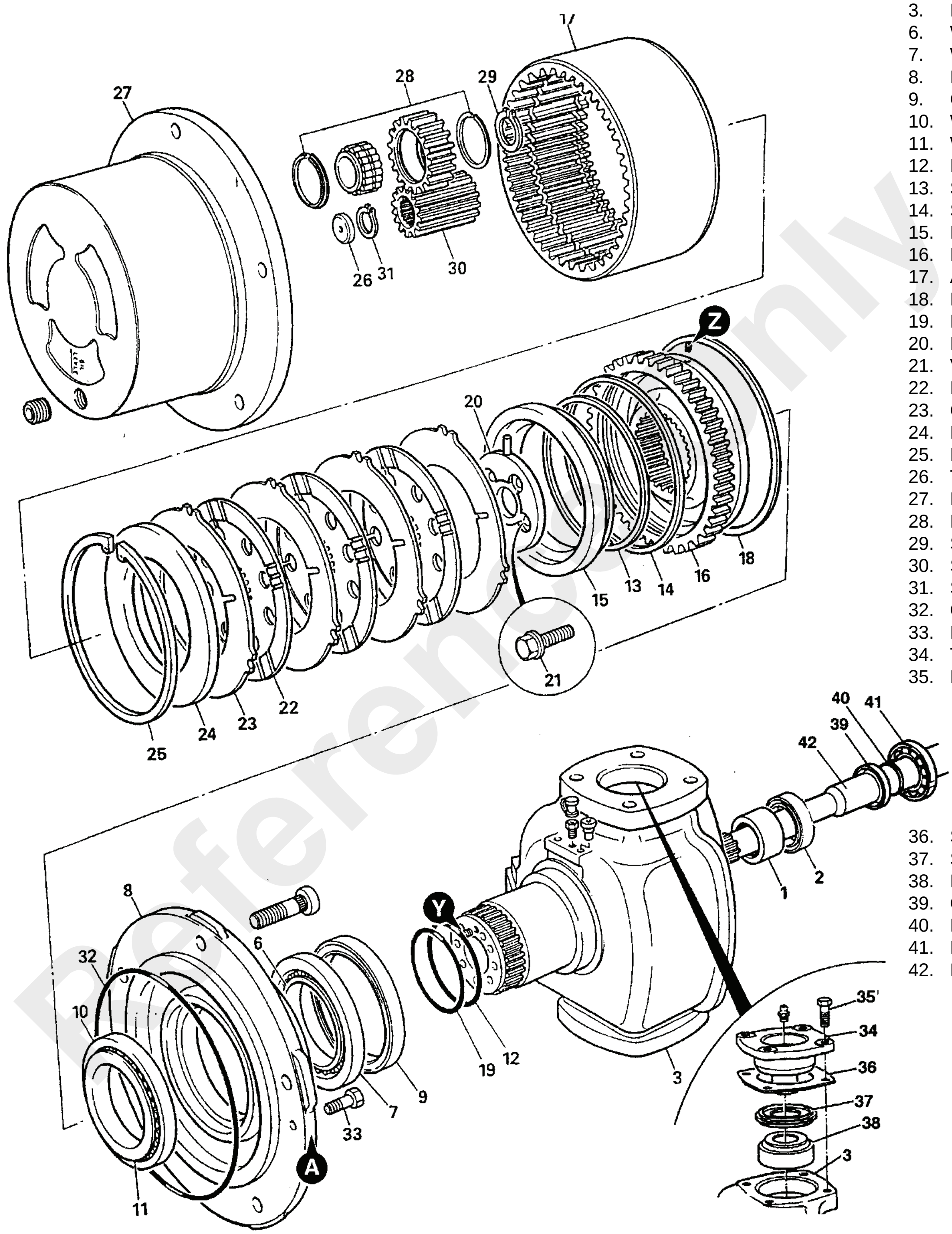
NOTE: Excessive wear of the brake and counterplates can indicate sticking brakes or possible residual pressure in the braking system. See Section 9, Brakes.

12. Remove Verbus Ripp bolts **21** Figure 8-45 and retaining plate **20**. These bolts are very tight and care must be taken not to distort the bolt heads. Use as short of extension as possible with a six sided socket. Discard the Verbus Rip bolts after removal.

CAUTION

Do **NOT** reuse Verbus Ripp bolts. They must be replaced throughout the assembly.

13. Remove brake seal **19**, then mark the relationship between the annulus carrier **16**, annulus ring **17** and the hub swivel. Remove the annulus carrier with the annulus ring from the hub swivel.
14. Remove retaining ring **18** to separate the annulus ring from the annulus carrier. Remove brake seal **12** from the hub swivel.



1. Bearing
2. Oil Seal
3. Hub Swivel
6. Wheel Bearing Cone
7. Wheel Bearing Cup
8. Bearing Carrier
9. Combination Seal
10. Wheel Bearing Cone
11. Wheel Bearing Cup
12. Brake Seal
13. Seal
14. Seal
15. Brake Piston
16. Brake Carrier
17. Annulus Ring
18. Retaining Ring
19. Brake Seal
20. Retainer Plate
21. Verbus Ripp Bolts (4)
22. Friction Plate (3)
23. Counter Plate (4)
24. Pressure Plate
25. Retaining Ring
26. Thrust Pad
27. Planet Gear Carrier
28. Planet Gear Assembly (3)
29. Snap Ring (3)
30. Sun Gear
31. Snap Ring
32. O-ring
33. Bolt (2)
34. Trunnion (2)
35. Bolt (8)
36. Shim
37. Seal (2)
38. Bearing (2)
39. Oil Seal
40. Retaining Ring
41. Bearing
42. Drive Shaft

NOTE! Items 39, 40 and 41 are used on drive axles only.

a2284

FIGURE 8-45

8

15. If removal is necessary, carefully remove the brake piston **15** from its housing. A hydraulic hand pump can be used to force the piston out of the housing.

16. Remove and discard seals **13** and **14**. Inspect the housing bore for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.

17. Pull off bearing carrier **8** together with outer bearing **11**.

18. Pull off inner bearing **6**.

19. Remove and discard combination seal **9**.

NOTE: Earlier axles may have an o-ring and wear ring installed. These parts should be discarded.

NOTE: The top and bottom trunnions are very similar (bottom trunnion is not illustrated in Figure 8-45) the only difference being that shims **36** are installed to the top trunnion.

20. Mark the position of the top and bottom trunnions **34**, remove bolts **35** and remove the trunnions. Keep shims **36** with the top trunnion. Remove hub swivel **3**.

NOTE: Trunnions may be removed easily and without damage to the shims by pumping grease through the grease fitting.

NOTE: On non-drive axles the short drive shaft will be removed with the hub swivel.

21. Remove top and bottom trunnion seals **37** and bearings **38**.

22. Remove drive shaft **42** from the hub swivel on non-drive axles and from the axle casing on drive axles.

23. Pry out the drive shaft outer oil seal **2**.

24. Remove bearing **1** using an impulse extractor adapter.

NOTE: Steps 25 through 27 are for drive axles only.

25. Pry out drive shaft inner seal **39**.

26. Remove retaining ring **40**.

27. Using an impulse extractor remove bearing **41**.

28. If there has been a component failure, remove all traces of debris and clean the magnetic drain plug.

Assembly

NOTE: The top and bottom trunnions are very similar (bottom trunnion is not illustrated in Figure 8-45, the only difference being that shims **36** are installed to the top trunnion.

NOTE: Steps 1 through 3 are for drive axles only.

1. Tap the drive shaft inner bearing **41** into position in the axle casing.

2. Install retaining ring **40**.

3. Install new oil seal **39**. Pack grease between the lips of the seal.

4. Tap drive shaft inner bearing **1** into position in hub swivel **3** drive shaft bore.

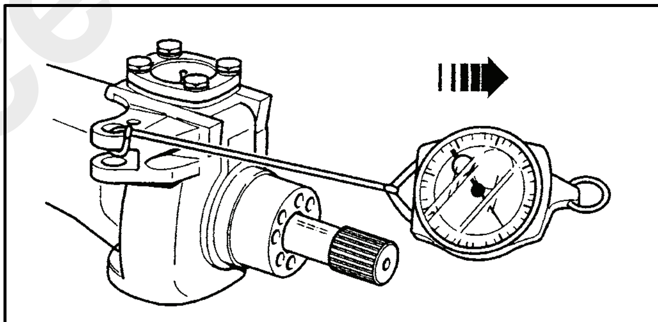
5. Install new oil seal **2**. Pack grease between the lips of the seal.

6. Install drive shaft **42**. Take care to locate inner end into splines of differential gears on the drive axle.

7. Press new top and bottom trunnion seals **37** into position, followed by bearings **38**.

8. Locate hub swivel **3** and install the bottom trunnion **34**. Apply Loctite 242 to threads of bottom trunnion bolts 35 and then tighten to a torque 42 lb-ft (56 Nm). Install top trunnion **34** with normal 0.25 mm (0.010 inch) shim **36** and leave top trunnion bolts **35** finger tight.

9. Attach a spring balance Figure 8-46 to track rod swivel and turn the swivel. Tighten the top trunnion bolts **35** to eliminate end play, but without bearing pre-load, i.e. no increase in spring balance reading.



a2283 **FIGURE 8-46**

10. Measure the gap at the top trunnion and subtract 1 mm (0.040 inches) to give shim thickness (bearing pre-load). For example:

Gap = 1,55 mm (0.061 inches)

less = <u>1,00 mm (0.040 inches</u>

Shim = 0,55 mm (0.021 inches)

NOTE: If the gap measures 1.00 mm (0.040 inches), then no shim is required.

NOTE: If, after installing the shims, the bearing pre-load is not attainable, install new bearings.

11. Reinstall the top trunnion. Apply Loctite 242 to the top trunnion bolt threads, install and tighten to a torque of 42 lb-ft (56 Nm).

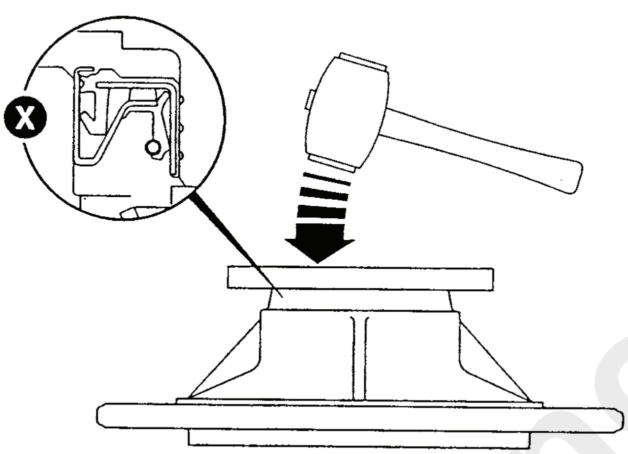
12. Check the spring balance reading which should be 10 lb. (4.5 kg) more than the reading recorded in step 9.

13. Connect the track rod and steering cylinder to the axle steering knuckle. Tighten the track rod nut to a torque of 100 lb-ft (135 Nm), then continue to tighten to next castellation and insert the pin.

14. Lightly oil the inner wheel bearing **6** and its cup **7**. Then install them into bearing carrier **8**.

15. Install a new combination seal **9** into the bearing carrier. Figure 8-47.

Do not lubricate before installing. Drive the seal squarely into carrier until locating lip is flush as shown at **X**.



a0496 FIGURE 8-47

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

16. Install the cup **10** of outer wheel bearing **11** into the bearing carrier **8**. Grease the bore of the seal and the surface of the stub.

17. Install the bearing carrier **8** onto hub swivel **3**.

18. Install new brake seal **12** to the hub swivel.

19. Install new seals **13** and **14** into the grooves in the brake piston **15** and annulus carrier **16**.

20. Carefully press piston **15** all the way into the annulus carrier housing.

21. Align relationship marks made on disassembly. Assemble annulus ring **17** to annulus carrier **16** and secure with retaining ring **18**. Make sure the two blanking plugs **Z** Figure 8-45 are installed to the annulus carrier. Apply Loctite 242 to threads.

NOTE: Inspect the inside of the annulus carrier and piston for marks. Any sign of scoring on a seal contact surface can cause leaks.

NOTE: Make sure blanking screw **Y** are installed. Apply Loctite 242 to threads.

22. Install the annulus assembly onto the splined hub. Check that the relationship marks align. Push the annulus assembly into the splined hub until the splines of the annulus assembly are flush with the end of the splined hub. Fit brake seal **19** onto the hub swivel.

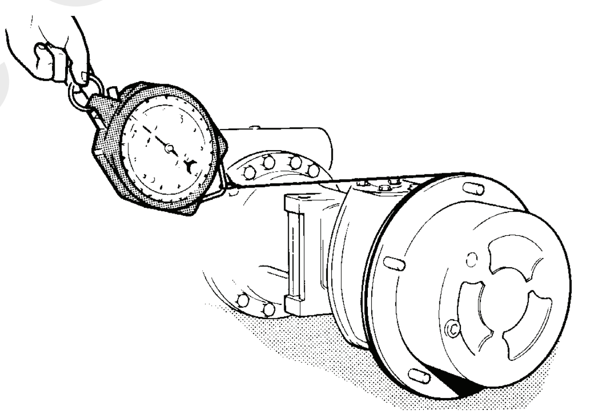
23. Install retainer plate **20**, making sure the breather hole and brake galleries align. Secure using Verbus Ripp bolts **21** and tighten until the annulus assembly just rocks.

24. Check the seal drag rolling force:

a. Use a spring balance and cord wrapped around the planet carrier flange Figure 8-48. Pull the spring balance so that the hub rotates. Do this several times to set the seal and then record the reading.

b. Remove the planet gear carrier and tighten the new Verbus Ripp bolts **21** to 122 lb-ft (166 Nm).

c. Repeat steps 24 and 24A and record the reading.



a2283 FIGURE 8-48

d. To get the rolling force, subtract the seal drag rolling force (Step 24 A) from reading obtained at step 24C. The result should be 3 to 34 lb (1,4 to 15,3 kg).

If the resulting force is outside these limits check that seal **9** is installed correctly and or replace bearings **6** and **11**.

NOTE: A high rolling force reading may indicate the oil seal was damaged during installation.

25. Assemble friction plates **22** and counter plates **23** onto the carrier **16**. If the original brake pack is being used, return the plates to their original positions (see Disassembly, step 10). Soak new friction plates in gear oil before assembly.

26. Assemble the brake friction plate **24**. Install retaining ring **25**.

27. If axle is attached to the machine, bleed the brake system. With the engine running, gently apply the brakes and then release them. Check that the piston activates and retracts correctly and does not stick in the applied position before installing planet gear carrier **27**.

If the brake piston has not retracted, the brake seal or piston assembly may have been assembled incorrectly. Alternatively, there may be residual pressure holding the piston. Unscrew the brake bleed nipple with the engine running and check that the piston retracts when the pressure is released. Investigate the cause if the piston remains in the applied position. See Residual Brake System Pressure in Section 7.

28. Press drive shaft thrust pad **26** (chamfered side down) into the recess in planet carrier **27**.

29. Install new planet gears **28** in place of any that were removed. Secure with retaining ring **29**.

NOTE: The large radius at the end of the bearing bore installs on the pin first.

30. Install sun gear **30** onto the drive shaft and secure with external retaining ring **31**. Install new o-ring **32**.

31. Install planet gear carrier **27** onto bearing carrier **8**, turning it slightly to engage the gear teeth and align the two tapped holes **A** Figure 8-45 in the bearing carrier. (The tapped holes are diametrically opposite each other.) Ensure that the planet gear carrier butts fully against the bearing carrier.

NOTE: Do not strike the center of the planet gear carrier **27** when installed, as this may dislodge drive shaft thrust pad **26**.

32. Install screws **33** and tighten to a torque of 41.3 lb-ft (56 Nm).

33. Fill the axle hub with oil. See Section 3, Preventive Maintenance.

Drive Head Repair (Drive Axles Only)

Disassembly Figure 8-49

NOTE: The axle need not be removed to disassemble the drive head.

1. Drain the oil from the axle center casing. Remove the rear drive shaft from the axle.

2. Remove both hub assemblies with drive shafts (see page 8-7).

3. Mark the installation position of the drive head carrier **2** Figure 8-49.

4. Remove bolts **1** and remove drive head carrier **2** from the axle casing.

5. Clean the drive head carrier and axle casing mating surfaces.

6. Pull out tension pins **3** and **4** and remove castellated nuts **5** and **6**.

7. Remove bearing outer races **7** and **8**.

8. Drive off the taper roller bearing cone **9** from the crownwheel differential case half.

9. Remove differential assembly **10** from the carrier.

10. Remove retaining bolts **11** and separate case halves **12** and **13**.

11. Remove the two differential side gears **14** and thrust washers **15**.

12. Remove the four planet gears **16** and thrust washers **17** from trunnion pins (**B**).

13. Pull off taper roller bearing cone **18** from differential case halve **12**.

14. Remove Verbus Ripp bolts **19** and separate the crownwheel **20** from differential case halve **13**.

CAUTION

Do NOT reuse Verbus Ripp bolts. They must be replaced through out the assembly.

15. Use a drive coupling spanner to prevent drive yoke **23** from rotating. Remove pinion nut **21** and washer **22**. Remove the drive yoke.

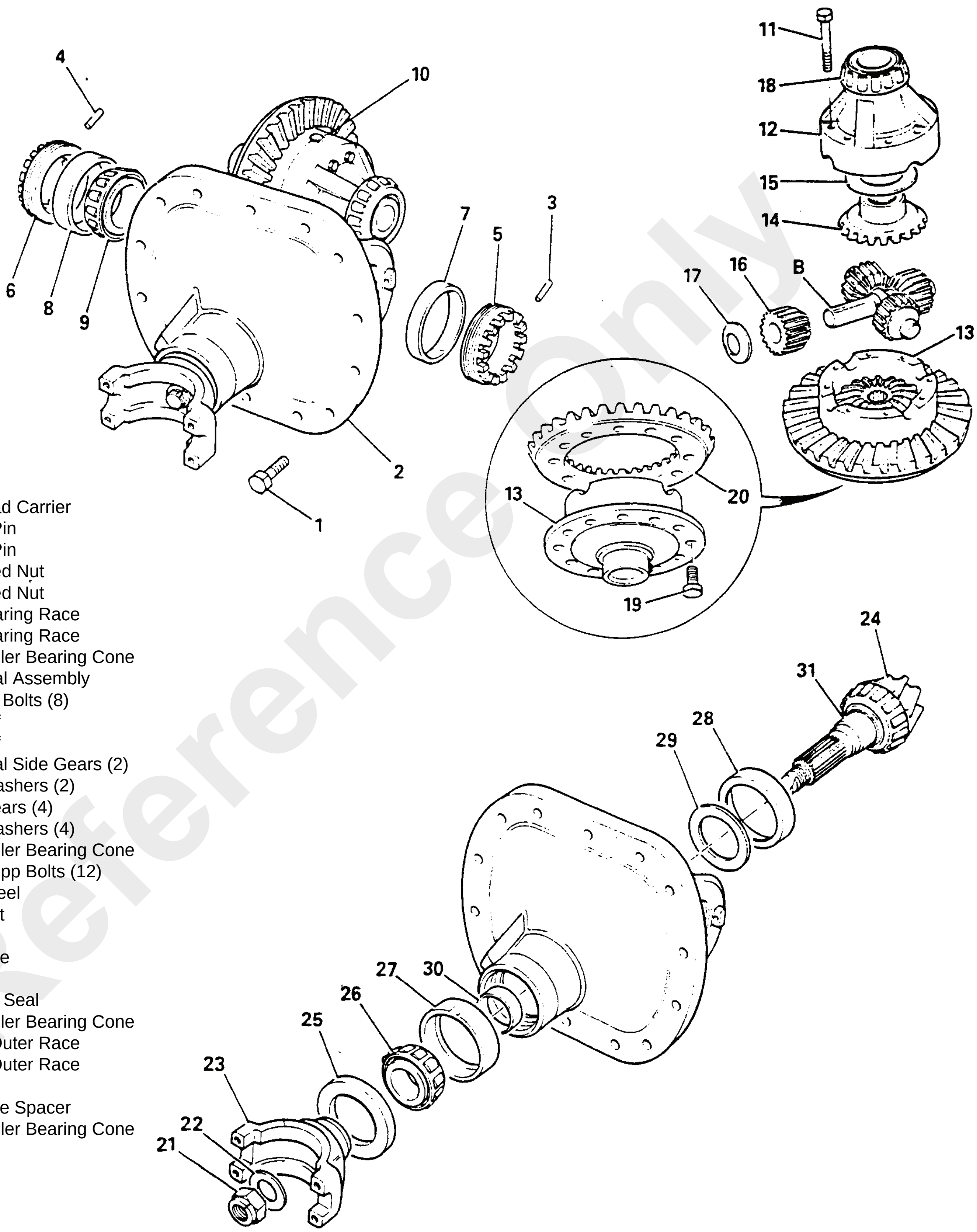
NOTE: On later axles, pinion nut **21** and washer **22** are combined. The separate nut and washer should be discarded and replaced with the new combined nut and washer.

16. Press pinion **24** from drive head carrier **2**.

17. Pull out pinion oil seal **25** and taper roller bearing cone **26**. If necessary remove bearing outer race **27**.

18. If necessary, drive out pinion bearing outer race **28** and shim(s) **29** from inner side of the drive head carrier.

19. Remove the collapsible spacer **30** and taper roller bearing cone **31** from pinion **24**.



1. Bolts (16)
2. Drive Head Carrier
3. Tension Pin
4. Tension Pin
5. Castellated Nut
6. Castellated Nut
7. Outer Bearing Race
8. Outer Bearing Race
9. Taper Roller Bearing Cone
10. Differential Assembly
11. Retaining Bolts (8)
12. Case Half
13. Case Half
14. Differential Side Gears (2)
15. Thrust Washers (2)
16. Planet Gears (4)
17. Thrust Washers (4)
18. Taper Roller Bearing Cone
19. Verbus Ripp Bolts (12)
20. Crownwheel
21. Pinion Nut
22. Washer
23. Drive Yoke
24. Pinion
25. Pinion Oil Seal
26. Taper Roller Bearing Cone
27. Bearing Outer Race
28. Bearing Outer Race
29. Shims
30. Collapsible Spacer
31. Taper Roller Bearing Cone

a0213

Drive Head

FIGURE 8-49

8

Assembly

NOTE: The crownwheel **20** Figure 8-49 and pinion **24** are matched and should be replaced as a pair if either one is damaged or excessively worn. The differential case halves **12** and **13** are also matched as are gears **14** and **16**. Do not use unmatched halves or gears.

Make sure all bearings are lightly oiled before installing and setting. Make sure bearings are rotated while being set.

1. Install pinion bearing outer race **28** Figure 8-49 to drive head carrier **2** together with required thickness of shims **29** to give correct pinion depth. (See Pinion Depth Setting Procedure on page 8-14). Install the shims behind the outer race Figure 8-49.

2. Install new taper roller bearing cone **31** and a new collapsible spacer **30** onto pinion **24**.

3. Install outer race **27** to drive head carrier **2**.

4. Insert pinion **24** into its bore. (Before inserting verify that the pinion matches the crownwheel. The code numbers are etched on the pinion end face and the crownwheel perimeter must be the same).

5. Install new taper roller bearing cone **26**. Pack the cavity between the lips of new oil seal **25** with grease and install the seal to the drive head carrier **2**.

6. Install the drive coupling yoke **23** and secure it with a new combined stake nut **21** and washer **22**.

- **a.** Hold the yoke with a drive coupling spanner.
- **b.** Tighten the stake nut until end float is almost zero then check the seal drag torque which should be between 3.5 to 6.6 lb-ft (0,40 to 0,75 Nm).
- **c.** Continue to tighten the stake nut to collapsible spacer **30** and give a rolling torque of 1.3 to 2.1 lb-ft (1,7 to 2,8 Nm) excluding seal drag, crownwheel not installed.

  IF THE STAKE NUT IS OVERTIGHTENED , THE COLLAPSIBLE SPACER MUST BE REPLACED.

  Make sure that yoke **23** is rotated in both directions to fully seat the bearings before measuring rolling torque.
- **d.** When the torque is correct, stake the nut to the pinion shaft, using a square ended staking tool.

7. Install crownwheel **20** to case halve **13**, tighten the Verbus Ripp bolts **19** to a torque of 122 lb-ft (166 Nm).

8. Assemble the four planet gears **16** and thrust washers **17** onto the trunnion pins. Install the planet gear assembly and two differential side gears **14** and thrust washers **15** into case half **13**.

9. Position top case half **12** onto bottom half assembly **13** aligning the match mark letters (see Important 1 on page 8-7). Apply Loctite 242 to the threads of bolts **11**, then install them and tighten to a torque of 32 lb-ft (56 Nm). Check the gears for free rotation.

10. Press taper roller bearing cone **18** onto the spigot of case half **12**.

11. Install the differential assembly **10** into the drive head carrier **2**.

12. Press taper roller bearing cone **9** onto the spigot of case half **13**.

13. Install bearing outer races **7** and **8**, castellated nuts **5** and **6** to drive head carrier **2**.

14. Adjust castellated nuts **5** and **6** to give bearing pre-load (see Important 2) of 1.0 to 1.84 lb-ft (1,36 to 2,5 Nm).

NOTE: Measure the pre-load by taking another rolling torque reading and subtract the torque figure measured at step 6C. The difference is the bearing pre-load.

15. Measure the crown wheel backlash, which should be 0.005 to 0.008 in. (0,13 to 0,20 mm). Adjust castellated nuts **5** and **6** by equal amounts when altering backlash. When backlash and pre-load are both correct, install tension pins **3** and **4**.

16. Verify that the crownwheel and pinion are set correctly: use an engineers marker on three of the pinion teeth and check markings on the crownwheel are as indicated on 6-18. Adjust if necessary.

17. Apply Loctite 275 to the drive head carrier mating face and then install the axle casing (the carrier assembly locates on two dowels). Make sure the assembly is installed in the same match-mark position (see step 3, Disassembly of page 8-11.

18. Apply Loctite 242 to bolts **1** and install. Tighten the bolts to a torque indicated in Important 3 and 4.

19. Assemble both hubs and drive shafts and install the rear drive shaft.

20. Fill the axle with recommended oil. See Preventative Maintenance, Chapter 5.

NOTE: Tightening torque depends on bolt type. The grade is stamped on the bolt head. If standard grade 8 bolt, tighten to a torque of 72 lb-ft (98 Nm).

NOTE: If Verbus Ripp 12.9 grade bolt is used, tighten to a torque of 122 lb-ft (166 Nm).

Use heavy duty socket.

CAUTION

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

DRIVE SHAFTS

Removal

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

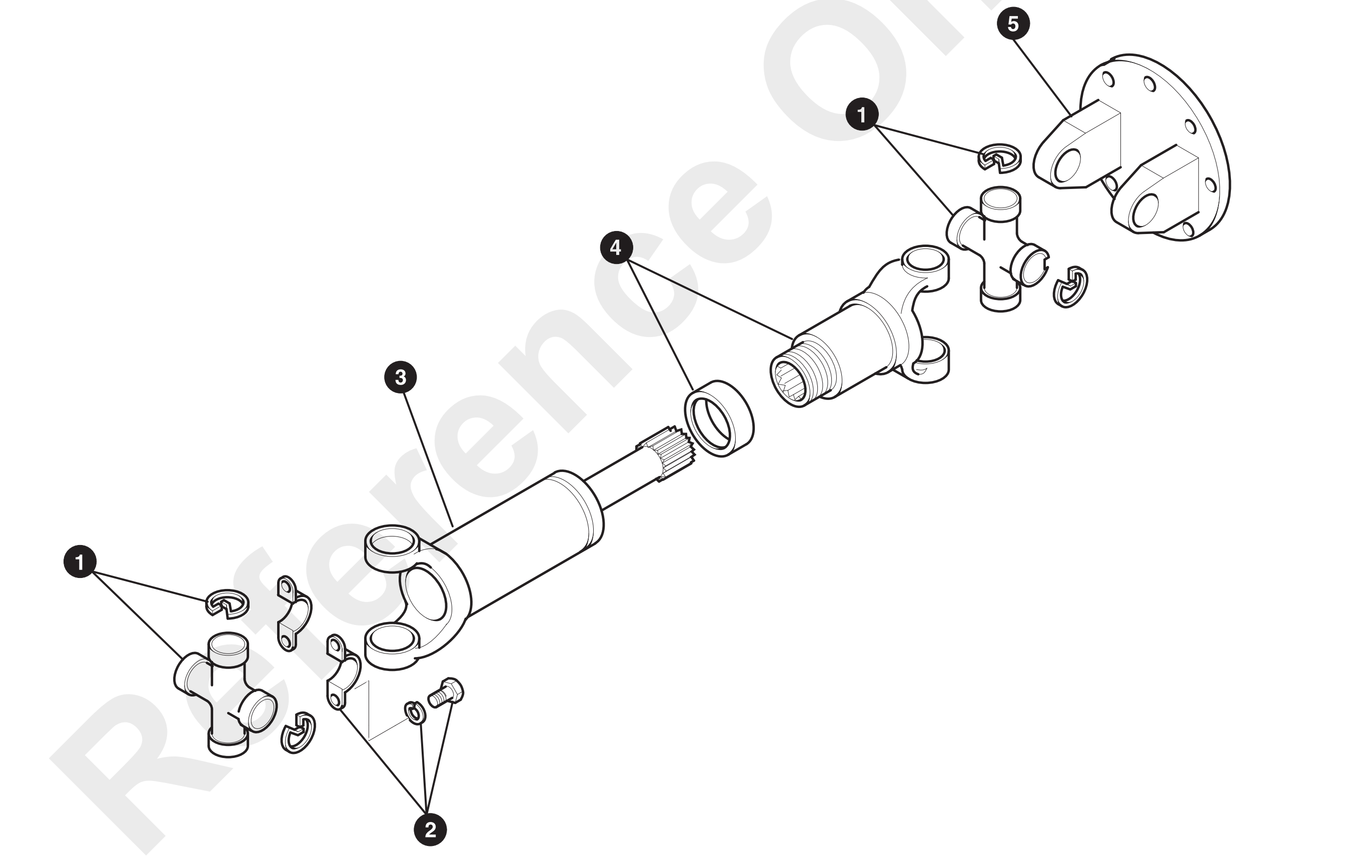
NOTE: The retaining straps **2** Figure 8-50 and Figure 8-51 stretch with use, therefore these straps must always be replaced with new ones.

Front Axle Drive Shaft

1. Remove bolts, lockwashers and mounting straps **2** Figure 8-50 from transmission.
2. Remove flange **5** from the parking brake disc.

Rear Axle Drive Shaft

1. Remove bolts, lockwashers and mounting straps **2**, Figure 8-50 from transmission.
2. Remove bolts, lockwashers and mounting straps **2** from rear axle.



a0315

FIGURE 8-50

Disassembly

Front Axle Drive Shaft

1. Put the flange yoke **5** Figure 8-50 in a vice. Using pliers, remove two snap rings from the bearing caps in the flange yoke.
2. Apply force on the drive shaft in the direction of the bearings to push the bearings out of the flange yoke. When the bearings are removed, tilt the journal cross to permit removal of the universal joint.
3. Disassemble the journal crosses **1** from the drive shaft using the procedure in step 2. After the snap rings are removed, use a soft drift with a flat face slightly smaller than the diameter of the bearing to remove the bearings.
4. To disassemble the sleeve yoke (3) from the slip yoke (4), turn the dust cap counterclockwise. When the dust

8

cap is free, pull the sleeve yoke and dust cap free of the slip yoke.

Rear Drive Shaft

1. Remove two snap rings from the bearing caps in the slip yoke **4** Figure 8-51.
2. After the snap rings are removed, use a soft drift with a flat face slightly smaller than the diameter of the bearing to remove the bearings.
3. Repeat steps 1 and 2 to the sleeve yoke end.
4. To disassemble the sleeve yoke **3** from the slip yoke **4**, turn the dust cap assembly counterclockwise. When the dust cap assembly is free, pull the sleeve yoke and dust cap free of the slip yoke.

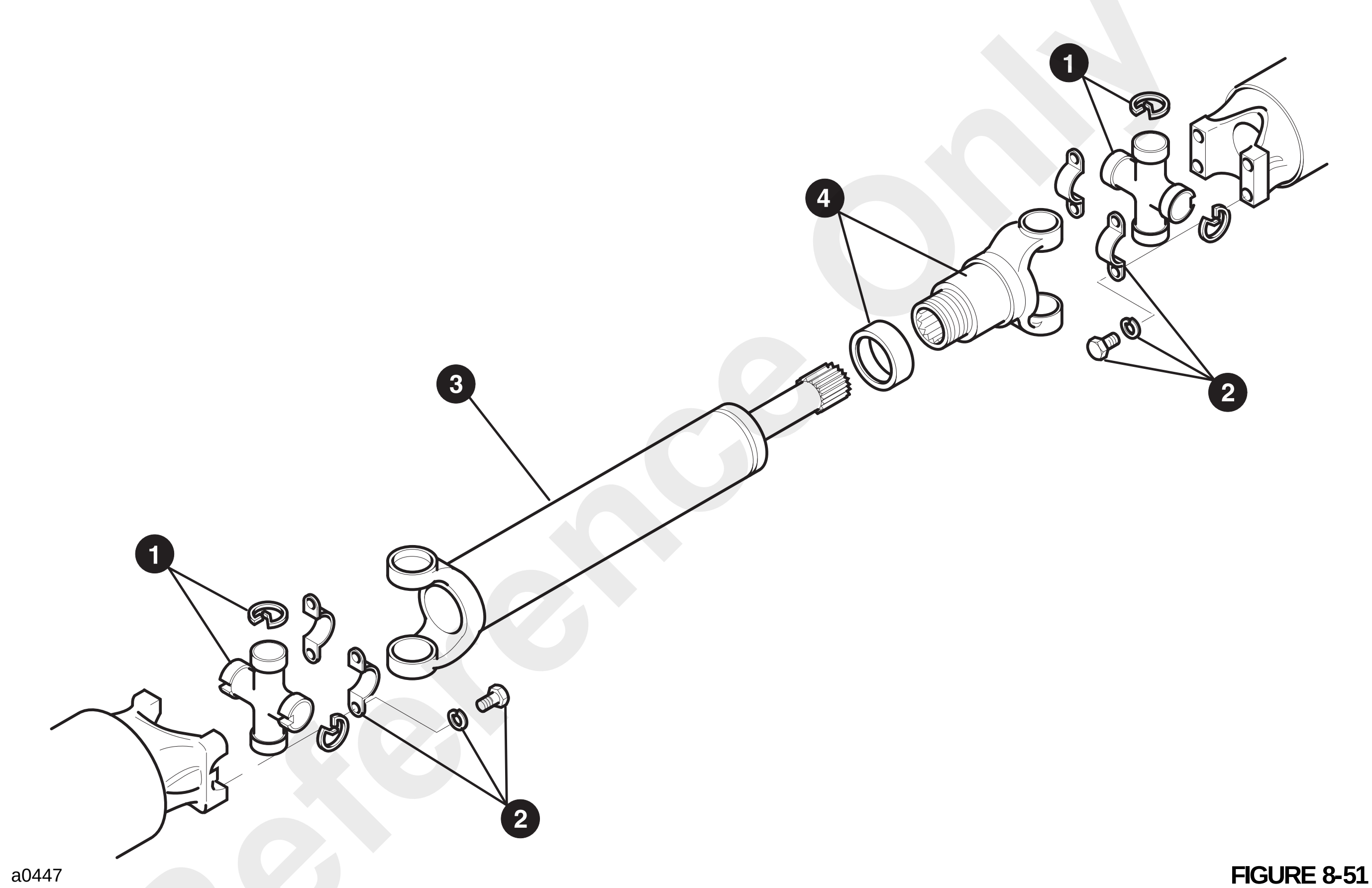


FIGURE 8-51

Inspection

Clean all parts with a suitable solvent. Remove all rough areas from any finished surfaces. Make sure the bearing surfaces on the journal crosses are smooth. Do not disassemble the needle bearings. Clean with a brush and compressed air. Apply a small amount of SAE 140 oil into each bearing cap and rotate the bearing on the trunnion to check for wear. If there is any indication of wear or damage to the needle bearings, bearing cap or journal crosses, replace the journal and bearings as an assembly.

Check for damage to the splines of the sleeve yoke. Make sure the splines are clean and smooth. Look for damage or distortion of the drive shaft tube. Damage can cause failure of the drive shaft under high torque loads. The drive shaft must be straight to inhibit vibration during operation. Replace the drive shaft if there is damage.

Assembly

Front Axle Drive Shaft.

1. If new journal and bearings are not being installed, inspect the seals in the bearing retainers. If they are damaged in any way, replace the complete journal and bearing assembly.
2. Install the journal cross into the yoke of the sleeve yoke. The relief must be towards the sleeve yoke.
3. Apply a small amount of SAE 140 oil to the trunnions on the journal cross. Press the bearings and cap

assemblies into place. Use care not to cause damage to the bearings or caps. Install the snap rings. Make sure the snap rings are engaged fully in the groove.

4. Repeat steps 1 through 3 on opposite end of drive shaft.

5. Repeat steps 1 through 3 to install the flange yoke to the drive shaft.

6. Apply SAE 140 oil to splines on the sleeve yoke **3** Figure 8-50 and Figure 8-51. Assemble the dust cap assembly to the sleeve yoke. Slide the sleeve yoke into the slip yoke (4). Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.

Rear Axle Drive Shaft

1. If new journal and bearings are not being installed, inspect the seals in the bearing retainers. If they are damaged in any way, replace the complete journal and bearing assembly.

2. Install the journal cross into the yoke of the sleeve yoke. The relief must be towards the sleeve yoke.

3. Apply a small amount of SAE 140 oil to the trunnions on the journal cross. Press the bearings and cap assemblies into place. Use care not to cause damage to the bearings or caps. Install the snap rings. Make sure the snap rings are engaged fully in the groove.

4. Repeat steps 1 through 3 on opposite end of drive shaft.

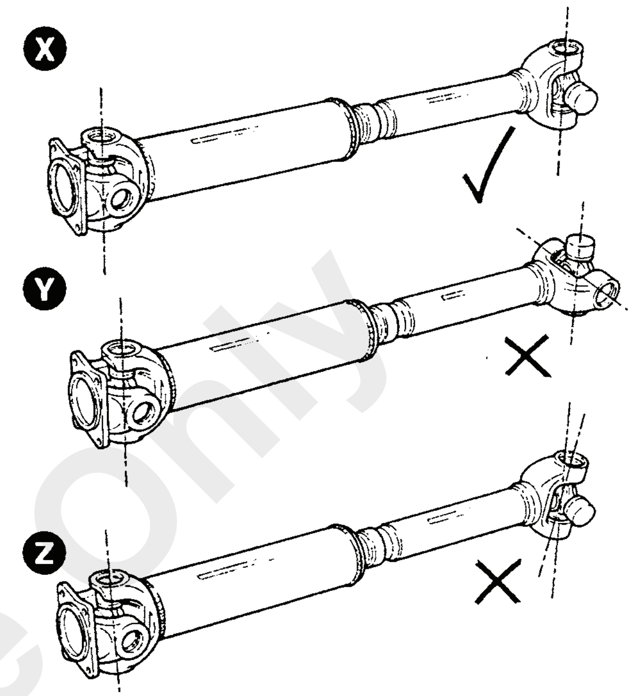
5. Apply SAE 140 oil to splines on the sleeve yoke **3** Figure 8-50 and Figure 8-51. Assemble the dust cap assembly to the sleeve yoke. Slide the sleeve yoke into the slip yoke **4**. Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.

Installation

Front Axle Drive Shaft

1. Fasten the flange yoke **5** Figure 8-50 to the parking brake disc on the front axle with eight bolts, lockwashers and nuts.

NOTE: The drive shaft must have both ends exactly on the same plane as shown in **X** Figure 8-52. The yokes must not be at right angles as at **Y** or at an intermediate angle as at **Z**.



a0316 **FIGURE 8-52**

2. Fasten the other end to the transmission using a new strap kit.

NOTE: The retaining straps (2) stretch with use, therefore these straps must always be replaced with new ones.

3. Apply grease with a grease gun to the fittings on the journal crosses and on the slip joint. Apply grease until it exists through the seals. See Lubrication Procedure on this page.

4. Check the drive shaft for correct balance before the machine is put into operation. Lower the outriggers to lift the wheels off the ground. Operate the drive train and check for vibration. If vibration is found, stop the machine and check the drive shaft. Make sure the drive shaft yokes are in the same plane.

Rear Axle Drive Shaft

1. Fasten cross **1** Figure 8-51 to the front axle yoke using a new strap kit **2**.

NOTE: The retaining straps **2**) stretch with use, therefore these straps must always be replaced with new ones.

2. Fasten the other end cross **1** to the transmission yoke with a new strap kits **2**.

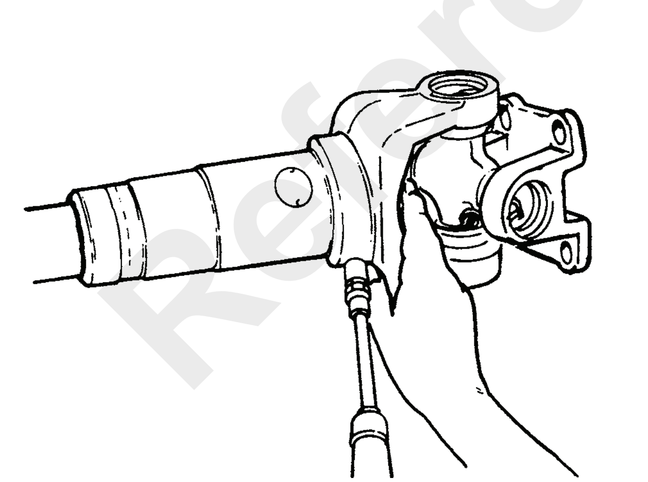
NOTE: The drive shaft must have both ends exactly on the same plane as shown in **X** Figure 8-51. The yokes must not be at right angles as at **Y** or at an intermediate angle as at **Z**.

3. Apply grease with a grease gun to the fittings on the journal crosses and on the slip joint. Apply grease until it exists through the seals. See Lubrication Procedure on this page.
4. Check the drive shaft for correct balance before the machine is put into operation. Lower the outriggers to lift the wheels off the ground. Operate the drive train and check for vibration. If vibration is found, stop the machine and check the drive shaft. Make sure the drive shaft yokes are in the same plane.

Lubrication Procedure

The drive shaft is an important part of the drive train and needs regular maintenance. There is a grease fitting on the slip joint and on each journal cross. Apply grease to these fittings every week or 50 hours of operation, whichever occurs first. Use Lithium based, E.P. No. 2 bearing grease. Always apply enough grease to the fitting to remove old grease. On the slip joint, apply grease to the fitting until the grease comes through the hole in the end off the shaft. Put your finger over the hole Figure 8-53 and continue to apply grease until the grease shows at the seal on slip joint.

At each lubrication, check the drive shaft for side movement. As wear in the bearings increases, the side movement will increase. Movement must be to minimum to prevent vibration during operation.



a0317 **FIGURE 8-53**

WHEEL & TIRES

WARNING

Never try to disassemble the wheel until all air is released from the tire. The retaining ring and rim of the wheel and tire can come off with explosive force and can cause serious injury or death. Be extremely careful when working with them. Always use a tire and rim cage guard when inflating tires.

Tire Inflation

Check the tire pressure daily before operation. Also look for cuts and damage.

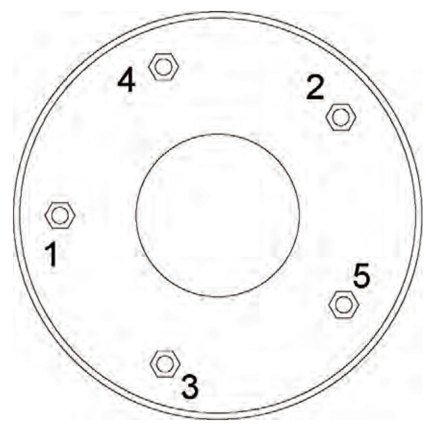
Tire Pressures

Tire Size	*Pressure*
385/65R22.5 Radial	120 psi. (828 kPa)

Wheel Stud Nuts

The tightening order of the stud nuts is shown in Figure 8-54. Check the tightness of the lug nuts weekly or after every 50 hours of operation, whichever occurs first.

Wheel stud torque is 500 lb-ft (680 Nm).



a0152 **FIGURE 8-54**

SECTION 9
BRAKE SYSTEM

TABLE OF CONTENTS

9

THIS PAGE BLANK

SECTION 9
BRAKE SYSTEM

TECHNICAL DATA

Front Axle Brakes

Type . . . . Oil-immersed multi-plate disc
Actuation . . . . Hydraulic
Location . . . . Inboard - Axle center casing (2 brake sets)
Friction Plates . . . . 5 per set
Outside Diameter . . . . 8.66 in (220 mm)
Inside Diameter . . . . 7.09 in (180 mm)
Nominal facing area/plate . . . . 19.5 in² (12 616 mm²)
Hydraulic Piston Diameter . . . . 8.5 in (216 mm)
Piston Operation . . . . Standard retraction

Rear Axle Brakes

Type . . . . Oil-immersed multi-plate disc
Actuation . . . . Hydraulic
Location . . . . Outboard - Axle hubs
Friction Plates . . . . 3 per set
Outside Diameter . . . . 8.66 in (220 mm)
Inside Diameter . . . . 7.09 in (180 mm)
Nominal facing area/plate . . . . 19.5 in² (12 616 mm²)
Hydraulic Piston Diameter . . . . 8.5 in (216 mm)
Piston Operation . . . . Standard retraction

Accumulator

Type . . . . Piston, Hydro-pneumatic
Volume . . . . 120.63 cu. in (2632 cu. cm)
Nitrogen Recharge Pressure . . . . 750 ± 40 psi (5171 ± 275 kPa).

Accumulator Charging Valve

Nominal Accumulator Charge Rate . . . . 2.7 ± 0.5 gpm (10.2 ± 1.9 L/min)
Nominal High Limit . . . . 2000 ± 50 psi (13 790 ± 345 kPa)
Nominal Low Limit . . . . 1650 ± 50 psi (11 376 ± 345 kPa)

Priority Flow Control Valve

Priority Flow Set At . . . . 3.25 gpm (12.3 L/min)
Control Pressure . . . . 110 psi (758 kPa)
Relief Valve Setting . . . . 2500 psi (17 237 kPa)

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 and Figure 9-2 consists of the second section of the secondary hydraulic pump, a relief valve included in the priority flow control valve, an accumulator charging valve, a low pressure warning switch, an accumulator, a needle valve, a brake modulating valve, a brake light switch and the front and rear axle service brakes.

Description Of Operation

Hydraulic Pump

The secondary hydraulic pump (Section No. 2) supplies hydraulic oil flow to the priority flow control valve Figure 9-1.

Priority Flow Control Valve

The priority flow control valve in normal operation supplies oil to the accumulator charging valve. If oil is required for the steering operation the priority flow control valve shifts to furnish flow to the steering system. (See Steering System, Section 8) The priority flow control valve also includes the relief valve used to protect the steering and brake systems.

Accumulator Charging Valve

The accumulator charging valve supplies oil to the accumulator on demand. This is accomplished at a preset rate at a selected pressure; neither of which is adjustable.

The flow to the downstream brake modulating valve will be reduced fractionally for a short time when the accumulator is charging. This does not noticeably affect the operation of these components. Full system pressure is available to the downstream components at all times, providing oil delivery and pressure from the pump and relief valve are not impeded.

The accumulator charging flow rates and upper and lower pressure limits are set at the time of manufacture and are not adjustable.

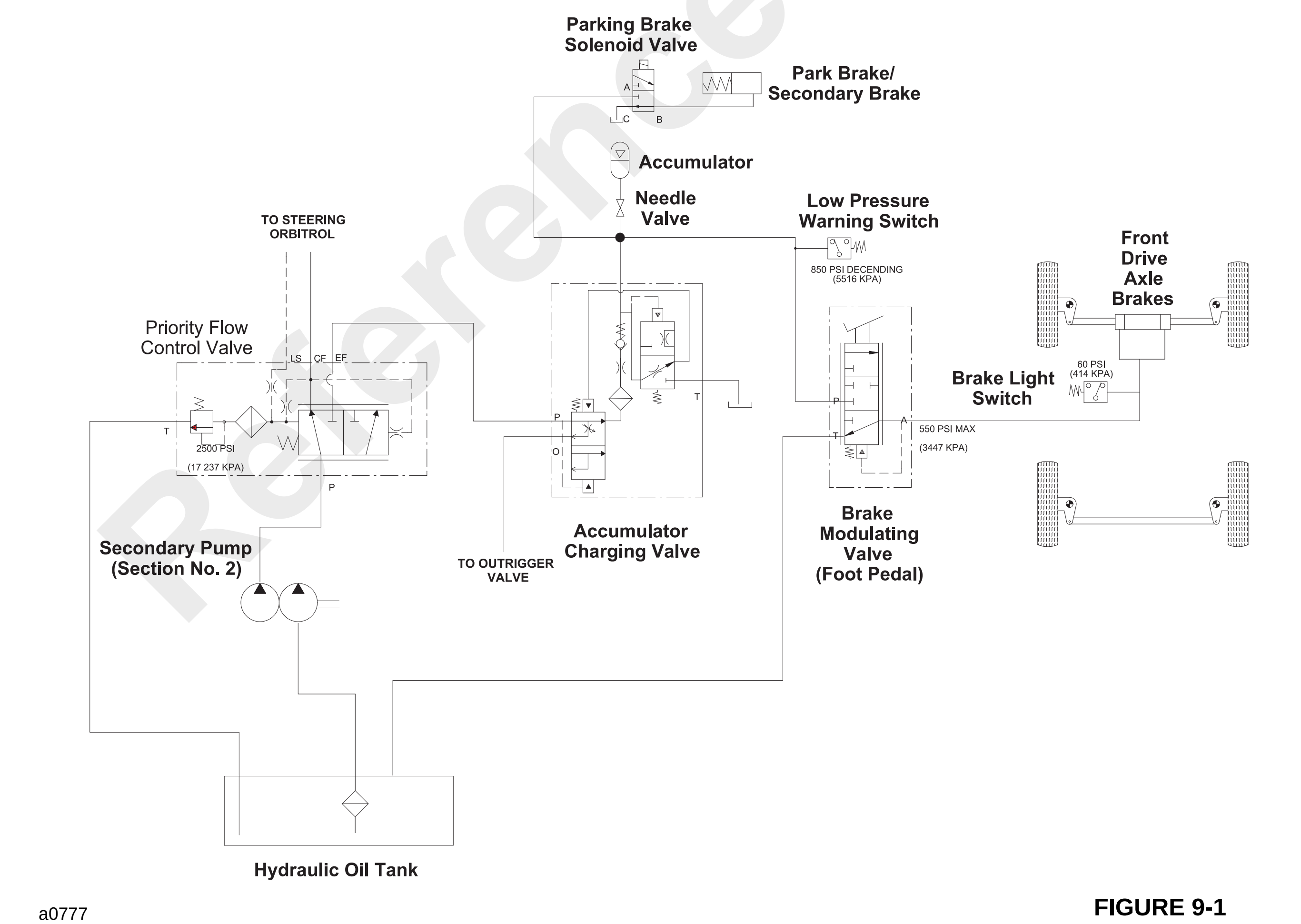


FIGURE 9-1

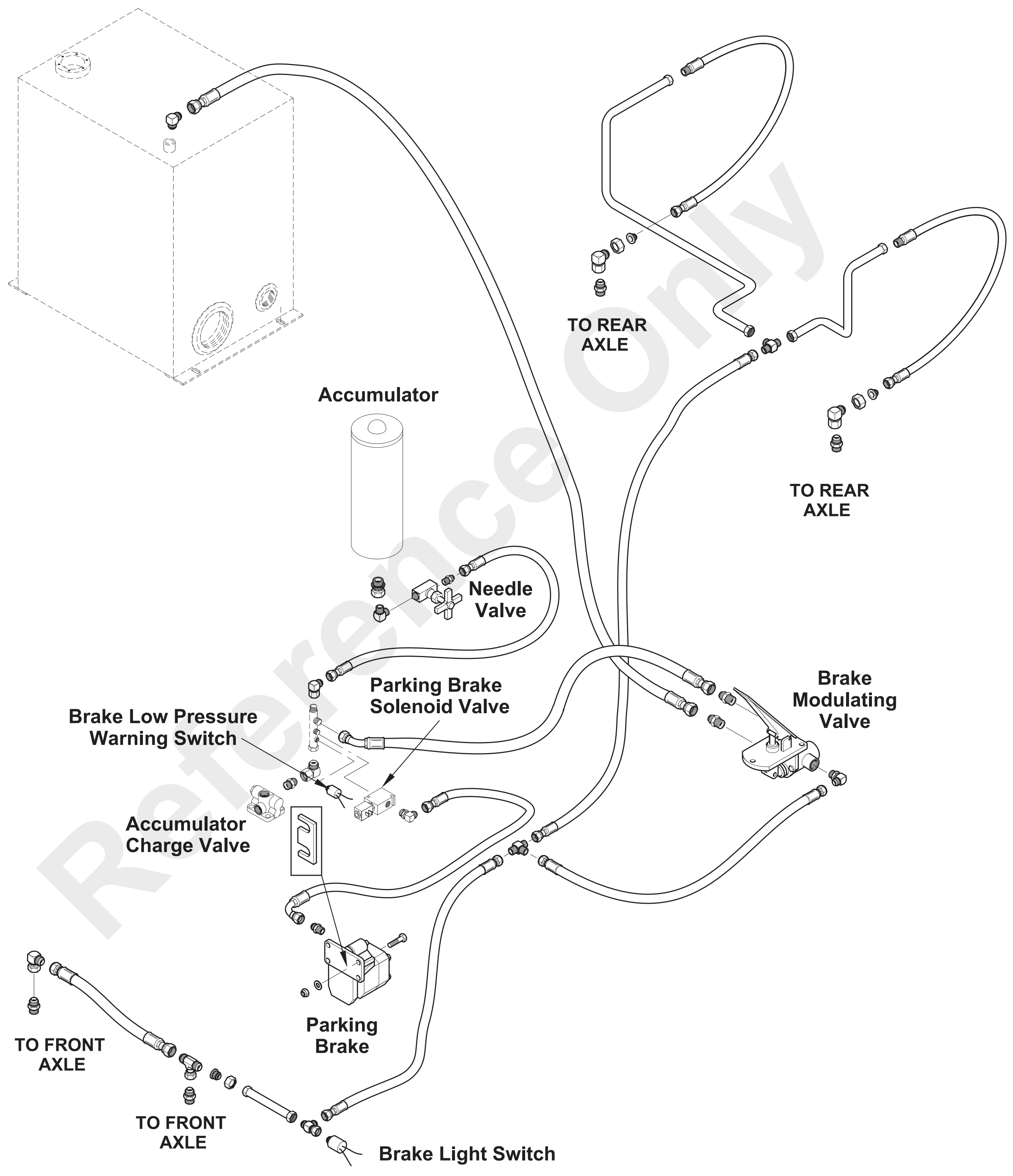

TO REAR
AXLE
Accumulator
TO REAR
AXLE
Needle
Valve
Parking Brake
Solenoid Valve
Brake
Modulating
Valve
Brake Low Pressure
Warning Switch
Accumulator
Charge Valve
Parking
Brake
TO FRONT
AXLE
TO FRONT
AXLE
Brake Light Switch
a1663

FIGURE 9-2

Low Pressure Warning Switch

The low pressure warning switch illuminates a red light on the dash when the brake pressure goes below 850 psi (5861 kPa). 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 2000 psi (13 790 kPa) for brake system usage.

Needle Valve

The needle valve is used during service of the brake system. When closed, It shuts of 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

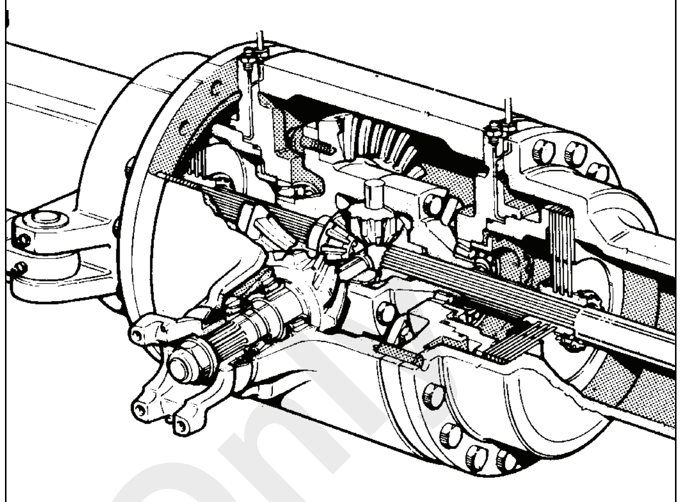
The brake modulating valve is a closed-center spool design. When the valve is in no-applied position, brake port, **A** Figure 9-1 is open to tank port **T**. As the valve is initially actuated, tank port **T** is closed off from brake port **T**. Additional actuation opens pressure port **P** to brake port **A**. More input force will increase the pressure to brake port **A** until actuation effort and hydraulic reaction forces are balanced. When actuation is released, the valve returns to its non-applied position.

Brake Light Switch

The brake light switch illuminates the brake lights when the brake modulating valve builds system pressure to 60 psi (414 kPa).

Front Axle Brakes

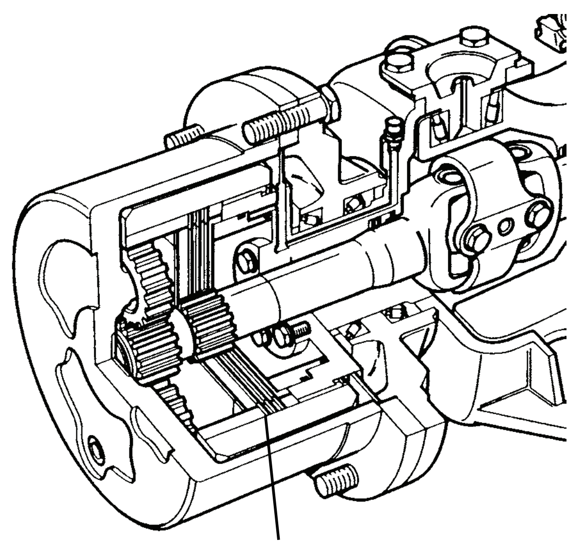
The front brakes are self-adjusting oil immersed and are located on both sides of the axle center housing Figure 9-3. Each brake assembly consists of five friction plates and six counter plates. The brakes are applied when the brake pedal in the operator's compartment is actuated. Brake fluid is forced from the master cylinder through the brake lines to both of axle brakes. The brake fluid under pressure reacts against the brake pistons, forcing the friction plates against the counter plates, slowing and/or stopping the crane.



a0216 FIGURE 9-3

Rear Axle Brakes

The rear brakes are self-adjusting, oil immersed and are located in each axle hub Figure 9-4. Each brake assembly consists of three friction plates and four counter plates. The brakes are applied when the brake pedal in the operator's compartment is actuated. Brake fluid is forced from the master cylinder through the brake lines to both of axle brakes. The brake fluid under pressure reacts against the brake pistons, forcing the friction plates against the counter plates, slowing and/or stopping the crane.



a0217 FIGURE 9-4

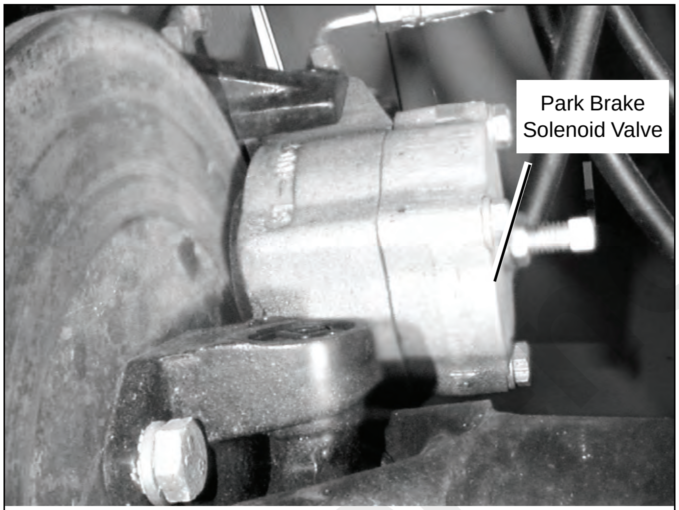
Parking Brake System

Description Of Operation

The parking brake system consists of two-way switch in the instrument panel, a solenoid valve and a parking brake. The system connects into the service brake system and uses the accumulator for system pressure.

Parking Brake

The parking brake is a disc-type brake Figure 9-5. 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.

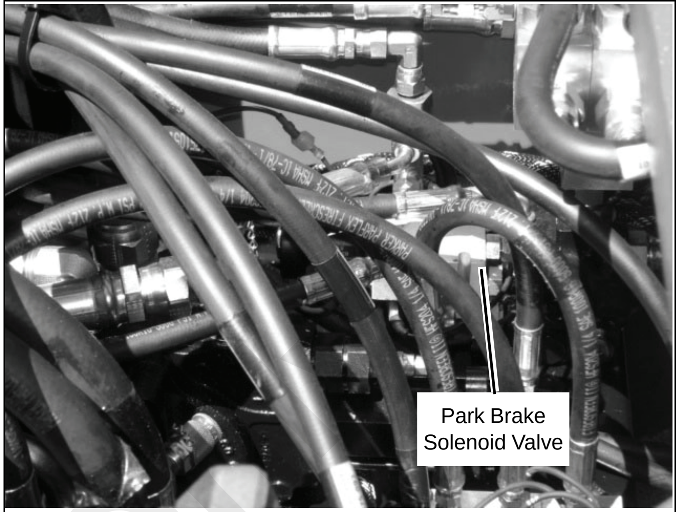


p0329 **FIGURE 9-5**

Parking Brake Solenoid Valve

The parking brake solenoid valve Figure 9-6 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.



p1870 **FIGURE 9-6**

MAINTENANCE AND ADJUSTMENTS

Service Brake Bleeding

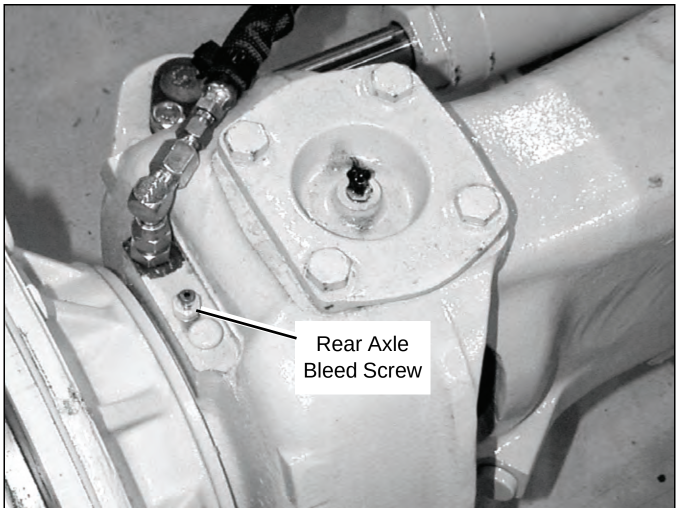
When ever a brake line is disconnected, the brake system must be bled to remove any trapped air. Air in the brake lines will cause the brakes to be spongy.

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.

Rear Axle

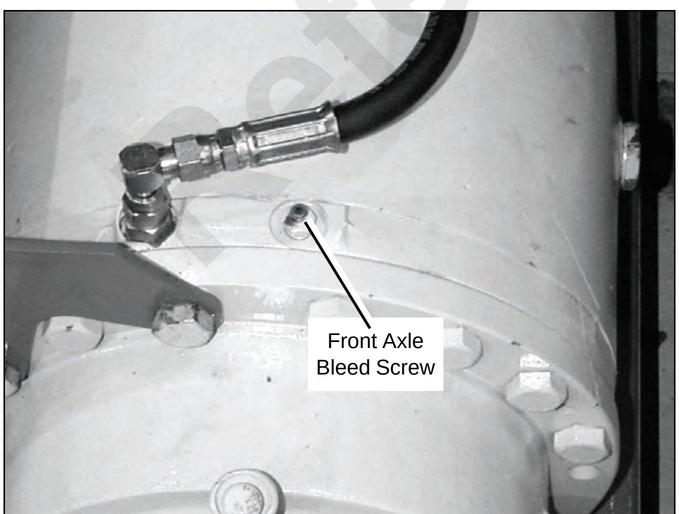
1. Engage the parking brake and shut off the engine. Block the rear wheels on both sides.
2. Attach a tube to the right hand bleed screw **A** Figure 9-7 ensuring that the free end of the tube is immersed in fluid contained in a suitable container.
3. Open the brake bleeder screw and apply full pedal strokes of the brake pedal until all air is expelled.
4. Close the brake bleed screw with the pedal fully depressed.
5. Repeat steps 2 through 4 using the left hand bleed screw.



p0085 **FIGURE 9-7**

Front Axle

1. Engage the parking brake and shut off the engine. Block the rear wheels on both sides.
2. Attach a tube to the one of the wheel bleed screws **A** Figure 9-8 ensuring that the free end of the tube is immersed in fluid contained in a suitable container.
3. Open the brake bleeder screw and apply one rapid stroke of the pedal followed by three rapid short strokes from the pedal half way down. After the third short stroke allow the pedal to return quickly to its stop.
4. Continue bleeding normally until all air is expelled. Close the brake bleed screw with the pedal fully depressed.
5. Repeat steps 2 through 4 for the other side.



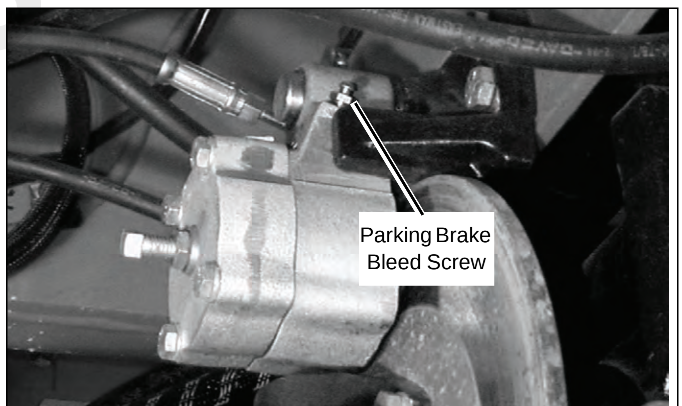
p0086 **FIGURE 9-8**

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 is 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 9-9 and place the other end in a suitable container.
3. Open the bleed screw, then disengage the parking brake.
4. Observe the fluid exiting the hose. When there is no air or fluid being released, close the bleed screw with the parking brake still disengaged.
5. Engage the parking brake.
6. Repeat steps 3-5 as needed until no air is release from the fluid.



p0828 **FIGURE 9-9**

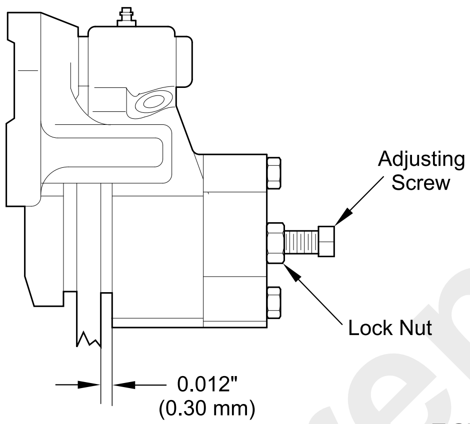
Parking Brake Adjustment

WARNING

Before adjusting the parking brake discs, make sure that the machine is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the adjustment.

When the parking brake is engaged and it will not hold the crane in position it may be necessary to adjust the parking brake disc pads.

1. Shut off the engine and place chock blocks in front and behind all four wheels. Release the parking brake. Check that the brake moves freely on the guide/slide pin.
2. Loosen the lock nut and adjusting screw Figure 9-10.
3. Place a 0.012 in (0,030 mm) 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 9-10

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 750 ± 40 psi (5171 ± 275 kPa).

Residual Brake System Pressure

if residual pressure is greater than the pressure required to overcome the brake retraction springs in the axle, brake piston retraction will jot occur resulting in excessive heat and wear on the brake components,

If the residual pressure in the braking system is above 5 psi (0.35 bar) in the hot condition, the system should be checked to identify the cause of the problem.

NOTE: Pressure cannot build up in the hydraulic tank until the oil is hot, or if the pressure is vented by removing the tank cap/breather.

Checking For Residual Pressure

The following should be done with the engine running and the hydraulic oil at working temperature.

1. Apply and release the brakes. Check that the brakes release immediately.
2. If the brakes do not release immediately, place a container under the axle hub to collect any spilled oil. Unscrew the bleed nipple on the axle to release any residual pressure.

NOTE: The same effort should be needed to rotate the hub with bleed nipple either open or closed. If the problem affects only one hub, disassemble and inspect the affected hub.

3. If the brakes release immediately, residual pressure should be suspected.
4. If the brakes do not release immediately, tighten the bleed nipple and check the following:
   a. Operation of the hydraulic tank breather.
   b. Foot brake valve operation.
   c. Hydraulic tank is overfilled.

TESTS

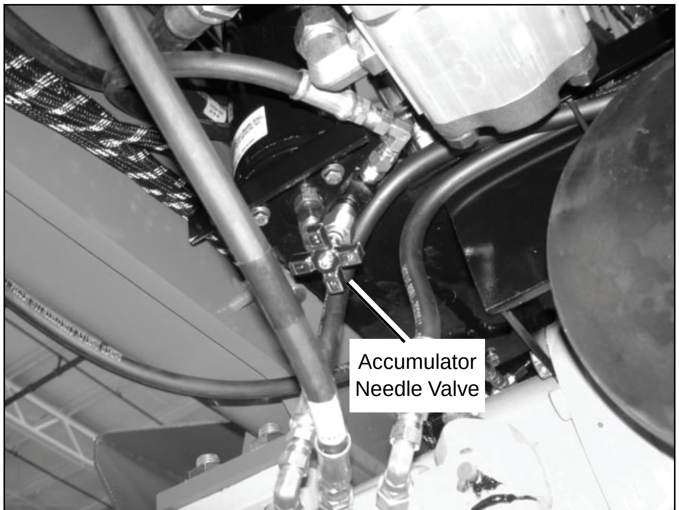
Brake Piston Seal Leakage Test (Front Axle Only)

The following test procedure explains how to check if a brake piston is severely damaged/destroyed or if the seals have a small cut or nick. The test procedure must only be done when the axle is COLD.

NOTE: Before working on the brake system make sure the 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 9-5.

1. With the engine shut off and the parking brake engaged, close the accumulator needle valve Figure 9-11 to shut off hydraulic pressure to the service brakes.

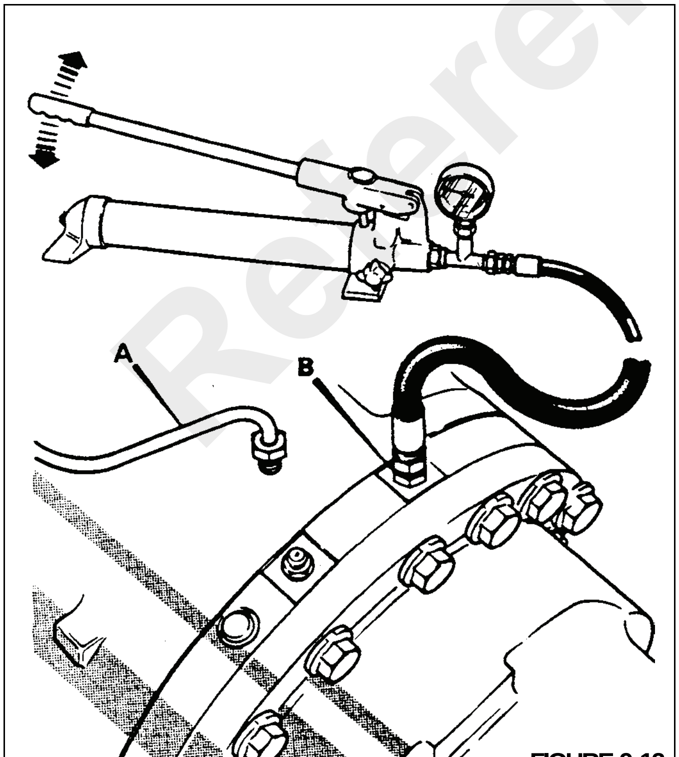


p1871 **FIGURE 9-11**

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 9-12.



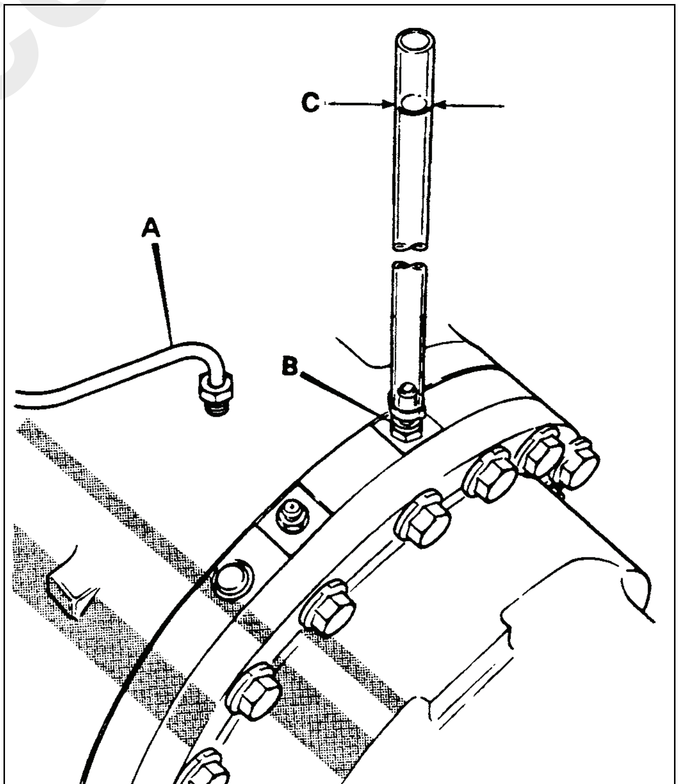
a0222 **FIGURE 9-12**

4. To check for severe piston seal damage:
   a. Fill the housing of hand pump with Mobil fluid 424, or equivalent hydraulic oil.
   b. Install the hand pump fitted with a 0 to 1000 psi (0 to 6890 kPa) pressure gauge to port **B** Figure 9-10.

NOTE: The hand pump MUST be filled with Mobil fluid 424 or equivalent hydraulic oil. System pressure is 550 psi (3790 kPa) DO NOT exceed 600 psi. (4134 kPa).

   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 4.75 in (120 mm) long to the brake piston port **B** Figure 9-13.



a0223 **FIGURE 9-13**

NOTE: The tube must be kept vertical during the test. Use tape to attach the tube to the side of machine.

   b. Fill the tube until is approximately three quarters full with Mobil fluid 424 or equivalent hydraulic oil.

c. Using a suitable pen, mark the level line (**C**) of the fluid in the tube.

d. After approximately 1/2 hour, check if the level has dropped below the original marked line. If it has then check the brake piston seals for slight nicks, cuts or general wear.

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 9-5.

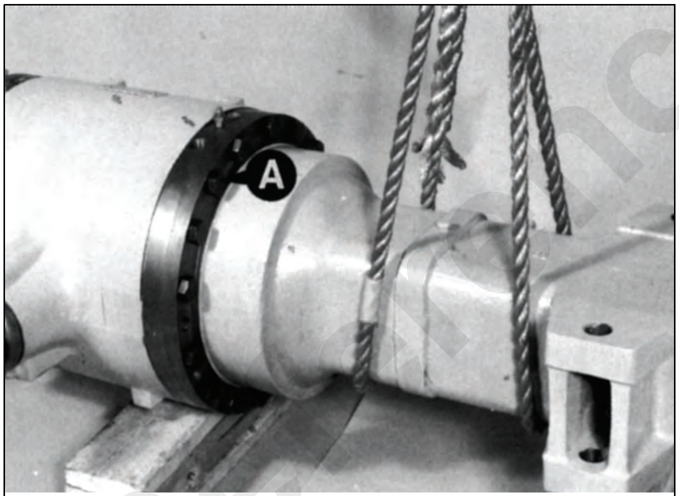
SERVICE BRAKE REPAIR

Front Axle Brakes

NOTE: It is recommended that the axle be removed from the machine when disassembling the front axle brakes. See Servicing the Front Axle in Section 6.

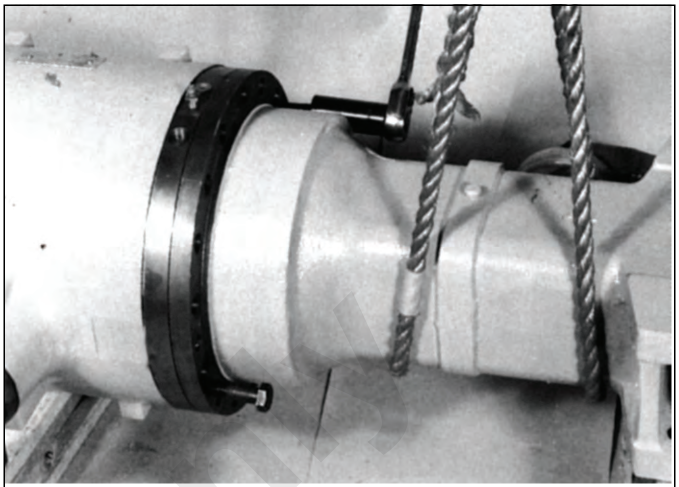
Disassembly

1. Support the axle arm Figure 9-14 and remove bolts **A**.



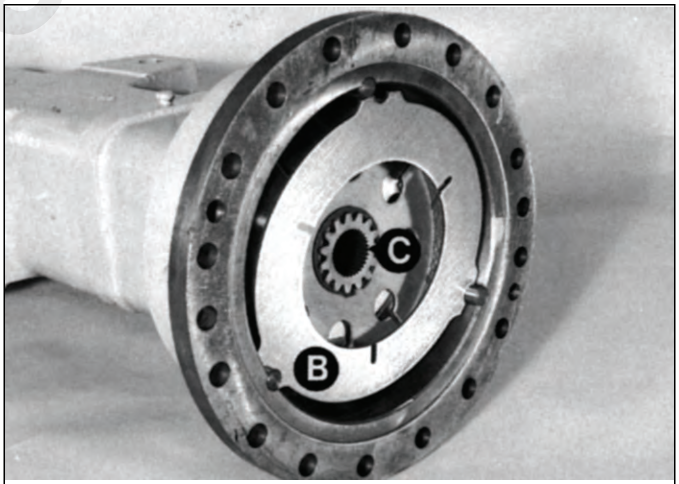
p0088 **FIGURE 9-14**

2. Jack the axle arm off the drive head, using drive head securing bolts Figure 9-15. Remove all traces of gasket from the mating surfaces.



p0089 **FIGURE 9-15**

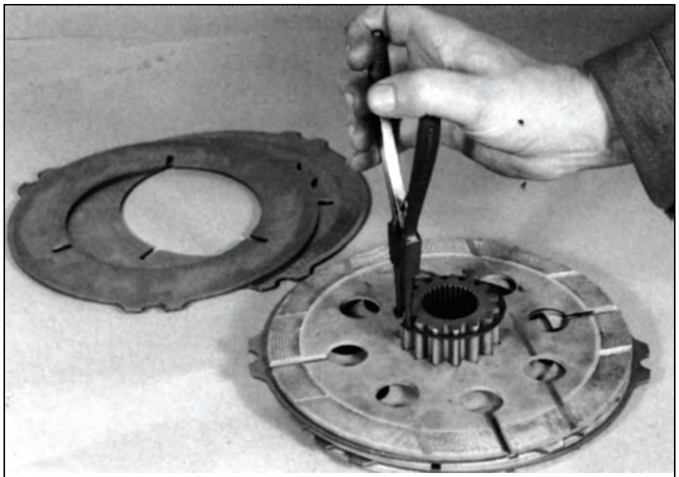
3. There are two counterplates **B** Figure 9-16 one at each end of the brake pack, which are secured to the plate carrier **B**. If the plates are to be reused, note their position and which way round they are then remove the brake pack.



p0090 **FIGURE 9-16**

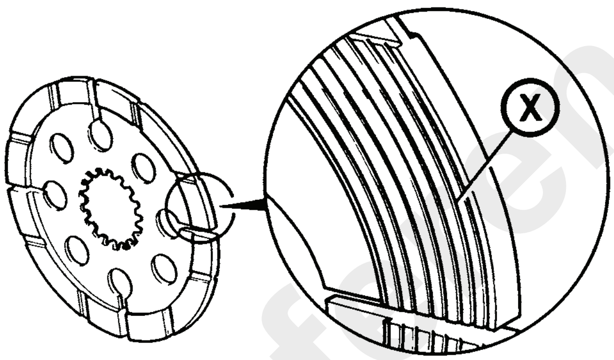
4. Remove the retaining ring Figure 9-17. If the brake pack is to be reused, note the position of the plates before removing them.

NOTE: The planet carrier has an internal chamber at the end which faces away from the drive head.



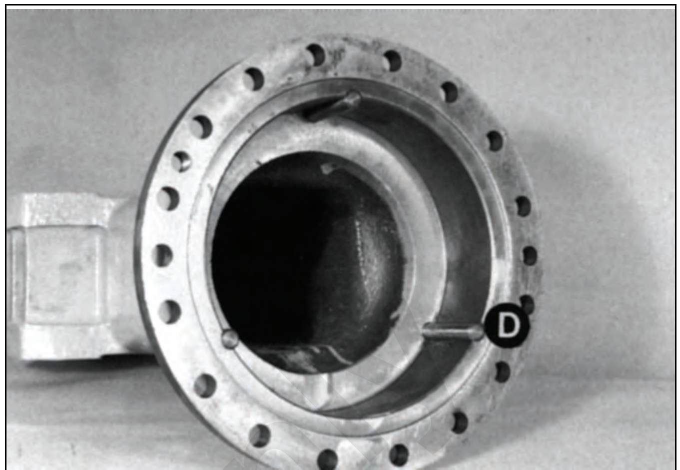
p0091 FIGURE 9-17

5. Wear limit of friction plates is to the depth of the circumferential grooves **X** Figure 9-18. Check all plates for flatness and damage. (Some scoring of the counterplates is normal.) Completely replace the brake pack if worn or damaged. Do not replace individual plates.



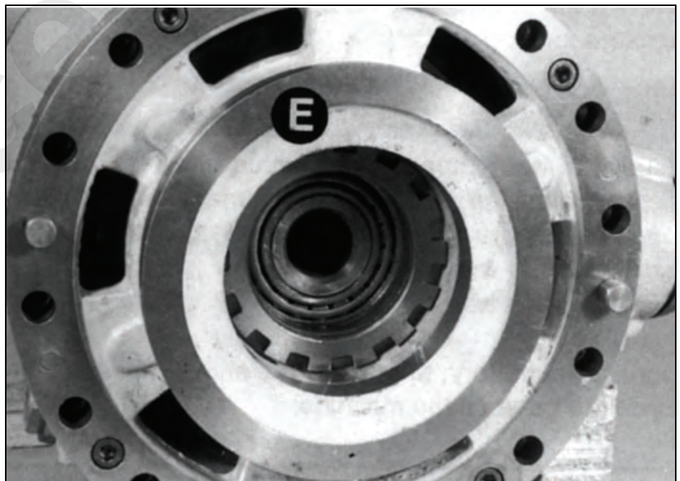
a0228 FIGURE 9-18

6. Remove the three reaction pins **D** Figure 9-19. Inspect for damage.



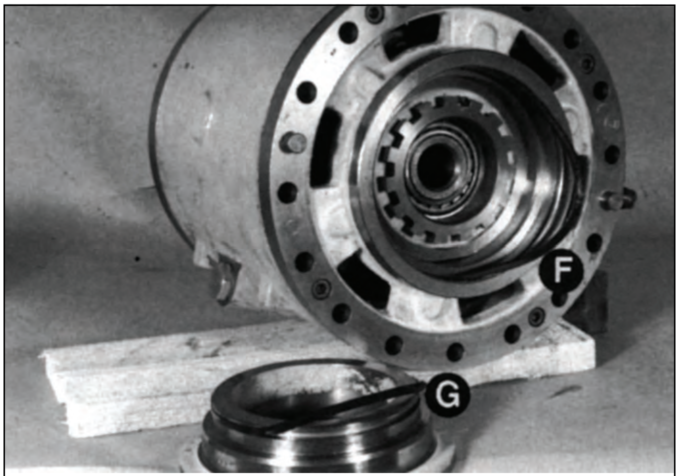
p0092 FIGURE 9-19

7. Carefully remove brake piston **E** Figure 9-20 from its housing, if removal is necessary. A hydraulic hand pump can be used to force the piston out of the housing.



p0093 FIGURE 9-20

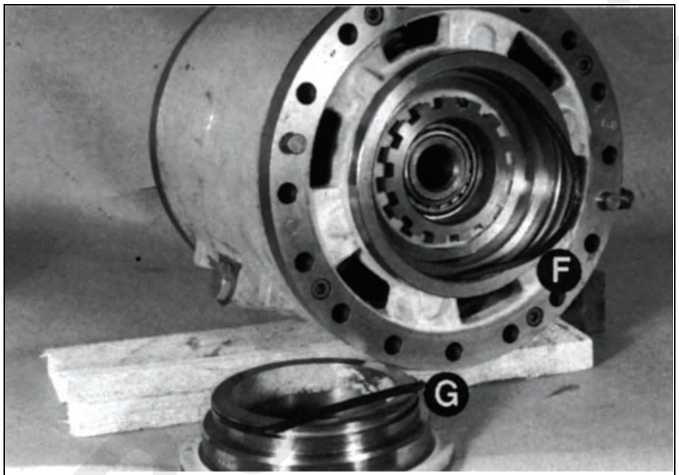
8. Remove and discard seals **F** and **G** Figure 9-21. Inspect the housing for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.



p0094 **FIGURE 9-21**

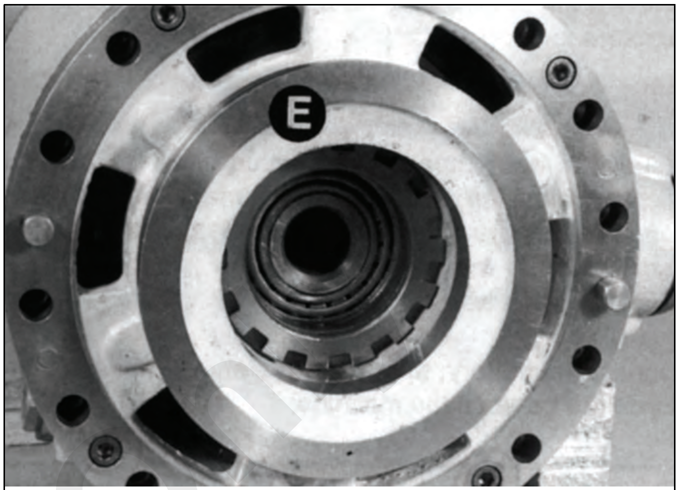
Assembly

1. Install new seals **F** and **G** Figure 9-22. Make sure they seat squarely in their grooves.



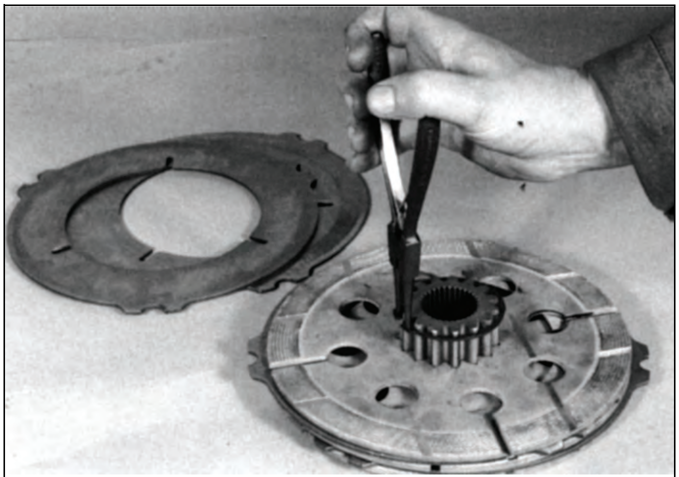
p0094 **FIGURE 9-22**

2. Carefully press piston **E** Figure 9-23 all the way into its housing.



p0093 **FIGURE 9-23**

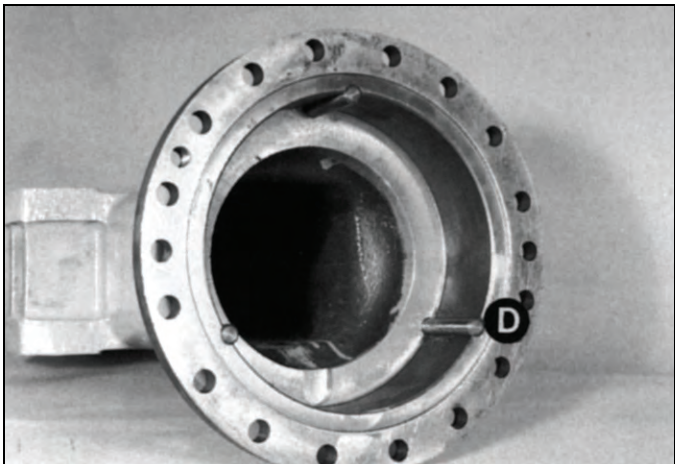
3. Assemble the friction plates and counterplates onto the carrier. If the original brake pack is being reused, return the plates to their original positions (see Disassembly step 3). Soak new friction plates in gear oil before assembly. Install retaining ring Figure 9-24.



p0091 **FIGURE 9-24**

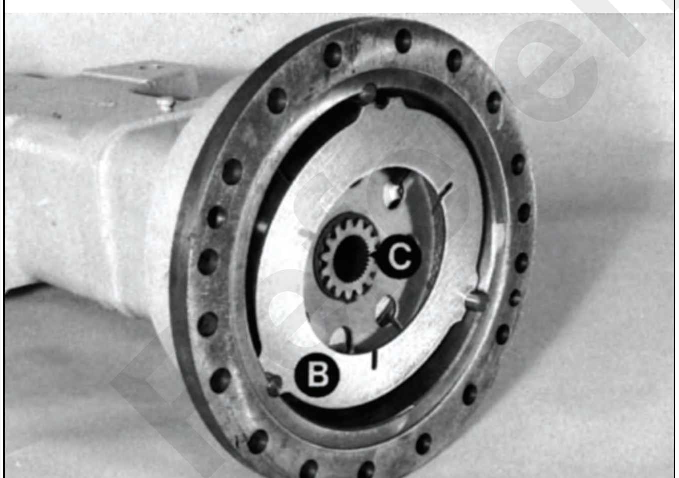
9

4. Locate the three reaction pins **D** Figure 9-25 into their grooves, securing them with grease. Push the pins fully into their location holes in the housing.



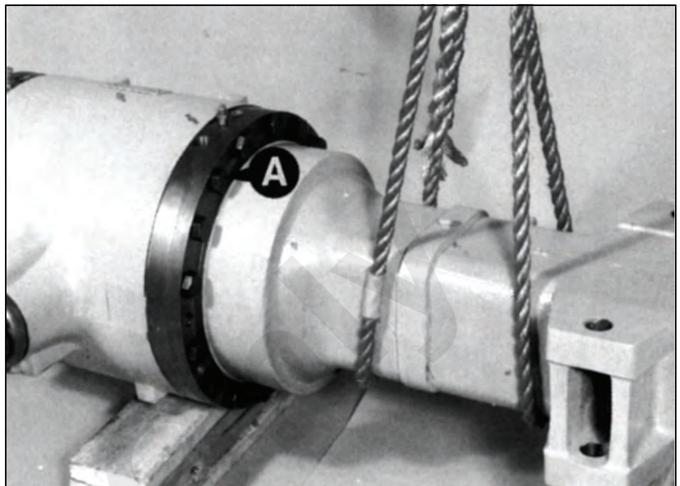
p0092 **FIGURE 9-25**

5. Install one counterplate **B** Figure 9-26 into the housing, then the brake pack, then the other counterplate. Ensure that the chamfered end of the brake carrier **C** faces away from the drive head. Return reused counterplates to their original positions. Push the brake pack fully home.



p0090 **FIGURE 9-26**

6. Apply Loctite 275 to the mating face of the drive head. Locate the axle arm onto the drivehead, with the embossed word “TOP” on the axle arm up most.



p0088 **FIGURE 9-27**

7. Install bolts **A** Figure 9-27 and tighten to a torque of 178 lb-ft (244 Nm).

NOTE: Check the grade of bolts installed. Grade 8.8 should be tightened to a torque of 178 lb-ft (244 Nm). Grade 12.9 bolts should be tightened to a torque of 295 lb-ft (400 Nm).

8. Fill the axle with recommended lubricant. See Section 3, Preventive Maintenance.

9. Install the axle to the crane’s frame. Refer to Section 6.

Rear Axle Brakes

Refer to Section 6 for Axle Hub Assembly Service. The service instructions include disassembly, replacement and assembly of the rear axle brakes.

PARKING BRAKE REPAIR

Lining Kit Replacement

WARNING

Before replacing the parking brake linings, make sure that the 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: The new linings must be kept free of grease, oil, etc.

The lining kit is indicated in Figure 9-28 with a ■ symbol.

1. Close the needle valve located under the accumulator Figure 9-11. 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 9-28 and back off adjusting bolt **7**.
5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake.
6. Separate the mounting bracket assembly **31** from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the clearance slot facing straight up.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

8. Remove two screws **27** through access holes in housing **26**. Using a thin blade tool, pry lining **25** from housing **26** and remove the lining and two bushings **24** through the disc clearance slot.
9. Rotate lining assembly **22** until screws **21** are aligned with the access holes in housing **26**. Remove the two flat head screws **21**. Pry lining **20** from piston **19** and remove the lining through the disc clearance slot.
10. Install new lining **20** into piston **19** through the disc clearance slot. Install new flat head screws **21** and tighten to a torque of 30-40 lb-in (3,.4 - 4,5 Nm).
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 22-28 lb-in. (2,5 - 3,2 Nm).
12. Assemble the brake assembly onto mounting bracket **31**. Install the parking brake assembly onto the frame of the crane. Attach the hydraulic hose.
13. Adjust the lining clearance as described on page 9-6.
14. Open the accumulator needle valve and then bleed air from the system as described on page 9-5.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

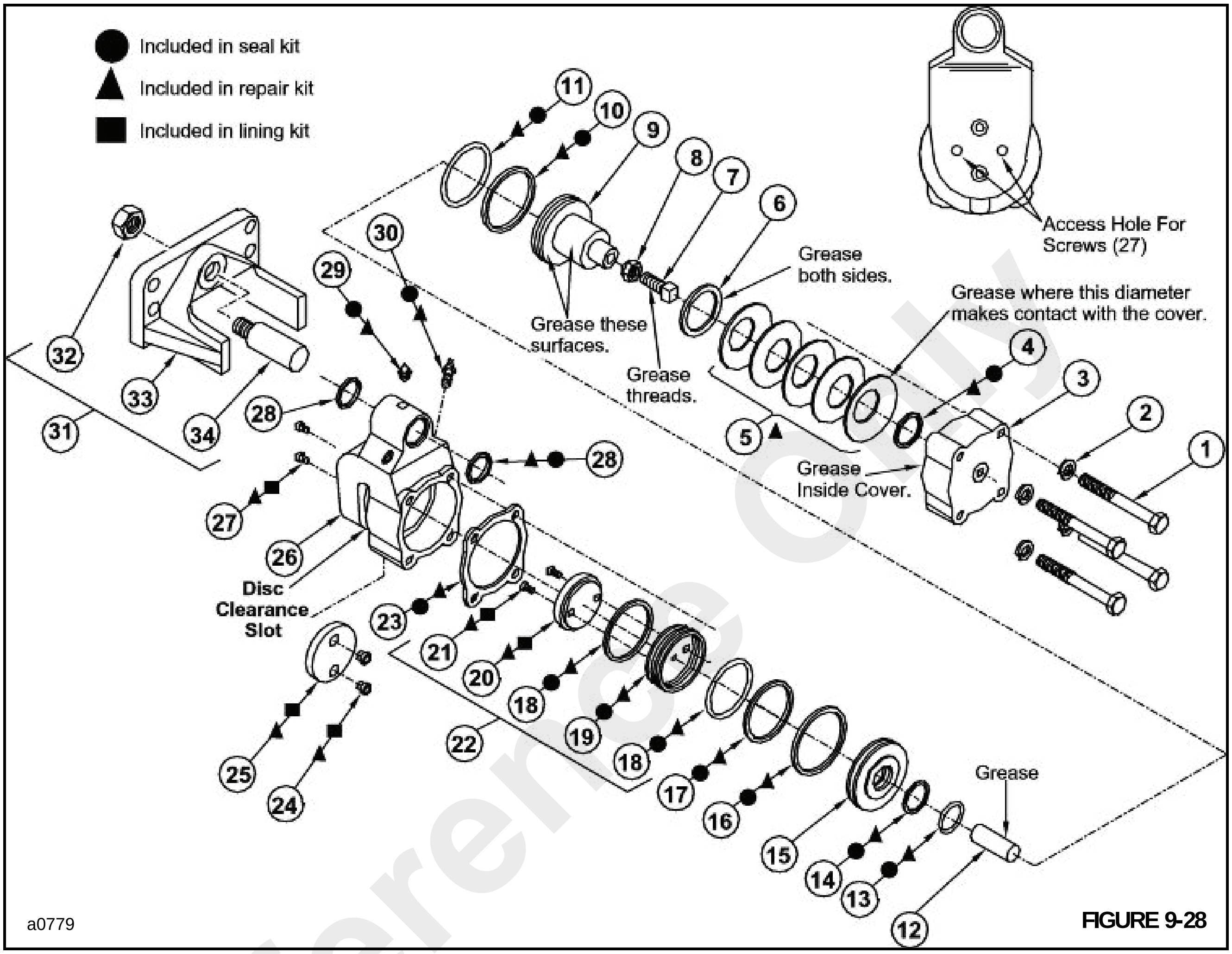


FIGURE 9-28

Item	Description	Qty	Item	Description	Qty
1	Capscrew	4	18	O-ring	2
2	Lockwasher	4	19	Piston	1
3	Cover	1	20	Lining	1
4	Seal	1	21	Screw	2
5	Belleville Springs	1	22	Lining Assembly	1
6	Washer	1	23	Gasket	1
7	Adjusting Bolt	1	24	Bushing	1
8	Lock Nut	1	25	Lining	1
9	Piston	1	26	Housing	1
10	Back Ring	1	27	Screw	2
11	O-Ring	1	28	Seal	2
12	Push Rod	1	29	Grease Zerk	1
13	O-Ring	1	30	Bleeder Screw	1
14	Backup Ring	1	31	Mounting Bracket Assy	1
15	Piston	1	32	Nut	1
16	O-Ring	1	33	Bracket	1
17	Backup Ring	1	34	Pin	1

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 9-28 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.

NOTE: The new linings must be kept free of grease, oil, etc.

1. Close the needle valve located under the accumulator Figure 9-11. 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 9-28 and back off adjusting bolt **7**.
5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake assembly.
6. Separate the mounting bracket assembly **31** from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the cover **3** in a vertical position.

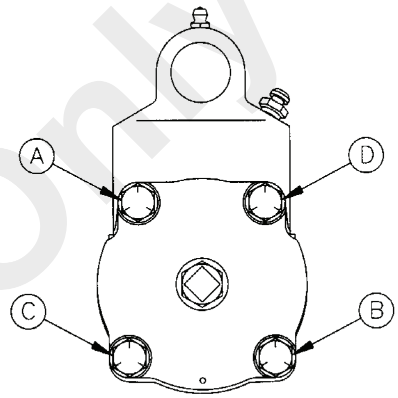
NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

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

WARNING

Cap (3) is under spring pressure. Use care when removing the cap to prevent personal injury.

10. Loosen but do not remove four capscrews **1**. Loosen screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-29 until spring pre-load is released.



a0783

FIGURE 9-29

11. Remove capscrews **1** Figure 9-28, lockwashers **2**, cover **3** and gasket **23**. Using a thin blade screw driver, remove seal **4** from cover **3**.
12. Remove belleville springs **5** and if present, washer **6**. When removing the belleville springs take note of the stacking sequence.
13. Remove piston **9** from housing **26** bore. Remove o-ring **11** and backup ring **10** from the piston. Push rod **12** should also come out with piston **9**.
14. Remove piston **15** from housing **26** bore. Remove o-rings **13** and **16** and backup rings **14** and **17** from piston **15**.
15. Remove lining and piston assembly **22** from housing **26** bore. Holding assembly on a flat surface, separate lining **20** and piston **19** by removing two flat head screws **21**. Remove o-rings **18** from piston **19**.
16. Loosen vice jaws and rotate the brake so that the disc clearance slot is facing upward. Remove pan head screws **27**, lining **25** and bushings **24** from housing **26**.
17. Lubricate all rubber components (NOT THE BRAKE LININGS) in clean hydraulic oil. Use the same type as used in the hydraulic system.
18. Clean all parts (EXCEPT LININGS) and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the

hydraulic system. Keep all parts free of contaminants, dirt and debris.

NOTE: Coat the surfaces indicated Figure 9-28 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

19. Install new lining **25** Figure 9-28 in housing **26** using new bushings **24** and pan head screws **27**. Tighten the screws to 22-28 lb-in. (2,5 - 3,3 Nm).

20. Install new lining **20** on piston **19** using new flat head screws **21**. Tighten screws to a torque of 30-40 lb-in (3,4 - 4,5 Nm). 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 9-15 lb-ft (12,2 - 20,3 Nm).

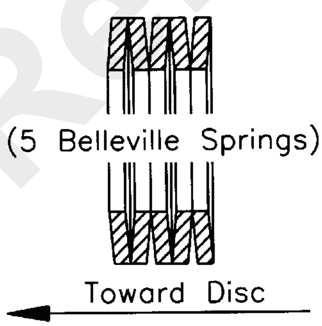
23. Install new o-rings **13** and **16** and new backup rings **14** and **17** on piston **15**. Be sure they are installed in the correct order.

24. Install piston **15** into housing **26** bore. Be sure piston is installed in the correct direction. Be careful not to pinch the o-rings on the inlet ports.

25. Install new backup ring **10** and new o-ring **11** on piston **9**. Be sure they are installed in the proper order. Install push rod **12** in bore of piston **9**. Install piston into housing **26** bore.

26. Fully lubricate the threads of adjusting screw **7** and lock nut **9** and install into cover **3**.

27. Install washer **6**, if used, and new belleville springs **5** over end of piston **9**. Follow the stacking sequence Figure 9-30.



a0782

FIGURE 9-30

28. Install new seal **4** in cover **3**. Be sure inside of cover is coated with grease.

29. Install new gasket **23**, cover **3**, lockwashers **2** and capscrews **1**. Tighten the screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-29. When installed, tighten each screw to a torque of 22-27 lb-ft (29,8 - 36,6 Nm).

30. Assemble the brake assembly onto the mounting bracket **31**.

31. Install the parking brake assembly onto the frame of the crane.

32. Attach the hydraulic hose.

33. Adjust the lining clearance as described on page 9-6.

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

Seal Kit Installation

The parking brake has a seal kit available. It includes all the parts necessary to replace all the seals in the brake These parts are indicated in Figure 9-28 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 backup rings be careful not to scratch or mar the pistons.

NOTE: The linings must be kept free of grease, oil, etc.

1. Close the needle valve located under the accumulator Figure 9-11. 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 9-28 and back off adjusting bolt **7**.

5. Remove the bolts and nuts used to fasten the brake mounting bracket to the crane. Remove the parking brake assembly.
6. Separate the mounting bracket **31** from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the cover **3** in a vertical position.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

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

WARNING

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** Figure 9-29 until spring pre-load is released.
10. Remove capscrews **1** Figure 9-28, lockwashers **2**, cover **3** and gasket **23**. Using a thin blade, remove seal **4** from cover **3**.
11. Remove belleville springs **5** and if present, washer **6**. When removing the belleville springs take note of the stacking sequence.
12. Remove piston **9** from housing **26** bore. Remove o-ring **11** and backup ring **10** from piston. Push rod **12** should also come out with piston **9**.
13. Remove piston **15** from housing **26** bore. Remove o-rings **13** and **16** and backup rings **14** and **17** from piston **15**.
14. Remove lining and piston assembly **22** from housing **26** bore. Remove o-rings **18** from the lining and piston assembly.
15. Lubricate all rubber components in clean hydraulic oil. Use the same type as used in the hydraulic system. Keep The Linings Free Of Oil, Grease And Solvents.
16. Clean all parts and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the hydraulic system. Keep all parts free of contaminants, dirt and debris.

NOTE: Coat the surfaces Figure 9-28 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

17. Install new o-rings **18** on lining and piston assembly **22** and insert the assembly into housing **26** bore.
18. Carefully install two new seals **28** in housing **26**. Be sure to install the seals the same direction as they were removed.
19. Install new o-rings **13** and **16** and new backup rings **14** and **17** on piston **15**. Be sure they are installed in the correct order.
20. Install piston **15** into housing **26** bore. Be sure piston is installed in the correct direction. Be careful not to pinch the o-ring on the inlet ports.
21. Install new backup ring **10** and new o-ring **11** on piston **9**. Be sure they are installed in the proper order. Install push rod **12** in bore of piston **9**. Install piston into housing **26** bore.
22. Fully lubricate the threads of adjusting screw **7** and lock nut **8** and install into cover **3**.

NOTE: Completely lubricate belleville springs with a light coat of Lithium Base, E.P. No. 2 bearing grease.

23. Install washer **6**, if used, and belleville springs **5** over end of piston **9**. Follow the stacking sequence Figure 9-30.
24. Install new seal **4** in cover of **3**. Be sure inside of cover is coated with grease.
25. Install new gasket **23**, cover **3**, lockwashers **2** and capscrews **1**. Tighten the screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-29. When installed, tighten each screw to a torque of 22-27 lb-ft (29,8 - 36,6 Nm).
26. Assemble the brake assembly onto the mounting bracket **31**.
27. Install the parking brake assembly onto the frame of the crane.
28. Attach the hydraulic hose.
29. Adjust the lining clearance as described on page 9-6.
30. Open the accumulator needle valve and then bleed air from the system as described on page 9-5.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

BRAKE MODULATING VALVE REPAIR

Removal

WARNING

A raised and badly supported 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 Figure 9-11.
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 9-31.
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 indicates with a ● in Figure 9-31.

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 9-31 with clean hydraulic oil and carefully slide into plug end of housing **12**.

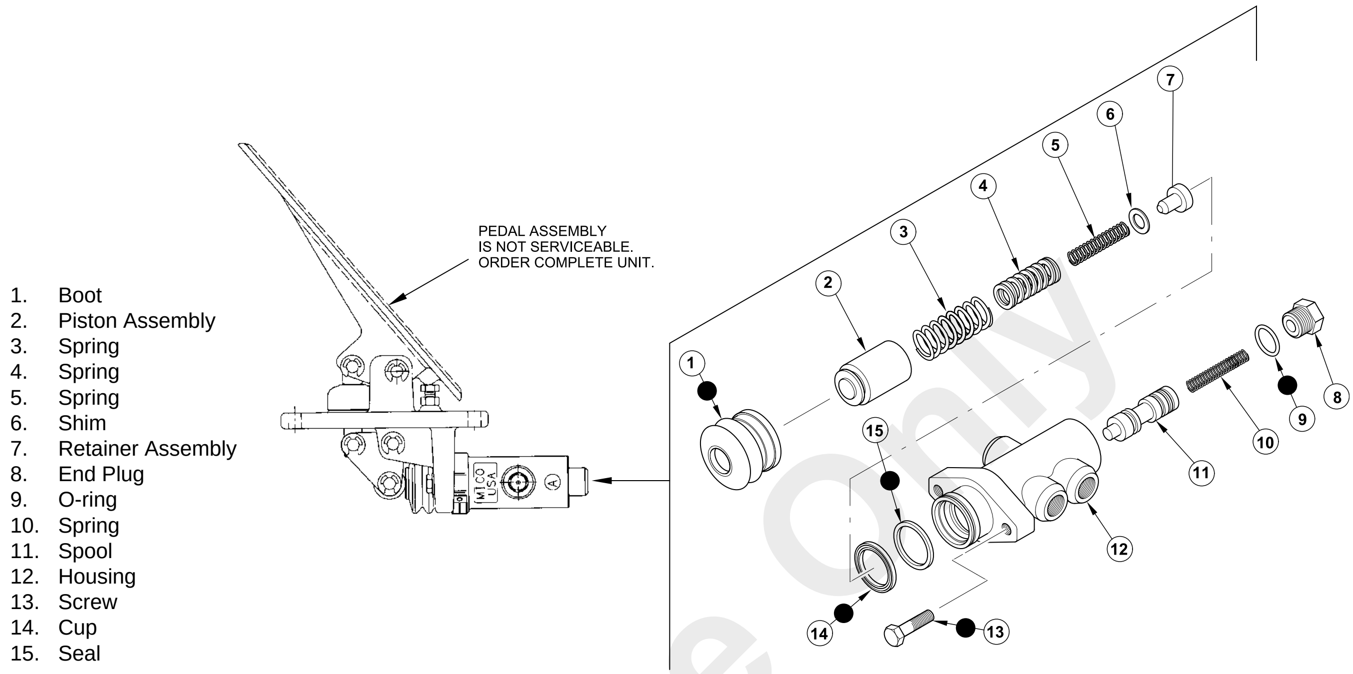
NOTE: The spool must slide freely into the bore. If either part is damaged, a new valve assembly may be required.

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 40 - 50 lb-ft (54.2 - 67.8 Nm).
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 18 - 22 lb-ft (24,4 - 29,8 Nm).
10. After final assembly, the valve must develop a pressure of 550 ± 50 psi (3792 ± 345 kPa).

Installation

1. Place the brake modulating valve and pedal assembly in location in the operator's cab. Secure to the cab floor with three capscrews and self-locking nuts.
2. Connect the three hydraulic hoses to the valve.
3. Open the accumulator needle valve and then start the engine. Allow pressure to build in the brake system.
4. Bleed air from the brake system. See page 9-5.

Published 10-21-2010, Control# 198-04



Brake Modulating Valve

FIGURE 9-31

TROUBLESHOOTING

Service Brakes

PROBLEM	POSSIBLE CAUSE	REMEDY
Warning light on instrument panel illuminates.	**1.** Loss of brake pressure.	**1.** Any cause under NO BRAKES.
No brakes.	**1.** Faulty brake modulating valve.	**1.** Repair or replace.
	2. Faulty priority flow control valve.	**2.** Replace.
	3. Loss of fluid from broken line, loose fitting of hose.	**3.** Check all circuit lines, hoses and fittings. Tighten or replace.
	4. Leakage past both brake pistons.	**4.** Perform leakage test.
	5. Faulty pump section.	**5.** Replace pump.
	6. Faulty accumulator charging valve.	**6.** Replace valve.
Bad brakes (pedal fully applied, crane gradually stops).	**1.** Severe wear in service brake discs.	**1.** Replace brake discs. See Section 6.
	2. Leakage past one brake piston.	**2.** Perform leakage test. Repair or replace. See Section 7.
Soft brake pedal.	**1.** Air in system.	**1.** Bleed brake system.
	2. High pressure leaks - external.	**2.** Apply full brake pressure, inspect for leakage in lines, hoses and fittings.

PROBLEM	POSSIBLE CAUSE	REMEDY
Charging valve actuates every time foot pedal is pressed.	**1.** Accumulator needle valve closed. **2.** Loss of nitrogen in accumulator. **3.** Insufficient hydraulic pressure in accumulator.	**1.** Open needle valve. **2.** Charge accumulator. **3.** Faulty accumulator charging valve. Replace.
Parking brake will not release.	**1.** Faulty solenoid valve. **2.** Loss of fluid from broken line, loose fitting or hose. **3.** Faulty priority flow control valve. **4.** Faulty parking brake switch. **5.** Loose electrical connections. **6.** Faulty pump section.	**1.** Replace solenoid valve. **2.** Check all circuit lines, hoses and fittings. Tighten or replace. **3.** Replace. **4.** Replace switch. **5.** Check and tighten. **6.** Replace pump.
_Parking brake will not hold.	**1.** Improperly adjusted parking brake. **2.** Severely worn brake linings. **3.** Faulty parking brake assembly.	**1.** Adjust brake lining clearance. **2.** Replace brake linings. **3.** Repair or replace.

Published 10-21-2010, Control# 198-04

SECTION 10
STEERING SYSTEM

TABLE OF CONTENTS

THIS PAGE BLANK

SECTION 10
STEERING SYSTEM

UNITS WITHOUT RETURN-TO-CENTER STEERING

TECHNICAL DATA

Rated pump output . . . . 16 gpm at 2500 rpm (20,8 l/min at 2500 rpm)

Relief valve setting . . . . 2500 ±50 psi at 2500 rpm (17 225 ± 345 kPa at 2500 rpm)

DESCRIPTION

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

- Two-wheel steering
- Four-wheel steering
- Crab steering

Two-Wheel Steering

During two-wheel steering, the rear wheels steer in the opposite direction that the steering wheel turns. The front wheels remain in a fixed forward position.

When turning to the right Figure 10-1, hydraulic oil under pressure from the steering pump flows to the steering orbitrol in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbitrol to port C1 of the rear steering solenoid valve. The rear steering solenoid valve is not energized in two-wheel steer mode, therefore the hydraulic oil flows out Port V1 to the rod end of the left rear steering cylinder and the base end of the right rear steering cylinder. The left cylinder rod retracts and the right cylinder rod extends, turning the rear wheels to make a right turn. Return oil from the rear steering cylinders flows back to tank through Ports V2 and C2 of the rear steering solenoid valve, Ports C2 and V1 of the front steering solenoid valve, Ports L and OUT of the steering orbitrol.

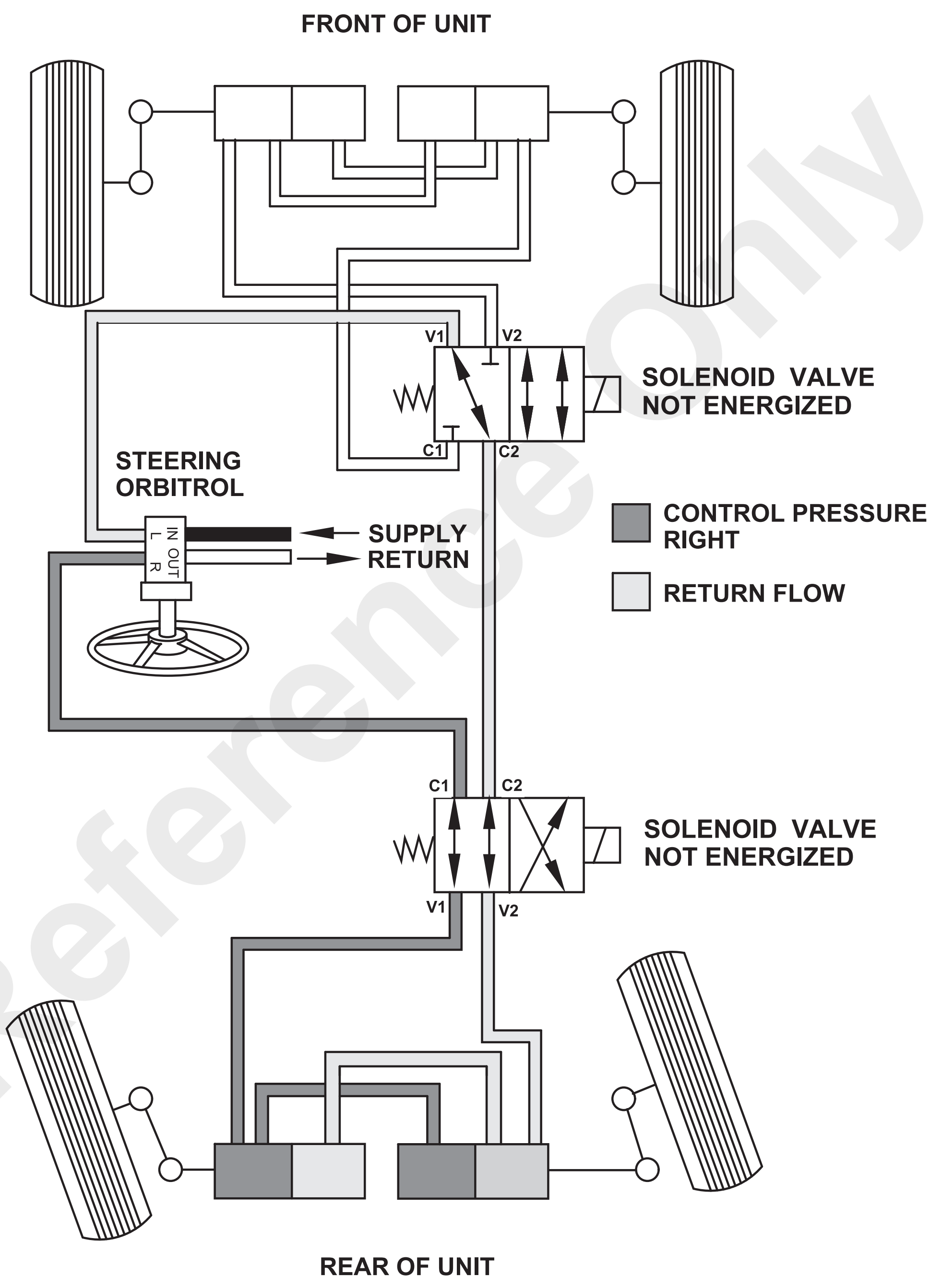
Four-Wheel Steering

During four-wheel steering, the front wheels steer in the direction that the steering wheel is turned, while the rear wheels turn in the opposite direction. This mode provides an extremely short turning radius. It allows the rear wheels to follow the track of the front wheels, which is an advantage in muddy or sandy conditions.

When turning to the right Figure 10-2, hydraulic oil under pressure from the steering pump flows to the steering orbitrol in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbitrol to port C1 of the rear steering solenoid valve. The rear steering solenoid valve is not energized in four-wheel steer mode, therefore the hydraulic oil flows out Port V1 to the rod end of the left rear steering cylinder and the base end of the right rear steering cylinder. The left cylinder rod retracts and the right cylinder rod extends, turning the rear wheels to make a right hand turn. Oil under reduced pressure from the rear steering cylinders flows back through Ports V2 and C2 of the rear steering solenoid valve to Ports C2 of the front steering solenoid valve. In four-wheel steer mode, the front steering solenoid valve is actuated and oil flows through Ports C2 and V2 to the rod end of the left front steering cylinder and the base end of the right front steering cylinder. The left front cylinder rod retracts while the right front cylinder rod extends, turning the wheels to make a right turn. Return oil from the steering cylinders flows back to tank through Ports C1 and V1 of the front steering solenoid valve and Ports L and OUT of the steering orbitrol.

Crab Steering

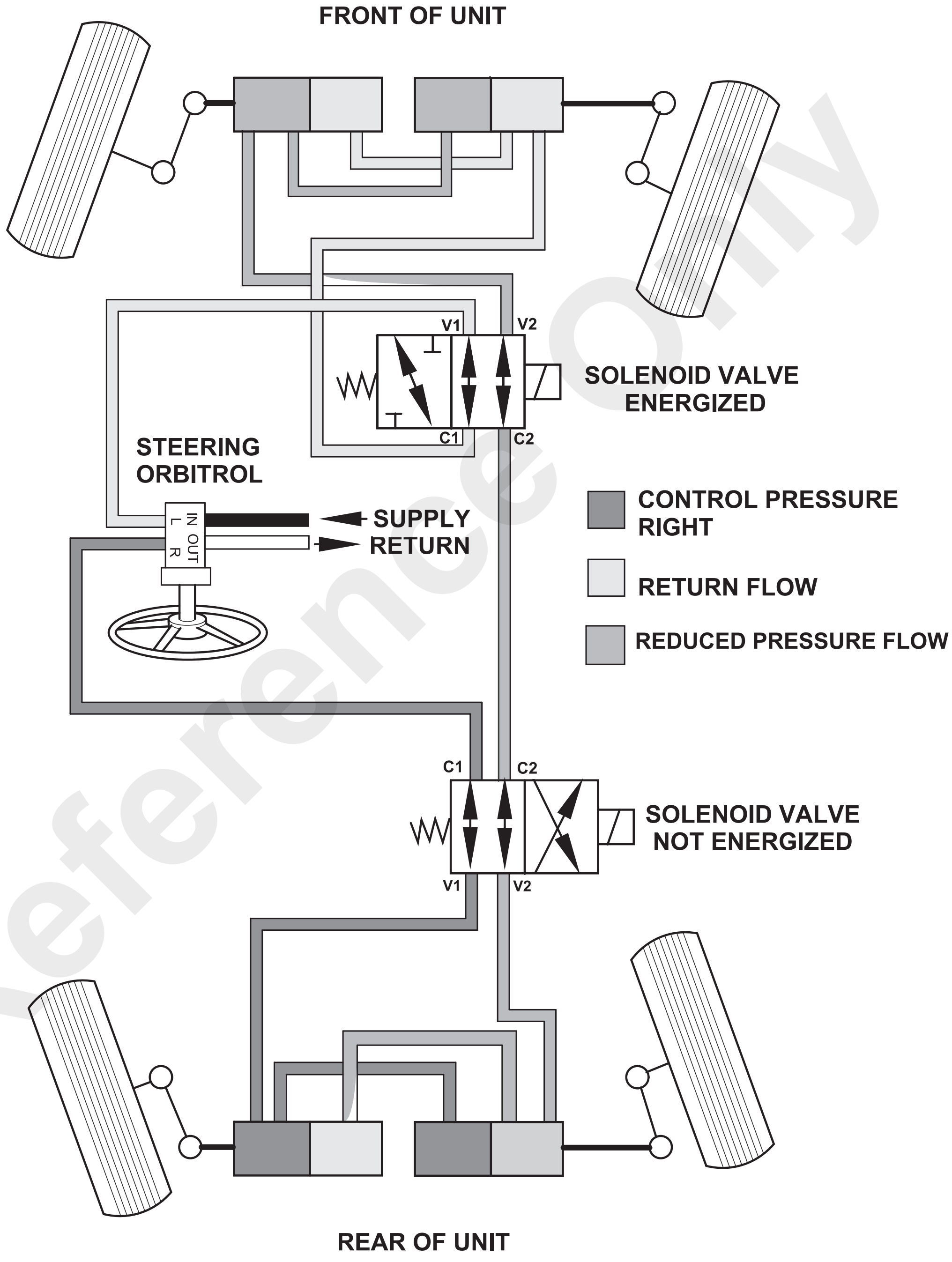
During crab steering all the wheels steer in the same direction. This mode allows the operator to move the machine sideways. This is especially helpful in tight areas on the job.



a0323

Right Turn in 2 Wheel Steer Mode

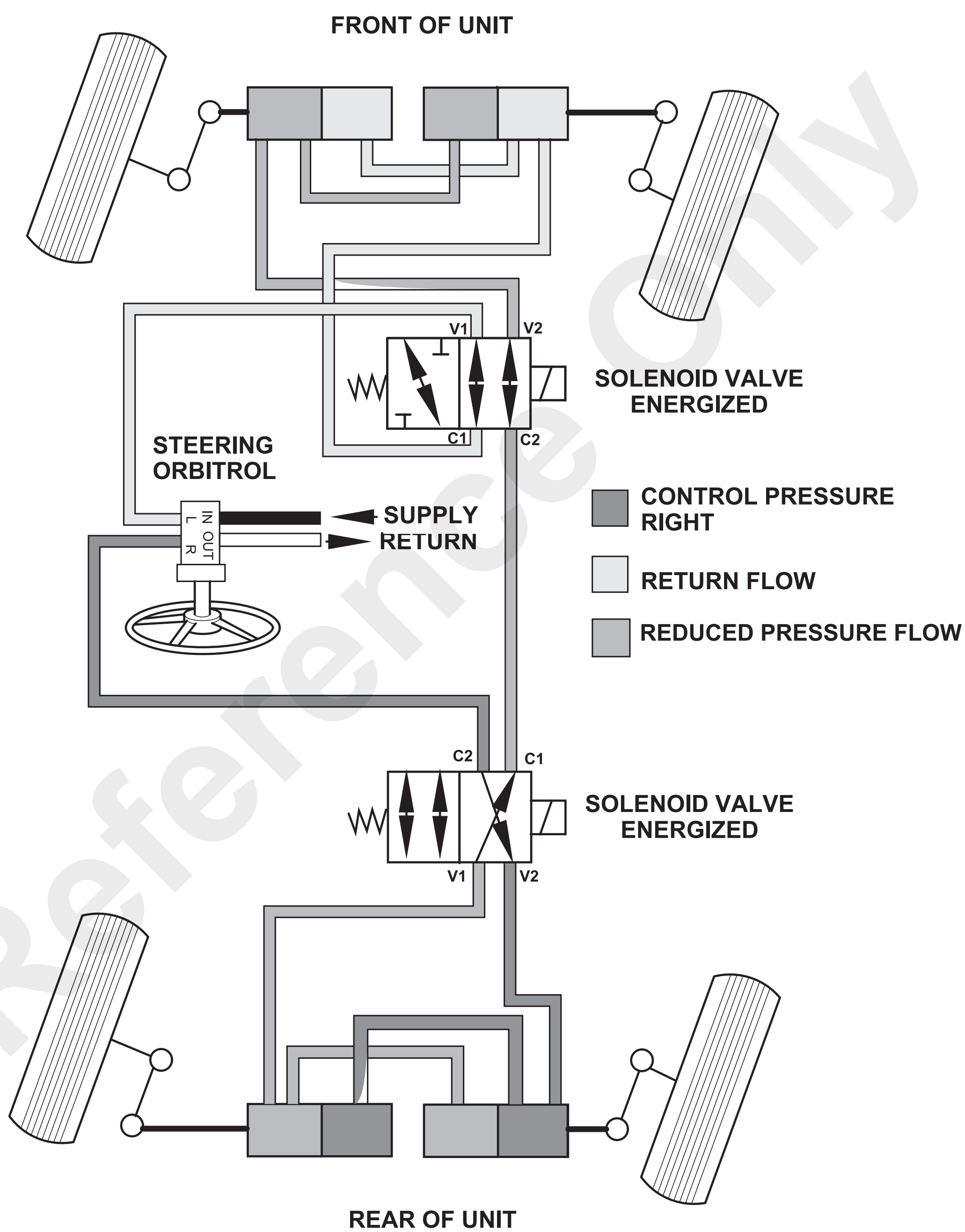
FIGURE 10-1



a0324

Right Turn in 4 Wheel Steer Mode

FIGURE 10-2



Right Side Ways in Crab Steer Mode

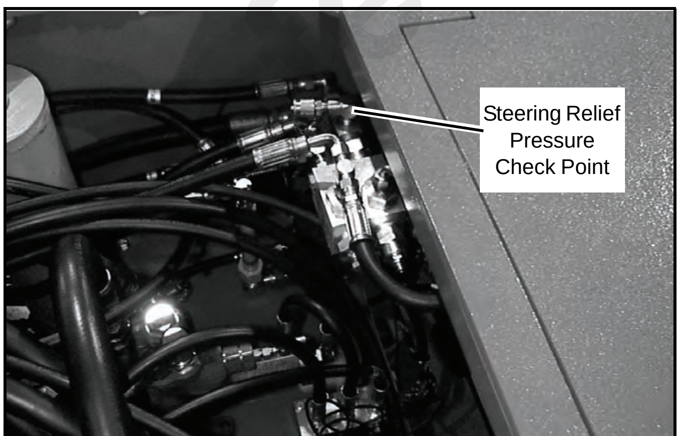
FIGURE 10-3

When moving side ways to the right Figure 10-3, hydraulic oil under pressure from the steering pump flows to the steering orbitrol in the operator’s compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbitrol to port C2 of the rear steering solenoid valve. The rear steering solenoid valve is energized in crab steer mode, therefore the hydraulic oil flows out Port V2 to the rod end of the right rear steering cylinder and the base end of the left rear steering cylinder. The right cylinder rod retracts and the left cylinder rod extends, turning the rear wheels to the right. Oil under reduced pressure from the rear steering cylinders flows back through Ports V2 and C1 of the rear steering solenoid valve to Ports C2 of the front steering solenoid valve. In crab steer mode, the front steering solenoid valve is actuated and oil flows through Ports C2 and V2 to the rod end of the left front steering cylinder and the base end of the right front steering cylinder. The left front cylinder rod retracts while the right front cylinder rod extends, turning the wheels to the right. Return oil from the steering cylinders flows back to tank through Ports V1 and C1 of the front steering solenoid valve and Ports L and OUT of the steering orbitrol.

RELIEF VALVE PRESSURE CHECK AND ADJUSTMENT

Pressure Check

1. Remove the deck cover over the hydraulic valves by removing four socket head screws.
2. Remove the cap Figure 10-4 from the quick-disconnect fitting located in the return circuit from the relief valve. Connect a 0-3000 psi (20 670 kPa) pressure gauge to the quick-disconnect fitting.

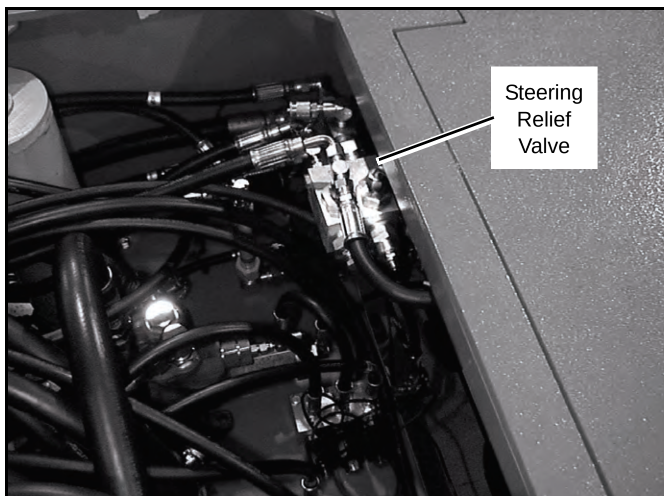


p0708 **FIGURE 10-4**

3. Start the engine allowing the hydraulic oil to reach operating temperature. Increase the engine speed to full rpm. Turn the steering wheel and put the wheels at the maximum angle. Continue to turn the steering wheel after the wheels are at their maximum angle. Read the pressure gauge and then release the steering wheel.
4. The correct pressure reading is 2500 ± 50 psi (17 225 ± 345 kPa). If not correct adjust the relief valve pressure setting.

Pressure Adjustment

1. Loosen the jam nut Figure 10-5 on the relief valve.
2. Start the engine. Turn the steering wheel and put the wheels at the maximum angle. Continue to turn the steering wheel after the wheels are at their maximum angle. Read the pressure gauge.
3. While holding the steering wheel and turn the adjusting screw clockwise (IN) to increase the pressure and counterclockwise (OUT) to decrease the pressure.
4. When correct setting is obtained, release the steering wheel and tighten the jam nut on the relief valve.
5. Recheck the pressure setting and adjust if necessary.
6. Remove the pressure gauge and install the cap.
7. Install the deck cover.



p0711 **FIGURE 10-5**

UNITS WITH RETURN-TO-CENTER STEERING

TECHNICAL DATA

Rated pump output . . . . .9.8 gpm at 2500 rpm (37,1 L/min at 2500 rpm)

Relief valve setting. . . . . .2500 ± 50 psi at 2500 rpm (17 225 ± 345 kPa at 2500 rpm)

Steering Proximity Switch Setting . . . . .1/8 - 7/32 inch (3,2 - 5,6 mm)

DESCRIPTION

General

The main components of the steering system are the second section of the secondary hydraulic pump Figure 10-6, 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 second section of the secondary 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

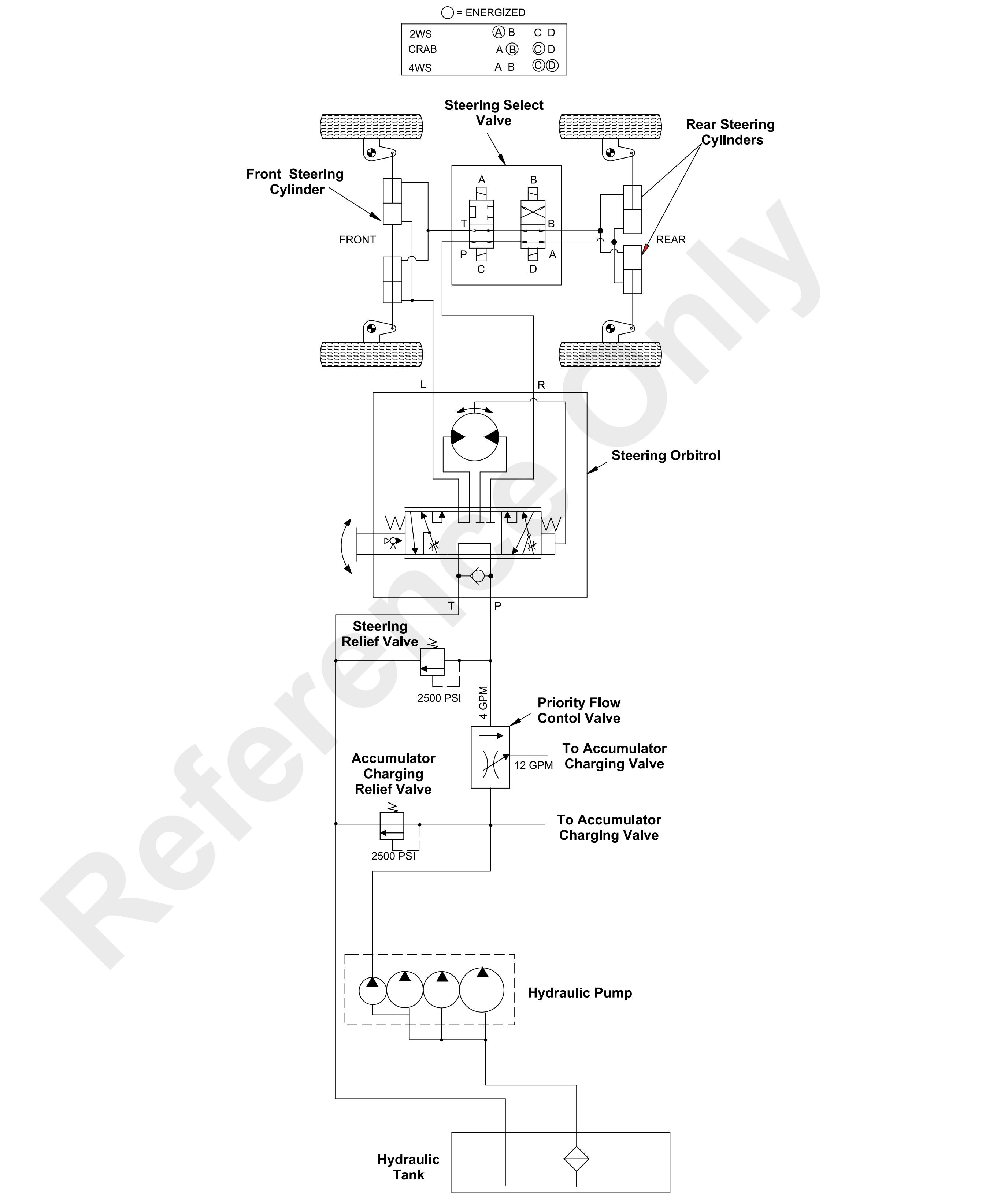
The crane can be operated in three steering modes. These modes are selected using the steering selector switch located to the right of the operator on the side instrument panel. The three modes are:

- Two-wheel steering
- Four-wheel steering
- Crab steering

Two-Wheel Steering

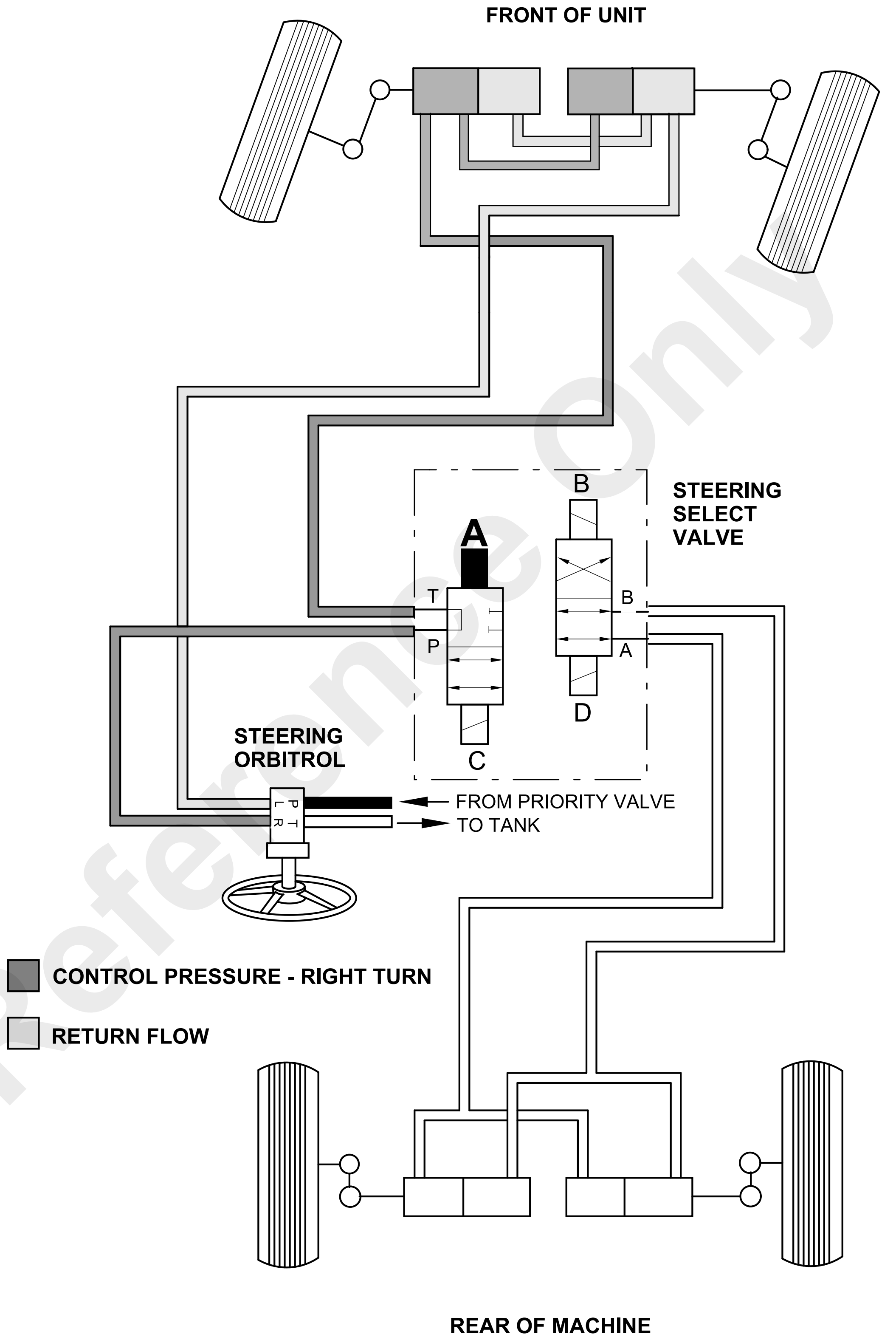
During two-wheel steering, the front wheels steer in the same direction that the steering wheel turns. The rear wheels remain in a fixed forward position.

When turning to the right Figure 10-7, 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 A is actuated. Oil passes through the porting of the valve block to the base end of the front axle steering cylinder. The piston moves to the left, extending the left cylinder rod and retracting the right cylinder rod, creating a right turn. Return oil from the steering cylinder flows into port L, out of port T of the steering orbitrol and back to tank.



Steering System

FIGURE 10-6



a2098

Right Turn in 2 Wheel Steer Mode

FIGURE 10-7

Four-Wheel Steering

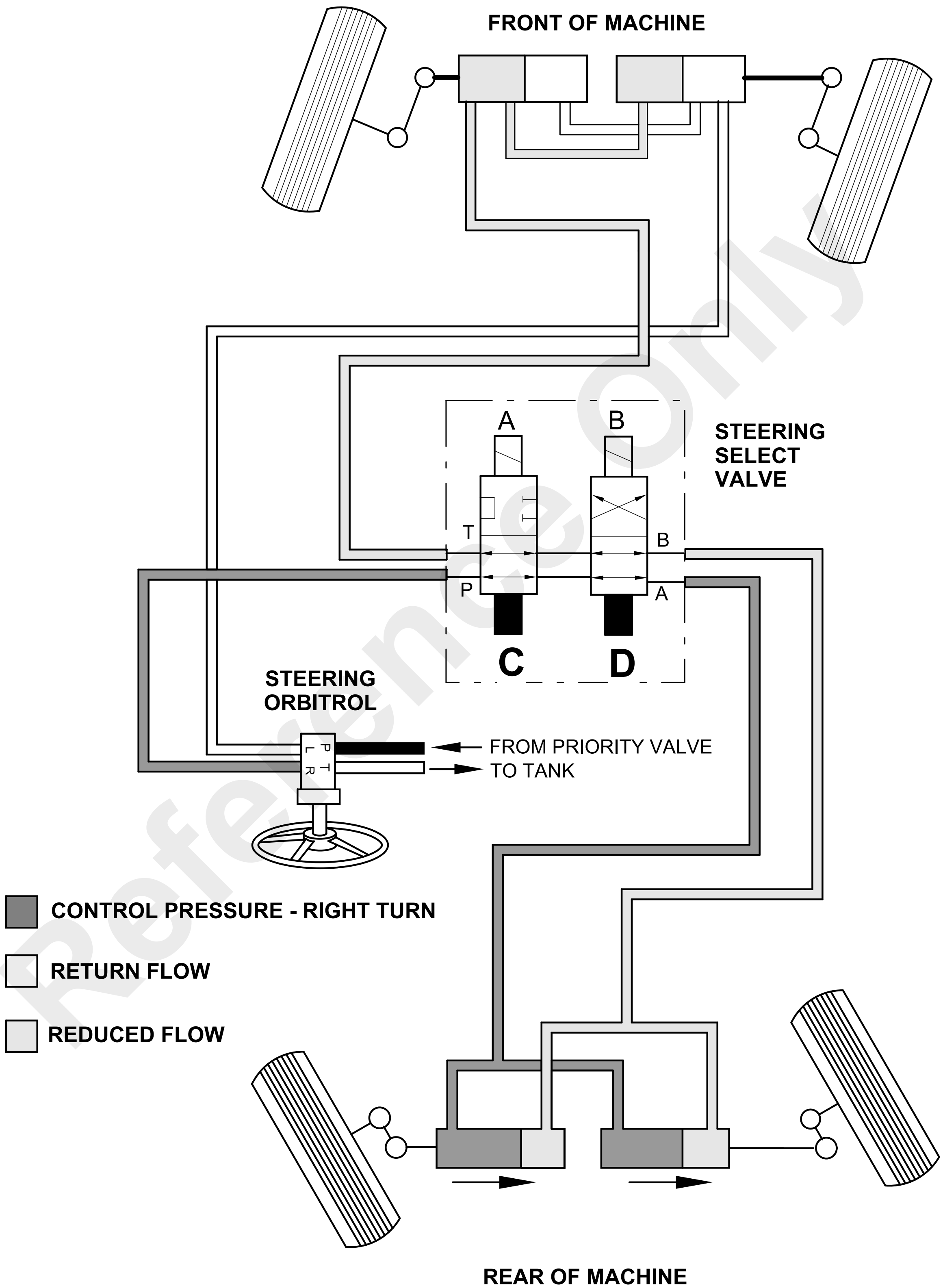
During four-wheel steering, the front wheels steer in the direction that the steering wheel is turned, while the rear wheels turn in the opposite direction. This mode provides an extremely short turning radius. It allows the rear wheels to follow the track of the front wheels, which is an advantage in muddy or sandy conditions.

When turning to the right Figure 10-8, 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 C and D are actuated. Oil passes through the porting of the valve block and out port A to the rear axle steering cylinder. Oil is directed to the rod end of the left steering cylinder and base end of the right cylinder, causing the rear wheels to turn to the left. Return oil under pressure from the rear steering cylinders flows into Port B of the steering select valve block and out Port T to the front steering cylinder. The left rod of the steering cylinder extends and the right rod retracts, turning the front wheels to the right. Return oil from the front steering cylinder flows into port L and out of port T of the steering orbitrol and back to tank.

Crab Steering

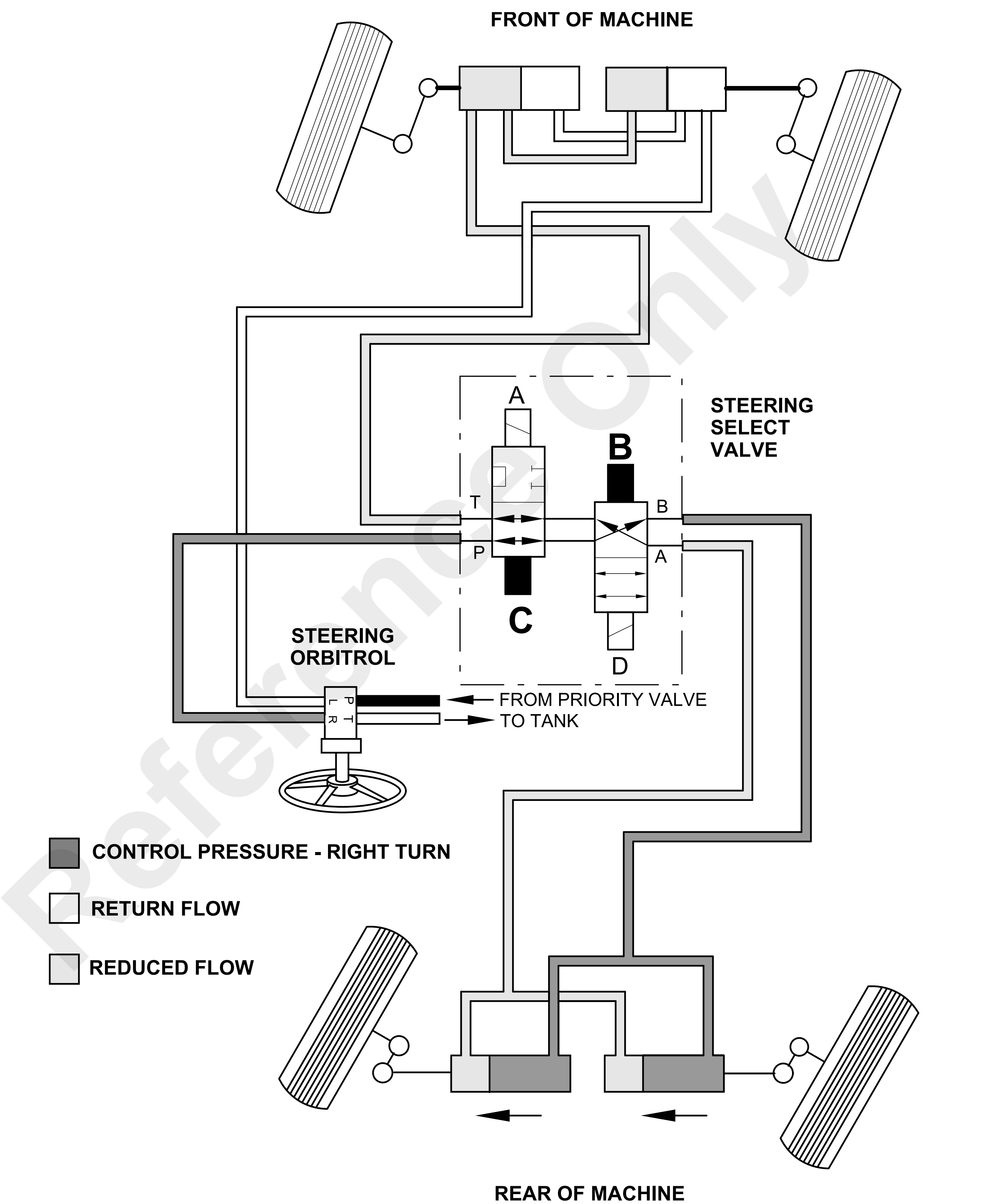
During crab steering all the wheels steer in the same direction. This mode allows the operator to move the machine sideways. This is especially helpful in tight areas on the job.

When turning sideways to the right Figure 10-9, 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 B and C are actuated. Oil passes through the porting of the valve block and out port B to the rear axle steering cylinders. Oil is directed to the base end of the left steering cylinder and rod end of the right cylinder, causing the rear wheels to turn to the right. Return oil under pressure from the rear steering cylinders flows to Port A of the steering select valve block and out port T to the front steering cylinder. The left rod of the steering cylinder extends and the right rod retracts, turning the front wheels to the right. Return oil from the front steering cylinder into port L and out of port T of the steering orbitrol and back to tank.



Right Turn in 4 Wheel Steer Mode

FIGURE 10-8



Right Side Ways in Crab Steer Mode

FIGURE 10-9

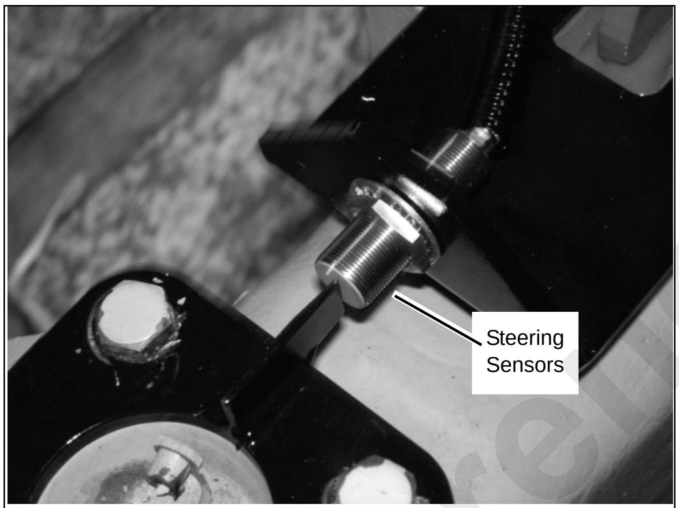
RELIEF VALVE PRESSURE CHECK AND ADJUSTMENT

Refer to page 10-5 for pressure check and pressure adjustment instructions.

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

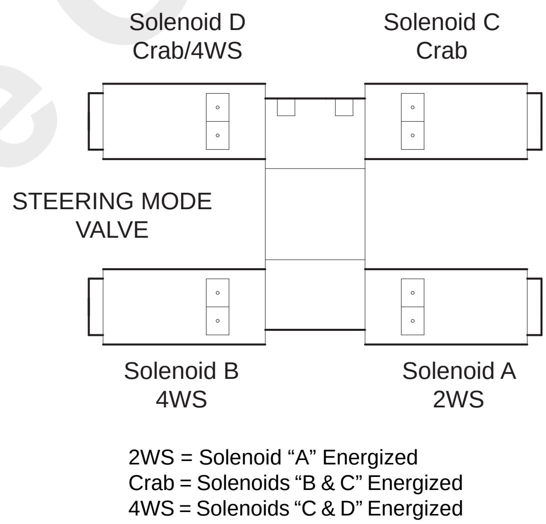


p1875 **FIGURE 10-10**

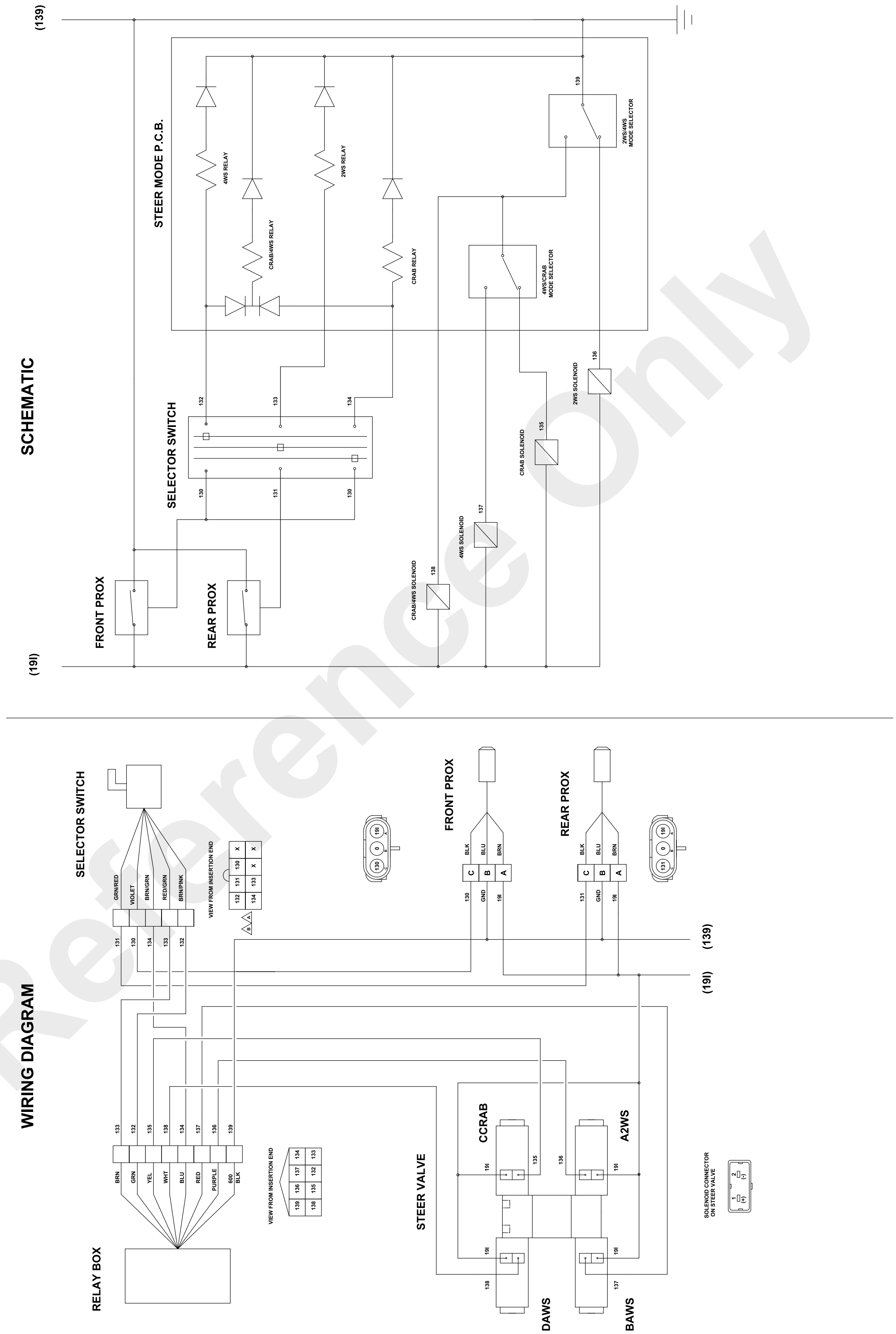
Principle Of Operation

The steering system electrical circuit includes two sensors Figure 10-12 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 10-11 to put the steering system in four wheel steer.



a0761 **FIGURE 10-11**



a2096

Steering Electrical Wiring Diagram

FIGURE 10-12

Sensor Operation And Spacing Checks

Checking Alignment and Operation

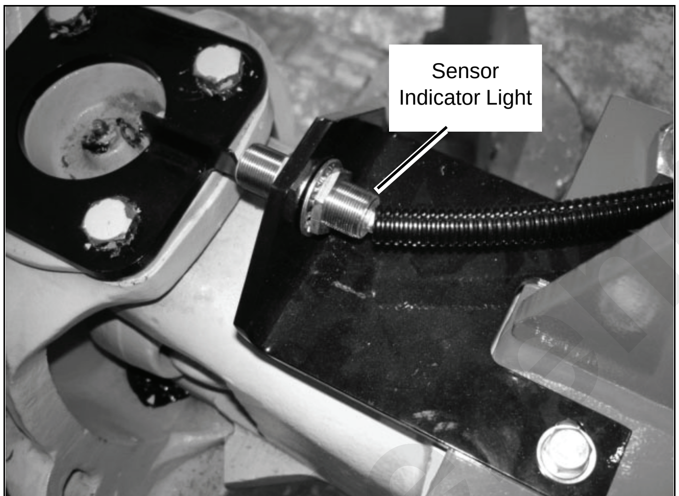
Both sensors must be working and spaced properly for the steering mode selection to function properly.

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 1/8 inch (3,2 mm) to 7/32 inch (5,2 mm) in front of the sensor. A yellow light Figure 10-13 will illuminate, indicating that the sensor is functioning.



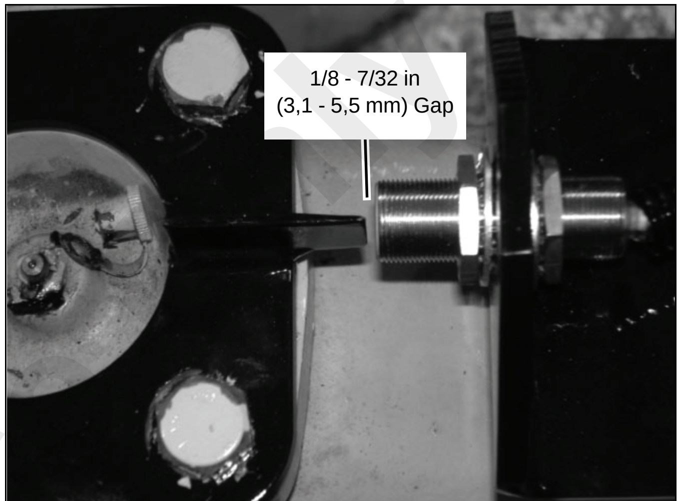
p1876 **FIGURE 10-13**

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 10-14.



p1877 Sensor Spacing **FIGURE 10-14**

2. Measure the distance between the end of the sensor and edge of the sensor bracket. The sensor spacing must be between 1/8 inch (3,3 mm) to 7/32 inch (5,6 mm). If the spacing is incorrect, adjust the spacing with the jam nuts on the sensor. Be sure they are tightened after proper gap is obtained.

Symptom	Probable Cause	Action
Slow steering, hard steering, or loss of power assist.	**1.** Worn or malfunctioning pump.	**1.** Repair or replace the pump.
	2. Priority valve not operating correctly.	**2.** Check for stick 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. Malfunctioning steering mode valve.	**7.** Check if spools are sticking. Repair or replace. Check if solenoids are operating. Replace if needed.
	8. Mechanical failure.	**8.** Check for damaged axle components, such as cylinders, tie rods, linkages, etc.
Steering wheel turns on its own.	**1.** Dirt in steering 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 10-17. Correct if required.
Machine will not turn when the steering wheel is turned.	**1.** Insufficient oil level.	**1.** Check for leaks and fill tank.
	2. Leaks in relevant hoses or component connections.	**2.** Check hoses and connections for leaks.
	3. Air in the hydraulic system.	**3.** Bleed system -bleed the load sense line.
	4. Low pump flow.	**4.** Check pump flow. If required, repair or replace the pump.
	5. Malfunctioning relief valve.	**5.** Replace priority valve.
	6. Worn or damaged parts in the steering orbitrol.	**6.** Remove, inspect and repair.
	7. Priority valve not operating correctly.	**7.** Check if the priority valve is sticking and repair if necessary. Check the load sense line for leaks or loose connections.
	8. Steering mode valve not operating correctly.	**8.** Check for sticking spools. Clean or replace. Check for faulty solenoids. Replace if necessary.
	9. Mechanical failure.	**9.** Check for damaged axle components, such as cylinders, tie rods, linkages, etc.
	10. Steering column splined shaft not fully engaged in orbitrol.	**10.** Check shaft engagement.

Symptom	Probable Cause	Action
Steering fails to respond to selected mode. IMPORTANT: The wheels must pass the proximity sensor to actuate relays to change steering mode.	**1.** Selector switch faulty. **2.** Proximity switches not operating correctly. **3.** Steering mode valve not operating. **4.** Leaks in relevant hoses or component connections. **5.** Electrical failure.	**1.** Replace switch. **2.** Check setting of proximity switch. Reset or replace switches. **3.** Check if spools are sticking. Repair or replace. **4.** Check hoses and connections for leaks. Tighten or replace. **5.** Check relevant electrical connectors if problem still persists, do a wiring continuity check o relevant circuits.
Wander - Tendency of vehicle to deviate from course.	**1.** Air in system. **2.** Worn steering linkage. **3.** Loose steering cylinder piston. **4.** Severe wear in steering orbitrol.	**1.** Correct condition and add fluid. Bleed system and load sense line. **2.** Repair or replace linkage. **3.** Repair or replace cylinder. **4.** Repair or replace the orbitrol.
Slip - A slow movement of steering wheel fails to cause any movement in steering wheels.	**1.** Leakage of cylinder piston seals. **2.** Worn steering orbitrol.	**1.** Repair or replace cylinder. **2.** Repair or replace orbitrol.
Erratic steering.	**1.** Air in system due to low level of hydraulic oil, cavitating pump, leaky fitting, pinched hose, etc. **2.** Loose steering cylinder piston. **3.** Sticking check valve. **4.** Turning steering wheel too rapidly.	**1.** Correct condition and add fluid. Bleed system and load sense line. **2.** Repair or replace cylinder. **3.** Clean or replace. **4.** Slow movement.
Spongy or soft steering.	**1.** Air in hydraulic system. Most likely air trapped in cylinders or lines. **2.** Low fluid level.	**1.** Correct conditions. Bleed air out of system and load sense line. **2.** Add fluid and check for leaks.
Free wheeling - Steering. Check wheel turns freely with no feel of pressure and no action on steering wheels.	**1.** Steering column shaft is loose or damaged. **2.** Lower splines of column may be disengaged or broken. **3.** Steering orbitrol meter has a lack of oil. This can happen on start up, after repair, or long down time intervals. **4.** Steering cylinder piston seal blown out.	**1.** Tighten the steering wheel nut. **2.** Repair or replace the column. **3.** Usually starting engine will cure the problem. Bleed system if necessary. **4.** Determine cause. Correct and replace the seal.
Excessive free play at steering wheel.	**1.** Loose steering wheel nut. **2.** Steering column shaft worn or damaged.	**1.** Tighten the nut. **2.** Repair or replace the steering wheel connection or column.
Excessive free play at steered wheels.	**1.** Leaky steering cylinder seals.	**1.** Replace cylinder seals.

Symptom	Probable Cause	Action
Binding or poor centering of steering wheel.	**1.** Large dirt particles can cause binding between orbitrol spool and sleeve.	**1.** Clean the orbitrol. Repair or replace if necessary. If another component has failed, generating contaminants, flush the hydraulic system while bypassing the orbitrol.
Steering orbitrol locks up.	**1.** Large particles of contamination in metering section. **2.** Severe wear and/or broken pin.	**1.** Clean the orbitrol. Repair or replace if necessary. **2.** Repair or replace the orbitrol.

STEERING ORBITROL

Description

General

The steering orbitrol Figure 10-16 provides directional control and metering of oil for precise steering control. In the neural or balance position, when the steering wheel is not turned, the IN port (P) is connected to the OUT port (T) and oil from the pump returns to tank Figure 10-16. 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 10-16. 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 10-16. 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 10-16 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.

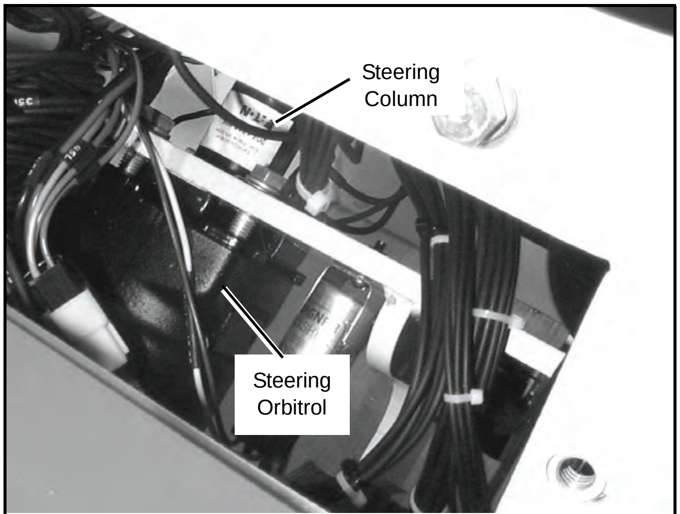
Orbitrol Repair

Special Tools

A spring installation tool, is required to assemble the orbitrol.

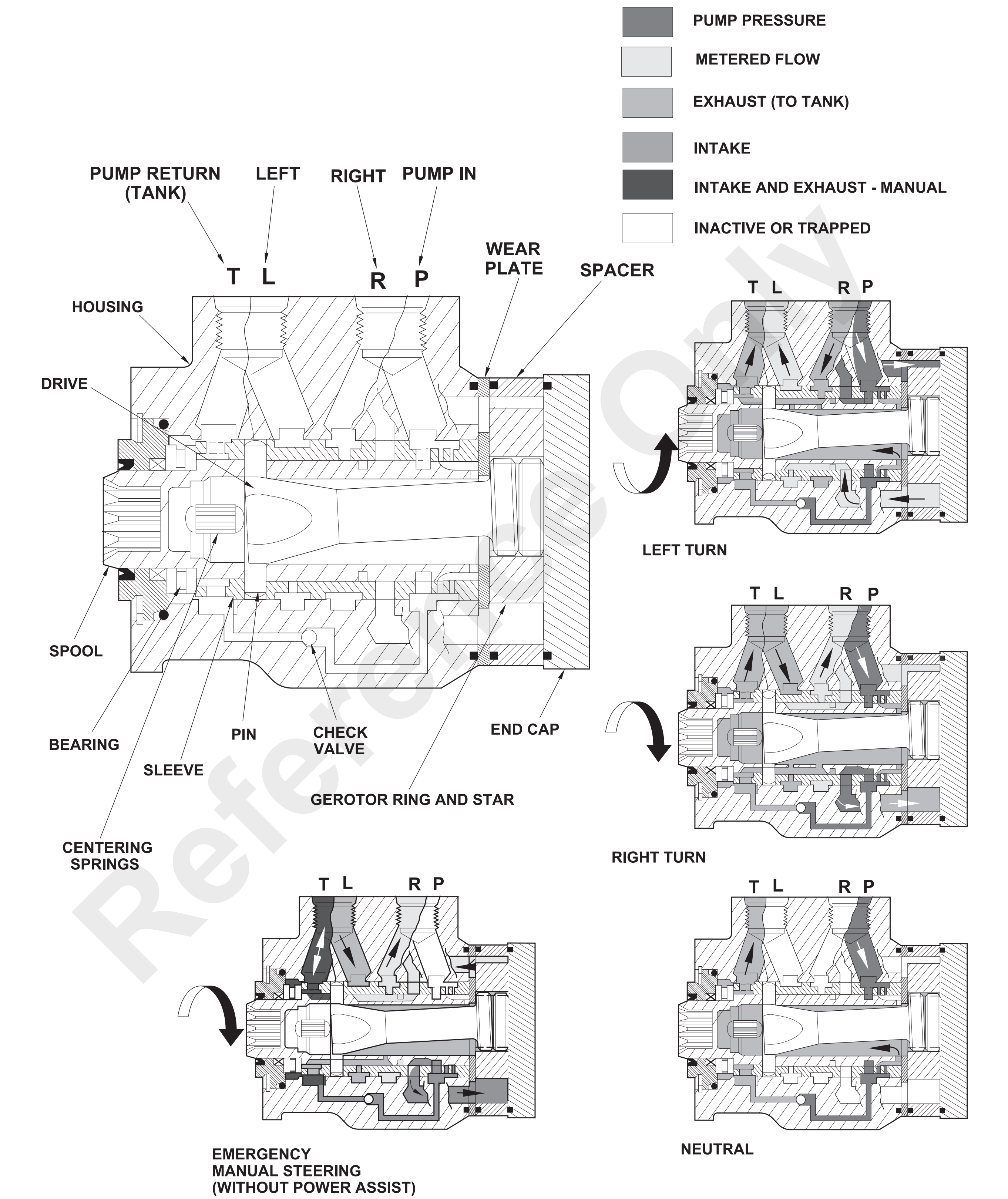
Removal

1. Remove the outside cover plate Figure 10-15 in front of the operator's compartment.



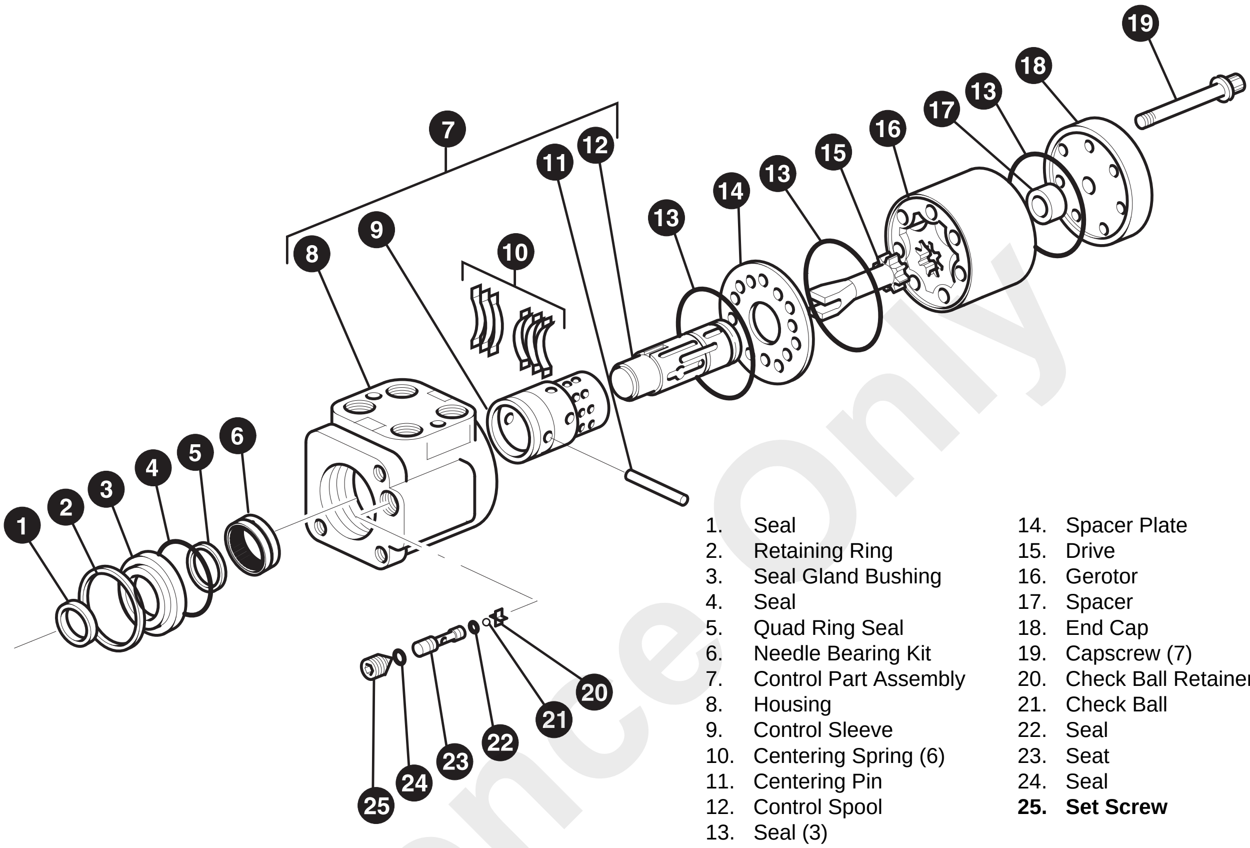
p0100 **FIGURE 10-15**

2. Completely clean around the area of the steering orbitrol.
3. Put tags on the lines to the steering orbitrol for identification at installation.



Steering Orbitrol

FIGURE 10-16



a0327

Steering Orbitrol

FIGURE 10-17

4. Rotate the steering wheel a small amount in each direction several times, then release to get a balance of pressure in the steering circuit. Slowly loosen the hydraulics lines at ports L and R to release any remaining pressure. Disconnect the hydraulic lines from IN and OUT ports. Put plugs and caps in the ports and hydraulic lines.
5. Remove the four bolts which fasten the steering column and orbitrol to the mounting bracket. Be sure to hold the steering orbitrol in position while the last bolt is being removed. Remove the steering orbitrol.

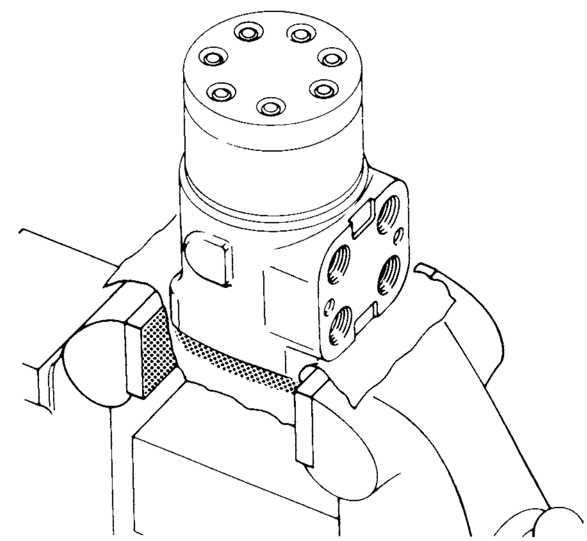
Disassembly

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.

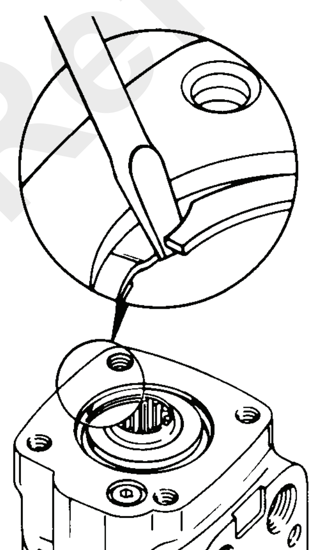
1. Clamp the unit in a vise, meter end up. Clamp lightly on the edges of the mounting area Figure 10-18. Use

protective material on the vise jaws. Housing distortion could result if the vise jaws are overtightened.



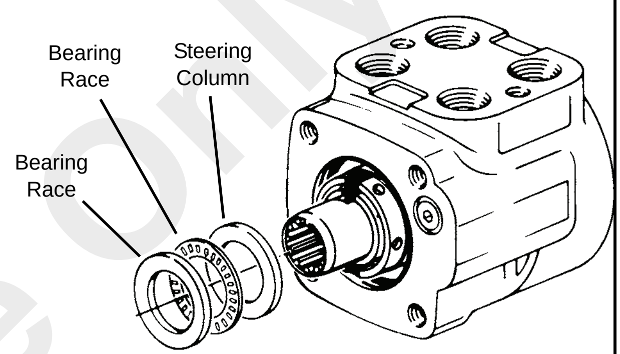
a0328 FIGURE 10-18

2. Remove the seven 6 pt. Torx Drive bolts 19 Figure 10-17. 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 10-19 to pry retaining ring (2, Figure 10-17 from housing (8).



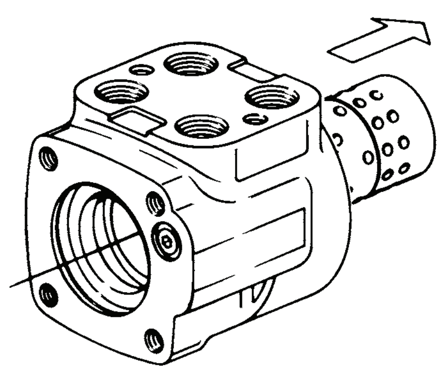
a0329 FIGURE 10-19

6. Rotate spool (12) and sleeve (9) until pin (11) is horizontal. Push the spool and sleeve assembly forward with your thumbs just far enough to free gland bushing (3) from the housing. Remove gland bushing (3).
7. Remove quad seal (5) from gland bushing (3).
8. Use a thin bladed screwdriver to pry dust seal (1) from gland bushing (3). Do not damage the gland bushing.
9. Remove needle bearing kit (6). The kit consists of two bearing races and a needle thrust bearing Figure 10-20.



a0330 FIGURE 10-20

10. Remove spool and sleeve assembly, 10 through 12, Figure 10-17. Remove from rear end of housing Figure 10-21.

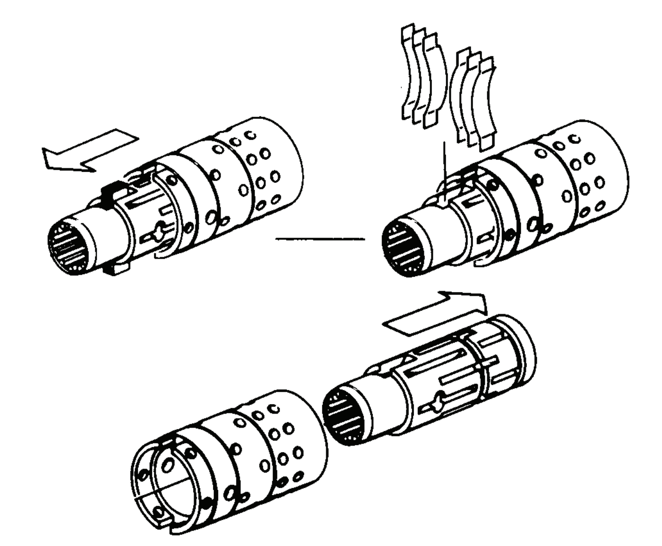


a0335 FIGURE 10-21

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 10-17 from spool and sleeve assembly.
12. Push spool (12) partially from control end of sleeve (9). Remove six centering springs (10) from the spool carefully by hand Figure 10-22

13. Push spool (12) back through and out of sleeve (9). Rotate spool slowly when removing from the sleeve Figure 10-22.



a0331 FIGURE 10-22

14. Remove seal **4** Figure 10-17 from housing (8).
15. Remove set screw (25).
16. Screw a No. 10-24 machine screw into the end of check ball seat (23). Then by pulling on the screw with a pliers, lift the seat out of the housing.
17. Remove two seals (22 and 24) from the check ball seat.
18. Tip the housing to remove check ball (21) and check ball retainer (20).

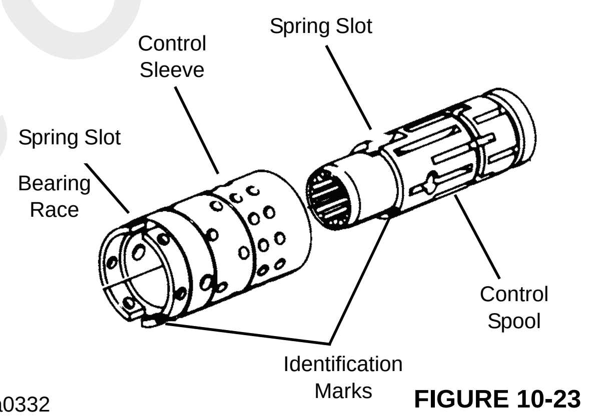
Inspection

Check all mating surfaces. Replace any parts that have scratches or burrs that could cause leakage or binding. Clean all metal parts in a clean solvent. Blow dry with air. Do not wipe dry with a cloth or paper towel, because lint or other matter can get into the hydraulic system and cause damage. Do not use a coarse grit emery cloth or try to file or grind any parts.

Replace all seals when assembling the unit. Lubricate all seals with clean petroleum jelly before assembling. DO NOT use excessive lubricant on seals for the meter section.

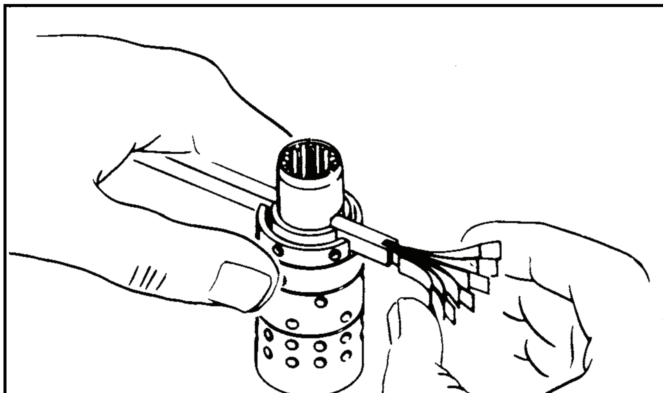
Assembly

1. Use a needle nose pliers to lower check ball retainer 20 Figure 10-17 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 100 lb-in (11.3 Nm). 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 10-23 line up at the same end. Rotate spool **12** Figure 10-17 while sliding the parts together. Some spools and sleeve sets have identification marks, align these marks as shown in Figure 10-23. Test for free rotation. The spool should rotate smoothly in the sleeve with finger tip force applied at splined end.



a0332 FIGURE 10-23

7. Bring spring slots of both parts in line and stand parts on end on the work bench Figure 10-23. Insert special spring installation tool through the spring slots of both parts. Position centering springs (in 2 sets of 3 each) on bench so that the extended edge is down and arched center section is together. In this position, insert one end of the entire spring set (all six) into the spring installation tool Figure 10-24 with spring notches facing the sleeve.



a0333 FIGURE 10-24

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 10-17 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 10-17. See Figure 10-25.

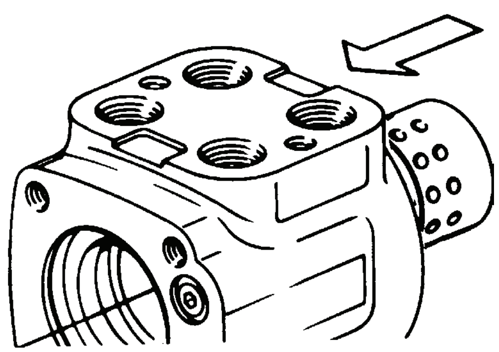
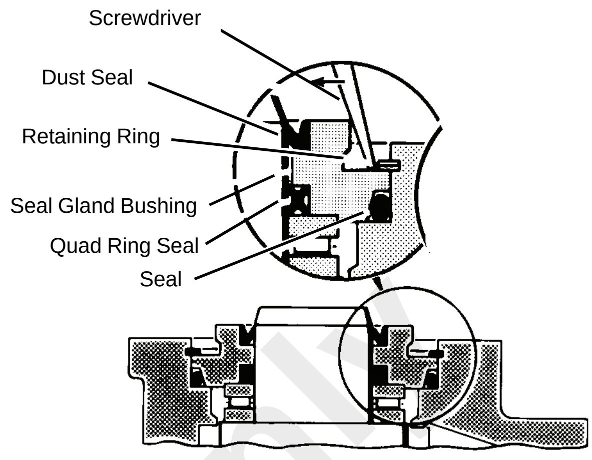

a0334

FIGURE 10-25

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 10-17 into housing (8).
13. Install needle bearing kit (6).
14. Install dust seal (1) into seal gland bushing (3). Flat or smooth side of the dust seal must face down towards the bushing Figure 10-26.



a0337

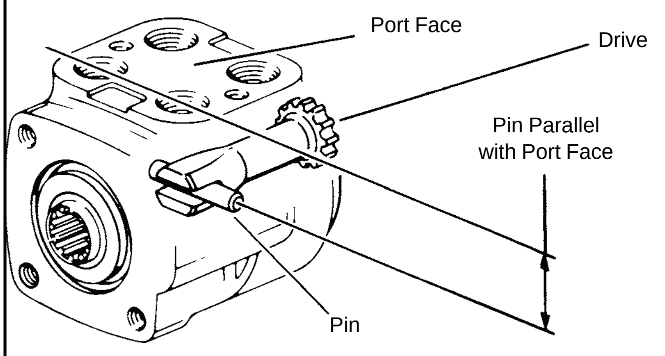
FIGURE 10-26

15. Install quad ring seal **5** Figure 10-17 into seal gland bushing (3). Smooth seal in place with your finger. Do not use any seal that falls freely into the pocket of the bushing Figure 10-26.
16. Install seal gland bushing **3** Figure 10-17 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 10-17 in the housing Figure 10-25. 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 10-17 in a vise. Clamp lightly on edges of mounting area. Do not over tighten the vise jaws.

NOTE: Check to ensure that the spool and sleeve assembly are flush or slightly below the mounting surface.

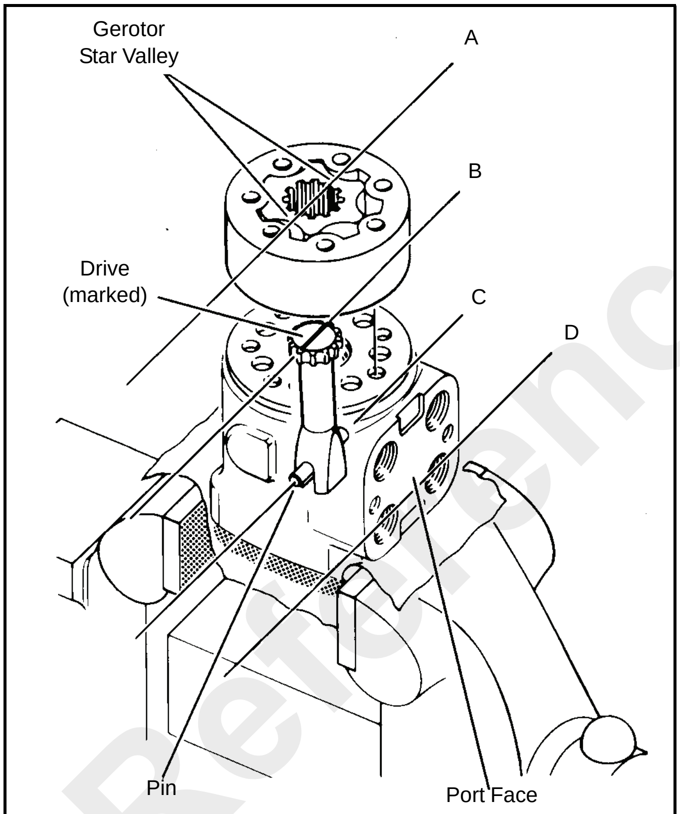
NOTE: Clean the upper surface of the housing by wiping with the palm of your hand. Clean each of the flat surfaces of the meter section parts in a similar way when ready for assembly. **DO NOT USE cloth or paper to clean the surfaces.**

19. Install seal (13) into groove in housing (8). Install spacer plate (14). Align bolt holes in spacer plate with tapped holes in the housing.
20. Rotate the spool and sleeve assembly until pin (11) is parallel with the port face Figure 10-27 Install drive 15, Figure 10-17, Make sure you engage the drive with pin (11). To ensure proper alignment, mark the drive as shown in Figure 10-28, Ref. B. Note relationship between the slotted end of the drive to the splined end of the drive when marking.



a0336

FIGURE 10-27



a0338

FIGURE 10-28

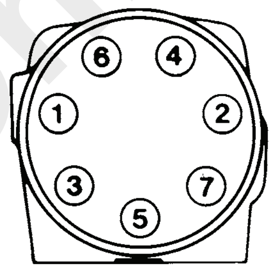
21. Install seal **13** Figure 10-17 into the gerotor (16).

22. With seal side of the gerotor toward spacer plate (14), align star valleys Figure 10-28 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 10-17 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 Figure 10-29 to a torque of 275 lb-in (31 Nm).



a0339

FIGURE 10-29

Installation

1. Locate the steering orbitrol and steering column in position on the mounting bracket under the instrument panel. Secure in place with four bolts and numerous flat washers.

2. Connect the hydraulic lines to the steering orbitrol.

3. Check the hydraulic oil level in the reservoir. Fill if necessary.

4. Start the engine and turn the steering wheel in both directions to fill the lines with hydraulic fluid and bleed air from the system. Check for leaks and repair if necessary.

5. Check the hydraulic oil level in the reservoir. Fill if necessary.

6. Install the outside cover to the operator's compartment.

STEERING CYLINDER

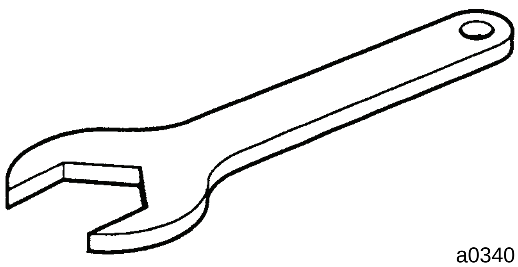
Technical Data

Cylinder Bore . . . . .2.36 inches (60 mm)

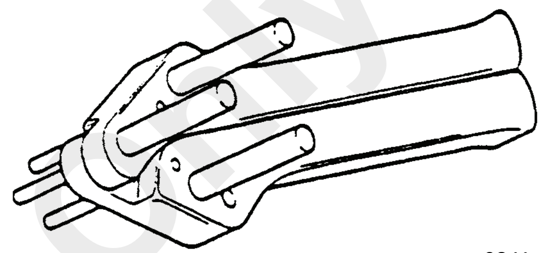
Stroke . . . . .8.30 inches (211 mm)

Rod Diameter. . . . . .1.18 inches (30 mm)

Special Tools



Hexagon Spanners for Cylinder Pistons and End Caps



Gland Seal Fitting Tool

FIGURE 10-30

Cylinder Repair

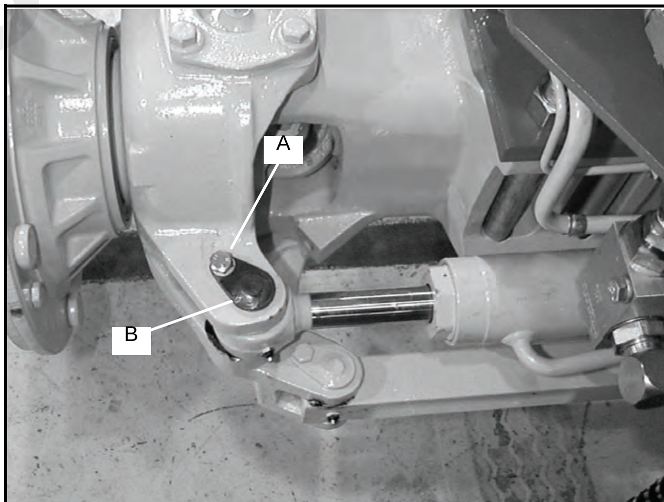
Removal

WARNING

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

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

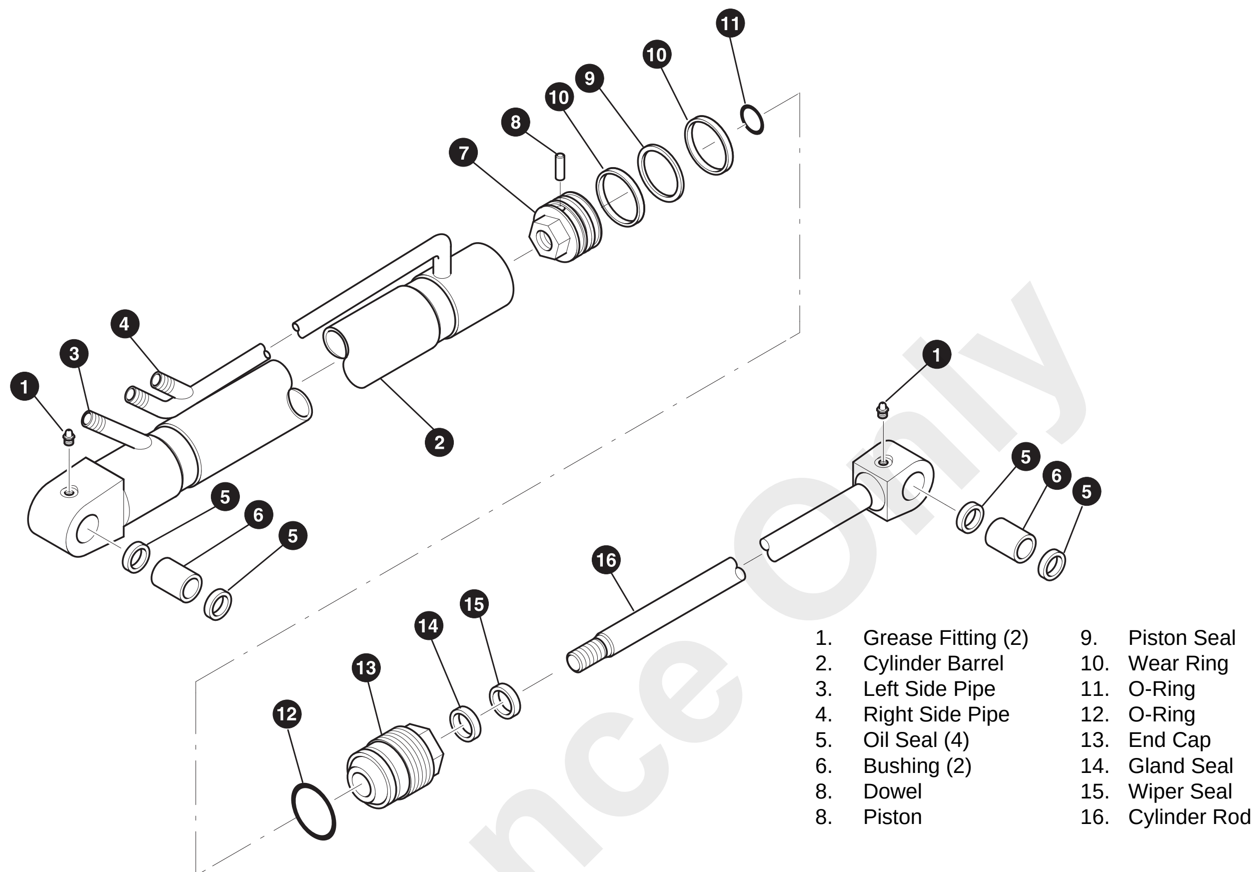
1. Raise and support the machine to gain access to the steering cylinder.
2. With the engine not running, turn the steering wheel in both directions to release any pressure in the hydraulic lines to the steering cylinder.
3. Be prepared to collect the oil as you remove the steering lines. Slowly loosen the hydraulic hoses to release any remaining pressure. Install a plug in the hose end and a cap on the cylinder port. Place a tag on the hoses for identification and correct assembly.
4. Remove locking bolts **A** Figure 10-31 and pivot pins B from both ends of the steering cylinder.
5. Remove the steering cylinder from the axle.



p0102 **FIGURE 10-31**

Disassembly

1. Remove the caps from the cylinder ports and drain remaining oil from the cylinder.
2. Secure the cylinder. If a vice is used, clamp only on the base end of the cylinder, DO NOT clamp across the cylinder tube.
3. Loosen end cap **13** Figure 10-32 using a special spanner wrench (See Special Tools, Figure 10-30) and remove the piston rod assembly **16** from the cylinder barrel.



a0342

FIGURE 10-32

⚠ CAUTION

If air or hydraulic pressure is used to force out the piston assembly, ensure that the end cap is securely installed. Severe injury can be caused by a sudden release of the piston rod.

4. Fasten the bushing end of the cylinder rod in a vice. Do not clamp a vise on the cylinder rod.
5. Remove and discard piston seal **9** and wear rings **10** from piston **7**.
6. Remove dowel **8** from piston head **7** using a metric screw threaded into the extraction hole in the dowel.
7. Using a special spanner wrench (See Special Tools, Figure 10-30) remove the piston **7** from rod **16**.
8. Remove and discard o-ring **11**.
9. Remove cap end **13** from cylinder rod **16**.
10. Remove and discard o-ring **12**, seal gland **14** and wiper seal **15** from cap end **13**.
11. Remove and discard the oil seals **5** from both the rod end and base ends of the cylinder.

Inspection

1. Clean all parts in a suitable solvent. Dry with compressed air. Make sure threads of piston rod, piston, end cap and cylinder are thoroughly cleaned using a wire brush to remove grease, hydraulic oil and Loctite.
2. Inspect cylinder rod for rust, distortion, pitting or damage to the chrome. If there is damage to the cylinder rod, replace it. Do not try to straighten a bent cylinder rod.
3. Inspect inside of the cylinder barrel for grooves, distortion or other damage. Use a light to illuminate the cylinder bore for careful inspection. Replace any cylinder barrel if there is distortion or damage.
4. Inspect the piston for damage to the lands.
5. Inspect rod and barrel bushings for wear or damage.
6. Replace all seals and rings.

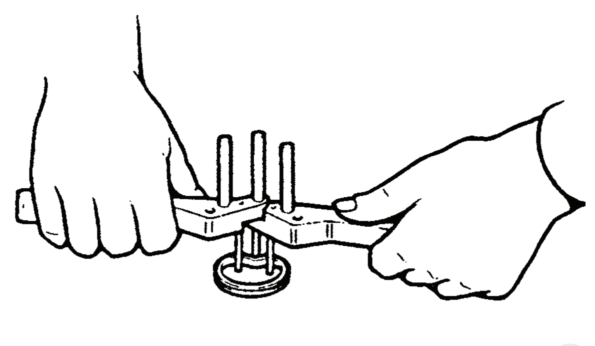
Assembly

1. Install new gland seal **14** Figure 10-32 using the special and installation tool as follows:

NOTE: The size (diameter) and position of pins is determined by the diameter and radial width of the gland seal being installed.

The pins are screwed into threaded holes in the tool body, the spacing of the holes is designed to fit small and large diameter gland deals.

a. Open the tool Figure 10-33 and insert the new gland seal. The seal must be installed behind the two front pins but in front of the rear pin as shown.

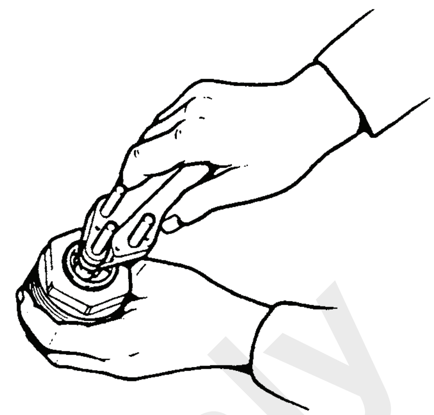


a0343 **FIGURE 10-33**

b. Close the tool Figure 10-34. The seal must form a kidney shape.

a0344 **FIGURE 10-34**

c. Locate the seal in the end cap groove Figure 10-35. When the seal is in position, open the tool to release the seal. Make sure the seal is correctly installed in its groove before then remove the tool.



a0345 **FIGURE 10-35**

2. Install a new wiper seal **15** Figure 10-32 and new o-ring **12** to end cap **13**. The lip of the wiper seal must be facing out.

3. Apply Loctite Activator T to threads of the end cap and cylinder barrel. Allow the activator to dry for 15 minutes before bringing in contact with Loctite.

NOTE: Be sure that lubricants used during assembly do not come in contact with Loctite.

4. Cover the threads on the cylinder rod to prevent lubricant from contacting the Loctite.

5. Apply petroleum jelly to the inside bore of the end cap. Carefully slide the end cap assembly over the end of the piston rod.

6. Install o-ring **11** into piston **7**.

7. Install piston **7** onto cylinder rod **16**. Tighten to a torque of 300 lb-ft (405 Nm).

8. New cylinder rod and piston installed.

If both are required, the following procedure should be followed:

a. Drill through the piston into the cylinder rod at the dimension Figure 10-36. Use an undersize drill first as a guide, drill to a depth of 24 mm. Then using a 6 mm drill bit, drill the hole for the dowel.

b. Remove all swarl and contamination. Insert dowel **8** Figure 10-32 into drilled hole. Make sure threaded extractor hole is to the outside.

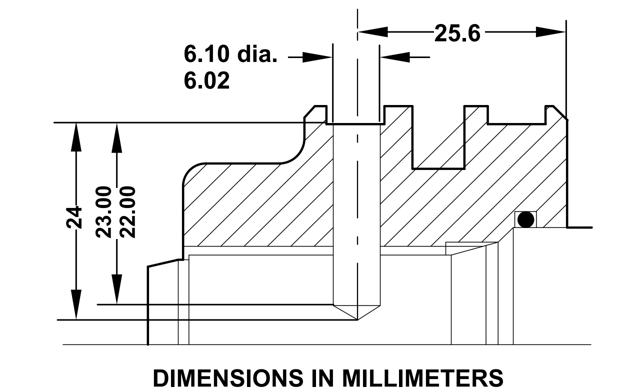


FIGURE 10-36

9. New piston on a predrill cylinder rod.

a. Re-drill and dowel BOTH the piston and cylinder rod at 90° from the existing drilled dowel hole in the cylinder rod. Follow procedures in step 8.

10. New cylinder rod installed to a predrilled piston.

Use the predrilled hole in the piston. Care must be taken not to elongate the existing hole in the piston.

a. Using a 6 mm drill make a center mark in the cylinder rod. DO NOT drill the cylinder rod at this time.

b. Use an undersized diameter drill bit to drill a guide hole to the depth of 24 mm Figure 10-36. Make sure the drill bit is centered correctly on the center mark made in Step A.

c. Use a 6 mm drill bit and drill a hole to the depth of the guide hole.

d. Remove all swarl and contamination. Install dowel **8** Figure 10-32.

11. Install wear ring **10** and piston seal **9** onto piston **7**.

12. Carefully insert the assembled cylinder rod into the cylinder barrel. Use care to prevent damage to the piston seal and wear ring during installation. Work the piston rod straight into the cylinder barrel.

13. Apply Loctite 932 to the first three threads of the end cap. Slide the end cap into the cylinder barrel and engage the threads. Tighten the end cap with the spanner wrench to a torque of 500 lb-ft (678 Nm).

NOTE: If hydraulic oil contacts uncured Loctite a weakening of the bond will result. Cure times vary according to the ambient temperature and the type of activator used. The curing time for Loctite 932 and Activator T at an ambient temperature of 68° F (20° C) is two hours. Do not apply oil to the cylinder before this time.

14. Fill and test the cylinder.

Installation

1. Locate the steering cylinder on the axle.

2. Apply anti-seize compound to pivot pins and install in both the rod end and base end of the cylinder.

3. Install locking bolts to hold pins in place.

4. Connect the hydraulic hoses to the cylinder.

5. Lubricate the grease fitting with Lithium based, E.P. No. 2 bearing grease.

6. Check the hydraulic oil level and add oil if necessary.

7. Start the engine and operate the cylinder(s) through several complete cycles to remove air from the system. Operate the cylinders slowly and do not let them hit bottom until movement is positive in both directions. After the circuit is filled with oil, the cylinders can be operated normally.

8. Check for leaks and repair if necessary.

9. Check the hydraulic oil level and fill if necessary.

THIS PAGE BLANK

Published 10-21-2010, Control# 198-04

SECTION 11
STRUCTURALS

11

TABLE OF CONTENTS

SECTION 11
STRUCTURALS

BOOMS

General

The three section boom as well as the four section boom is hydraulically extended and retracted by a dual telescope cylinder inside the boom.

Extending the Fourth Boom Section

1. Extend the outriggers.

2. Lower the boom to its horizontal position.

3. Completely retract the boom.

4. On the left side of the boom, remove pin “A” (Figure 11-1) from hole “D” by first removing the snapper pin retaining pin “A” and then the pin.

5. Hook the handle of pin “A” in hole “B”.

6. Fully extend the fourth boom section (Figure 11-2), by actuating the telescope control lever in the cab.

7. Retract the telescope cylinder (Figure 11-3) The fourth section will remain in the extended position.

8. Unhook the handle of the pin “A” from hole “B” (Figure 11-2).

9. Install pin “A” into holes “D” and “E” (Figure 11-3). Install the snapper pin to retain pin “A”.

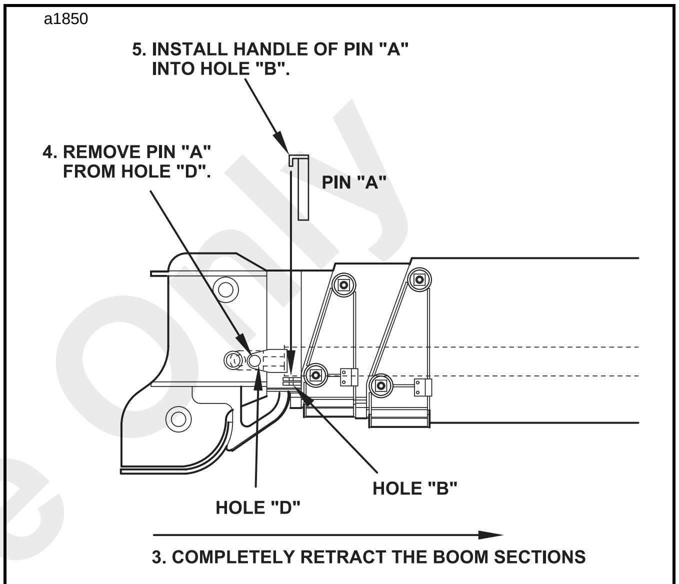


FIGURE 11-1

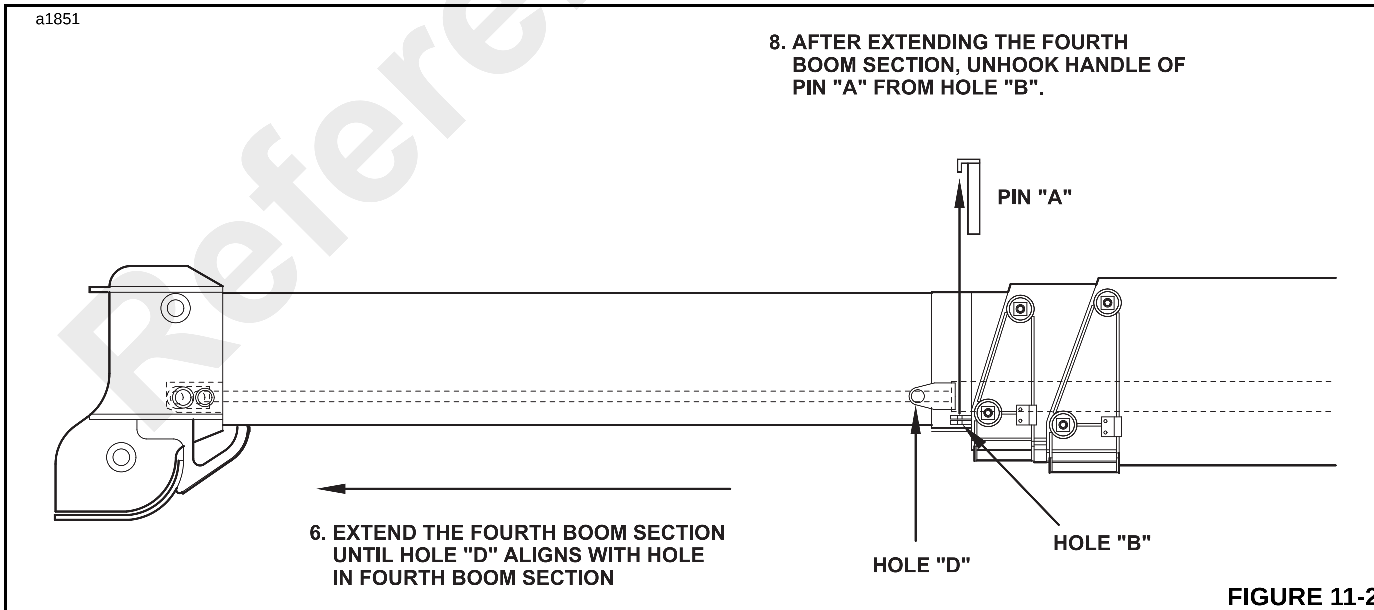


FIGURE 11-2

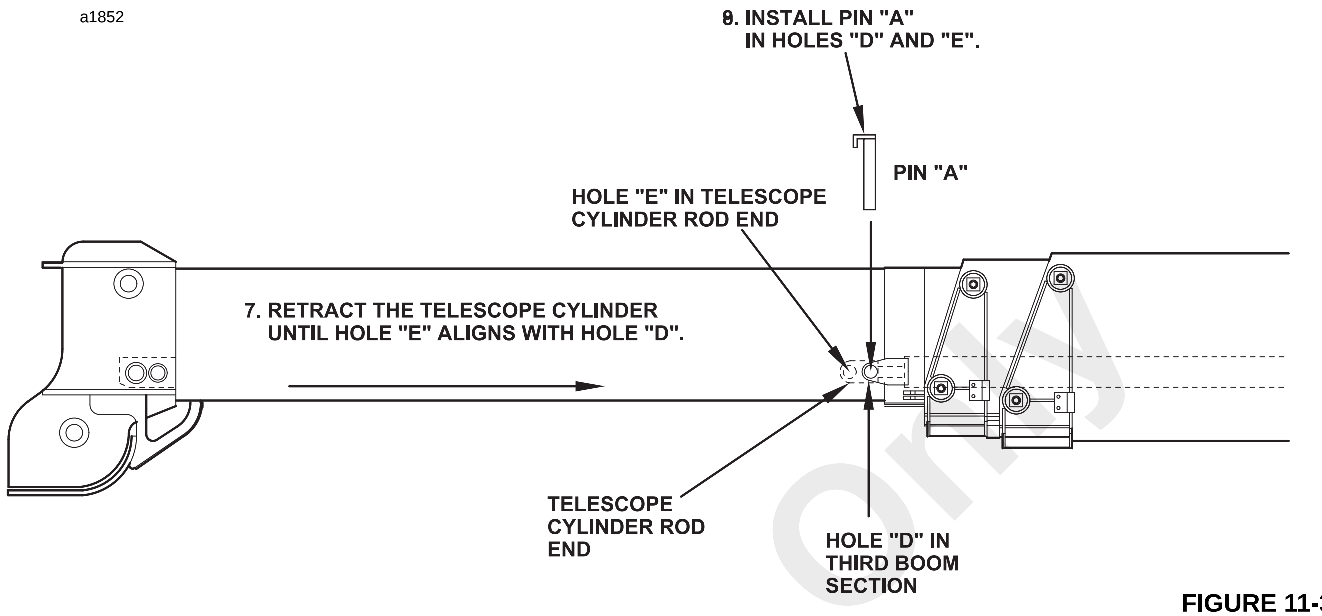

a1852
9. INSTALL PIN "A"
IN HOLES "D" AND "E".
PIN "A"
HOLE "E" IN TELESCOPE
CYLINDER ROD END
7. RETRACT THE TELESCOPE CYLINDER
UNTIL HOLE "E" ALIGNS WITH HOLE "D".
TELESCOPE
CYLINDER ROD
END
HOLE "D" IN
THIRD BOOM
SECTION

FIGURE 11-3

Retracting the Fourth Boom Section

1. Extend the outriggers.
2. Lower the boom to its horizontal position.
3. Completely retract the boom (Figure 11-4).
4. Remove the snapper pin from retaining pin “A (Figure 11-4). Remove pin “A” from holes “D” and “E” at the rear of the fourth boom section and the bracket on the third boom section.
5. Hook the handle of pin “A” into hole “B”.
6. Fully extend the telescope cylinder by actuating the telescope lever in the cab (Figure 11-3).
7. Install pin “A” into holes “C” and “F”.
8. Completely retract the fourth boom section (Figure 11-6).
9. Remove pin “A” from hole “C”.
10. Install pin “A” into holes “D” and “E”. Install the snapper pin to retain pin “A”.

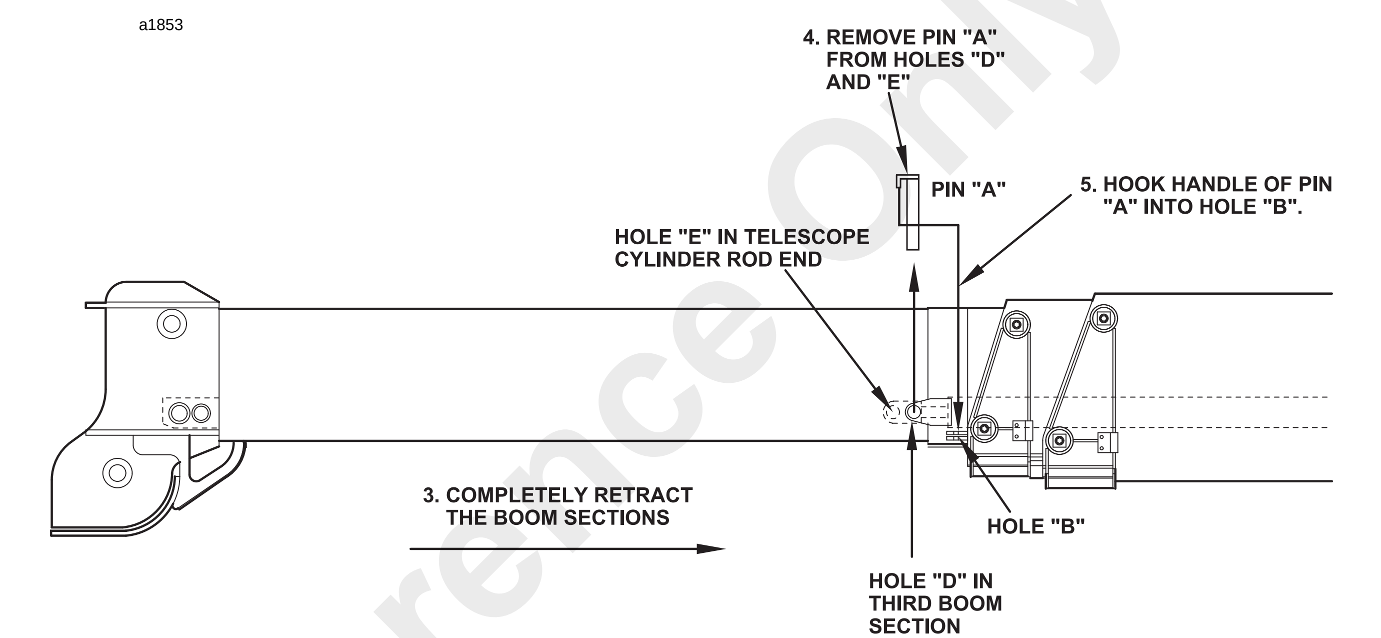


FIGURE 11-4

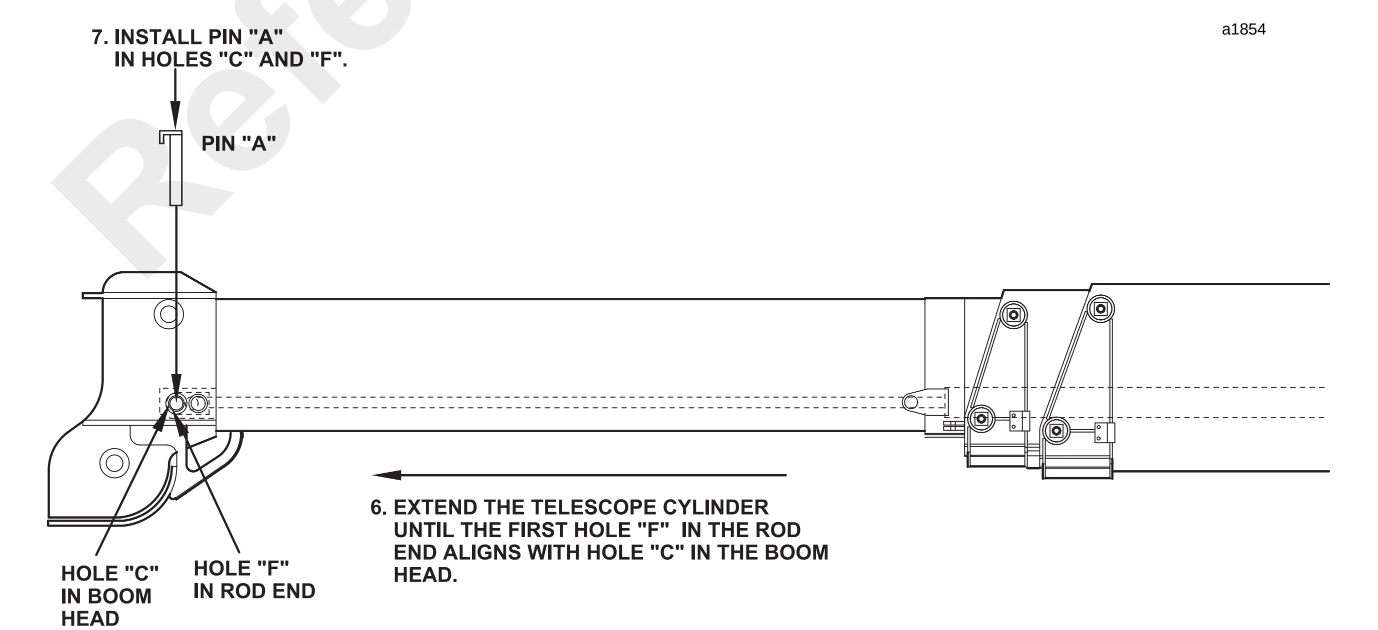


FIGURE 11-5

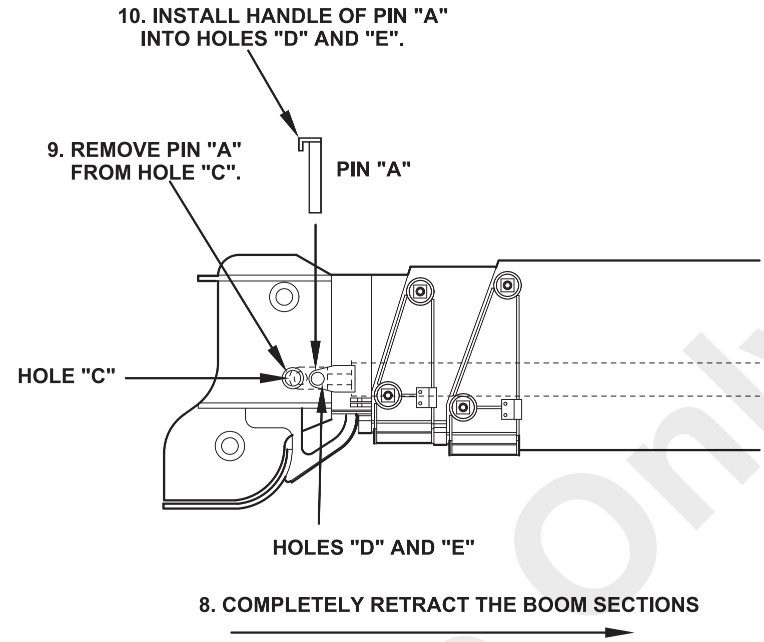


FIGURE 11-6

Removal of Boom Assembly

1. Remove the hook block and wire rope.
2. Retract the boom
3. Remove the boom extension, if installed.
4. Raise the boom until the pin in the rod end of the lift cylinder can be seen.

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

5. Connect a hoist to the boom that will lift more than 4000 lb. (1812 kg).
6. Release the hydraulic pressure in the winch and telescope circuits. Disconnect the hydraulic tubes on mast from the hydraulic hoses coming from the boom. Put caps and plugs on the hydraulic tubes and hoses.
7. Disconnect any electrical wires. See Electric System, Section 11.
8. Place a support under the cylinder to inhibit damage to the cylinder. Remove the pin from the rod of the lift cylinder. Retract the lift cylinder rod.
9. Remove the boom pivot pin and remove the boom. Place the boom on blocks or steel horses.

Installation of the Boom Assembly

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

1. Using an overhead crane, position the boom between the ears of the mast. Install the mounting pin and fasten with keeper pins and bolts.
2. Lower the boom or extend the lift cylinder as necessary to install the lift cylinder pin and keeper pin and bolt.
3. Connect hoses from the hydraulic swivel to the telescope cylinder.
4. Connect electrical wiring as necessary. Refer to Section 11, Electrical System.
5. Install the wire rope and hook block.
6. Start the engine and operate all boom functions in both directions to remove air from the hydraulic system. Check for leaks.

Disassembly

NOTE: Refer to Figure 11-7 for steps 1 thru 7.

1. At the rear of the assembly, remove the hoses and fittings from the telescope cylinder. Cap or plug all openings.
2. Remove the cotter pin, nut and washer securing the upper telescope cylinder rod to the rear of boom section 1. (Refer to Figure 11-11)
3. Loosen the front top and bottom side wear pads on boom section 1.
4. Remove the bolts and lock washers securing the wear pad retainer plates to the front of boom section 1, remove the retainer plates.
5. Raise up on the boom section 2 assembly and remove the wear pads from the boom section 1.
6. Slide the assembly out of the boom section 1.
7. As necessary, remove the following items from the boom section 1:
   - **a.** Wire rope guide.
   - **b.** Boom angle indicator.
   - **c.** Anti-two block and LMI components.
   - **d.** Jib attachment brackets.
   - **e.** Upper rear cable wear pad.
   - **f.** Grease fittings and boom pivot pin bushings.
   - **g.** Remove the front top and bottom side wear pads, plugs and set screws.

1. Wire Rope Guide
2. Boom Section 1
3. Lockwasher
4. Bolt
5. Cover
6. Bolt
7. Washer
8. Wear pad
9. Grease Fittings
10. Bronze Bushing
11. Bearing
12. Boom Angle Indicator
13. Washer
14. Bolt
15. Keeper Pin
16. Bolt
17. Pin
18. Wear Pads
19. Plug
20. Set Screw
21. Wear Pad
22. Retainer plate
23. Lockwasher
24. Bolt
25. Bolt
26. Washer
27. Nut

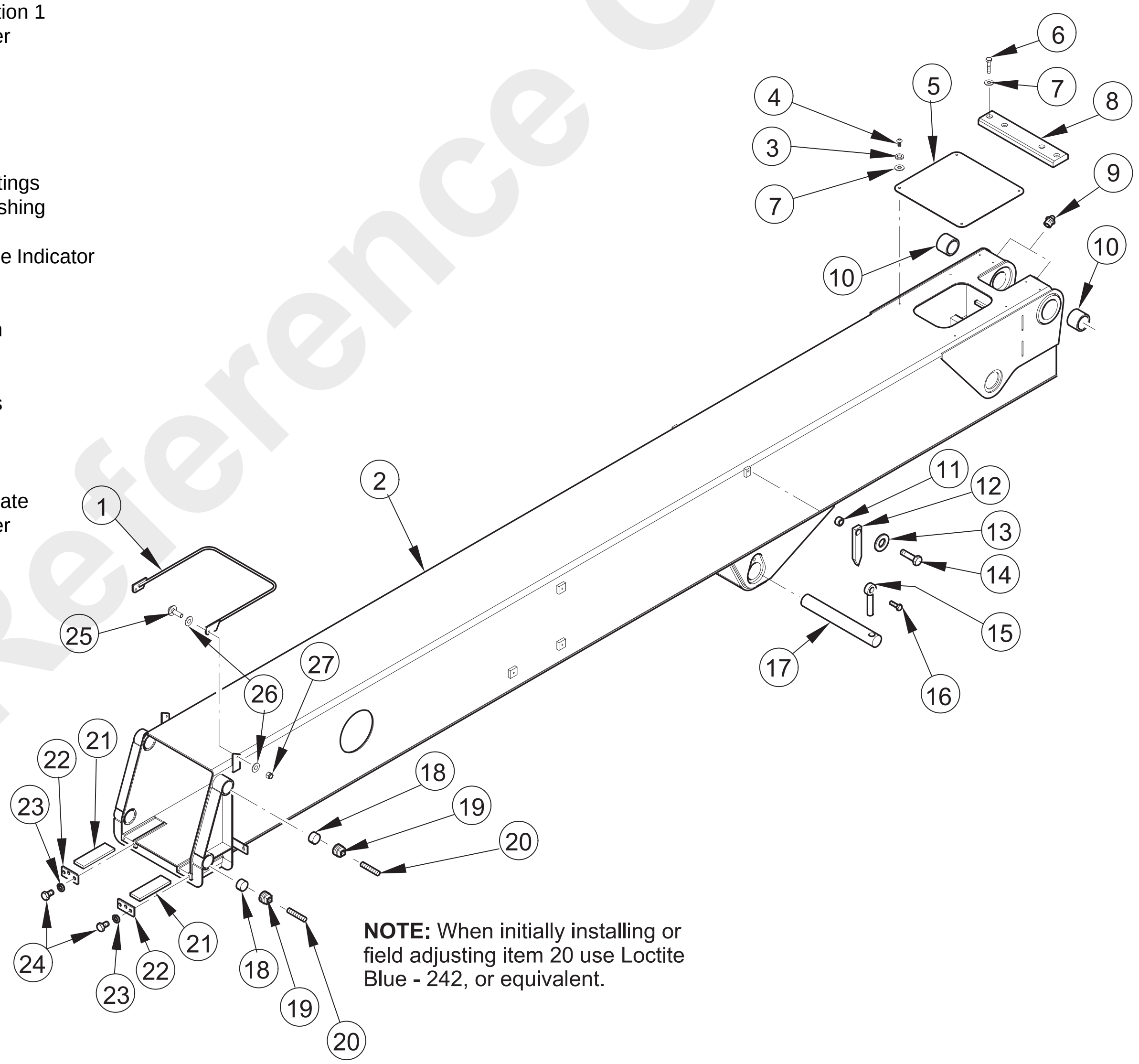


FIGURE 11-7

NOTE: Refer to Figure 11-8 for steps 8 thru 14.

8. Remove the top rear wear pads from boom section 2.

9. Remove the cotter pin and pin securing the telescope cylinder bracket to the rear of boom section 2. (Refer to Figure 11-11)

10. Loosen the front top and bottom side wear pads on boom section 2.

11. Remove the bolts and lock washers securing the wear pad retainer plates to the front of boom section 2, remove the retainer plates.

12. Raise up on the boom section 3 assembly and remove the wear pads from the boom section 2.

13. Slide the assembly out of the boom section 2.

14. As necessary, remove the following items from the boom section 2:

- **a.** Remove the bolts and lockwashers securing the lower rear wear pads, remove the wear pads.
- **b.** Remove the front top and bottom side wear pads, plugs and set screws.

1. Boom Section 2
2. Wear Pad
3. Bolt
4. Lockwasher
5. Wear Pad
6. Wear Pad
7. Plug
8. Set Screw
9. Wear Pad
10. Retainer Plate
11. Bolt

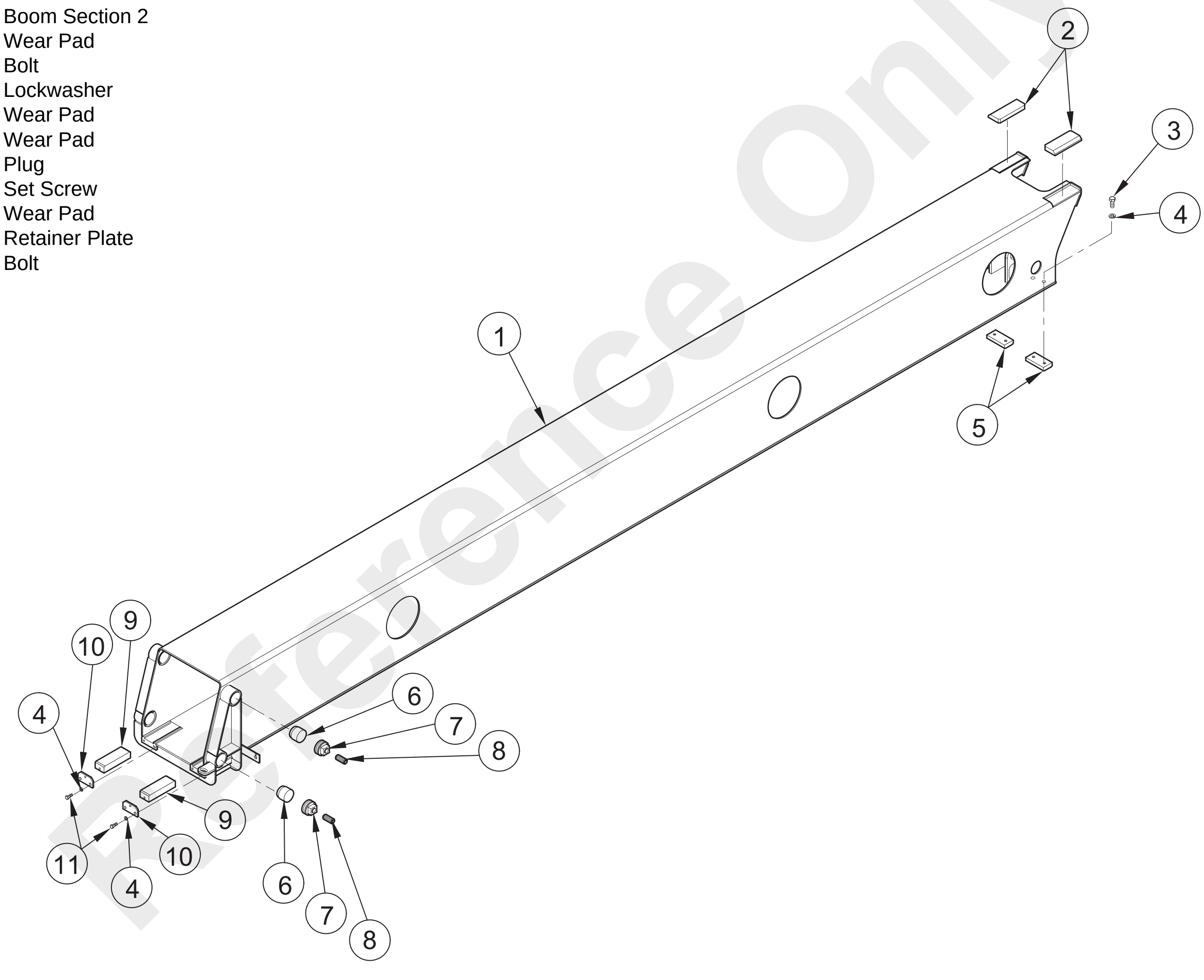


FIGURE 11-8

NOTE: Refer to Figure 11-9 For steps 15 thru 18.

Steps 15 thru 18 pertain only to the disassembly of boom section 3 of the four section boom.

15. Remove the top rear wear pads from boom section 3.

16. Raise up on the boom section 4 assembly and remove the bolts and lockwashers securing the front bottom wear pads and remove the wear pads from the boom section 3.

17. Slide the assembly out of the boom section 3.

18. As necessary, remove the following items from the boom section 3:

a. Remove the bolts and lockwashers securing the lower rear wear pad, remove the wear pad.

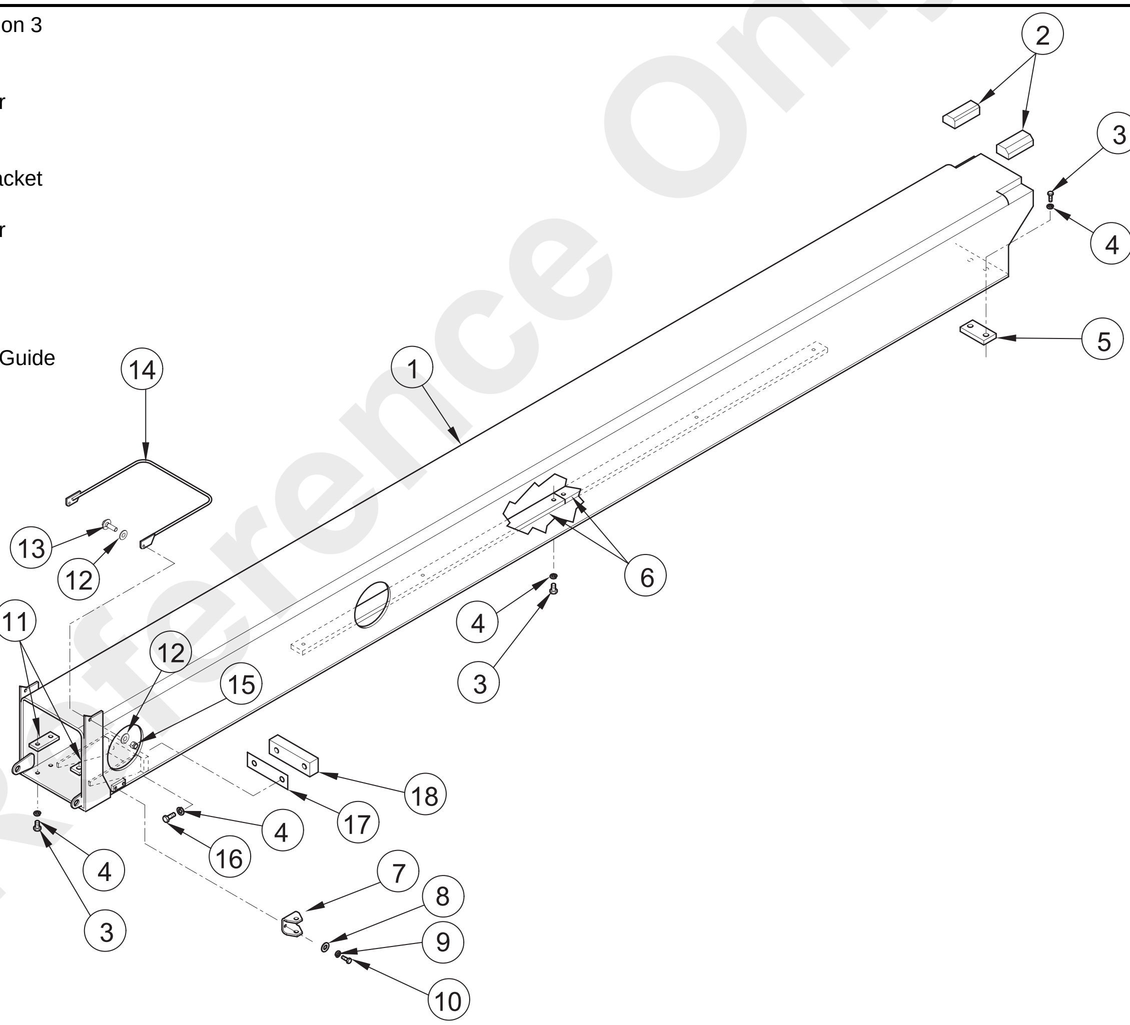
b. Remove the wire rope guide.

c. Remove the bolts and lockwashers securing the two long wear bars in the bottom of the section and remove the wear bars.

d. Remove the bolts and lockwashers securing the bumper to the bracket in the front of the section and remove the bumper and shim(s).

e. Remove the bolt, lockwasher and washer securing the holding bracket to the side of the boom section and remove the bracket.

1. Boom Section 3
2. Wear Pad
3. Bolt
4. Lockwasher
5. Wear Pad
6. Wear Pad
7. Holding Bracket
8. Washer
9. Lockwasher
10. Bolt
11. Wear Pad
12. Washer
13. Bolt
14. Wire Rope Guide
15. Nut
16. Bolt
17. Shim(s)
18. Bumper



11528

FIGURE 11-9

NOTE: Refer Figure 11-10 For steps 19 thru 22.

Steps 19 thru 22 pertain to the disassembly of boom section 4 of the four section boom and section 3 of the three section boom.

19. Remove the top rear wear pads from the boom section.

20. Remove the snapper pin and pin securing the telescope cylinder to the boom section. (refer to Figure 11-11)

21. Slide the telescope cylinder assembly out of the boom section.

22. As necessary, remove the following items from the boom section:

a. On the three section boom only, remove the bolts and lockwashers securing the rear bottom wear pad and remove the wear pad.

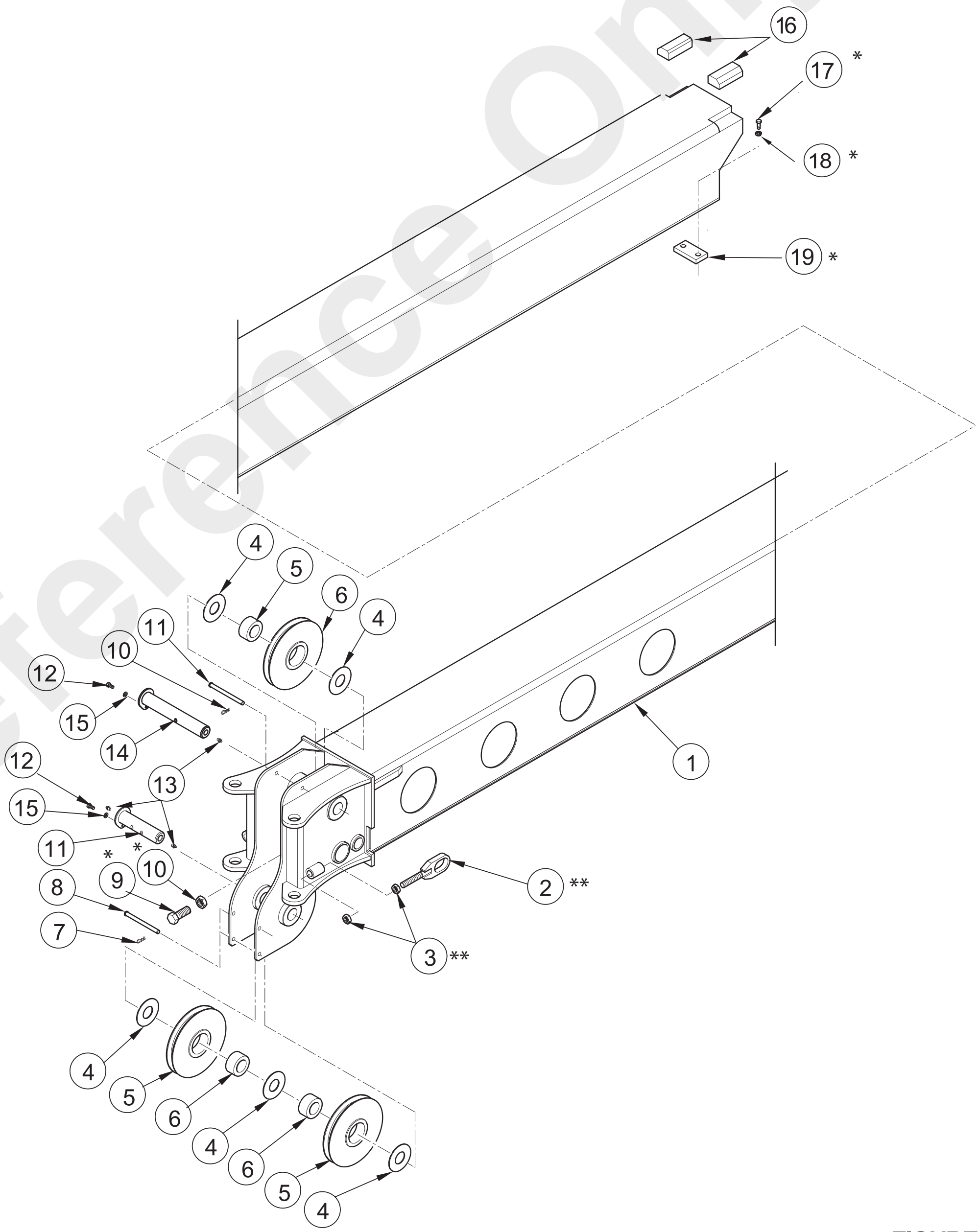
b. On the boom nose, remove the three cotter pins and clevis pins.

c. On the four section boom, remove the retract adjuster.

d. Remove the bolt securing the upper sheave pin and remove the pin, sheave and two nylatron washers.

e. Remove the bolt securing the lower sheave pin, and remove the pin, two sheaves and three nylatron washers.

1. Boom Section
2. Retract Adjuster **
3. Nut **
4. Nylatron Washer
5. Sheave
6. Bearing
7. Cotter Pin
8. Clevis Pin
9. Bolt **
10. Nut **
11. Lower Sheave Pin
12. Bolt
13. Grease Fitting
14. Upper Sheave Pin
15. Lockwasher
16. Wear Pad
17. Bolt *
18. Lockwasher *
19. Wear Pad *



11537-A

FIGURE 11-10

Manitowoc Crane Care

NOTE: Refer to Figure 11-11 For steps 23 thru 31.

Steps 23 thru 31 pertain to disassembly (as necessary) of the telescope cylinder assembly.

23. On the four section boom, remove the bolts, washers, lockwashers and nuts securing the guide pad and pad support bar to the piston end of the lower telescope cylinder.

24. Remove the bolts and nuts securing the wear pad to the bracket on the lower cylinder barrel, remove the wear pad.

25. Disconnect the tubing from the fitting on the piston end of the lower cylinder. Remove the fitting and plug the hole in the cylinder.

26. Disconnect the tubing from the barrel end of the upper cylinder. Remove the fitting and plug the hole in the cylinder.

27. Disconnect the tubing from the piston end of the upper cylinder. Remove the fitting and plug the hole in the cylinder.

28. Remove the tubing with check valve manifold from the cylinders.

29. Remove the upper cylinder from the lower cylinder by removing the four bolts and lockwasher at the barrel end of the upper cylinder and removing the four bolts, washer, lockwashers and nuts from the piston end of the upper cylinder.

30. Remove the four bolts and lockwashers securing the bracket to the barrel end of the lower cylinder.

31. Disassemble the tubing as necessary.

1. Upper Telescope Cylinder
2. Counterbalance Valve
3. Washer
4. Cotter Pin
5. Nut
6. Nut
7. Lockwasher
8. Lower Telescope Cylinder
9. Pin
10. Cotter pin
11. Bolt
12. Lockwasher
13. Washer
14. Bolt
15. Wear Pad
16. Bolt
17. Pin
18. Nut *
19. Guide Pad *
20. Washer *
21. Pad Support Bar *
22. Snapper Pin
23. Nut
24. Omitted
25. Bracket
26. Elbow Fitting
27. Tube Assembly
28. Tube Assembly
29. Nut
30. Washer
31. Tube Block
32. Bolt
33. Elbow Fitting

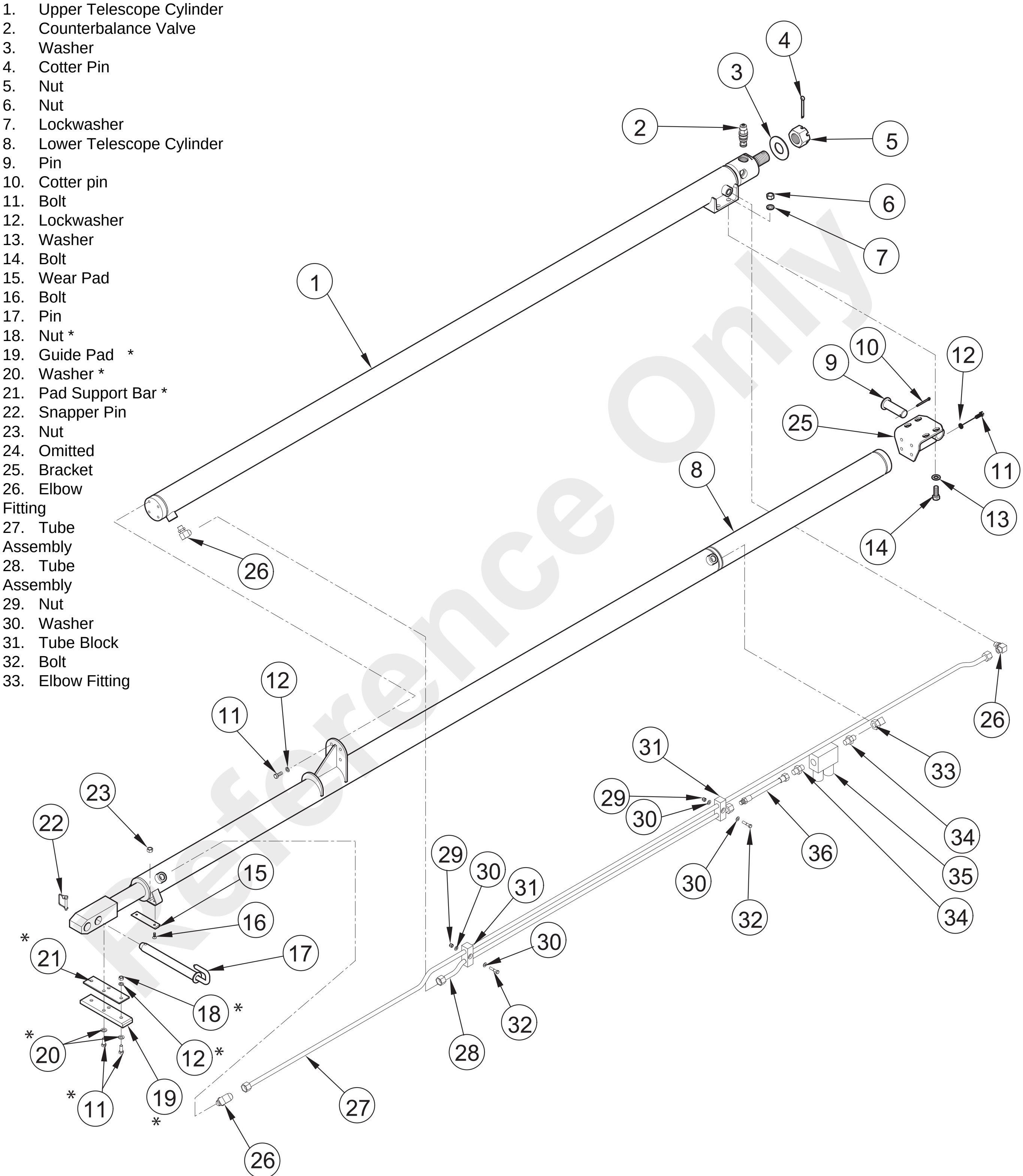


FIGURE 11-11

Assembly

NOTE: During assembly, use Loctite 242 (blue) on all fastener threads. Apply lubricant (bronze anti-seize) to all wear pads. Apply grease to the inside bottom, top, and sides of all boom sections.

NOTE: Refer to Figure 11-11 For steps 1 thru 11.

Steps 1 thru 11 pertain to assembly (as necessary) of the telescope cylinder assembly.

1. Install the elbow fittings in the ports of both telescope cylinders. Do no tighten at this time.

2. Position the bracket on the barrel end of the lower cylinder and secure the four bolts and lockwashers.

3. Install the upper cylinder on the lower cylinder by installing the four bolts and lockwasher at the barrel end of the upper cylinder and installing the four bolts, washer, lockwashers and nuts at the piston end of the upper cylinder.

4. Connect the longer tube between the elbow fittings on the upper and lower cylinder piston ends.

5. Connect one end of the shorter tube to the elbow fitting on the barrel end of the upper cylinder.

6. Connect the hose assembly to the other end of the shorter tube.

7. Install a connector fitting in each port of the check valve manifold and connect the manifold to the hose assembly.

8. Connect the manifold to the elbow fitting on the barrel end of the lower cylinder.

9. Tighten all fittings.

10. Position the wear pad on the bracket on the lower cylinder barrel and secure with the bolts and nuts.

11. On the four section boom, install the guide pad and pad support bar to the piston end of the lower telescope cylinder and secure with the bolts, washers, lockwashers and

NOTE: Refer to Figure 11-10 For steps 12 thru 15.

Steps 12 thru 15 pertain to the disassembly of boom section 4 of the four section boom and section 3 of the three section boom.

12. As necessary, install the following items on the boom section:

- **a.** On the three section boom only, install the rear bottom wear pad and secure with the bolts and lockwashers.
- **b.** On the boom nose, install the three clevis pins and cotter pins.
- **c.** On the four section boom, install the retract adjuster using two nuts.
- **d.** Replace the bearings in the sheaves as necessary.
- **e.** Install the upper sheave and two nylatron washers. Install the upper sheave pin and secure with a bolt.
- **f.** Install the lower sheave and three nylatron washers. Install the lower sheave pin and secure with a bolt.

13. Install the top rear wear pads on the boom section.

14. Slide the telescope cylinder assembly into the boom section.

15. Install the pin securing the telescope cylinder to the boom section. Install the snapper pin in the pin. (refer to Figure 11-11)

NOTE: Refer to Figure 11-9 For steps 16 thru 19.

Steps 16 thru 19 pertain only to the disassembly of boom section 3 of the four section boom.

16. As necessary, Install the following items on the boom section 3:

- **a.** Install the lower rear wear pad and secure with the bolts and lockwashers.
- **b.** Install the wire rope guide two bolts, washers(4), lockwashers, and nuts.
- **c.** Install the two long wear bars in the bottom of the section and secure with the bolts and lockwashers.
- **d.** Install the bumper and shim(s) to the bracket in the front of the section and secure with the bolts and lockwashers.
- **e.** Install the holding bracket on the side of the boom section and secure with the bolt, lockwasher and washer.

17. Slide the assembly into the boom section 3.

18. Raise up on the boom section 4 assembly and install the front bottom wear pads in the boom section 3. Install the bolts and lockwashers securing the wear pads.

19. Install the top rear wear pads on the boom section 3.

NOTE: Refer to Figure 11-8 for steps 20 thru 26.

20. As necessary, install the following items on the boom section 2:

- **a.** Install the lower rear wear pads and secure with the bolts and lockwashers.
- **b.** Install the front top and bottom side wear pads, plugs and set screws. Do not tighten the set screw at this time.

21. Slide the assembly into the boom section 2.

22. Install the pin and cotter pin securing the telescope cylinder bracket to the rear of boom section 2. (Refer to figure 9-11)

23. Raise up on the boom section 3 assembly and install the front lower wear pads in the boom section 2.

24. Install the wear pad retainer plates to the front of boom section 2 and secure with the bolts and lock washers.

25. Install the top rear wear pads on boom section 2.

26. Tighten the front top and bottom side wear pad set screws on boom section 2 to center the assembly in boom section 2.

NOTE: Refer to Figure 11-7 for steps 27 thru.

27. As necessary, install the following items on the boom section 1:

- **a.** Wire rope guide.
- **b.** Boom angle indicator.
- **c.** Anti-two block and LMI components.
- **d.** Jib attachment brackets.
- **e.** Upper rear cable wear pad.
- **f.** Grease fittings and boom pivot pin bushings.
- **g.** Install the front top and bottom side wear pads, plugs and set screws. Do not tighten set screws at this time

28. Slide the assembly into the boom section 1.

29. Install the nut, washer, and cotter pin securing the upper telescope cylinder rod to the rear of boom section 1. (Refer to figure 9-11)

30. Raise up on the boom section 2 assembly and install the front lower wear pads in the boom section 1.

31. Install the wear pad retainer plates to the front of boom section 1and secure with the bolts and lock washers.

32. At the rear of the assembly, install the hoses and fittings to the telescope cylinder.

33. Tighten the front top and bottom side wear pad set screws on boom section 1to center the assembly in the boom section 1.

WIRE ROPE, SHEAVES AND HOIST BLOCKS

Wire Rope Description

A wire rope is a machine, by definition: "An assemblage of parts that transmit forces, motion and energy from one to another in some predetermined manner and to some desired end."

A typical wire rope may contain dozens, even hundreds, of individual wires which are formed and fabricated to operate at close bearing tolerances one to another. When a wire rope bends, each of its many wires slide and adjust in the bend to accommodate the differences in length between the inside and the outside of the bend. The sharper the bend, the greater the movement.

Every wire rope has three basic components (Figure 11-12): (1) The wires which form the strands and collectively provide rope strength; (2) the strands, which are laid helical around the core, and (3) the core, which forms a foundation for the strands. The core used in the crane wire rope is an Independent Wire Rope Core (IWRC), which is actually a smaller rope, or a strand similar to the outer strands of the rope. The IWRC core adds about 7.5% to the nominal strength of the wire rope.

The greatest differences in wire ropes are found in the strands, which may vary widely in the pattern and number of wires which are laid together.

The wires of the rope may be made of various metals, including steel, iron, stainless steel, monel, and bronze. The materials of which wires are made is the primary determination of rope strength. High-carbon steel is used in the crane wire rope.

Carbon steel wire ropes come in various grades. The term “Grade” is used to designate the nominal strength of the wire rope. The most common grades are Traction Steel (TS), Plow Steel (PS), Improved Plow Steel (IPS), Extra Improved Plow Steel (EIPS) and Extra Extra Improved Plow Steel (EEIPS). The wire rope used on this crane is an EIPS Grade.

One cannot determine the grade of wire rope by its feel or appearance. To be sure you are using the proper rope, always obtain the wire rope from your dealer.

a0358

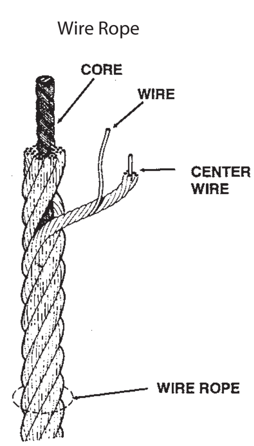


FIGURE 11-12

Wire Rope Safety

The following information is not a complete discussion of wire rope. What follows is a brief outline of the basic information required to safely use wire rope.

1. Wire rope WILL FAIL IF WORN-OUT, OVERLOADED, MISUSED, DAMAGED or IMPROPERLY MAINTAINED.
2. In service, wire rope looses strength and work capability. Abuse and misuse increases the rate of loss.
3. The NOMINAL STRENGTH, sometimes called CATALOG strength, of a wire rope applies ONLY to a NEW, UNUSED rope.
4. The Nominal Strength of a wire rope SHOULD BE CONSIDERED the straight line pull which will ACTUALLY BREAK a NEW UNUSED rope. The Nominal Strength of a wire rope SHOULD NEVER BE USED AS ITS WORKING LOAD.
5. WIRE ROPES WEAR OUT. The strength of a wire rope begins to decrease when the rope is put to use and continues to decrease with each use.
6. NEVER OVERLOAD A WIRE ROPE. This means NEVER use the wire rope where the load applied to it is greater than the working load determined by the rope manufacturer.
7. NEVER “SHOCK LOAD” a wire rope. A sudden application of force or load can cause both visible external and internal damage. There is no practical way to estimate the force applied by shock loading a rope. The sudden release of a load can also damage a wire rope.
8. Lubricant is applied to the wires and strands of a wire rope when it is manufactured. The lubricant is depleted when the rope is in service and should be replaced periodically. See Preventative Maintenance, for lubrication intervals and procedures.
9. In the U.S.A., regular INSPECTIONS of the wire rope and keeping of PERMANENT RECORDS SIGNED BY A QUALIFIED PERSON ARE REQUIRED BY OSHA FOR ALMOST EVERY WIRE ROPE APPLICATION. The purpose of the inspection is to determine whether or not a wire rope may continue to be safely used on the application. Inspection criteria, including number and location of broken wires, wear and elongation, have been established by OSHA, ANSI, ASME and similar organizations.

   IF IN DOUBT, REPLACE THE ROPE. An inspection should include verification that none of the specified removal criteria for this usage are met by checking for such things as:

   - Surface wear; nominal and unusual.
   - Broken wires; number and location.
   - Reduction in diameter.
   - Rope stretch (elongation).
   - Integrity of end attachments.
   - Evidence of abuse or contact with another object.
   - Heat damage.
   - Corrosion.

   In addition, an inspection should include condition of sheaves, drums and other apparatus with which the wire rope makes contact.
10. When a wire rope has been removed from service because it is no longer suitable for use, it must not be reused on another application.
11. Every wire rope user should be aware of the fact that each type of fitting attached to a wire rope has a specific efficiency rating which can reduce the working load of the wire rope assembly or rope system, and this must be given due consideration.
12. Some conditions that lead to problems in wire rope systems include:
   - Sheaves that are too small, worn or corrugated can cause damage to a wire rope.
   - Broken wires mean a loss in strength.
   - Kinks permanently damage a wire rope and must be avoided.
   - Wire ropes are damaged by knots. Wire rope with knots must never be used.
   - Environmental factors such as corrosive conditions and heat can damage a wire rope.
   - Lack of lubrication can significantly shorten the useful life of a wire rope.°
   - Contact with electrical wires and resulting arcing will damage a wire rope.

Inspecting Wire Rope

Inspect entire length of wire rope for any conditions listed in Figure 11-13. If any of the conditions exist, replace the wire rope.

If the wire rope shows severe wear, make a full inspection of sheaves and drums for grooves, correct alignment, etc.

Inspection of Sheaves

Inspect all sheaves for wear and proper alignment.

For maximum life of the wire rope, the sheave grooves must be smooth and must be a little larger than the diameter of the wire rope.

As wear in the sheaves increases, the groove for the wire rope gets smaller, NOT larger. Tracks in the sheaves are caused by the wire rope, and the wire rope will continue to engage the tracks (for example; like a chain engaging a sprocket). A twist in the wire rope or a small change of lay will prevent the wire rope from engaging the track in the sheave. The result will be a rapid wear on the wire rope and on the sheave.

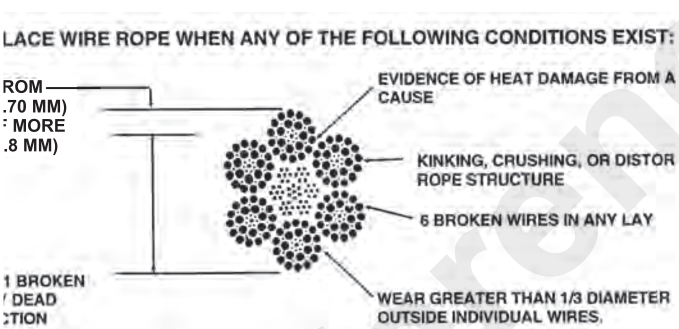
Wire Rope Lubrication

Lubricate the wire rope with a good grade of spray wire rope lubricant or a light weight oil. A more frequent lubrication (more than monthly) may be required due to operating conditions and usage.

Proper lubrication of the wire rope is just as important as lubrication of other components. The wire rope has many moving parts. Initial lubrication will not last throughout the life of the wire rope. Lubrication is essential to reduce wear and inhibit corrosion of the wires.

After cleaning, apply a light weight oil that will penetrate into the wire rope, or a light weight oil that has been preheated to a temperature between 60° and 100° (18° and 36° C). Use a brush or cloth to apply the oil.

Wire Rope Inspection



Wire Rope Installation

Installation of Socket and Wedge

Always connect the socket so that the load is pulled on the same line as the socket (See Figure 11-14).

WARNING

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.

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 11-14.

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

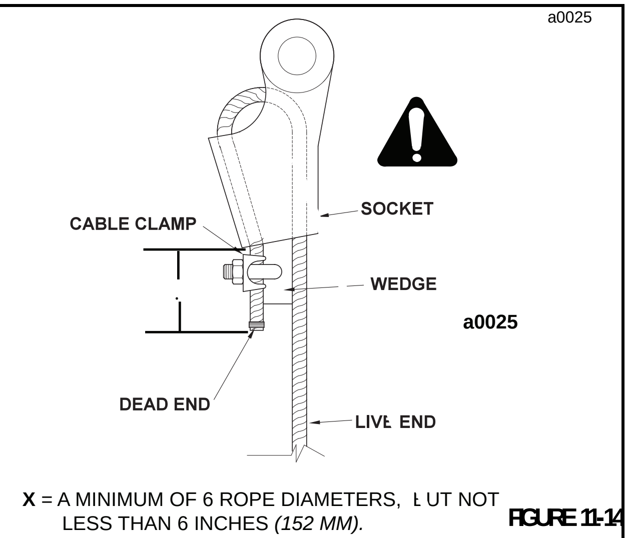


FIGURE 11-14

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 11-15. Use care to prevent reverse bend in the wire rope.

1. Make sure that the equipment (drum, sheaves, etc.) are in good condition.
2. Unwind enough rope from the reel to connect the wire rope to the winch drum. Use care to prevent twists or sharp bends.

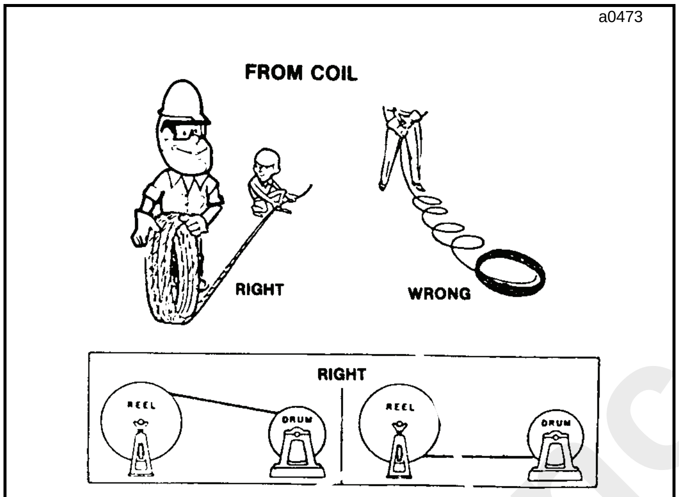


FIGURE 11-15

3. Operate the winch slowly to move the wire rope directly from the reel to the winch 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.

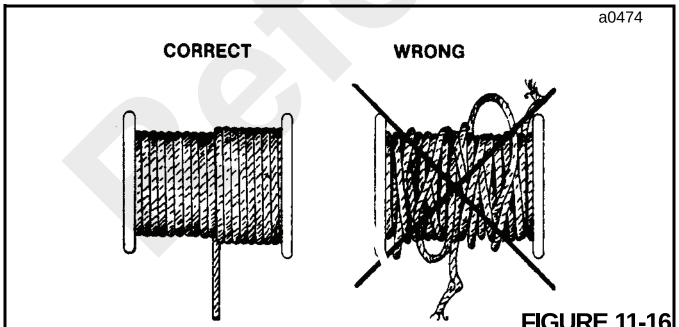


FIGURE 11-16

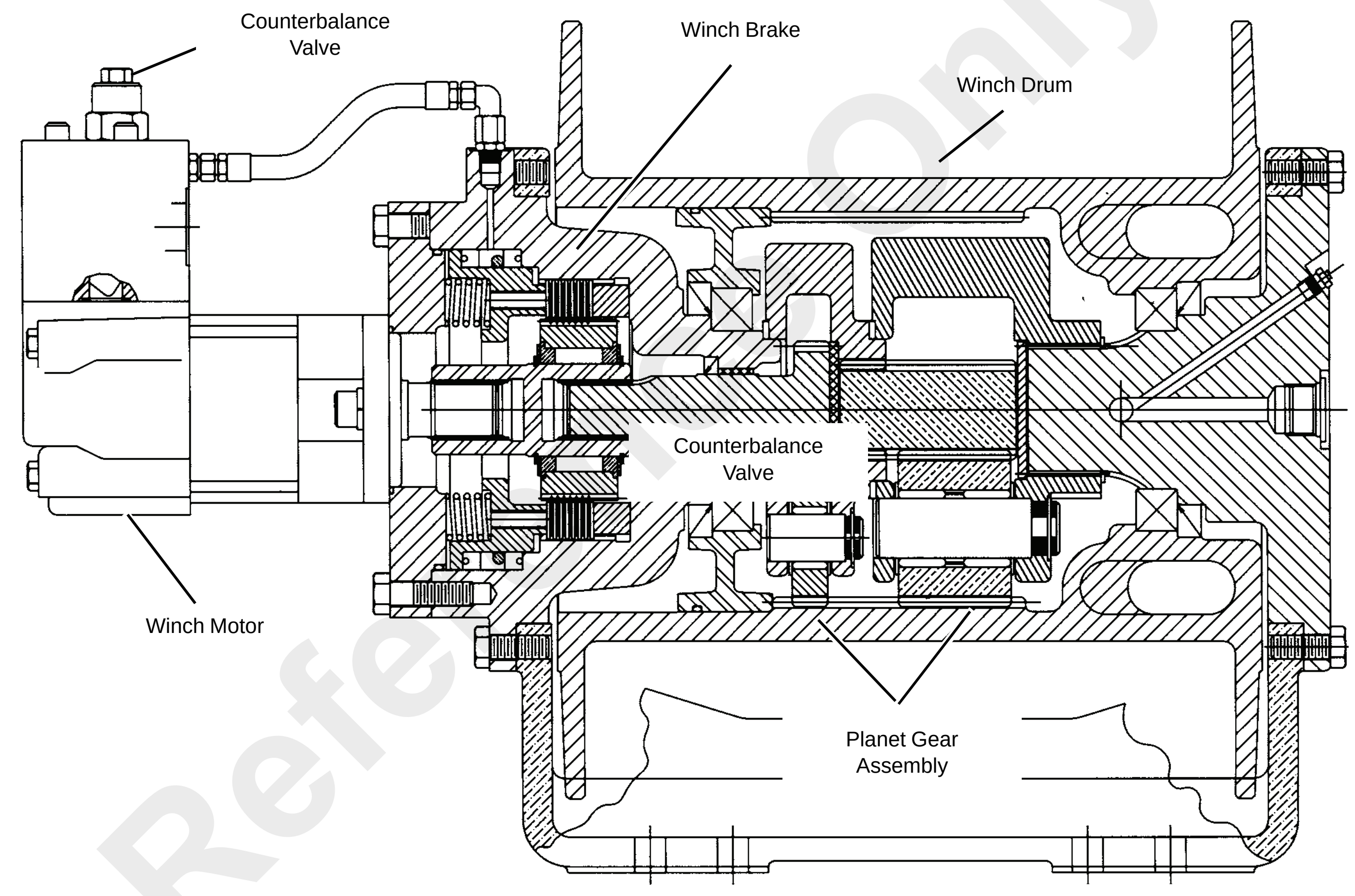
4. After installation, operate the winch with a minimum load until you see the wire rope is moving easily over the sheaves and is winding correctly on the winch drum.
5. Gradually increase the speed and load until the wire rope is moving at normal load and speed. This run-in period adjusts the moving parts to each other.

MAIN WINCH (TULSA MODEL)

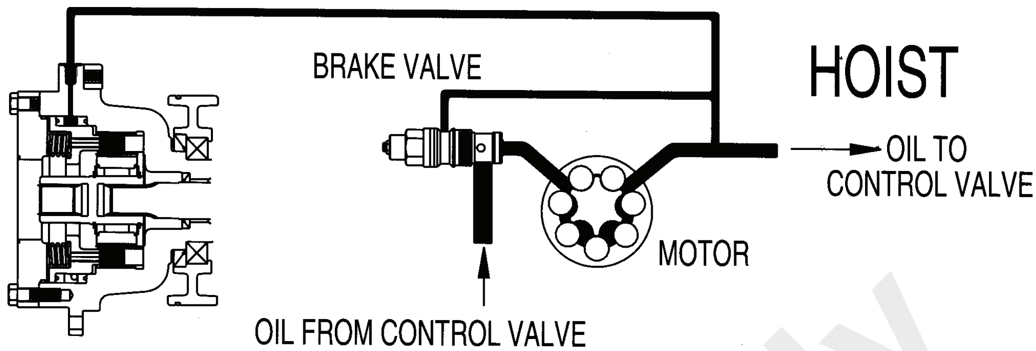
Theory Of Operation

The main winch design (Figure 11-17) is composed of a high speed, low torque gerotor motor, driving through a multiple disc brake, through 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 in-haul (Figure 11-18) 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 inhibited from moving by the brake. During payout (Figure 11-19), a counterbalance valve is used to inhibit the load from moving faster than desired. The counterbalance 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 counterbalance valve modulates by sensing pressure on the other mainline, the line from the main control valve to the motor. Also, anytime there is sufficient pressure to modulate the counterbalance valve, this same pressure releases the multiple disc brake.

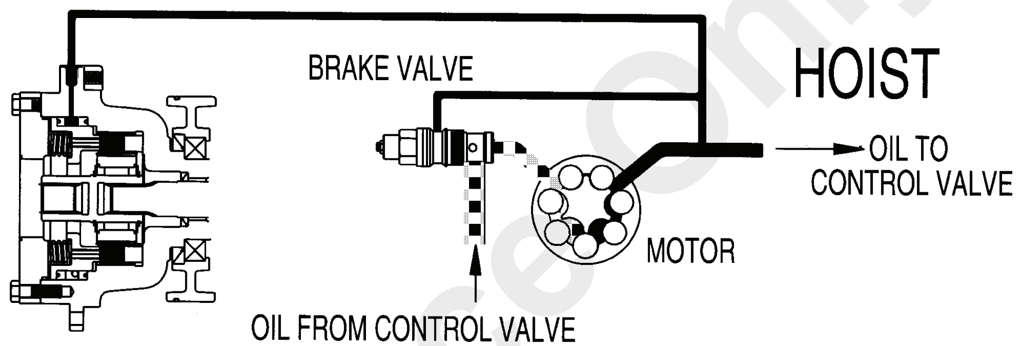


Typical Main Winch Assembly - Cut-Away View **FIGURE 11-17**



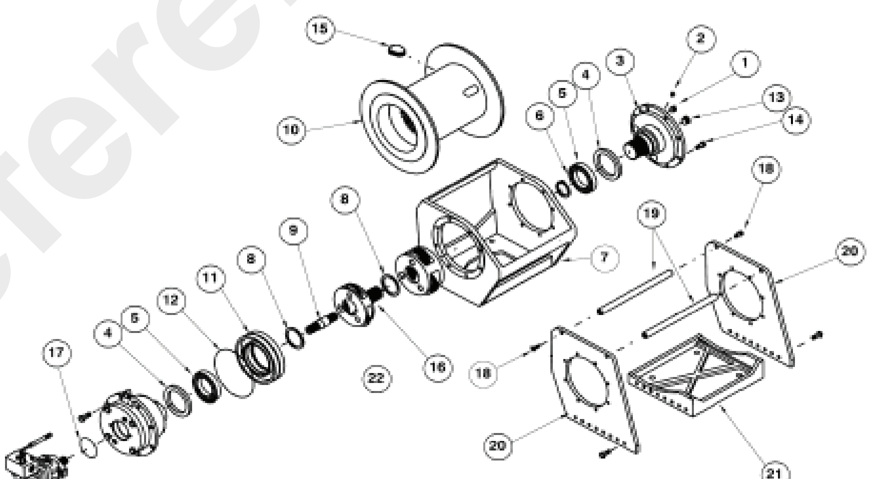
a0481

FIGURE 11-18



a0482

FIGURE 11-19



1. Plug
2. Breather
3. 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

a0485

Winch Exploded View

FIGURE 11-20

Repair

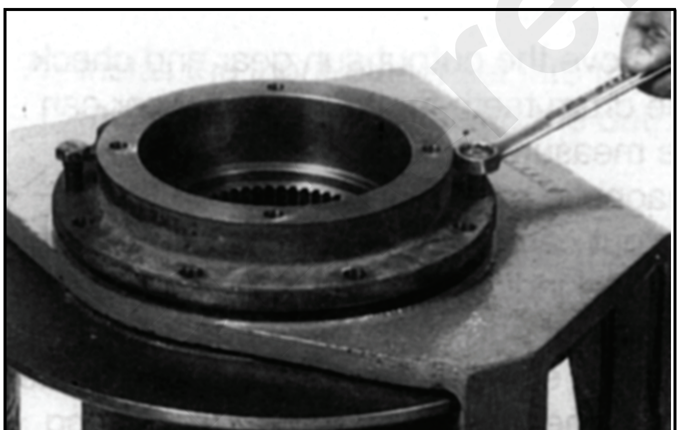
Removal

1. Remove the wire rope from the winch drum.
2. With the engine shut off, move the winch control level back and forth several times to release any hydraulic pressure in the winch hydraulic circuit.
3. Disconnect and cap or plug all hydraulic lines.
4. Attach an overhead hoist to the winch and remove the hex bolts, structural washers and structural nuts securing the winch to the mast assembly. Remove the winch.

Winch Assembly

Disassembly

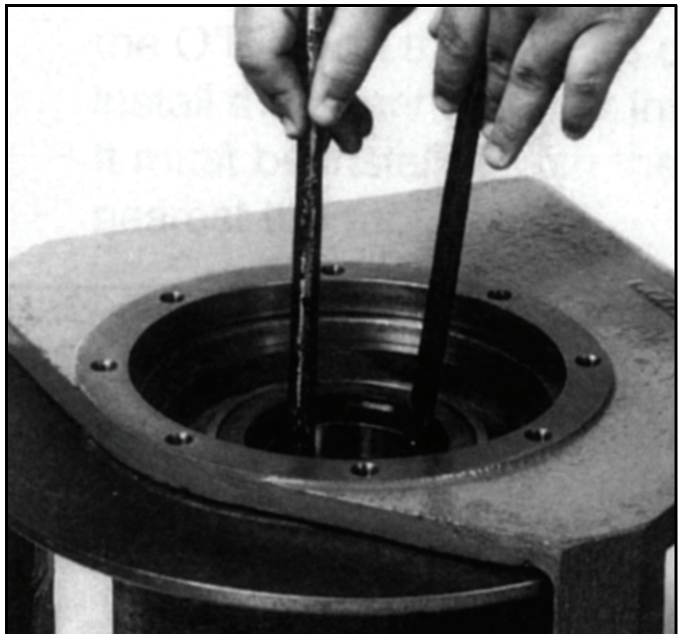
1. Stand the winch on its end with the motor pointing up.
2. Remove any hydraulic lines or hoses from the winch assembly. Remove the motor and counterbalance valve from the winch.
3. Remove the brake subassembly from the winch by removing eight capscrews holding the brake housing to the mounting bracket. Install two of the capscrews into the extra two tapped holes (Figure 11-21) and tighten then evenly until the brake housing has come loose from the mounting bracket. See Brake Section for repair instructions.



p0188

FIGURE 11-21

4. Using two crows foot pry bars (Figure 11-22) from inside and pull it out of the cable drum. Remove the bearing 5 and seal 4 from the bearing carrier 11.



p0189

FIGURE 11-22

5. Remove the input sun gear (9) from the input planet assembly.
6. Install three 1/4 inch eyebolts into the three planet pins in the input planet set. Use a piece of chain (Figure 11-23) to pull the planet set from the drum. Inspect the planet set for wear and repair as needed. See Planet Sets (Page 6-26) for repair instructions.

p0190

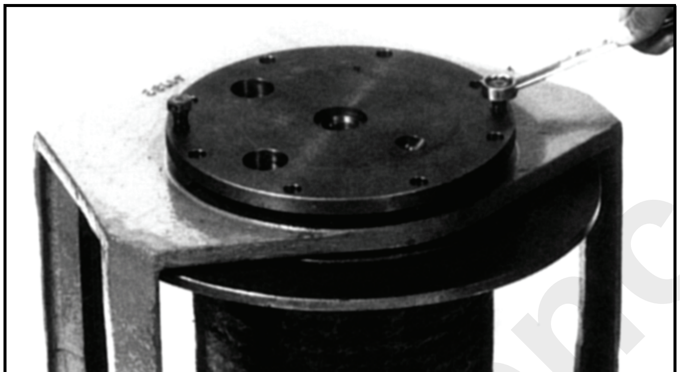
FIGURE 11-23

7. Remove the output sun gear and check drum teeth for wear. This wear can be measured as follows:
   a. Place a magnetic base dial indicator on the output carrier and adjust the plunger of the dial indicator at

approximately 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 0.025 inches (0.64 mm), then the drum should be replaced.Using the same procedure as in Step 5, remove the output planet set from the drum. Inspect the planet set for wear and repair as necessary. See Planet Sets (Page 6-26) for repair instructions.

8. Turn the winch over onto the motor end and remove the capscrews holding the output shaft (3, Figure 11-24) into the mounting bracket. Install two of the capscrews into the extra threaded holes in the output shaft (Figure 11-23) and evenly tighten them until the output shaft is free from the mounting bracket.



p0191 **FIGURE 11-24**

9. Remove the drum from the mounting bracket.

10. Remove the bearing and seal (Figure 11-25) from the drum and inspect the bearing for signs of pitting and spalling.

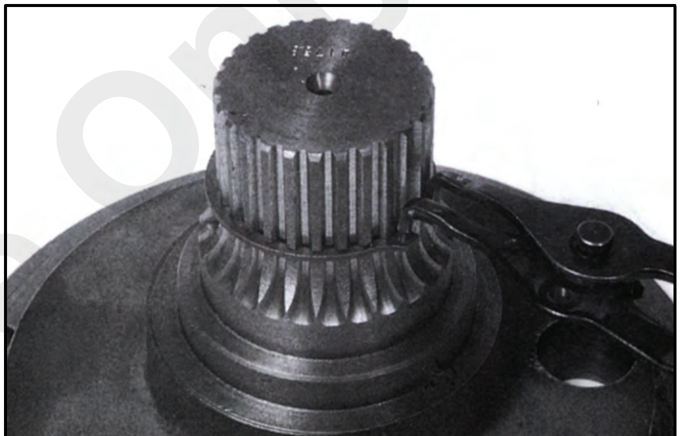
p0192 **FIGURE 11-25**

Assembly

1. Thoroughly clean all parts. Replace those which show wear.

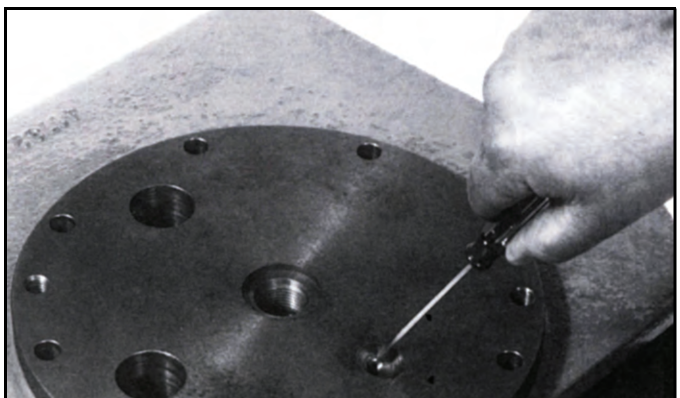
2. After inspecting the drum for excessive wear in the gear teeth and both the drum and mounting bracket for structural integrity, install bearing (5, Figure 11-25) and seal 6 into the drum. Stand the mounting bracket up on the motor end and slide the drum into it. Make sure the drum is installed in the same direction as it was removed or the winch assembly will be wrong when completed.

3. Check the snap ring (Figure 11-26) to ensure it is in its groove and not bend over. Replace if necessary.



p0196 **FIGURE 11-26**

4. Install the output shaft (Figure 11-27) 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 a 100 to110 lb-ft. (130 to 143 Nm).



p0195 **FIGURE 11-27**

5. Turn the assembly over onto the output shaft side and install the output planet carrier. Use the same eyebolts and chain used to disassemble the unit.

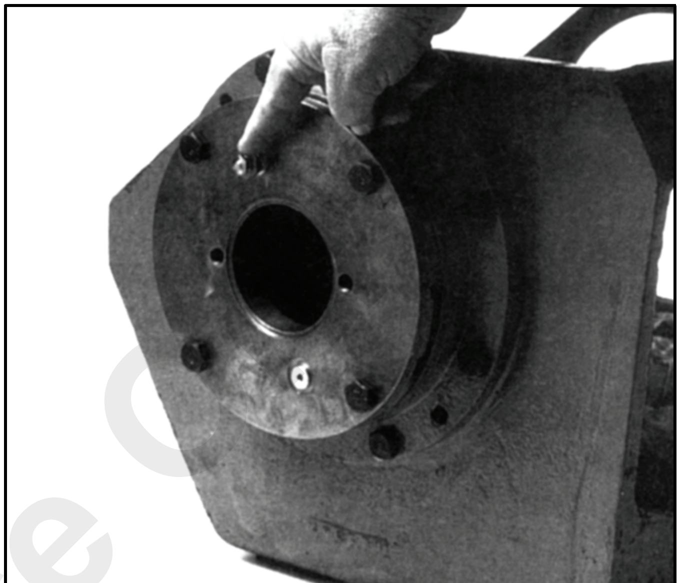
6. Put a light coating of grease on the thrust washer (8, Figure 11-20) to keep it in place.Install it into the output planet set and insert the output sun gear 16 into the output planet set.

7. Install the input planet set into the drum. Make sure it fits into the output sun gear.
8. Install the input sun gear 9 and thrust washer9 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 (Figure 11-28) Install the bearing (5, Figure 11-20) into the bearing carrier (Figure 11-28). Grease the o-ring on the bearing carrier and install the bearing carrier into the drum. It must be installed with the o-ring nearest the motor end.

p0193 **FIGURE 11-28**

p0194 **FIGURE 11-29**

10. Place the brake section into the winch bracket (Figure 11-29). 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 100 to110 lb-ft. (130 to 143 Nm). Also, make sure that the level and vent plugs (Figure 11-30) in the cover are properly oriented.

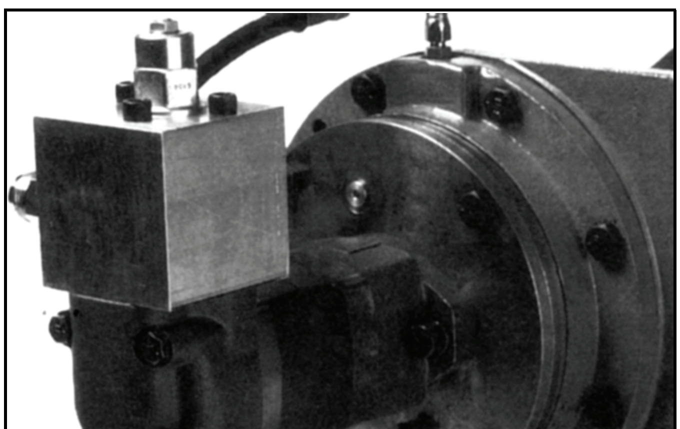


p0197 **FIGURE 11-30**

11. Install a new o-ring (17, Figure 11-20) 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 Preventative Maintenance, Section 5.

Motor Group

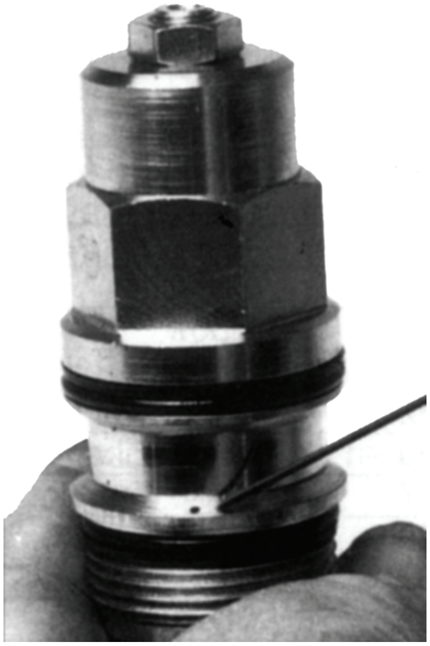
1. Tag the hoses for proper installation and remove them from the motor and brake valve. See Figure 11-31.



p0198 **FIGURE 11-31**

2. Remove the counterbalance valve assembly from the motor.

Remove the cartridge from the counterbalance valve assembly and inspect the metering hole (Figure 11-32) 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 11-32

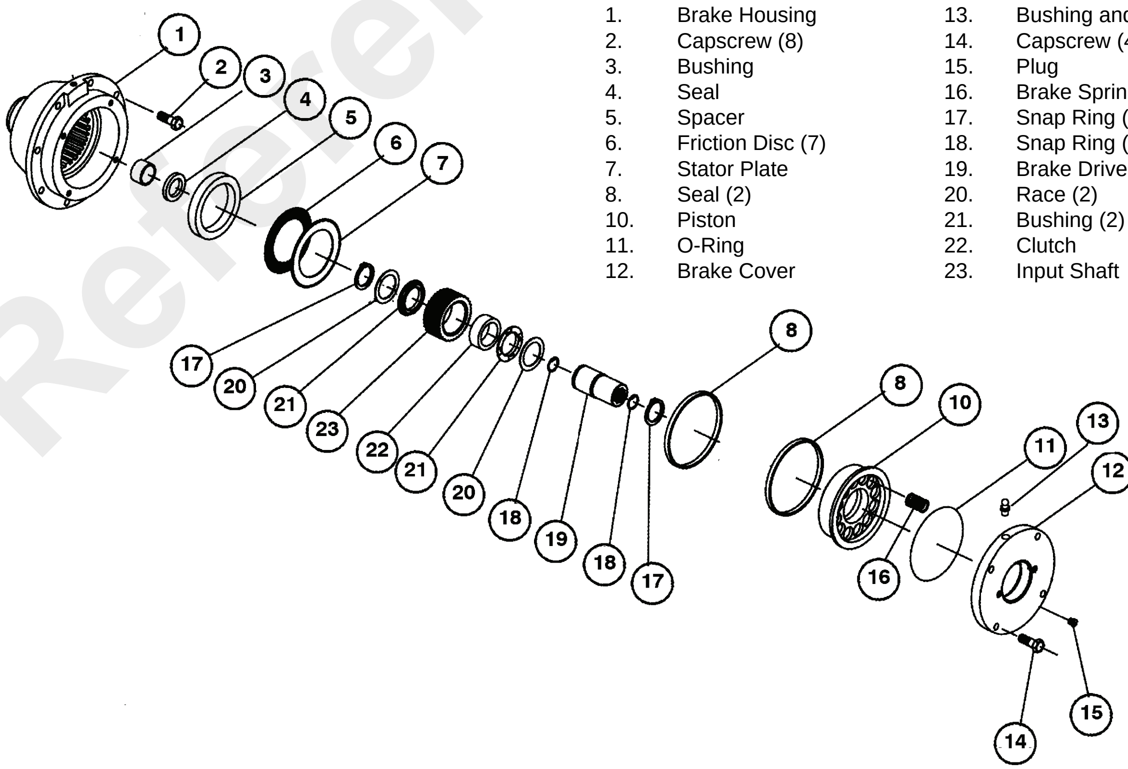
3. The motor and cartridge valve are not serviceable in the field.

Brake Section

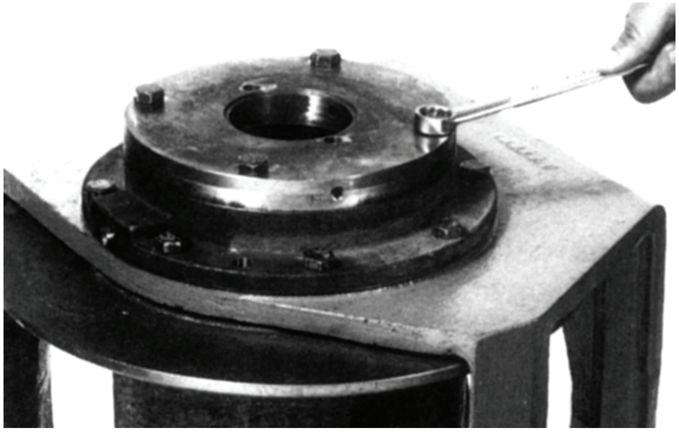
Disassembly

1. Remove the capscrews (Figure 11-34) holding the motor cover in place. Spring pressure will raise the cover as the capscrews are loosened. Carefully remove cover from the brake housing.
2. Remove the springs (Figure 11-35) from the piston and check them for free height. Each spring should be at 1.200 inches (30.5 mm) with no force on them.

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	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

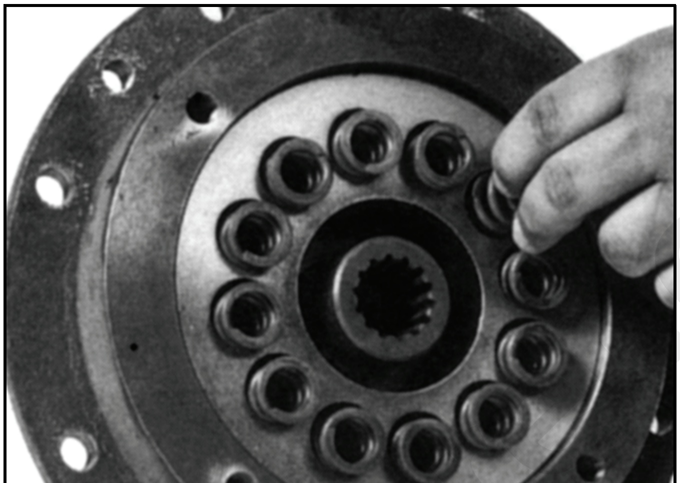


p0478 Brake Exploded View FIGURE 11-33



p0200

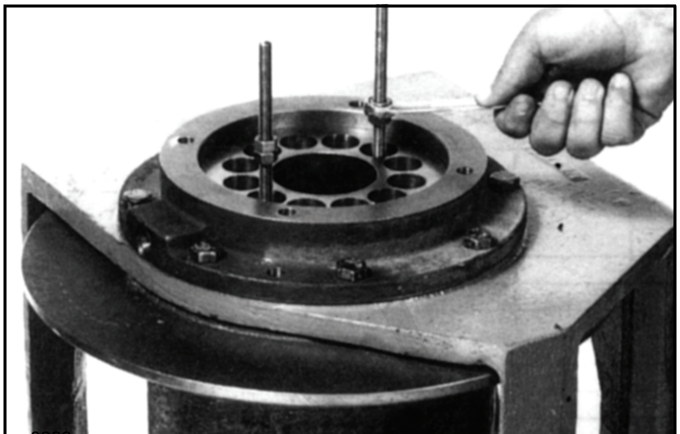
FIGURE 11-34



p0201

FIGURE 11-35

3. Remove the piston by installing two pieces of3/8 NC all-thread (Figure 11-36) in the bottom of the 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.



p0202

FIGURE 11-36

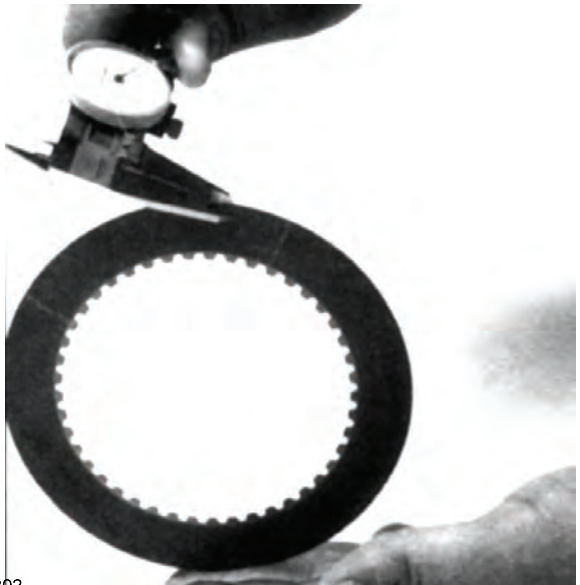
4. If one or both of the square seals (8, Figure 11-33) remain in the bore of the brake housing, remove them.

5. Grasp the brake driver/clutch assembly (items17 through 23, Figure 11-33) and remove it from the brake housing.

6. Remove the stator plates 7 and friction discs6 from the brake housing and check them for excessive wear. Replace if necessary. Be sure to check the top stator plate (Figure 11-37) for scoring caused by the removal tools and polish if necessary. Friction discs (Figure 11-38). should measure no less than 0.055 inches (1.40 mm) thickness and stator plates should measure no less 0.068 inches (1.72 mm) thickness.

p0204

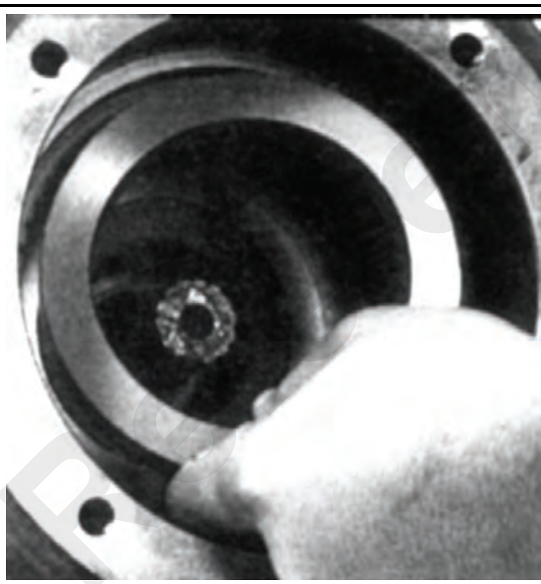
FIGURE 11-37



p0203

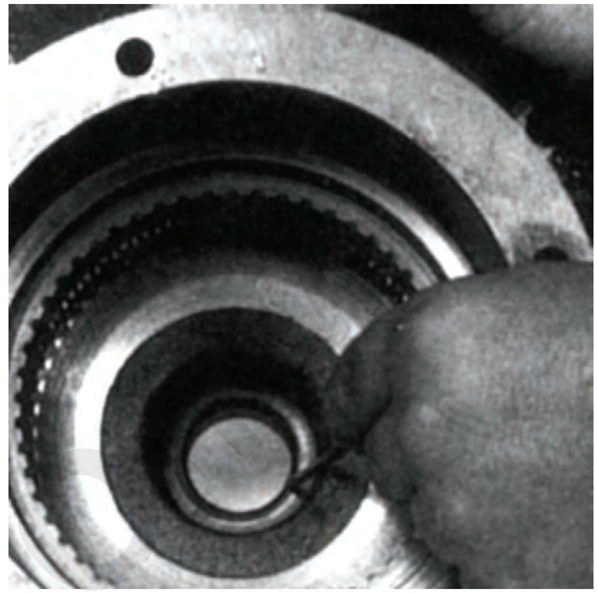
FIGURE 11-38

7. Remove the spacer (Figure 11-39) from the brake housing. With a hook (Figure 11-40) or pry bar, remove the seal.



p0205

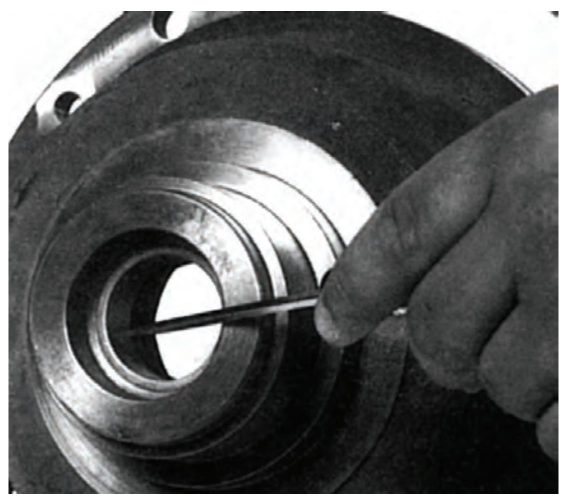
FIGURE 11-39



p0206

FIGURE 11-40

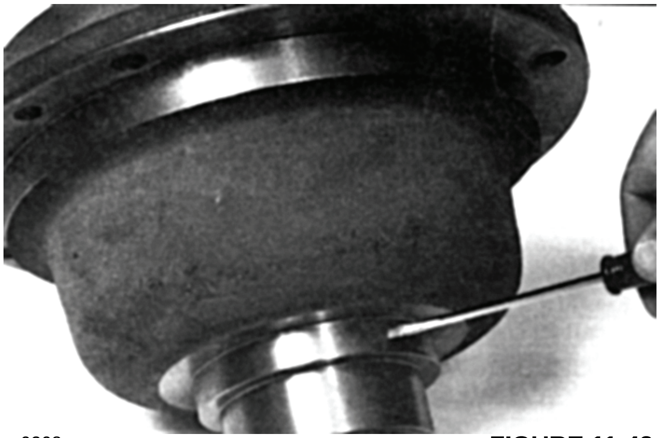
8. .Examine the bushing (Figure 11-41) in the brake housing for wear and if found replace it.



p0207

FIGURE 11-41

Examine the journal for wear on the brake housing (Figure 11-42) where the seal runs. If severely worn, replace the brake housing.

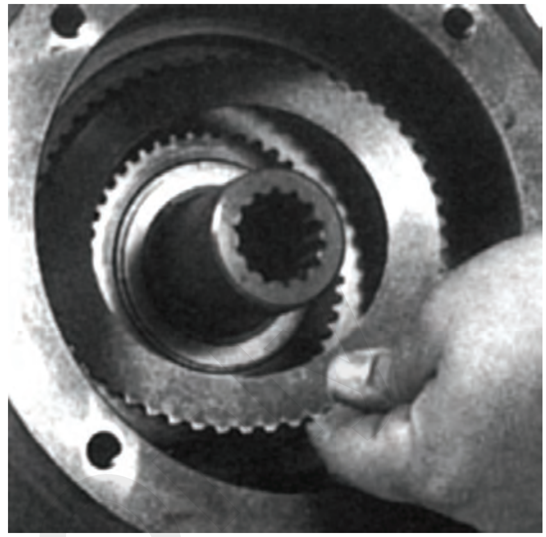


p0208 FIGURE 11-42

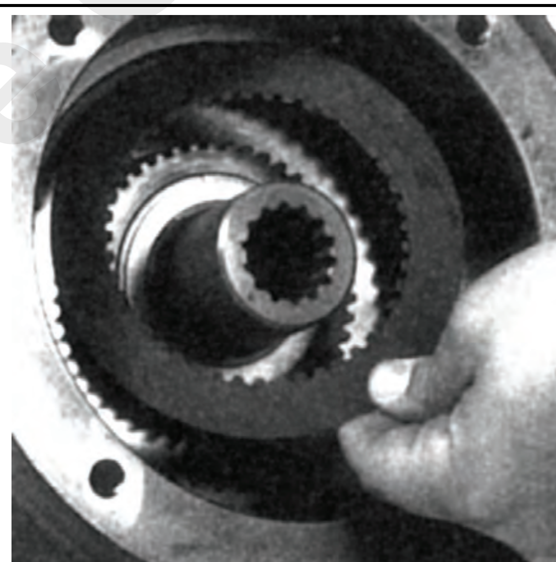
9. Carefully disassemble the brake driver clutch assembly noting the direction of lockup on the clutch. The clutch assembly must be assembled with the arrow pointing in the proper direction for the winch to operate properly. Inspect the area on the driver where the clutch runs. If there is any pitting 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 11-33) into the brake housing, temporarily install the input sun gear, and slide the 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 11-43) and followed by a friction disc (Figure 11-44). 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.

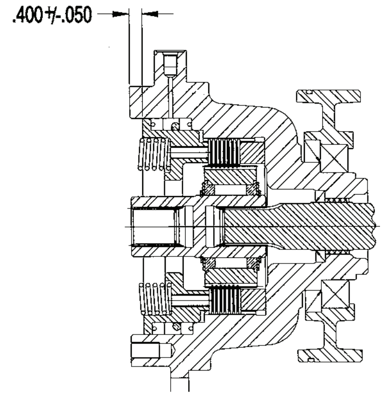


p0210 FIGURE 11-43



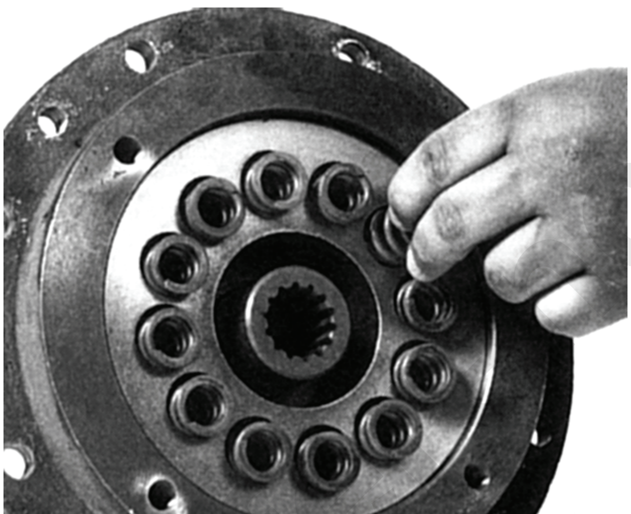
p0211 FIGURE 11-44

After installation, check the brake stack-up to make sure that the dimensions are within the tolerance shown in Figure 11-45. 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 11-45

4. Inspect each new seal (8, Figure 11-33) to make sure it has an o-ring (Figure 11-46) in the groove.

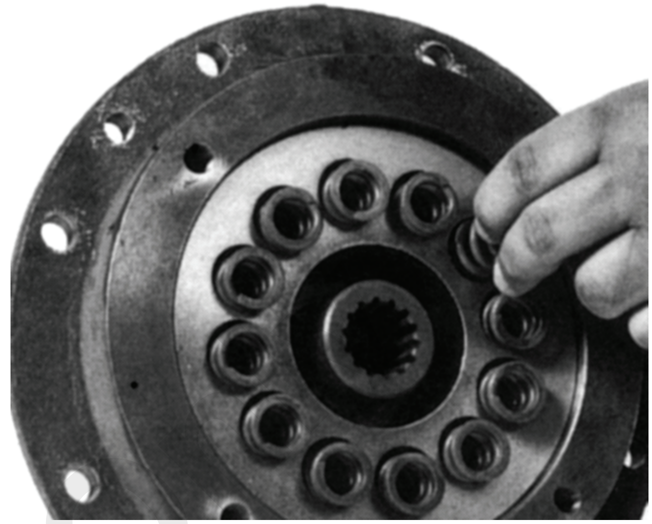


p0213 FIGURE 11-46

5. Install one seal into the bore of the break housing with the o-ring facing out. Install the other seal with o-ring facing in.

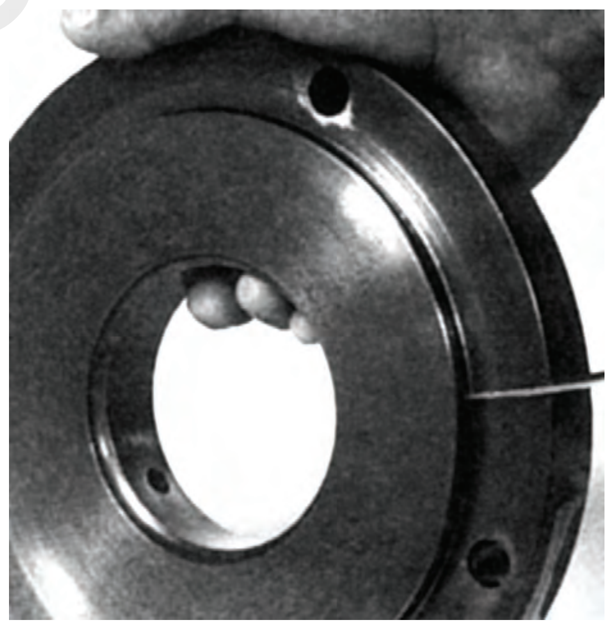
6. Install the piston into the brake housing and gently tap it down until it is seated.

7. Install the springs (Figure 11-47) into the spring pockets. If working in a horizontal position, coat the bottom of each spring with grease to keep them in place.



p0201 FIGURE 11-47

8. Coat a new o-ring (Figure 11-48) with light oil and install the o-ring into the groove on the brake cover.



p0214 FIGURE 11-48

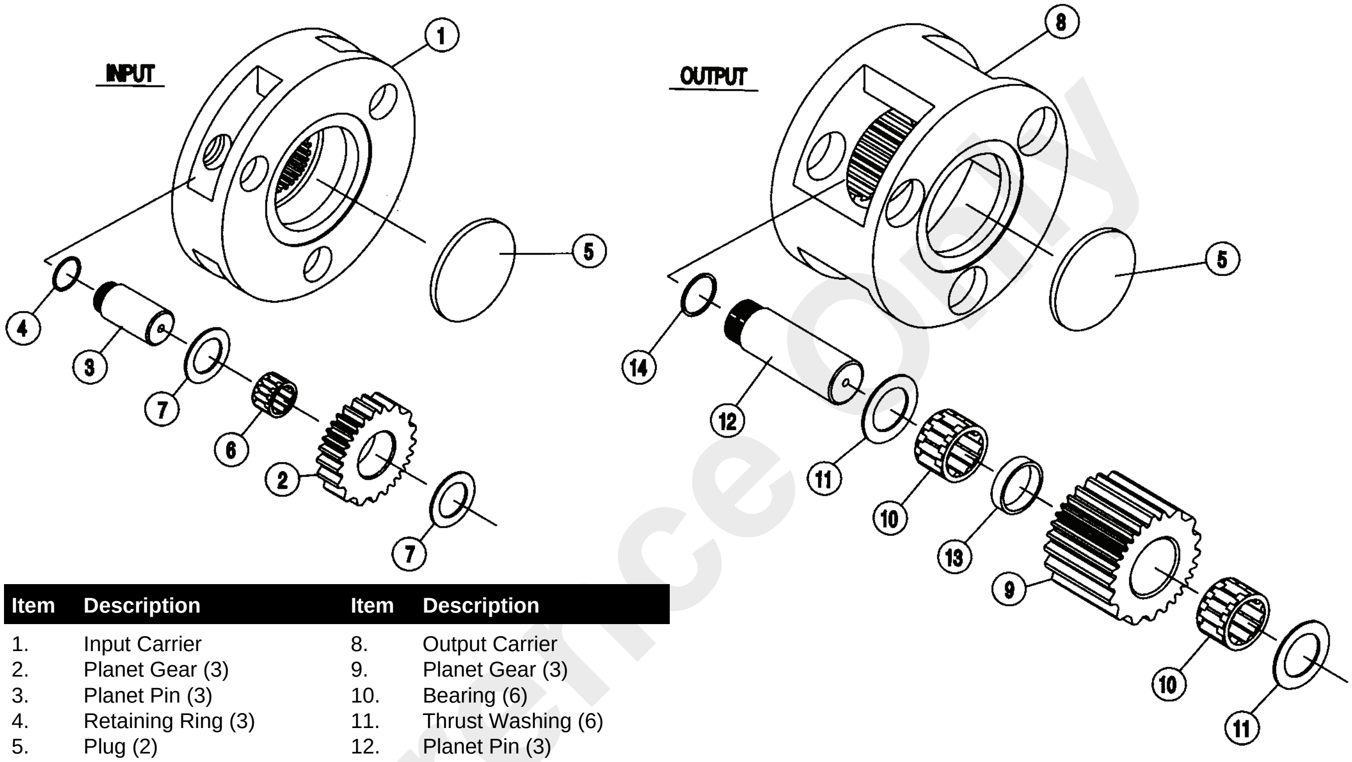
9. Install the cover onto the brake housing and draw it down evenly, alternating between opposite capscrews. Make sure that the cover is properly aligned with brake housing to orient the motor as it should be.

10. Check the brake release with a portable pump. Full release should be obtained at 350 psi (1034 kPa), plus or minus 20 psi (138 kPa). Also, check the brake for proper operation by applying 280 psi (1929 kPa) to the

brake port and adapting a torque wrench to input shaft. The torque here in the payout direction should be 95 to 115 lb. (10.6 to 12.9 Nm).

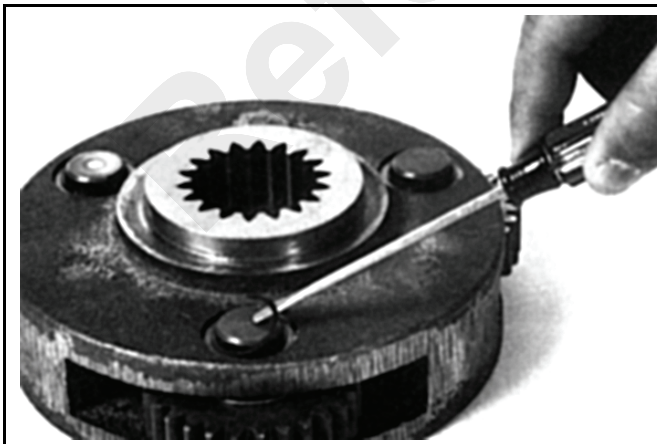
Planet Sets

1. Remove the spiral ring from the planet pins (Figure 11-50).
2. Remove the pins from the carrier by carefully tapping them out (Figure 11-51).



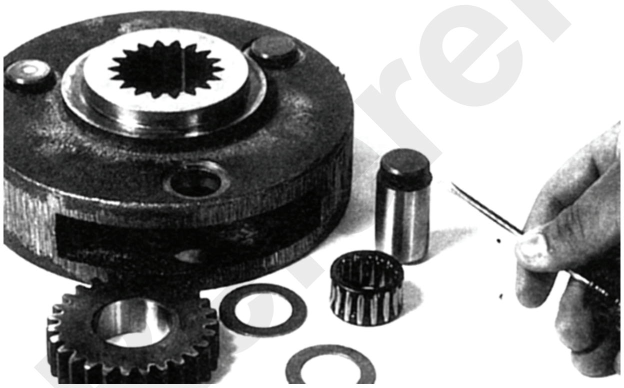
Item	Description	Item	Description
1.	Input Carrier	8.	Output Carrier
2.	Planet Gear (3)	9.	Planet Gear (3)
3.	Planet Pin (3)	10.	Bearing (6)
4.	Retaining Ring (3)	11.	Thrust Washing (6)
5.	Plug (2)	12.	Planet Pin (3)
6.	Bearing (3)	13.	Spacer (3)
7.	Thrust Washing (6)	14.	Retaining Ring (3)

p0480 Planet Sets - Exploded View **FIGURE 11-49**



p0215 **FIGURE 11-50**

p0216 **FIGURE 11-51**



p0217 **FIGURE 11-52**

3. Remove the planet gears, thrust washers and bearings from the carrier (Figure 11-52).
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 with a spacer between them are used.
6. Before assembling the planet sets. Be sure to insert the round plates (Figure 11-53) in the carriers.

p0218 **FIGURE 11-53**

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.

Troubleshooting

.

Trouble	Possible Cause	Remedy
Winch won't hold load.	**1.** Excessive back pressure in the winch circuit. **2.** Brake discs are worn out.	**1.** Check the circuit or restrictions reduce the back pressure. **2.** Replace the brake discs.
Winch will not raise the load.	**1.** Relief valve setting may be too low. **2.** Load being lifted exceeds maximum load.	**1.** Increase relief valve setting. **2.** Reduce the load.
Winch will not lower the load.	**1.** The winch brake valve was not properly hooked up after being disconnected. **2.** Metering hole in brake valve the cartridge is plugged	**1.** Check plumbing and connect connect lines properly. **2.** Remove and clean cartridge.
Oil leaks from vent on motor side of the winch.	**1.** Failed motor shaft seal. **2.** Failed brake piston seals.	**1.** Replace the shaft seal and reduce back pressure if that is what caused the failure. **2.** Service the brake section and replace worn parts.

MAIN WINCH (BRADEN MODEL)

Theory Of Operation

Description Of Winch (**Figure 11-54**)

The winch has five basic component parts:

1. Winch base.
2. Winch tension roller subassembly.
3. Hydraulic motor subassembly.
4. Brake cylinder and motor support.
5. Drum assembly.

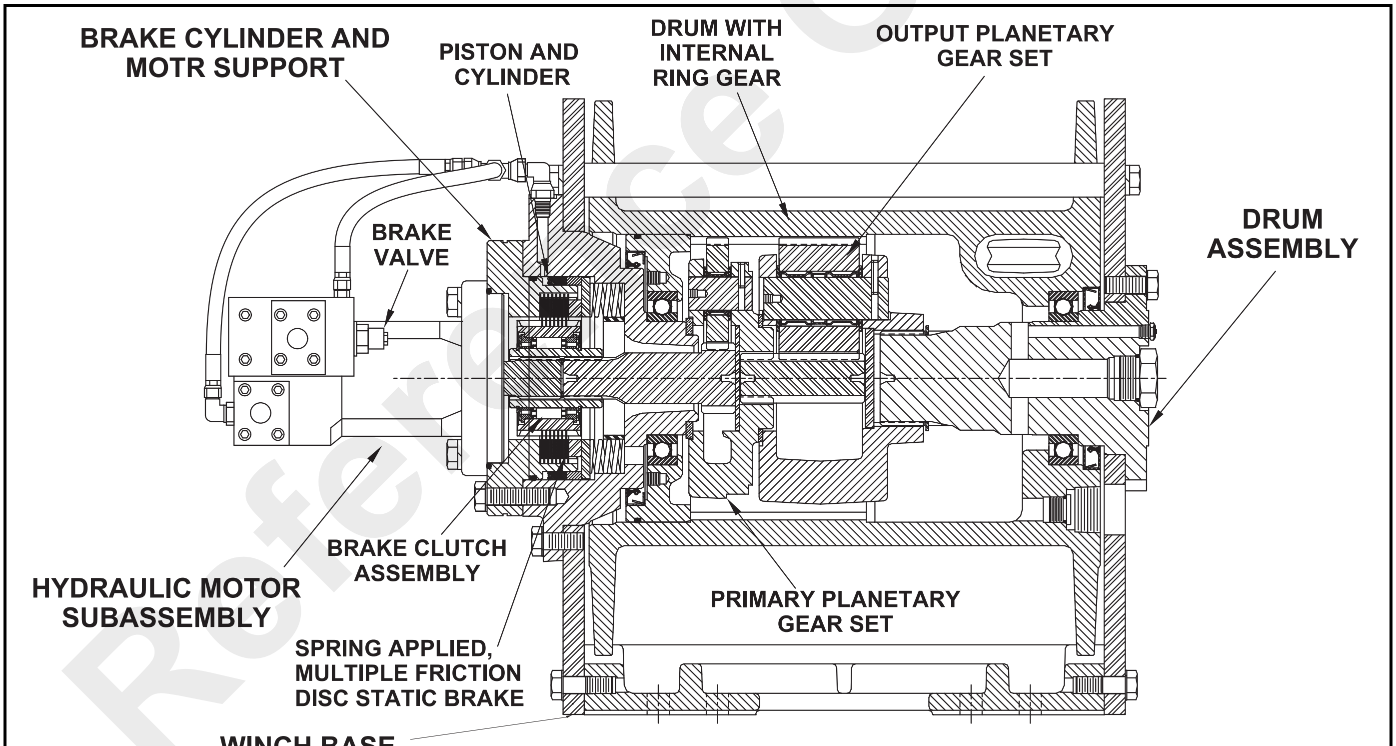
The drum assembly consists of three assemblies:

1. 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 is 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.

Winch Operation

The hydraulic motor drives the sun gear of the primary planetary gear set through the spline dinner 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.



Winch Cut-Away View

FIGURE 11-54

The primary planet carrier drives the output planet sun gear, which in turn drives the planet gears.The output planet carrier is splined to the bearing support and cannot rotate. Therefore, as the output planet gears are driven by the sun gear, they will drive the ring gear/drum.

Dual Brake System -Description

The dual brake system consists of dynamic brake system and a static brake system.

The dynamic brake system has two operating components:

1. Brake valve assembly.
2. Hydraulic motor.

The brake valve is a counterbalance valve which contains a check valve to allow free flow of oil to the motor in the hoisting direction, and a pilo 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 11-55.

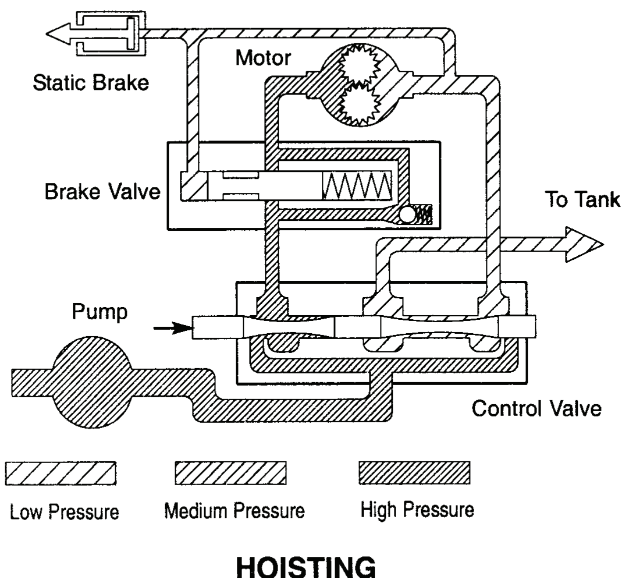


FIGURE 11-55

When the control valve is placed in the lowering position, the spring loaded, pilot operated spool valve remains closed (Figure 11-56) until sufficient pilot pressure is applied to the end of the spool valve to shift it against spring pressure; opening a flow passage (Figure 11-57). After the pilot operated spool valve cracks open, the pilot pressure becomes flow-dependent and modulates the spool opening which controls the lowering speed.

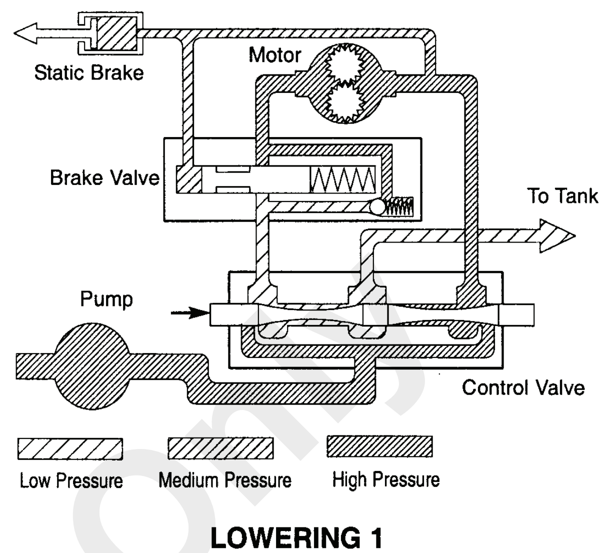


FIGURE 11-56

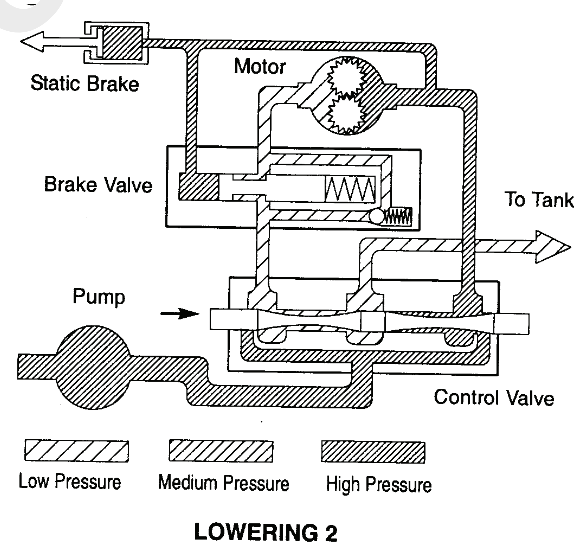


FIGURE 11-57

The static brake system has thee operating components (see Figure 11-54):

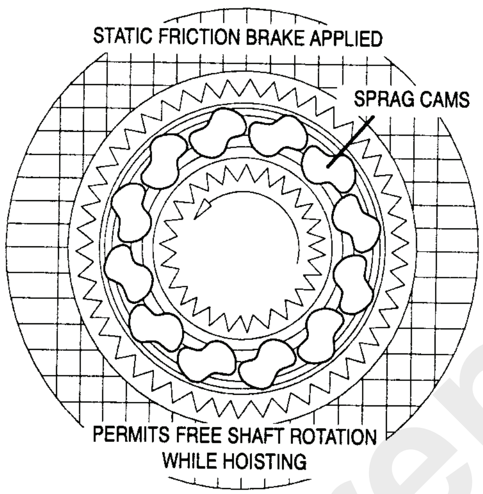
1. Spring applied, multiple friction disc static brake.
2. Brake clutch assembly.
3. Hydraulic piston and cylinder.

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.

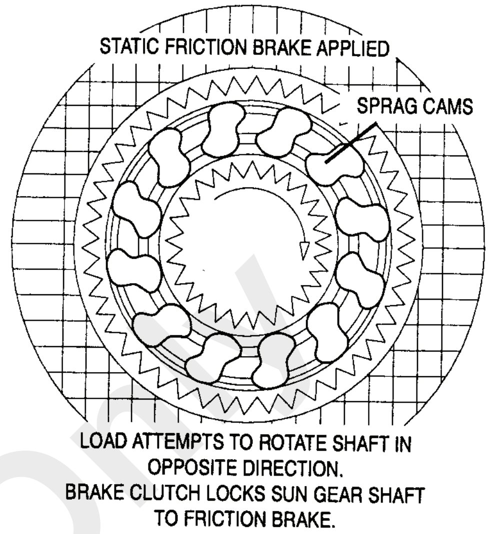
The friction brake is load holding brake only, and has nothing to do with dynamic braking or rate of descent of a load.

The brake clutch is splined to the primary sun gearshaft between the motor and the primary sun gear.It will allow this shaft to turn freely in the direction to raise a load and lock up to force the brake discs to turn with the shaft in the direction to lower a load. See Figure 11-58 and 11-59.

The hydraulic cylinder, when pressurized will release the spring pressure on the brake disc, allowing the brake discs to turn freely.



a2209 **FIGURE 11-58**



a2210 **FIGURE 11-59**

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 11-58). The friction brake remains fully engaged. The winch, in raising a load, is not affected by any braking action. See Figure 11-54.

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 11-59).

When the which 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 11-56 and 11-57. The friction bake within the winch 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 winch 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 winch 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

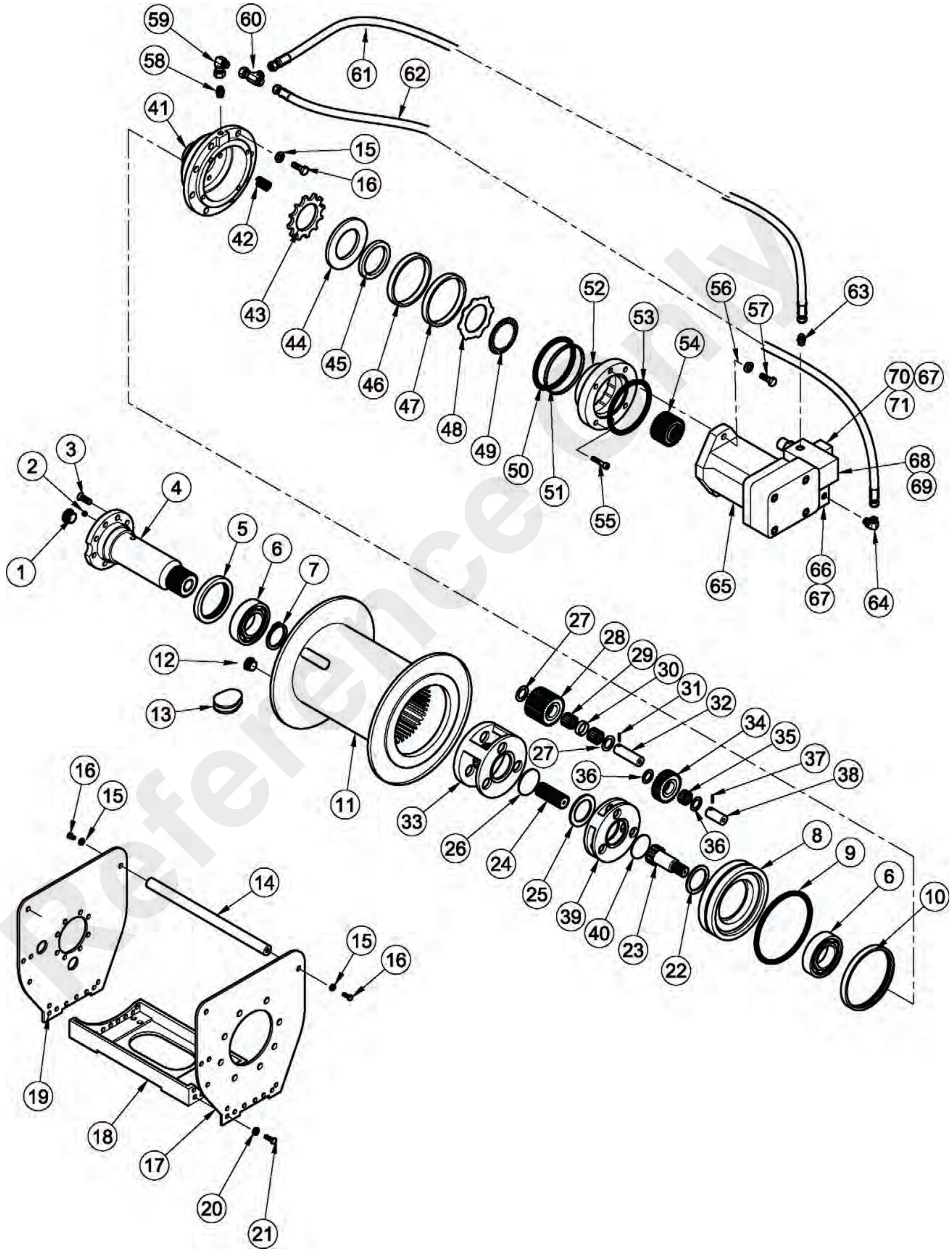
1. Remove the wire rope from the winch drum.

NOTE: Be sure hydraulic pressure is relieved in the winch circuit before disconnecting any hydraulic lines.

2. Disconnect hydraulic hoses from the winch motor and motor drain ports.

3. Securely fasten and overhead hoist to the winch assembly. Remove the winch mounting hardware and then remove the winch.

Legend For Figure 11-60		
1.Sight Gauge	26.Output Spacer	52.Motor Support
2.Relief Valve	27.Thrust Washer (6)	53.*O-Ring
3.Capscrew (8)	28.Planet Gear (3)	54.Clutch Assembly
4.Bearing Support	29.Roller Bearing (6)	55.Capscrew (4)
5.*Sealg	30.Output Spacer	56.Lockwasher (2)
6.Ball Bearing	31.Spirol Pin (3)	57.Capscrew (2)
7.Retaining Ring	32.Planet Gear Shaft	58.Fitting
8.Drum Closure	33.Planet Carrier	59.Elbow
9.*O-Ring	34.Planet Primary Gear	60.Tee
10.*Seal	35.Roller Bearing (3)	61.Hose Assembly
11.Drum	36.Bearing Race (6)	62.Hose Assembly
12.Plug	37.Spirol Pin (3)	63.Fitting
13.Cable Wedge	38.Primary Planet Gear Shaft	64.Elbow
14.Spacer Bar	39.Primary Planet Carrier	65.Hydraulic Motor
15.Lock Washer (12)	40.Primary Spacer	66.Manifold
16.Capscrew (12)	41.Brake Cylinder	67.Capscrew (6)
17.Motor Side Plate	42.Spring (12)	68.Brake Valve Block
18.Base	43.Spring Spacer	69.Capscrew (2)
19.Support Side Plate	44.Pressure Plate	70.Manifold
20.Lockwasher (16)	45.Spacer	71.Capscrew (2)
21.Capscrew (16)	46.Backup Piston Ring	
22.Thrust Washer	47.*Seal48.Brake Disc (8)	* Seal Kit
23.Primary Sun Gear	49.Friction Disc (7)	
24.Output Sun Gear	50.O-Ring	
25.Thrust Washer	51.Backup Ring	



a2204 Winch Exploded View **FIGURE 11-60**

Service Precautions

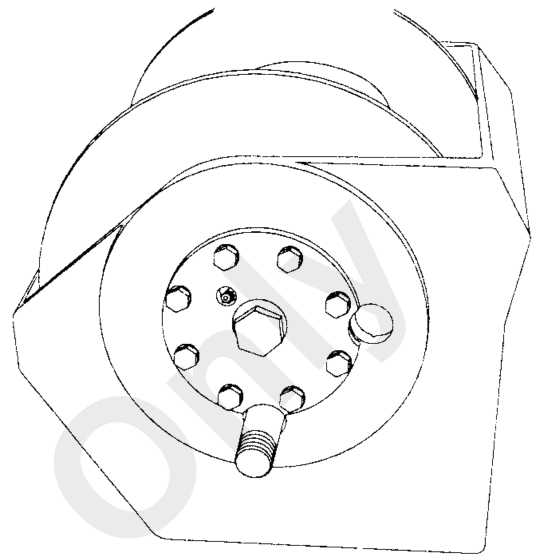
- Before any part is removed from the winch, all service instructions should be read and understood.
- Work in a clean dust free area as cleanliness is of the utmost importance when servicing hydraulic equipment.
- Inspect all replacement parts, prior to installation, to detect any damage which might have occurred in shipment.
- Use only Grove replacement parts for optimum results. Never reuse expendable parts such as oil seals and o-rings.
- Inspect all machined surfaces for excessive wear or damage before assembling the winch.
- 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.

Winch Assembly

Disassembly

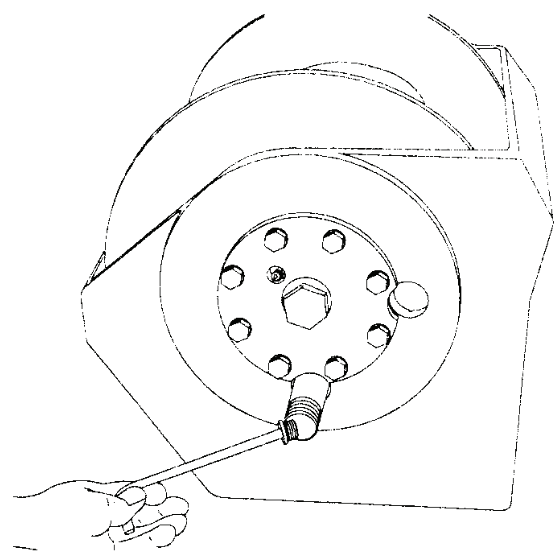
NOTE: Some illustrations may not depict the exact winch you are disassembling, but the disassembly procedure are the same. Use Figure 11-60 as a reference.

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 winch is removed from its mounting, thoroughly clean the outside surfaces. To drain the oil, install a short piece of 1 inch threaded pipe in the larger threads of the drain hole (Figure 11-61). 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 11-61**

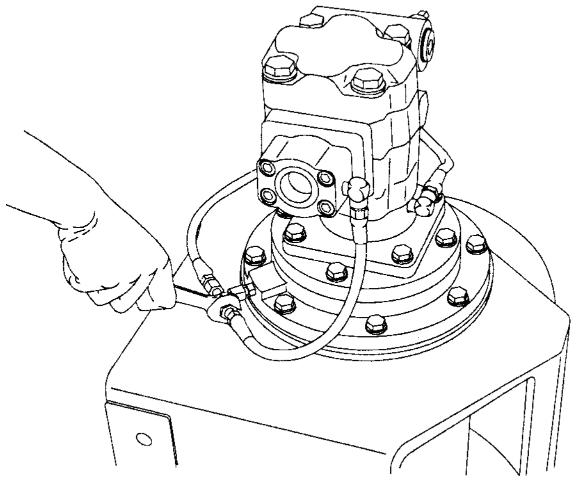
2. Use a 5/16 inch Allen wrench to remove the drain plug through the pipe (Figure 11-62).



a2212 **FIGURE 11-62**

NOTE: It is not necessary to remove the winch tension roller subassembly to disassembly the winch. But if it becomes necessary, see Winch Tension Roller Subassembly Service (Page 9-48) for disassembly procedures.

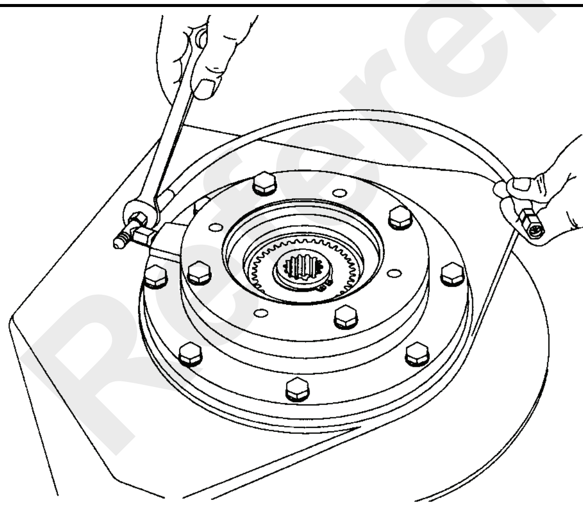
3. Begin disassembly by removing the oil level plug and standing the winch on the bearing support end. Tag and remove the hydraulic hoses that connect the brake valve and manifold to the brake cylinder (Figure 11-63).



a2213 **FIGURE 11-63**

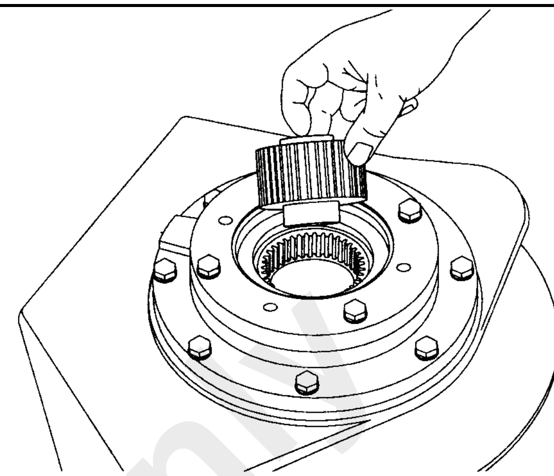
4. Remove the capscrews securing the motor, and lift the motor off the winch. Remove and discard the o-ring installed on the pilot of the motor.

5. Tag and remove the hoses and fittings from the brake cylinder release port (Figure 11-64).



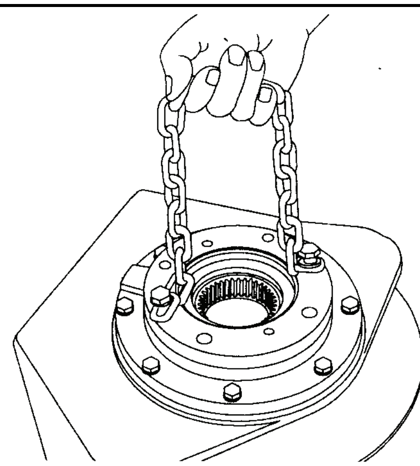
a2214 **FIGURE 11-64**

6. Remove the brake clutch (Figure 11-65) assembly from the motor support. Refer to “Brake Clutch Service,” for additional information.



a2215 **FIGURE 11-65**

7. Remove the motor support capscrews and install two (2) capscrews and a short piece of chain (Figure 11-66) 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” for additional information.

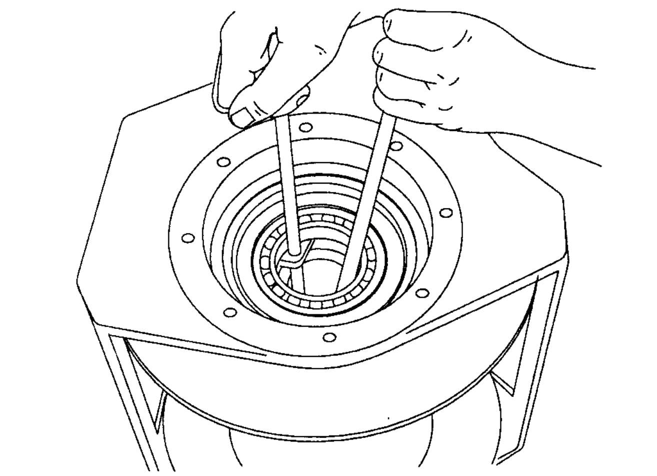


a2216 **FIGURE 11-66**

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” for additional information.

9. Using two heel type pry bars (Figure 11-67) placed between the primary planet carrier and the drum closure, pry upward to remove the drum closure.

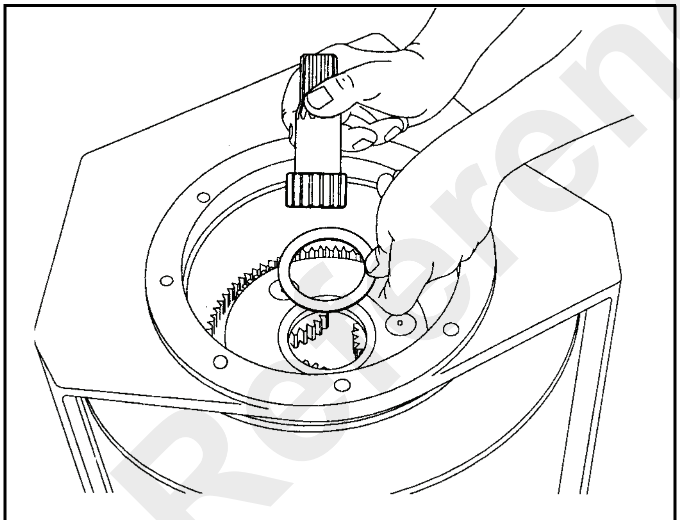
Remove and discard the O-ring from the outside of the drum closure.



a2217 FIGURE 11-67

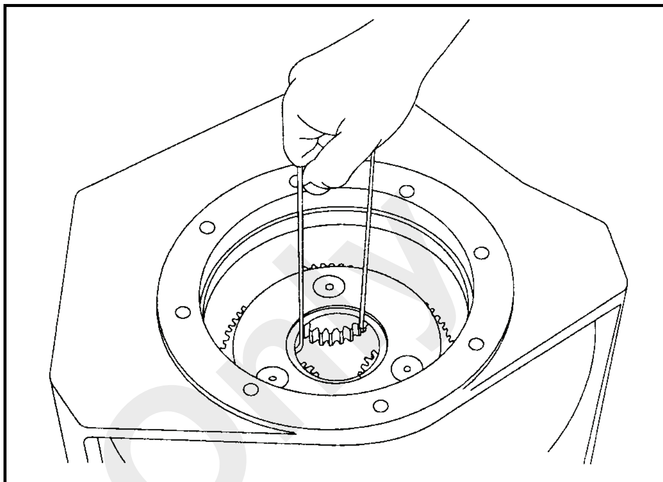
10. Remove the seal and bearing from inside of closure.

11. Remove the primary sun gear and thrust washer (Figure 11-68) from the primary planet carrier.



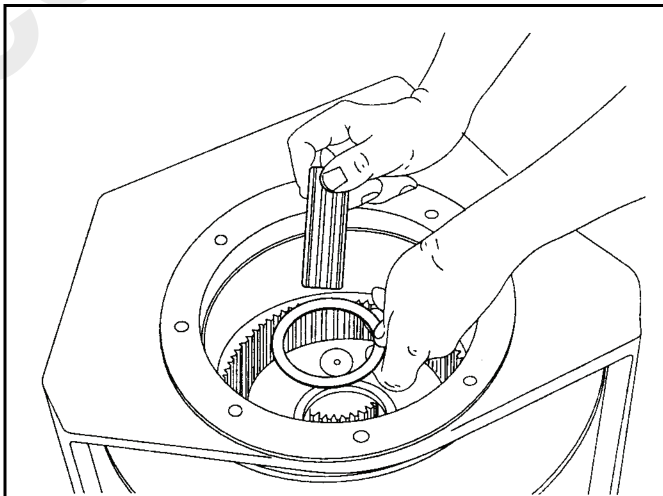
a2218 FIGURE 11-68

12. Remove the primary planet carrier from the drum (Figure 11-69). Refer to “Planet Carrier Service,” for additional information.



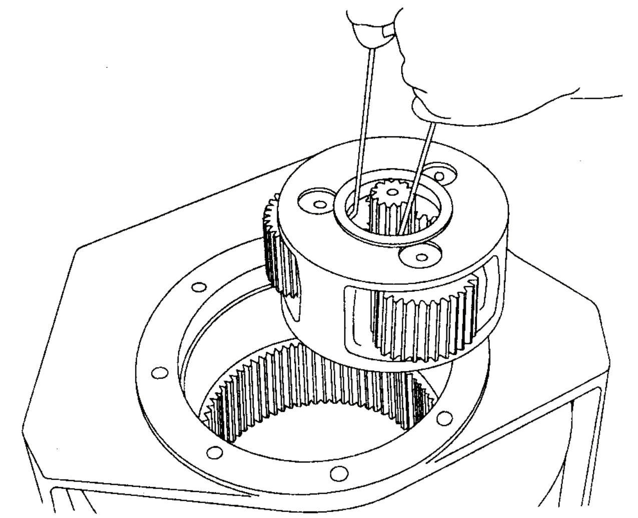
a2219 FIGURE 11-69

13. Remove the output sun gear and thrust washer (Figure 11-70) from the output planet carrier.



a2220 FIGURE 11-70

14. Remove the output planet carrier (Figure 11-71) from the drum. Refer to “Planet Carrier Service”, for additional information.



a2221 FIGURE 11-71

15. Stand winch on motor end with bearing support up. Then remove eight (8) bearing support capscrews and bearing support being careful to avoid damaging the sealing or bearing surfaces.

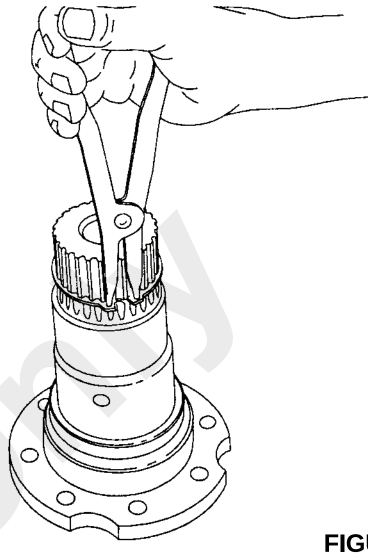
16. Slide drum cut of base onto a work bench and remove seal and bearing from support end.

17. Thoroughly clean and inspect drum and base.Check ring gear (machined into inside surface of drum) teeth for nicks, spalling or excessive wear. Replace if wear is greater than 0.015 in. (0.4 mm) when compared to unworn area of teeth.

Assembly

NOTE: Winches with a three piece fabricated base special shoulder capscrews to fasten side plates the base plate. DO NOT use standard capscrews in their pace.

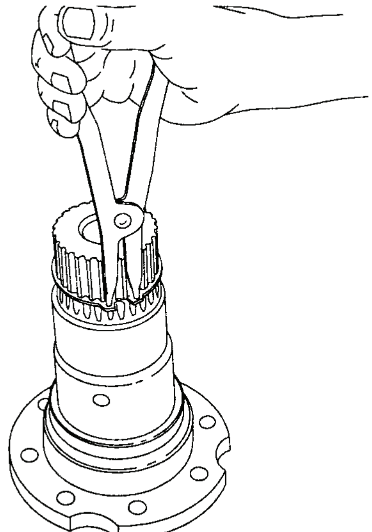
1. Place winch base on side with bearing supported up (Figure 11-72).



a2222 FIGURE 11-72

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 he 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 11-73).

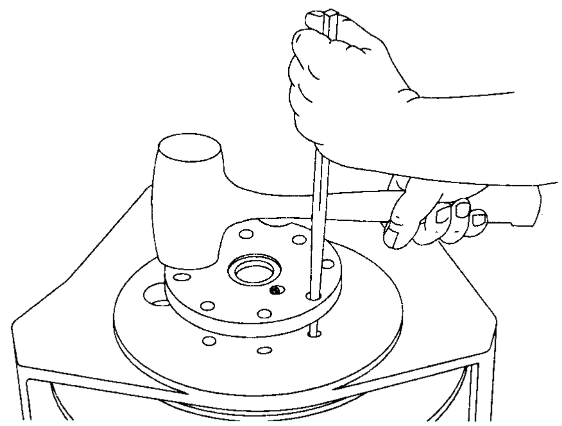


a2223 FIGURE 11-73

Make certain the snap ring is installed on the bearing support. This snap ring will keep the output planet carrier correctly positioned in the winch.Gear train damage may occur if this snap ring is omitted.

4. Center the drum in the opening of the base (Figure 11-74). Lubricate the bearing support with petroleum jelly or gear oil and install in base and drum.

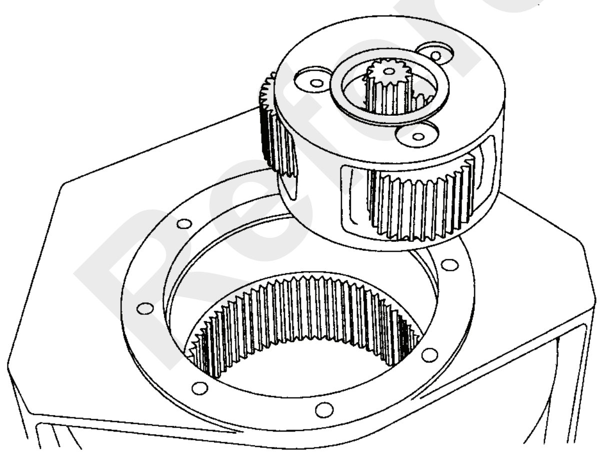
NOTE: Be sure the vent plug is located above the horizontal center line for the intended application.Oil leakage may occur if vent is positioned incorrectly.



a2224 **FIGURE 11-74**

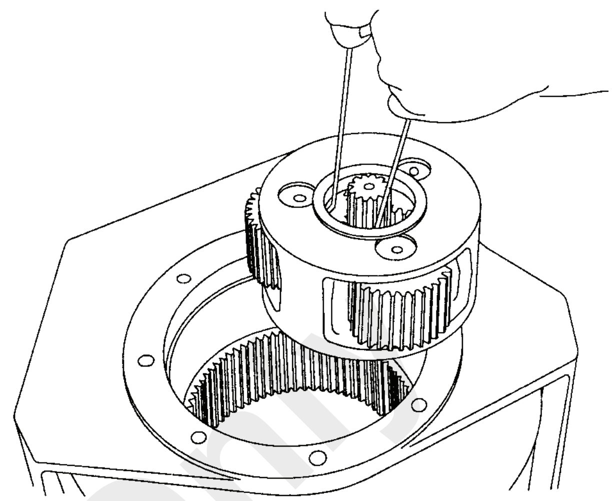
5. 5.Install and tighten the bearing support capscrews to the recommended torque.

6. Stand winch on bearing support end. Install the output sun gear and thrust washer into output planet carrier (Figure 11-75).



a2225 **FIGURE 11-75**

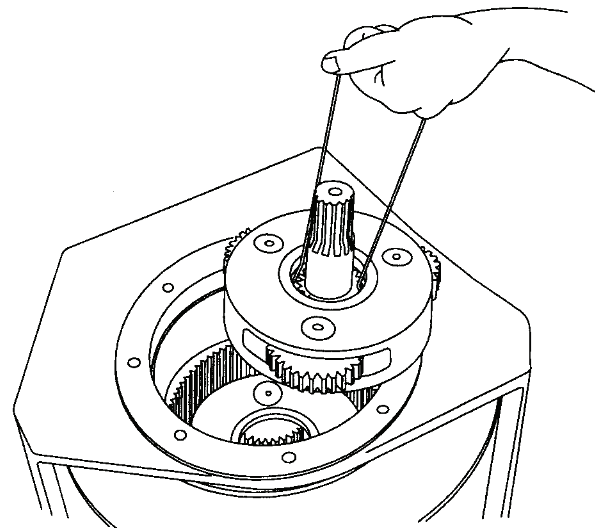
7. Install the output planet carrier (Figure 11-76) into the drum while meshing the planet gears with the ring gear and the planet housing with the bearing support.



a2226 **FIGURE 11-76**

8. Install the primary sun gear and thrust washer into the primary planet carrier.

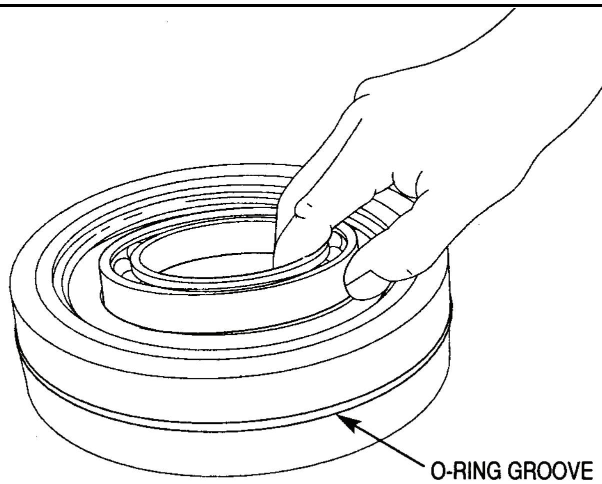
9. Install the primary planet carrier (Figure 11-77), meshing the planet gears with the ring gear and the planet housing with the output sungear.



a2227 **FIGURE 11-77**

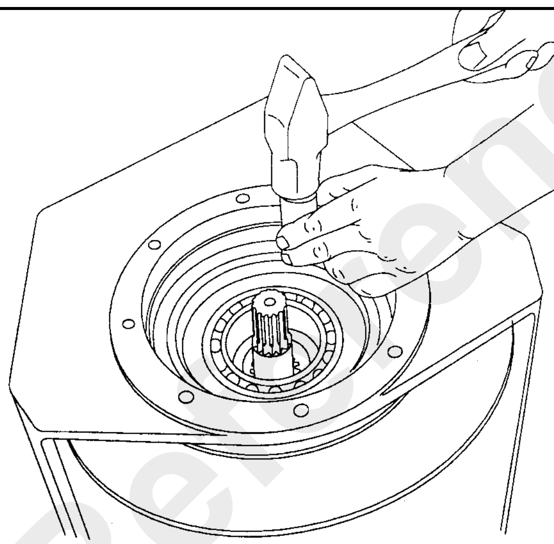
10. Install a new bearing (Figure 11-78) in the drum closure as required. Use sealant on the outside surface of the oil seal. Install with spring side of the seal toward bearing, using a flat plate to avoid distortion.

Install a new o-ring (Figure 11-78) in the groove on the O.D. of the drum closure.



a222/8 **FIGURE 11-78**

11. Lubricate the O-ring and drum opening with petroleum jelly or gear oil and install the drum closure (Figure 11-79) into the drum.



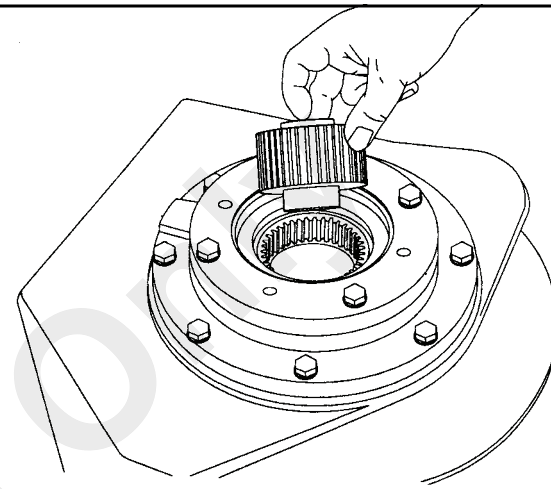
a2229 **FIGURE 11-79**

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 11-80) 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.

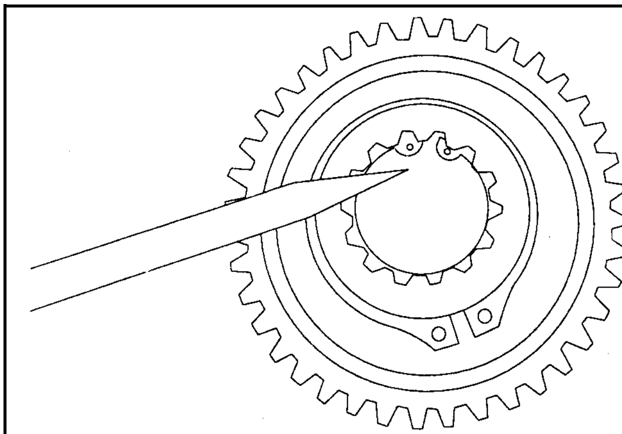
If the clutch free wheels in the wrong direction, disassembly the clutch and reverse the inner race. Refer to “Brake Clutch Service”, for additional information.



a2230 **FIGURE 11-80**

WARNING

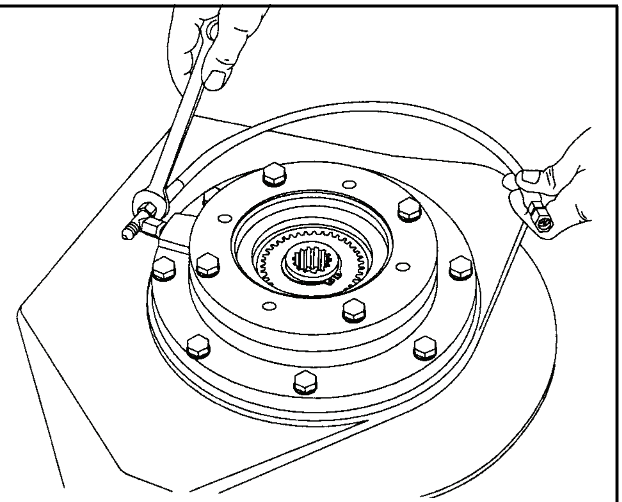
Be certain the snap ring (Figure 11-81) is seated in me groove in the splined bore of the inner race. This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted.



a2231 **FIGURE 11-81**

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 11-82).

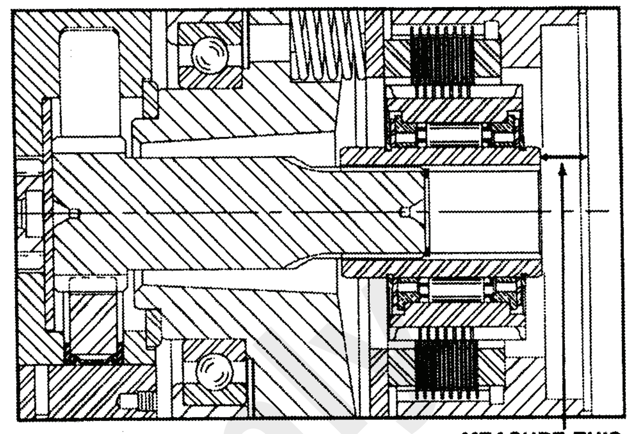


a2232 **FIGURE 11-82**

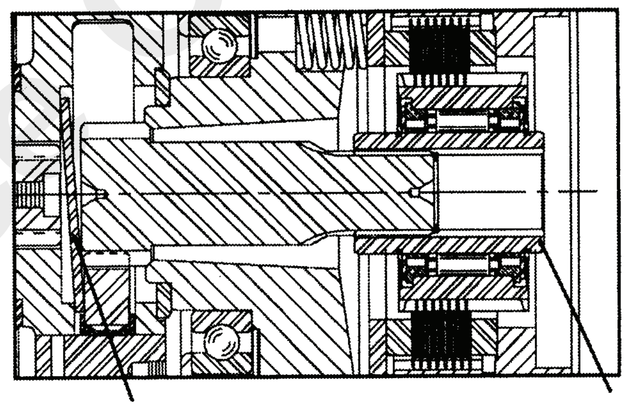
16. Install a new O-ring on the motor pilot then lubricate with petroleum jelly or gear oil.

NOTE: Care must be taken to assure the primary thrust plate remains properly located in its counter bore when the motor is installed for the first time, or is being reinstalled on the winch. 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 winch 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 winch components could result.

17. Measure the distance from the motor mounting surface to the inner brake race (Figure 11-83). With all components properly installed, this distance should be 11/16 in.(17.5 mm) to 3/4 in. (19.1 mm). If this distance is less than 9/16 in. (14.3 mm), the primary spacer may be positioned as shown in Figure 11-84 and should be checked.



a2233 **FIGURE 11-83**

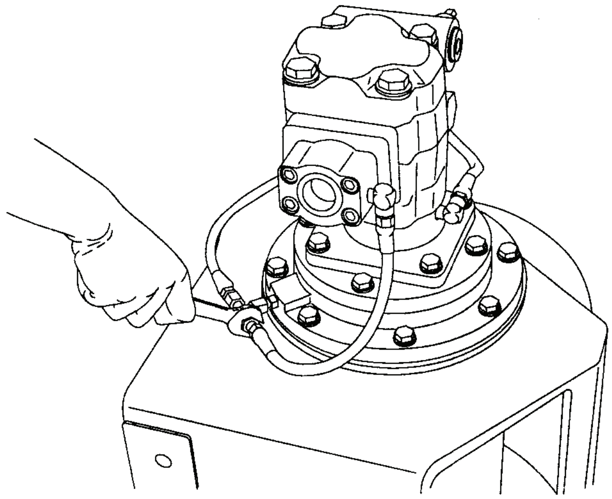


a2233 **FIGURE 11-84**

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 11-85).



a2235 FIGURE 11-85

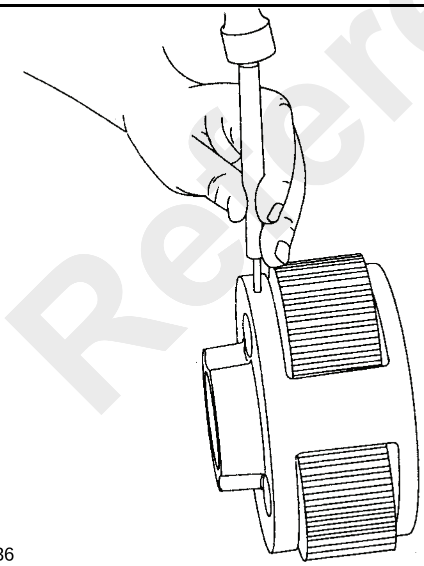
20. After the winch assembly is complete, check all capscrews and fittings to make certain they have been tightened correctly.

21. Refill the winch with the recommended oil listed in Section 3, and install the oil level plug.

Planet Carrier Service

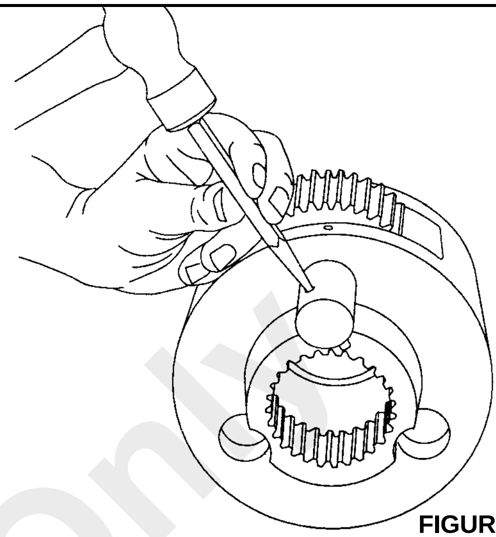
Planet Carrier Service Disassembly

1. Remove the planet gears by driving the roll pins into the center of the planet shafts (Figure 11-86).



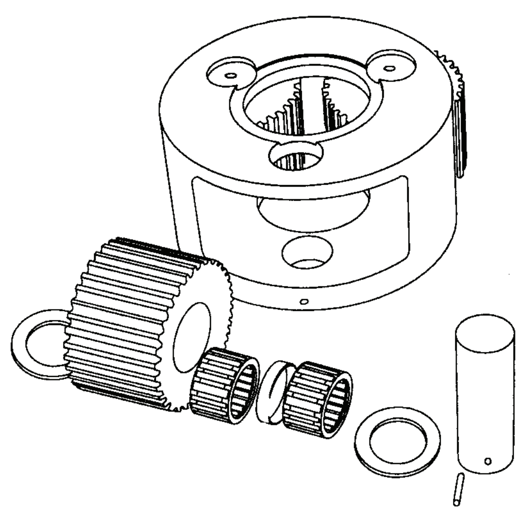
a2236 FIGURE 11-86

2. Use a punch (Figure 11-87) to drive the roll pins from the planet shafts. Do not reuse the roll pins.



a2237 FIGURE 11-87

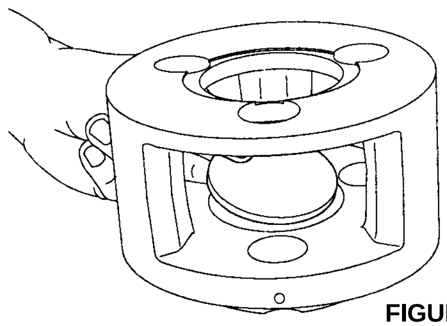
3. Now you can remove the planet shafts, bearings, spacer, thrust washers and gears.Thoroughly clean all parts and inspect for damage and wear. The bearing rollers should not exhibit any irregularities. If the rollers show any sign of spalling, corrosion, discoloration, material displacement or abnormal 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 11-88

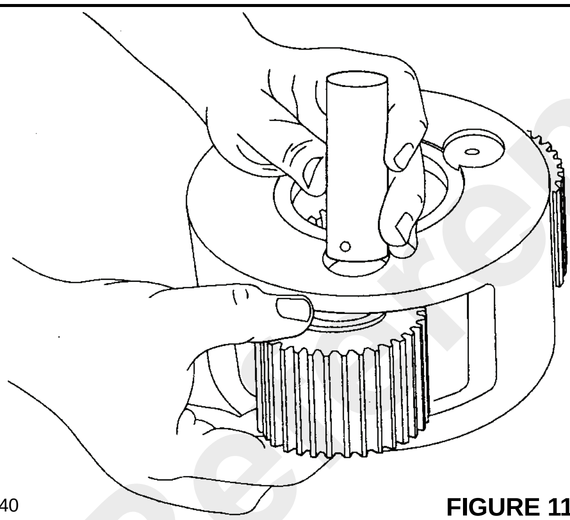
Assembly

1. Place the output planet carrier on workbench with splined coupling side down. Install output thrust plate in center of carrier (Figure 11-89).



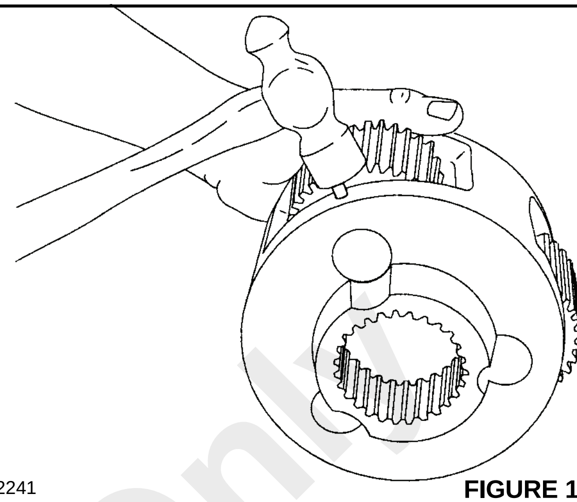
a2239 FIGURE 11-89

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 11-90).



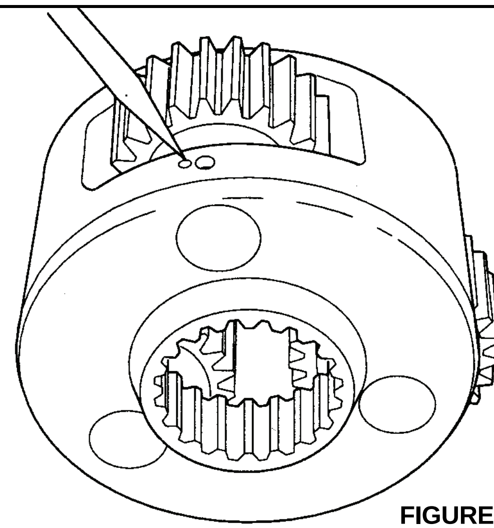
a2240 FIGURE 11-90

3. Carefully align the pin hole in the carrier with the hole in the planet gear shaft (Figure 11-91) 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 11-91

4. Note that the roll pin is slightly recessed in the carrier when properly installed. With a center punch (Figure 11-92); 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.



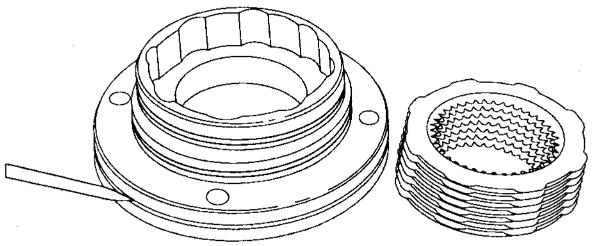
a2242 FIGURE 11-92

Primary Planet Carrier

To service the primary planet carrier, the step 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

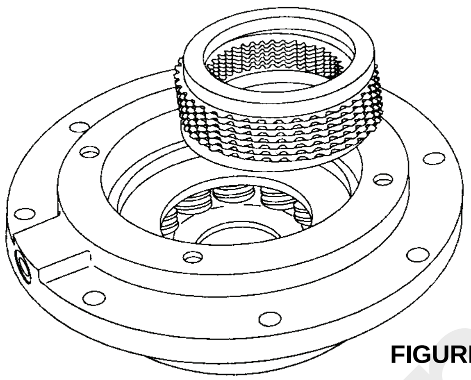
NOTE: Some of the illustrations show spined brake discs. This brake uses a lobed steel brake separator and motor support as shown in Figure 11-93.



a2243 FIGURE 11-93

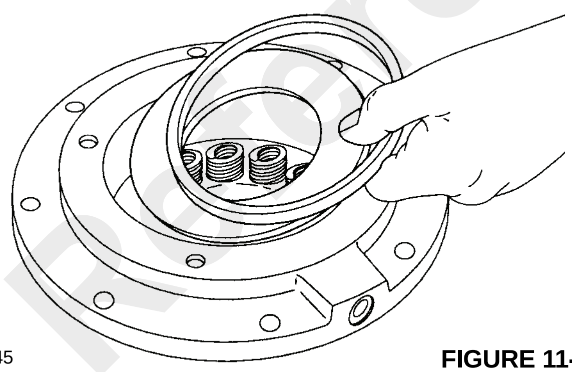
Disassembly

1. Remove spacers, friction brake discs and steel brake discs (Figure 11-94).



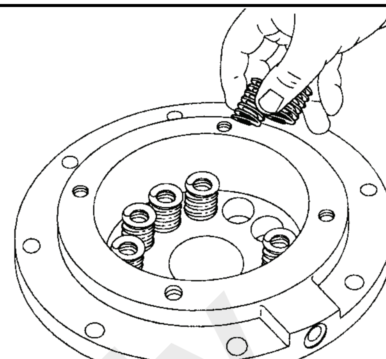
a2244 FIGURE 11-94

2. Remove the piston backup ring and pressure plate (Figure 11-95).



a2245 FIGURE 11-95

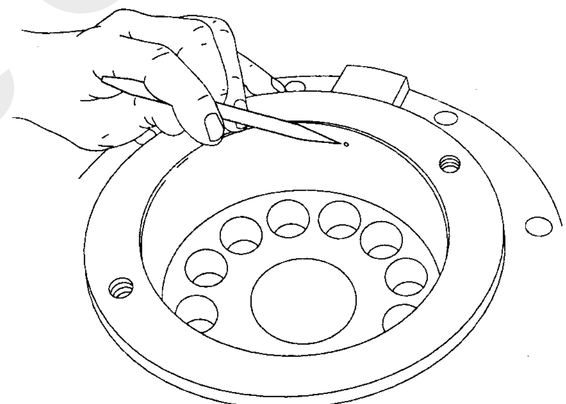
3. Remove brake springs (Figure 11-96) and the spring spacer.



a2246 FIGURE 11-96

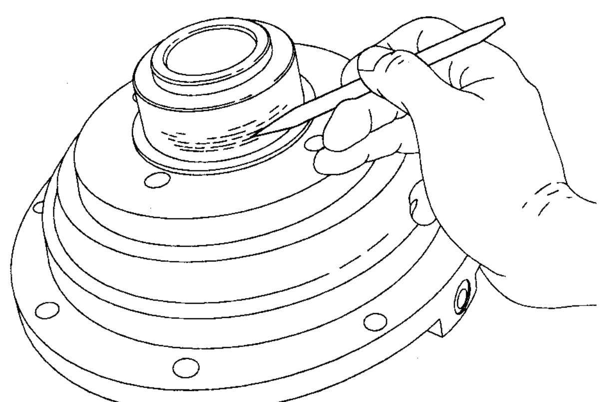
Clean and Inspect

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 11-97).



a2247 FIGURE 11-97

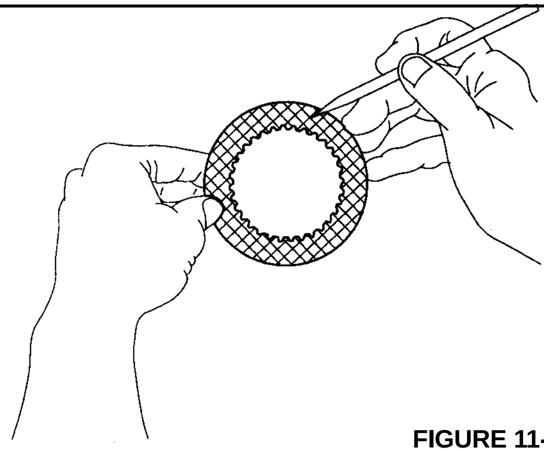
2. Check oil seal and baring surfaces on the brake cylinder for damage and wear (Figure 11-98).



a2248 FIGURE 11-98

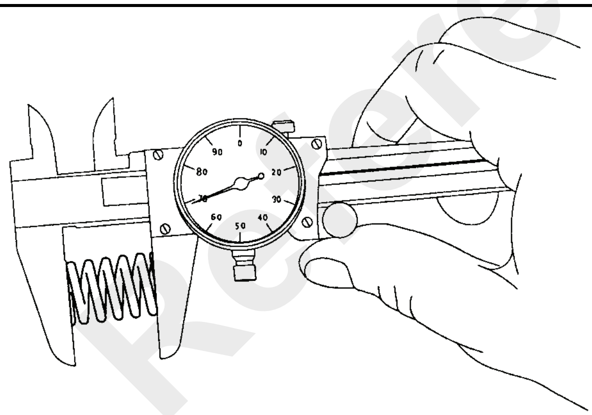
3. Place friction plate disc on a flat surface and check for distortion with a straight edge.Friction material should appear even across the entire surface with the groove

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 11-99

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 hear. 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 11-100). Minimum free length is 1-3/16 inch (30.2 mm). Check springs for any sign of cracking or failure. If a brake spring must be replaced, then all brake springs must be replaced.

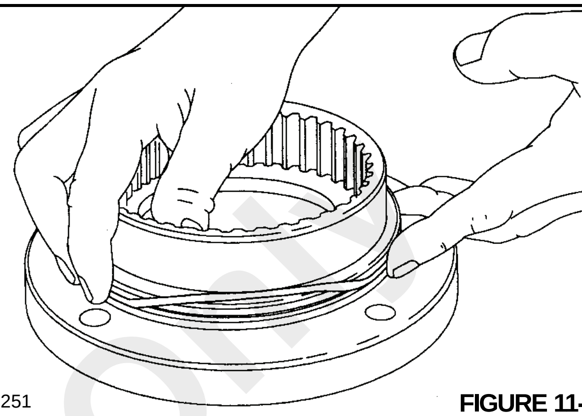


a2250 FIGURE 11-100

NOTE: Failure to replace brake springs as a set may result in uneven brake application pressure and repeated brake spring failure.

Assembly

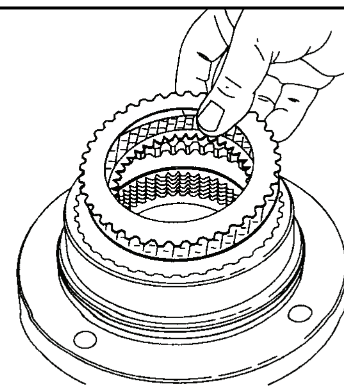
1. Begin assembly by placing the motor support on the workbench with motor mounting surface down. Install new o-ring and brake-spring (Figure 11-101).



a2251 FIGURE 11-101

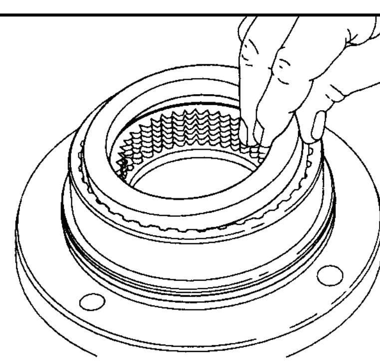
2. Insert first, a steel brake disc followed by a friction disc. Then, alternate steel friction discs until seven (7) friction and eight (8) steel discs have been installed (Figure 11-102). Finish with a steel brake disc on top.

NOTE: It is good practice to pre-lubricate the discs in a light motor oil prior to assembly.



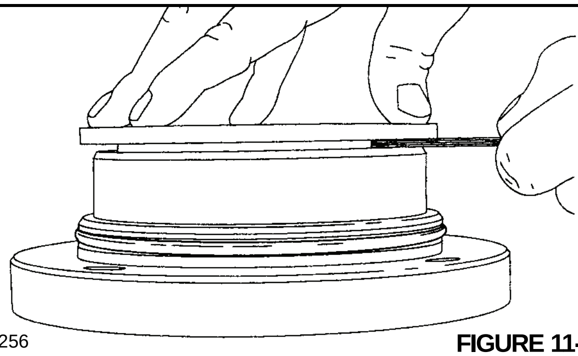
a2254 FIGURE 11-102

3. Install the brake spacer on top of the last steel brake disc (Figure 11-103).



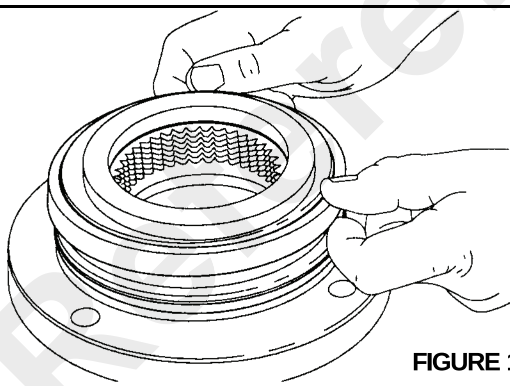
a2255 FIGURE 11-103

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 11-104). Average gap must measure between 0.153 in. (4 mm) maximum and 0.80 in. (2 mm) minimum. If the gap exceeds the maximum limit, there are too many brake discs in the stack-up, or the brake discs are distorted. If the gap is less than the minimum, there are too few discs in the stack-up, or the discs are worn out. If the stack-up height is correct, remove pressure plate and continue with assembly.



a2256 **FIGURE 11-104**

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 11-105).

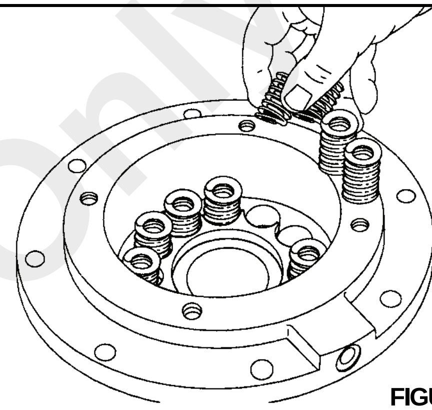


a2257 **FIGURE 11-105**

6. Install the spring spacer and then the brake springs (Figure 11-106).

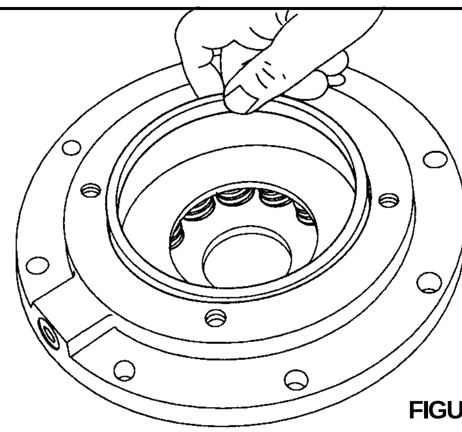
WARNING

Always use the molded spring spacer with the brake cylinder. The brake springs must be properly positioned by the spring spacer. Failure to install the spring spacer may allow the springs to contact each other and become damaged. This could result in loss of load control, property damage, injury or death.



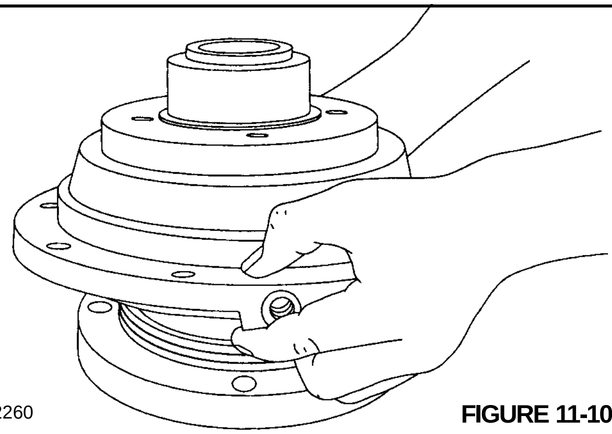
a2259 **FIGURE 11-106**

7. Install the pressure plate into the brake cylinder followed by the piston backup ring (Figure 11-107). The close fitting piston backup ring may be depressed slightly to one side to lodge the backup ring in the brake cylinder bore.Temporarily hold the pressure plate and springs in place while lowering the brake cylinder over the motor support.



a2258 **FIGURE 11-107**

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 11-108) being careful to avoid damaging the piston seal or motor support o-ring. A press may be necessary to avoid cocking the brake cylinder during installation.

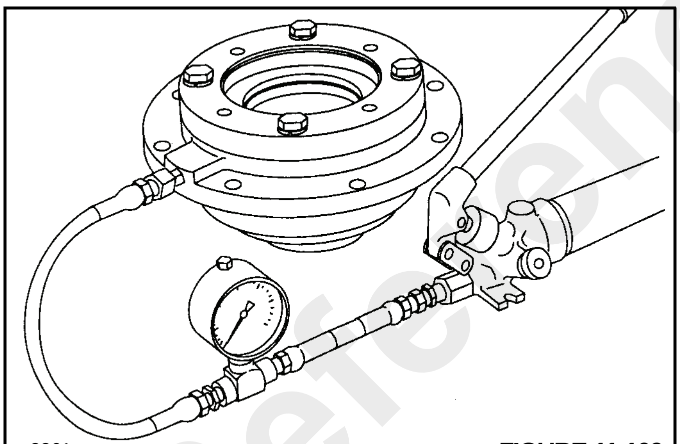


a2260 FIGURE 11-108

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 - 2000 psi (0 - 3 800 kPa) pressure gauge and shut-off valve to this fitting (Figure 11-109).



a2261 FIGURE 11-109

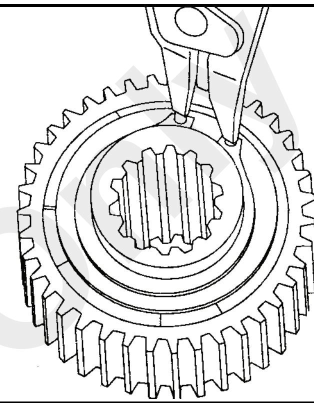
2. WHILE PRESSURE IS APPLIED AND THE BRAKE RELEASED, install the brake clutch assembly in the brake pack, short end of the inner race toward the motor. Turn the clutch back and forth as you align the outer race splines with the brake disc splines.

3. Release the pressure on the cylinder, and then remove the brake clutch assembly. The brake cylinder assembly is now compete and ready to install in the winch.

Brake Clutch Service

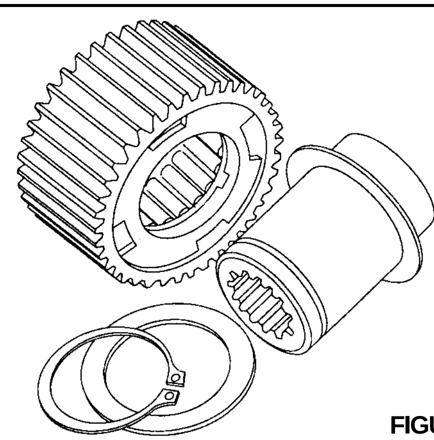
Disassembly

1. Remove the snap ring and sprag bushing retainer from one end only (Figure 11-110).



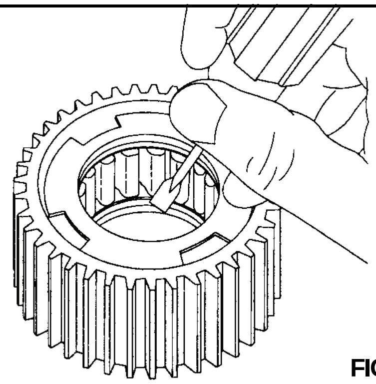
a2262 FIGURE 11-110

2. Pull the inner race out (Figure 11-111). Examine the race for scoring, wear, or indentations cause by the sprag cams.



a2263 FIGURE 11-111

3. Use a screwdriver and mallet to remove the sprag bushing from one end of the outer race (Figure 11-112). 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.

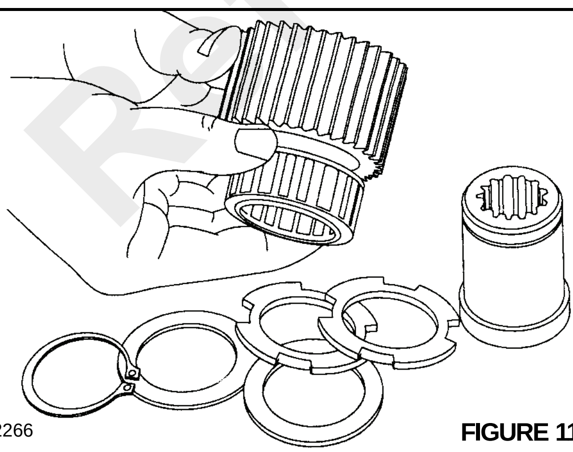


a2264 FIGURE 11-112

4. Next, slide the sprag clutch out. Inspect the sprag clutch closely for abnormal war, 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

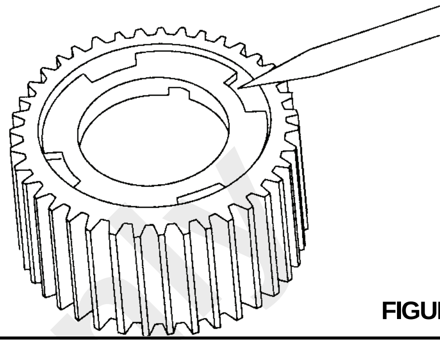
The polished surfaces of the races and sprag cams must be perfectly smooth to ensure positive engagement of the clutch.The slightest defect may reduce brake clutch effectiveness, which may lead to loss of load control and result in property damage, personal injury, or death. It is recommended to replace the entire brake clutch assembly in any component isdefective.



a2266 FIGURE 11-113

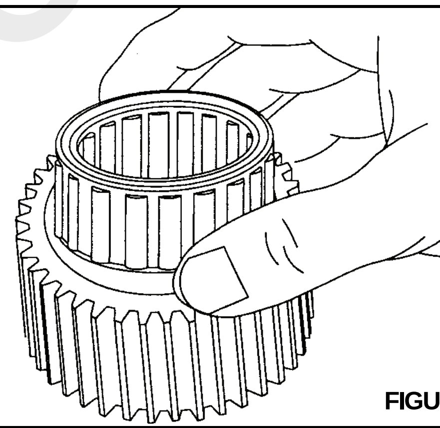
Assembly

1. Press a sprag bushing into the outer race, using a suitable press. A flat plate of approximately the same diameter as the bushing flange outside diameter should be placed between the press and bushing. This will protect the busing from damage. Be certain the bushing flange is against the shoulder in the outer race (Figure 11-114).



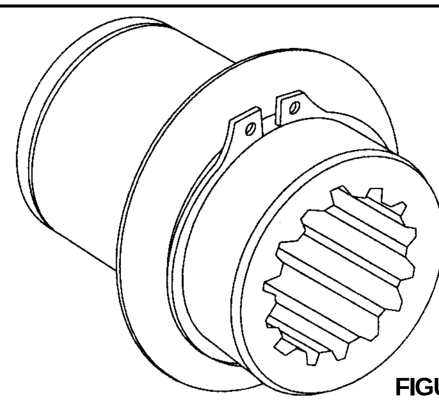
a2267 FIGURE 11-114

2. Turn the assembly over and install the sprag clutch in the bore of the outer race (Figure 11-115).



a2265 FIGURE 11-115

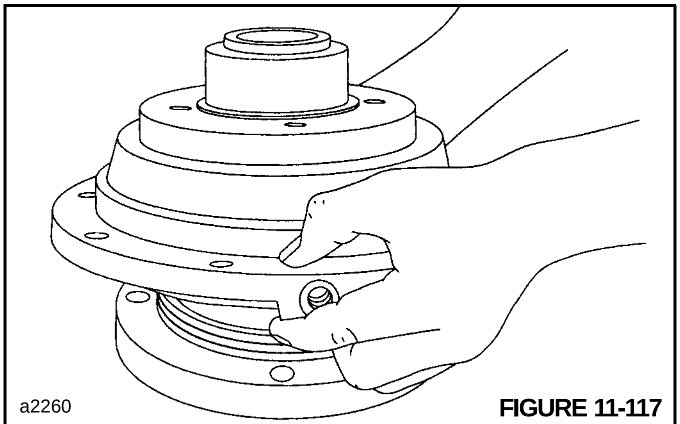
3. Press the remaining bushing against the race.Again, make sure the bushing is against the shoulder.
4. Next, install a spag bushing retainer, then a snap ring on the inner race (Figure 11-116). Be sure the snap ring is seated in the snap ring groove.



a2268 FIGURE 11-116

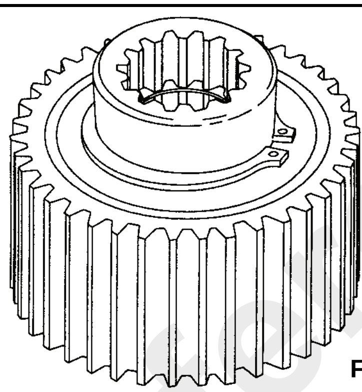
5. Slide the inner race through the bushings and sprag clutch. The race will have to be rotated in the

freewheeling direction to start it through the sprag clutch. If the inner race will not go through the bushings, the bushings have probably been damaged and should be replaced.



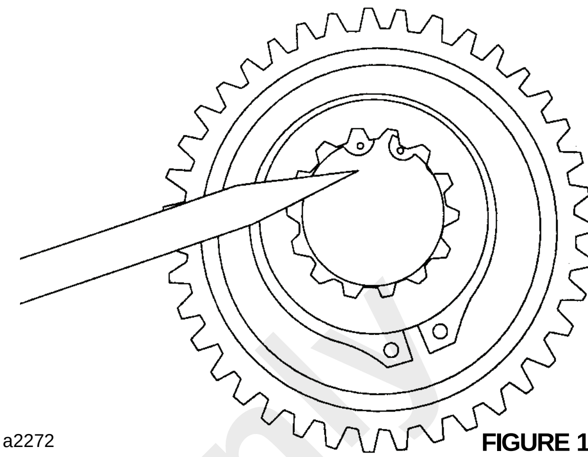
a2260 **FIGURE 11-117**

6. Turn the assembly over with the snap ring down. Install the second retainer and snap ring (Figure 11-118). Make sure the snap ring is properly seated in the groove.



a2271 **FIGURE 11-118**

7. Figure 11-119 shows a completed clutch assembly.



a2272 **FIGURE 11-119**

WARNING

Be certain the snap ring is seated in the groove in the splined bore of the inner race.This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted.

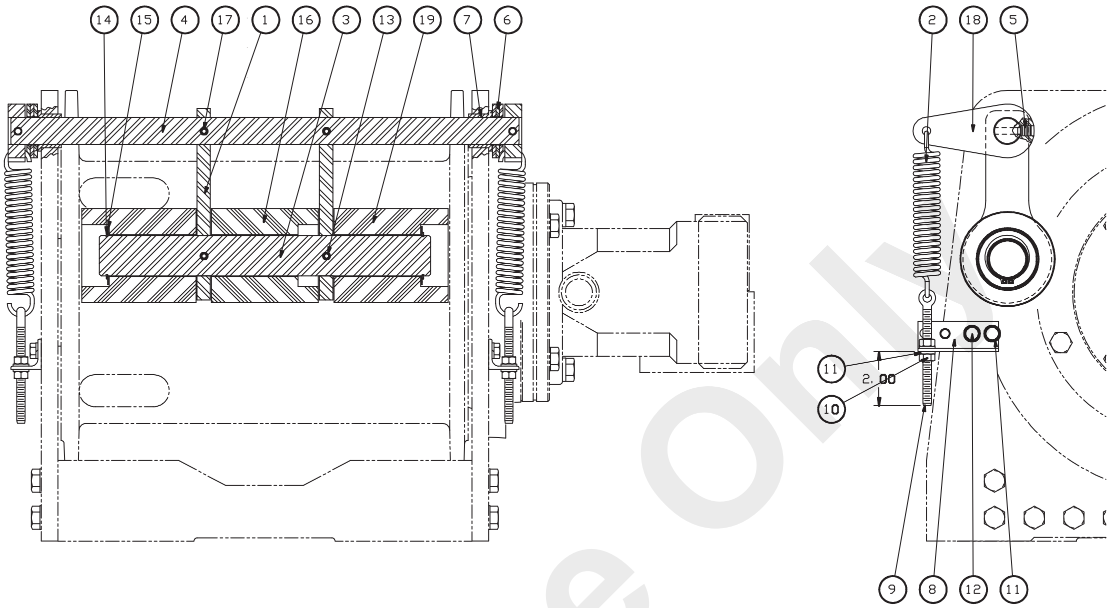
Winch Tension Roller Subassembly Service

Disassembly

Use Figure 11-120 as a guide in disassembling the tension roller assembly.

Assembly

1. When assembling the tension roller assembly use washers (6, Figure 11-120) to center the roller assembly between the drum flanges.
2. Tighten each eyebolt (9) to the dimension shown in Figure 11-120.
3. Apply grease to shaft and I.D. of rollers. Rollers must turn freely.



a2270

Winch Tension Roller Subassembly Cut-Away View

FIGURE 11-120

Item	Description	Item	Description
1.	Tension Roller Arm	11.	Lockwasher (8)
2.	Tension Spring (2)	12.	Capscrew (4)
3.	Tension Roller Shaft	13.	Roll Pin (2)
4.	Tension Arm Shaft	14.	Snap Ring (2)
5.	Set Screw (2)	15.	Thrust Race (2)
6.	Washer (6)	16.	Roller
7.	Roller Bushing (2)	17.	Roll Pin (2)
8.	Spring Anchor (2)	18.	Lever Arm (2)
9.	Roller Rod End (2)	19.	Roller (2)
10.	Nut (4)		

Troubleshooting

.

Trouble	Possible Cause	Remedy
A - The winch 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 winch vent plug.	**1.** 1.Check brake cylinder seal as follows: **a.** Disconnect the swivel tee from the brake release port.Connect a hand pump with an accurate 0-2000 psi (0-13 790 kPa) pressure gauge and shut-off valve to fitting in the brake release port. **a.** Apply 1000 psi (6895 kPa) to the brake. Close the shutoff valve and let stand for five (5) minutes. **a.** 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”.
	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.”
B - Oil leaks from vent plug.	**1.** Same as A2. **2.** Motor seal my be defective as a result of high system back pressure.	**1.** Same as A2. **2.** System back pressure must not exceed 500 psi (3448 kPa). 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.

Trouble	Possible Cause	Remedy
C - The brake will not hold a load with the control lever in neutral.	**1.** Excessive system back pressure act in 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 winch with a suitable solvent.Thoroughly drain the solvent and refill winch with recommended planetary oil. See Section 3.
D - The winch runs hot.	**1.** Excessively worn or damaged internal winch parts.	**1.** Disassemble winch to inspect/ replace worn parts.
E - Winch “chatters while raising rated load.	**1.** Hydraulic oil flow to motor may be too low. **2.** Hoist control being operated too quickly.	**1.** Hydraulic pump not operating efficiently. **2.** Conduct operator training as required.
F - The wire rope does not spool smoothly on the drum.	**1.** Improper wire rope being used. **2.** The winch may have been overloaded, causing permanent set in the wire rope.	**1.** Use only wire rope purchased from Grove. **2.** Replace wire rope.

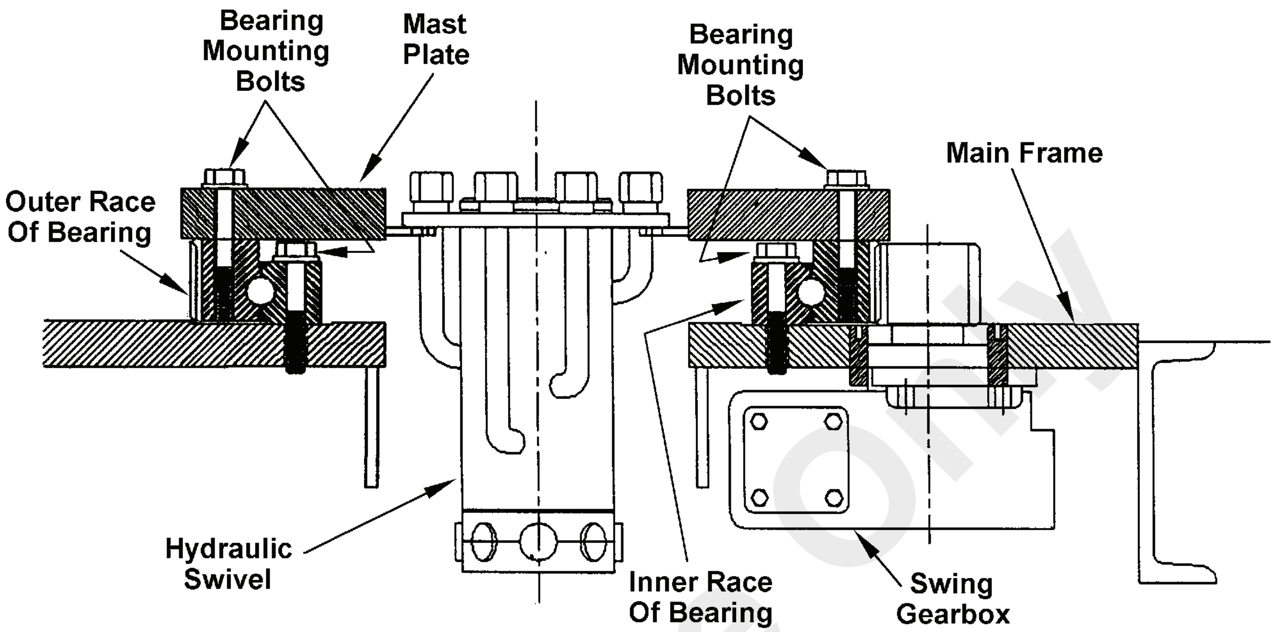
BEARING, MAST AND RELATED PARTS

General

The mast is fastened to the main frame of the crane through a bearing. The inner race of the bearing is fastened to the mast and the outer race of the bearing is fastened to the frame. See Figure 11-121.

The rotation of the mast is done by a gearbox which is mounted below the frame deck. A hydraulic motor connected to the gearbox provided power for rotation of the mast.

The bearing is filled with grease through two grease fittings on the inner race of the bearing. A slotted hole in the mast plate allows access to the inner race and the grease fittings.



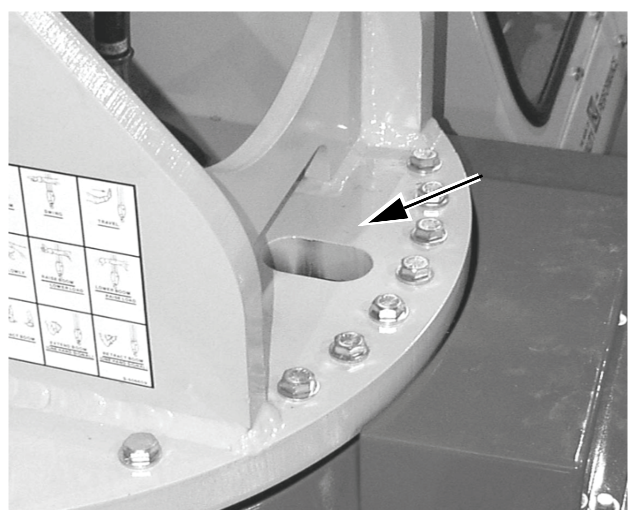
a0490 Cross Section of Mast Bearing **FIGURE 11-121**

Mast Bearing

The bearing is a ball thrust bearing. The inner race rotates inside the outer race on a row of steel balls.

Apply grease weekly or every 50 hours of operation, whichever occurs first. Use a Lithium based, E.P. No. 2 bearing grease, or equivalent.

There are two grease fittings to grease the bearing and they are directly across from each other.Rotate the mast until the access hole (Figure 11-122) aligns with the grease fitting. Apply grease to the bearing. Rotate the mast through several rotation and then repeat the procedure with the other grease fitting. The old grease will be removed at the bottom of the bearing.



p0220 Access Hole **FIGURE 11-122**

Mast Bearing Bolts

Very high stress is put on the mast bolts during crane operation. It is important that these bolts be checked at regular intervals.

Check the torque on the bolts after the first week or 50 hours of operation, whichever occurs first, and then every month or 250 hours of operation, whichever occurs first. Make a record of any loose bolt. If any bolt does not hold to correct torque after the second check, remove and replace the bolt. A loose bolts indicates possible failure of the bolt.

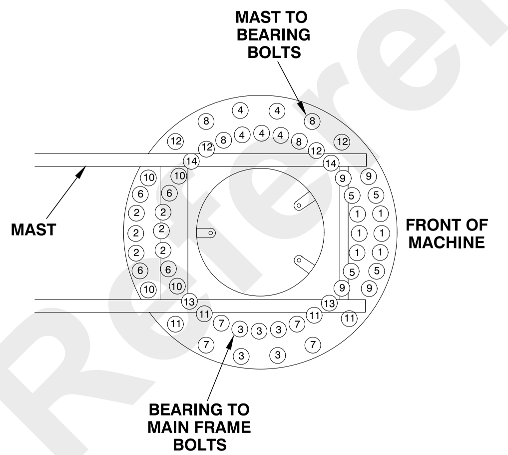
The correct torque on each outside bolt (mast to swing bearing) should be 159 lb-ft. (216 Nm). The correct torque on each inside bolt (swing bearing to frame) should be 282 lb-ft. (384 Nm).

Use the torque sequence shown in Figure 11-123 when check the torque on the bolts.

NOTE: Use only special Grade 8 bolts for replacement of the mast bolts. Order the bolts from your Grove dealer, 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.

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



a0495 Swing Mechanism **FIGURE 11-123**

Inspection For Bearing Wear

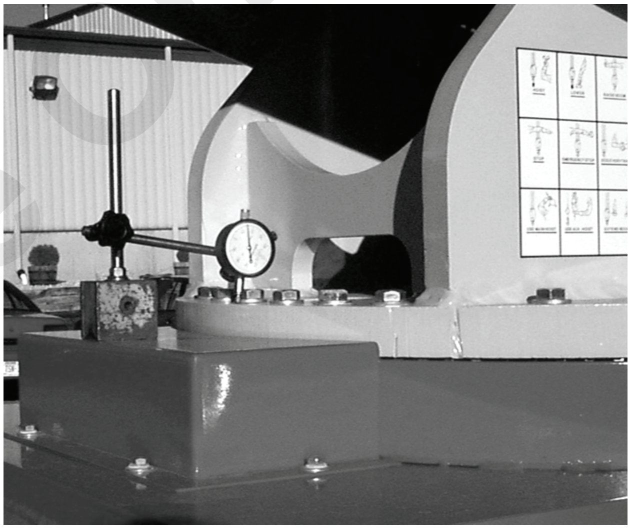
Because of conservative design parameters, static loading and slow intermittent rotation, there are very few mast bearings that ever see their full design use.

However, the mast bearing does have moving internal parts that are prone to wear if not maintained properly. As the bearing wears, there will be free-play or movement in the bearing.Some of the symptoms of mast bearing wear are:

- **a.** Metal particles in the grease around the seal.
- **b.** Increased drive power required.
- **c.** Noisy rotation.
- **d.** Rough rotation.

If one or more of the above symptoms are present, the following procedure should be used to test the bearing for excessive wear.

1. On a level, hard packed surface, set the machine up on its outriggers.
2. With the boom forward, fully extended and in a horizontal position, place a dial indicator on the swing gearbox cover and mast as shown in Figure 11-124.
3. Set the dial indicator to zero.



p0222 **FIGURE 11-124**

4. Raise the boom to its full raised position and record the amount of movement on the dial indicator.
5. Lower the boom and then rotate it 180°. Repeat steps 2 though 4.
6. Average the two readings. The maximum allowable movement is 0.060 inches (1.52 mm). The mast bearing must be replaced if the movement is greater than the stated measurement.

Replacing The Mast Bearing

Removal

1. Refer to boom removal in this section and remove the boom from the mast.
2. Remove swivel stop (25, Figure 11-125) from the bottom of the hydraulic swivel 26.
3. Attach tags to the hydraulic hoses and lines with the swivel port number to which they connect.

4. Disconnect the hydraulic lines from the lower swivel ports. Put caps or plugs on the fittings and hydraulic lines.
5. Using an overhead crane, remove the two counterweights 2 and 4 from the mast.
6. Refer to winch removal in this section and remove the winch assembly.
7. Connect a hoist to the mast capable of handling the weight of the mast. Remove the 26 bolts 9 and flat washers 10, which fasten the mast to the mast bearing.
8. Remove the mast and place it on blocks.
9. Remove the 26 bolts 23 and structural washers 7 and remove the mast bearing 11 from the frame.

Installation

1. Using a suitable solvent, clean the holes in the bearing plate on the main frame. Remove the residue with compressed air. Clean all dirt from the bearing plate.
2. Locate the mast bearing (11, Figure 11-125) in place on the bearing plate.
3. Install the bolts 26 and structural washers 7 to fasten the mast bearing to the bearing plate.
4. Figure 11-123 shows order of tightening the bolts. Each bolt must first be tightened to a torque of 282 lb-ft. (384 Nm) and then loosened slightly. After which, each bolt must again be torqued to 282 lb-ft. (384 Nm).
5. Make sure the top surface of the mast bearing and the bottom surface of the mast base are clean.
6. With a hoist, raise and the lower the mast into position over the mast bearing. Install bolts (9, Figure 11-125) and washers 10.
7. Figure 11-123 shows the order for tightening the bolts. Each bolt must first be tightened to a torque of 159 lb-ft. (216 Nm), and then loosened slightly. After which, each bolt must again be tightened to a torque of 158 lb- ft.(215 Nm).
8. Install swivel stop (25, Figure 11-125) to hydraulic swivel 26.
9. Connect the hydraulic lines to the hydraulic swivel.
10. Install counterweights 2 and 4 into the mast.
11. Install the winch assembly to the mast.
12. Install the boom assembly.

Swing Gearbox And Pinion

Maintenance

Gearbox

The swing gearbox has a worm gear set which rotates on taper roller bearings. The gears and bearings are given lubrication by the grease in the gearbox. Gaskets inhibit external leakage from the gearbox.Keep the gear case filled with grease.

Swing Gear/Pinion

The swing pinion and gear must be lubricated at regular intervals.

Adjustment

Checking Backlash

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

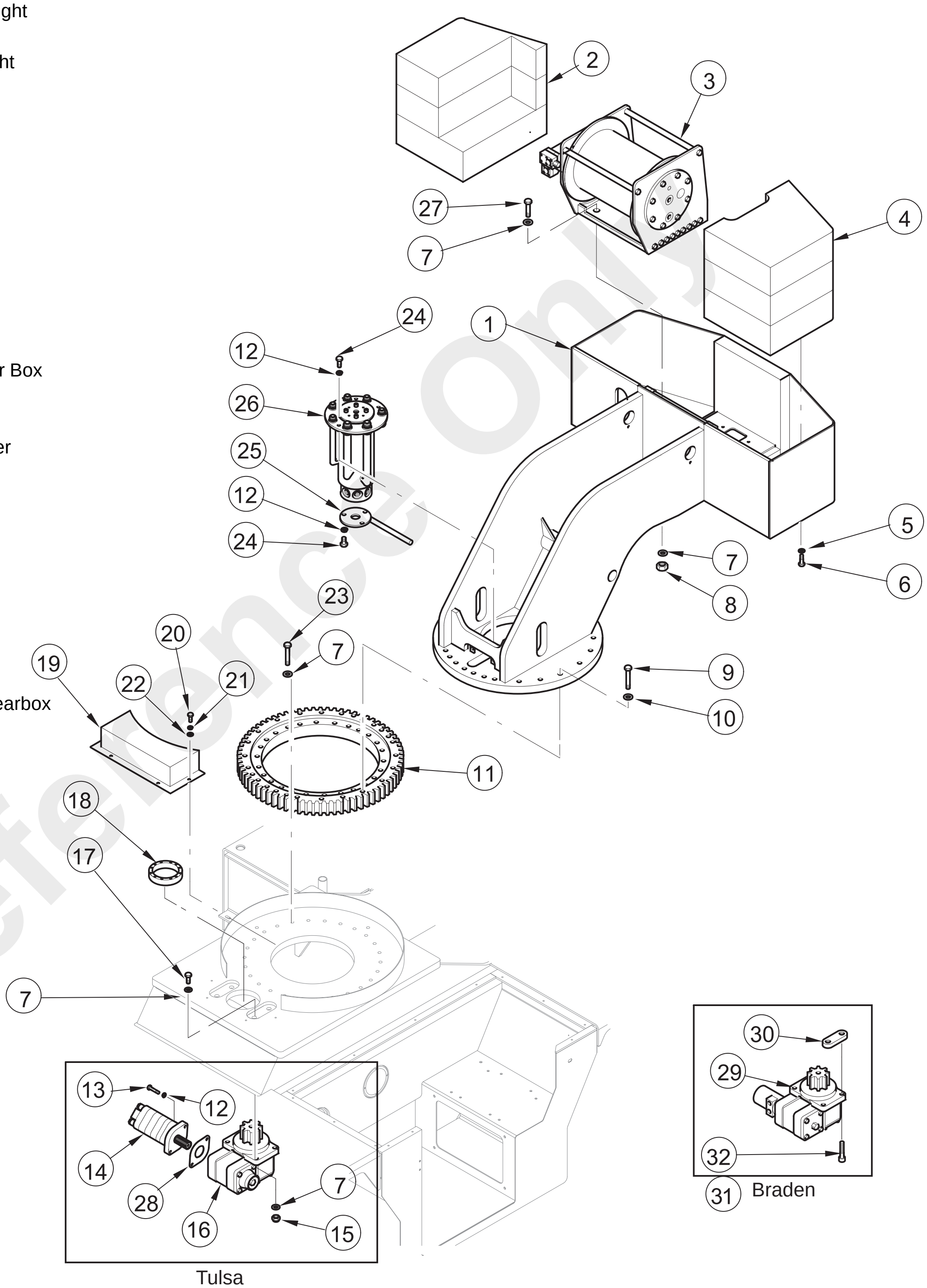
1. Remove the swing gear pinion cover.
2. Start the engine and rotate the mast until the high point on the swing gear is engaged with the pinion (Figure 11-126). The high point is punch-marked on the edge of the metal base plate.
3. Using a feeler gauge, check the backlash between the gear and pinion. There should be no clearance between the swing gear tooth the pinion tooth. If there is any clearance, adjust the backlash.

Backlash Adjustment

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

1. Slightly loosen the four bolts securing the gearbox (Figure 11-126).

Item	Description
1	Mast
2	Right Counterweight
3	Winch
4	Left Counterweight
5	Washer
6	Bolt
7	Washer
8	Nut
9	Bolt
10	Washer
11	Swing Bearing
12	Lock Washer
13	Bolt
14	Swing Motor
15	Nut
16	Tulsa Swing Gear Box
17	Bolt
18	Eccentric Ring
19	Pinion Gear Cover
20	Bolt
21	Lock Washer
22	Washer
23	Bolt
24	Bolt
25	Stop Assembly
26	Hydraulic Swivel
27	Bolt
28	Gasket
29	Braden Swing Gearbox
30	Bar
31	Bolt



a0488

Mast Assembly

FIGURE 11-125

2. With a spanner wrench, turn the eccentric ring to move the pinion until it contacts the swing gear tooth (zero backlash).
3. Tighten the four bolts to appropriate torque.
4. Install the swing pinion cover.

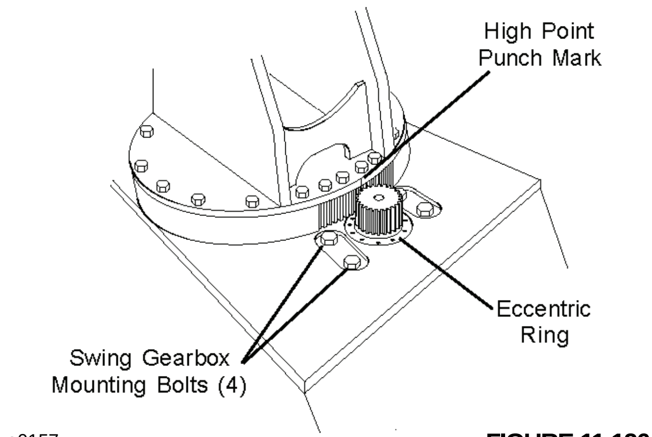


FIGURE 11-126

Swing Gearbox Repair (Tulsa Gearbox)

Removal

1. Use a hoist and blocks to hold the boom in position and prevent the mast from rotating
2. Remove the swing motor from the gearbox.

NOTE: Do not rotate the mast after the hydraulic motor has been removed from the gearbox. Internal bearings will become dislodged. Make note of the position of the swing motor for installation.

3. Provide support for the gearbox and remove the four bolts which fasten the gearbox to the frame. Remove the gear box and eccentric ring from beneath the machine.

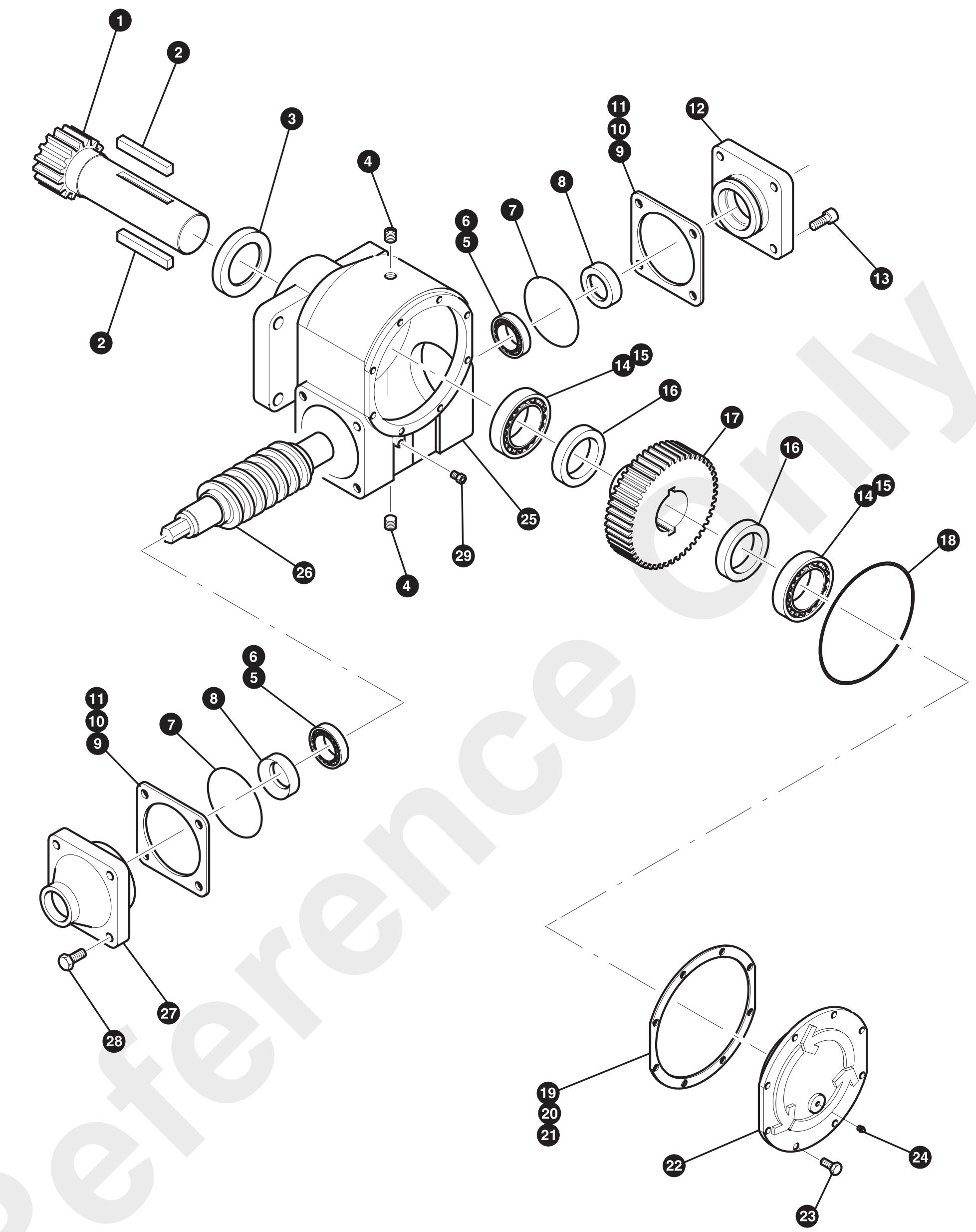
Disassembly

1. Clean the outside of the gearbox before disassembly.
2. Loosen bolts (23, Figure 11-127) from cover 22). Remove the cover from the gear housing 25.
3. 3.Clean as much grease out of the housing as possible. Properly dispose of the grease.

NOTE: Tie the shim sets together to inhibit any shim from being lost.

4. Remove shims 19 through 21 from the gear case. Be careful not to damage or lose any of the shims.
5. Remove o-ring 18 and cover 22.
6. Remove socket head capscrews 13. Remove end motor cap 12.
7. If shims 9 though 11 are located between cover 12 and housing 25 remove the shims. Be sure not damage of lose any of the shims.
8. Remove and discard o-ring 7 and seal 8.
9. Remove capscrews 28 and remove end cap 27.
10. If shims 9 through 11 are located between cover 27 and housing 25 remove the shims.Be sure not damage of lose any of the shims.
11. Remove and discard o-ring 7 from end cap 27.
12. Using a suitable puller, remove bearing cup 5 from end cap 27. Remove and discard seal 8.

13. Using a suitable puller, remove bearing cone 15 from pinion shaft 1. Remove spacer 16.
14. Using a suitable puller, remove worm gear 17from pinion shaft 1. Remove spacer 16.
15. Using a suitable puller, remove bearing cone 15 from pinion shaft 1.
16. Remove pinion shaft 1 and worm 26 from housing 25.
17. Remove wiper seal 3 from housing 25.



Item	Description
1	Pinion Shaft
2	Key (2)
3	Oil Seal
4	Pipe Plug (2)
5	Bearing Cup (2)
6	Bearing Cone (2)
7	O-Ring (2)
8	Seal (2)
9	Shim (2)
10	Shim (2)

Item	Description
11	Shim (2)
12	End Motor Cap
13	Socket Head Capscrew
14	Bearing Cup (2)
15	Bearing Cone (2)
16	Spacer (2)
17	Worm Gear
18	O-Ring
19	Shim
20	Shim

Item	Description
21	Shim
22	Cover
23	Capscrew (8)
24	Grease Fitting
25	Housing
26	Worm
27	End Cap
28	Capscrew (4)
29	Breather

a0489

Tulsa Swing Gearbox Exploded View

FIGURE 11-127

18. Using a suitable puller, remove bearing cup14 from housing 25.
19. Using a suitable puller, remove bearing cup 14 from cover 22.

Inspection

Clean all parts. See Section 1. Make sure the breather (29, Figure 11-127) is clean. Make a careful inspection of all parts, including gears, shafts and bearings.

Replace all seals and gaskets.

Assembly

1. If removed, install a new bearing cup 14 into housing 25.
2. Install new wiper 3 into housing 25.
3. Install pinion shaft 1 into housing 25 through seal 3 Be careful not to damage the seal.

NOTE: Before installing any bearing cone, pack the bearing with a Lithium base, E.P. No. 2 bearing grease.

4. Pack both bearing cones 6 with grease and install onto worm 26.
5. Insert worm 26 into housing 25.
6. Pack first bearing cone 15 with grease and install onto pinion shaft 1. Install firsts pacer 16.
7. Using two keys 2, install worm gear 17 onto pinion shaft 1.
8. Install second spacer 16 and second bearing cone (15) onto pinion shaft 1. Be sure bearing cones are packed with grease before assembly.
9. Install seal 8 into end cap 12. Install bearing cup 5. Install o-ring 7. Lubricate the seal and o-ring with grease before assembly.
10. Install seal 8 into motor cap 27. Install o-ring 7. Lubricate seal and o-ring with grease before assembly.
11. Insert the end of worm 25 into end motor cap12. Fasten end motor cap 12 to housing 25 with socket head capscrews 13.
12. Align the gear teeth of worm 25 with the teeth of worm gear 17.
13. If the original bearing cups and cones were installed in the end caps and onto the worm, the existing shims 9 through 11 may be installed between housing 25 and end cap 27. Install the shims and end cap 27. Attach end cap 27 with capscrews 28.

    If new bearings were installed, proper bearing pre-load must be determined before final installation of the end cap 27.

    a. Install end cap 27 without shims installed.
    b. Using a dial indicator, measure the amount of axial movement of the worm. Proper axial movement must be between -0.001 to + 0.002 inches (-0.025 to +0.05 mm).Determine the amount of shims required to acquire the proper axial movement. Then, install the shims between housing 25 and end cap 27. Fasten with capscrews 28.
14. If the original bearings were installed on pinion shaft 1, then the existing shims 19 through 21may be installed between cover 22 and housing 25. Install shims and fasten cover 22with capscrews 23.

    If new bearings were installed, proper bearing pre-load must be determined before final installation of the cover.

    a. Install the cover without shims.
    b. Using a dial indicator, measure the amount of axial movement of the pinion shaft.Proper axial movement must be between -0.003 to -0.005 inches (-0.076 to -0.127 mm). Determine the amount of shims required to acquire the proper axial movement. Then, install the shims between housing 25 and cover 22.Fasten with capscrews 23.
15. Fill the housing with a Lithium base E.P. No. 2bearing grease through the grease fitting on the cover. See Section 3, Preventive Maintenance.

Installation

1. Install the gearbox in reverse order of removal.
2. When installing the swing motor, use a new gasket.
3. Align the pinion gear with the swing gear following instructions.

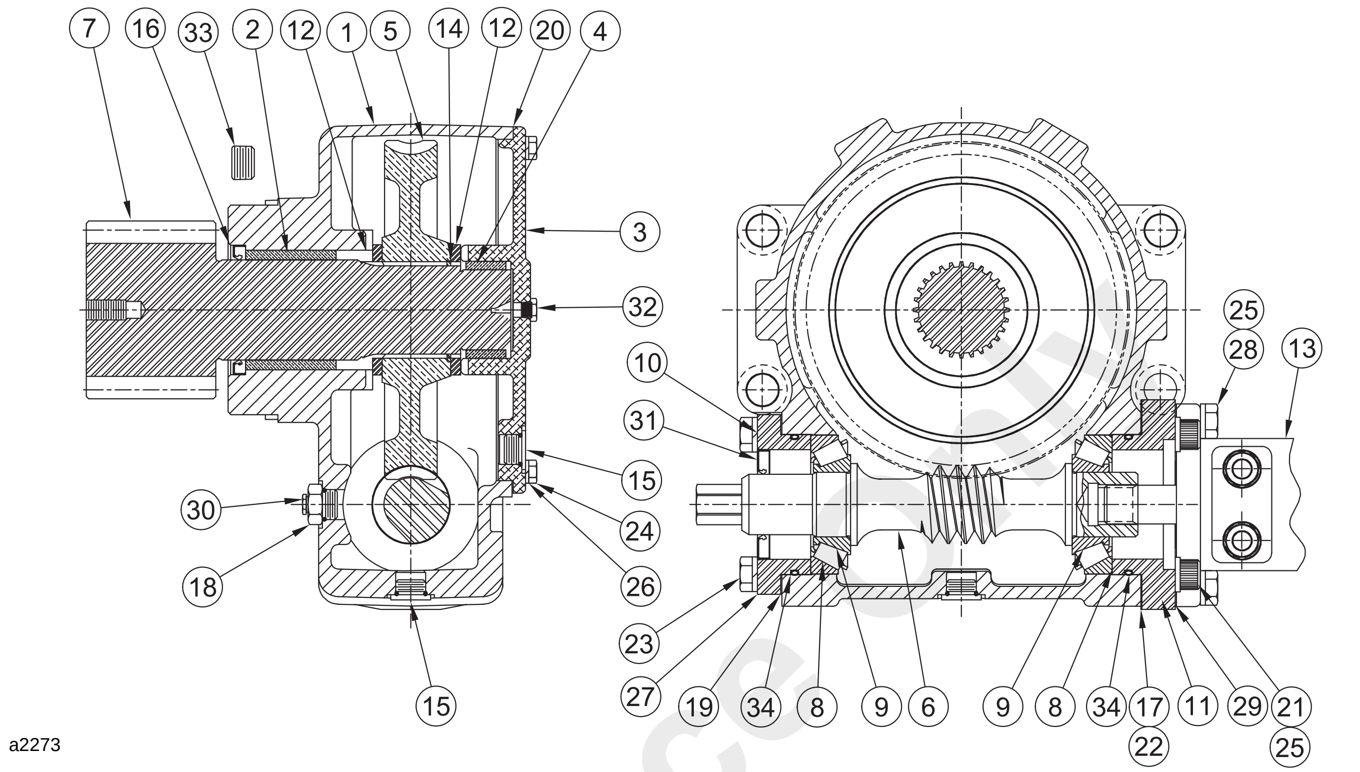
Swing Gearbox Repair (Braden Gearbox)

Removal

1. Use a hoist and blocks to hold the boom in position and prevent the mast from rotating.
2. Tag and disconnect the hydraulic hoses from the swing gearbox. Plug the hoses and cap the hydraulic fittings.
3. Provide support for the gearbox and remove the four bolts which fasten the gearbox to the frame. Remove the gear box and eccentric ring from beneath the machine.

Disassembly

1. Clean the outside of the gearbox before disassembly.
2. Remove hydraulic motor 13 (Figure 11-128) and gasket 29 from the gearbox.
3. Remove drain plug 15 and drain all lubricating oil into a suitable container. Install the drain plug.



Item	Description
1	Worm Housing
2	Bushing
3	Worm Housing Cover
4	Bushing
5	Worm Gear
6	Worm
7	Output Pinion
8	Bearing Cup (2)
9	Bearing Cone (2)

Item	Description
10	Bearing Retainer
11	Motor Adapter
12	Retaining Ring (2)
13	Hydraulic Motor
14	Retaining Ring
15	O-Ring Plug
16	Oil Seal
17	Gasket -0.015” (4)
18	Reducer

Item	Description
19	Gasket - 0.031”
20	Cover Gasket
21	Capscrew (4)
22	Shim
23	Capscrew (4)
24	Capscrew (6)
25	Lockwasher (6)
26	Lockwasher (6)
27	Lockwasher (4)

Item	Description
28	Capscrew (4)
29	Motor Gasket
30	Relief Valve
31	Seal
32	Pipe Plug
33	Plug
34	O-Ring

Winch Tension Roller Subassembly Cut-Away View

FIGURE 11-128

4. Remove four socket head capscrews 21and lockwashers 25. Remove motor adapter11.
5. Remove gasket 17 and shim 22. Be sure not to damage or loose the shim.
6. Remove and discard o-ring 34.
7. Remove four capscrews 23 and lockwashers27. Remove bearing retainer 10 and gasket19.
8. Remove and discard o-ring 34 and seal 31.
9. Using a wench on the hex on the end of the work gear shaft 6, turn the worm shaft and walk the worm shaft and bearings 8 and 9 out the end of the worm housing.
10. Remove bearing cones 8 and cups 9 from worm shaft 6.
11. Remove six capscrews 24 and lockwashers 26. Remove worm gear housing cover 3 and cover gasket 20.
12. Remove retaining ring 12 and then retaining ring 14.
13. Pull worm gear 5 off of output pinion shaft 7. Remove the remaining retaining ring 12.
14. Pull output pinion 7 from worm housing 1.
15. Remove and discard oil seal 16.
16. If necessary, remove bushing 2 from worm housing 1 and bushing 4 from worm housing cover 3.

Inspection

Clean all parts. See Section 1. Make sure breather (30, Figure 11-128 is clean. Make a careful inspection of all parts, including gears, shafts and bearings. Replace all seals and gaskets.

Assembly

1. If removed, install bushing 2 and 4 into worm housing 1 and worm housing cover 3.
2. Install bearing cups 8 and bearing cones 9 onto worm shaft 7.
3. Install the assembled worm shaft and bearings into worm housing 1. Seat the bearing cones into the worm housing.
4. Install a new oil seal 16 into worn housing 1.
5. Insert output pinion shaft 7 through oil seal 16and bushing 2.
6. Install the lower retainer ring 12 over the output pinion shaft.
7. Install worm gear 5 onto output gear shaft 7. Mesh the teeth of the worm gear with the teeth of the worm.
8. Install retaining ring 14. Install the top retaining ring 12.
9. Place a new 0.031” thick gasket 19 on bearing retainer 10.
10. Attach the gasket and bearing retainer to the worm housing using four lockwashers 27 and capscrews 23.
11. Place a new 0.015” thick gasket 17 and shim 22 on the motor adapter 11.
12. Using four socket head capscrews 21 and lockwashers 25 attach motor adapter to 11 to worm housing 1.
13. Check the backlash between the worm and worm gear in both directions. Backlash should be 0.010” (0.254 mm) or less.
14. Place a new worm cover gasket 20 on the face of worm housing 1. Using six capscrews24 and lockwashers 26, attach worm housing cover 3 to the worm housing. Coat the threads of capscrews 23 with Loctite No. 242 before installation.
15. Check the end play on the worm shaft using a dial indicator. Set the base of dial indicator on the worm gear housing. Turn the output gear in one direction slightly. Place the dial indicator on the end of the worm shaft and set it to zero (0). Turn the output gear in the opposite direction and read the dial indicator. The end play must be between 0.000 to 0.002 inches (0.000 to 0.05 mm). Add or remove shims as necessary to obtain the correct end play.
16. Fill the gear housing with the recommended gear lubricant. See Section 3.
17. Using a new gasket, install the hydraulic motor 13 to motor adapter 11 using capscrews 28 and lockwashers 25.

Installation

1. Install the gearbox in reverse order of removal.
2. Align the pinion gear with the swing gear following the instructions.

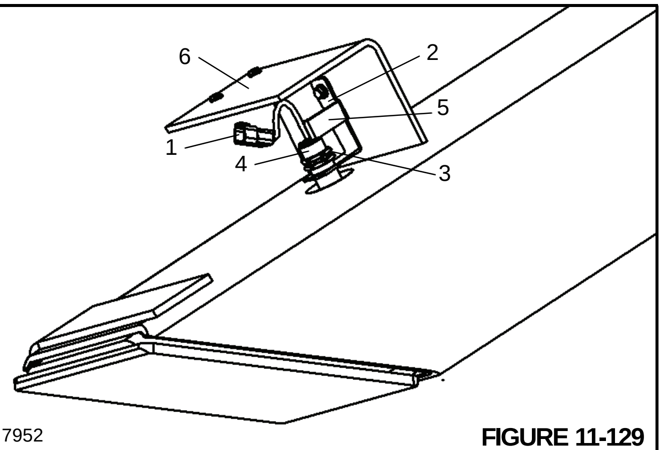
OUTRIGGERS

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

The Outrigger Monitoring System (OMS) proximity switches (if equipped) are mounted outside the outrigger housing tubes. The proximity switches identify whether an outrigger beam is at the fully extended position or at any position less than fully extended.

Removal

1. Disconnect switch cable (1) from harness.
2. Remove switch mounting bracket (2).
3. Remove jam nuts (3) and thread switch (4) out of the mounting bracket.



7952 **FIGURE 11-129**

Installation

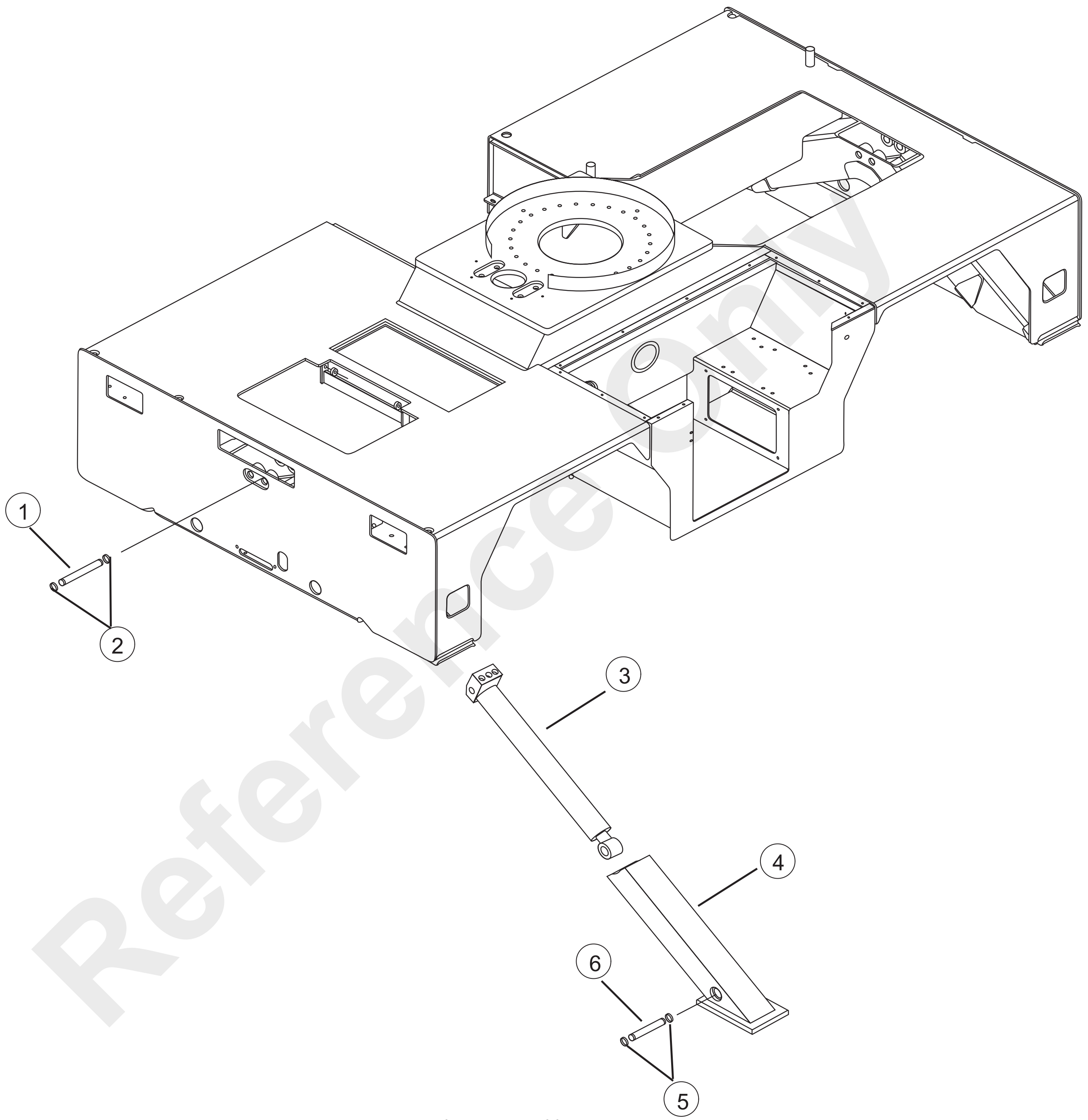
1. Feed cable through the mounting bracket and jam nuts.
2. Thread switch through mounting bracket.
3. Thread nuts on switch.
4. Thread switch up until it touches tab (5) of mounting bracket and LED is pointed away from the bracket.
5. Tighten jam nuts against mounting bracket.
6. Install bracket with switch onto outrigger angle bracket (6).
7. Adjust bracket and/or switch to have .12 to .38 in (3 to 10 mm) gap beween end of switch and outrigger beam.
8. Connect switch cable to wire harness.

Cylinder Removal

1. Position the crane so that the outrigger is over some sort of a pit. If a pit is not available, an overhead crane of sufficient capacity can be used to raise the end of the crane far enough to remove the outrigger. DO NOT use a jack to raise the crane, unless the crane can be blocked in position to inhibit the crane from falling when the outrigger is removed.
2. Engage the parking brake and place chock blocks at the wheels to inhibit machine movement.
3. Disconnect the hydraulic lines from the cylinder. Cap and plug the hoses and fittings.
4. Remove the counterbalance valve (Figure 9-129) from the outrigger cylinder.
5. Remove the cylinder base end pin (See Figure 9-129).
6. Pull the outrigger beam and cylinder from the outrigger tube in the main frame.
7. Remove the cylinder rod end pin and remove the cylinder.

Cylinder Installation

1. Insert the outrigger cylinder into the outrigger beam and then install the rod end pin and retaining rings (See Figure 9-129).
2. Install the outrigger beam (Figure 9-129) and cylinder into the outrigger tube on the main frame. Push the outrigger into tube until the cylinder base end pin can be installed.
3. Install the cylinder base end pin and retaining rings.
4. Install the counterbalance valve.
5. Connect the two hoses to the outrigger cylinder.
6. Apply a small amount of lubricant to the upper surface of the outrigger beam.
7. Using the outrigger control, extend and retract the outrigger several times to remove any air in the hydraulic lines.



a0490

Outrigger Assembly

FIGURE 11-130

Item	Description
1	Pin
2	Retaining Ring
3	Cylinder
4	Outrigger Boom
5	Retaining Ring
6	Pin

SECTION 12
SCHEMATICS/WIRING DIAGRAMS

THIS PAGE BLANK

ALPHABETICAL INDEX