Grove GRT655/655L

Service Manual

Grove Manitowoc National Crane Potain

Manitowoc

WARNING

California Proposition 65

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

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

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

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

California Spark Arrestor

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

The original language of this publication is English.

GROVE
by Manitowoc

SERVICE MANUAL

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

GRT655/655L

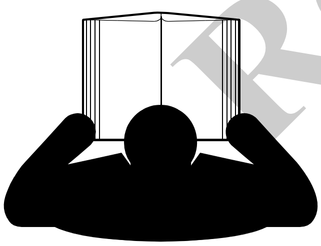
Crane Model Number

This Manual is divided into the following Sections:

NOTICE

The crane serial number is the only method your distributor or the factory has of providing you with correct parts and service information.

The crane serial number is stamped on the top of the outrigger box. ***Always furnish crane serial number*** when ordering parts or communicating service problems with your distributor or the factory.



DANGER

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

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

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SECTION 1
INTRODUCTION

SECTION CONTENTS

DESCRIPTION

This Manual provides information for the maintenance of the Model GRT655/655L Series Grove Crane.

The lift capacities are listed on the Load Chart in the cab.

The crane incorporates an all welded parallel box construction steel frame, using planetary drive axles to provide four-wheel drive. Axle steering is accomplished utilizing hydraulic steer cylinders. The engine is mounted at the rear of the crane carrier and provides motive power through a six speed forward and reverse transmission.

The carrier frame incorporates an integral fifth wheel, to which the rear axle is mounted, to provide axle oscillation. Axle oscillation lockout is automatic when the superstructure rotates from the travel position.

The superstructure is capable of 360 degree rotation in either direction. All crane functions are controlled from the fully-enclosed cab mounted on the superstructure. The crane is equipped with either a four-section or five-section, full power, sequenced and synchronized boom. Additional reach is obtained by utilizing an optional swingaway boom extension. Lifting is provided by a main hoist and an optional auxiliary hoist.

NOTE: Throughout this manual, reference is made to left, right, front, and rear when describing locations. When operating the crane, these reference locations are to be considered as those viewed from the operator seat with the superstructure facing forward over the front of the carrier frame.

NOTE: Transportation and Lifting Decal is shown in (Figure 1-1).

LIST OF SPECIFICATIONS

General

Model GRT655/655L
Rated Capacity . . . . . See Load Chart in cab
Drive . . . . . 4 x 4 x 4
Gross Weight . . See Axle Weight Distribution Table

Dimensions

NOTE: Dimensions listed are for a crane with all components fully retracted in the travel mode.

Wheelbase . . . . . 3810 mm (150 in)
Overall Crane Length
- GRT655 . . . . . 12,660 mm (498 in)
- GRT655L . . . . . 12,788 mm (503 in)

Overall Crane Width
- Standard Tire Width 3079 (121)
- Narrow Tire Width 2938 (116)
- Frame Width 2990 (118)

Overall Crane Height
- 23.5x25 tire . . . . . 3478 mm (136.9 in)
- 18.0x25 tire . . . . . 3500 mm (137.8 in)

Outside Turning Radius (23.5x25 tire)
- 2 Wheel Steer . . . . . 10,161 mm (400 in)
- 4 Wheel Steer . . . . . 6140 mm (242 in)

Outside Turning Radius (18.0x25 tire)
- 2 Wheel Steer . . . . . 10,138 mm (399 in)
- 4 Wheel Steer . . . . . 6116 mm (241 in)

Outside Curb Clearance (23.5x25 tire)
- 2 Wheel Steer . . . . . 10,459 mm (412 in)
- 4 Wheel Steer . . . . . 6435 mm (253 in)

Outside Curb Clearance (18.0x25 tire)
- 2 Wheel Steer . . . . . 10,386 mm (409 in)
- 4 Wheel Steer . . . . . 6362 mm (250 in)

Outrigger Spread
- Retracted . . . . . 2790 mm (110 in)
- Mid Extend . . . . . 4799 mm (189 in)
- Fully Extended . . . . . 6809 mm (268 in)

Capacities

Fuel Tank . . . . . 322 L (85 gal)
Coolant System . . . . . 43 L (45.4 qt)
Engine Lubrication System . . . . . 18 L (19 qt)
Hydraulic Tank (Reservoir Capacity)
- Total . . . . . 524 L (138.5 gal)
- Full Level . . . . . 470 L (124.1 gal)

Hoist . . . . . 8.5 L (18 pt)
Swing Gearbox . . . . . 5.0 L (10.6 pt)
Axle Planetary Hub . . . . . 2.4 L (2.5 qt)
Axle Differential . . . . . 28.4 L (30 qt)
Transmission (includes Torque Converter)
. . . . . 29.3 L (61.9 qt)
Diesel Exhaust Fluid (DEF) Tank . . . 37.9 L (10 gal)

Torque Converter

Stall Ratio 2.024:1
Charge Pump Capacity . . . . . 61 L/min (16 gpm)
. . . . . @ 2000 rpm

Transmission

Gear Ratios
Forward and Reverse
Low Range
- 1st 10.805
- 2nd 4.727
- 3rd 1.576

High Range
- 4th 4.825
- 5th 2.111
- 6th 0.704

Engine

Cummins QSB 6.7 - Tier 4F

Type . . . . . 4-cycle, Diesel, Turbocharged
Number of Cylinders 6
Horse Power Rating . 122 kW (164 hp) @ 2300 rpm
Fuel . . . . . Maximum 15 ppm “Ultra Low Sulfur Diesel Fuel” + diesel exhaust fluid (DEF)

Cummins QSB 6.7 - Tier 3

Type . . . . . 4-cycle, Diesel, Turbocharged
Number of Cylinders 6
Horse Power Rating . 119 kW (160 hp) @ 2500 rpm
Fuel . . . . . Maximum 5,000 ppm Sulfur Diesel

Axles

Total Ratio 24.817:1
Carrier Ratio 5.86:1
Planetary Ratio 4.235:1

Brakes

Type . . . . . Four-Wheel Hydraulic Disc

Wheels and Tires

Lugs per Wheel 12
Torque . . . . . 407 to 475 N-m (300 to 350 lb-ft)
Tire Size
- Standard . . . . . 23.5 x 25 - 24 ply rating
- Optional . . . . . 18.0 x 25 - 28 ply rating

NOTE: For roading and lifting pressures, refer to the Load Chart Book in the cab.

Swing Gearbox

Reduction Ratio 36.2:1
Output Torque . . . . . 5630 N-m (49,830 in-lb)

Boom

Length . . . . . 10.7 to 43 m (35.3 to 141.2 ft)
Power . . . . . 5 Section, Full Power
Length . . . . . 10.6 to 34.8 m (34.9 to 114.3 ft)
Power . . . . . 4 Section, Full Power
Elevation . . . . . -3 to +80 degrees
Extensions (Optional)
- Manual Telescopic . 7.92 to 13.7 m (26 to 45 ft)
- Offset . . . . . 0°, 15°, or 30°

Swivel Assembly

Electrical . . . . . 20 Slip Rings
Hydraulic . . . . . 10 ports
Water . . . . . 2 ports
Air Conditioning . . . . . 2 ports

Hydraulic Pumps

NOTE: Pump output figures are theoretical.

Pump #1

Type . . . . .Piston
Sections 1
Output - @ loaded engine speed
Section 1 . . . . 246 L/min (65 gpm)

Pump #2

Type . . . . .Gear
Sections 1
Output - @ loaded engine speed
Section 1 . . . . 46.6 L/min (12.3 gpm)

Pump #3

Type . . . . .Gear
Sections 1
Output - @ loaded engine speed
Section 1 . . . . 87 L/min (22.9 gpm)

Hoists

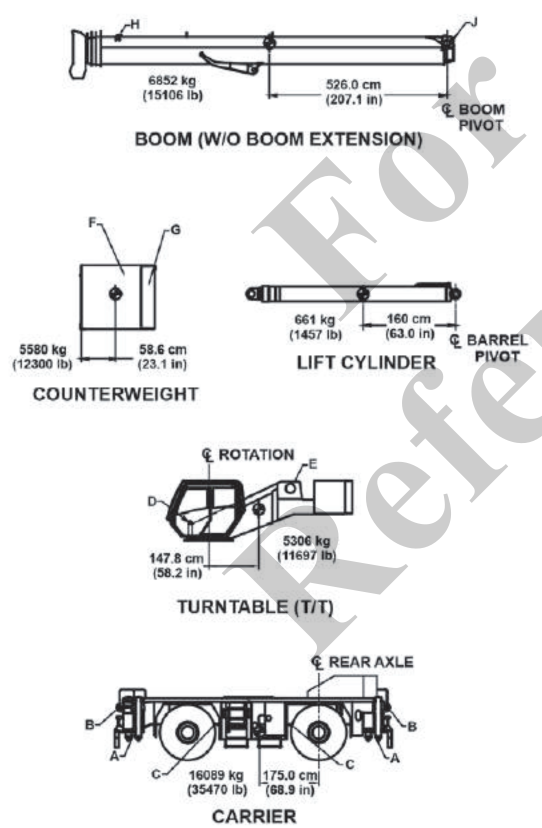
Drum Dimensions
Diameter . . . . 270 mm (10.63 in)
Length. . . . . 578 mm (22.74 in)
Cable, 35x7 Steel
Diameter . . . . 16 mm
Length. .180 m (590 ft)
Max Permissible
Line Pull . . . . 5552 kg (12,240 lb)
Cable, Synthetic
Diameter . . . . 18 mm
Length. .180 m (590 ft)
Max. Permissible
Line Pull . . . . 5771 kg (12,723 lb)
Max. Single Line Speed at:
Max. Motor Displacement . . 76 mpm (250 fpm)
Min. Motor Displacement . 137 mpm (450 fpm)
Motor Displacement
Maximum. . . . . 77 cc (4.70 cu-in)
Minimum . . . . 41 cc (2.50 cu-in)

Outriggers

Outrigger Jack Cylinder Stroke635 mm (25 in)
Outrigger Pad Diameters
Polymer. . . . . 500 mm (19.68 in)
Aluminum . . . . 611 mm (24.06 in)
Maximum Individual O/R Pad Load356 KN
(80 KIPS)

TRANSPORTATION AND LIFTING DATA – GRT655

TRANSPORTATION AND LIFTING DATA GRT655



FITTINGS	NO./UNIT	TOTAL UNIT LIFT	TOTAL UNIT TOW	TOTAL UNIT TIE DOWN	CARRIER LIFT	CARRIER TOW	CARRIER TIE DOWN	S/S LIFT	LIFT CYL LIFT	BOOM LIFT	CWT LIFT	FITTING CAPACITY (TONS) LIFT	TOW	TIE DOWN FORE & AFT	TIE DOWN SIDE	TIE DOWN DOWN
A	4	X			X							33	SEE NOTE #5			
B	4		X	X		X	X						73	73	19	21
C	4			X			X							73	19	21
D								X				52				
E								X				50				
F									X							
G											X	5				
H										X		6				
J										X		6				

1. LIFTING OF ENTIRE CRANE OR MAJOR CRANE ASSEMBLIES MUST BE ACCOMPLISHED BY UTILIZING SPECIFIC FITTINGS INDICATED ON ABOVE CHART. USE OF FITTINGS FOR PURPOSES OTHER THAN THOSE DESIGNATED ON CHART IS PROHIBITED. FITTING CAPACITIES ARE MAXIMUM ALLOWABLE LOADS PER INDIVIDUAL FITTING.
2. RIGGING PERSONNEL SHALL BE RESPONSIBLE FOR PROPER SELECTION AND PLACEMENT OF ALL SLINGS AND LOAD HANDLING DEVICES.
3. DIMENSIONS AND WEIGHTS SHOWN ARE FOR LARGEST CONFIGURATION AVAILABLE. WEIGHTS DO NOT INCLUDE BOOM EXTENSION AND / OR JIB, EXCEPT WHERE NOTED.
4. RIGGING PERSONNEL SHALL VERIFY DIMENSIONS AS REQUIRED FOR CLEARANCE.
5. EXTEND OUTRIGGER BEAMS 46 CM (18 IN) AND SLING AROUND BEAMS TO LIFT.
6. DO NOT USE PINTLE HOOKS OR CWT LUGS FOR LIFTING OR TIE DOWN OF ENTIRE CRANE.

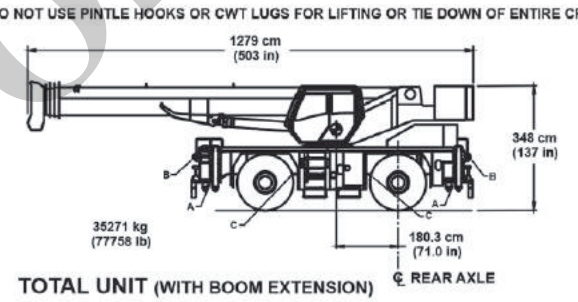


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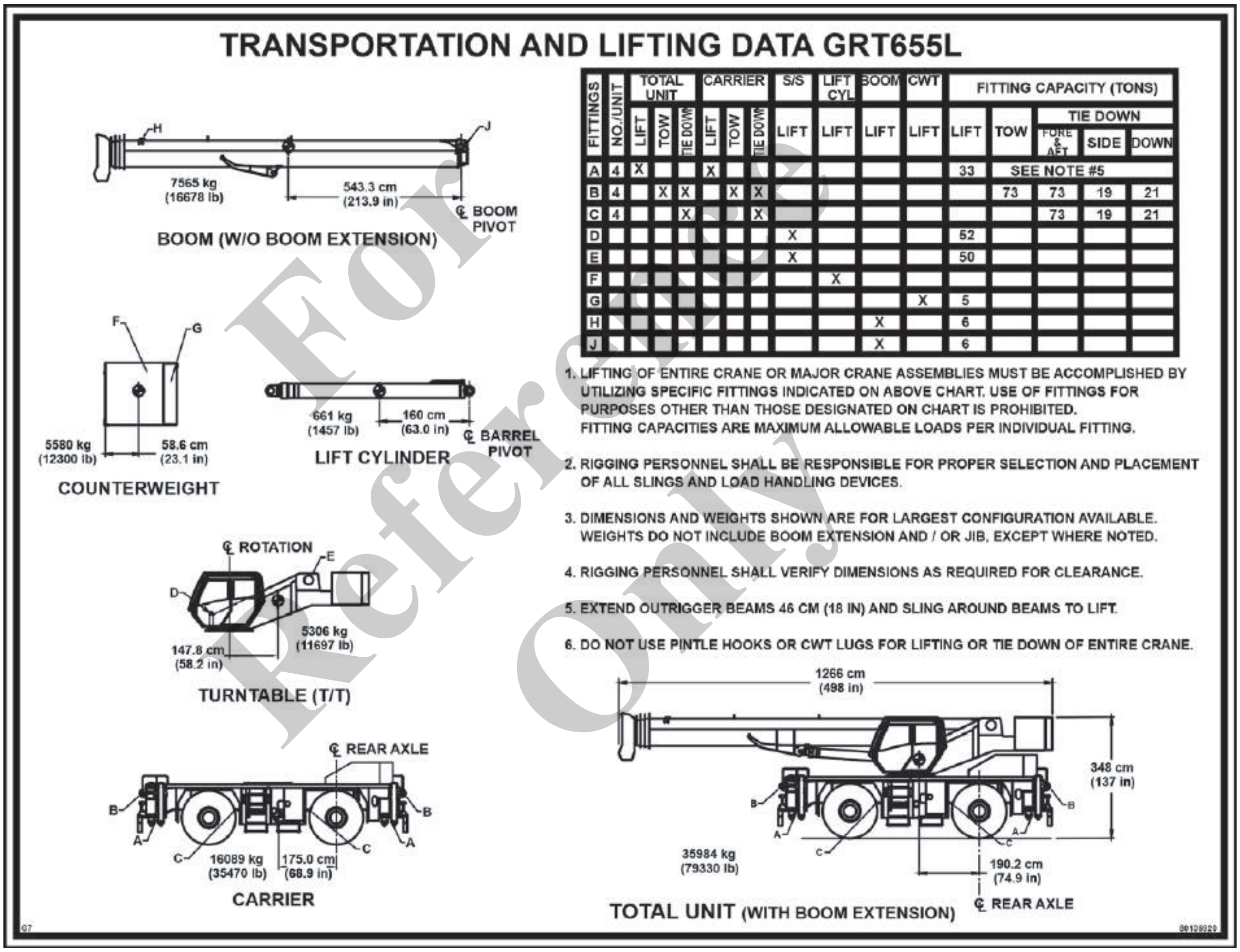
FIGURE 1-1

TRANSPORTATION AND LIFTING DATA – GRT655L



FITTINGS	NO./UNIT	TOTAL UNIT			CARRIER			S/S	LIFT CYL	BOOM	CWT	FITTING CAPACITY (TONS)				
		LIFT	TOW	TIE DOWN	LIFT	TOW	TIE DOWN	LIFT	LIFT	LIFT	LIFT	LIFT	TOW	TIE DOWN FORE & AFT	TIE DOWN SIDE	TIE DOWN DOWN
A	4	X			X							33	SEE NOTE #5			
B	4		X	X		X	X						73	73	19	21
C	4			X			X							73	19	21
D								X				52				
E								X				50				
F									X							
G											X	5				
H										X		6				
J										X		6				

1. LIFTING OF ENTIRE CRANE OR MAJOR CRANE ASSEMBLIES MUST BE ACCOMPLISHED BY UTILIZING SPECIFIC FITTINGS INDICATED ON ABOVE CHART. USE OF FITTINGS FOR PURPOSES OTHER THAN THOSE DESIGNATED ON CHART IS PROHIBITED. FITTING CAPACITIES ARE MAXIMUM ALLOWABLE LOADS PER INDIVIDUAL FITTING.
2. RIGGING PERSONNEL SHALL BE RESPONSIBLE FOR PROPER SELECTION AND PLACEMENT OF ALL SLINGS AND LOAD HANDLING DEVICES.
3. DIMENSIONS AND WEIGHTS SHOWN ARE FOR LARGEST CONFIGURATION AVAILABLE. WEIGHTS DO NOT INCLUDE BOOM EXTENSION AND / OR JIB, EXCEPT WHERE NOTED.
4. RIGGING PERSONNEL SHALL VERIFY DIMENSIONS AS REQUIRED FOR CLEARANCE.
5. EXTEND OUTRIGGER BEAMS 46 CM (18 IN) AND SLING AROUND BEAMS TO LIFT.
6. DO NOT USE PINTLE HOOKS OR CWT LUGS FOR LIFTING OR TIE DOWN OF ENTIRE CRANE.

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FIGURE 1-2

Table 1-1
GRT655 Axle Weight Distribution Table

Description	CG to CL Rear Bogie cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
Tire & Wheel Allowable - 23.5x25(24PR)			19595 (43200)	19595 (43200)
Tire & Wheel Allowable - 18.00x25(28PR)			19255 (42450)	19255 (42450)
Axle Allowable			19051 (42000)	21319 (47000)
Basic Unit				
Standard Carrier Assy (4x4) + All Fluids	167.08 (65.78)	14712 (32435)	6452 (14224)	8260 (18211)
Superstructure Assy w/Cab, Main Hoist + cable & IPO Cwt	55.37 (21.80)	5098 (11240)	741 (1634)	4357 (9606)
Bolt on Counterweight	-162.56 (-64.00)	5579 (12300)	-2380 (-5248)	7960 (17548)
4 Section Boom Assy, 2/4 Sheaves, Lift Cyl Upr Pin & Pivot Pin	486.41 (191.50)	6706 (14783)	8561 (18873)	-1855 (-4090)
Lift Cylinder & Lower Shaft	327.91 (129.10)	662 (1460)	570 (1257)	92 (203)
Complete Basic Machine: 10.6 - 34.8 m (35 - 114 ft) 4-Section Boom, Cummins QSB6.7L Tier 4 Engine, 23.5x25 (24 ply) Tires, Main Hoist w/180 m (590 ft) of 16 mm (5/8 in) 35x7 cable, Full Fuel and Hydraulic Oil	162.18 (63.85)	32758 (72218)	13943 (30739)	18815 (41479)
Add to Basic Unit Weight				
7.9 - 13.7 m (26 - 45 ft) Tele Boom Extension	684.78 (269.60)	831 (1832)	1494 (3293)	-663 (-1461)
Boom Extension Carrier Brackets (Bolt On)	590.55 (232.50)	101 (223)	157 (346)	-56 (-123)
Aux Boom Nose - installed	1066.80 (420.00)	45 (100)	127 (280)	-82 (-180)
6 t (6.6 ton) Overhaul Weight - tied to O/R Box	612.14 (241.00)	105 (231)	168 (371)	-64 (-140)
51 t (56 ton) Hookblock (5 sheave) - stowed in tray	393.70 (155.00)	425 (937)	439 (968)	-14 (-31)
32 t (35 ton) Hookblock (4 sheave) - stowed in tray	393.70 (155.00)	388 (855)	401 (884)	-13 (-29)
17 t (18.7 ton) Hookblock (1 sheave) - stowed in tray	393.70 (155.00)	261 (575)	269 (594)	-9 (-19)
Rubber Mat in Front Stowage Tray	393.70 (155.00)	25 (56)	26 (58)	-1 (-2)
Driver Controlled Differential Locks	182.88 (72.00)	52 (114)	25 (55)	27 (59)
Driveline Brake Retarder	233.68 (92.00)	402 (886)	246 (543)	156 (343)
Air Conditioning - Carrier	50.80 (20.00)	9 (19)	1 (3)	7 (16)
Air Conditioning - Superstructure	33.02 (13.00)	32 (71)	3 (6)	29 (65)
360 Degree Swing Lock	190.50 (75.00)	33 (73)	17 (37)	17 (37)
270 Degree Camera System on Superstructure	22.86 (9.00)	32 (71)	2 (4)	30 (67)

Description	CG to CL Rear Bogie cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
Driver	203.20 (80.00)	113 (250)	60 (133)	53 (117)
Cold Weather Package - Carrier (-29°)	45.72 (18.00)	63 (138)	8 (17)	55 (121)
Cold Weather Package - Carrier (-40°)	101.60 (40.00)	119 (263)	32 (70)	88 (193)
Cold Weather Package - S/S (-29° or -40°)	114.30 (45.00)	37 (81)	11 (24)	26 (57)
CE Components - Carrier	149.86 (59.00)	34 (76)	14 (30)	21 (46)
CE Components - Superstructure	55.88 (22.00)	85 (188)	13 (28)	73 (160)
Substitutions and Removals				
SUB: Aux Hoist (replace IPO cwt with aux hoist + cable)	-60.96 (-24.00)	24 (54)	-4 (-9)	29 (63)
SUB: Tier 3 Engine	-93.98 (-37.00)	-124 (-273)	30 (67)	-154 (-340)
SUB: 18.00 x 25 (28PR) Tires	190.50 (75.00)	345 (760)	172 (380)	172 (380)
SUB: Synthetic Rope on Main Hoist (185 m (606 ft) of 18 mm (11/16 in) K-100)	-96.77 (-38.10)	-198 (-437)	50 (111)	-249 (-548)
SUB: Synthetic Rope on Aux Hoist (185 m (606 ft) of 18 mm (11/16 in) K-100)	-162.81 (-64.10)	-198 (-437)	85 (187)	-283 (-624)
REM: Main Hoist cable (180 m (590 ft) of 16 mm (5/8 in) 35x7)	-96.77 (-38.10)	-241 (-531)	61 (135)	-302 (-666)
REM: Aux Hoist cable (180 m (590 ft) of 16 mm (5/8 in) 35x7)	-162.81 (-64.10)	-241 (-531)	103 (227)	-344 (-758)

Table 1-2
GRT655L Axle Weight Distribution Table

Description	CG To CL Rear Bogie cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
Tire & Wheel Allowable - 23.5x25(24PR)			19595 (43200)	19595 (43200)
Tire & Wheel Allowable - 18.00x25(28PR)			19255 (42450)	19255 (42450)
Axle Allowable			19051 (42000)	21319 (47000)
Basic Unit				
Standard Carrier Assy (4x4) + All Fluids	167.08 (65.78)	14712 (32435)	6452 (14224)	8260 (18211)
Superstructure Assy w/Cab, Main Hoist + cable & IPO Cwt	55.37 (21.80)	5098 (11240)	741 (1634)	4357 (9606)
Bolt on Counterweight	-162.56 (-64.00)	5579 (12300)	-2380 (-5248)	7960 (17548)
5 Section Boom Assy, 2/4 Sheaves, Lift Cyl Upr Pin & Pivot Pin	504.19 (198.50)	7419 (16355)	9817 (21643)	-2399 (-5288)
Lift Cylinder & Lower Shaft	327.91 (129.10)	662 (1460)	570 (1257)	92 (203)
Complete Basic Machine: 10.8 - 43.0 m (35 - 141 ft) 5-Section Boom, Cummins QSB6.7L Tier 4 Engine, 23.5x25 (24 ply) Tires, Main Hoist w/180 m (590 ft) of 16 mm (5/8 in) 35x7 cable, Full Fuel and Hydraulic Oil	173.02 (68.12)	33471 (73790)	15200 (33509)	18271 (40281)
Add To Basic Machine Weight				
7.9 - 13.7 m (26 - 45 ft) Tele Boom Extension	697.31 (274.53)	831 (1832)	1521 (3353)	-690 (-1521)
Boom Extension Carrier Brackets (Bolt On)	603.25 (237.50)	101 (223)	160 (353)	-59 (-130)
Aux Boom Nose - installed	1079.25 (424.90)	45 (100)	128 (283)	-83 (-183)
6 t (6.6 ton) Overhaul Weight - tied to O/R Box	612.14 (241.00)	105 (231)	168 (371)	-64 (-140)
51 t (56 ton) Hookblock (5 sheave) - stowed in tray	393.70 (155.00)	425 (937)	439 (968)	-14 (-31)
32 t (35 ton) Hookblock (4 sheave) - stowed in tray	393.70 (155.00)	388 (855)	401 (884)	-13 (-29)
17 t (18.7 ton) Hookblock (1 sheave) - stowed in tray	393.70 (155.00)	261 (575)	269 (594)	-9 (-19)
Rubber Mat in Front Stowage Tray	393.70 (155.00)	25 (56)	26 (58)	-1 (-2)
Driver Controlled Differential Locks	182.88 (72.00)	52 (114)	25 (55)	27 (59)
Driveline Brake Retarder	233.68 (92.00)	402 (886)	246 (543)	156 (343)
Air Conditioning - Carrier	50.80 (20.00)	9 (19)	1 (3)	7 (16)
Air Conditioning - Superstructure	33.02 (13.00)	32 (71)	3 (6)	29 (65)
360 Degree Swing Lock	190.50 (75.00)	33 (73)	17 (37)	17 (37)
270 Degree Camera System on Superstructure	22.86 (9.00)	32 (71)	2 (4)	30 (67)

Description	CG To CL Rear Bogie cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
Driver	203.20 (80.00)	113 (250)	60 (133)	53 (117)
Cold Weather Package - Carrier (-29°)	45.72 (18.00)	63 (138)	8 (17)	55 (121)
Cold Weather Package - Carrier (-40°)	101.60 (40.00)	119 (263)	32 (70)	88 (193)
Cold Weather Package - S/S (-29° or -40°)	114.30 (45.00)	37 (81)	11 (24)	26 (57)
CE Components - Carrier	149.86 (59.00)	34 (76)	14 (30)	21 (46)
CE Components - Superstructure	55.88 (22.00)	85 (188)	13 (28)	73 (160)
Substitutions and Removals				
SUB: Aux Hoist (replace IPO cwt with aux hoist + cable)	-60.96 (-24.00)	24 (54)	-4 (-9)	29 (63)
SUB: Tier 3 Engine	-93.98 (-37.00)	-124 (-273)	30 (67)	-154 (-340)
SUB: 18.00 x 25 (28PR) Tires	190.50 (75.00)	345 (760)	172 (380)	172 (380)
SUB: Synthetic Rope on Main Hoist (185 m (606 ft) of 18 mm (11/16 in) K-100)	-96.77 (-38.10)	-198 (-437)	50 (111)	-249 (-548)
SUB: Synthetic Rope on Aux Hoist (185 m (606 ft) of 18 mm (11/16 in) K-100)	-162.81 (-64.10)	-198 (-437)	85 (187)	-283 (-624)
REM: Main Hoist cable (180 m (590 ft) of 16 mm (5/8 in) 35x7)	-96.77 (-38.10)	-241 (-531)	61 (135)	-302 (-666)
REM: Aux Hoist cable (180 m (590 ft) of 16 mm (5/8 in) 35x7)	-162.81 (-64.10)	-241 (-531)	103 (227)	-344 (-758)

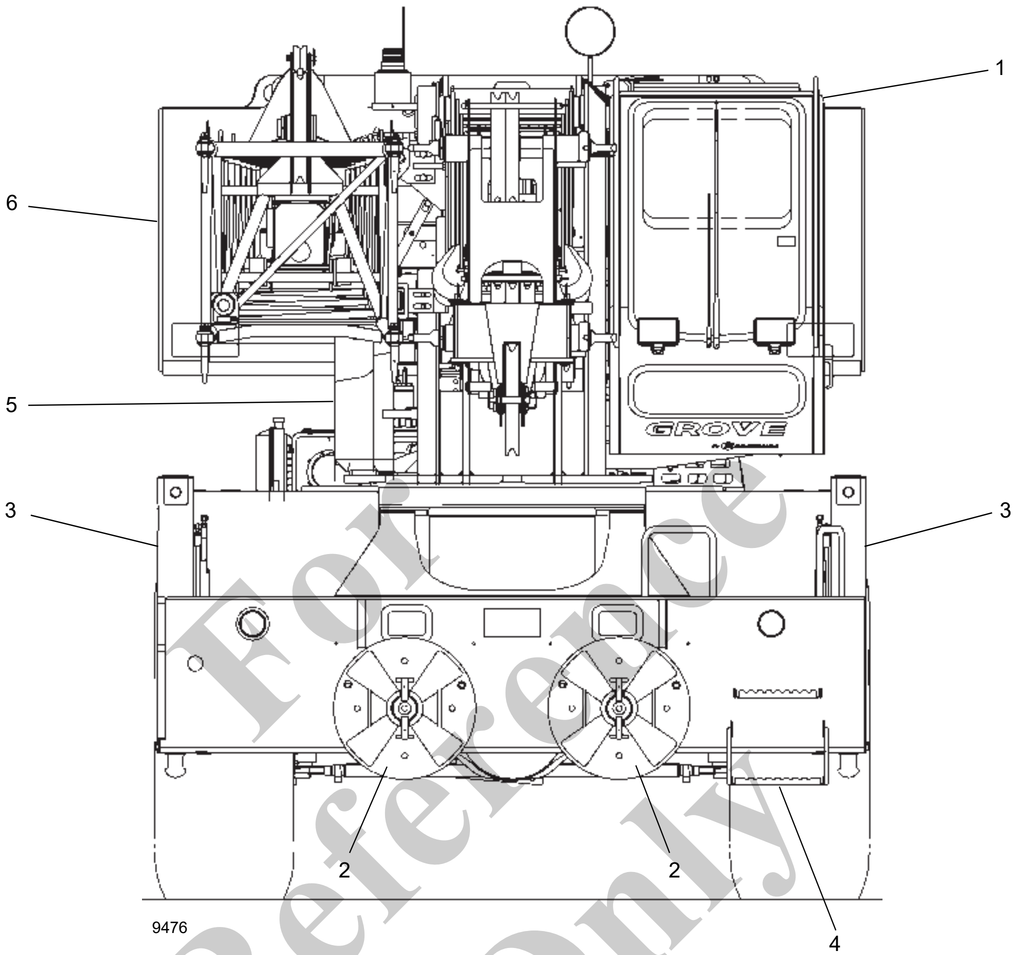

FIGURE 1-3

1	Cab	4	Steps
2	Outrigger Float	5	Valve Cover
3	Outrigger Jack Cylinder	6	Counterweight

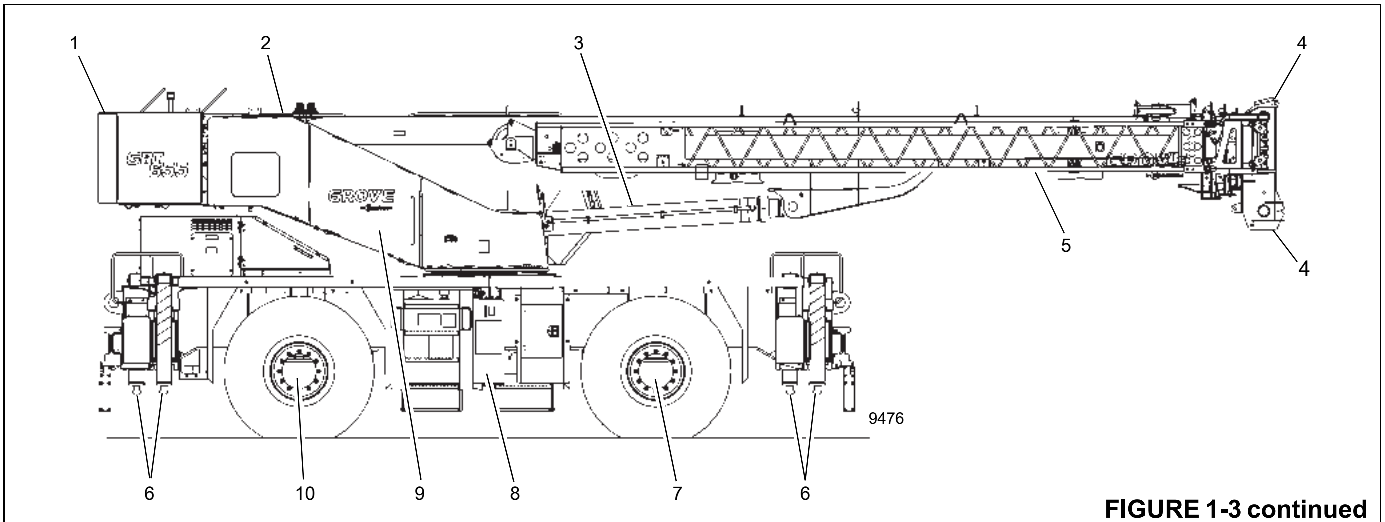

FIGURE 1-3 continued

1	Counterweight	6	Outrigger Jack Cylinder
2	Boom Pivot	7	Front Axle
3	Lift Cylinder	8	Hydraulic Tank
4	Boom Nose Sheaves	9	Valve Cover
5	Boom Extension	10	Rear Axle

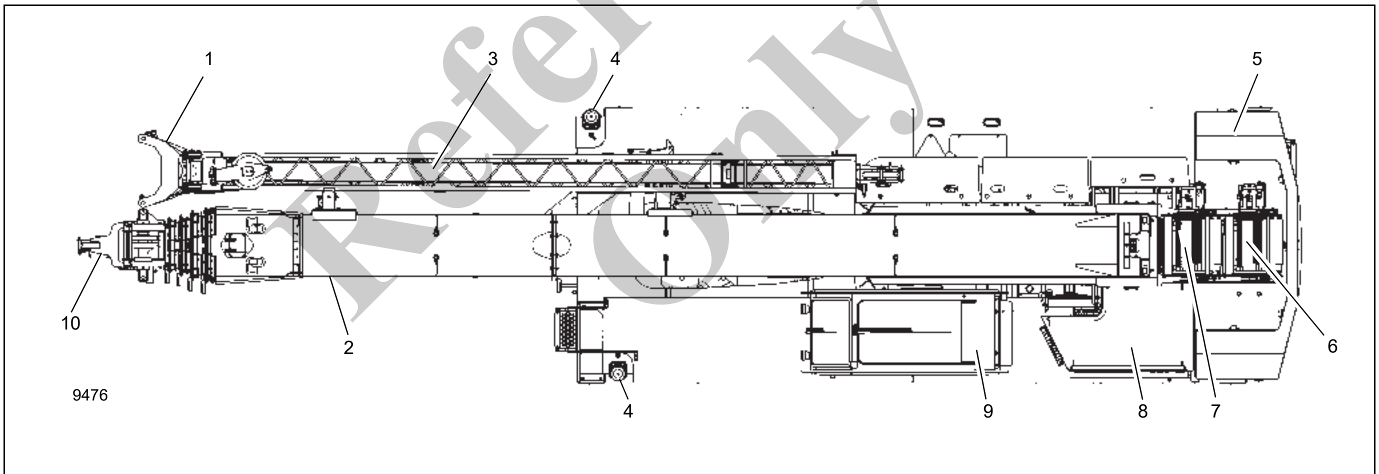

FIGURE 1-3 continued

1	Boom Extension	6	Auxiliary Hoist
2	Boom	7	Main Hoist
3	Stinger	8	Hoist Access Platform
4	Outrigger Jack	9	Cab
5	Counterweight	10	Auxiliary Boom Nose

GENERAL MAINTENANCE

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

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.

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.

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 disconnect. 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 pressure and keep air stream away 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 portion of a crane or a complete crane, ensure the crane is blocked securely and the weight is supported by blocks 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. All supporting members (chains and cables) should be parallel to each other and as near perpendicular as possible to the top of the object being lifted.

CAUTION

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 assembling or disassembling a component or system, complete each step in turn. Do not partially assemble one part and start assembling some other part. 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 the job.

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.

Locks

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, 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 1-4):

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

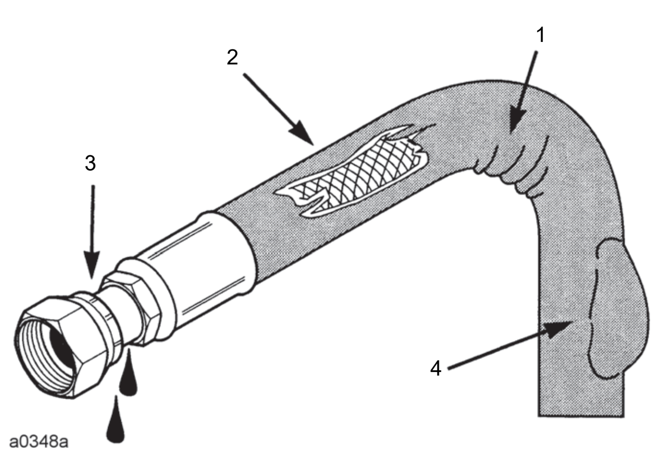

FIGURE 1-4

Installation

1. When installing a new hose, loosely connect each end and make sure the hose takes up the designed position before tightening the connection. Clamps should be tightened sufficiently to hold the hose without crushing and to 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 anti friction 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 burned. 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 anti friction bearing will be shortened if not properly lubricated. Dirt in an anti friction 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 121°C (250°F). 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 of preload to 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 on a bearing, 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 lubricant 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

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.

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 the machine or another hose and has a minimum of bending and twisting. Tighten bolts in both couplings.

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

Visual Inspection of Hoses and Fittings

CAUTION

Ensure that the hydraulic hose is depressurized before loosening the connections.

1. Visually inspect hoses and fittings once a month or every 250 hours for the following:
    - a. Leaks at hose fitting or in hose
    - b. Damaged, cut, or abraded cover
    - c. Exposed reinforcement
    - d. Kinked, crushed, flattened, or twisted hose
    - e. Hard, stiff, heat cracked, or charred hose
    - f. Blistered, soft, degraded, or loose cover
    - g. Cracked, damaged, or badly corroded fittings
    - h. Fitting slippage on hose
    - i. 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:
    - a. Leaking Ports
    - b. Leaking valve sections or manifolds and valves installed into cylinders or onto motors.
    - c. Damaged or missing hose clamps, guard, or shields.
    - d. 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.
4. Hydraulic hose assemblies operating in a temperature climate zone “C” (Table 1-3) are recommended to be replaced after 8000 hours of service life.

Table 1-3: Climate Zones

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

5. Hydraulic hose assemblies operating in climate zones “A” and “B” (Table 1-3) 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” (Table 1-3) cold climates should expect a degrade of mechanical properties such as elasticity, therefore, it is recommended these hoses be inspected and addressed accordingly.

Hydraulic Fittings

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

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

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

Follow these steps when tightening all fitting connections:

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

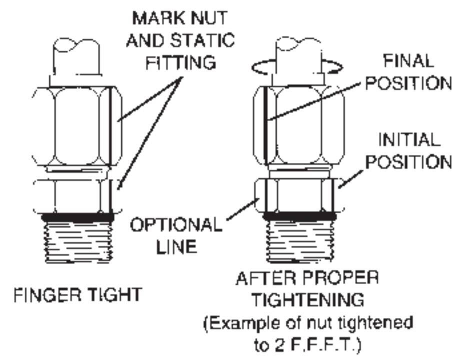

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FIGURE 1-5

5. Tighten the joint by the number of flats as specified in Table 1-4 and 1-5 for size and type of fitting.
6. Optionally for future tightening of the same connection: extend the line from the nut at its new location onto the hex of the static fitting or port (Figure 1-5).

37° Flared Steel Fitting: Tube or Hose to Fitting

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

Table 1-4: Tube and Swivel Nut/Hose Fittings

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

T-2-5

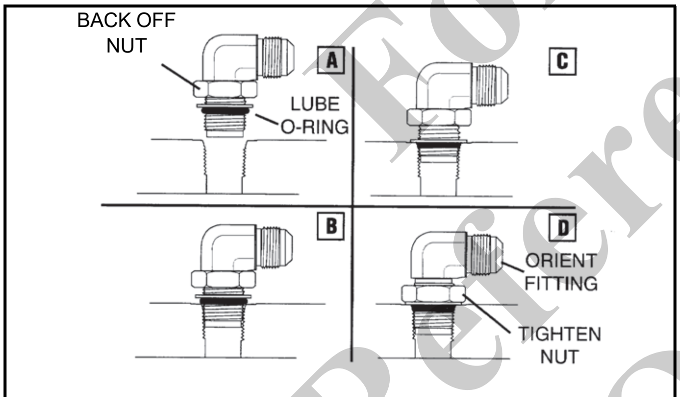
Adjustable Straight Thread O-ring Fittings

Refer to Figure 1-6 and Table 1-5 for the following procedure.

Table 1-5: Adjustable Straight Thread O-ring Fittings

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

T-2-6



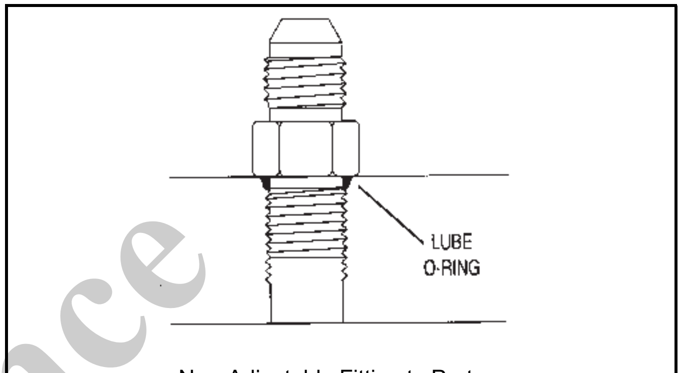
Adjustable Fitting to Port **FIGURE 1-6**

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

Nonadjustable Straight Thread O-ring Fitting: Fitting to Port

Refer to Table 1-6 for the following procedure.

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Lubricate O-ring with clean oil (Figure 1-7).



Non-Adjustable Fitting to Port **FIGURE 1-7**

3. Turn fitting until finger tight.
4. Using the assembly torque method, tighten to given torque for size from Table 1-6.

Table 1-6: Straight Thread Fittings

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

T-2-7

Electrical System

Connectors, 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 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 1-3). 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 10,000 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 be commensurate with the age of the equipment, the severity of the application, and the experience of the operators and maintenance personnel.The following are known high stress areas applicable to Manitowoc/Grove machines, and a visual inspection of these areas should be made part of an owner's planned preventive maintenance program:

1. Power Telescope Boom - wear pad retaining structures, hydraulic cylinder attaching points, boom pivot shaft retaining structures.
2. Outrigger pads, beams, boxes and attachment structures.
3. Main frames - generally in the area of doubler plates and crossmembers; at the junction of front and rear frame members on truck cranes.
4. Turntable bearing connection.
5. Counterweight support structures.
6. Chassis axle and suspension mounting structures.
7. 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 them by contacting the local Manitowoc/Grove distributor.

Loctite® Thread Locking Compound

DANGER

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/Grove distributor.

Application of Medium Strength Loctite

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

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

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

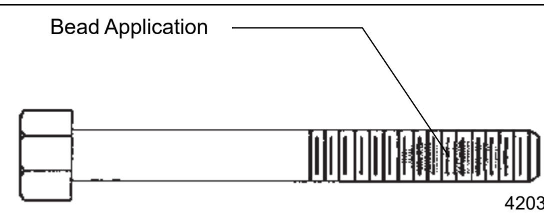


FIGURE 1-8

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (Figure 1-8).
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 (N-m), multiply the pounds-foot quantity by 1.3558.

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

Torque Values

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

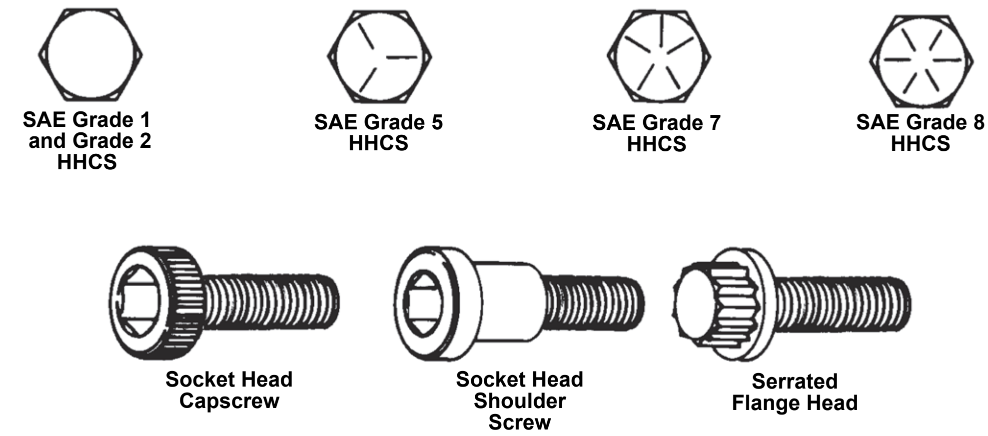


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FIGURE 1-9

Table 1-7: UNC (Coarse) Thread: Torque Values for Zinc-Flake Coated and Untreated Fasteners

Bolt Diameter - Inches

Torque Values (Pounds-Foot, Maximum/Minimum)

	SAE Grade	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2
Zinc-Flake	**5**	7	14	25	40	61	88	121	213	342	512	636	884	1532
	8	10	20	36	57	86	124	171	301	483	723	1032	1433	2488
Untreated	**5**	9.0	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 1-8: UNF (Fine) Thread: Torque Values for Zinc-Flake Coated and Untreated Fasteners

Bolt Diameter - Inches

Torque Values (Pounds-Foot, Maximum/Minimum)

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

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

Table 1-9: Metric Fasteners, Coarse Thread, Zinc-Flake Coating

Bolt Diameter - Metric

Torque Values (N-m)

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

Table 1-10: Metric Fasteners, Coarse Thread, Untreated

Bolt Diameter - Metric

Torque Values (N-m, Maximum/Minimum)

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

Table 1-11: Metric Fasteners, Fine Thread, Zinc-Flake Coating

Bolt Diameter - Metric

Torque Values (N-m)

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

Table 1-12: Metric Fasteners, Fine Thread, Untreated

Bolt Diameter - Metric

Torque Values (N-m, Maximum/Minimum)

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

Table 1-13: UNC (Coarse) Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

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

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

Table 1-14: Metric Coarse Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

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

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

Weld Studs

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

Table 1-15: Weld Stud Torque Values

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

T-2-4

WIRE ROPE

General

The following information is a compendium of information from various wire rope manufacturers and includes inspection, replacement, and maintenance guidelines for wire rope as established by ANSI/ASME B30.5, federal regulations, and 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:

1. It should be free from acids and alkalis.
2. It should have sufficient adhesive strength to remain on the ropes.
3. It should be of a viscosity capable of penetrating the interstices between wires and strands.
4. It should not be soluble in the medium surrounding it under the actual operating conditions (i.e. water).
5. It should have a high film strength.
6. 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 1-10).

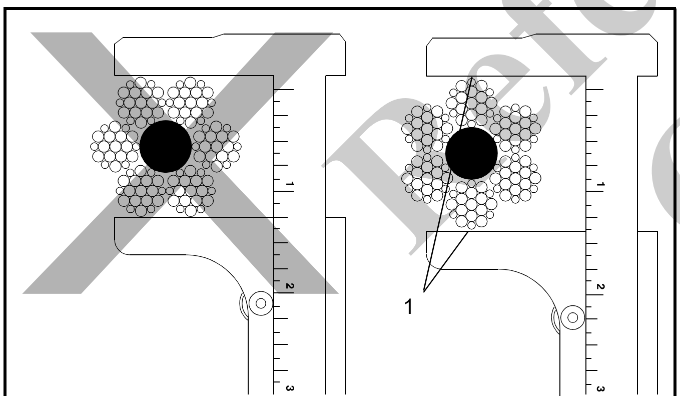


FIGURE 1-10

13. When checking for broken wires (5) (Figure 1-11) 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 spoke of in relations to "Lay Length" (2) which is the distance measured along rope in which one strand (3) makes one complete revolution around core (4).

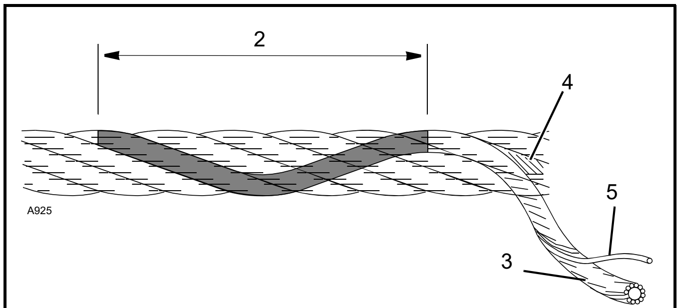


FIGURE 1-11

Wire Rope Inspection (Running Ropes and Pendant Cables)

Wire rope should be inspected frequently/dally 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:

1. Distortion, Kinking, Crushing, Un-stranding, Bird caging, Reduction of diameter, etc.
2. General corrosion.
3. Broken or cut strands.
4. Number, distribution and type of broken wires.
5. Evidence of core failure.
6. End fitting wear/abrasion.

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

1. Pick-up Points: Sections of wire rope that are repeatedly stressed during each lift, such as those sections in contact with sheaves.
2. 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.
3. 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:

1. Inspect for reduction of rope diameter below nominal diameter.
2. Inspect for severely corroded or broken wires at end connections.
3. Inspect for severely corroded, cracked, bent, worn, or improperly applied end connections.
4. 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.
5. 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 weekly inspection of all boom extension and retraction cables be performed using the following guidelines. The inspection shall cover all visible areas of the extension and retraction cables of an assembled boom. Note that extending and/or retracting the boom may be required to access visual inspection holes.

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

1. Inspect for reduction of rope diameter below nominal diameter.
2. Inspect for severely corroded or broken wires at end connections.
3. Inspect for severely corroded, cracked, bent, worn, or improperly applied end connections.
4. 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.
5. Inspect for damaged or wobbly boom extension and retraction sheaves that may cause rapid deterioration of the wire rope.
6. Inspect for unusual cable sag/stretch and be sure cables used in sets all have an equal tension applied. Repeated need for adjustment of an individual cable is evidence of cable stretch and indicates the need for additional and more thorough inspection in order to determine and correct the cause.

Wire Rope Inspection/Replacement (All Wire Rope)

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

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

- Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than 5%.
- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
- In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.
- In rotation resistant rope, two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
- Severe corrosion as evidenced by pitting.
- 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 1-12), 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.

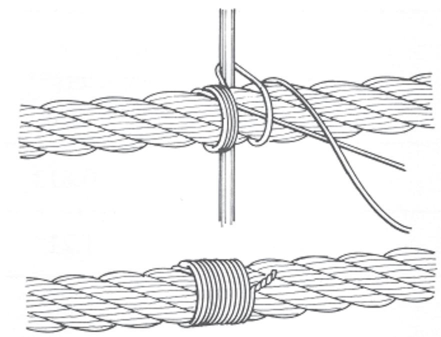


FIGURE 1-12

Method 2

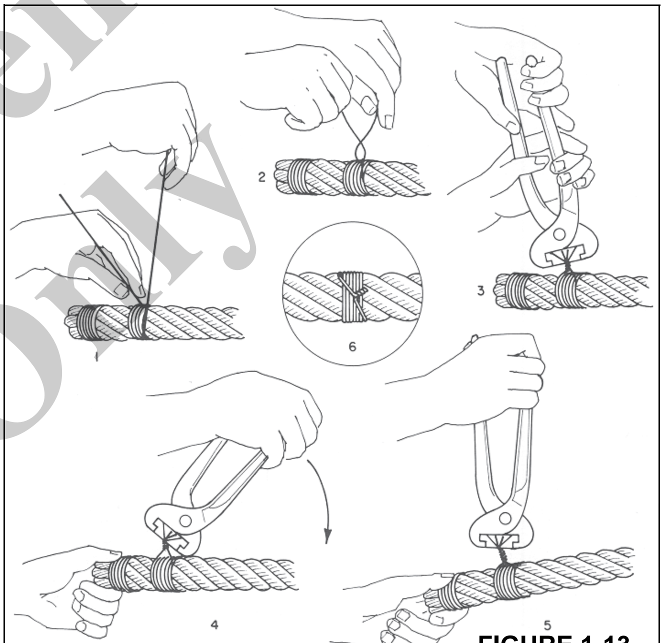


FIGURE 1-13

Wind a length of soft annealed wire (Figure 1-13) 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 1-14) should have three seizings (3) located on each side of the cut (4) as compared to performed wire rope (2).

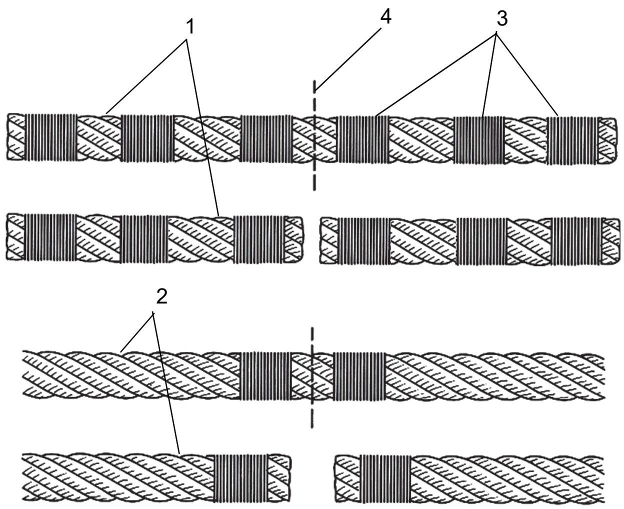


FIGURE 1-14

Installing 35x7 Class Wire Rope

CAUTION

Any cutting of this specific wire rope is not recommended. If 35x7 class wire rope must be cut for any reason, it is necessary to follow the attached instructions. Also, unlike other types of wire rope, the ends on this wire rope must be welded to retain the rotation resistant characteristics.

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. Attach rope's end to drum. Pull the rope over the point sheave and attach the end to the 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 in 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 your new 35x7 class rope: After installation, you should properly break in your rope, which allows the rope's component parts to adjust themselves to your 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. Stand back and watch 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 35x7 Class Wire Rope

35x7 class wire rope is a special wire rope that must be handled differently than any other rope we manufacture. 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 35x7 class rope 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 for shipment of the rope.

4. Attach a “Do not remove welded ends” tag on each reel flange.

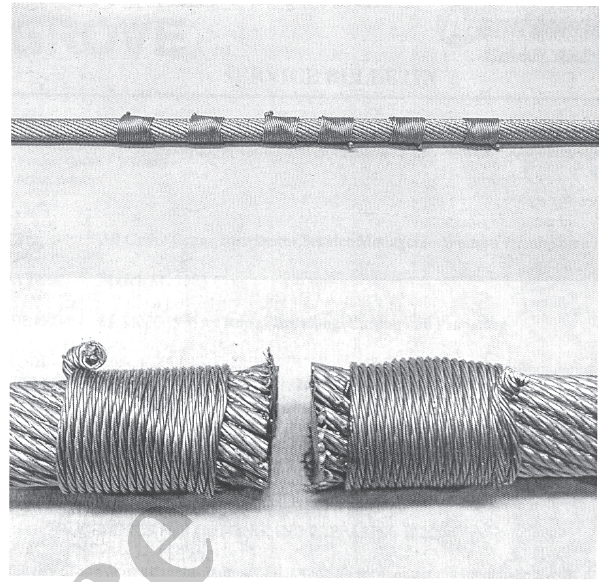


FIGURE 1-15

SECTION 2
HYDRAULIC SYSTEM

SECTION CONTENTS

DESCRIPTION

This section describes the hydraulic system, the components which make up the hydraulic system, and the components dependent upon the hydraulic system for their operation. This includes descriptions of the supply pressure and return hydraulic circuit, hydraulic pumps, all hydraulic valves, and all hydraulic cylinders. Detailed descriptions and operation of individual hydraulic circuits are discussed within their individual sections as applicable. A complete hydraulic system schematic showing all options is at the back of this manual and a figure titled A.N.S.I. Graphical Symbols provides hydraulic symbol information for this section (Figure 2-1 and Figure 2-2).

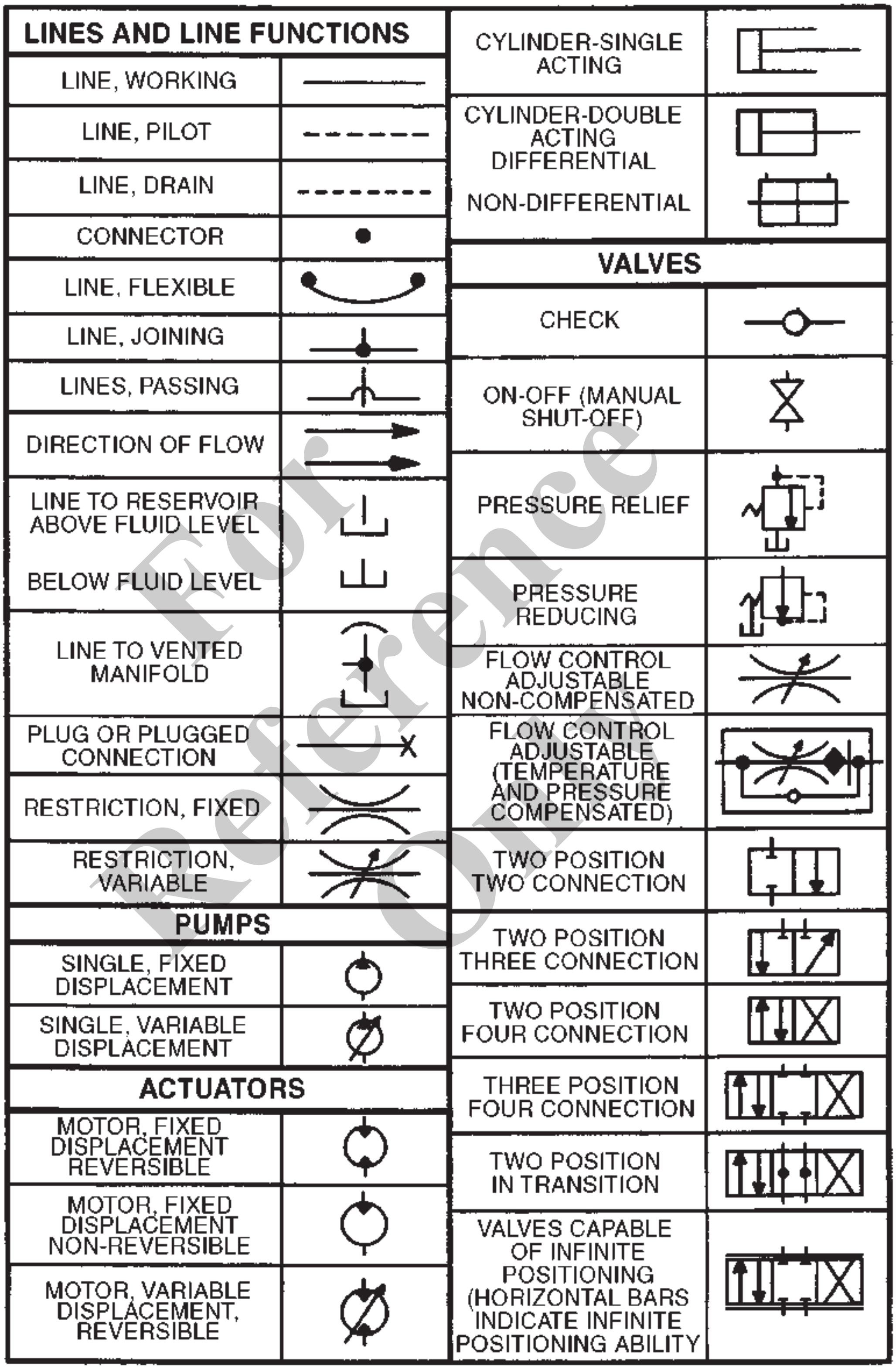

LINES AND LINE FUNCTIONS
LINE, WORKING
LINE, PILOT
LINE, DRAIN
CONNECTOR
LINE, FLEXIBLE
LINE, JOINING
LINES, PASSING
DIRECTION OF FLOW
LINE TO RESERVOIR ABOVE FLUID LEVEL
BELOW FLUID LEVEL
LINE TO VENTED MANIFOLD
PLUG OR PLUGGED CONNECTION
RESTRICTION, FIXED
RESTRICTION, VARIABLE
PUMPS
SINGLE, FIXED DISPLACEMENT
SINGLE, VARIABLE DISPLACEMENT
ACTUATORS
MOTOR, FIXED DISPLACEMENT REVERSIBLE
MOTOR, FIXED DISPLACEMENT NON-REVERSIBLE
MOTOR, VARIABLE DISPLACEMENT, REVERSIBLE
CYLINDER-SINGLE ACTING
CYLINDER-DOUBLE ACTING DIFFERENTIAL
NON-DIFFERENTIAL
VALVES
CHECK
ON-OFF (MANUAL SHUT-OFF)
PRESSURE RELIEF
PRESSURE REDUCING
FLOW CONTROL ADJUSTABLE NON-COMPENSATED
FLOW CONTROL ADJUSTABLE (TEMPERATURE AND PRESSURE COMPENSATED)
TWO POSITION TWO CONNECTION
TWO POSITION THREE CONNECTION
TWO POSITION FOUR CONNECTION
THREE POSITION FOUR CONNECTION
TWO POSITION IN TRANSITION
VALVES CAPABLE OF INFINITE POSITIONING (HORIZONTAL BARS INDICATE INFINITE POSITIONING ABILITY
1951-1

FIGURE 2-1

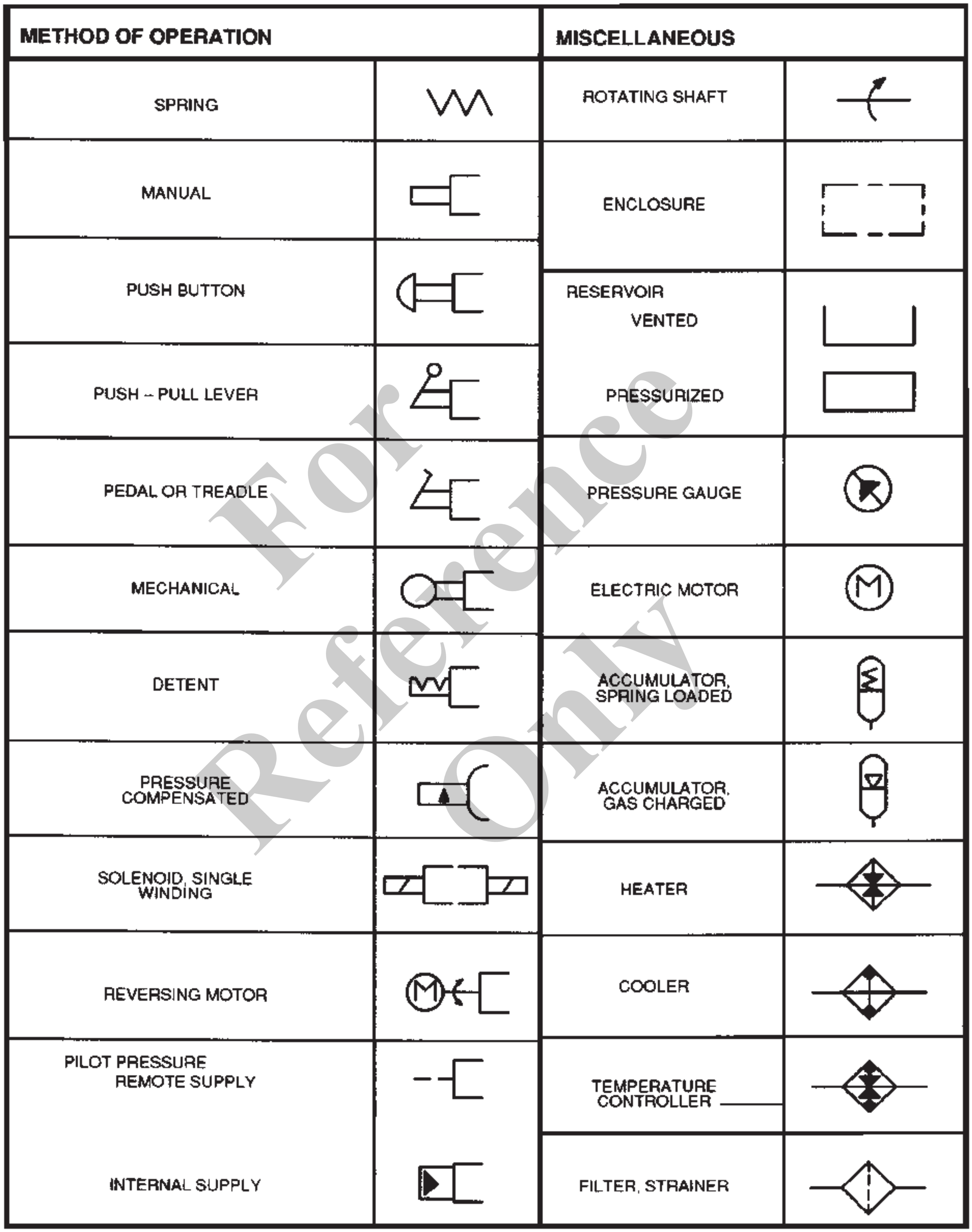

METHOD OF OPERATION
SPRING
MANUAL
PUSH BUTTON
PUSH – PULL LEVER
PEDAL OR TREADLE
MECHANICAL
DETENT
PRESSURE COMPENSATED
SOLENOID, SINGLE WINDING
REVERSING MOTOR
PILOT PRESSURE
REMOTE SUPPLY
INTERNAL SUPPLY
MISCELLANEOUS
ROTATING SHAFT
ENCLOSURE
RESERVOIR
VENTED
PRESSURIZED
PRESSURE GAUGE
ELECTRIC MOTOR
ACCUMULATOR, SPRING LOADED
ACCUMULATOR, GAS CHARGED
HEATER
COOLER
TEMPERATURE CONTROLLER
FILTER, STRAINER

FIGURE 2-2

MAINTENANCE

Hydraulic Oil Recommendations.

For the hydraulic oil specifications, refer to Section 9 - LUBRICATION.

Hydraulic Oil Sampling Test

The hydraulic oil sampling is used to establish the cleanliness and condition of the hydraulic fluid. The recommended maintenance interval is every 6 months or 1,000 hours, whichever comes first.

Steps to follow to provide oil sample test:

1. Order the Oil Sampling Test Kit - p/n 90044404 from Manitowoc Crane Care.
2. Start and run engine to allow crane operating temperature to normalize to ambient conditions while cycling all actuators and motors with at least 30 minutes of operation. The temperature should not exceed 82°C (180°F).
3. Shutdown the engine before taking sample.
4. Take a 3 ounce oil sample from the upper level of the hydraulic reservoir while the crane is at normal operating temperature and place in the sampling container.
5. Complete the form documenting the crane information, date and crane hours.
6. Return the sample to the independent testing laboratory as directed in kit.

Draining and Flushing

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

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

CAUTION

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

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

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

CAUTION

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

10. Disconnect the return lines from a pair of outrigger jack cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger jack cylinders to the stowed position. Replenish the reservoir hydraulic oil level as necessary.
12. Repeat Steps 10 and 11 for the remaining two outrigger cylinders.
13. Disconnect the return line from the telescope cylinder and fully extend the boom.
14. Connect the return line and retract the boom. Replenish the reservoir hydraulic oil level as necessary.
15. Disconnect the return lines from both front steer cylinders and turn the front wheels to the extreme right.
16. Connect the return lines and turn the front wheels to the extreme left and then back to center. Replenish the reservoir hydraulic oil level as necessary.
17. Repeat Steps 15 and 16 for the rear steering cylinders.
18. Raise the crane on outriggers.
19. Disconnect the line from port A of the axle lockout valve.
20. Using a jack under the rear wheel on one side of the crane, jack up the wheel to maximum travel.

21. Connect the line to port A of the axle lockout valve and disconnect the line from Port B.
22. Repeat step 19 using the other rear wheel.
23. Connect the line to port B of the axle lockout valve. Energize the axle lockout valve. Replenish the reservoir hydraulic oil level as necessary.
24. Disconnect the return line from the main hoist motor and fully hoist up the hoist.
25. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the reservoir hydraulic oil level as necessary.
26. Repeat Steps 24 and 25 for the auxiliary hoist as necessary.
27. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
28. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

CAUTION

When hydraulic oils are changed or added, ensure that hydraulic oils of different manufacturers are of the same specifications. Discoloration may occur.

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

Removing Air from the Hydraulic System

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

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

Seal all normal openings in the hydraulic system and the reservoir. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to 13.8 to 27.6 kPa (2 to 4 psi) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the reservoir after completing any repairs or service. Operate all hydraulic circuits several times in both directions.

This action should return any entrapped air to the reservoir where it can be removed from the hydraulic oil by the baffles.

DANGER

Tipping Hazard

To avoid death or serious injury, locate the machine on a firm supporting surface and position the boom over the front on outriggers when extending the boom at low angles.

To remove entrapped air from telescope cylinders, lower the boom to below horizontal and fully telescope the boom in and out several times.

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

DANGER

Pressurized fluid can cause serious injury or death. Extreme care must be used when removing any plugs or restrictions from a hydraulic system suspected to have entrapped air that may be pressurized.

Entrapped air may be removed from cylinders having wet rods by cycling. On certain cylinders, a plugged port is provided on the rod end to bleed off entrapped air.

DANGER

Pressurized fluid can cause serious injury or death. Do not attempt to loosen fittings in pressurized lines or while the hydraulic pumps are in operation.

In the event that air entrapment should persist, bleeding of air by loosening various clamp and screw type fittings may become necessary.

If the above procedures fail to eliminate air entrapment, contact your authorized Grove Distributor.

Parts Replacement

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

Directional Control Valves

The control valves that control the crane functions are installed on the right side on the outside of the superstructure side plate.

Inspection

Inspect the control valves for visible damage, binding spools, and evidence of leakage. If excessive internal leakage is suspected during operation with a spool in its center position, it is possible that the area between the spool and working section bore of the valve body is worn beyond serviceable limits. If this condition exists, the spool and body must be replaced as an assembly.

Valve Leakage

Dripping hydraulic oil indicates some type of external leakage. The machine should be removed from service for immediate repairs. External leaks sometimes develop at fittings and seals. Seals may be damaged by temperatures that are too high, or by dirt or paint accumulation on the spool. Damaged or torn seals must be replaced.

A component functioning at reduced efficiency may indicate that the control valve for that component is leaking internally. If preliminary check-out reveals that adequate volume is being supplied to the affected valve bank, relief valves are properly adjusted, and the component is not at fault, check the valve for scored or worn parts. Scoring is a sign of the number one problem in hydraulics - contamination (external contamination by dust or internal contamination by debris from deteriorating components or oxidized hydraulic oil). Scored or severely worn valve components must be replaced.

Check valves in the control valves are designed to permit a flow of hydraulic oil in one direction only. If a piece of dirt or rust has worked its way into the check valve and lodges between the poppet and seat, it will keep the valve open and allow a return flow of hydraulic oil. The remedy is to clean the valve, but it is also a good idea to follow through and ensure the hydraulic system filter is still serviceable.

Binding Spools

Some of the most common causes for stiff spool movement or jammed spool action are system overheating, excessive pressure, contaminated or deteriorated hydraulic oil, or warped mountings. When scorched, deteriorated hydraulic oil or contamination is the cause, flushing the system and replenishing with clean hydraulic oil may solve the problem. If the spool bores are badly scored or galled, the valve must be removed for servicing.

Warping occurs when mounting plates are not level or they become distorted from machine damage. As mentioned previously, the valve can be shimmed level.

Also, check the valve for rust. Rust or dirt collecting on the valves can prevent free movement of the spool, and keep it from the true center position. Excessive system pressure can create both internal and external leaks in valves that are otherwise sound. Only qualified technicians using the correct equipment should make pressure adjustments when pressure adjustments are needed.

SUPPLY PRESSURE AND RETURN CIRCUIT

Description

The supply pressure and return circuit is made up of several circuits which route hydraulic oil from the hydraulic pumps to the directional control valves for the individual operating circuits. The supply pressure and return circuit consists of the reservoir and integral filter, two hydraulic pumps, a hydraulic oil cooler, and a 12-port hydraulic swivel. Refer to HYDRAULIC PUMPS in this section for descriptions and maintenance instructions for each hydraulic pump. Refer to Section 6 - SWING for description and maintenance instructions for the 12-port hydraulic swivel.

The supply pressure and return circuit uses Ports 5 and 6 for pump supply and the dual Port 4 for return. Each operating circuit's description and components begin with the circuit's directional control valve.

Hydraulic Reservoir and Filter

The reservoir (Figure 2-3), attached to the right side of the carrier frame, has a capacity of 524.3 L (138.5 gal) total, 469.8 L (124.1 gal) to the full mark. The all-steel reservoir has an internally mounted full-flow filter and integral baffles that help cool the hydraulic oil and prevent hydraulic oil foaming.

Hydraulic oil flows through three tubes at the rear of the reservoir to the three hydraulic pumps. All return flow goes through the filter at the top of the reservoir except for the pump and motor case drain oil and the excess oil from relief valves.

Two magnetic drain plugs in the bottom of the reservoir collect metal particles from the hydraulic oil if it becomes contaminated.

A sight gauge is located on the front of the reservoir to indicate hydraulic oil level.

A breather/fill cap located on the top of the reservoir allows air to enter or exhaust the reservoir. It consists of a breather, fill neck, gaskets and strainer. It is important that the breather be kept clean to prevent damage to the reservoir. The breather/fill cap also provides for filling the reservoir.

A large access cover on top of the reservoir provides for cleaning. The access cover can also be used to fill the reservoir after it has been completely drained.

Hydraulic oil temperature is monitored by the crane control through a thermistor installed in the rear of the reservoir.

The hydraulic oil filter (Figure 2-4) is located in the top of the reservoir. The filter housing contains a replaceable filter element. Returning hydraulic oil flows through the filter head, through the filter element and into the reservoir.

An element condition indicator on the filter head indicates when to change the filter element. When back pressure caused by a dirty filter element exceeds 172.3 kPa (25 psi), the filter head's bypass feature functions to allow the hydraulic oil to bypass the filter element and flow into the reservoir through the bypass outlet instead. A bypass filter screen prevents gross contamination from passing through the filter even during bypass. Refer to *Hydraulic Reservoir and Filter*, page 2-8 for filter changing instructions.

Hydraulic Reservoir Removal

Remove the capscrews, flatwashers, lockwashers and hex nuts securing the reservoir to the fame. Using a suitable lifting device, remove the reservoir.

NOTE: Hydraulic reservoir weighs approximately 205 kg (450 lb).

Hydraulic Reservoir Installation

Using a suitable lifting device, install the reservoir to the frame and secure with the capscrews, flatwashers, lockwashers and hex nuts. Torque the capscrews see *Fasteners and Torque Values*, page 1-19.

Hydraulic reservoir weighs approximately 205 kg (450 lb).

Filter Element Removal

DANGER

Ensure that all hydraulic systems are shut down and the pressure is relieved.

---

1. Shut down all hydraulic systems.
2. Wipe any dirt from the filter head and cap assembly.

NOTE: The bypass valve assembly is installed to the cap and is removed with the cap.

3. Remove the four bolts securing the cap assembly to the filter head. Remove the cap and bypass valve assembly.
4. Remove the filter element from the filter bowl (housing).
5. Ensure the new filter element is correct by comparing their part numbers with the part numbers of the used element.
6. Discard the element.

Filter Element Installation

1. Place a new element into the filter bowl (housing).
2. Install new O-ring in the cap assembly.
3. If by-pass valve was removed from cap, install by-pass capscrews to cap.
4. Install cap assembly on filter head and secure with the four bolts. Torque bolts 14.9 ±2.7 N-m (11 ±2 lb-ft) until

the gasket starts to bulge slightly. Do not over torque. Torque bolt in a criss-cross pattern.

5. Activate the hydraulic system and check for leaks. make repairs as necessary.

Pump Distribution

Pump No. 1 is mounted off a drive pad of the torque converter. Pump No. 2 is mounted to the rear of Pump No. 1. Pump No. 3 is mounted directly to the engine.

Pump No. 1

Pump No. 1 is a variable displacement axial piston pump with a maximum displacement of 112 cm^3/rev (6.83 in^3/rev) delivering a theoretical flow of 246 Lpm (65 gpm). The pump differential or standby pressure is 2.41 MPa (350 psi). Pump No. 1 supplies oil to the integrated outrigger/rear steer valve, boom lift, telescope, hoist, brakes and pilot functions.

Pump No. 2

Pump No. 2 is a single positive displacement gear pump with a displacement of 21 cm^3/rev (1.29 in^3/rev) delivering a theoretic flow of 86.7 Lpm (22.9 gpm). Pump No. 2 supplies oil to the two engine-transmission cooling package fan motors, each of which has a displacement of 6.6 cm^3/rev (0.4 in^3/rev).

Pump No. 3

Pump No. 3 is a single positive displacement gear pump with a displacement of 39 cm^3/rev (2.40 in^3/rev) delivering a theoretic flow of 84 Lpm (21.9 gpm). Pump No. 3 supplies oil to the front steer and swing circuits.

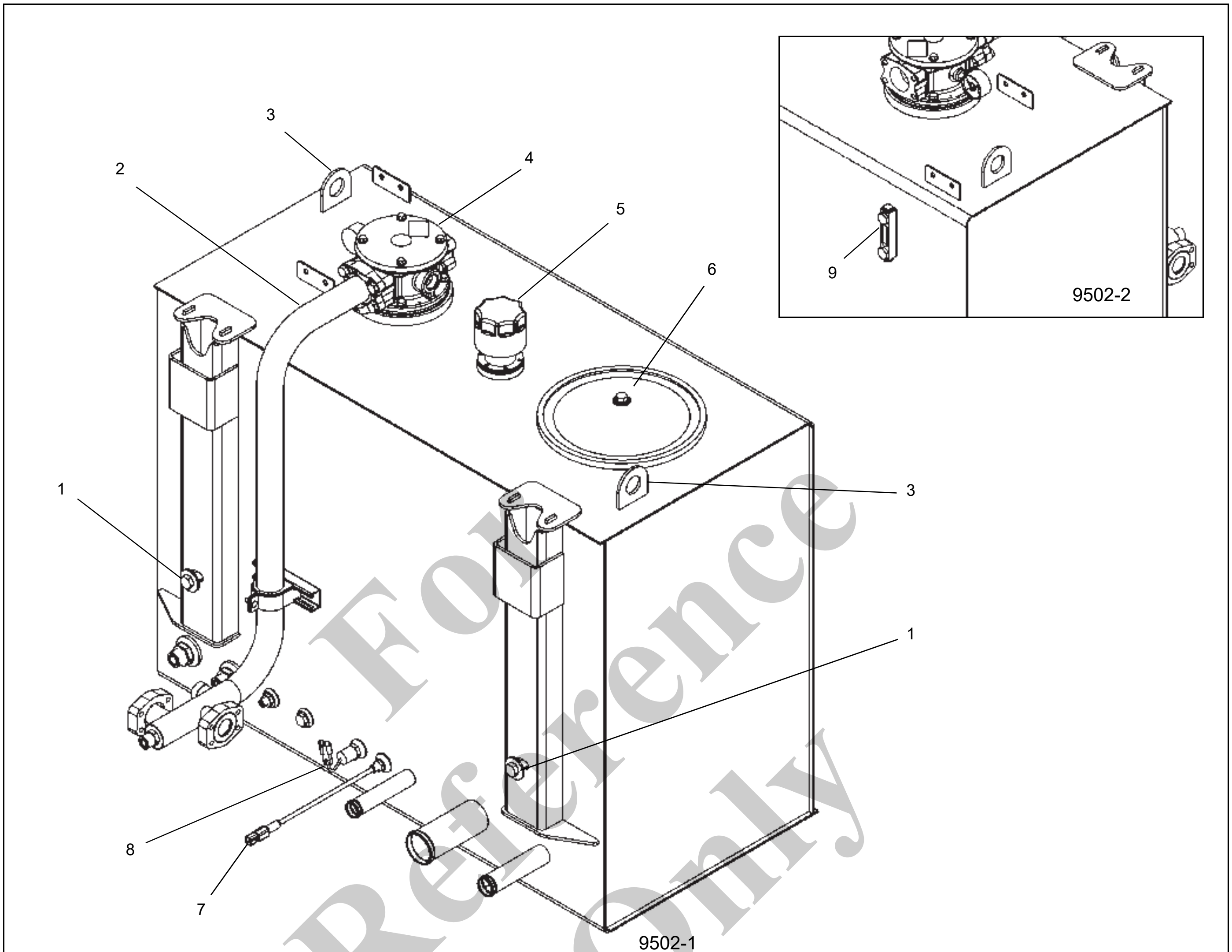


FIGURE 2-3

Item	Description
1	Reservoir Mounting Bolt
2	Return Manifold
3	Lifting Lug
4	Return Filter
5	Breather

Item	Description
6	Access Cover
7	Thermistor
8	Temperature Switch
9	Sight Gauge

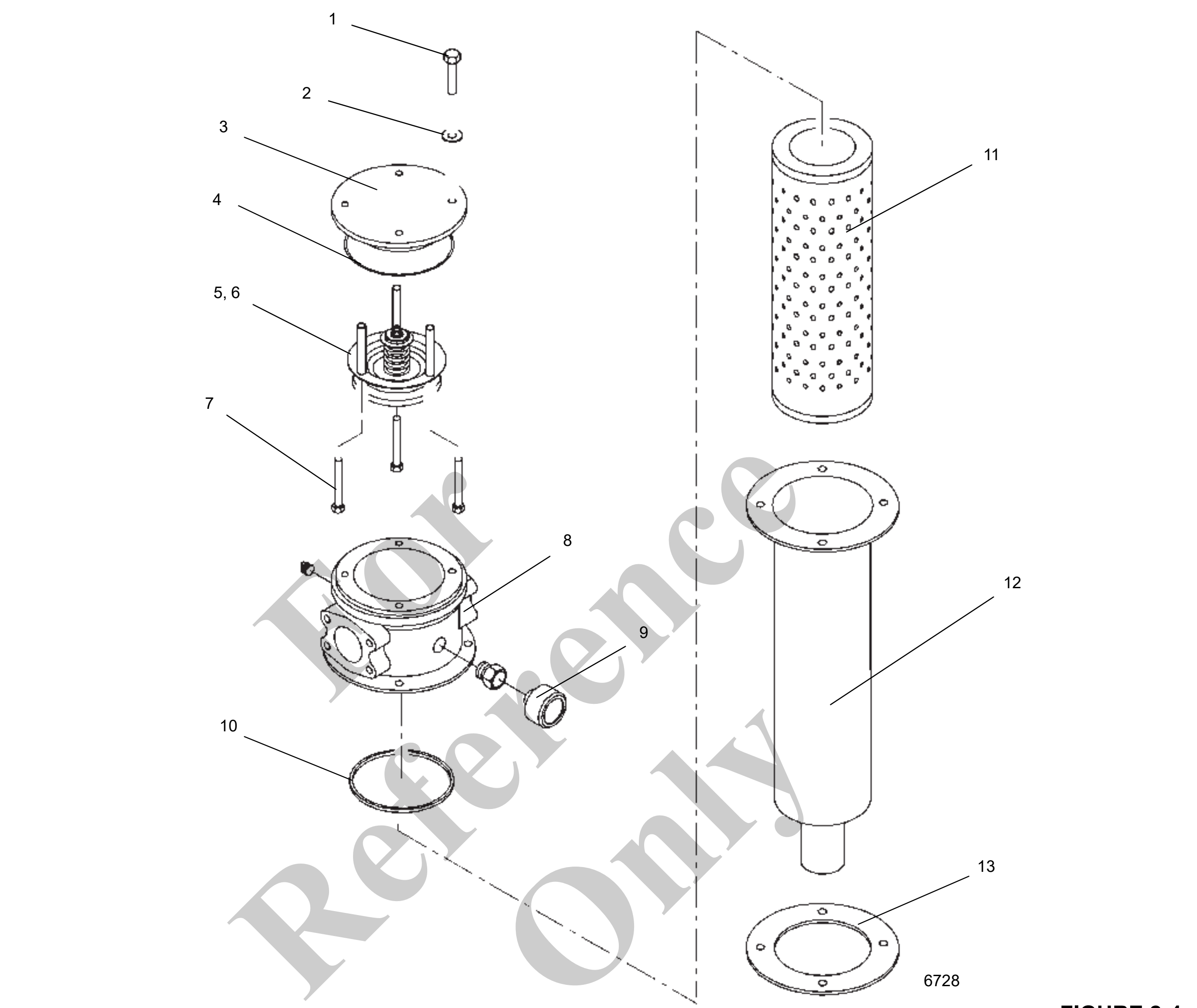


FIGURE 2-4

Item	Description
1	Capscrew
2	Washer
3	Cap
4	O-ring
5	Bypass Valve
6	Spacer
7	Capscrew

Item	Description
8	Filter Head
9	Gauge
10	O-ring
11	Element
12	Bowl
13	Gasket

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. No hydraulic oil flows in systems.	**a.** Low hydraulic oil level.	**a.** Fill reservoir.
	b. Reservoir-to-pump suction lines broken or restricted. Air entering at suction lines. Pump not priming.	**b.** Clean, repair, or replace lines as necessary. Check lines for security, absence of cracks, and proper attachment. Tighten, repair, or replace parts as necessary.
	c. Pump shaft sheared or disengaged.	**c.** If drive shaft is damaged or sheared, remove and repair or replace as necessary
	d. Internal pump issue.	**d.** Repair or replace.
2. Slow response.	**a.** Low hydraulic oil level.	**a.** Fill reservoir.
	b. Hydraulic oil temperature too high (watery thin oil) or too low (thick sluggish oil).	**b.** If too low, warm up system. As needed, troubleshoot cooler circuit. If too high, troubleshoot cooler circuit. Likely suspects are in-line check valve and related hydraulic circuits.
	c. Faulty pump section(s).	**c.** Repair or replace pump section(s) or entire pump.
	d. Software settings.	**d.** Refer to *Adjusting Electronic Joysticks*, page 3-16.
3. Pump noise accompanied by hydraulic oil foaming in reservoir.	**a.** Low hydraulic oil level.	**a.** Fill reservoir.
	b. Excessive engine speed.	**b.** Regulate engine speed.
	c. Air entering at suction lines.	**c.** Check all lines for security and proper repair. Tighten, repair, or replace as needed.
4. Excessive pressure buildup.	**a.** System relief valve set too high.	**a.** Using adequate pressure gauge, adjust system relief valve as necessary.
	b. Restricted pump-to-control valve supply line.	**b.** Clean, repair, or replace line as necessary.
5. Specific hydraulic system (lift, hoist, telescope, swing) not working.	**a.** Leak in system.	**a.** Repair leak.
	b. Faulty electric controls/signals.	**b.** Adjust or replace controls signals.
	c. Faulty directional control valve.	**c.** Replace valve.
	d. Poorly adjusted control in circuit.	**d.** Troubleshoot circuit with schematic. Adjust hydraulic component per schematic.
	e. Faulty hydraulic cylinder, motor, or valve.	**e.** Replace faulty component.
	f. Software settings.	**f.** Refer to *Adjusting Electronic Joysticks*, page 3-16.

HYDRAULIC OIL COOLER

Description

An air cooled hydraulic oil cooler (Figure 2-5) is installed on the right rear of the superstructure beside the hoists.

A hydraulic oil thermistor in the hydraulic tank indicates to the crane control system the temperature of the hydraulic oil. When the hydraulic oil temperature reaches 27°C (80.6°F), the crane control system will turn on the hydraulic oil cooler electric motor at 25% of it maximum speed, which drives the oil cooler fan and pulls cool air through the cooling fins on the cooler.

The crane control system varies the speed of the hydraulic oil cooler motor/fan relative to the temperature of the hydraulic oil received from the thermistor. The fan comes on when the hydraulic oil temperature reaches approximately 27°C (80.6°F) and proportionally increases in speed as the oil temperature increases. When the hydraulic oil temperature reaches approximately 55°C (131°F), the fan is rotating at its maximum speed of approximately 2450 ±100 rpm.

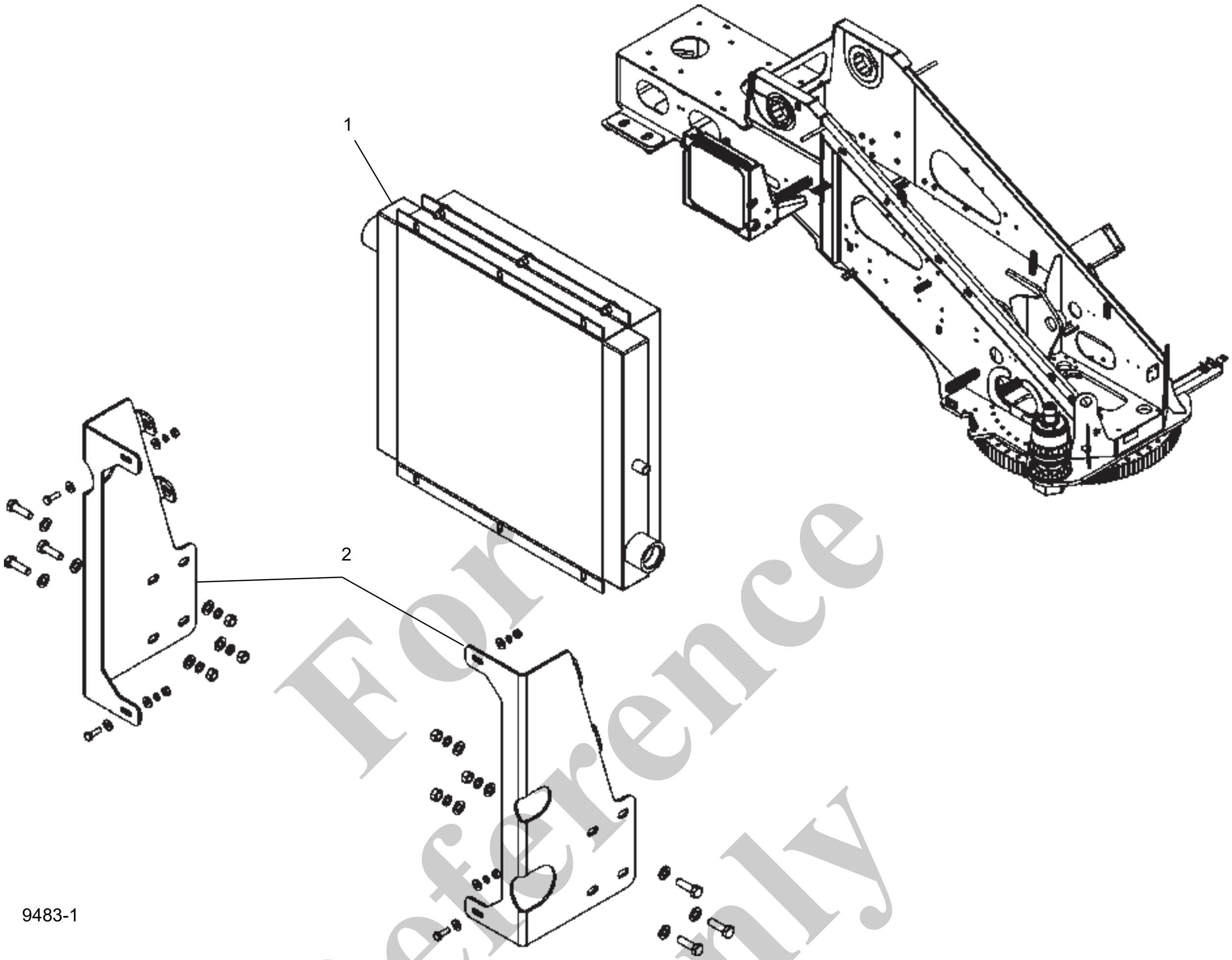
A normally closed hydraulic oil temperature switch in the hydraulic tank will open when the hydraulic oil is too high [87.8°C (190°F) and above]. When this open circuit is sensed by the crane control system, the crane control system will cause the Hydraulic Oil Temperature Indicator on the Main Screen of the Operator Display Module (ODM) to come on (red).

When either the hydraulic oil thermistor or the hydraulic oil temperature switch indicates a temperature of 87.8°C (190°F), the crane control system will check for an equal measurement from the other. If both the hydraulic oil thermistor and the hydraulic oil temperature switch do not simultaneously indicate an approximate temperature of 87.8°C (190°F) to the crane control system, the crane control system will cause the Hydraulic Oil Temperature Indicator to flash (red) and will produce an error that is viewable on the Crane Fault Code function screen of the ODM.

A fail-safe system exists that will cause the hydraulic oil cooler electric motor/fan to come on and run at 100% if the hydraulic oil temperature switch is open [oil temperature above 87.8°C (190°F)] or if the hydraulic oil thermistor indicates an out-of-range signal.

Normally, most hydraulic oil from components is routed through the oil cooler by way of a return line and on to the filter in the reservoir. When several hydraulic functions are being used at one time (hoisting, lifting, and telescoping), more oil has to flow through this return line, causing a pressure buildup. When this pressure reaches 310 kPa (45 psi), the normally closed check valve in the return line (in parallel with the return line through the hydraulic oil cooler) will open, letting some hydraulic oil bypass the hydraulic oil cooler and flow directly into the reservoir filter.

When fewer functions are being used, the pressure in the system will decrease below 310.3 kPa (45 psi) and the check valve will close again.



Item	Description
1	Hydraulic Oil Cooler
2	Mounting Brackets

FIGURE 2-5

HYDRAULIC PUMPS

Description

Pump No. 1 is mounted off a drive pad of the torque converter. Pump No. 2 is mounted to the rear of Pump No. 1. Pump No. 3 is mounted directly to the engine (Figure 2-6).

Pump No. 1

Pump No. 1 is a variable displacement axial piston pump with a maximum displacement of 112 cm^3/rev. (6.83 in^3/rev). The pump differential or standby pressure is 241 MPa (350 psi). Pump No. 1 supplies oil to the integrated outrigger/rear steer valve, boom lift, telescope, hoist, brakes and pilot functions.

Pump No. 2

Pump No. 2 is a single positive displacement gear pump with a displacement of 21 cm^3/rev (1.29 in^3/rev) delivering a theoretic flow of 86.7 Lpm (22.9 gpm). Pump No. 2 supplies oil to the two engine-transmission cooling package fan motors.

Pump No. 3

Pump No. 3 is a single positive displacement gear pump with a displacement of 39 cm^3/rev (2.40 in^3/rev) delivering a theoretic flow of 84 Lpm (21.9 gpm). Pump No. 3 supplies oil to the front steer and swing circuits.

Maintenance

No. 1 Pump Removal

CAUTION

Absolute cleanliness is essential when working on the hydraulic pumps. Always work in a clean area. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.

NOTE: Pump No. 1 weighs approximately 41 kg (90 lb) and pump No. 2 weighs approximately 14 kg (31 lb).

1. For ease of removal, gain access to the pump by removing the engine hood. The pump is bolted to the engine's torque converter.
2. Tag and disconnect the supply line from pump No. 1 and No. 2. Cap or plug the lines and ports.
3. Tag and disconnect the pump distribution lines from pump No. 1 and No. 2. Cap or plug the lines and ports.

CAUTION

When removing the pump, keep the pump as level as possible to avoid damaging the input spline.

4. Remove the capscrews and washers attaching pump No. 1 to the drive pad on the torque converter. Remove the pumps.
5. Clean the gasket material from the drive pad on the torque converter and the pump's mounting surface.
6. Cover the drive pad's opening to prevent dirt from entering.

No. 1 Pump Installation

1. Clean pump mounting surfaces with Loctite cleaning solvent or similar.
2. Install new gasket using Loctite Primer N7649 and Loctite Master Gasket 518, or similar, following the manufacturer's directions.
3. Install pump on torque converter drive pad with capscrews and washers. Make sure the splines mesh properly. Tighten capscrews following torque specifications found under *Fasteners and Torque Values*, page 1-19.
4. Connect the distribution and supply lines as tagged during removal.

CAUTION

Do not feed hot hydraulic oil into a cold pump. This may cause the pump to seize.

5. Prime pumps following procedures under *Piston Pump Start-up Procedure*, page 2-17 and *Hydraulic Gear Pump Start-up Procedure*, page 2-16.

No. 2 Pump Removal

CAUTION

Absolute cleanliness is essential when working on the hydraulic pumps. Always work in a clean area. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.

NOTE: Pump No. 2 weighs approximately 14 kg (31 lb).

1. For ease of removal, gain access to the pump by removing the engine hood.
2. Tag and disconnect the supply line from the pump. Cap or plug the line and port.

3. Tag and disconnect the pump distribution line(s) from the pump. Cap or plug the line(s) and port.

CAUTION

When removing the pump, keep the pump as level as possible to avoid damaging the input spline.

4. Remove the capscrews and washers attaching the No. 2 pump to the No. 1 pump. Remove the pump.
5. Cover the drive pad's opening to prevent dirt from entering.

No. 2 Pump Installation

1. Using coupler, install pump on to No. 1 pump with capscrews and washers. Make sure gear teeth mesh properly. Tighten capscrews following torque specifications found under *Fasteners and Torque Values*, page 1-19.
2. Connect the distribution and supply lines as tagged during removal.

CAUTION

Do not feed hot hydraulic oil into a cold pump. This may cause the pump to seize.

3. Prime pump following procedures under *Hydraulic Gear Pump Start-up Procedure*, page 2-16.

No. 3 Pump Removal

CAUTION

Absolute cleanliness is essential when working on the hydraulic pumps. Always work in a clean area. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.

1. For ease of removal, gain access to the pump by removing the engine hood.
2. Tag and disconnect the supply line from the pump. Cap or plug the line and port.
3. Tag and disconnect the pump distribution line(s) from the pump. Cap or plug the line(s) and port.

CAUTION

When removing the pump, keep the pump as level as possible to avoid damaging the input spline.

4. Remove the capscrews and washers attaching the No. 3 pump to the engine. Remove the pump.
5. Remove the gasket material from the drive pad on the engine and the pump's mounting surface.
6. Cover the drive pad's opening to prevent dirt from entering.

No. 3 Pump Installation

1. Clean pump mounting surfaces with Loctite cleaning solvent or similar.
2. Install new gasket using Loctite Primer N7649 and Loctite Master Gasket 518, or similar, following the manufacturer's directions.
3. Install pump on to engine with capscrews and washers. Make sure gear teeth mesh properly. Tighten capscrews following torque specifications found under *Fasteners and Torque Values*, page 1-19.
4. Connect the distribution and supply lines as tagged during removal.

CAUTION

Do not feed hot hydraulic oil into a cold pump. This may cause the pump to seize.

5. Prime pump following procedures under *Hydraulic Gear Pump Start-up Procedure*, page 2-16.

Hydraulic Gear Pump Start-up Procedure

1. Ensure the reservoir is filled with the proper hydraulic fluid to the high level mark on the reservoir sight gauge.
2. Ensure no air is entering the pump inlet, and that the pump suction or inlet fluid is not bleeding back to the reservoir when the engine is stopped, by making sure all suction or inlet lines are air tight.

NOTE: The following step can be done before the pump is installed by removing the plastic cap from the outlet port(s). Fill housing full of hydraulic oil. Re-install the plastic cap(s) and then install the pump.

3. Remove adapter(s) and hose(s) from all outlet ports. Fill housing full of hydraulic oil. Re-install the adapter(s) and hose(s).
4. Start the engine.
   a. Idle engine for two to three minutes with no functions actuated. Check for leaks and repair if required. Lay hand on pump to check for excessive heat build-up. If the pump section is too hot to touch, stop the engine immediately.

      If the pump makes excessive noise, air is probably entering the pump and keeping it from priming. If this occurs, stop engine, and inspect all connections of the suction hose/tube for a loose connection, or a missing or damaged O-ring.

b. Increase the RPM to 1500 to 1800 for 1 to 2 minutes with no functions actuated and make checks again as outlined in step a. Incrementally increase throttle to full RPM and then cycle the functions that the pump supplies to verify proper speed (verify pump flow).

5. Check pressure settings. Refer to *Pressure Setting Procedures*, page 2-19.

Piston Pump Start-up Procedure

1. Ensure the reservoir is filled with the proper hydraulic fluid to the high level mark on the reservoir sight gauge.
2. Ensure no air is entering the pump inlet, and that the pump suction or inlet fluid is not bleeding back to the reservoir when the engine is stopped, by making sure all suction or inlet lines are air tight.
3. Remove the case drain hose and adapter from port DR on the pump, and fill housing with the same hydraulic oil that was used to fill the hydraulic reservoir to the bottom of the O-ring case drain port. Install the case drain adapter and hose.
4. Start the engine.

   a. Idle engine for two to three minutes with no functions actuated. Check for leaks and repair if required. Lay hand on pump to check for excessive heat build-up. If the pump section is too hot to keep a hand on, stop immediately.

   If the pump makes excessive noise, air is probably entering the pump and keeping it from priming. If this occurs, stop engine, and inspect all connections of the suction hose/tube for a loose connection, or a missing or damaged O-ring.

   Re-start the engine and run until the pump takes prime for a maximum of 30 seconds. If the pump does not prime in 30 seconds, stop the engine and repeat until the pump primes.

   b. Increase the RPM to 1500 to 1800 for 1 to 2 minutes with no functions actuated and make checks again as outlined in step a. Incrementally increase throttle to full RPM and then cycle the functions that the pump supplies to verify proper speed (verify pump flow).

5. Check pressure settings. Refer to *Pressure Setting Procedures*, page 2-19.

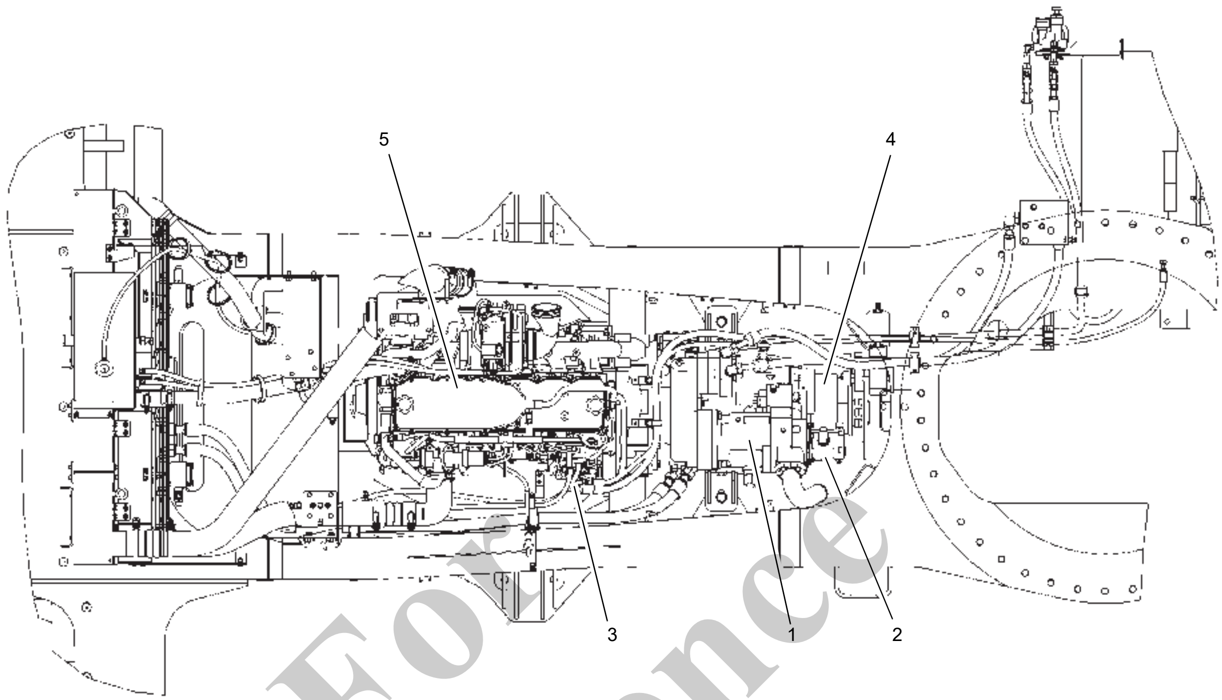
Testing After Rebuild or Replacement

1. Operate the pump for at least two minutes at zero pressure and moderate speed (not over 1500 rpm).

CAUTION

If the pump becomes hot to the touch, it is binding and may seize. Stop engine, disassemble pump, and repair it so it will not bind.

2. Touch pump to verify it has not become hot from binding. Listen for abnormal noises indicating low hydraulic oil level or internal pump problems. If the pump appears to be operating satisfactorily, increase the rpm by steps, until reaching governed rpm. Operate pump about five minutes while checking for proper operation and leakage. Fix leaks; make repairs as needed.
3. Cycle the components the pump powers to verify the pump drives them all properly.



Pump Location On Engine

Item	Description
1	Pump No. 1 - Piston Pump
2	Pump No. 2 - Gear Pump
3	Pump No. 3 - Gear Pump
4	Transmission
5	Engine

FIGURE 2-6

PRESSURE SETTING PROCEDURES

The following procedures should be used to properly check, adjust and set the hydraulic system pressures.

NOTE: A Digital Pressure Gauge and accessories may be purchased through Manitowoc Crane Care.

The following equipment is required for checking the hydraulic pressure settings.

- Pressure Gauge
- Three dial gauge 0-34.5 MPa (0-5000 psi)
- Pressure check diagnostic quick disconnect - Grove P/N 9999101806 and straight adapter fitting 7447040401
- ORFS reducers as required to attach work port hoses to the gauge.

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

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

NOTE: GP (Gauge Port) and number corresponds to gauge ports on the valve and on the hydraulic schematic.

Table 2-1
Valve Pressure Setting Table

Valve To Be Set	Pressure Setting PSI (MPa)	Tolerance PSI (MPa)	Adjustment Location
Hoist(s) and Lift Pressure Setting	4000 (27.6)	± 50 (0.4)	GP2 - Superstructure mounted main directional control valve load sense relief valve (Figure 2-7 and Figure 2-8)
Telescope Extend Pressure Setting	3600 (24.8)	± 50 (0.4)	GP7 - Superstructure mounted main directional control valve port relief valve (Figure 2-8)
Outrigger Extend/Retract, Rear Steer,	2500 (17.3)	± 50 (0.4)	GP2 - Carrier mounted outrigger control manifold (Figure 2-9)
Swing Left and Right Work Port Relief Pressures	2100 - 2450 (14.5 - 16.9)	See Range	GP1 - Superstructure mounted accessory manifold with swing directional control valve (Figure 2-7)
Front Steer Pressure Setting	2500 (17.3)	± 50 (0.4)	GP5 - Superstructure mounted accessory manifold with swing directional control valve (Figure 2-7)
Swing Brake Release Pressure Setting	250 - 275 (1.7 - 2.1)	See Range	GP6 - Superstructure mounted accessory manifold with swing directional control valve (Figure 2-7)
Pilot Supply Pressure Setting	600 (4.1)	See Range	GP3 - Superstructure mounted accessory manifold with swing directional control valve (Figure 2-7)
Non-CE Cranes Piston Pump ΔP Pressure Setting **CE Cranes** Piston Pump ΔP Pressure Setting	350 - 400 (2.4 - 2.8) 475 - 525 (3.3 - 3.6)	See Range	GP2 - Carrier mounted piston pump (Figure 2-11)
Cab Tilt Pressure	3100 (21.4)	± 50 (0.4)	GPBR - Superstructure mounted accessory manifold with swing directional control valve (Figure 2-7)
Service Brake High Charge Limit	2900 (20.0)	+72, -145 (0.5) (1.0)	GP (Figure 2-12) Non-adjustable
Service Brake Low Charge Limit	2490 (17.2)	±145 (1.0)	GP - (Figure 2-12) Non-adjustable
Service Brake Accumulator Pre-charge	1200 - 1250 (8.3 - 8.6)	See Range	Accumulator (Figure 2-10)

Published 3-26-2021, Control # 676-02

NOTE: Procedures A through I in the following text correlate with Figure 2-7 through Figure 2-12.

Procedure A - Checking/Setting the Main Directional Control Valve for Hoist(s), Boom Lift and Piston Pump

NOTE: Procedure A for max. and Δ P settings.

Set hoist(s) and boom lift as follows:

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at the GP2 Port of the accessory manifold with swing directional control valve Figure 2-7.
2. Ensure piston pump cut-off max. Figure 2-11 factory setting is correct. Loosen the jam nut on the cut-off max adjusting screw and turn it in until it softly seats or bottoms out. Then back the adjusting screw out 1/4 to 1/2 turn and lock in place with jam nut. This will ensure that full system pressure of 27.6 MPa (4000 psi) can be obtained in step 5.
3. Ensure piston pump ΔP (stand-by) factory setting is correct. With diagnostic quick disconnect still installed at the GP2 port of the accessory manifold with swing directional control valve Figure 2-7, start engine and at idle RPM adjust the piston pump differential setting screw "in" to increase or "out" to decrease so that a gauge reading of 2.4 - 2.8 MPa (350 - 400 psi) Figure 2-11. For CE machines, this pressure is 3.3 - 3.6 MPa (475-525 psi)
4. If the lift cylinder is not installed, plug the extend hose (the larger of the two). If lift cylinder is installed, omit this step and continue to step 5.
5. With diagnostic quick disconnect still installed at the GP2 port of the accessory manifold with swing directional control valve Figure 2-7, start engine and throttle up to full RPM. Feather into the boom lift controller to full controller stroke (up or down) and hold. If the boom is installed, boom up to max elevation and hold or boom down to minimum elevation and hold. Adjust the load sense relief valve "in" to increase or "out" to decrease so that a gauge pressure reading of 27.6± 0.4 MPa (4000 ± 50 psi) is achieved Figure 2-8.
6. Stop engine and remove the diagnostic couplers from the test nipples

Set telescope extend as follows:

7. Install a pressure check diagnostic quick disconnect with gauge onto test nipple at the GP7 port of the main directional control valve Figure 2-8.
8. Cap hose (the larger of the two) running from port A, telescope section of the main directional control valve to the swivel joint at the boom pivot on the right side of the crane.

NOTE: The extend hose must be capped to check/set the telescope extend pressure. At full telescope extension, the pressure is reduced by the crane control system to prevent damage to the cylinder.

9. Start engine and throttle up to full RPM. Attempt to telescope OUT by feathering into the controller to full controller stroke. Adjust the telescope extend port relief "in" to increase or "out" to decrease so that a gauge pressure of 24.8 ±0.4 MPa (3600 ±50 psi) is achieved Figure 2-8.
10. Stop engine and remove pressure gauge and re-connect plumbing.

Procedure B - Setting The Outrigger/Rear Steer/Oil Cooler Motor Pressures

1. Install a pressure check diagnostic quick disconnect with gauge onto test nipple at G2 port of the outrigger control manifold Figure 2-9.
2. Start engine and let idle. With all beams and stabilizer cylinders retracted, select one beam or stabilizer using the jog dial selector and then select and hold the outrigger "retract" switch on the left arm rest. Slowly throttle up to full RPM and adjust the pressure relief valve in the outrigger selector valve manifold "in" to increase or "out" to decrease so that a gauge pressure of 2500 ±50 psi is achieved Figure 2-9.
3. Stop engine. Remove the diagnostic coupler.

Procedure C - Checking/Setting the Swing Directional Control Valve Work Port Relief Valves

NOTE: To adjust the Imax, a Windows-based PC, a CAN-link service software (80112606), and a connection cable (80078354) are required. The CAN-Link service software and connection cable are available through Manitowoc Crane Care to those service technicians who have attended the Grove New Technology training course.

1. With engine off, install a pressure check diagnostic coupler with gauge onto test nipple at GP1 port of the accessory manifold with swing directional control valve Figure 2-7.
2. Start engine and throttle up to full RPM. With the swing house lock engaged, swing full right and hold controller. Pressure gauge should read 2100 to 2450 psi. If the reading is not within this range, the Imax needs to be adjusted using the service software.Lowering the Imax will lower the pressure and raising the Imax will increase the pressure.
3. Repeat step #2 for swing left.
4. Stop engine. Remove the diagnostic coupler.

Procedure D - Checking/Setting the Cab Tilt Pressure

1. With engine off, install a pressure check diagnostic coupler with gauge onto test nipple at the GPBR port of the accessory manifold with swing directional control valve (Figure 2-7).
2. Start engine and throttle up to full RPM. Activate and hold the cab lower switch. Adjust the inlet pressure reducing valve “in” to increase or “out” to decrease so that a gauge pressure reading of 21.4 ±0.4 MPa (3100 ±50 psi) is achieved (Figure 2-7).
3. Stop engine. Remove the diagnostic coupler.

Procedure E - Checking/Setting the Service Brake Dual Accumulator Charge Valve Charging Limits

1. With engine off, discharge all of the pressurized fluid stored in the accumulators by depressing the service brake pedal on the cab floor 8 - 10 times.
2. Install a pressure check diagnostic quick disconnect with gauge onto test nipple at A1 port of the dual accumulator charge valve Figure 2-12.
3. Start engine and idle. The charging valve will immediately start to charge the accumulators. Watch the pressure gauge. The high charge limit should read 20.0 MPa +0.5, -1.00 (2900 +72, -145 psi) when the pressure stops rising. This accumulator charge valve is non-adjustable.

   If the pressure is under specification and the valve does not stop charging, perform the pressure check in Procedure D and then repeat this procedure.
4. With the engine still at idle, repeatedly depress the service brake pedal on the cab floor until the gauge pressure reads approximately 17.9 MPa (2600 psi).Push the brake pedal again to recharge. Watch the gauge and verify the low charging limit to be 17.2 ±1.00 MPa (2490 ±145 psi) (when it starts to recharge). This accumulator charge valve is non-adjustable.
5. Stop engine. Remove pressure gauge.

Procedure F - Checking/Pre-Charging the Service Brake Accumulators

1. With the engine off, discharge all of the pressurized oil stored in the accumulators by depressing the service brake pedal on the cab floor 4-6 times. Remove the gas valve guard and cap on the accumulator (Figure 2-11).
2. Before attaching the gas charging assembly (Figure 2-11) onto the gas valve, back the gas chuck “T” handle all the way out (counterclockwise).
3. Close the charging assembly bleed valve. Attach the swivel nut onto the gas valve and tighten 1.1 to 1.6 N-m (10 to 15 lb-in).
4. Turn the gas chuck “T” handle all the way down (clockwise) which will depress the core in the gas valve.
5. Check the pre-charge pressure. The gauge should read 8.3 to 8.6 MPa (1200 to 1250 psi).
6. If the pressure is 8.3 to 8.6 MPa (1200 to 1250 psi), remove the charging valve assembly by turning the “T” handle all the way out on the gas chuck and then opening the bleed valve(Figure 2-11). If the pressure is low, see pre-charging procedure below.
7. Secure the gas valve, loosen the swivel nut and remove the charging assembly. Replace the gas valve cap and guard.

Pre-charging the Accumulator (if required)

1. With the engine off, discharge all of the pressurized oil stored in the accumulators by depressing the service brake pedal on the cab floor 4 - 6 times. Remove the gas valve guard and cap on the accumulator (Figure 2-11).
2. Ensure the nitrogen supply bottle is shut off, then attach the charging valve assembly to it.
3. Before attaching the charging assembly to the accumulator gas valve, back the gas chuck “T” handle all the way out (counterclockwise).
4. Close the charging assembly bleed valve. Without looping or twisting the hose, attach the swivel nut to the accumulator gas valve and tighten 1.1 to 1.7 N-m (10 to 15 lb-in).
5. Turn the gas check “T” handle all the way down (clockwise) which will depress the core in the gas valve.
6. Slowly open the nitrogen bottle valve and fill the accumulator. Close the valve when the pre-charge is 8.3 to 8.6 MPa (1200 to 1250 psi).
7. If the precharge is higher than specified in step 6, close the nitrogen bottle and slowly open the bleed valve on the charging assembly (Figure 2-11) until the pressure is to specification.
8. Remove the charging valve assembly by turning the “T” handle all the way out (counterclockwise) on the gas chuck and then open the bleed valve.
9. Secure the gas valve, loosen the swivel nut and remove the charging assembly. Replace the gas valve cap and guard.

Procedure G - Checking/Setting the Front Steer Pressure

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at GP5 port of the accessory

manifold with swing directional control valve (Figure 2-7).

2. Start engine and throttle up to full RPM. Fully turn and hold the steering wheel left or right against the axle stop. Adjust the steering load sense relief valve in the accessory manifold with swing directional control “in” to increase or “out” to decrease so that a gauge pressure of 17.3 MPa (2500 psi) is achieved (Figure 2-7).

3. Stop engine. Remove diagnostic couplers.

Procedure H - Checking/Setting the Pilot Supply Pressure

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at GP3 port of the accessory manifold with swing directional control valve Figure 2-7.

2. Start engine and at idle RPM, lower right armrest, fully stroke and hold the boom lift raise or lower controller. Adjust the pilot pressure reducing valve of the accessory manifold with swing directional control valve “in” to increase or “out” to decrease so that a gauge pressure of 4.1 MPa (600 psi) is achieved Figure 2-7.

3. Stop engine. Remove diagnostic couplers.

Procedure I - Checking/Setting the Swing Brake Release Pressure

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at GP6 port of the accessory manifold with swing directional control valve Figure 2-7.

2. Start engine and idle, lower right armrest and adjust the swing brake pressure reducing valve “in” to increase or “out” to decrease so that a gauge pressure of 1.7 to 2.1 MPa (250 to 275 psi) is achieved Figure 2-7.

3. If adjustment can’t obtain the setting in step 2, stop engine and install a pressure check diagnostic quick disconnect with gauge onto the test nipple at the GP2 at the accessory manifold valve Figure 2-8. Follow procedure A, step 3 to set pump stand-by and then repeat this step.

4. Stop engine. Remove diagnostic couplers.

Procedure J - Setting Threshold on Electronic Controllers

Refer to *Adjusting Electronic Joysticks*, page 3-16.

Item	Description
1	Inlet Pressure Reducing Valve
2	Gauge Port 6
3	Gauge Port 3
4	Gauge Port 5
5	Gauge Port 1
6	Pilot Pressure Reducing Valve
7	Swing Brake Pressure Reducing Valve
8	Front Steer Load Sense Relief Valve
9	Gauge Port 4
10	Gauge Port 2
11	GPBR

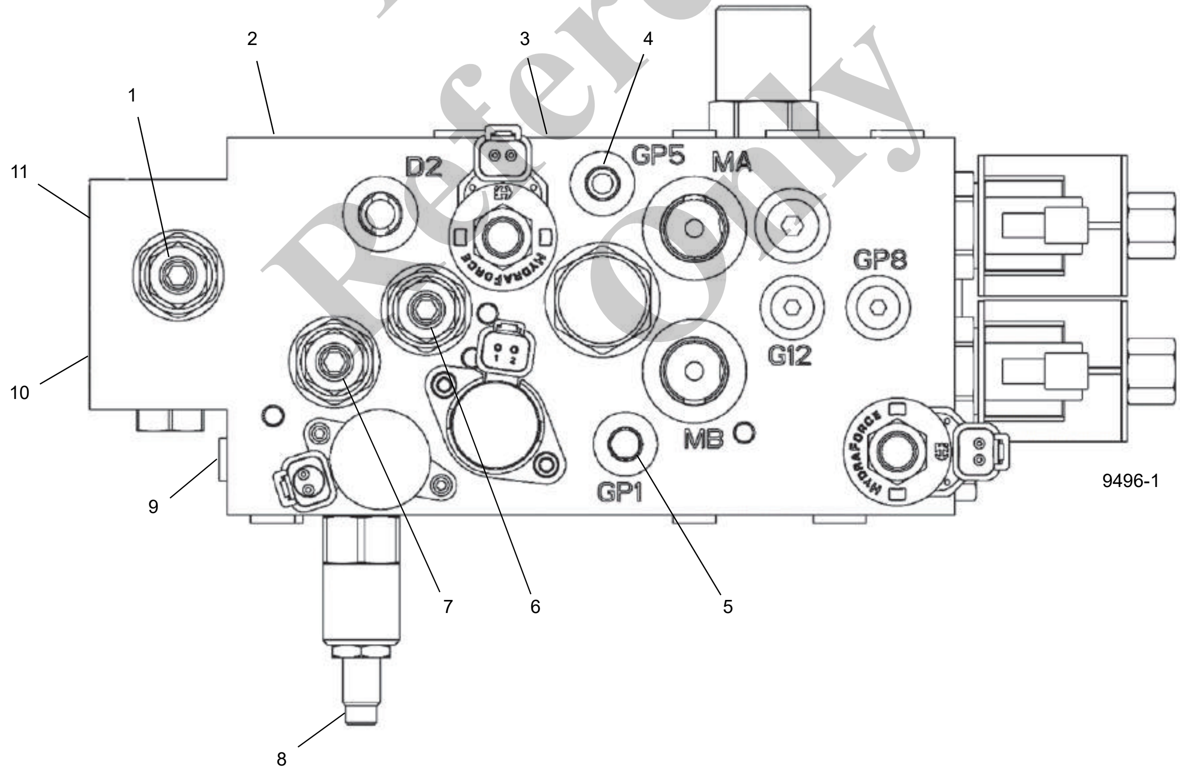


FIGURE 2-7

Item	Description
1	Gauge Port 7
2	Pilot End Cap GPB - Main Hoist Down
3	Pilot End Cap GPA - Optional Auxiliary Hoist Down
4	Pilot End Cap GPC - Telescope Extend
5	Pilot End Cap GPD - Lift Up
6	Telescope Extend Port Relief
7	Load Sense Relief Valve
8	Lift Down Port Relief

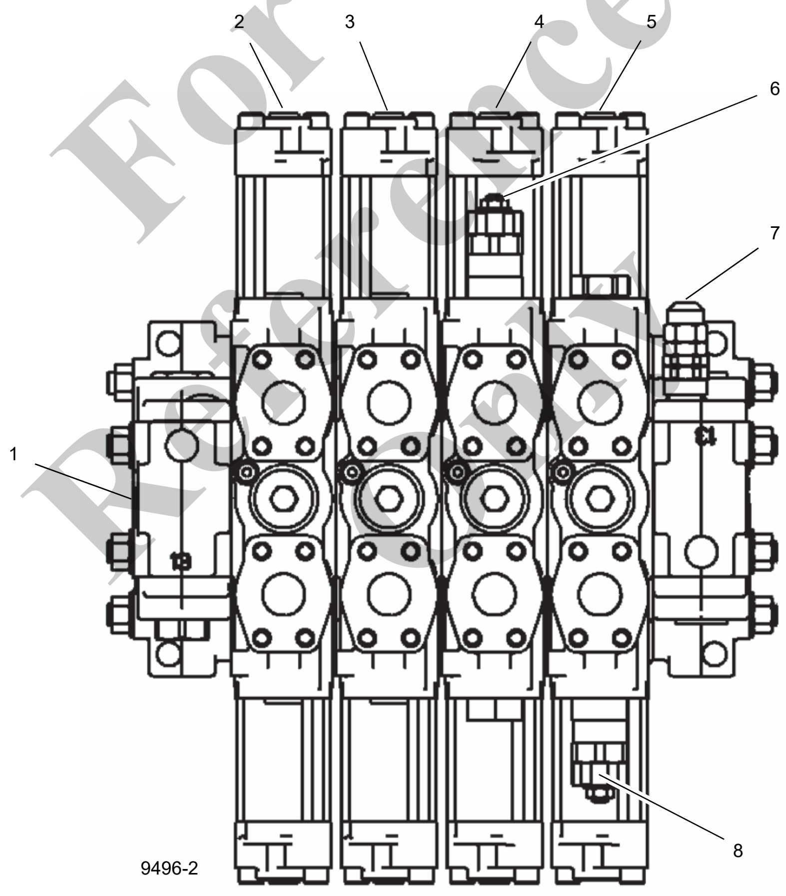


FIGURE 2-8

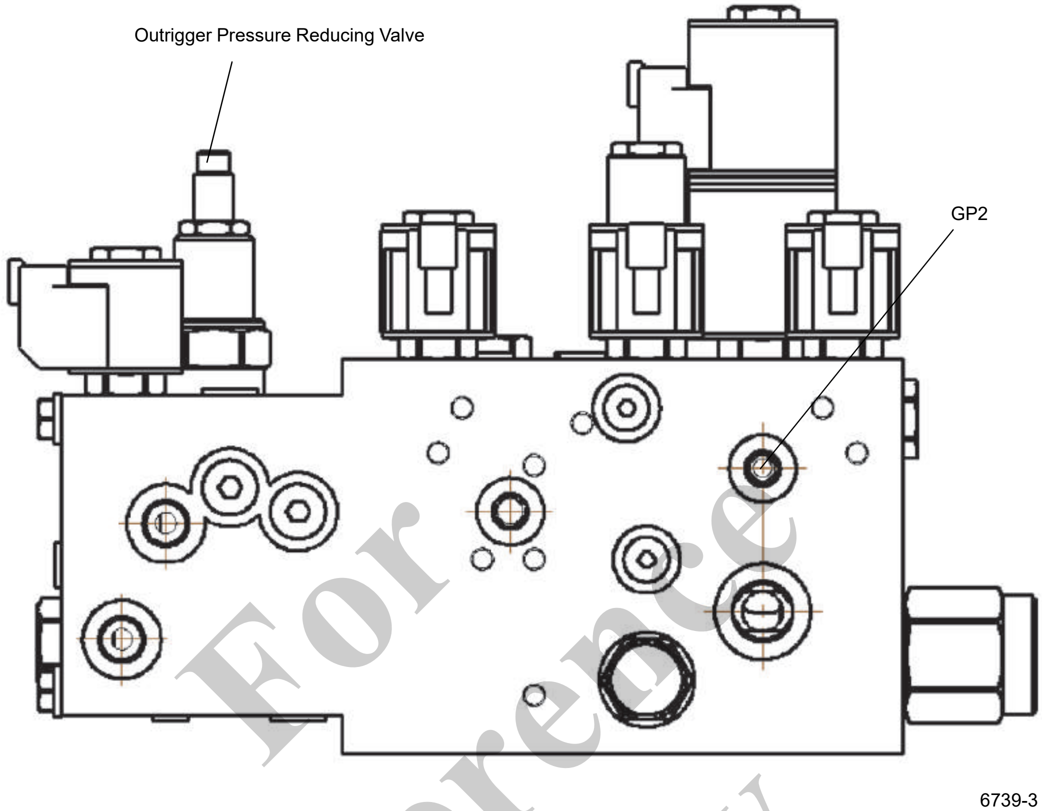
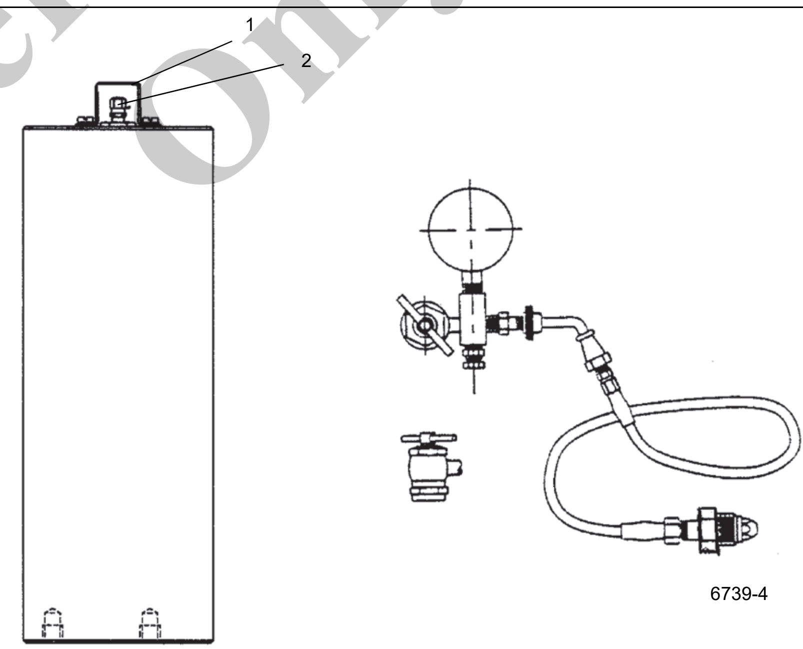


FIGURE 2-9



Item	Description
1	Gas Valve Guard
2	Gas Valve

FIGURE 2-10

Item	Description
1	Pump Cut-Off Max Setting Adjustment
2	Pump ΔP (Stand-by) Adjustment

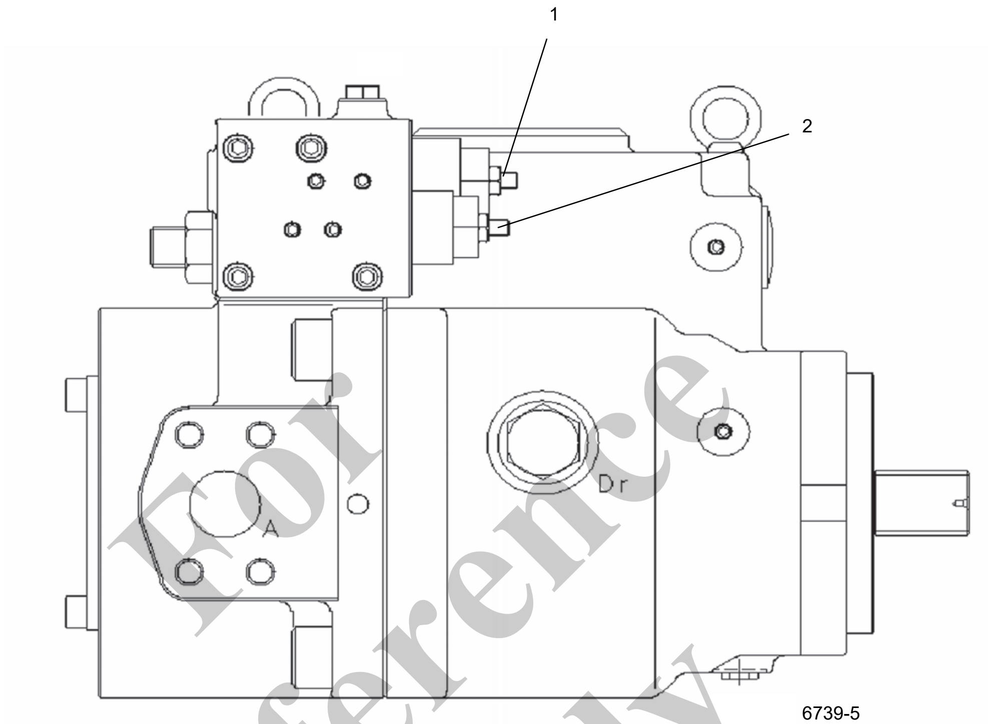


FIGURE 2-11

Item	Description
1	Gauge Port
2	A1 Port

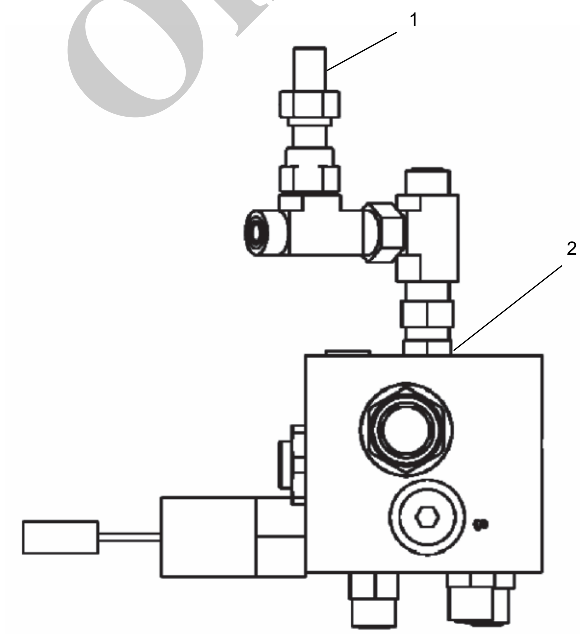


FIGURE 2-12

VALVES

General

This subsection provides descriptive information for all the hydraulic valves used on this crane. For a listing of all valves, the circuit they are used in and their physical location, refer to (Table 2-2). Refer to Figure 2-13 for valve locations. The description of each valve given here is for the valve itself. For information on how each valve functions in the individual circuits, refer to the description and operation procedures of that circuit.

NOTE: On each valve illustration in this section, each item number in table correlates to location on the valve, and to the valve hydraulic schematic.

Table 2-2
Valve Usage Table

Valve Name	Circuit Used In	Physical Location
Directional Control Valves	Boom Lift/Telescope(s)/Hoist(s)	Superstructure Right Side Plate
Steering Control Valve	Front Axle Steer Control	Cab Steering Column
Accessory Manifold with Swing Directional Control Valve	Front Axle Steer Supply Swing Directional Control Swing Brake Release Pilot Supply	Superstructure Right Side Plate
Tandem Brake Valve with Treadle	Service Brakes	Cab Floor
Dual Accumulator Charging Valve	Service Brakes	Superstructure Left Side Plate
Accumulator(s)	Service Brake	Rear Superstructure
Holding Valves	Boom Lift Telescope (2)	Lift Cylinder (Bolt on Manifold) Cylinder Port Blocks (Cartridge style)
Integrated Outrigger/Rear Steer Valve	Axle Lockout Control Rear Steer Control Outrigger Control	Center of Front Carrier Frame
Hoist Motor Control Valve	Hoist(s)	Both Hoists (see Hoist section)
Check Valves	Return Circuit	One in Parallel With Oil Cooler
Outrigger Control Manifold	Outrigger	On Front and Rear Face of Carrier Frame Front and Rear Cross Member
Pilot Operated Check Valve	Outrigger	Port Block of each Jack Cylinder (4)
Cross Axle Differential Lock Valve	Differential Lock (Optional)	Carrier Bulkhead Plate Forward of the Engine
Range Shift and Parking Brake Valve	Parking Brake Front Axle Disconnect Transmission High.Low Range Control	Carrier Bulkhead Plate Forward of the Engine

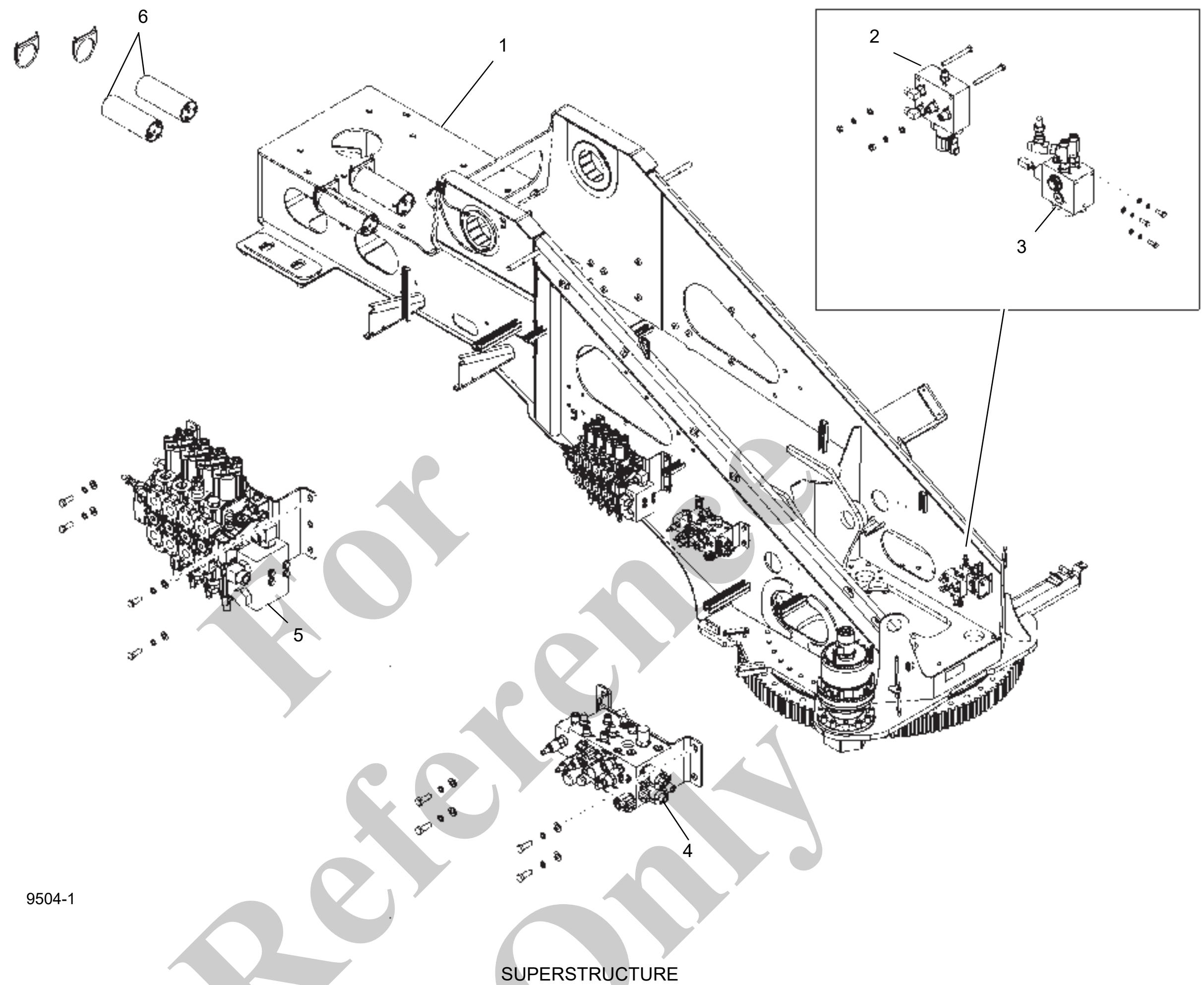


FIGURE 2-13

1	Superstructure	4	Accessory Manifold with Swing Directional Control Valve
2	Cab Tilt Valve Assembly	5	Boom Lift/Telescope/Hoist Control Valve
3	Service Brake Dual Accumulator Charge Valve	6	Accumulators

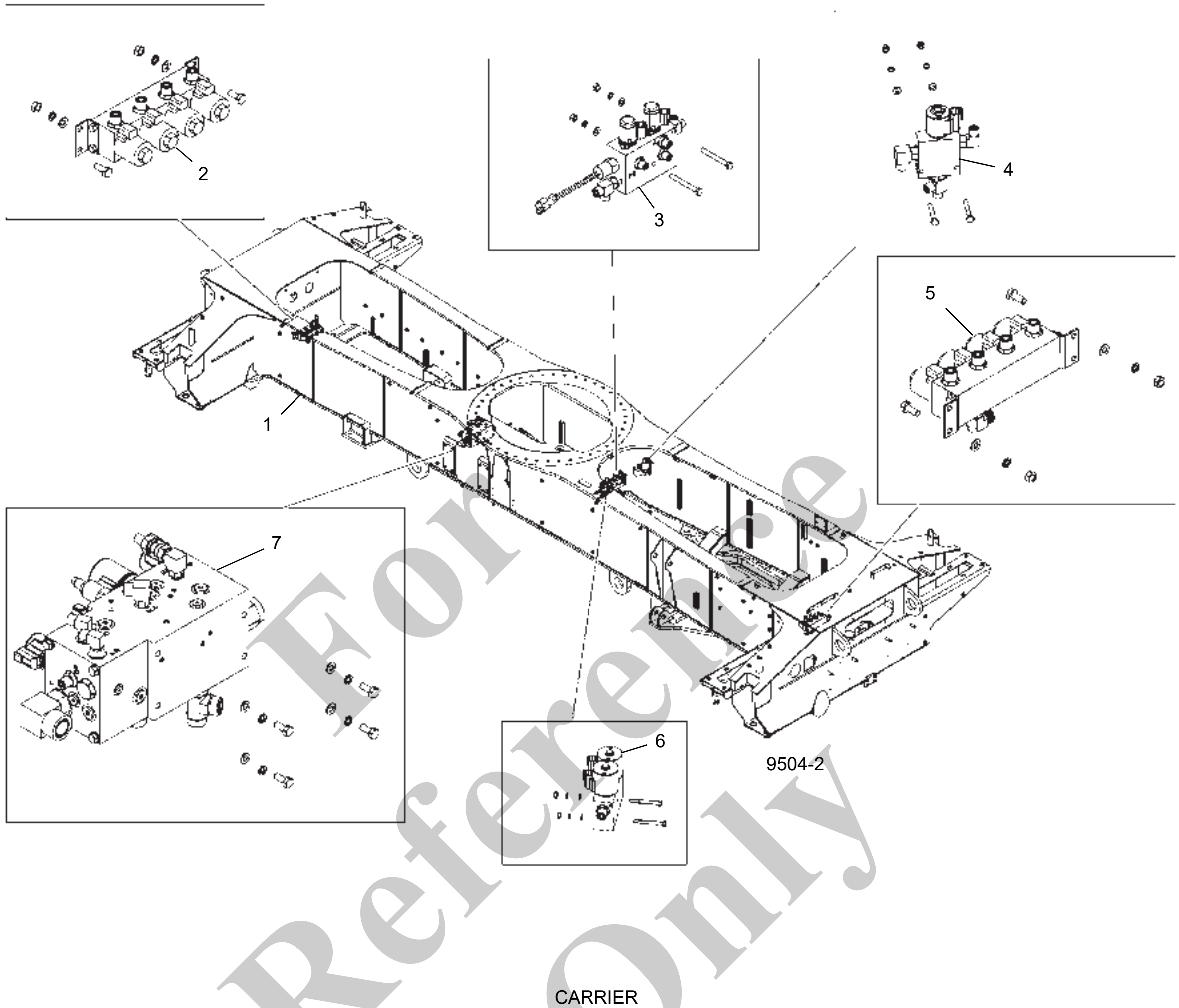


FIGURE 2-13 continued

1	Frame	5	Rear Outrigger Control Manifold
2	Front Outrigger Control Manifold	6	Axle Lockout Valve
3	Park Brake Range Shift Valve	7	Outrigger/Rear Steer Valve
4	Differential Lock Valve (Optional)		

MAIN DIRECTIONAL CONTROL VALVES

Description

The directional control valves direct and control hydraulic oil flow from the pumps to the boom lift and telescope cylinders, each hoist motor, the swing motor, and the front steer cylinders from the front steer control valve. The boom lift/telescope/hoist directional control valve (Figure 2-14) is located on the outside of the right superstructure side plate. The valve bank is removed and installed as an assembly.

The boom lift/telescope/hoist control valve is a three position, four way pressure compensated, closed center directional valve. It receives pump flow from hydraulic swivel port 6 and pump No. 1. Lift, telescope and hoist(s) functions are controlled by proportional two position two way solenoid cartridges installed into the valve's casting under each spool.These valves receive an electrical signal from the controllers on the cab armrest.

These valve are electrically controlled by the crane control system through the CAN bus system when the controllers in the cab are actuated.

RCL lockout is achieved by de-energizing the proportional solenoids.

The inlet section of the boom lift/telescope/hoist directional control valve contains a load sense relief valve set at 27,579 kPa (4000 psi) protecting the main and auxiliary hoist and boom lift sections. The boom lift retract has a thermal port relief set of 29,647 kPa/ (4300 psi). The telescope extend section has its port relief set at 24,820 kPa (3600 psi), but is reduced further by the crane control system at long boom lengths. The telescope retract pressure is controlled by the system (pump) relief of 27,580 kPa (4000 psi).

The swing directional control valve is installed on the outside of the right superstructure side plate. Refer to *Accessory Manifold With Swing Directional Control Valve*, page 2-34.

Maintenance

Removal

1. Tag and disconnect all of the electrical connectors from the valve.
2. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.

NOTE: The lift/telescope/hoist valve bank, fittings, and mounting bracket weigh approximately 96 kg (212 lb).

3. Remove the capscrews, lock washers, and flat washers securing the valve bank's mounting bracket to the superstructure. Remove the valve bank.
4. Remove the capscrews, washers, and nuts securing the valve to the mounting bracket.

Installation

NOTE: Tighten all capscrews following the specifications found under *Fasteners and Torque Values*, page 1-19.

1. Attach the valve bank to the mounting bracket using capscrews, washers, and nuts.
2. Place the valve bank/mounting bracket on the superstructure side plate and secure it with the capscrews, lock washers, and flat washers.
3. Connect the hydraulic lines to the valves as tagged during removal.
4. Connect the electrical connectors as tagged during removal.

Functional Check

1. Start the engine and run it at normal speed.
2. Operate the functions that the directional control valve controls. Check for smooth operation of cylinders and motors.
3. Check the valve bank(s) and lines for leakage. Make repairs as needed.

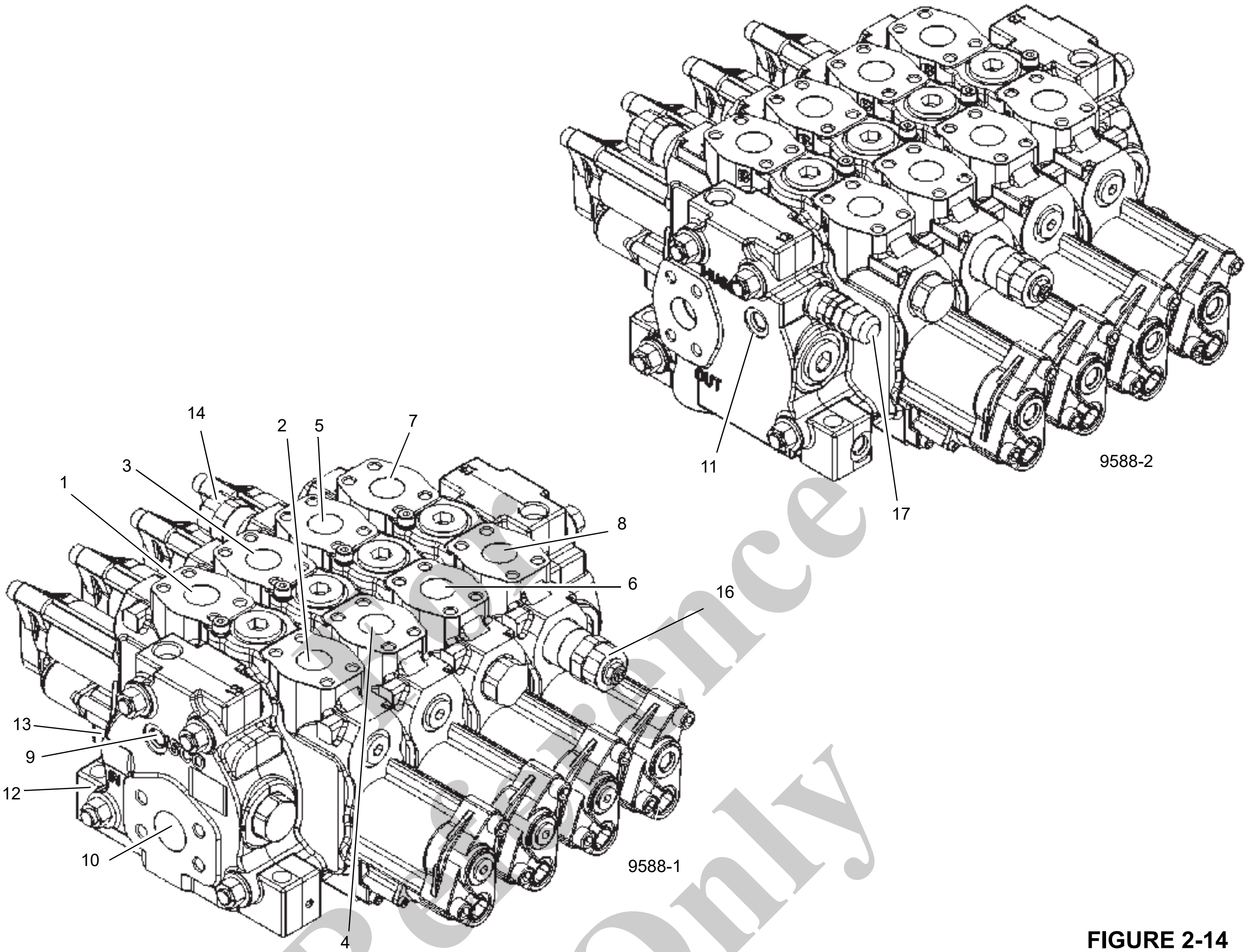
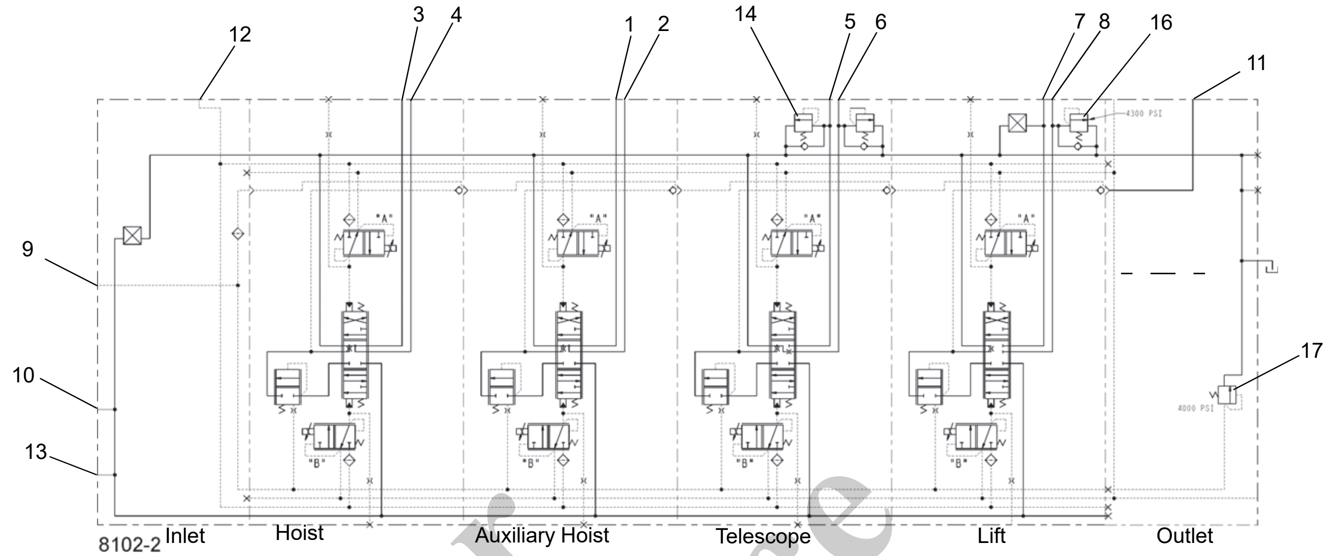


FIGURE 2-14

1	Port 1A -Main Hoist Up	9	Load Sense - Outlet Port
2	Port 1B - Main Hoist Down	10	Port P1 - From Swivel Port 6
3	Port 2A - Aux Hoist Up	11	Load Sense - Inlet Port
4	Port 2B - Aux Hoist Down	12	Port PS - Pilot Supply
5	Port 3A - Telescope Extend	13	Gauge Port
6	Port 3B - Telescope Retract	14	Relief Valve - Telescope Extend
7	Port 4A - Lift Up	16	Relief Valve - Lift
8	Port 4B - Lift Down	17	Relief Valve - Load Sense



Boom Lift/Telescope/Hoist Main Valve Hydraulic Schematic

FIGURE 2-14 continued

ACCESSORY MANIFOLD WITH SWING DIRECTIONAL CONTROL VALVE

Description

The accessory manifold with swing directional control valve (Figure 2-15) is located on the right side of the turntable. The manifold contains two adjustable pressure reducing valves, five 3-way two position solenoid valves, a 3-way four position swing directional valve, and a check valve.

A main pressure relief valve set to 21.4 MPa (3100 psi). One pressure reducing valve provides 1.72 MPa (250 psi) for operation of the swing brake. The other provides 4.1 MPa (600 psi) for the pilot circuit.

Each solenoid valve is held in its normally closed position by a spring. When the solenoid is energized, the plunger assembly forces the spool to shift, causing the valve to shift. De-energizing the solenoid causes spring pressure to shift the spool to its normally closed position.

One two position, three way solenoid valve serves as the swing brake release valve. This normally closed valve, when de-energized, prevents hydraulic oil pressure from releasing the swing brake. When the swing brake switch is off, this valve opens to allow hydraulic oil pressure to release the swing brake.

One proportional two position, three way solenoid valve actuated by the cab swing foot brake proportionally supplies pressurized oil to the swing brake.

A dual pilot-operated, proportional control valve ensures oil flow from the No. 3 gear pump goes to the steering circuit first and then to the swing circuit. A second dual pilot-operated, proportional control valve controls the oil flow from the steering priority valve to maintain pressure in the left and right swing circuits. Excess oil from the valve flows back to tank. The left and right swing functions are controlled by two pilot-operated, solenoid-controlled proportional valves. An additional solenoid-controlled valve acts as a “swing enable” valve, which is only energized when the left or right swing function is actuated. When energized, this valve sends oil through a pilot line to shift the dual pilot-operated, proportional control valve to send full flow from the No. 3 gear pump to the swing circuit.

Maintenance

Removal

1. Tag and disconnect all of the electrical connectors or manual control levers.
2. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.

NOTE: The swing/steer/brake valve manifold, fittings, and mounting bracket weigh approximately 17.0 kg (38.0 lb).

3. Remove the capscrews, lock washers, and flat washers securing the valve bank’s mounting bracket to the superstructure. Remove the valve bank.
4. Remove the capscrews, washers, and nuts securing the valve to the mounting bracket.

Installation

NOTE: Tighten all capscrews following the specifications found under *Fasteners and Torque Values*, page 1-19.

1. Attach the valve bank to the mounting bracket using capscrews, washers, and nuts.
2. Place the valve bank/mounting bracket on the superstructure side plate and secure it with the capscrews, lock washers, and flat washers.
3. Connect the hydraulic lines to the valves as tagged during removal.
4. Connect the electrical connectors to the valve as tagged during removal.

Functional Check

1. Start the engine and run it at normal speed.
2. Operate the functions that the directional control valve controls. Check for smooth operation of cylinders and motors.
3. Check the valve bank(s) and lines for leakage. Make repairs as needed.

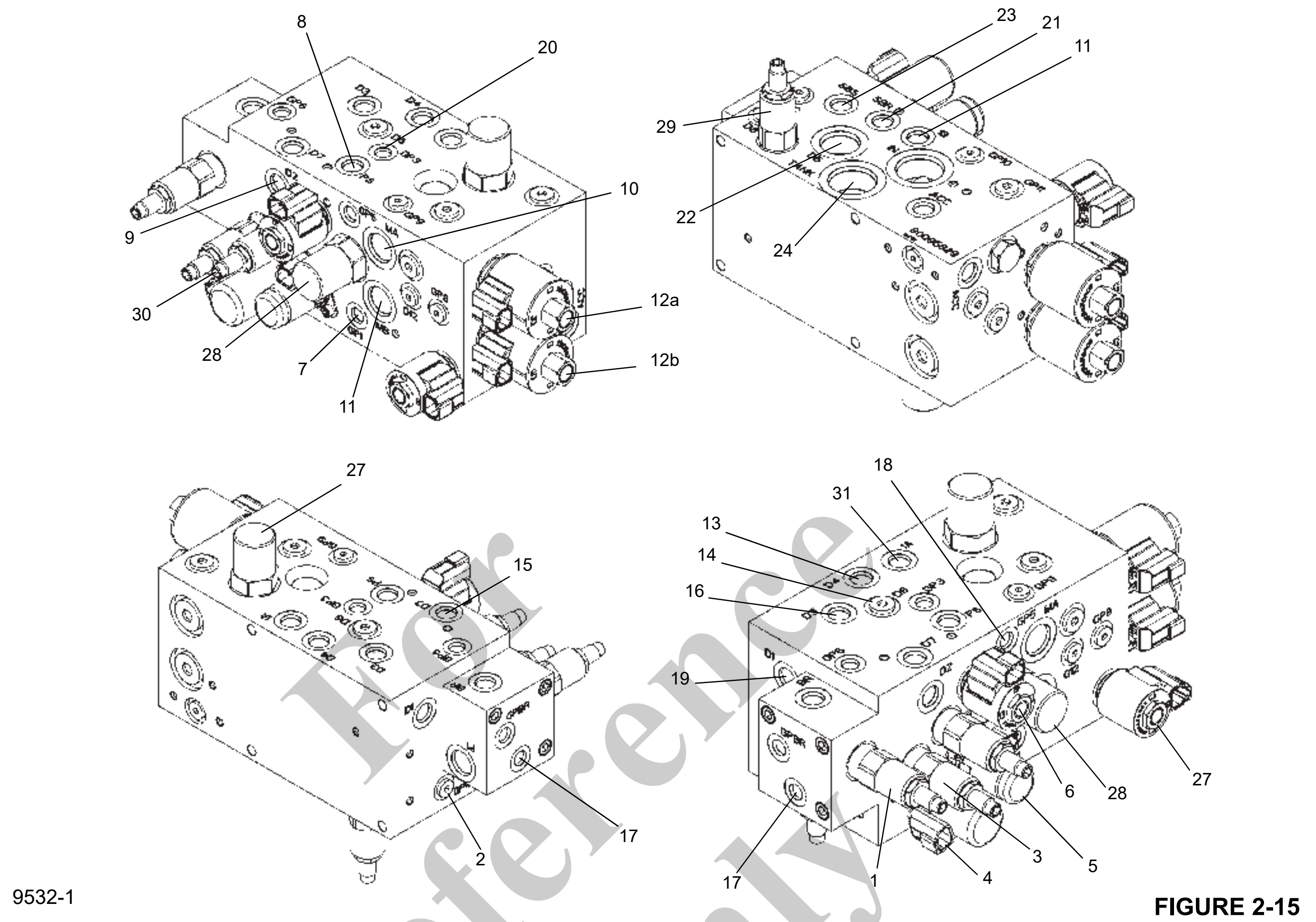


FIGURE 2-15

1	Pilot Supply Relief Valve	16	Drain Port - D3
2	Gauge Port - GP4	17	Gauge Port - GP2
3	Swing Brake Relief Valve	18	Gauge Port - GP5
4	Solenoid Valve - Swing Brake	19	Drain Port - D1
5	Solenoid Valve - Swing Brake Release	20	Gauge Port - GP3
6	Solenoid Valve - Pilot Supply	21	Swing Brake Release Port - SBR
7	Gauge Port - GP1	22	Drain Port - D5
8	Pilot Supply Port - PS	23	Swing Brake Supply Port - SBS
9	Drain - D2	24	Tank Port
10	Port MA - Swing Left	25	Gauge Port - GP6
11	Port MB - Swing Right	26	Gauge Port - GP8
12a	Solenoid Valve - Swing Left	27	Pressure Compensating Proportional Valve - Swing
12b	Solenoid Valve - Swing Right	28	Steering Priority Valve
13	Drain Port - D4 (Swing Motor Pilot Supply)	29	Steer Circuit Load Sense Relief
14	Drain Port - D6 (Hoist/Tele/Lift Valve Pilot Supply)	30	Pilot Supply Relief Valve
15	Drain Port - D7 (Swing Brake/Lift Cylinder Pilot)	31	Steering Load Sense Port, - 1A

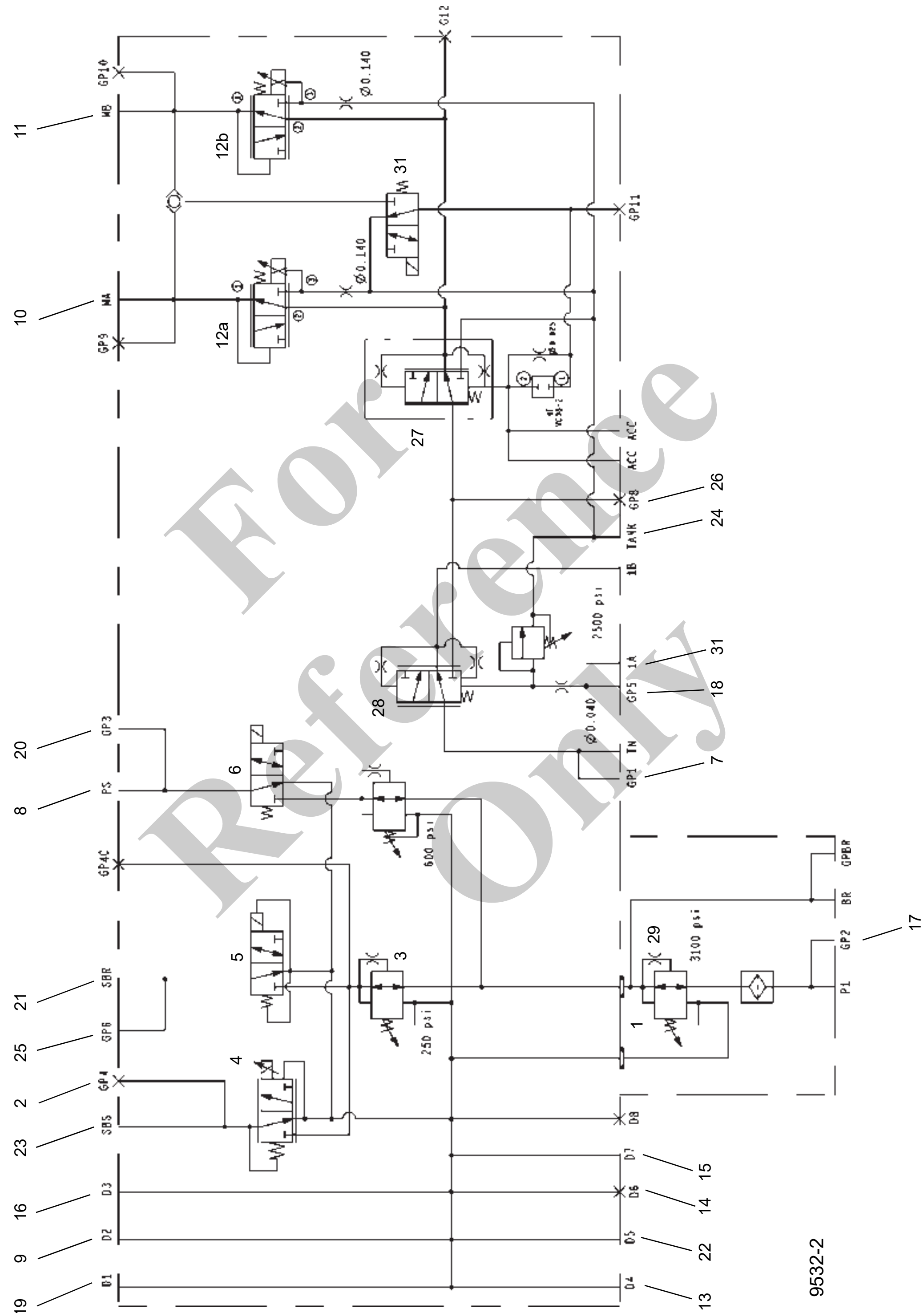


FIGURE 2-15 continued

STEERING CONTROL VALVE

Description

The steering control unit Figure 2-16 controls hydraulic flow to the front steering cylinders. It is located on the steering column of the cab.

Both work ports are connected to the rod side of one steer cylinder and to the piston side of the other steer cylinder. A steering wheel input will connect the load sense port #5 to the steering cylinder load demand by way of the steer priority valve located in the swing/steer manifold.

Displacement of the valve is 315 cm^3 (19.22 in^3).

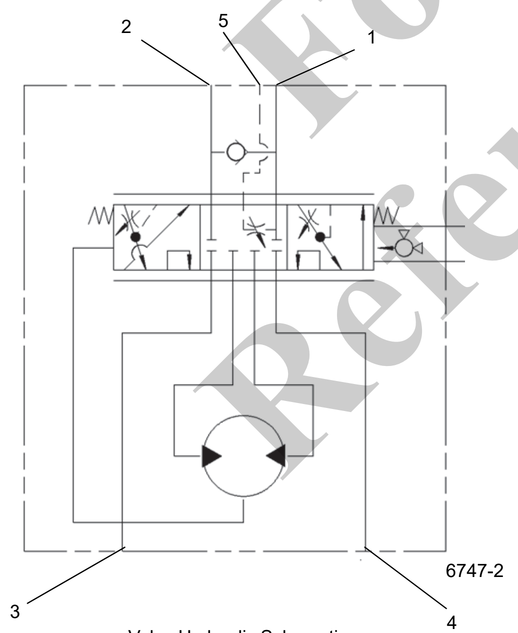
Maintenance

Removal

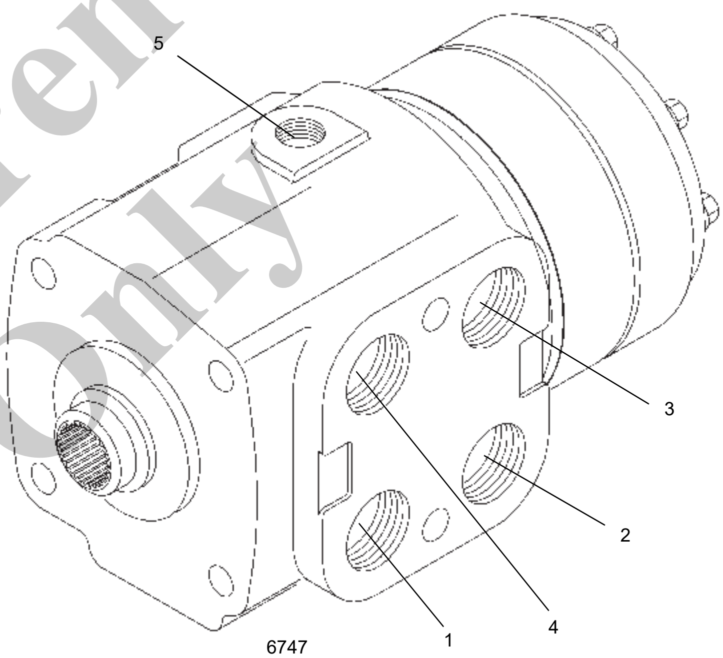
1. Tag and disconnect the electrical connector to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the capscrews and washers and remove the valve from the steering column.

Installation

1. Secure the valve to the steering column and secure with the capscrews and washers. Torque the capscrews see *Fasteners and Torque Values*, page 1-19.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Verify proper operation of the valve.
5. Check valve and hydraulic connections for leaks. Make repairs as needed.



Valve Hydraulic Schematic



Item	Description
1	Port T - Tank Port
2	Port P - Pressure Port
3	Port R - Right Front Steer Cylinder Piston and Left Front Steer Cylinder Rod
4	Port L - Left Front Steer Cylinder Piston and Right Front Steer Cylinder Rod
5	Port LS - Load Sense

FIGURE 2-16

TANDEM BRAKE VALVE WITH TREADLE PEDAL

Description

The tandem brake valve consists of a tandem valve body, a closed center spool, a treadle pedal and a mechanical spring assembly to limit the output pressure to the brake actuators to 15,860 kPa (2300 psi).

The tandem brake valve with treadle pedal (Figure 2-17) is located on the floor of the cab. The tandem brake valve provides split system braking for the primary (front) brakes and the secondary (rear) brakes.

The valve modulates the output pressure [15,860 kPa (2300 psi)] to the brake actuators. The valve is mechanically actuated by a treadle pedal (Figure 2-17). The direct acting spool provides a pedal feel which accurately represents the brake pressure, similar to automotive style pedal feedback as the brake pedal pressure increases, the pedal effort increases proportionally. As the pedal is initially actuated, the tank ports are closed off from the brake ports. With further application of the pedal, the pressure ports are opened to the brake ports until the pedal actuation force and the hydraulic pressure force are balanced.

Also when the pedal is actuated, a pressure switch located off a tee in port F2 provides an electrical signal for brake lights. When the pedal is released, the valve and the pedal return to the non-applied position. In normal operation, the secondary system is piloted from the primary section providing pressure to both systems.

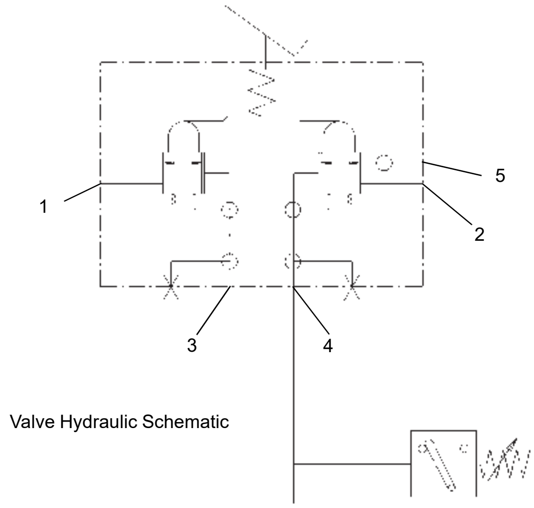
Maintenance

Removal

1. Tag and disconnect the electrical connector to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the capscrews, lockwashers, flatwashers and nuts securing the valve to the cab Floor. Remove the valve.

Installation

1. Secure the valve to the cab floor with the capscrews, lockwashers, flatwashers and nuts. Torque the capscrews 10 to 11 N-m (7.4 to 8.1 lb-ft).
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Bleed the brake system. Refer to *Bleeding the Brake System*, page 8-15.
5. Start the engine and check valve and hoses for leaks. Make repairs as needed.



Item	Description
1	Pressure Port P1
2	Pressure Port P2
3	Port F1 - Front Brakes
4	Port F2 - Rear Brakes
5	Port T - Tank

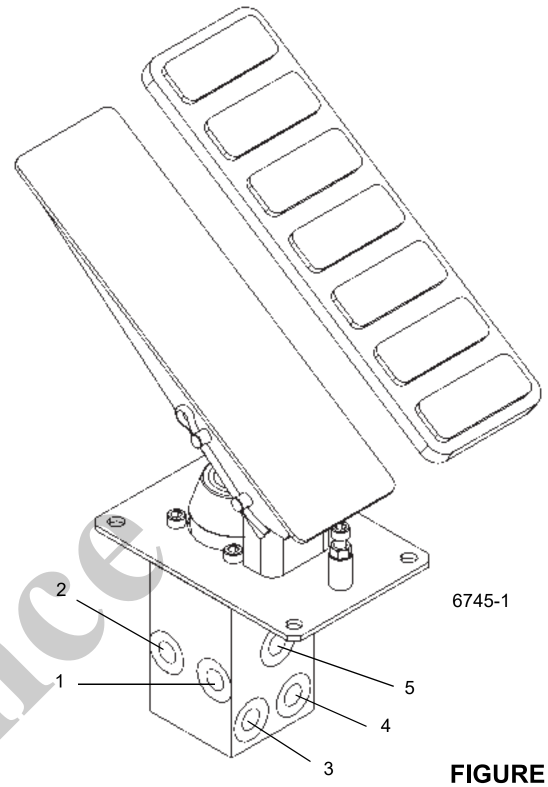


FIGURE 2-17

DUAL ACCUMULATOR CHARGE VALVE

Description

The load sensing dual accumulator charging valve is located on the inside of the left superstructure side plate. The purpose of the valve is to provide pressure regulation to the service brake circuit.

The dual accumulator charge valve consists of an inlet main check valve, a load sense control section with a pilot spool that controls the pump stroke and an inverted shuttle that controls the accumulator charging Figure 2-18.

When the valve is charging the accumulators, the load sense control section is in neutral position, connecting the load to the pump by way of the load sense line. This brings the piston pump No. 1 on stroke to supply fluid for charging. Fluid passes through the main check valve connecting to the pilot end and through the spool onward to the inverted shuttle that connects the accumulators.

When the control pilot spool bias spring senses the low limit pressure of 17,168 kPa (2490 psi), the spool shifts to the neutral position, allowing the pump to charge the accumulators to a maximum of 19995 kPa (2900 psi). The inverted shuttle cartridge senses the pressure in the accumulators to pilot the cartridge closed when maximum charge pressure is reached. Maximum charge pressure also pilots the control pilot spool to open the load sense line to tank, destroking the piston pump No. 1.

Maintenance

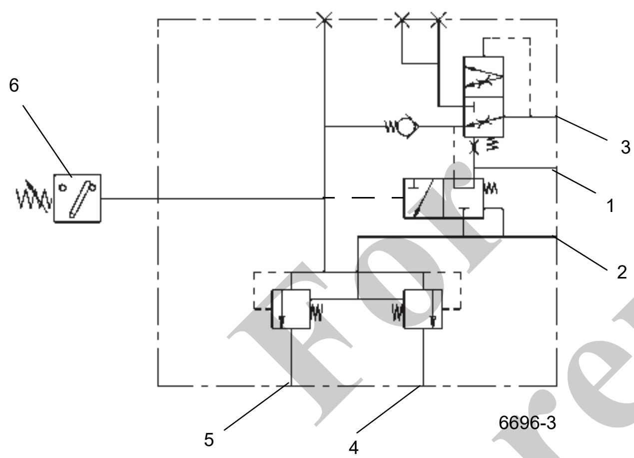
Removal

1. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
2. Remove the capscrews, flatwashers and lockwashers securing the valve to the turntable. Remove the valve.

Installation

1. Position the valve on the turntable and secure with the capscrews, flatwashers, and lockwashers. Torque capscrews see *Fasteners and Torque Values*, page 1-19
2. Connect the hydraulic hoses to the valve ports as tagged during removal.
3. Start the engine and check for leaks. Make repairs as needed.
4. Depress the brake pedal several times to cause the brake valve to charge. Make several turns with the steering wheel, and swing the superstructure left and right. Verify the brakes, swing and front steering work properly.

Item	Description
1	Port LS - Load Sense Port
2	Port T - Tank Port
3	Port P - Pressure Port
4	Accumulator Port A1
5	Accumulator Port A2
6	Pressure Switch



Valve Hydraulic Schematic

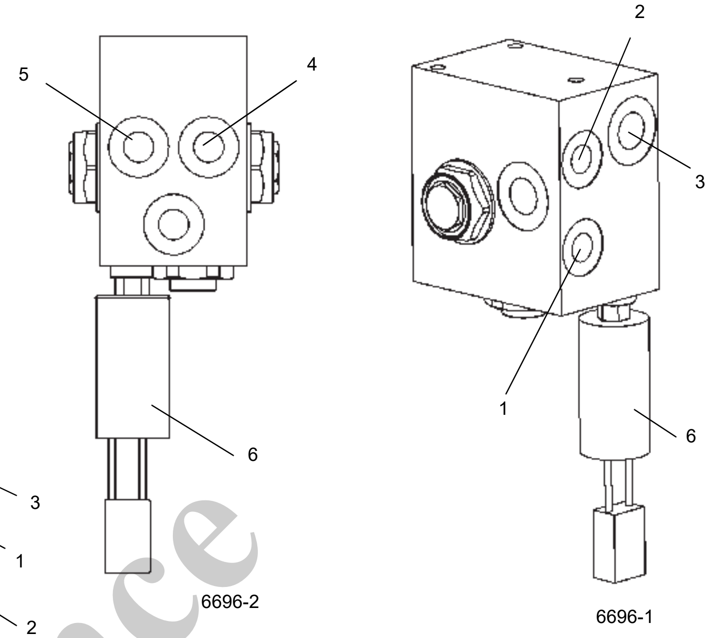


FIGURE 2-18

HYDRAULIC ACCUMULATOR SERVICE BRAKE

Description

The service brake hydraulic accumulators are located in the rear of the superstructure under the hoists. The purpose of each accumulator is to provide stored energy, an oil volume of 1.48 L (90.1 cu in) at a maximum pressure of 20 MPa (2900 psi), to actuate the service brake circuits. The dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits.

Each accumulator has two chambers divided by a piston. One side is pre-charged to 8274 kPa (1200 psi) with high purity nitrogen. This maintains a constant pressure in the other chamber which is connected to the modulating brake valve. After the accumulators are fully charged, they will provide the necessary brake system flow and pressure to actuate the brakes.

The accumulator consists of a tube, piston, seals, gas charging valve, and a gas valve guard.

Maintenance

Removal

1. With the engine shutdown, deplete the hydraulic pressure in the accumulators by depressing the service brake pedal several times.
2. Tag and disconnect the hydraulic hose from the accumulator. Cap or plug the line and port.
3. Remove the two nuts securing each clamp half. Remove the each clamp half and accumulator from the turntable.

Installation

1. Position the accumulator in the clamps and secure with the removable clamp halves and nuts.
2. Connect the hydraulic hose to the port on the accumulator as tagged during removal.
3. Pre-charge the accumulator. Refer to paragraph titled Pre-Charging Accumulator in Sub-Section titled Pressure Setting Procedures.
4. Start the engine and check accumulator and hoses for leaks. Make repairs as needed.
5. Depress the brake pedal several times, make several turns with the steering wheel, and swing the superstructure left and right. Verify the brakes, swing, and front steering work properly.

Servicing

The pre-charge nitrogen pressure should be checked every 200 hours or once a month, whichever comes first. Refer to Pressure Setting Procedures in this section.

HOLDING VALVES

Description

A cartridge style holding valve is installed on the boom lift cylinder. A cartridge style holding valve is used on the telescope cylinder installed in the piston side of the cylinder.

The holding valve provides meter out control, will lock the cylinder in place, prevent a load from running ahead of the oil supply, and will relieve excess pressure caused by thermal expansion.

Maintenance

DANGER

Boom must be fully lowered and fully retracted before removing lift cylinder and telescope cylinder holding valves.

Removal

1. Unscrew holding valve from its port block or manifold.

Installation

1. Check the inside of the port block or manifold for any sharp edges or burrs and remove as necessary with emery cloth.
2. Install new O-rings onto the holding valve.
3. Lubricate the holding valve and O-rings with clean hydraulic oil.

CAUTION

Do not damage the O-rings during installation of the holding valve. If the holding valve turns freely then gets hard to turn, then easy to turn, remove the holding valve and check the O-rings. They have probably been damaged by a sharp edge on one of the ports.

NOTE: The holding valve should turn by hand until compression of the O-rings begins.

4. Carefully install the holding valve into the port block or manifold until fully seated. Tighten holding valve to a torque of 61 to 68 N-m (45 to 50 ft-lb).
5. Test the holding valve and port block or manifold by operating the lift cylinder and/or the telescope cylinder, as applicable. Verify lift cylinder and/or telescope cylinder works without problems; verify there is no leaking. Make repairs as needed.

CROSS AXLE DIFFERENTIAL LOCK VALVE

Description

The optional cross axle differential lock valve is mounted on the right side of the aft center frame cross member. The valve consists of a three way, two position valve without a reducing valve Figure 2-19. The valve is used to control the application of the crane's hydraulically applied and spring released cross axle differential lock actuators.

Pressing the top of the cross axle differential lock switch on the left armrest shifts the three-way, two-position solenoid valve so hydraulic oil can flow to the engage port of the cross axle differential lock actuators, extending them. When the actuators extend, they engage the splines on the differential case and the axle shafts to lock the differential assemblies together.

Releasing the cross axle differential lock switch unlocks the three-way, two-position solenoid valve to release hydraulic pressure to retract-the actuators. As the actuators retract, they unlock the axles.

Maintenance

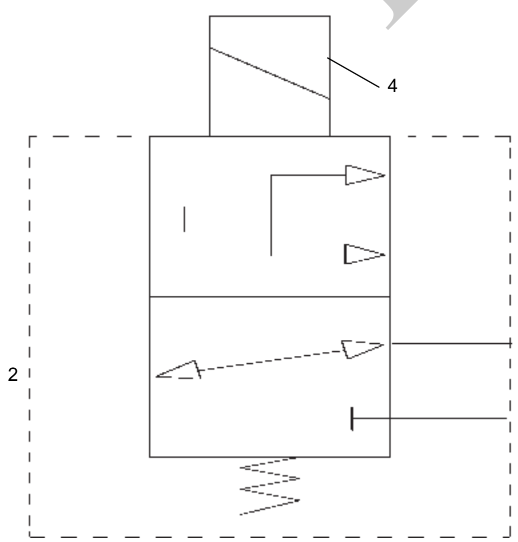
Removal

1. Tag and disconnect the electrical connector from the valve.
2. Tag and disconnect the hydraulic lines attached to the valve. Cap or plug lines and ports.
3. Remove the capscrews, flatwashers, lockwashers and nuts securing the valve to the frame. Remove the valve.

Installation

1. Secure the valve to the frame with the capscrews flatwashers, lockwashers and nuts. Torque the capscrews, see *Fasteners and Torque Values*, page 1-19.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Apply and release the cross axle differential lock several times. Verify the cross axle differential lock holds the axle from moving when applied so there is no differential action between the wheels.
5. Check for leaks. Make repairs as needed.

Item	Description
1	Port 1 to Front and Rear Axle Differential Lock Actuators
2	Port 2 to Park Brake/Shift Valve Port T
3	Port 3 to Park Brake/Shift Valve Port P
4	Coil



Hydraulic Schematic

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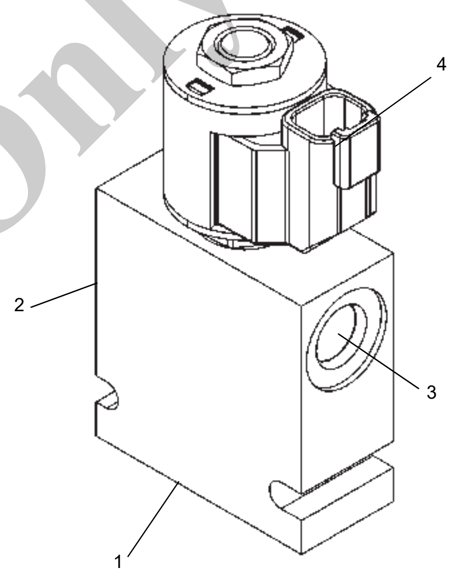

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FIGURE 2-19

OUTRIGGER CONTROL MANIFOLD

Description

There are two outrigger control manifolds utilized on the crane, one for the front outriggers and one for the rear outriggers. The manifold consists of four normally closed two position two way solenoid valves Figure 2-20. They are mounted inside the frame of their respective outrigger box.

When energized, the solenoid shifts the spool to open allowing extension or retraction of the outrigger cylinders.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines to the solenoid valves; cap all lines and openings.
2. Tag and disconnect the electrical connectors.
3. Remove the capscrews, nuts, lockwashers and flatwashers securing the manifold to the outrigger box; remove the manifold.

Inspection

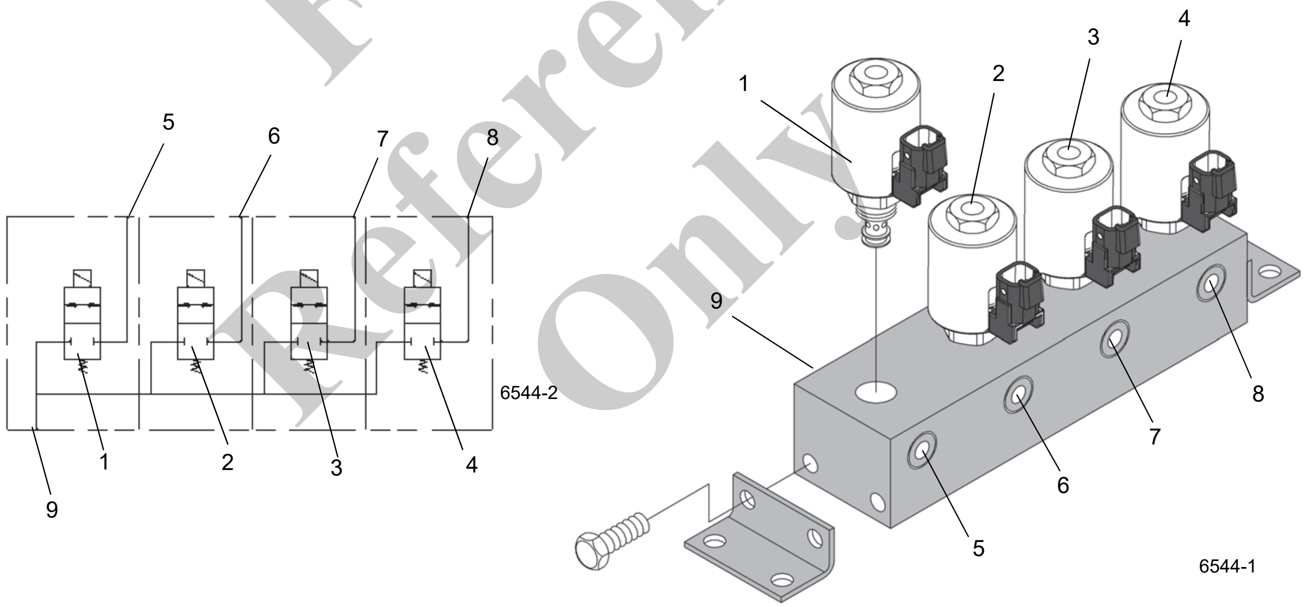
Visually inspect the valves and hydraulic connections for any evidence of leaks or other damage. Check security of the electrical connections. Inspect the wiring for any evidence of cracks or breaks.

Installation

1. Position the manifold on the mounting and secure with the lockwashers, flatwashers, nuts and capscrews. Torque capscrews see *Fasteners and Torque Values*, page 1-19.
2. Connect the electrical connectors to the solenoids as marked during removal.
3. Connect the hydraulic lines to the valves as marked during removal.

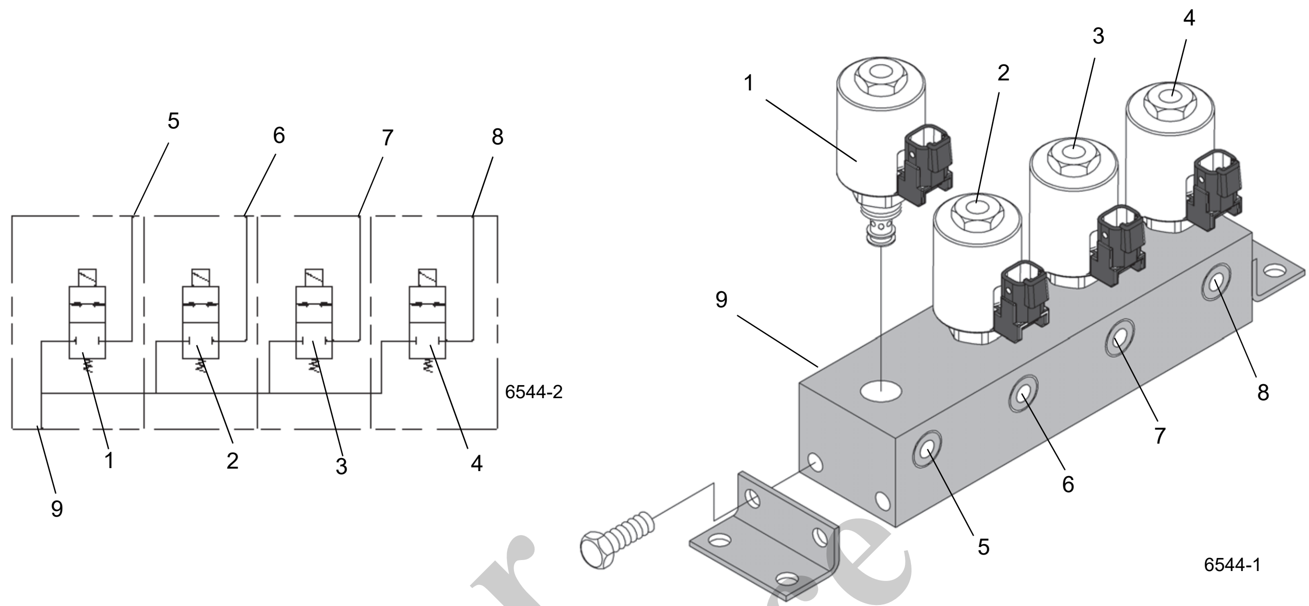
Functional Check

Activate the hydraulic system and cycle the affected cylinder(s) several times. Observe for proper functioning of the affected cylinder(s). Ensure the solenoid valve hydraulic connections are secure.



1	Solenoid Valve - Left Front Extension Cyl	6	Outlet Port Left Front Jack Cylinder
2	Solenoid Valve - Left Front Jack Cylinder	7	Outlet Port Right Front Jack Cylinder
3	Solenoid Valve - Right Front Jack Cylinder	8	Outlet Port Right Front Extension Cyl
4	Solenoid Valve - Right Front Extension Cyl	9	Inlet Port (Far Side) - From Port B of Outrigger Selector Valve
5	Outlet Port - Left Front Extension Cyl		

FIGURE 2-20



1	Solenoid Valve - Left Rear Extension Cyl	6	Outlet Port Left Rear Jack Cylinder
2	Solenoid Valve - Left Rear Jack Cylinder	7	Outlet Port Right Rear Jack Cylinder
3	Solenoid Valve - Right Rear Jack Cylinder	8	Outlet Port Right Rear Extension Cyl
4	Solenoid Valve - Right Rear Extension Cyl	9	Inlet Port (Far Side) - From Port B of Outrigger Selector Valve
5	Outlet Port - Left Rear Extension Cyl		

FIGURE 2-20 continued

PILOT OPERATED CHECK VALVE

Description

A pilot operated (PO) check valve is located in each outrigger jack cylinder port block. The check valve functions as a holding valve for the jack cylinder. Oil flow is directed from the “V” port to the “C” ports, while blocking flow in the opposite direction. Flow is reversed from “C” to “V” when pressure pilot oil is applied to the opposite side “V” port Figure 2-21

Maintenance

DANGER

Make sure there is no load on the outrigger jack before removing the outrigger jack cylinder holding valve.

Removal

1. With no load on the cylinder, unscrew the check valve from the jack cylinder port block.

Installation

1. Check the inside of the port block for any sharp edges or burrs and remove as necessary with emery cloth.
2. Install new O-rings onto the check valve.
3. Lubricate the check valve and O-rings with clean hydraulic oil.

CAUTION

Do not damage the O-rings during installation of the check valve. If the check valve turns freely then gets hard to turn, then easy to turn, remove the check valve and check the O-rings. They have probably been damaged by a sharp edge of a port.

NOTE: The check valve should turn by hand until compression of the O-rings begins.

4. Carefully install the check valve into the port block until fully seated. Tighten check valve to a torque of 149 N-m (110 ft-lb).
5. Test the check valve and port block by operating the affected outrigger’s jack cylinder. Verify it extends and retracts without problems; verify there is no leaking. Make repairs as needed.

NOTE: Refer to *Testing Pilot Operated Check Valve For Leakage*, page 8-36.

Item	Description
1	Port C - Cylinder
2	Port P - Pilot
3	Port V - Valve

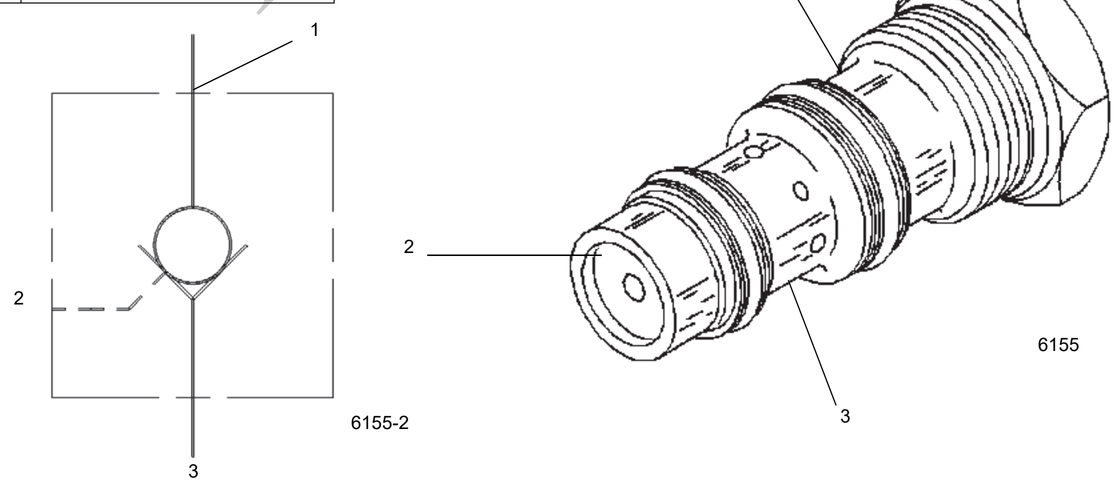


FIGURE 2-21

INTEGRATED OUTRIGGER/REAR STEER MANIFOLD

Description

The integrated outrigger/rear steer manifold (Figure 2-22) controls the outrigger, rear steer circuit, and axle lockout. The valve is mounted on the frame center section to the rear of the front axle.

The manifold is made up of two sections; an inlet section and a working section.

The inlet section contains a 17,200 kPa (2500 psi) pressure reducing valve and a load sense shuttle valve. The solenoid valve is a normally closed two position two way valve. It unloads the load sense line to the pump to ensure the pump is de-stroked during engine start.

The rear steer section contains a three position four way solenoid controlled directional valve that controls left and right rear steer. The rear steer cylinders are positive locked by the double pilot operated check valves integral to the work ports.

The outrigger section contains a three position four way pilot controlled directional valve, two check valves, two load sense shuttle valves, and two, two position three way solenoids for pilot control of the outrigger extend and retract function.

Maintenance

Removal

1. Tag and disconnect the electrical connectors to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the capscrews and washers securing the valve to the frame bracket. Remove the valve.

Installation

1. Secure the valve to the frame bracket with the washers and capscrews. Torque the capscrews see *Fasteners and Torque Values*, page 1-19.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.
4. Verify operation as follows:
   - Operate the rear steer left and right to verify smooth operation.
   - On outriggers, swing over the front outriggers to ensure the axle oscillation cylinders lockout.
5. Check valve and hoses for leaks. Make repairs as needed.

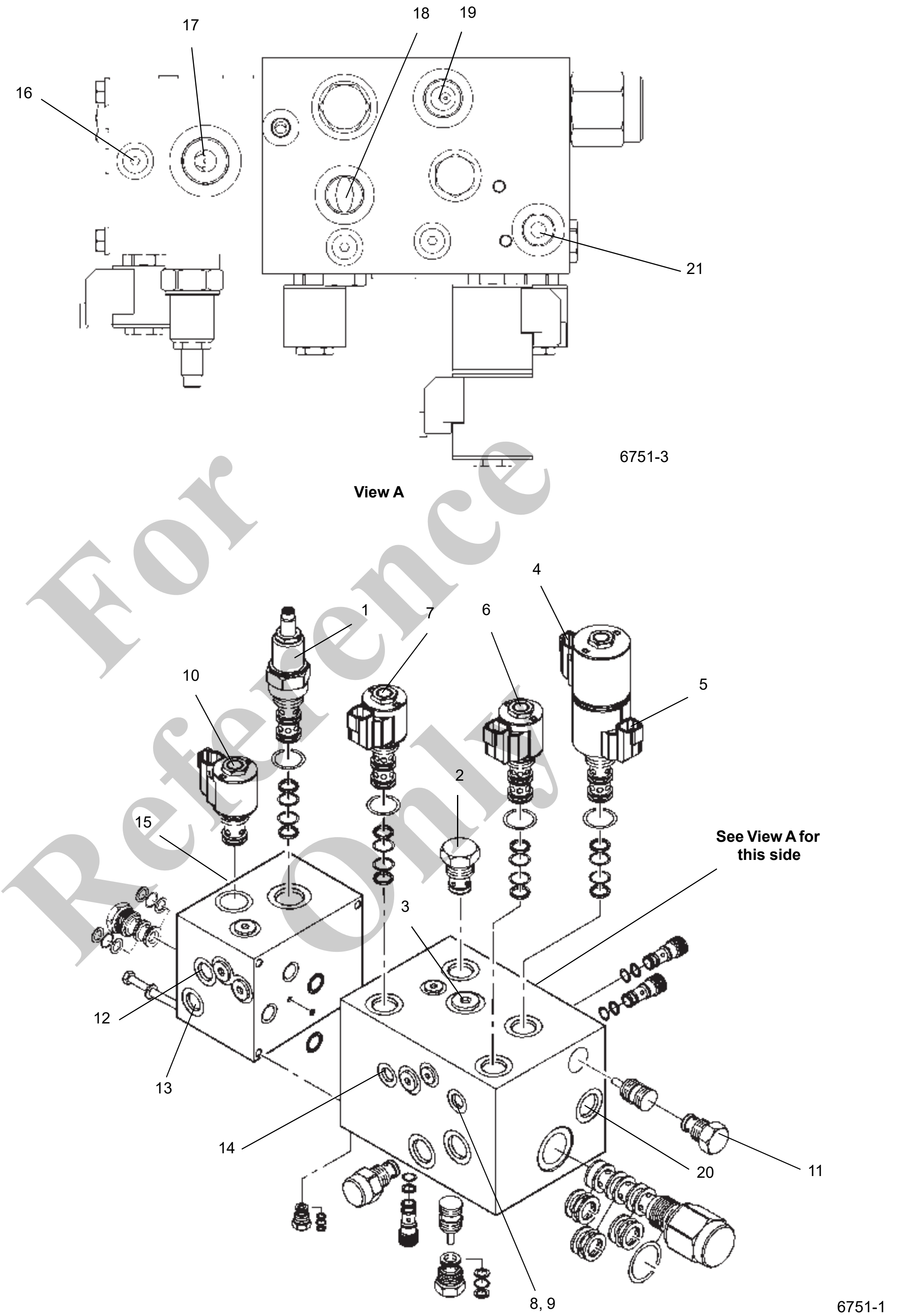

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FIGURE 2-22

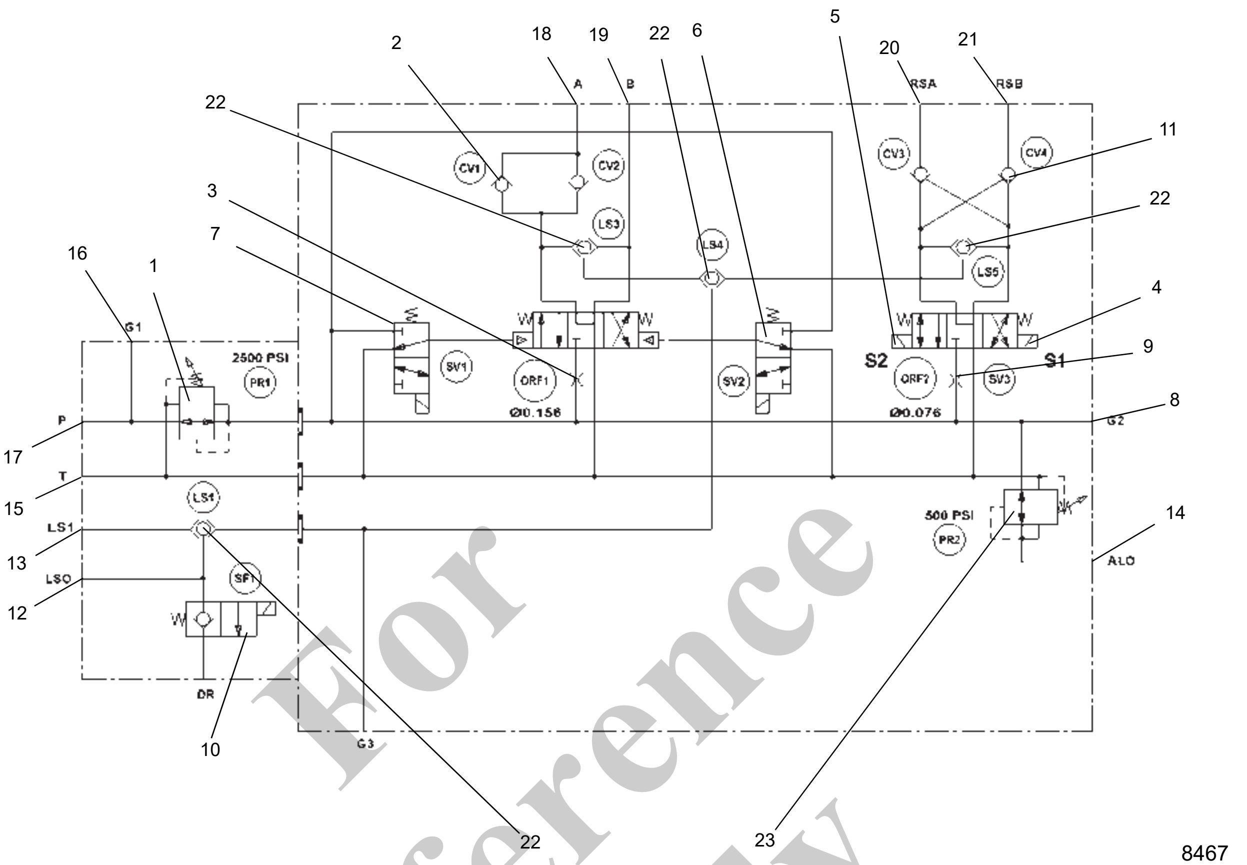


FIGURE 2-22 continued

1	Pressure Reducing Valve - PR1	13	Load Sense - LS1
2	Check Valve - CV1	14	Port ALO - To Axle Lockout Valve
3	Orifice - ORF1	15	Port T - Tank
4	Solenoid Valve - Rear Steer S1	16	Port G1 - Gauge Port
5	Solenoid Valve - Rear Steer S2	17	Port P - Pressure From Pump #1
6	Solenoid Valve - SV2	18	Port A - Outrigger Retract
7	Solenoid Valve - SV1	19	Port B - Outrigger Extend
8	Gauge Port - G2	20	Port RSA - Left Rear Steer
9	Orifice - ORF2	21	Port RSB - Right Rear Steer
10	Solenoid - SF1	22	Load Sense Shuttle Valve
11	Check Valve - CV4	23	Pressure Reducing Valve - PR2
12	Load Sense - LS0		

CHECK VALVES

Description

Check valves are used in the crane hydraulic system to block flow in one direction and allow free flow in the opposite direction.

A check valve is plumbed in-line at the inlet of the front steer control valve. It prevents steering wheel kick-back if the steer cylinder pressure rises above the inlet port pressure.

A 310 KPa (45 psi) check valve in the tank line of the Main Directional Control Valve (Boom Lift/Telescope/Hoist) helps to direct oil flow to the hydraulic oil cooler.

Maintenance

Removal

1. Tag and disconnect hydraulic lines from the valve and cap or plug all openings and remove valve.

Installation

1. Connect the hydraulic lines as tagged during removal.
2. Check valve and hydraulic connections for leaks. Make repairs as needed.

RANGE SHIFT/PARKING BRAKE VALVE

Description

The range shift/parking brake valve controls the flow of oil to the parking brake, transmission hi-low range and axle disconnect actuators by the use of two solenoid valves Figure 2-23. The valve is located on the center of the frame. Pressure is supplied to the valve from the transmission charge pump.

The parking brake solenoid valve is a two position three-way valve. In its de-energized position, the inlet port is blocked and the parking brake actuator is drained to the reservoir. When the solenoid is energized, the reservoir port is blocked and pressurized oil is directed to the actuator, releasing the parking brake.

The range shift solenoid valve is a two position four-way valve. In its de-energized position, pressurized oil flows to the "B" port of the range shift actuator, while the "A" port is drained to the reservoir along with the axle disconnect actuator for two wheel drive/high range. When the solenoid is energized, pressurized oil is directed to the "A" port of the range shift actuator hydraulic spring release while port "B" of the range shift actuator is drained to the reservoir for four wheel drive/low range.

Maintenance

Removal

1. Tag and disconnect the electrical connectors to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the capscrews, lockwashers, flatwashers and nuts securing the valve to the frame. Remove the valve.

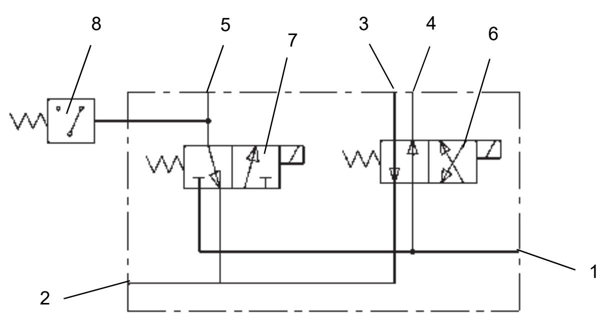
Installation

1. Secure the valve to the frame with the nuts, flatwashers, lockwashers and capscrews. Torque the capscrews, see *Fasteners and Torque Values*, page 1-19.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.

Functional Tests

1. Start and idle engine.
2. With units on outriggers, check for proper two/four wheel operation.

Item	Description
1	Port P - Pressure
2	Port T - Tank
3	Port A - Range Shift Actuator
4	Port B - Range Shift Actuator
5	Port PB - To Park Brake
6	Solenoid Valve - Range Shift
7	Solenoid Valve - Park Brake
8	Pressure Switch



Hydraulic Schematic

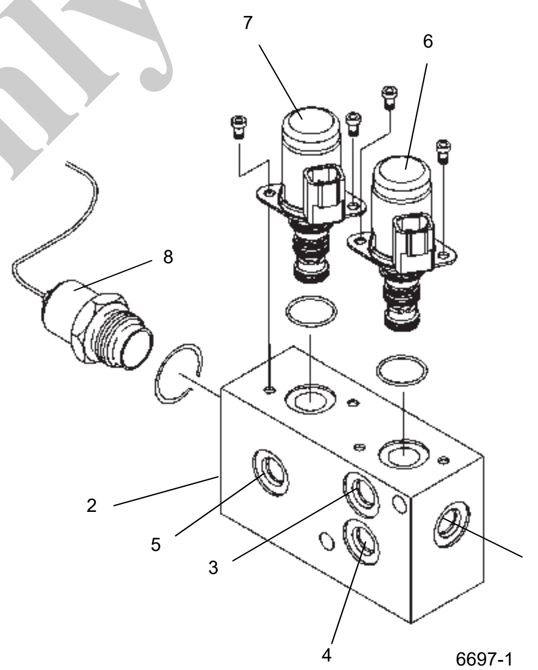


FIGURE 2-23

AXLE OSCILLATION LOCKOUT VALVE (STANDARD UNITS)

Description

The axle oscillation lockout valve (Figure 2-24) is used in the rear axle oscillation lockout circuit. The valve is located on the left inner center frame rail. It consists of a valve body and two normally-closed, two way, two position solenoid valves. It keeps the lockout cylinders from oscillating, unless the turntable is centered forward.

The area definition potentiometer in the electrical swivel energizes and deenergizes the axle oscillation relay. When the superstructure is more than 3 degrees left or right of directly over the front, the axle oscillation relay is deenergized.

When the axle oscillation lockout valve is open, the normally closed solenoid valves are deenergized and isolate the lockout cylinders from hydraulic oil supply. This keeps the cylinders from oscillating (moving up and down) because hydraulic oil cannot leave the cylinders. Instead, the cylinders remain full of hydraulic oil and rigid.

When the axle oscillation lockout valve is closed, the solenoid valves are energized and open. This allows hydraulic oil in and out of the cylinders, allowing them to oscillate.

Maintenance

Removal

1. Tag and disconnect the electrical connectors to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the capscrews, hex nuts, flatwashers and lockwashers securing the valve to the frame. Remove the valve.

Installation

1. Secure the valve to the crane with the capscrews, hex nuts, flatwashers and lockwashers. Torque the capscrews, see *Fasteners and Torque Values*, page 1-19.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.
4. Check valve and hoses for leaks. Make repairs as needed.

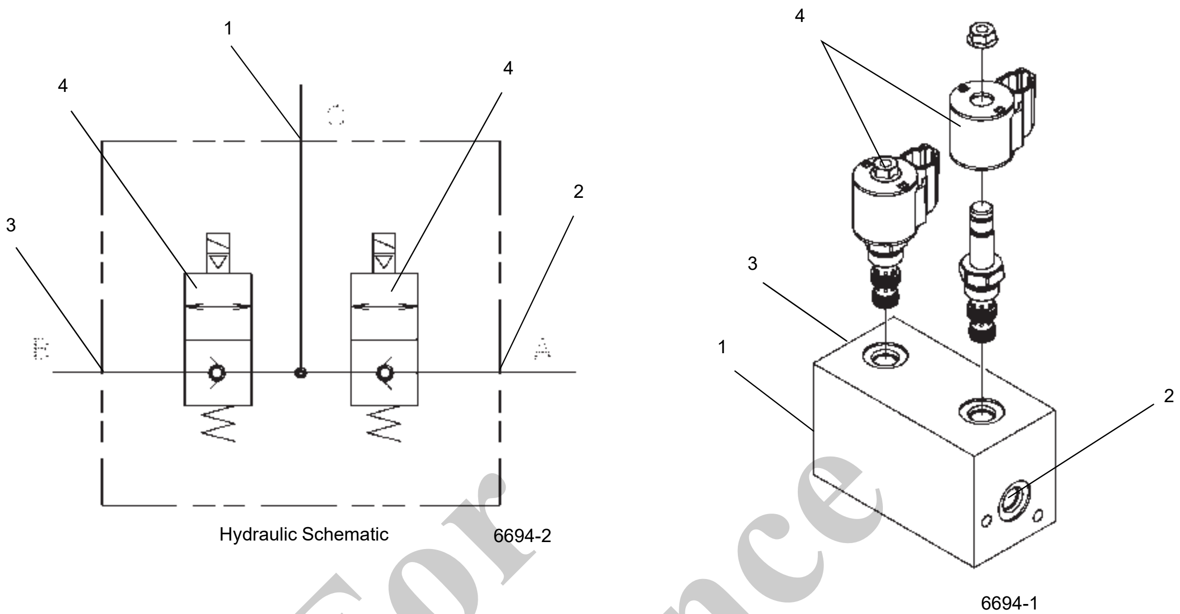


FIGURE 2-24

1	Port C- Pressure From Axle Lockout Port On Outrigger Selector Valve	3	Port B - To Left Hand Lockout Cylinder
2	Port A - To Right Hand Lockout Cylinder	4	Solenoid Valve

AXLE OSCILLATION LOCKOUT VALVE (OPTIONAL CE UNITS)

Description

The axle oscillation lockout valve (Figure 2-25) is used in the rear axle oscillation lockout circuit. The valve is located on the left inner center frame rail. It consists of a valve body, a normally-closed three-way, two position solenoid valve and a pressure reducing valve. It keeps the lockout cylinders from oscillating unless the turntable is centered forward.

The area definition potentiometer in the electrical swivel energizes and deenergizes the axle oscillation relay. When the superstructure is more than 3 degrees left or right of directly over the front, the axle oscillation relay is deenergized.

When the axle oscillation lockout valve is open, the normally closed solenoid valves are deenergized and isolate the lockout cylinders from hydraulic oil supply. This keeps the cylinders from oscillating (moving up and down) because hydraulic oil cannot leave the cylinders. Instead, the cylinders remain full of hydraulic oil and rigid.

When the axle oscillation lockout valve is closed, the solenoid valves are energized and open. This allows hydraulic oil in and out of the cylinders, allowing them to oscillate.

Maintenance

Removal

1. Tag and disconnect the electrical connectors to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the capscrews, hex nuts, flatwashers and lockwashers securing the valve to the frame. Remove the valve.

Installation

1. Secure the valve to the crane with the capscrews, hex nuts, flatwashers and lockwashers. Torque the capscrews, see *Fasteners and Torque Values*, page 1-19.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.
4. Check valve and hoses for leaks. Make repairs as needed.

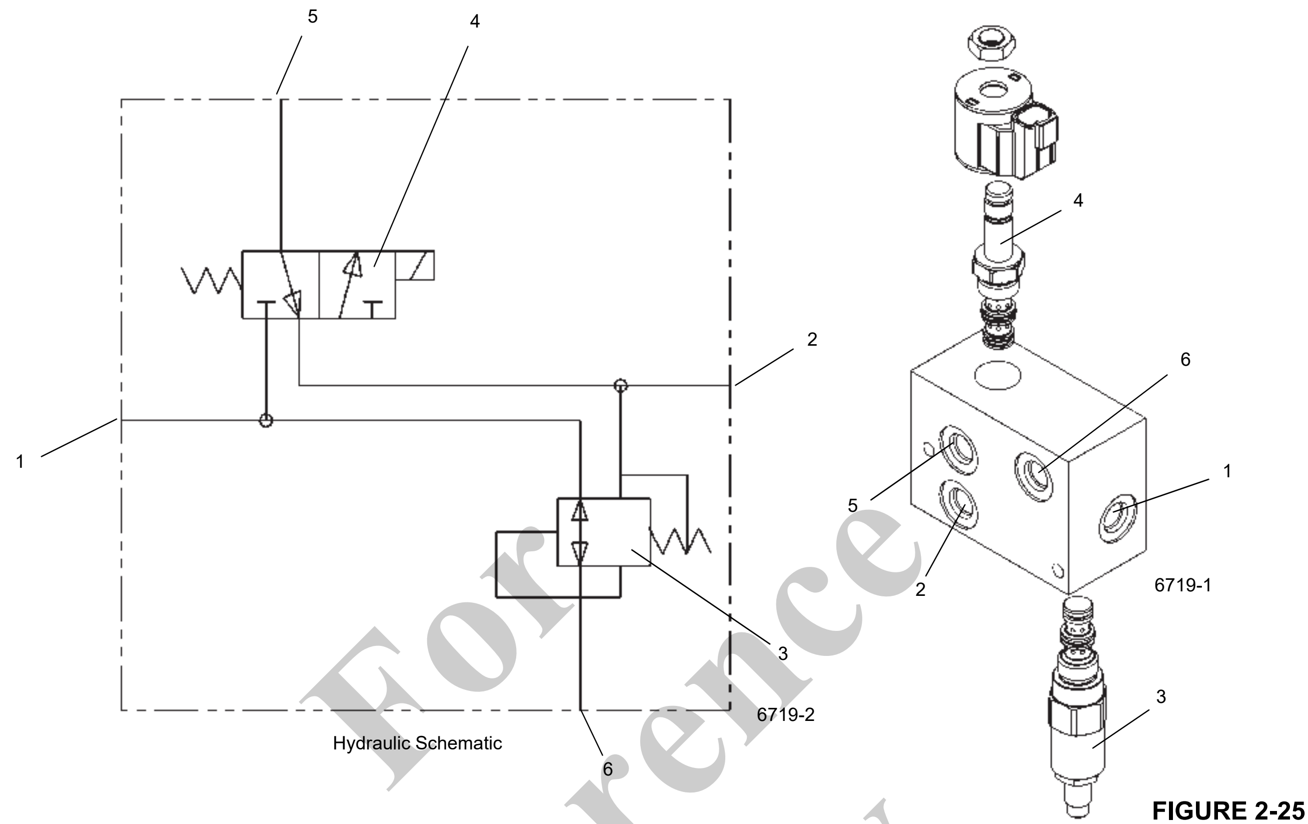


FIGURE 2-25

Item	Description
1	Port P - Pressure From Axle Lockout Port On Outrigger Selector Valve
2	Port T - Tank
3	Pressure Reducing Valve

Item	Description
4	Solenoid Valve
5	Port B - To Lockout Cylinder Pilot
6	Port P1 - To Lockout Cylinders

CYLINDERS

General

This subsection provides descriptive information for all the hydraulic cylinders used on this crane. The description of the cylinder given here is for the cylinder itself. For information on how the cylinder functions in the individual circuits, refer to the Description and Operation of that circuit.

Maintenance

General

There must be a gap between the ends of each wear ring when it is installed onto the piston (as applicable) or head. In addition, each wear ring gap is to be located as follows: Divide 360 degrees by the number of wear rings on the component. The resulting value is the number of degrees each wear ring gap is to be located with respect to each other.

The approximate wear ring gaps are as follows:

Table 2-3
Wear Ring Gap

Head (or Piston) Size		Wear Ring Gap	
Inch	**mm**	**Inch**	**mm**
1 to 4.75	25.4 to 120.7	0.125	3.18
5 to 10.0	127.0 to 254.0	0.187	4.75
greater than 10.0	greater than 254.0	0.250	6.35

Surface Protection for Cylinder Rods

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

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

NOTE: Cylinder operation and inclement weather will remove the Boeshield® protectant; therefore, inspect machines once a week and reapply Boeshield® to unprotected rods.

Leakage Check

A hydraulic cylinder should not be disassembled unless it is essential. The following checks will provide a means of determining if a cylinder has a faulty or leaking piston seal.

1. Extend the rod to its maximum stroke. Remove the retract hose from the cylinder. Cap the retract hose.

DANGER

Ensure pressure is applied to the piston side of the cylinder only and the retract hose is capped.

2. Apply hydraulic pressure to the piston side of the cylinder and observe the open cylinder port for leakage. If leakage is observed, the seals in the cylinder must be replaced.
3. Fully retract the cylinder rod (except the telescope cylinder). Remove the extend hose from the cylinder. Cap the extend hose.

DANGER

Ensure pressure is applied to the retract (rod) side of the cylinder only and that the extend hose is capped.

4. Apply hydraulic pressure to the retract (rod) side of the cylinder and observe the open cylinder port for leakage. If leakage is observed, the seals in the cylinder must be replaced.
5. Reconnect all cylinder ports.

Temperature Effects on Hydraulic Cylinders

Hydraulic oil expands when heated and contracts when cooled. This is a natural phenomena that happens to all liquids. The coefficient of expansion for API Group 1 hydraulic oil is approximately 0.00043 cubic inches per cubic inch of volume for 1°F of temperature change. **Thermal contraction will allow a cylinder to retract as the hydraulic fluid which is trapped in the cylinder cools.** The change in the length of a cylinder is proportional to the extended length of the cylinder and to the change in temperature of the oil in the cylinder. For example, a cylinder extended 25 feet in which the oil cools 60°F would retract approximately 7 3/4 inches (see chart below). A cylinder extended 5 feet in which the oil cools 60°F would only retract approximately 1 1/2 inches. The rate at which the oil cools depends on many factors and will be more noticeable with a larger difference in oil temperature verses the ambient temperature.

Thermal contraction coupled with improper lubrication or improper wear pad adjustments may, under certain conditions, cause a “stick-slip” condition in the boom. This “stick-slip” condition could result in the load not moving smoothly. Proper boom lubrication and wear pad adjustment is important to permit the boom sections to slide freely. Slow movement of the boom may be undetected by the operator, unless a load is suspended for a long period of time. To minimize the effects of thermal contraction or “Stick-slip” it is recommended that the telescope control lever is activated periodically in the extend position to mitigate the effects of cooling oil.

If a load and the boom is allowed to remain stationary for a period of time and the ambient temperature is cooler than the trapped oil temperature, the trapped oil in the cylinders will cool. The load will lower as the telescope cylinder(s) retracts allowing the boom to come in. Also, the boom angle will decrease as the lift cylinder(s) retracts causing an increase in radius and a decrease in load height.

This situation will also occur in reverse. If a crane is set up in the morning with cool oil and the daytime ambient temperature heats the oil, the cylinders will extend in similar proportions.

The charts below have been prepared to assist you in determining the approximate amount of retraction/extension that may be expected from a hydraulic cylinder as a result of change in the temperature of the hydraulic oil inside the cylinder. The chart is for dry rod cylinders. If the cylinder rod is filled with hydraulic oil, the contraction rate is somewhat greater.

NOTE: Operators and service personnel must be aware that load movement, as a result of this phenomena, can be easily mistaken as leaking cylinder seals or faulty holding valves. If leaking seals or faulty holding valves are suspected to be the problem, refer to Service Bulletin 98-036 dealing with testing telescope cylinders.

Table 2-4 Boom Drift Chart (Cylinder length change in inches)

Coeff. =	0.00043	(in^3/in^3/ °F)								
STROKE	Temperature Change (°F)									
(FT.)	10	20	30	40	50	60	70	80	90	100
5	0.26	0.52	0.77	1.03	1.29	1.55	1.81	2.06	2.32	2.58
10	0.52	1.03	1.55	2.06	2.58	3.10	3.61	4.13	4.64	5.16
15	0.77	1.55	2.32	3.10	3.87	4.64	5.42	6.19	6.97	7.74
20	1.03	2.06	3.10	4.13	5.16	6.19	7.22	8.26	9.29	10.32
25	1.29	2.58	3.87	5.16	6.45	7.74	9.03	10.32	11.61	12.90
30	1.55	3.10	4.64	6.19	7.74	9.29	10.84	12.38	13.93	15.48
35	1.81	3.61	5.42	7.22	9.03	10.84	12.64	14.45	16.25	18.06
40	2.06	4.13	6.19	8.26	10.32	12.38	14.45	16.51	18.58	20.64
45	2.32	4.64	6.97	9.29	11.61	13.93	16.25	18.58	20.90	23.22
50	2.58	5.16	7.74	10.32	12.90	15.48	18.06	20.64	23.22	25.80
55	2.84	5.68	8.51	11.35	14.19	17.03	19.87	22.70	25.54	28.38
60	3.10	6.19	9.29	12.38	15.48	18.58	21.67	24.77	27.86	30.96

Length change in inches = Stroke (Ft.) X Temperature Change (°F) X Coeff. (in^3/in^3/ °F) X 12 in/ft

Table 2-5 Boom Drift Chart (Cylinder length change in millimeters)

Coeff. =	0.000774 (1/ °C)										
STROKE	Temperature Change (°C)										
(m)	5	10	15	20	25	30	35	40	45	50	55
1.5	5.81	11.61	17.42	23.22	29.03	34.83	40.64	46.44	52.25	58.05	63.86
3	11.61	23.22	34.83	46.44	58.05	69.66	81.27	92.88	104.49	116.10	127.71
4.5	17.42	34.83	52.25	69.66	87.08	104.49	121.91	139.32	156.74	174.15	191.57
6	23.22	46.44	69.66	92.88	116.10	139.32	162.54	185.76	208.98	232.20	255.42
7.5	29.03	58.05	87.08	116.10	145.13	174.15	203.18	232.20	261.23	290.25	319.28
9	34.83	69.66	104.49	139.32	174.15	208.98	243.81	278.64	313.47	348.30	383.13
10.5	40.64	81.27	121.91	162.54	203.18	243.81	284.45	325.08	365.72	406.35	446.99
12	46.44	92.88	139.32	185.76	232.20	278.64	325.08	371.52	417.96	464.40	510.84
13.5	52.25	104.49	156.74	208.98	261.23	313.47	365.72	417.96	470.21	522.45	574.70
15	58.05	116.10	174.15	232.20	290.25	348.30	406.35	464.40	522.45	580.50	638.55
16.5	63.86	127.71	191.57	255.42	319.28	383.13	446.99	510.84	574.70	638.55	702.41
18	69.66	139.32	208.98	278.64	348.30	417.96	487.62	557.28	626.94	696.60	766.26

Length change in mm = Stroke (m) X Temperature Change (°C) X Coeff. (1/ °C) X 1000 mm/m

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SECTION 3
ELECTRIC SYSTEM

SECTION CONTENTS

DESCRIPTION

General

The electrical system is 24-volt operation with 24-volt starting, consisting of an alternator and two lead-acid batteries. The system is the single wire ground return type, using the machine's structure as ground

Alternator

The alternator is mounted on the engine and is belt driven. It is a 70 ampere alternator. When the engine is running, and the alternator is turning, the alternator's output terminal supplies the crane electrical circuits. The output terminal also supplies the current to recharge the batteries.

Batteries

The batteries are located in a box on the left side of the crane (1) (Figure 3-1). The batteries are maintenance free and completely sealed except for a small vent hole in the side. The vent hole allows what small amount of gases that are produced in the battery to escape. On some batteries, a test indicator located on the top of the battery is used to indicate charge level.

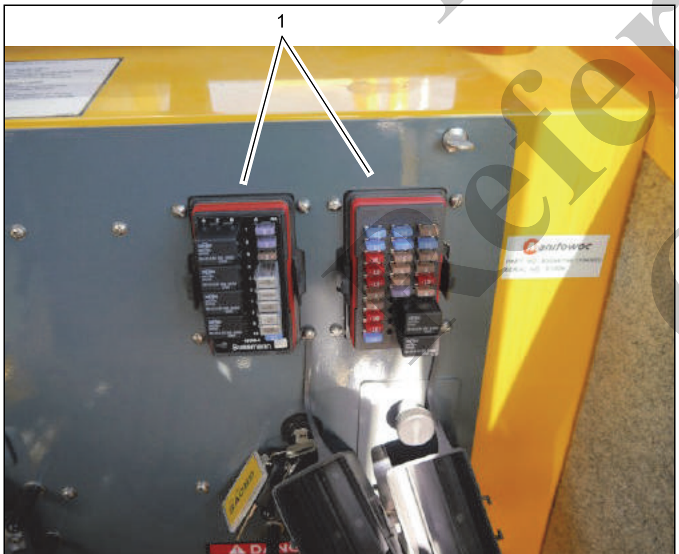
There is a battery disconnect switch (1) (Figure 3-2) located to the right on the battery box.

FIGURE 3-1

9582 **FIGURE 3-2**

Fuse and Relay Panels

Fuses and relays are located behind the seat in the cab (1, Figure 3-3). In the battery box fuse panel (1, Figure 3-4).



9583 **FIGURE 3-3**

The cab fuse and relay assignments are as follows:

Table 3-1 Cab Fuse and Relay Box 1

Fuse	Protects	Amps	Location
F1	UB + T/T CCM10 Module Battery Power	15	Figure 3-3
F2	UB + T/T CCM10 Module Battery Power	15	Figure 3-3
F3	UB + Cab IOL32 Module Battery Power	10	Figure 3-3
F4	UB + Cab IOL32/SCM0 Module/Operator Display Battery Power	15	Figure 3-3
F5	Keyswitch Power	10	Figure 3-3
F6	Steering Column Power	5	Figure 3-3
F7	Dome Lights	5	Figure 3-3
F8	Work Lights	10	Figure 3-3
F9	12V Outlet	10	Figure 3-3
F10	Diagnostic Tool Power	15	Figure 3-3
F11	UB + T/T IOL30 Module Battery Power	15	Figure 3-3
F12	UB + T/T IOL30 Module Battery Power	15	Figure 3-3
F13	UE + Cab SCM0/IOL32 Module Battery Power	5	Figure 3-3
F14	UE + T/T CCM10/IOL30 Module Battery Power	5	Figure 3-3
F15	Jog Dial/Status Light Bar/Operator Displayed Fused Relay Power	5	Figure 3-3
F16	Accessory Lights Power	5	Figure 3-3
F17	Heater/AC Panel Power	15	Figure 3-3
F18	Circulating Fan	5	Figure 3-3
F19	Spare	5	Figure 3-3
F20	Skylight Wiper	10	Figure 3-3
F21	Cranestar Battery Power	5	Figure 3-3
F22	Switch Power	3	Figure 3-3
K104	Jog Dial/Status Light Bar/Operator Display Relay	-	Figure 3-3
K103	Skylight Wiper Relay	-	Figure 3-3

Table 3-2 Cab Fuse and Relay Box 2

Fuse	Protects	Amps	Location
F1	Keyswitch Ignition	3	Figure 3-3
F2	System Wake Up	3	Figure 3-3
F3	Ignition Signal from E-Stop Switch	5	Figure 3-3
D1	Fused Keyswitch Ignition	-	Figure 3-3
D2	Brake Pedal Pressure Switch	-	Figure 3-3
D3	Hazard/Signal Lights	-	Figure 3-3
D4	Marker Lights	-	Figure 3-3
D5	Horn	-	Figure 3-3
F4	Accessory Relay Fused Power	-	Figure 3-3
F5	Hydraulic Oil Cooler Power	-	Figure 3-3
K102	Accessory Relay	-	Figure 3-3
K105	Available	-	Figure 3-3
K106	Available	-	Figure 3-3
K107	Horn Relay	-	Figure 3-3

Table 3-3 Carrier Fuse and Relay Box 1

Fuse	Protects	Amps	Location
F1	Fused Battery Power	20	Figure 3-4
F2	UE + Carrier CCM3/ IOL31 Module Battery Power	15	Figure 3-4
F3	Engine ECM Power	30	Figure 3-4
K108	Starter Lockout Relay	-	Figure 3-4

Table 3-4 Carrier Fuse and Relay Box - Tier 4 Only

Fuse	Protects	Amps	Location
F101	DEF Lines Heater Fused Relay Power	15	Figure 3-4
F102	DEF Lines Heater Fused Relay Coil Power	5	Figure 3-4
F103	DEF Supply Module Fused Relay Power	10	Figure 3-4
F104	Aftertreatment Sensors Fused Relay Power	10	Figure 3-4
F105	Aftertreatment Sensors Fused Relay Coil Power	5	Figure 3-4
D1	Pressure Line Heater	-	Figure 3-4
D2	Return Line Heater	-	Figure 3-4
D3	Suction Line Heater	-	Figure 3-4
K109	DEF Lines Heater Relay	-	Figure 3-4
K110	DEF Supply Module	-	Figure 3-4
K111	Aftertreatment Sensors Power Relay	-	Figure 3-4

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FIGURE 3-4

3

Table 3-5 Carrier Fuse and Relay Box 2

Fuse	Protects	Amps	Location
F1	Air Intake Heater Power	125	Figure 3-6
F2	Battery Feed to Cab Wire #5	100	Figure 3-6
F3	Battery Feed to Cab Wire #1274	100	Figure 3-6
F4	Battery Feed to Cab Wire #6	100	Figure 3-6
FA	Module Battery Power	15	Figure 3-6
FB	UB + Carrier CCM11/ IOL31 Module Battery Power	15	Figure 3-6
FC	Starter Lockout Fused Relay Power	5	Figure 3-6
FD	Cold Weather Power	15	Figure 3-6
FE	Cold Weather Power	15	Figure 3-6
FF	Diagnostic Tool Power	5	Figure 3-6

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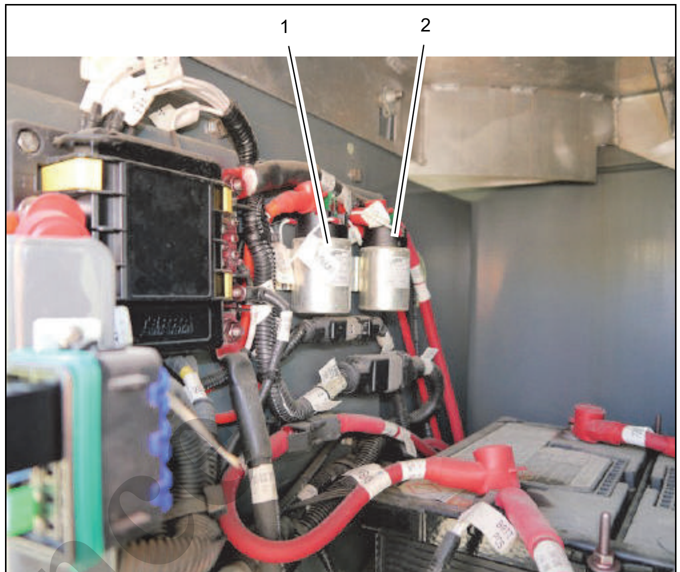
FIGURE 3-5

Relays

The relays are located at the back of the battery box (Figure 3-6): starter relay (1) and grid heater relay (2).



9585

FIGURE 3-6

MAINTENANCE

General

Electrical system maintenance includes troubleshooting and replacement of damaged components. Observe standard wiring practices when replacing components.

CAUTION

If it is necessary to perform electrical maintenance on live or hot circuits, remove all rings, watches, and other jewelry before performing maintenance as serious burns result from accidental grounding or shorting circuits.

CAUTION

Ensure the batteries are disconnected before performing any maintenance on an electrical circuit which is not fused or when performing continuity checks.

Never replace original wiring with wiring of a smaller size (gauge).

Dielectric Grease

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

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

Excluded Connections

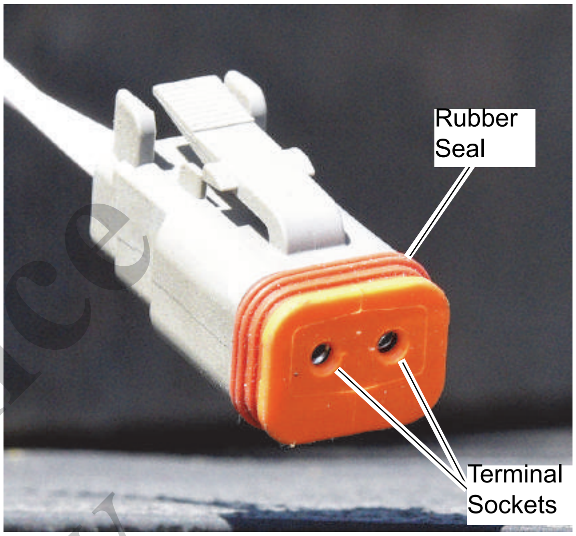
Do not apply dielectric grease to the following connections:

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

Applying Dielectric Grease to an Electrical Connector

Use the following procedure to apply dielectric grease to an electrical connection. Grease should be applied immediately prior to securing the connector. Ensure that grease is applied to all terminal sockets (Figure 3-7).

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



Example. For illustration purposes only. Your connector may differ. **FIGURE 3-7**

4. Use a clean towel to remove excess grease from the surface of the connector, and wipe grease into the terminal sockets (Figure 3-7).
5. Ensure grease is applied to each terminal socket. The towel with excess grease can be used to fill empty terminal sockets (Figure 3-7).
6. Ensure grease is applied to the entire surface of the connector's rubber seal (Figure 3-7).

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

7. If clean up is necessary, contact cleaner or petroleum distillates can be used.
8. Secure the connector when complete.

General Troubleshooting

CAUTION

Many steps in the troubleshooting procedures require testing live (energized) components. Perform these steps observing good safety practices to avoid electrical shock injury.

NOTE: Make voltage checks at terminations when components are installed and operating. Make continuity checks (with batteries disconnected) when components are isolated or removed. Troubleshoot per the following guidelines:

1. First, use reported symptoms to identify a problem or a suspect component.
2. Test the suspect component per instructions in this section. The instructions identify the circuit breakers and components and guide you from the easiest and most likely problems to the hardest and least likely problems.
3. Using a multimeter, test the circuit for continuity if you suspect a broken circuit or for voltage if you suspect a power problem. Check the electrical schematic and wiring diagram for most accurate wiring information.
4. If the component proves faulty, replace it with a known working component.
5. If wiring proves faulty, this is typically the result of another failure within the electrical system. Identify and investigate the root cause of failure. Make necessary component repairs as outlined in the following sections. Proceed to make appropriate wiring fault repair. Wiring repairs must be made using Manitowoc approved materials.
6. Splicing sections of broken wire must have terminations that meet minimum pull test requirements listed in Table 3-6. Splices must be completely covered with adhesive lined shrink tubing. Tubing must extend beyond any bare conductors by at least ¼”.

Table 3-6 Minimum Pull Values (lbs)

Wire Gauge	Single Wire	Two Wire Termination
24	10	8
22	15	10
20	20	17
18	30	20
16	40	30
14	60	50
12	70	60
10	80	70
8	90	80
6	100	90
4	140	120

7. After troubleshooting, test the repaired harness. Verify the circuit works properly.

Troubleshooting Swivel-Caused Electrical Problems

Troubles common to the swivel are improper mounting, foreign material between the brushes and slip rings, incorrect wiring from the swivel to the components, incorrect wire size, worn brushes, improper spring tension on the brush assembly, and loose setscrews on the slip ring assembly. Refer to the electrical schematic and wiring diagram for slip ring connections and amperages.

Connector Troubleshooting

The cause of an electrical problem may be a loose or corroded connection in the pin or socket connectors. Check the connectors to ensure that the pins and sockets are properly seated and engaged. If the pins and sockets show any signs of corrosion, use a good quality electrical contact cleaner or fine sandpaper to clean them. When the pins or sockets show signs of arcing or burning, it indicates another failure within the electrical system that might cause the condition. Identify and investigate the root cause of the failure, make necessary component repairs and then proceed to make the necessary wire terminal repairs.

When replacing wire terminals, use the proper crimp tool to ensure the proper crimping method. Refer to the tables at the end of this section listing tools necessary for connector maintenance. These tables list common tools; contact Manitowoc CraneCare to ensure the proper crimp tool is available.

Refer to Table 3-7 Amp Extraction Tool Table, Table 3-8 Amp Crimping Tool Table, Table 3-9 Deutsch Extraction Tool Table and Table 3-10 Deutsch Crimping Tool Table for listing of tools necessary for connector maintenance.

Table 3-7
Amp Extraction Tool Table

Description	Amp Part Number	Grove Part Number
14 gauge wire (connectors)	305183	9-999-100176
12 to 8 gauge wire (connectors)	91019-3	9-999-100175
4 to 9 circuit (in-line connectors)	453300-1	N/A
15 circuit (in-line connectors)	458944-1	N/A

Table 3-8
Amp Crimping Tool Table

Description	Amp Part Number		Grove Part Number	
	Tool	Die	Tool	Die
14 to 12 gauge wire	69710-1	90145-1	9-999-100177	N/A
10 to 8 gauge wire	69710-1	90140-1	9-999-100177	9-999-100178
4 to 9 circuit (in-line connectors	69710-1	90306-1	9-999-100177	N/A
15 circuit (in-line connectors	90299-1	--	N/A	--

Table 3-9
Deutsch Extraction Tool Table

Description	Deutsch Part Number	Grove Part Number
12 gauge wire	114010	9-999-100194
16 gauge wire	0411-204-1605	9-999-100195
8-10 gauge wire	114008	7-902-000012
4-6 gauge wire	114009	7-902-000009

Table 3-10
Deutsch Crimping Tool Table

Description	Deutsch Part Number	Grove Part Number
12, 14, 16, 18, 20 gauge wire	HDT-48-00	9-999-100808
4, 6, 8, 10 gauge wire	HDT04-08	9-999-100842

Because the pins and sockets are crimped to the wires, it is not possible to remove them. Using the proper extraction tool, remove the pin(s) or socket(s) from the plug or receptacle. Cut the wire as close to the pin or socket as possible. After cutting the pin or socket off, the wire will most likely be too short. Using a wire that is too short will allow pressure to be applied to the pin or socket and wire where they are crimped when the pin or socket is inserted in the plug or receptacle. Splice a short length of wire to the short wire according to the guidelines in the General Troubleshooting section.

Jump Starting Hazard

Do not attempt to jump start the crane.

CAUTION

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

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

The batteries should be completely disconnected from the crane electrical system and charged using a battery charger of appropriate voltage level or replace the batteries with fully charged batteries. Refer to *Charging the Batteries*, page 3-8.

Charging the Batteries

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

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

Troubleshooting Engine Starting Problems

1. Verify the battery terminals are connected and clean, none of the fuses are blown, the transmission is in neutral, and the machine is fueled.
2. Turn on the head lights, tails lights, marker lights, dome light, work light, or gauge lights and panel lights to verify the battery has at least some charge. If none of these lights comes on, suspect the battery. Charge battery as needed or replace the battery.
3. If you hear the starter relay clicking repeatedly, power is reaching the starter, but not enough; suspect the battery. Charge battery as needed or replace the battery.
4. If the problem remains, troubleshoot the starter lockout relay. Use service tool for starter lockout input signal to CCM11. Also, check starter lockout relay to ensure it is energized.
5. Using the service tool (see "Using Service Tool Section"), check for proper Keyswitch input signals and Start output signals. With the Service Tool connected to the crane A channel, Select View, Cab, Steering Column. Watch the Keystate value for each position of the Keyswitch:

   O=OFF

   I=ON

   II=START
6. If the battery, fuses, secondary circuit, ignition switch, and power circuit to the ignition switch check out, do one of the following:
   a. If you hear no noise when you try to turn the starter, troubleshoot the start circuit (ignition switch, electric shifter, and wiring from ignition switch to starter relay). Make repairs as needed.
   b. If the engine still won't start, and you hear no noise or just a single click, suspect the starter. Troubleshoot the starter circuit from the starter relay through the starter solenoid to the starter motor and ground. Make repairs as needed. If the starter solenoid or the starter motor is faulty, replace the starter.
   c. If the starter engages but can't turn the engine (and the lights dim, signaling power drain during start attempt), check the starter's feed circuit from the batteries for resistance.
   d. If the starter turns the engine, but it still won't start, suspect a fuel problem. Ensure fuel system can draw fuel from the tank and pump it to the engine; make repairs as needed.
   e. If the engine starts, then shuts down, suspect a fuel problem. Ensure fuel system can draw fuel from the

tank and pump it to the engine; make repairs as needed.

7. Refer to the engine manual for further instructions.

NOTE: If the starter won't disengage during running, verify the starter is mounted properly so its gear won't mesh with the engine's flywheel when not trying to start engine. Troubleshoot the starter relay and ignition switch for closed contacts. If these components check out, replace the starter.

Troubleshooting Battery Charging Problems

1. Verify battery terminals are connected and clean and all wires in the charging system are in good repair and are connected properly.

2. Verify the alternator belt is properly installed and is under proper tension.

3. Verify the batteries are charged to 24 volts minimum. Charge battery as needed so the battery can supply a minimum excitation voltage to the engine's charging system.

4. With the crane running, verify that the alternator output is close to 27VDC on the voltmeter.

5. Replace the alternator if the other conditions check out.

NOTE: If the alternator runs noisily, check belt tension. If problem persists, replace alternator.

NOTE: If the alternator overcharges (voltmeter reads high, light bulbs burn out quickly), check for a short to ground. If external wiring checks out, replace alternator.

Troubleshooting Accessories

If the crane's engine starts and charges properly, but none of its components except the horn or lights work, the accessory circuitry may be faulty. Check as follows:

1. Turn the ignition switch to ON (Position 1). Try to turn on the cab circulating fan, the heater fan, the defroster fan, or the windshield wipers or washer. If none of these come on (but the head lights, tail lights, marker lights, dome light or work light will come on), there is an accessory circuitry problem.

2. Check the primary power circuit to the accessory relay K101 in the Cab fuse & relay panel. Make circuit repairs as needed.

3. If the problem remains, check the ignition switch and the accessory control circuit from the ignition switch through the coil of the accessory relay (KS1) to ground. Turn the ignition switch to ON (Position 1) and shift the electric shifter to reverse; if the backup lights and backup alarm do not turn on, then there is no power through the switch when it is on (Position 1). Replace ignition switch if there is no power through it when it is ON (Position 1). Replace accessory relay if there is no continuity through it's coil. Make circuit repairs to accessory control circuit as needed.

4. If the problem remains, check the accessory relay (K101) contacts and the accessory power circuit. Replace relay if its contacts stay open when the coil is energized. Make circuit repairs as needed.

Alternator Replacement

Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove and isolate the negative battery cables.
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the alternator.
7. Turn the tensioner below the alternator clockwise to remove tension from the belt. Slip the belt off of the alternator pulley, then let the tensioner return to its normal position.
8. Remove and tag all wires.
9. Remove the four bolts securing the alternator to the engine. Remove the alternator.

Installation

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

Check

1. Run engine. Verify reading of voltmeter on front console is 24 volts or greater. Make repairs as needed.
2. Continue troubleshooting charging system as needed if replacement of alternator did not correct problem in charging system.

Starter Replacement

Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove and isolate the negative battery cables.
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the starter.
7. Remove the bolts holding the starter to the mounting pad. Remove the starter.

Installation

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

Check

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

Battery Replacement

Removal

CAUTION

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

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

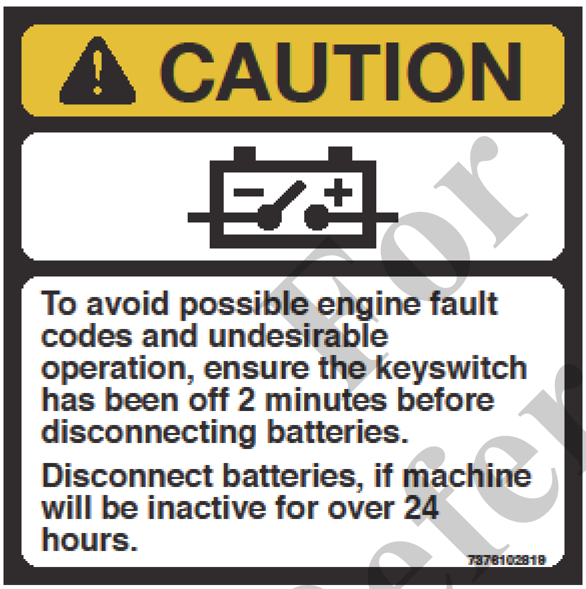


FIGURE 3-8

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove the negative battery cables.
5. Remove the positive battery cables.
6. Tag and disconnect leads from the battery terminals starting with the positive terminals.
7. Remove the nuts and washers from the bracket hold down rods. Remove the hold down bracket.
8. Remove the batteries.

Installation

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

Relay Panel Component Replacement

Accessory Relay

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Tag and disconnect the electrical leads from the suspect relay.
4. Remove the hardware securing the suspect relay to the relay panel assembly. Remove suspect relay.
5. Install replacement relay on relay panel and secure it with attaching hardware.
6. Connect the electrical leads to the relay as tagged during removal.
7. Connect the batteries.
8. Turn the battery disconnect switch to the ON position.
9. Verify proper installation by operating all components involved with the replacement relay verifying they all work.

Steering Column Rocker Switch Replacement

Use the following procedures and refer to Figure 3-9 when removing/installing a switch.

Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
4. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
5. Remove the four screws (13) securing the left and right side covers (8, 9) together.
6. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).

7. Remove the left side cover (8) from the steering column.
8. Disconnect the wire harness from the back of the ignition switch (10).
9. Remove the right side cover (9) from the steering column.
10. Disconnect the wire harness from the bottom of the switch (4) that must be replaced. Remove the switch by squeezing the retaining clips on each side of switch and pushing upwards until switch is free of cover.

Inspection

1. Visually check the switch for evidence of cracks, damaged connections, or other damage. Replace damaged switch as needed.
2. Check wiring for damaged insulation or damaged connectors. Repair as needed.
3. Check all connectors for corrosion. Replace corroded components as needed.
4. Perform the following check to determine switch serviceability.
   a. Using an ohmmeter, check for continuity between the switch terminals with switch at ON or activated position(s). Ohmmeter should register zero ohms (continuity).
   b. Place switch at OFF or deactivated position. Ohmmeter should register infinity (no continuity).
   c. Replace switch if it fails either part of the check.

Installation

1. Remove the rocker (3) from the old switch by holding the switch by its sides in one hand and then squeezing the left and right sides of the rocker with the other hand and pulling up.
2. Orient the rocker (3) correctly relative to the new switch (4), then install rocker in switch.
3. Install the switch (4) in the gauge/switch cover (6) by pushing the switch (4) down through the top of the gauge/switch cover (6) until the switch's retaining clips click in place.
4. Connect the wire harness to the bottom of the switch (4).
5. Install the right side cover (9) on the steering column.
6. Connect the wire harness to the ignition switch (10).
7. Install the left side cover (8) on the steering column.
8. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).
9. Secure the left and right side covers (8, 9) together using four screws (13).
10. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
11. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).
12. Turn the battery disconnect switch to the ON position.

Check

1. Operate the switch per the Operator Manual. Verify each of its functions works.
2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the switch or associated wiring.

Ignition Switch Replacement

Use the following procedures and refer to Figure 3-9 when removing/installing the ignition switch.

Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
4. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
5. Remove the four screws (13) securing the left and right side covers (8, 9) together.
6. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
7. Remove the left side cover (8) from the steering column.
8. Disconnect the wire harness from the back of the ignition switch (10).
9. Remove the right side cover (9) from the steering column.
10. Remove the locking nut that secures the ignition switch (10) to the right cover (9) and remove the ignition switch (10).

Inspection

1. Visually check the ignition switch for evidence of cracks, damaged connections, or other damage. Replace damaged ignition switch as needed.
2. Check wiring for damaged insulation or damaged connectors. Repair as needed.
3. Check all connectors for corrosion. Replace corroded components as needed.
4. Perform the following check to determine ignition switch serviceability.

a. Using an ohmmeter, check for continuity between the switch terminals with switch at ON or activated position(s). Ohmmeter should register zero ohms (continuity).

b. Place switch at OFF or deactivated position. Ohmmeter should register infinity (no continuity).

c. Replace switch if it fails either part of the check.

Installation

1. Install the ignition switch (10) in the right side cover (9) and secure with the locking nut.
2. Install the right side cover (9) on the steering column.
3. Connect the wire harness to the ignition switch (10).
4. Install the left side cover (8) on the steering column.
5. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).
6. Secure the left and right side covers (8, 9) together using four screws (13).
7. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
8. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).
9. Turn the battery disconnect switch to the ON position.

Check

1. Operate the ignition switch per the Operator Manual. Verify each of its functions works.
2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the switch or associated wiring.

Turn Signal Lever and Transmission Shift Lever Replacement

Use the following procedures and refer to Figure 3-9 when removing/installing the turn signal lever or transmission shift lever.

Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
4. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
5. Remove the steering wheel by doing the following:

   a. Remove the steering wheel cap (1) using a twisting motion by pushing on the side of the cap closest to you with your thumbs while simultaneously pulling on the side of the cap farthest from you with your fingers.

   b. Remove the securing nut from the steering column shaft and remove the steering wheel (2).
6. Remove the four screws (13) securing the left and right side covers (8, 9) together.
7. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
8. Remove the left side cover (8) from the steering column.
9. Disconnect the wire harness from the back of the ignition switch (10).
10. Remove the right side cover (9) from the steering column.
11. Disconnect the wire harness from the bottom of the gauge cluster (5).
12. Tag and disconnect the wire harness from the bottom of each switch (4).
13. Remove the gauge/switch cover (6) from the steering column.
14. Disconnect the wire harnesses from the bottom of the turn signal and transmission shift levers (7).
15. Remove the two bolts and nuts securing the two levers (7) together.

Installation

1. Align the location pins of the turn signal and transmission shift levers (7) with the holes in the steering column.
2. Secure the two levers (7) together using the two bolts and nuts.
3. Connect the wire harnesses to the levers (7).
4. Install the gauge/switch cover (6) on the steering column.
5. Connect the wire harness to the bottom of the gauge cluster (5).
6. Install the wire harnesses on the switches (4) as tagged during removal.
7. Install the right side cover (9) on the steering column.
8. Connect the wire harness to the ignition switch (10).
9. Install the left side cover (8) on the steering column.
10. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).

3

11. Secure the left and right side covers (8, 9) together using four screws (13).
12. Install the steering wheel (2); torque the securing nut to 30 lb-ft ±4 (40 N-m ±5).
13. Install the steering wheel cap (1).
14. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
15. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).
16. Turn the battery disconnect switch to the ON position.

Check

1. Operate the turn signal lever or transmission shift lever per the Operator Manual. Verify each of its functions work.
2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the switch or associated wiring.

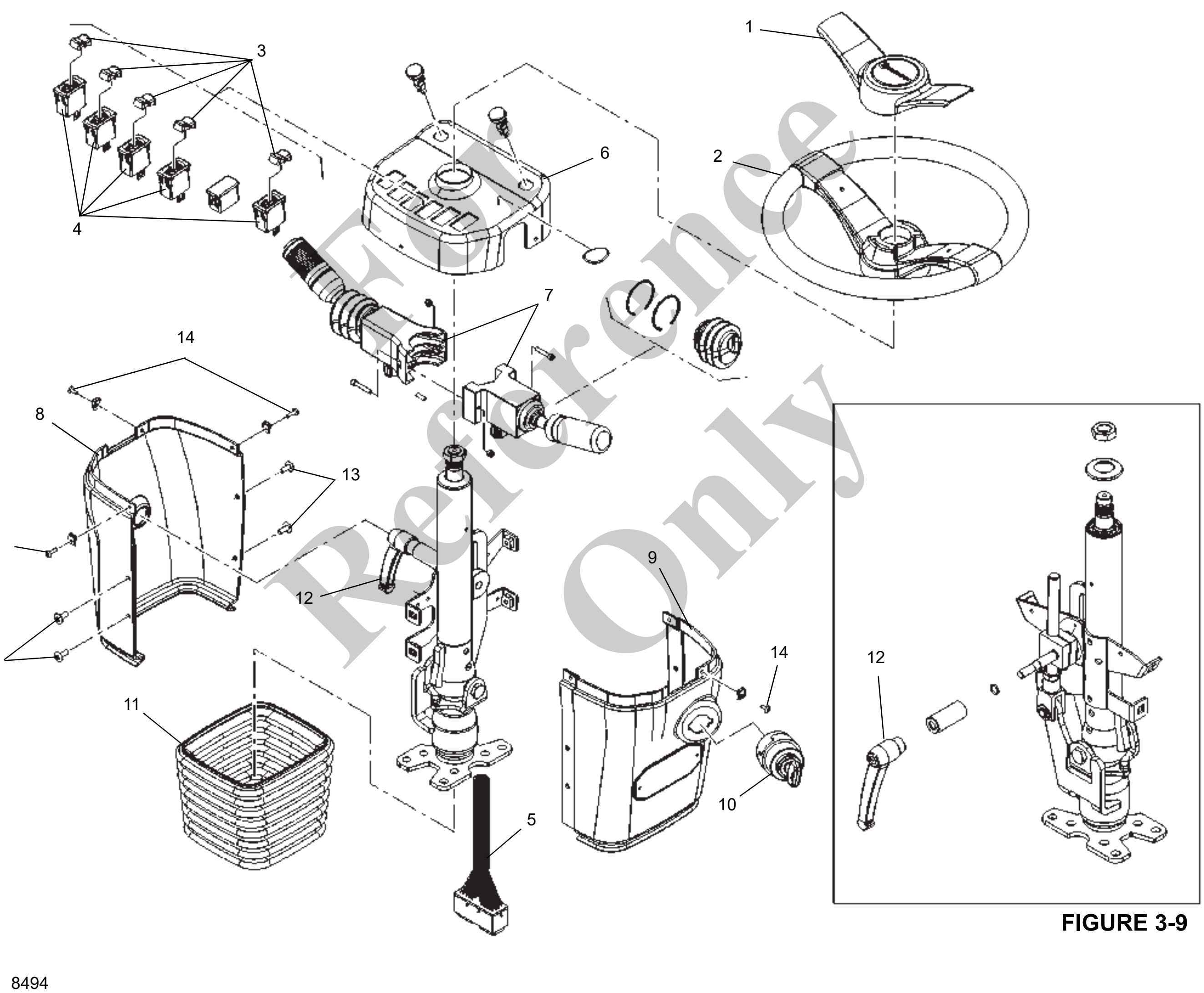


FIGURE 3-9

Windshield Wiper Assembly Replacement

Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Tag and disconnect the electrical leads from the motor.
4. Disconnect the washer hose on the wiper arm from the washer nozzle fitting assembly.
5. Remove the cap nut and washer securing the wiper arm to the pantograph adapter kit. (The nut and washer are part of the pantograph adapter kit.) Remove the cap nut, washer, and tapered sleeve securing the wiper arm to the pivot shaft kit. (The nut, washer, and sleeve are part of the pivot shaft kit.)
6. Remove the wiper arm from the pantograph adapter kit and the pivot shaft kit.
7. Remove the flanged sleeve, nut, and two flat washers from the pivot shaft kit. (The sleeve, nut, and washers are part of the pivot shaft kit.)
8. Remove the two capscrews and lockwashers securing the pantograph adapter kit's adapter to the cab exterior. Remove the pantograph adapter kit's adapter and gasket.
9. Remove attaching hardware to free the windshield wiper motor bracket from the cab interior. Remove the bracket, with motor and pivot shaft connected, from the cab.

NOTE: You may have to remove or move other parts to get the bracket and attached parts around the steering column. Take care not to damage any parts.

10. Remove the nut to free the wiper motor's shaft from the wiper motor kit crank. Remove the three screws and washers to free the wiper motor from its bracket. Remove the wiper motor from its bracket. Leave the other parts attached to the bracket for now.

Inspection

1. Visually check the motor housing for evidence of cracks or other damage. Check for excessive shaft end play indicating worn or damaged bearings. Replace motor if damaged.
2. Inspect the wiper blade for serviceability. Replace wiper blade when worn.
3. Inspect the wiper arm and parts of the linking component kits (pantograph adapter kit, pivot shaft kit, wiper motor kit link and crank, wiper motor bracket) for damage. Replace as needed.

Installation

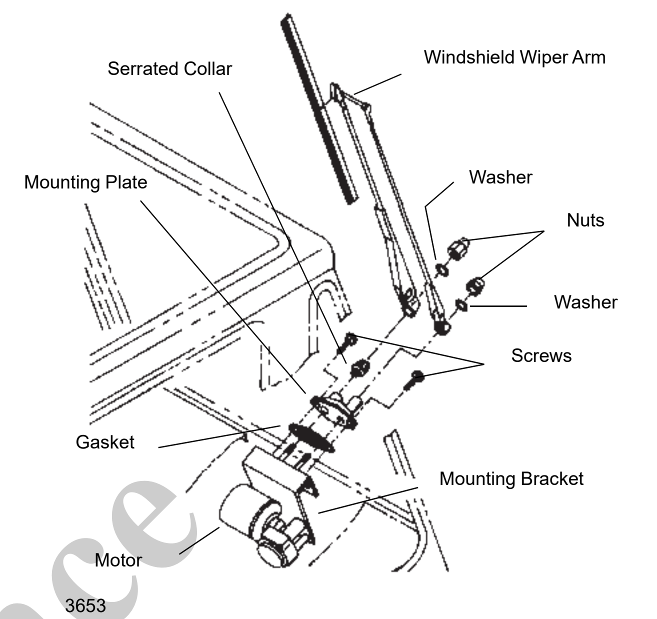


FIGURE 3-10

1. Verify the pivot shaft and the wiper motor kit link and crank are in place on the motor bracket. (Washers and clip springs fasten the link to the pivot pins on the crank and the pivot shaft. The pivot shaft's pivot pin mounts in the hole nearest the end of the pivot shaft's lever.)
2. Connect the wiper motor to the motor bracket with screws and washers. Connect the wiper motor's shaft to the wiper motor kit crank with the nut and washer.
3. Secure the adapter and the gasket of the pantograph adapter kit to the cab exterior with capscrews and lockwashers.
4. Install the motor bracket and attached parts in the cab interior with attaching hardware. Ensure the pivot shaft sticks through the hole in the pantograph adapter kit.

NOTE: Take care not to damage any parts while moving the bracket and attached parts around the steering column.

5. Secure the pivot shaft to the pantograph adapter with the pivot shaft kit's nut and washers. Install the flanged sleeve on the pivot shaft.
6. Install the wiper arm on the shafts of the pantograph adapter kit and the pivot shaft kit. Secure the wiper arm to the pantograph adapter kit shaft with the kit's own washer and cap nut. Secure the wiper arm to the pivot shaft with the pivot shaft kit's own tapered sleeve, washer, and cap nut.
7. Connect the wiper arm's washer hose to the washer nozzle fitting assembly.

8. Connect the electrical leads to the wiper motor as marked before removal.
9. Turn the battery disconnect switch to the ON position.

Check

1. Squirt some cleaning fluid onto the windshield with the windshield washer.
2. Operate the windshield wiper. Verify it works. (Replace wiper blade as needed if it streaks or otherwise wipes poorly.)

Windshield Washer Assembly Replacement

Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Locate the windshield washer container and pump behind the cab.
4. Tag and disconnect the pump's electrical lead and ground wire.
5. Disconnect the hose from the windshield washer pump. Point it so it won't spill cleaning fluid. Catch cleaning fluid from the windshield washer container with a suitable container.
6. Remove bolts, flat washers, lock washers, and nuts securing the windshield washer container to the turntable. Remove the windshield washer container and pump.
7. Remove pump and pump seal from container.

Inspection

1. Visually check the pump for evidence of cracks, leaks, or other damage. Replace pump if damaged.
2. Inspect the container for leaking. Replace pump seal if it is leaking. Replace container if it is damaged and leaking.
3. Inspect spray nozzle on the wiper arm. As needed, clean the nozzle with a fine piece of wire and compressed air.

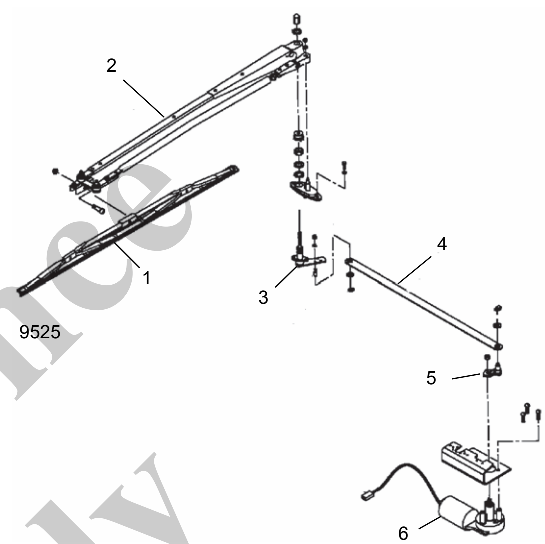
Installation

1. Install pump and pump seal on container.
2. Install windshield washer container on to the turntable. Attach the container with bolts, flat washers, lock washers, and nuts.
3. Attach the hose to the windshield washer pump.
4. Connect the pump's electrical lead and ground wire as tagged during removal.
5. Turn the battery disconnect switch to the ON position.
6. Fill the container with cleaning fluid.

Check

1. Squirt some cleaning fluid onto the windshield with the windshield washer.
2. Make repairs if windshield washer doesn't work.

Skylight Wiper Assembly Replacement



Item	Description
1	Wiper Blade
2	Wiper Arm
3	Pivot Shaft
4	Link
5	Drive Arm Link
6	24V Motor Assembly

FIGURE 3-11

Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Tag and disconnect the electrical leads from the motor.
4. Remove the wiper arm from the motor shaft.
5. Remove the nut, spacer, leather washer, and nylon flat washer from the motor shaft outside the cab roof.

6. Remove the nut and lockwasher securing the motor bracket to the cab roof and remove the motor from the cab roof. Remove large nylon flat washer from motor shaft and flat washer and smaller nylon flat washer from mounting screw.
7. Remove mounting screw and nylon flat washer from outside cab roof.
8. Clean any sealing material from around holes in cab roof.

Inspection

1. Visually check the motor housing for evidence of cracks or other damage. Check for excessive shaft end play indicating worn or damaged bearings. Replace motor if damaged.
2. Inspect the wiper blade for serviceability. Replace wiper blade when worn.
3. Inspect the wiper arm and parts for damage. Replace as needed.

Installation

1. Install sealant material around both holes in cab roof, both inside and outside.
2. Install screw with nylon flat washer (from outside) through mounting hole in cab roof.
3. Install flat nylon washer on motor shaft and insert motor shaft through hole in cab roof. Position small nylon washer and flat washer on screw between mounting bracket and cab roof. Secure with lockwasher and nut.
4. Install nylon flat washer, leather washer, spacer, and nut on motor shaft. Tighten nut.
5. Install wiper arm and blade on motor shaft.
6. Connect the electrical leads to the wiper motor as marked before removal.
7. Turn the battery disconnect switch to the ON position.

Check

1. Operate the skylight wiper. Verify it works. (Replace wiper blade as needed if it streaks or otherwise wipes poorly.)

Adjusting Electronic Joysticks

If the meter-in dead band of a joystick function is too fast or too slow or its maximum function speed is slower or faster than design specifications, adjustments can be made using the service software providing the following have been performed:

- All function pressures have been set correctly following the procedures in the *Pressure Setting Procedures*, page 2-19.
- Correct function speeds cannot be attained by adjustments made through the crane control system (CCS) control screens of the Operating Display Module (ODM).
- Correct function control cannot be attained by adjustments made through the CCS control screen selectable curves in the Operating Display Module (ODM)

To adjust the meter-in dead band and maximum function speed of a joystick, a Windows-based PC, a service software (80112606), and a connection cable (80078354) are required. The service software and connection cable are available through Manitowoc Crane Care to those service technicians who have attended the Grove New Technology training course.

FAULT CODES

The crane control system (CCS) monitors the engine, transmission, and crane functions to ensure they are functioning properly. If a malfunction is detected within any of these areas, the crane control system display will illuminate the Engine Warning Indicator for engine and transmission faults, or the Crane Fault Indicator for any crane function faults. Both of these icons are located on the main menu screen of the Operator Display Module (ODM) inside the cab.

Refer to the *GRT655/655L Operator Manual* for information on how to view engine and transmission fault codes, and crane fault codes/

A list of all fault codes and their definitions are available through Manitowoc Crane Care to those service technicians who have attended the Grove New Technology training course.

AIR CONDITIONER (OPTIONAL)

Refrigerant from the engine mounted compressor passes through port 12 of the swivel to the turntable mounted condenser that is cooled by an electric powered fan.The refrigerant goes from the condenser to the dryer, also mounted to the turntable, then onto the expansion valve and evaporator mounted under the operator’s seat in the cab. The refrigerant goes from the evaporator back down to the swivel where it passes through port 11 on its way back to the compressor.

When servicing the air conditioning system, observe the following specifications:

- Minimum Evacuation Time — 60 minutes
- Refrigerant Charge Levels — 2.5 pounds (±0.5 oz)
- Additional Pag Oil Required Above the 6 ounces in Compressor — 5.0 ounces

BIRDSEYE CAMERA (OPTIONAL)

The Birdseye Camera is a visual aid for the operator. It provides a view of the area surrounding the crane as if there were one camera mounted directly above the crane.

The Birdseye Camera uses three cameras, which are mounted to the counterweight, to make one overhead image of the crane surroundings. The image is displayed on the 7 inch Birdseye Camera Display mounted in the front-right corner of the crane cab above the Rated Capacity Limiter Display Module (RDM) and the Operator Display Module (ODM).

Refer to the Operators Manual for information regarding the operation of the system.

Checking the Camera System Performance

A performance check of the system should be done to ensure the three cameras are properly aligned and provide an accurate and clear view of the area around the crane.

Checking for a Dirty Camera Lens

Dirt or water droplets on the lens can cause the image on the Birdseye Camera Display to be unclear.

Perform a visual check of the camera lens in the following instances.

- When the view on the display is not clear.
- After the crane has been rained on or washed.
- On a routine basis. The frequency at which the routine check is done may range from daily to monthly and is dependent upon the crane's duty cycle and environmental conditions.

If the camera lens is determined to be dirty, clean the lens following procedures under *Cleaning the Camera Lens*, page 3-19.

Checking for a Misaligned Camera

Perform a check for proper camera alignment in the following instances.

- Camera suffers an impact
- Area supporting a camera suffers an impact
- Camera is removed and replaced
- Any suspicion that the system is not performing as expected
- On a routine basis. The frequency at which the routine check is done may range from daily to monthly and is dependent upon the crane's duty cycle and environmental conditions.

The computer within the Birdseye Camera System creates the realistic, synthesized image of the crane and its surroundings by combining and placing the images from the three properly aligned cameras around a graphic, or picture, of the crane.

Synthesizing the three camera views together to obtain one view results in objects that are low in height to be more accurately displayed with respect to their distance from the crane. As the height of an object increases above ground level, the object will appear to be farther away from the crane. This ultimately results in vertical objects appearing to lean away from the crane. Also, objects or persons in the overlapping camera views are seen by two cameras simultaneously, which can result in the object or person appearing twice as they lean away from each camera. Due to the computer synthesizing the overlapping views together, the full height of the object or person in the overlapping area may not be visible.

If one or more cameras are not properly aligned, the image shown on the display will not accurately represent the surrounding area with respect to the crane.

To perform the camera alignment check, do the following:

1. Rotate the superstructure so that the boom is centered over the front of the carrier.
2. Fully extend and set the four outriggers.
3. Look at the Birdseye Camera Display in the cab and ensure the outrigger pad overlays (red circles, Figure 3-12) align with the actual pads of the outrigger jacks.

   Circle overlays that do not align with the outrigger jack pads indicate a camera is out of alignment.
4. Fully retract the outriggers.
5. While watching the Birdseye Camera Display, have someone walk around the crane while maintaining a distance of 5 ft from the crane. Ensure the person can be seen throughout the walk-around, especially at the corners of the crane where the cameras view overlap (note: in the overlap areas, the person may not be fully visible).

   If the camera view of the person walking around the crane does not maintain an equal distance from the crane and transition smoothly when walking around the corners of the crane, a camera is out of alignment.
6. While watching the Birdseye Camera Display, have someone stand directly behind the crane at the center of the crane bumper and ensure he or she is visible.

   If the person is not visible, the rear camera is out of alignment.

If a camera is determined to be out of alignment, contact your authorized Grove Distributor or Manitowoc Crane Care for assistance.

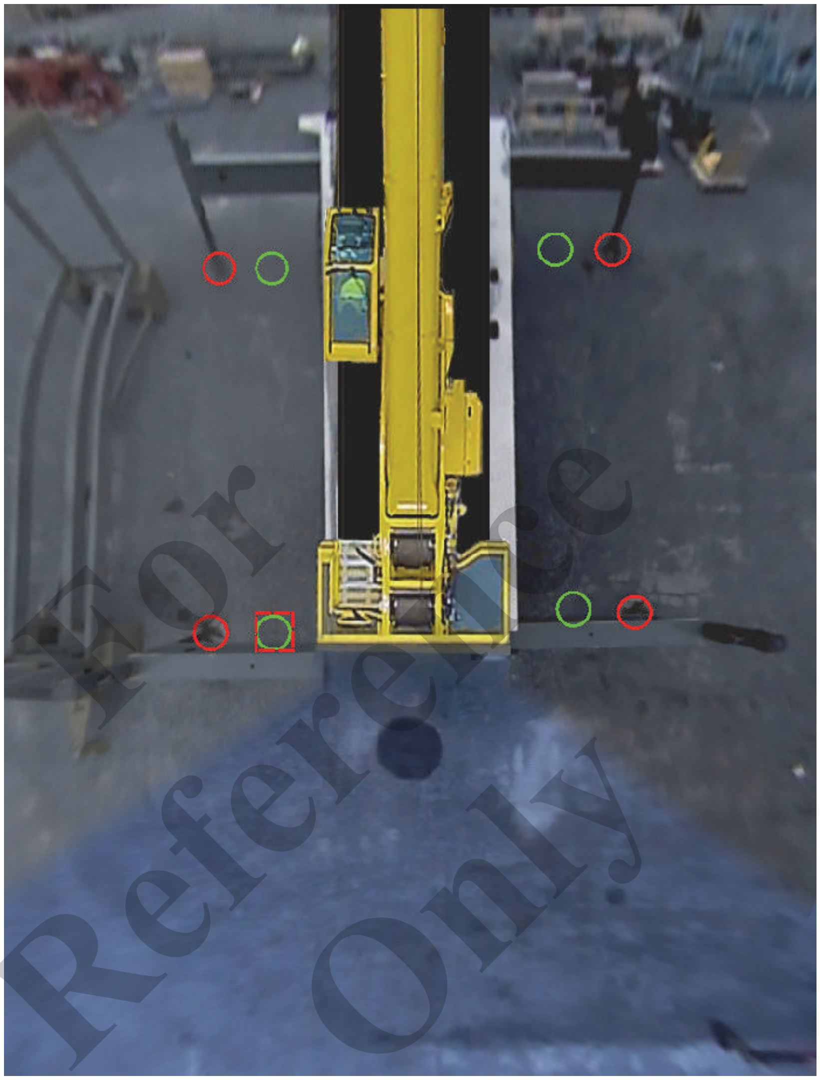


FIGURE 3-12

Cleaning the Camera Lens

Light soiling

1. Wet the camera lens with water.
2. Gently wipe the lens with a clean soft cloth moistened with a glass cleaner containing isopropyl alcohol (IPA).

Heavy Soiling

1. Wet all dried-on deposits on the camera lens with water and allow to soak.
2. Gently wash the lens with water using a clean sponge or clean soft cloth.
3. Gently wipe the lens with a clean soft cloth moistened with a glass cleaner containing isopropyl alcohol (IPA).

Fault Codes

The Birdseye Camera system can self-diagnose and display most faults that can occur. Refer to Table 3-11 for descriptions of these faults and the actions to take to repair the system.

Table 3-11: Birdseye Camera System Fault Codes

Icon	Fault Description	Solution
	Camera 2A - Watchdog failure	If camera does not work on known good cable, replace camera. If camera does work on known good cable, replace cable.
	Camera 2A - Intrinsic data not read	If camera does not work on known good cable, replace camera. If camera does work on known good cable, replace cable.
	Camera 2A - LIN communication failure	If camera does not work on known good cable, replace camera. If camera does work on known good cable, replace cable.
	Camera 2A - IIC error	Replace camera.

Icon	Fault Description	Solution
	Camera 3 - Watchdog failure	If camera does not work on known good cable, replace camera. If camera does work on known good cable, replace cable.
	Camera 3 - Intrinsic data not read	If camera does not work on known good cable, replace camera. If camera does work on known good cable, replace cable.
	Camera 3 - LIN communication failure	If camera does not work on known good cable, replace camera. If camera does work on known good cable, replace cable.
	Camera 3 - IIC error	Replace camera.

Icon	Fault Description	Solution
	Camera 4 - Watchdog failure	If camera does not work on known good cable, replace camera. If camera does work on known good cable, replace cable.
	Camera 4 - Intrinsic data not read	If camera does not work on known good cable, replace camera. If camera does work on known good cable, replace cable.
	Camera 4 - LIN communication failure	If camera does not work on known good cable, replace camera. If camera does work on known good cable, replace cable.
	Camera 4 - IIC error	Replace camera.

Icon	Fault Description	Solution
	ECU - RAM error	Replace ECU.
	ECU - RTC error	
	ECU - EEPROM error	
	ECU - IIC error	
	ECU - Memory error	Contact your authorized Grove Distributor or Manitowoc Crane Care for assistance.

Icon	Fault Description	Solution
#70	ECU - PBL error	Contact your authorized Grove Distributor or Manitowoc Crane Care for assistance.
#71	ECU - EEPROM error	
#72	ECU - EEPROM error	
#73	ECU - PBL error	
#74	ECU - EEPROM error	
#75	ECU - EEPROM error	

SECTION 4
BOOM

SECTION CONTENTS

DESCRIPTION

The crane is equipped with a four-section 10.6 to 34.8 m (34.9 to 114.3 ft) or five-section 10.7 to 43 m (35.3 to 141.2 ft), full power, fully synchronized boom.

The boom is rectangular in design and utilizes one two-stage double-acting, rod ported telescope cylinder. The telescoping sections are supported on graphite impregnated nylatron wear pads. Adjustable side wear pads prevent metal to metal contact between the sections.

Boom assembly lift is provided by a single lift cylinder. Boom elevation range is from -3 to +80 degrees.

An optional auxiliary boom nose (rooster sheave) is available for the boom to simplify single part cable usage. The rooster sheave is installed on the main boom nose and is secured by pins that pass through the rooster sheave.

The boom has a 7.92 m (26 ft) offsetable or a 7.92 to 13.7 m (26 to 45 ft) telescoping offsetable swingaway boom extension provided to obtain additional boom reach. The boom extension mounts directly to the boom nose utilizing a four point attachment. The boom extensions may be offset at 0, 15, or 30 degrees. In addition, the swingaway can be stowed on the right side of the boom base section.

SAFETY

Do not attempt to work on the boom without experienced supervision.

DANGER

To prevent serious injury or death, always wear personal protective equipment; i.e., a hard hat, eye protection, gloves and metatarsal boots.

BOOM SYSTEM COMPONENTS - 4-SECTION BOOM

Refer to Figure 4-1 for item locations.

Telescope Cylinder

The telescope cylinder is attached to the boom in three places:

- The outer rod end of the telescope cylinder is secured to the boom base section.
- The inner rod end is secured to the tele 1.
- The cylinder barrel is secured to the tele 2.

Extension and Retraction Synchronizing Cables

The extension synchronizing cables (5) are connected to the rear of the tele 2 (3) and are routed around two sheaves on the side front of the tele 1 (2), and secured to the rear of the base section (1).

The four retraction synchronizing cables (7) are secured at the outside front of the base section (1), are routed around sheaves mounted on the end of the tele 1 (2) and are secured at the opposite end to the tele 2 (3).

Tele 3 Extend and Retract Cables

The four extension cables (6) are secured to the tele 1 (2) and are routed around a four groove sheave assembly at the barrel end (boom nose) of the telescope cylinder. These cables are secured at the base end of the tele 3 (4).

The two retraction cables (8) are secured at the outside front of the tele 1 (2), are routed around sheaves mounted on the end of the tele 2 (3) and are secured at the opposite end to the tele 3 (4).

Boom Sequence

Refer to Figure 4-1 for item locations.

Extension

As the telescope cylinder extends, the cylinder barrel, which is attached to the tele 2 (3), and the inner cylinder rod end, which is attached to the tele 1 (2), pulls the tele 1 and tele 2 sections out along with it.

The extend synchronizing cables (5) the tele 1 (2), tele 2 (3), and telescope cylinder remain in synchronization.

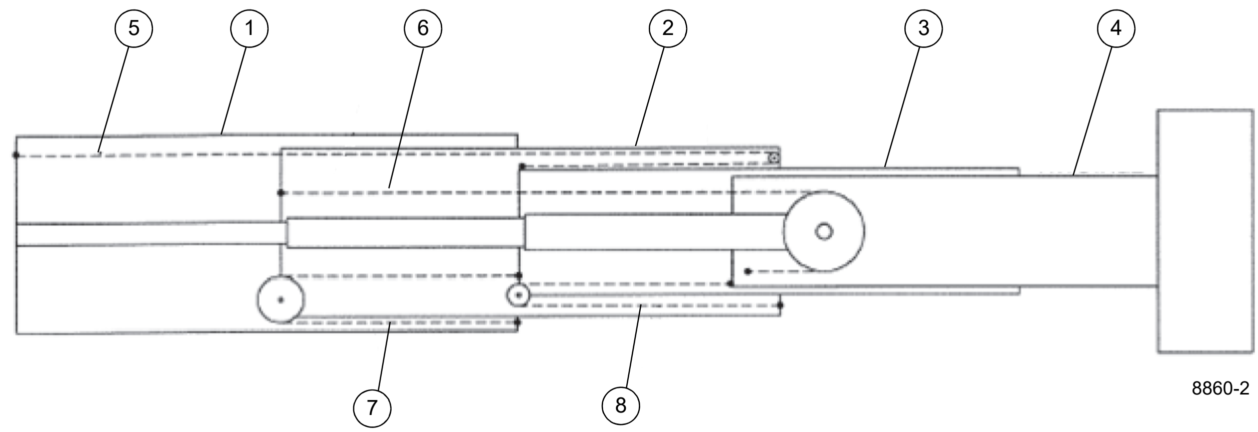
At the same time, the four groove sheave assembly at the nose end of the telescope cylinder pulls on the four tele 3 extension cables (6) around it. This causes tele 3 (4), tele 2 (3), and tele 1 (2) to extend at the same time and rate.

Retraction

As the telescope cylinder is retracted, the tele 2 (3) (attached to the cylinder barrel) and the tele 1 (2) (attached to the inner cylinder rod) are pulled in.

The retract synchronizing cables (7) the tele 1 (2), tele 2 (3), and telescope cylinder remain in synchronization.

At the same time the two tele 3 retraction cables (8) are forced around sheaves at the rear of tele 2 (3). This causes tele 3 (4), tele 2 (3), and tele 1 (2) to retract at the same time and rate.



4-Section Boom

1	Base	5	Tele 1 and 2 Extension Synchronizing Cables
2	Tele 1	6	Tele 3 Extend Cables
3	Tele 2	7	Tele 1 and 2 Retraction Synchronizing Cables
4	Tele 3	8	Tele 3 Retract Cables

FIGURE 4-1

BOOM SYSTEM COMPONENTS - 5-SECTION BOOM

Refer to Figure 4-2 for item locations.

Telescope Cylinder

The telescope cylinder is attached to the boom in three places:

- The outer rod end of the telescope cylinder is secured to the boom base section.
- The inner rod end is secured to the tele 1.
- The cylinder barrel is secured to the tele 2.

Extension and Retraction Synchronizing Cables

The extension synchronizing cables (6) are connected to the rear of the tele 2 (3) and are routed around two sheaves on the side front of the tele 1 (2), and secured to the rear of the base section (1).

The four retraction synchronizing cables (9) are secured at the outside front of the base section (1), are routed around sheaves mounted on the end of the tele 1 (2) and are secured at the opposite end to the tele 2 (3).

Tele 3 Extend and Retract Cables

The four extension cables (7) are secured to the tele 1 (2) and are routed around a four groove sheave assembly at the barrel end (boom nose) of the telescope cylinder. These cables are secured at the base end of the tele 3 (4).

The two retraction cables (10) are secured at the outside front of the tele 1 (2), are routed around sheaves mounted on the end of the tele 2 (3) and are secured at the opposite end to the tele 3 (4).

Tele 4 Extend and Retract Cables

The four extension cables (8) are secured to the tele 2 (3) and are routed around sheave assemblies at the front end of the tele 3. These cables are secured at the rear end of the tele 4 (5).

The two retraction cables (11) are secured at the tip of the telescope cylinder, are routed around sheaves mounted on the rear end of the tele 3 (4) and are secured at the opposite end to the tip of tele 4 (5).

Boom Sequence

Refer to Figure 4-2 for item locations.

Extension

As the telescope cylinder extends, the cylinder barrel, which is attached to the tele 2 (3), and the inner cylinder rod end, which is attached to the tele 1 (2), pulls the tele 1 and tele 2 sections out along with it.

The extend synchronizing cables (6) make sure the tele 1 (2), tele 2 (3), and telescope cylinder remain in synchronization.

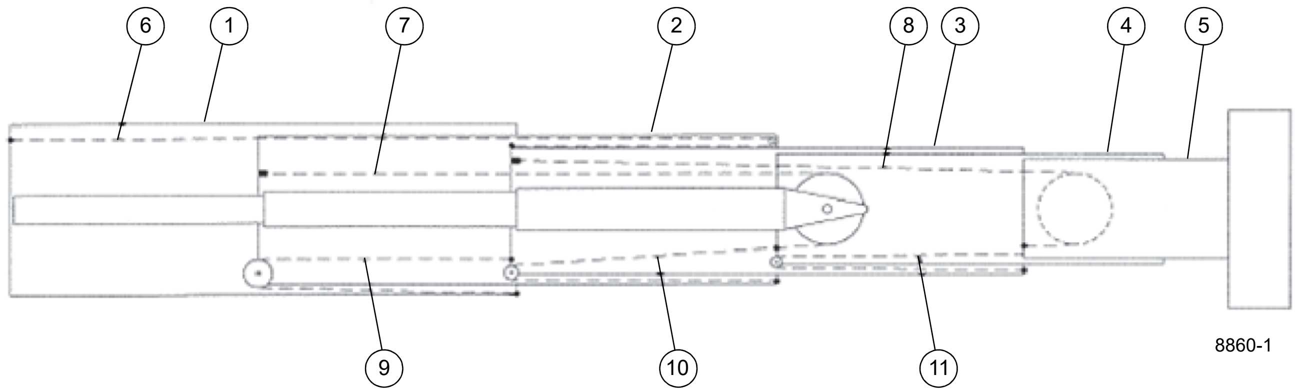
At the same time, the four groove sheave assembly at the nose end of the telescope cylinder pulls on the four tele 3 extension cables (6). Also, at the same time, the four single-sheave assemblies at the nose end of the tele 3 pull on the four tele 4 extension cables (8). This causes tele 4 (5), tele 3 (4), tele 2 (3), and tele 1 (2) to extend at the same time and rate.

Retraction

As the telescope cylinder is retracted, the tele 2 (3) (attached to the cylinder barrel) and the tele 1 (2) (attached to the inner cylinder rod) are pulled in.

The retract synchronizing cables (9) make sure the tele 1 (2), tele 2 (3), and telescope cylinder remain in synchronization.

At the same time, the two tele 3 retraction cables (10) are forced around sheaves at the rear of tele 2 (3). Also, at the same time, two tele 4 retraction cables (11) are forced around sheaves at rear of tele 3 (4). This causes tele 4 (5), tele 3 (4), tele 2 (3), and tele 1 (2) to retract at the same time and rate.



5-Section Boom

1	Base	7	Tele 3 Extend Cables
2	Tele 1	8	Tele 4 Extend Cables
3	Tele 2	9	Tele 1 and 2 Retraction Synchronizing Cables
4	Tele 3	10	Tele 3 Retract Cables
5	Tele 4	11	Tele 4 Retract Cables
6	Tele 1 and 2 Extension Synchronizing Cables		

FIGURE 4-2

TELESCOPE CIRCUIT

Description

The boom telescope circuit consists of the telescope function remote control, telescope directional control valve, holding valves, and the telescope cylinder.

NOTE: If the crane is equipped with an auxiliary hoist, the telescope function is controlled by a foot pedal instead of a controller.

The telescope control valve is the closed spool type and is described under *Valves*, page 2-28.

The boom telescope cylinder is a two stage double acting, rod ported cylinder. Foreign material is prevented from entering the cylinder by a wiper seal during rod retraction. O-ring seals prevent internal and external leakage.

The extend and retract holding valves are threaded into a port block on the inner rod end of the telescope cylinder. The holding valve functions during the retraction, extension, or holding operation. When holding the elevated boom section at a given length, oil is trapped in the cylinder by the extend holding valve. When lowering the boom below 0° to erect the boom extension, oil is trapped in the cylinder by the retract holding valve.

Theory Of Operation

Flow from the pump travels to the telescope directional control valve. Moving the telescope controller from its neutral position to the extend or retract position sends an electrical signal to shift the related extend or retract solenoid control valve.

When extending the boom, the telescope extend solenoid control valve is actuated, which directs oil flow to shift the telescope directional control valve. When the telescope directional control valve shifts, oil flows from the directional control valve through the check valve in the telescope extend holding valve and on to the piston side of the telescope cylinder. Oil entering the telescope cylinder forces the rods out of the cylinder, causing the boom section to extend. At the same time, oil flow from the extend circuit is routed to the telescope retract holding valve, which unseats the poppet valve and allows oil in the rod side of the telescope cylinder to escape and return to the reservoir.

When retracting the boom, the telescope retract solenoid control valve is actuated, which directs oil flow to shift the telescope directional control valve. When the telescope directional control valve shifts, oil flows from the directional control valve through the check valve in the telescope retract holding valve and on to the rod side of the telescope cylinder. Oil entering the telescope cylinder forces the rods in to the cylinder, causing the boom section to retract. At the same time, oil flow from the retract circuit is routed to the telescope extend holding valve, which unseats the poppet valve and allows oil in the piston side of the telescope cylinder to escape and return to the reservoir.

LIFT CIRCUIT

Description

The boom lift circuit consists of the lift function remote control, lift directional control valve, holding valve, and the lift cylinder. These components enable the boom to be raised or lowered to various degrees of elevation ranging from -3 to +80 degrees from horizontal.

The lift directional control valve is the closed spool type and is described under *Valves*, page 2-28.

The lift cylinder is the double acting type. Dirt and other foreign material is prevented from entering the cylinder and causing internal damage by a wiper seal during rod retraction. Oil seals on both the piston and cylinder head prevent internal and external hydraulic oil leakage.

The holding valve is a balanced poppet type hydraulic valve. It is threaded into the port block which is an integral portion of the lift cylinder barrel. The holding valve functions when booming up (cylinder rod extended), booming down (cylinder rod retracted), or holding (cylinder rod stationary).

Small orifices under the RCL transducers in the lift cylinder port blocks allow pressure to reach the transducers, but will limit flow if an external leak occurs. The leakage through the orifice is such that the lift function can still be controlled and maneuvered into a safe condition for repair.

Theory Of Operation

The directional control valve bank housing the lift control valve is supplied by flow from the hydraulic pump.

When booming up, oil unseats the poppet (check) valve in the holding valve, letting oil flow to the piston side of the cylinder. Pressure is applied to the piston, forcing the rod to extend, raising the boom.

When booming down, oil enters the retract port of the port block and flows to the cylinder rod side. At the same time, pilot pressure from the retract solenoid control valve unseats the holding valve and allows oil to flow from the piston side of the cylinder to the reservoir.

All return flow from the control valve goes to the reservoir.

GENERAL MAINTENANCE NOTES

- Apply medium strength thread locking adhesive/sealant and primer to all hardware.
- Unless otherwise specified, torque values for all metric class 8.6 and/or 0.9 and grade 5 and/or grade 6 fasteners shall be as specified under *Fasteners and Torque Values*, page 1-19.
- Apply multipurpose grease to all wear surfaces.
- Adjust bottom front adjustable wear pads such that wear pad is within mm 1 from side plate or bottom plate of next inner section. Remove shims only if section needs to be adjusted for twist.
- Using shims, adjust top rear adjustable wear pads such that the wear pad is just in contact with side plate of next outer section.
- To adjust lower side wear pads use shims so that wear pads are just in contact with the side plate of the next outer section.
- To adjust rear bottom wear pads use shims so that wear pads are within 2 mm of the bottom plate of the next outer section.

BOOM EXTENSION - REMOVING/INSTALLING

Removing the Boom Extension

DANGER

Before attempting to remove the boom extension; read and strictly adhere to all danger decals installed on the boom/boom nose, boom extension, and stowage brackets.

DANGER

To prevent serious injury or death, do not stand on crane decking unless boom extension is secure.

Tools required:

- 1/2 in Impact Wrench
- 24 in - 1/2 in Drive Impact Extension (p/n 80104116)
- 1/2 in Square Drive Socket - 1/2 in Square Nut (80104383)

NOTE: Refer to Figure 4-9 for an illustration of the boom extension.

NOTE: Complete boom extension weighs approximately 820 kg (1810 lb).

1. Fully extend and set the outriggers using normal setup procedures.
2. If extended, fully retract all of the boom sections.
3. Set boom angle to 0° (zero degrees).

NOTE: The auxiliary boom nose (rooster sheave) does not have to be removed. However, if reeved, the hoist rope must be removed from the sheave.

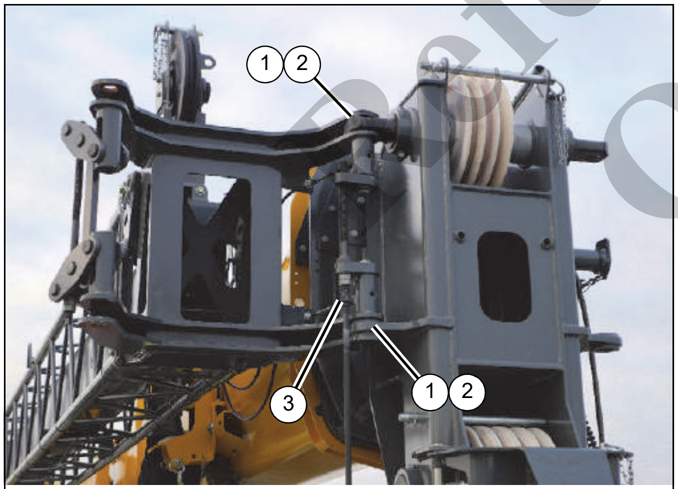
4. Fold out the ramp (1, Figure 4-3) at the rear stowage bracket. Secure in place with spring-locking pin (2, Figure 4-3).

FIGURE 4-3

5. Make sure the attachment pin securing the boom extension to the front stowage bracket is engaged (1, Figure 4-4).

9216-9 **FIGURE 4-4**

6. Remove the attachment pin securing the boom extension to the rear stowage bracket. Place the attachment pin in the stowage hole and secure with retaining clip.
7. Using the tag line, swing the boom extension out to engage the boom extension anchor fittings (1, Figure 4-5) with the boom nose attachment lugs (2).



9216-2 **FIGURE 4-5**

8. Attach the boom extension base section to the boom nose by installing the right side attachment pins through the anchor fittings and attachment lugs.

   Use an impact wrench and the provided extension (80104116) and socket (80104383) to turn the jack screw (3, Figure 4-5) counterclockwise to engage the attachment pins. Make sure the attachment pins are fully engaged.

DANGER

Boom Extension Fall Hazard

An unsecured boom extension may fall resulting in death or serious injury.

Do not remove the cross pin (1, Figure 4-6) unless the boom extension is securely attached to the boom nose.

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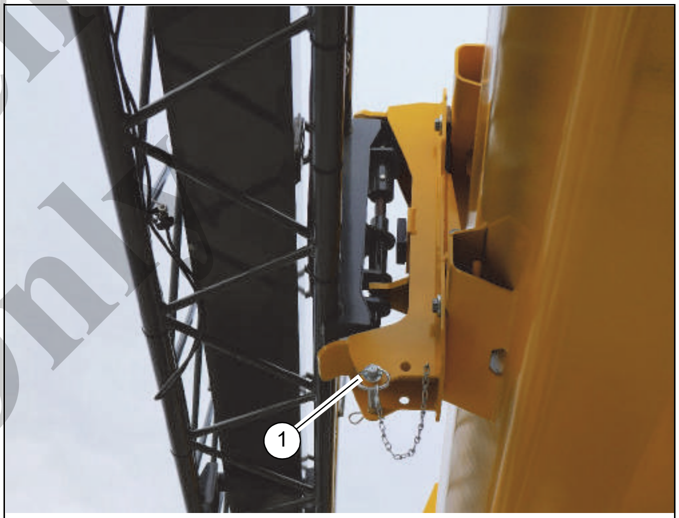
9. Remove the cross pin (1, Figure 4-6) at the front stowage bracket. Place the cross pin in the stowage hole and secure with retaining clip.



9216-9 **FIGURE 4-6**

10. Disconnect the boom extension from the front stowage bracket by using an impact wrench and the provided extension (80104116) and socket (80104383) to turn the jack screw counterclockwise (1, Figure 4-7).

    Make sure the jack screw bottoms out and the top attachment pin is fully disengaged.

9216-8

FIGURE 4-7

9216-3

FIGURE 4-8

DANGER

When erecting the boom extension, make sure that all personnel and equipment are kept clear of the swing path.

11. Slightly raise and/or lower the boom to help control the boom extension. Using the tag line attached to the tip of the boom extension, manually swing the boom extension into place ahead of the boom nose, engaging the attachment lugs with the anchor fittings on the left side of the boom nose (Figure 4-8).

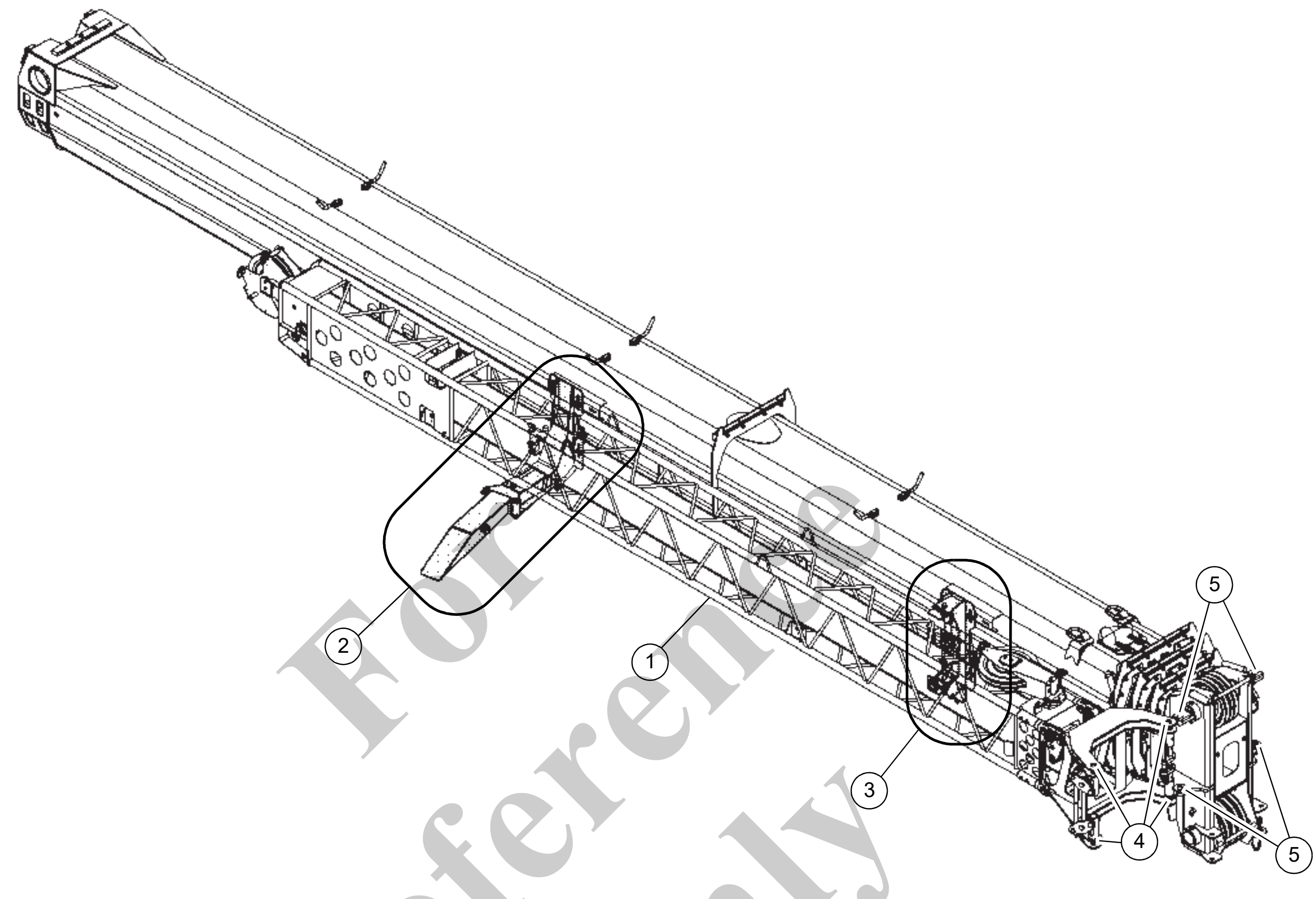
12. Lower the boom and remove the tag line from the tip of the boom extension.

13. Attach straps (not chains) to the boom extension chords. Slightly lift boom extension, taking pressure off of the attachment pins, until the center of gravity is found.

14. Disengage the attachment pins securing the boom extension to the right side of the boom nose.

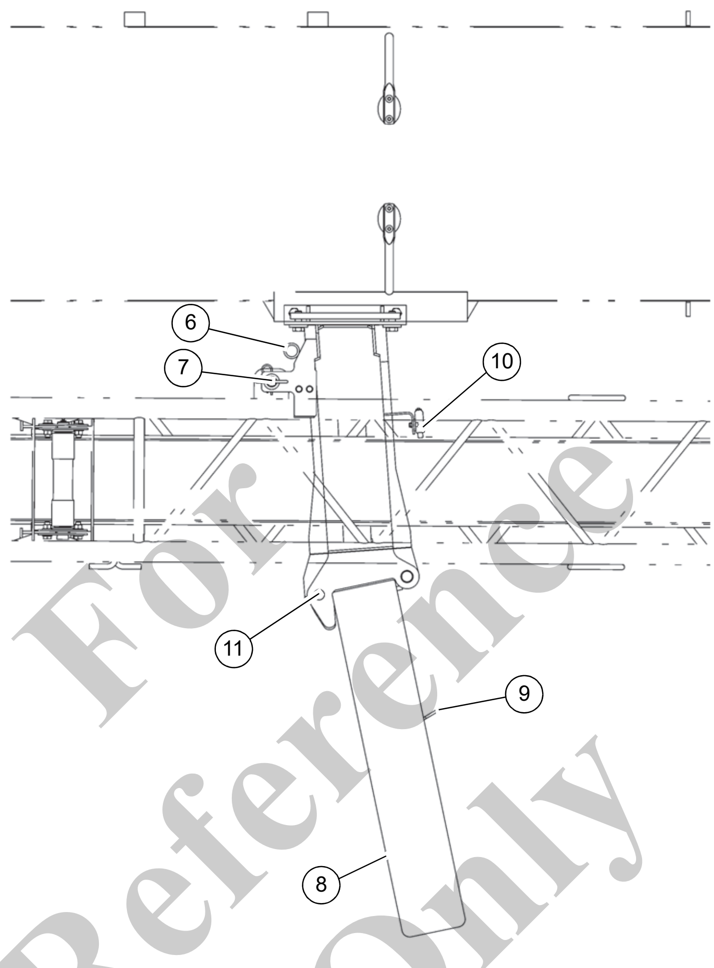
Use an impact wrench and the provided extension (80104116) and socket (80104383) to turn the jack screw (1, Figure 4-13) clockwise. Make sure the attachment pins are fully disengaged.

15. Place the now free swingaway boom extension in a safe secure location.

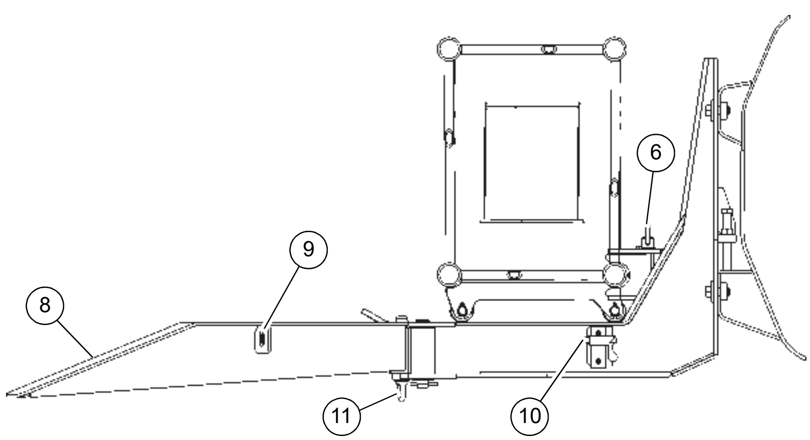


Item	Description	Item	Description
1	Boom Extension	11	Ramp Spring-Locking Pin
2	Rear Stowage Bracket and Ramp Assembly	12	Cross Pin
3	Front Stowage Bracket Assembly	13	Cross Pin Hole - Locked Position
4	Boom Extension Anchor Fittings	14	Cross Pin Hole - Stowed Position
5	Boom Nose Attachment Lugs	15	Front Stowage Bracket Jack Screw
6	Attachment Pin Hole - Stowed Position	16	Front Stowage Bracket Attachment Pin
7	Attachment Pin Hole - Locked Position	17	Left Side Boom Extension Jack Screw
8	Ramp	18	Left Side Boom Extension Attachment Pins
9	Ramp Stowage Bracket	19	Right Side Boom Extension Jack Screw
10	Ramp Stowage Pin	20	Right Side Boom Extension Attachment Pins

FIGURE 4-9

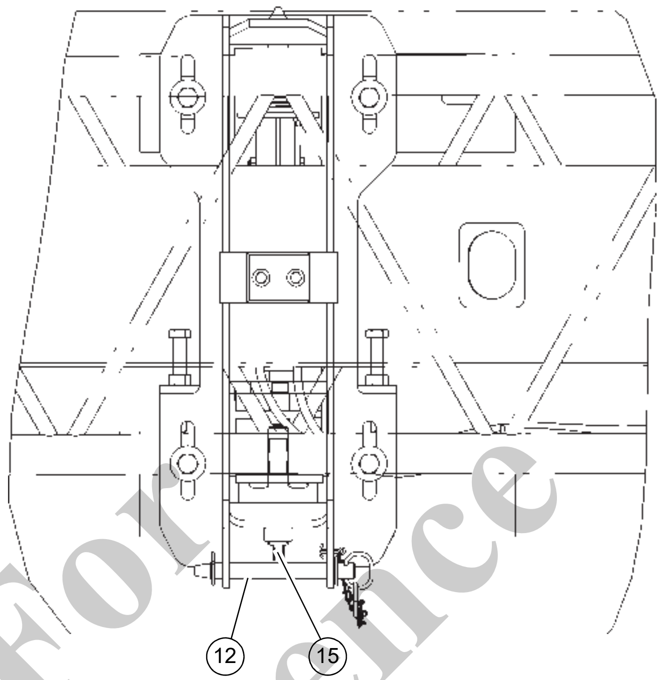


Rear Stowage Bracket and Ramp Assembly - Top View

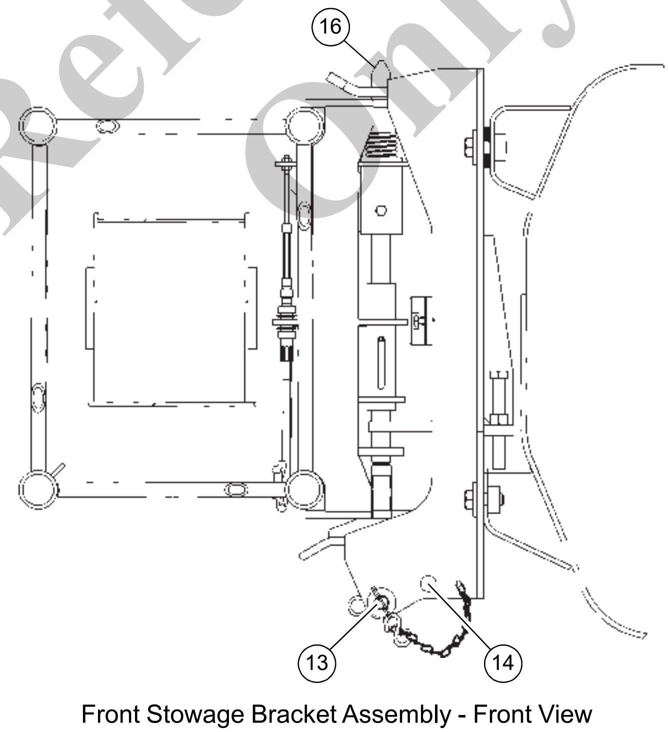


Rear Stowage Bracket and Ramp Assembly - Front View

FIGURE 4-9 continued

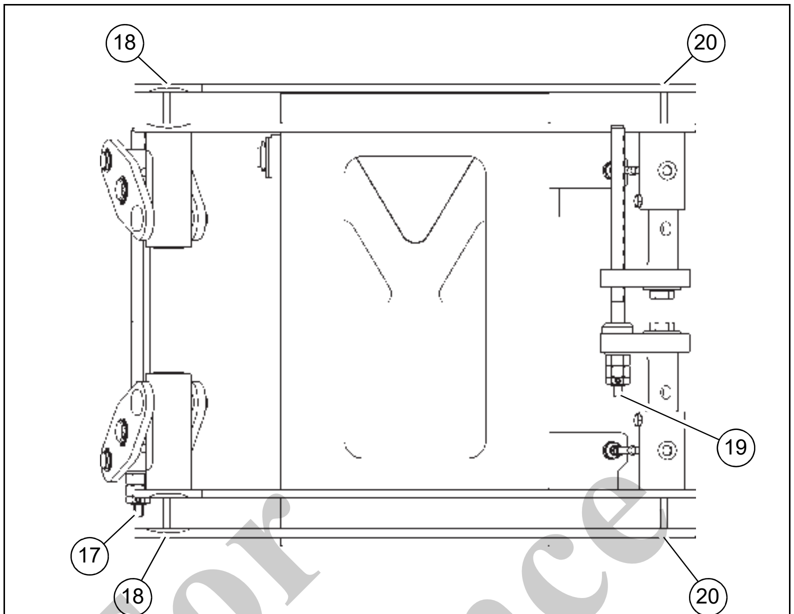


Front Stowage Bracket Assembly - Right Side View



Front Stowage Bracket Assembly - Front View

FIGURE 4-9 continued



Boom Extension - Rear View

FIGURE 4-9 continued

Installing the Boom Extension

DANGER

To prevent serious injury or death, always wear personal protective equipment; i.e., a hard hat, eye protection, gloves and metatarsal boots.

DANGER

Before attempting to install the boom extension, read and strictly adhere to all danger decals installed on the boom/boom nose, boom extension, and stowage brackets.

NOTE: The boom extension must be set at the minimum offset and, if used, the telescoping section must be fully retracted. Refer to *Section 5 - Set-up and Installation* in the GRT655/655L Operator Manual for setting 0° offset and retracting the telescope section.

Tools required:

- 1/2 in Impact Wrench
- 24 in - 1/2 in Drive Impact Extension (p/n 80104116)
- 1/2 in Square Drive Socket - 1/2 in Square Nut (80104383)

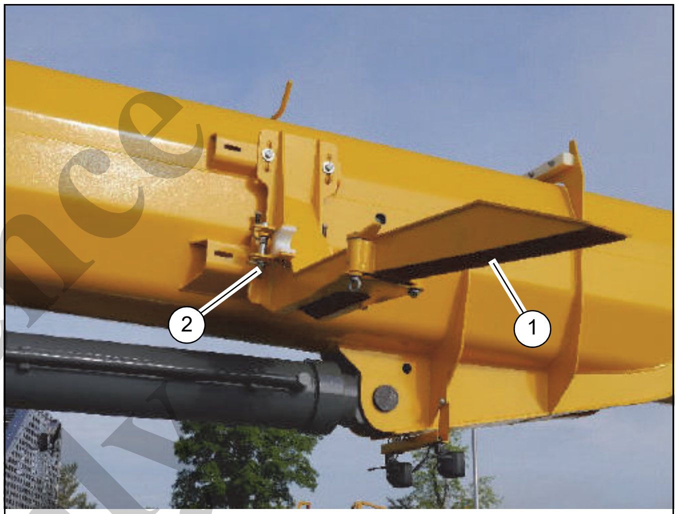
NOTE: Refer to Figure 4-9 for an illustration of the boom extension.

NOTE: Complete boom extension weighs approximately 820 kg (1810 lb).

1. Fully retract the boom.
2. Lower the boom to minimum elevation.
3. Attach straps (not chains) to the boom extension chords. Slightly lift boom extension until the center of gravity is found.
4. Attach a length of rope to the boom extension tip.
5. Position the boom extension ahead of the boom nose.
6. Using the rope attached to the tip of the boom extension, manually align the boom extension anchor fittings to the boom nose attachment lugs.

   Move the boom slightly up or down to help align the boom extension anchor fittings with the boom nose attachment lugs.
7. Attach the boom extension base section to the boom nose by installing the right side attachment pins through the anchor fittings and attachment lugs.

   Use an impact wrench and the provided extension (80104116) and socket (80104383) to turn the jack screw counterclockwise to engage the attachment pins. Make sure the attachment pins are fully engaged.
8. Detach the lifting device from the boom extension lifting lugs.
9. Make sure the attachment pin (2, Figure 4-10) that secures the boom extension to the rear stowage bracket is in the stowed position and that the rear stowage ramp (1) is folded out and locked in position.



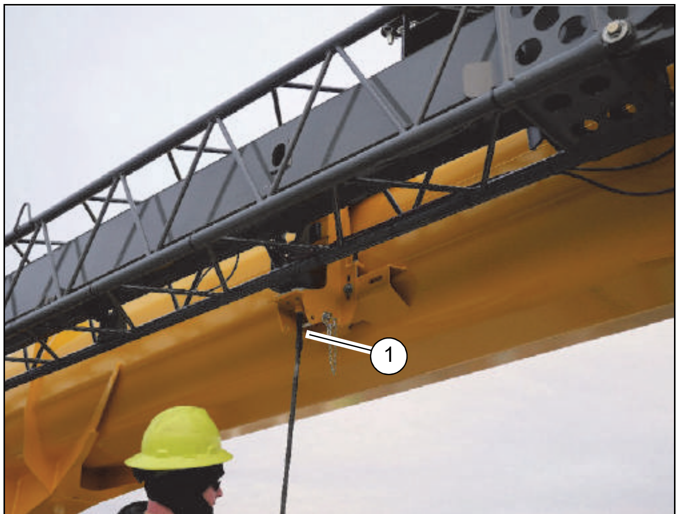
9216-13

FIGURE 4-10

DANGER

When installing the boom extension, make sure that all personnel and equipment are kept clear of the swing path.

10. Sufficient momentum is needed to swing and engage the boom extension to the front stowage bracket. Using the tag line attached to the tip of the boom extension, manually swing the boom extension up the folded out ramp until the front stowage lugs engage the front stowage bracket (Figure 4-11). Raise and lower the boom as needed to help control the movement of the boom extension.

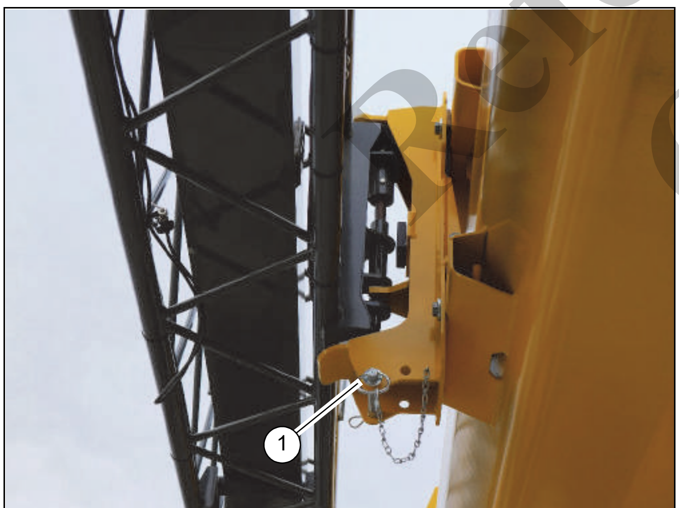


9216-8 **FIGURE 4-11**

11. Connect the boom extension to the front stowage bracket by using an impact wrench and the provided extension (80104116) and socket (80104383) to turn the jack screw (1, Figure 4-11) clockwise.

Make sure the jack screw bottoms out and the top attachment pin is fully engaged (spring will be compressed).

12. At the front stowage bracket, install the cross pin (1, Figure 4-12) in the holes underneath the jack screw. Secure the cross pin in position with retaining clip.



9216-9 **FIGURE 4-12**

DANGER

Boom Extension Fall Hazard

An unsecured boom extension may fall resulting in death or serious injury.

Do not remove the boom nose attachment pins until the boom extension is supported on the rear stowage bracket ramp and securely attached to the front stowage bracket with the attachment pin.

13. Disengage the attachment pins securing the boom extension to the right side of the boom nose.

Use an impact wrench and the provided extension (80104116) and socket (80104383) to turn the jack screw (1, Figure 4-13) clockwise. Make sure the attachment pins are fully disengaged.

9216-2 **FIGURE 4-13**

14. Using the tag line, swing the boom extension towards the boom until the boom extension engages the rear stowage bracket. Raise the boom as necessary to help the boom extension engage the rear stowage bracket.

15. Remove the attachment pin (2, Figure 4-14) from its stowed position and secure the boom extension to the rear stowage bracket. Secure the attachment pin in position with retaining clip.

16. Fold in the ramp (1, Figure 4-14) at the rear stowage bracket.

17. Remove the tag line.

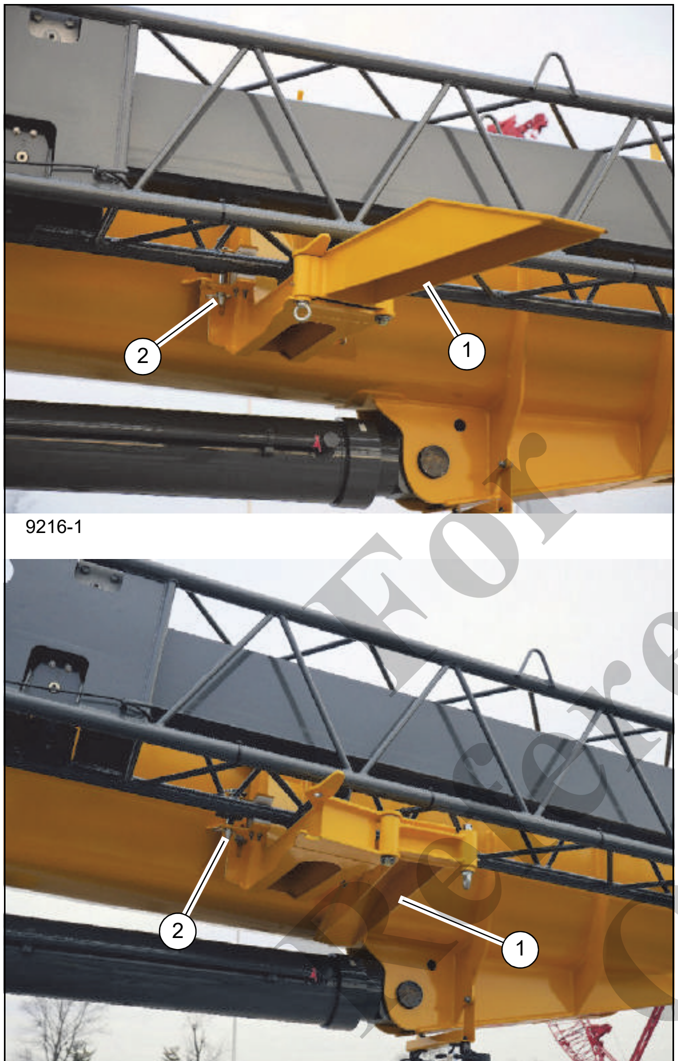


FIGURE 4-14

BOOM - REMOVING/INSTALLING

Removing the Boom

NOTE: 4-section boom weighs approximately 6405 kg (14,125 lb). 5-section boom weighs approximately 7300 kg (16,100 lb). Removal of the swingaway boom extension will simplify boom removal; therefore, the above weight is for the boom is without the swingaway boom extension attached.

NOTE: Refer to Figure 4-15.

1. Extend and set outriggers to level the crane. Make sure boom is fully retracted and in a horizontal position over front of the crane.
2. If equipped, remove the swingaway boom extension. See *Removing the Boom Extension*, page 4-8.

CAUTION

Wear gloves when handling wire rope. Moderate to minor injury may result if using bare hands.

3. Remove hook block or overhaul ball and wind all wire rope onto the hoist drum.
4. Elevate boom slightly to allow for withdrawal of the lift cylinder rod end from the lift cylinder attach fitting on the bottom of the boom.

DANGER

Ensure lifting device is capable of supporting the boom assembly. Death or serious injury may result if the lifting device cannot support the load.

5. Attach a lifting device to the four lifting lugs at top of boom that provides for equal weight distribution.
6. Disconnect all electrical wiring from the boom.
7. Tag and disconnect hydraulic lines to the telescope cylinder. Cap/plug all openings.

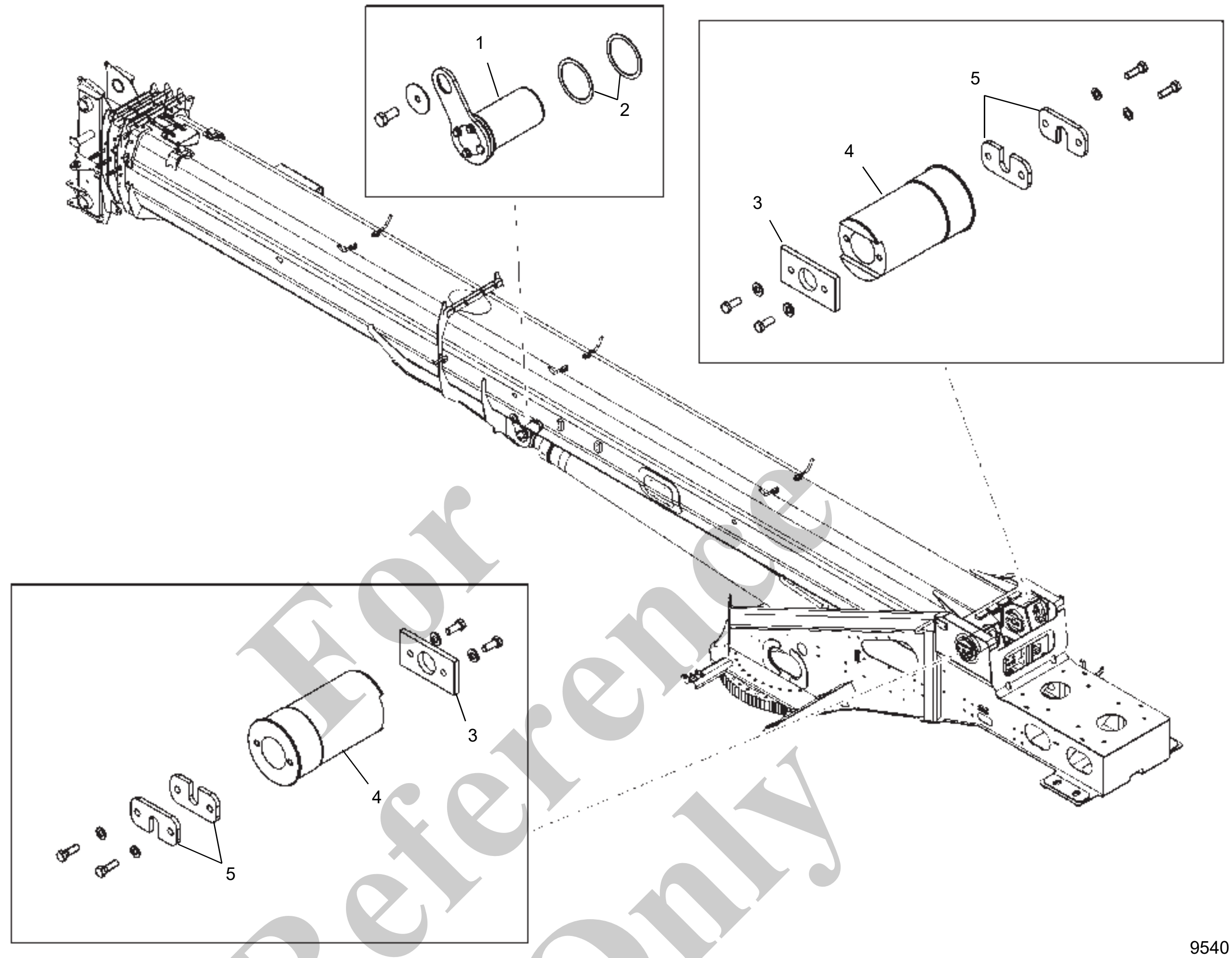
DANGER

Ensure boom lift cylinder is properly supported before disconnecting it from the boom. Death or serious injury may result if lift cylinder is not supported.

8. Block the lift cylinder.
9. Remove the capscrews, washers, and end plate securing the upper lift cylinder shaft to the side of the attachment fitting on the boom. Loosen the set screws on opposite side.
10. Remove the upper lift cylinder shaft and shims.
11. Activate hydraulic system and retract the lift cylinder rod enough to clear the attachment fitting.

NOTE: Shut down crane before proceeding.

12. Take up slack on the boom lifting device.
13. Remove capscrew, washer, and wear pads from each of the two pivot shafts that secure the boom to the superstructure, then remove the capscrew and washer from the opposite side of each pivot shafts. Remove the two pivot shafts.
14. Raise boom clear of crane and lower to ground level. Set adequate supports under base section to level boom for service.



1	Pin Assembly	4	Shaft
2	Shim	5	Wear Pad
3	Keeper Plate		

FIGURE 4-15

Installing the Boom

NOTE: The following procedure applies to a boom totally removed from the crane.

DANGER

Make sure the lifting device is capable of supporting the boom assembly. Death or serious injury may result if the lifting device cannot support the load.

NOTE: 4-section boom weighs approximately 6405 kg (14,125 lb). 5-section boom weighs approximately 7300 kg (16,100 lb).

NOTE: Refer to Figure 4-15.

1. Attach a lifting device to the four lifting lugs at top of boom that provides for equal weight distribution.
2. Lower the boom into position and align the boom pivot shaft mounting holes for installation of the pivot shafts to the superstructure assembly.
3. Lubricate and install the boom pivot shafts. Secure each pivot shaft in place with the washer and capscrew on one side and wear pads, washer, and capscrew on the opposite side.

DANGER

Block the boom before doing any work under the boom. Failure to properly support the boom may result in death or serious injury.

4. Block the boom in place.
5. Attach a suitable lifting device to the lift cylinder.

DANGER

Failure to properly support the boom lift cylinder may result in death or serious injury.

6. Using the lifting device attached to the boom, lower the boom onto the lift cylinder rod end and extend the lift cylinder as necessary to align rod with attach fitting on boom.

DANGER

If the hydraulic system must be activated to extend or retract the lift cylinder, ensure the rod end is properly aligned with the lift cylinder attach fitting.

7. Install the upper pivot shaft through the cylinder and boom attach points, inserting the spacers and shims as noted during disassembly. Shut down the engine.
8. Install end plate, washers, and capscrews which secure upper pivot shaft to the side of the attachment fitting on the boom.
9. Evenly tighten the setscrews on the opposite side until both setscrews make contact with the cylinder, then loosen both setscrews until a gap of 2 mm (0.08 in) is attained between end of setscrews and cylinder. Secure setscrews with nuts.
10. Remove the boom lifting device.
11. Activate the hydraulic system and remove the boom and lift cylinder blocking devices. Lower the boom to horizontal. Shut down the crane.
12. Connect the hydraulic lines to the telescope cylinder as tagged prior to removal.
13. Connect any electrical wires as tagged prior to removal.

CAUTION

If removed, ensure the large access covers on each side of the boom base section are installed before extending the boom. Boom damage could occur.

14. For cable adjustments, refer to either *Tensioning the 4-Section Boom Extend and Retract Cables*, page 4-138 or *Tensioning the 5-Section Boom Extend and Retract Cables*, page 4-138.

4-SECTION BOOM - DISASSEMBLING/ASSEMBLING

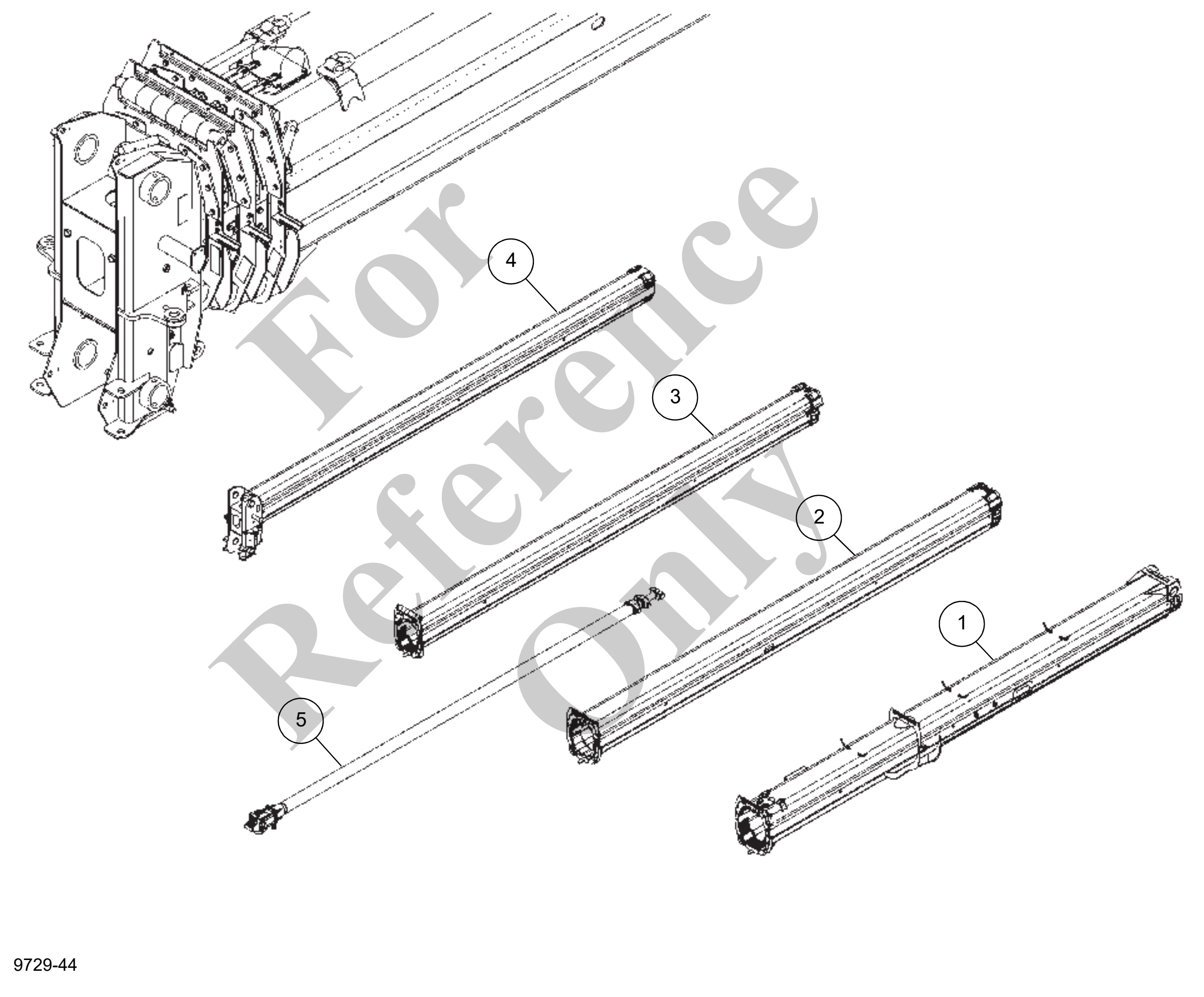


FIGURE 4-16

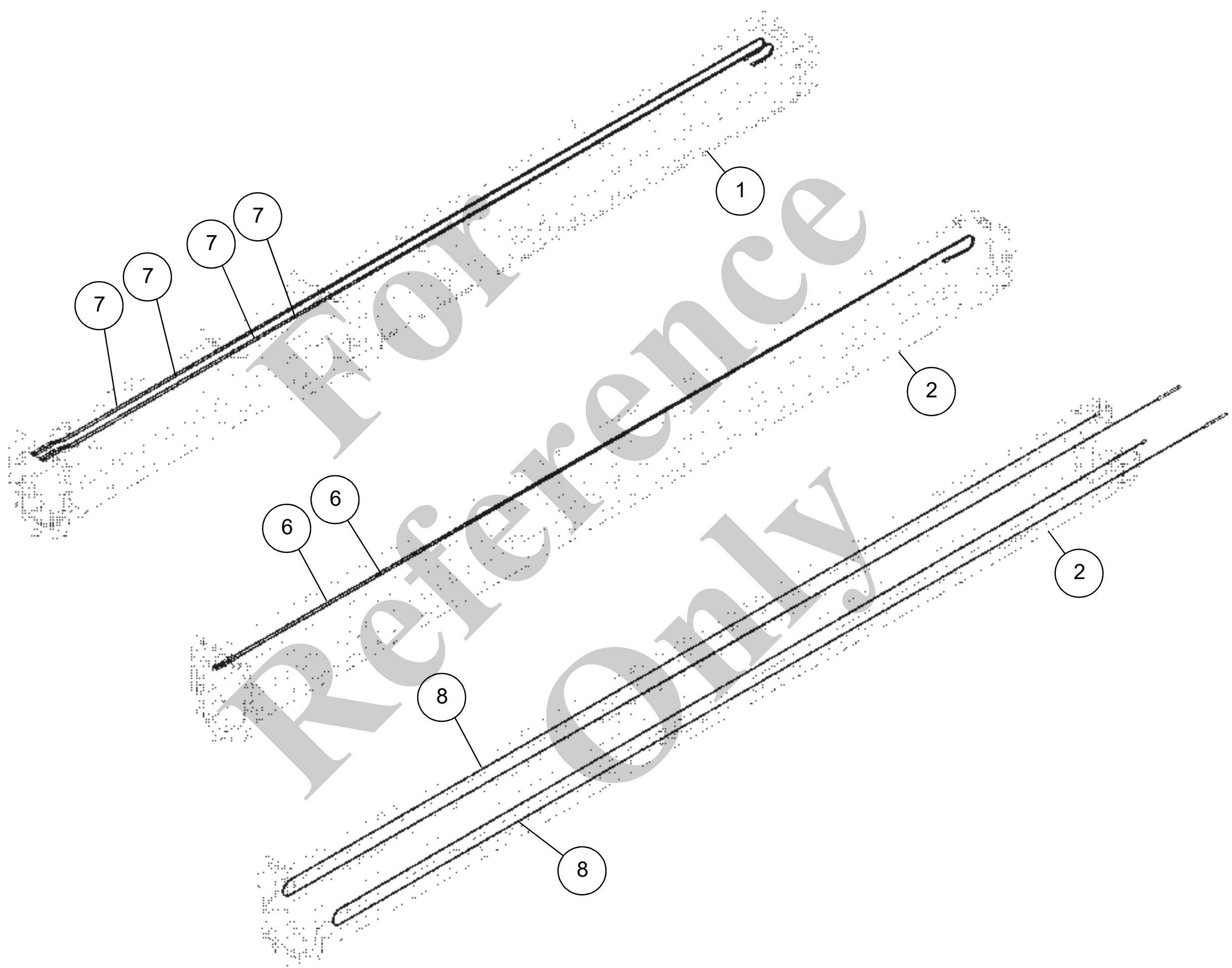


FIGURE 4-16 continued

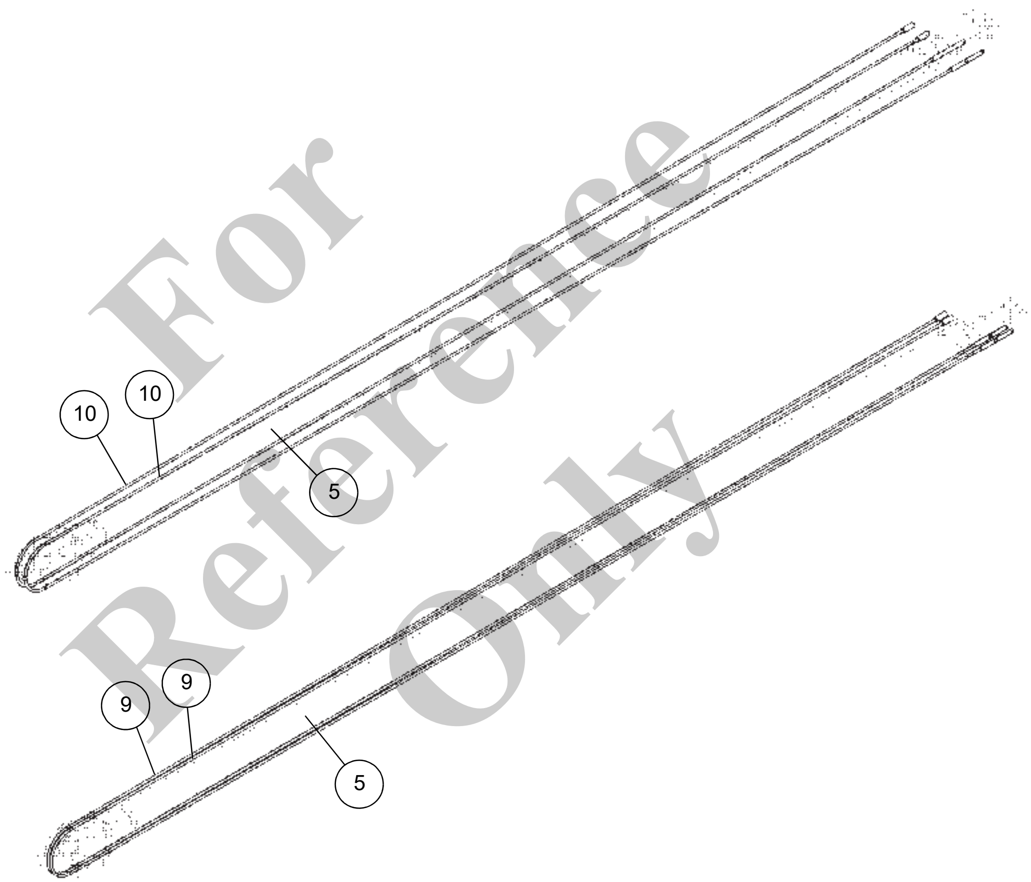
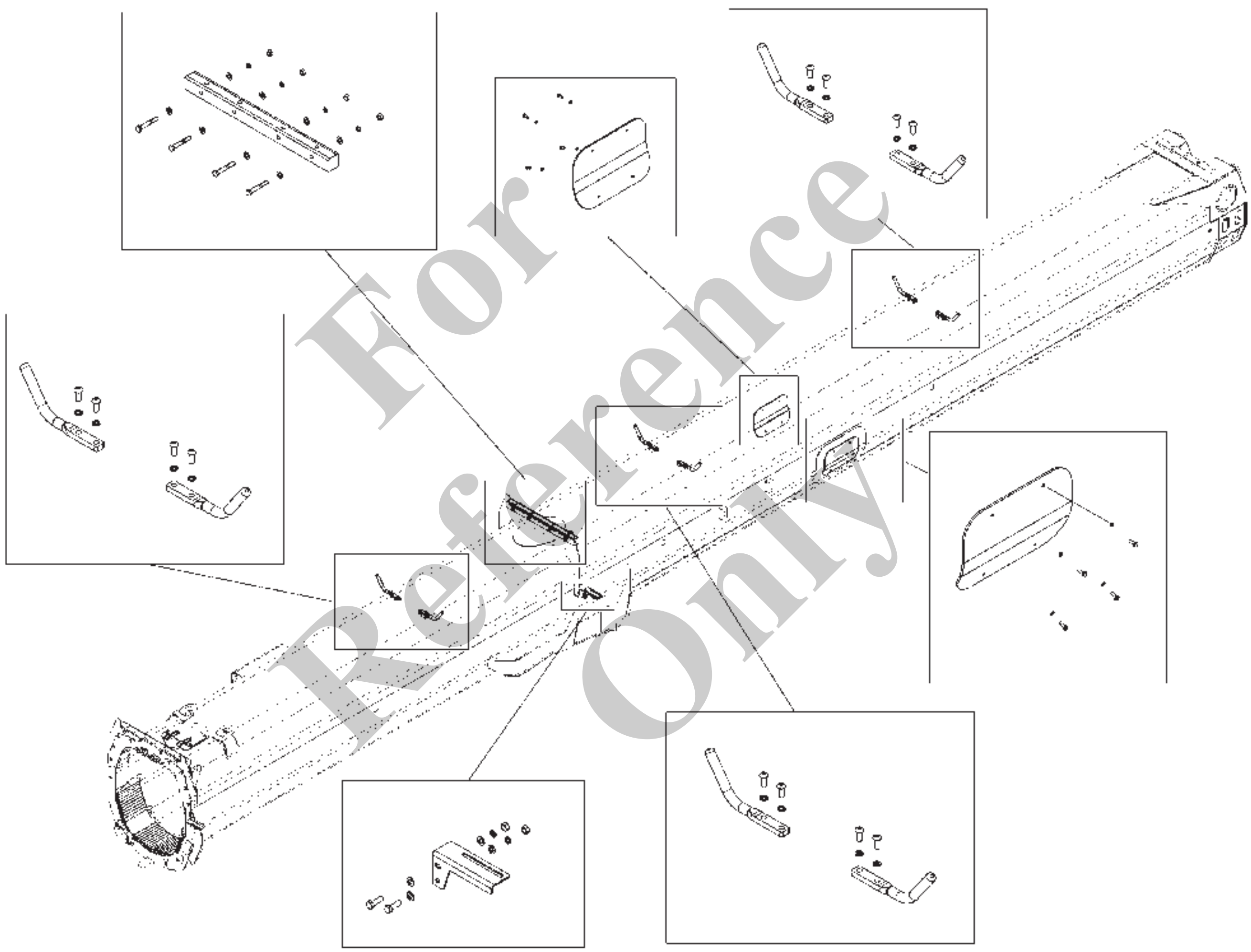


FIGURE 4-16 continued



9729-35

FIGURE 4-16 continued

Published 3-26-2021, Control # 676-02

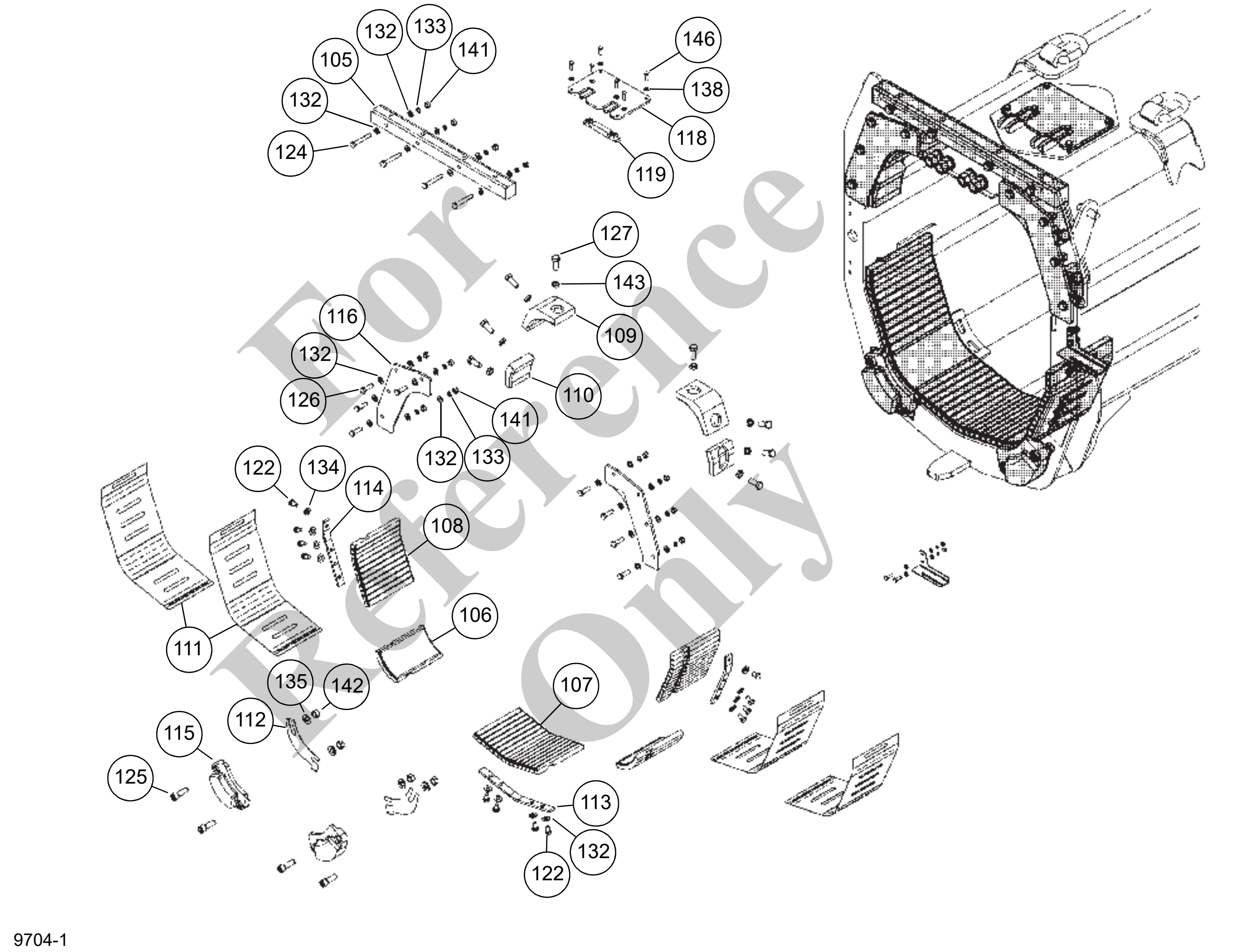
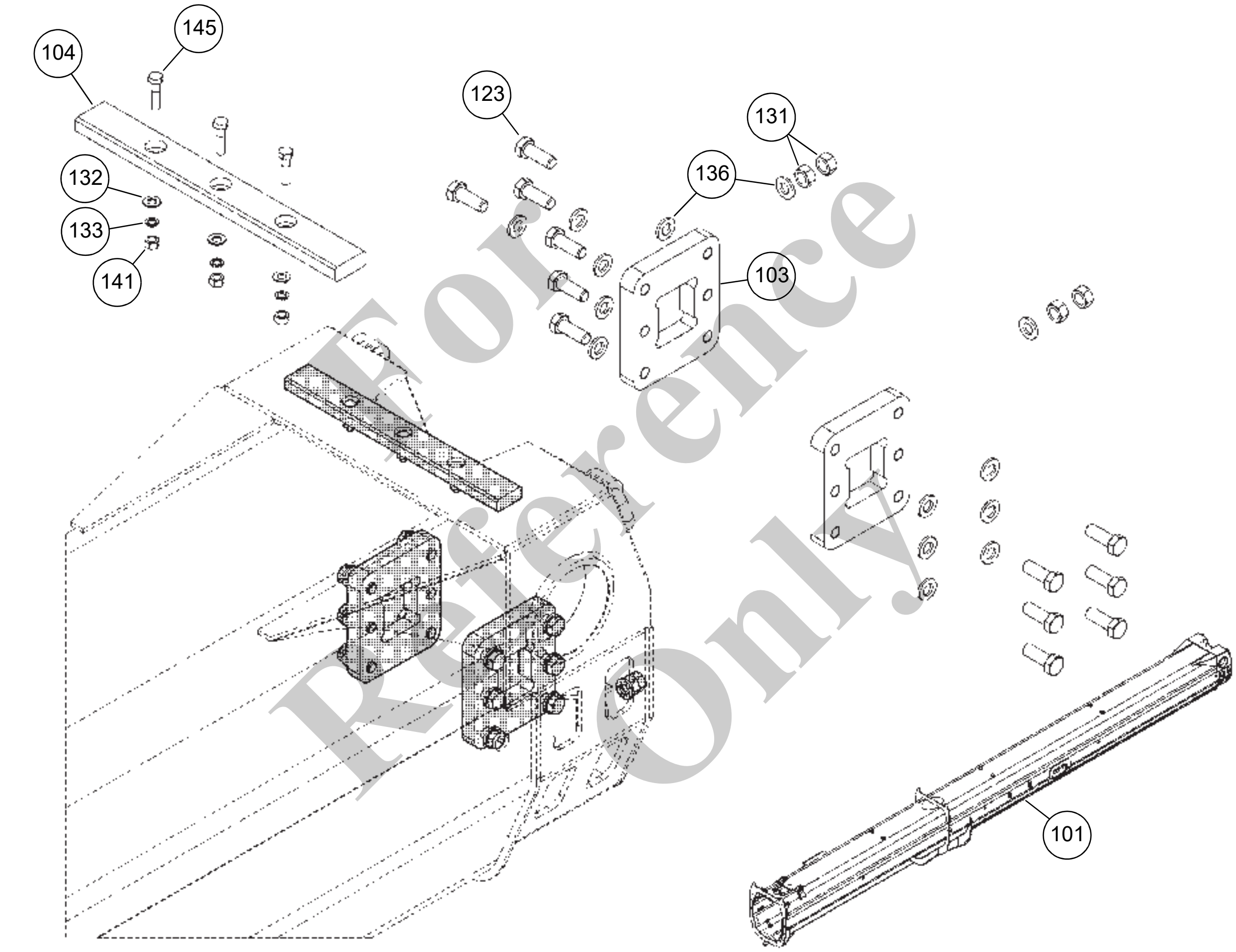
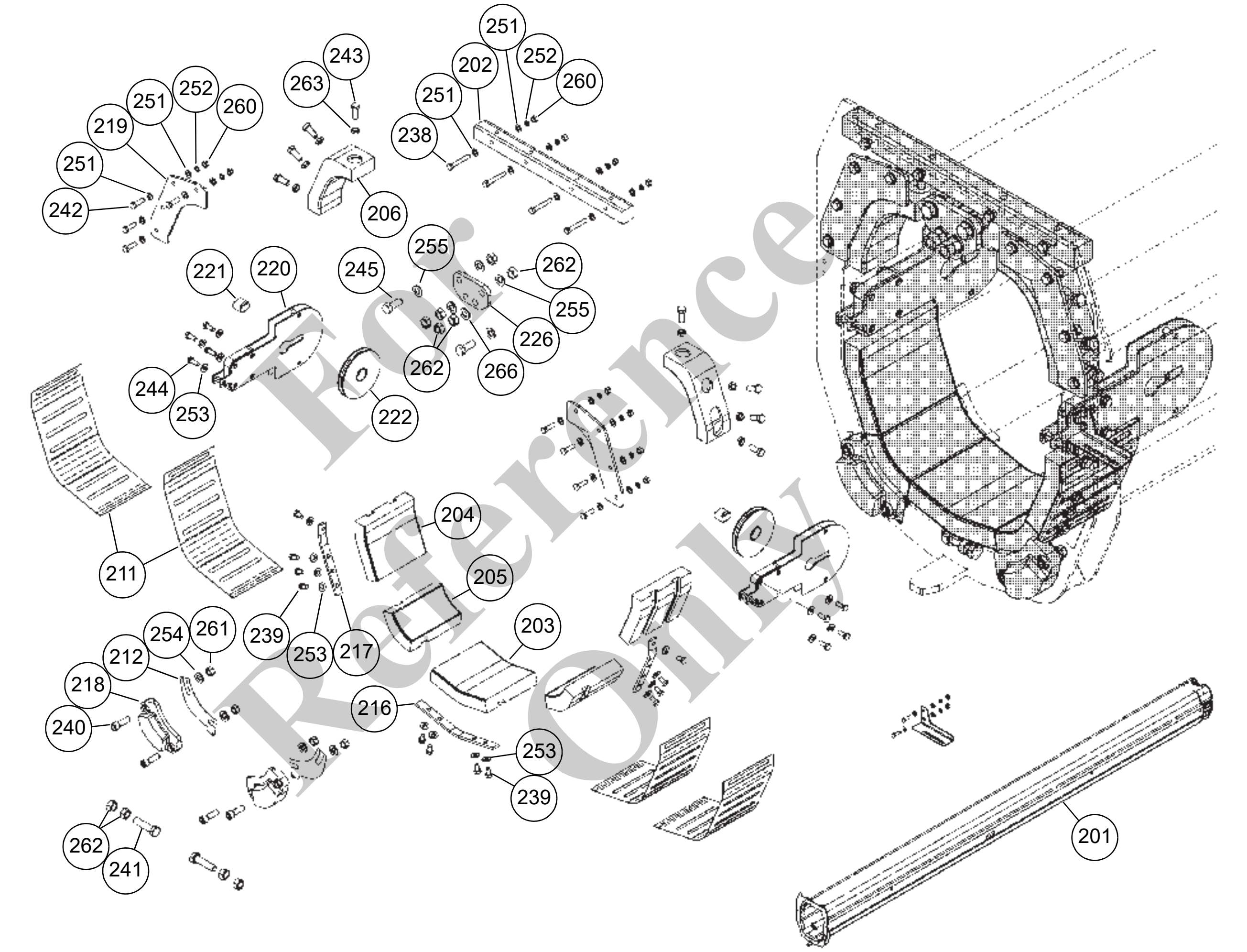


FIGURE 4-16 continued



9704-2

FIGURE 4-16 continued



9704-3

FIGURE 4-16 continued

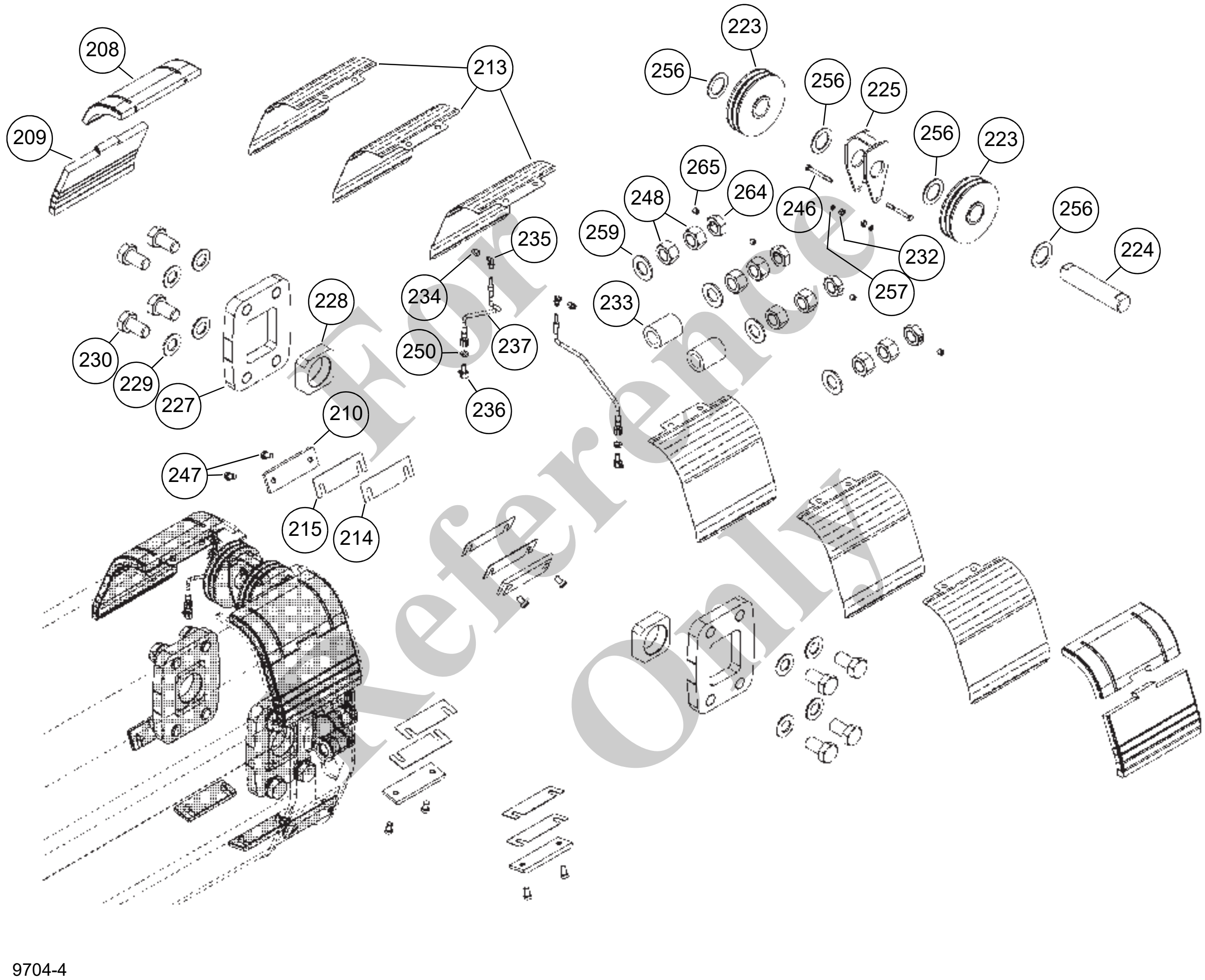
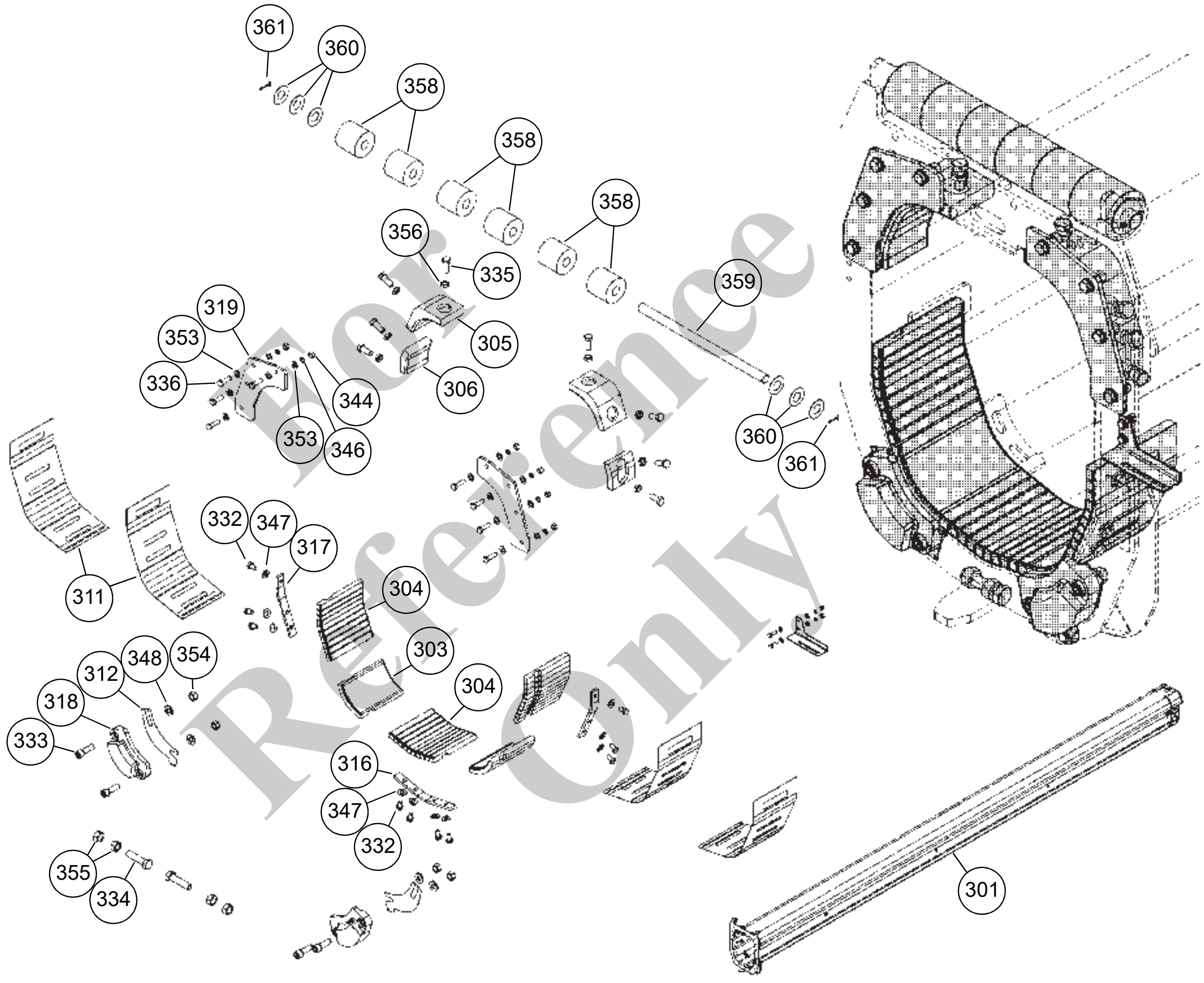


FIGURE 4-16 continued



9704-5

FIGURE 4-16 continued

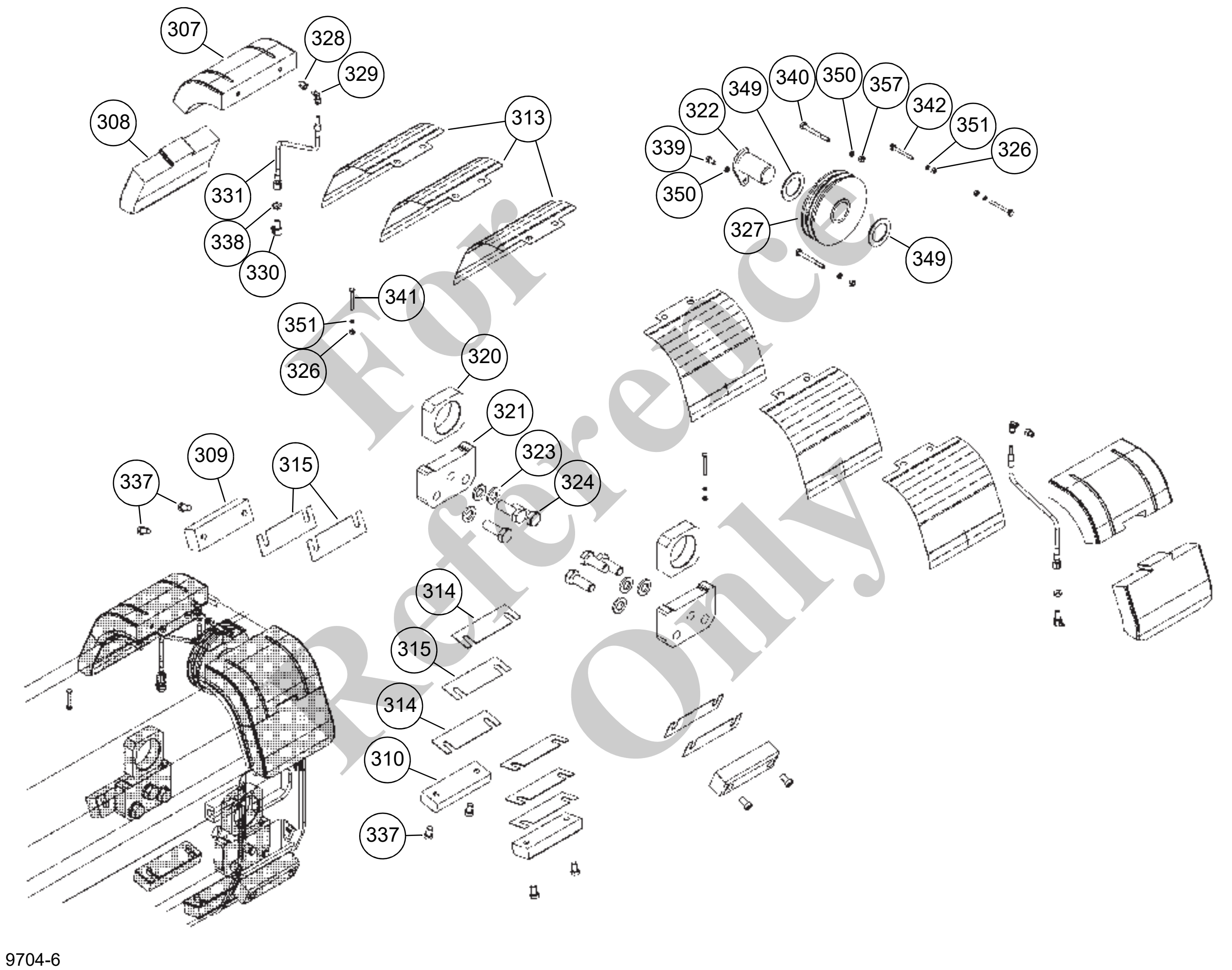


FIGURE 4-16 continued

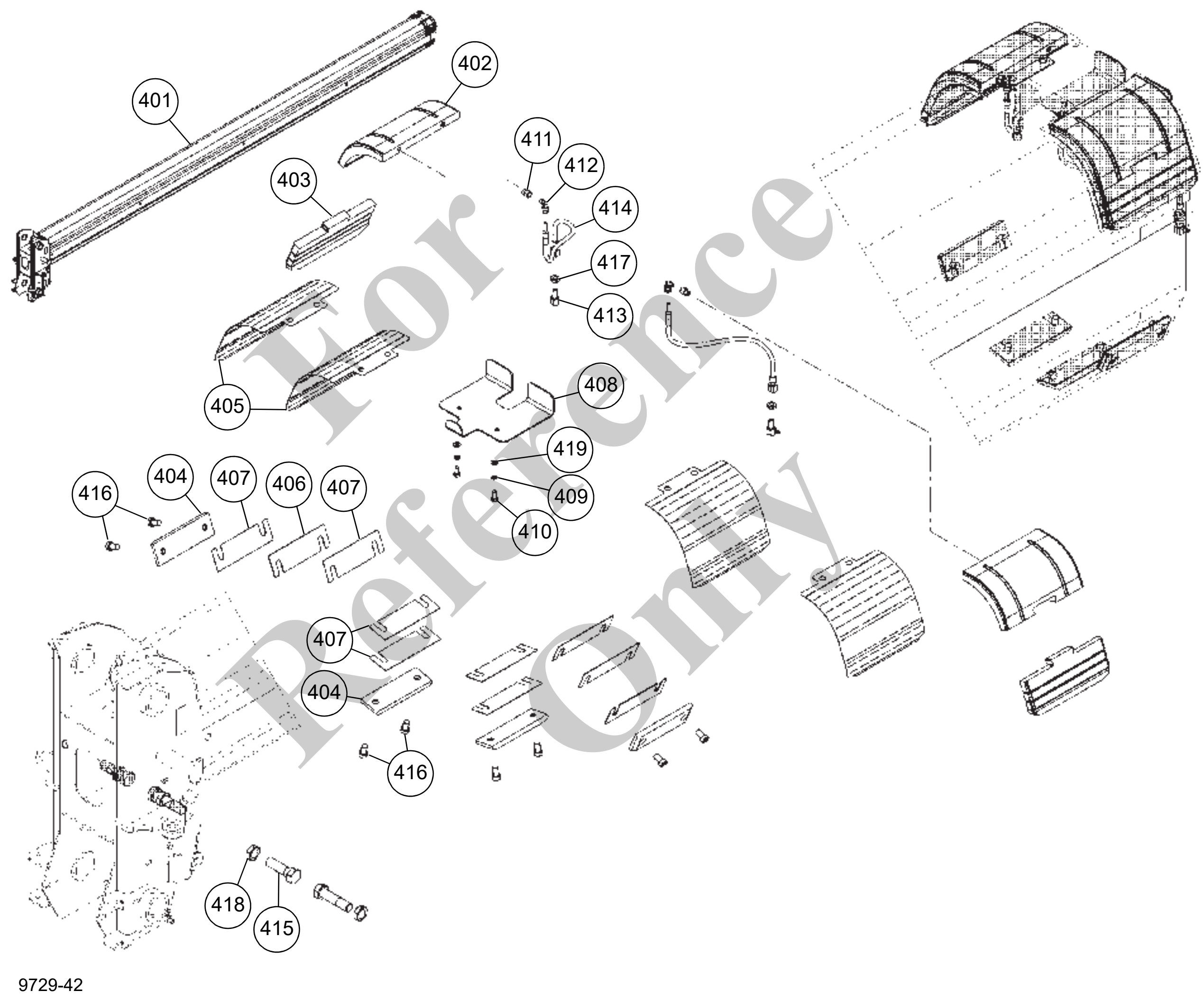


FIGURE 4-16 continued

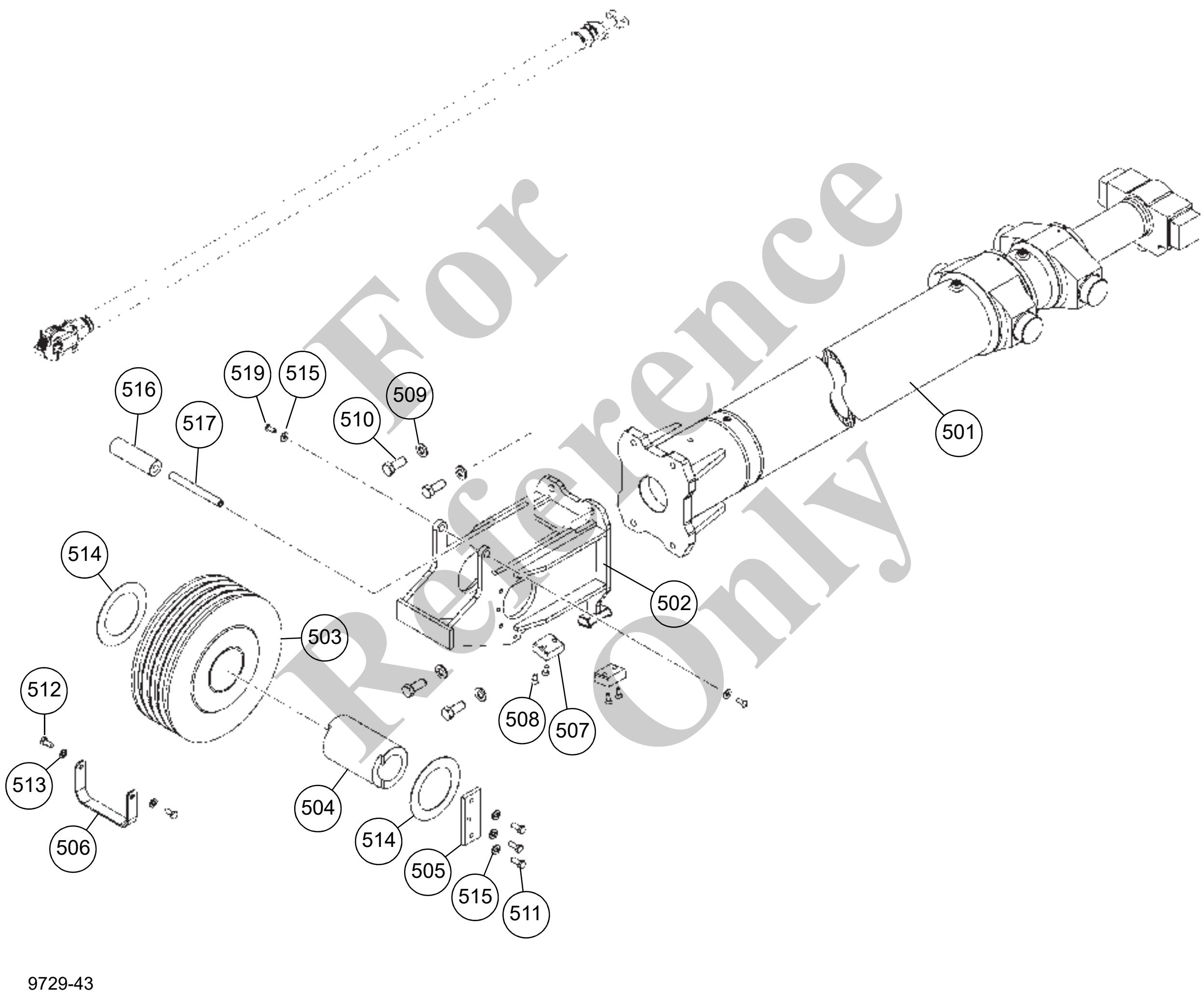


FIGURE 4-16 continued

ITEM	DESCRIPTION
1	BASE ASSEMBLY
2	TELE 1 ASSEMBLY
3	TELE 2 ASSEMBLY
4	TELE 3 ASSEMBLY
5	CYLINDER ASSEMBLY
6	CABLE RETRACT
7	CABLE RETRACT
8	CABLE SYNCHRO
9	CABLE EXTEND
10	CABLE EXTEND
101	BASE WELDMENT
102	BAR BENT KEEPER
103	PLATE TRUNNION
104	WEAR STRIP
105	PROTECTION STRIP
106	WEAR PAD
107	WEAR PAD
108	WEAR PAD
109	WEAR PAD ASSY
111	SHIM FRONT
112	SHIM
113	PLATE RETAINER
114	PLATE RETAINER
115	BLOCK STOP
116	RETAINER
117	COVER
118	WELDMENT CABLE MOUNT
119	PLATE CABLE RETAINER
120	BRACKET
121	SBCS M10X25 SS ISO 7380
122	HHCS M12X20 -10.9 ISO 4017
123	SCR CAP HEX HD M20 X 55 LG
124	HHCS M12X80 8.8 ISO 4014
125	SHCS M16X50 10.9 ISO 4762
126	HHCS M12X40 8.8 ISO 4017
127	HHCS M16X40 10.9 ISO 4014
128	HHCS M6X16 SS ISO 4017
129	HHCS FULL THREAD, 8 X 25 8.8

ITEM	DESCRIPTION
130	L WASHER, 8 ST DIN 7980
131	HEX NUT M20 8 ISO 4032
132	F WASHER, 12 ST ISO 7089
133	L WASHER, 12 ST DIN 7980
134	F WASHER 1/2” HARD ASTM F-436
135	F WASHER 5/8” HARD ASTM F-436
136	F WASHER 3/4” HARD ASTM F-436
137	L WASHER 6 -HRC44-51 DIN 7980
138	F WASHER 5/16” HARD ANSI B27.2”
139	F WASHER, 8 ST ISO 7089
140	HEX NUT, 8 8 ISO 4032
141	HEX NUT M12 8 ISO 4032
142	HEX NUT M16 8 ISO 4032
143	HEX JAM NUT, 16-8 ISO 4035
144	L WASHER, 10 ST DIN 7980
145	HHCS M12X45 8.8 ISO 4014
146	HHCS M8 X 25 -10.9 ISO 4017
201	TELE 1 WELDMENT
202	PROTECTION STRIP
203	WEAR PAD
204	WEAR PAD
205	WEAR PAD
206	WEAR PAD ASSY
208	WEAR PAD
209	WEAR PAD
210	SLIDER
211	SHIM FRONT
212	SHIM
213	SHIM REAR
214	FILL PLATE
215	FILL PLATE
216	PLATE RETAINER
217	PLATE RETAINER
218	BLOCK STOP
219	RETAINER
220	WELDMENT SHEAVE MOUNT
221	SHAFT
222	SHEAVE ASSEMBLY

ITEM	DESCRIPTION
223	SHEAVE ASSEMBLY
224	SHAFT
225	WELDMENT GUARD
226	PLATE
227	PLATE TRUNNION
228	BLOCK
229	F WASHER 1-1/8” HARD ASTM F-43
230	HHCS M30X55 10.9 ISO 4017
231	BRACKET
232	HEX NUT, 8 8 ISO 4032
233	BUSHING
234	ADAPTER
235	ELBOW, PUSH-IN
236	PIPE UNION
237	LUBRICANT HOSE
238	HHCS M12X80 8.8 ISO 4014
239	HHCS M12X20 -10.9 ISO 4017
240	SHCS M16X50 10.9 ISO 4762
241	HHCS M20X80 8.8 ISO 4017
242	HHCS M12X40 8.8 ISO 4017
243	HHCS M16X40 10.9 ISO 4014
244	HHCS M12X30 10.9 ISO 4017
245	HHCS M20X50 10.9 ISO 4014
246	HHCS M8X75 -8.8 ISO 4014
247	SHCS-LOW M12X20 8.8-A3C DIN 79
248	HEX NUT 1-1/4-7UNC SAE-8
249	HHCS FULL THREAD, 8 X 25 8.8
250	THIN NUT M12X1.5 5 DIN 80705
251	F WASHER, 12 ST ISO 7089
252	L WASHER, 12 ST DIN 7980
253	F WASHER 1/2” HARD ASTM F-436
254	F WASHER 5/8” HARD ASTM F-436
255	F WASHER, 20 ST ISO 7089
256	THRUST WASHER 1.75X2.6X0.13” B
257	L WASHER, 8 ST DIN 7980
258	F WASHER, 8 ST ISO 7089
259	F WASHER 1-1/4” HARD ASTM F-43
260	HEX NUT M12 8 ISO 4032

ITEM	DESCRIPTION
261	HEX NUT M16 8 ISO 4032
262	HEX NUT M20 8 ISO 4032
263	HEX JAM NUT, 16-8 ISO 4035
264	JAM NUT, 1 1/4-7 UNC P.L.
265	HSSS-L-FLAT 1/2-13UNCX0.50 ST
266	F WASHER 3/4” HARD ASTM F-436
267	HEX LOCK NUT PA, 8 8 ISO 7040
301	TELE 2 WELDMENT
303	WEAR PAD
304	WEAR PAD
305	WEAR PAD ASSY
307	WEAR PAD
308	WEAR PAD
309	WEAR PAD
310	WEAR PAD
311	SHIM
312	SHIM
313	SHIM
314	FILL PLATE
315	FILL PLATE
316	PLATE
317	PLATE
318	BLOCK STOP
319	PLATE
320	BLOCK
321	PLATE
322	SHAFT WELD
323	F WASHER 3/4” HARD ASTM F-436
324	SCR CAP HEX HD M20 X 55 LG
325	BRACKET
326	HEX NUT M6 8 ISO 4032
327	SHEAVE ASSEMBLY
328	ADAPTER
329	ELBOW, PUSH-IN
330	PIPE UNION
331	LUBRICANT HOSE
332	HHCS M12X20 -10.9 ISO 4017
333	SHCS M16X50 10.9 ISO 4762

ITEM	DESCRIPTION
334	HHCS M20X80 8.8 ISO 4017
335	HHCS M16X40 10.9 ISO 4014
336	HHCS M12X40 8.8 ISO 4017
337	SHCS-LOW M12X20 8.8-A3C DIN 79
338	THIN NUT M12X1.5 5 DIN 80705
339	HHCS M8X16 SS ISO 4017
340	HHCS M8X75 -8.8 ISO 4014
341	HHCS M6X50 SS ISO 4017
342	HHCS M6X60 8.8 ISO 4014
343	HHCS FULL THREAD, 8 X 25 8.8
344	HEX NUT M12 8 ISO 4032
346	L WASHER, 12 ST DIN 7980
347	F WASHER 1/2” HARD ASTM F-436
348	F WASHER 5/8” HARD ASTM F-436
349	THRUST WASHER 1.75X2.6X0.13” B
350	L WASHER, 8 ST DIN 7980
351	L WASHER 6 -HRC44-51 DIN 7980
352	F WASHER, 8 ST ISO 7089
353	F WASHER, 12 ST ISO 7089
354	HEX NUT M16 8 ISO 4032
355	HEX NUT M20 8 ISO 4032
356	HEX JAM NUT, 16-8 ISO 4035
357	HEX NUT, 8 8 ISO 4032
358	ROLLER
359	SHAFT
360	SHIM
361	COTTER PIN 0.13X1.75” ST
362	HEX LOCK NUT PA, 8 8 ISO 7040
401	TELE 3 WELDMENT
402	WEAR PAD
403	WEAR PAD
404	SLIDER
405	SHIM
406	FILL PLATE
407	FILL PLATE
408	PLATE
409	L WASHER, 8 ST DIN 7980
410	HHCS M8X16 SS ISO 4017

ITEM	DESCRIPTION
411	ADAPTER
412	ELBOW, PUSH-IN
413	PIPE UNION
414	LUBRICANT HOSE
415	HHCS M20X80 8.8 ISO 4017
416	SHCS-LOW M12X20 8.8-A3C DIN 79
417	THIN NUT M12X1.5 5 DIN 80705
418	HEX JAM NUT M20 04 ISO 4035
419	F WASHER, 8 ST ISO 7089
501	CYL HYD
502	WELDMENT SHEAVE MOUNT
503	SHEAVE ASSEMBLY
504	SHAFT
505	PLATE
506	PLATE CABLE KEEPER
507	WEAR PAD
508	SLOT FMS 3/8-16UNCX1 G1
509	F WASHER 3/4” HARD ASTM F-436
510	HHCS M20X50 10.9 ISO 4014
511	HHCS M12X30 10.9 ISO 4017
512	HHCS FULL THREAD, 12 X 25 8.8
513	F WASHER, 12 ST ISO 7089
514	SPACER
515	F WASHER 1/2” HARD ASTM F-436
516	ROLLER
517	BAR
518	F WASHER 3/8” HARD ANSI B27.2
519	SBCS M10X25 SS ISO 7380

Disassembling the 4-Section Boom

NOTE: 4-section boom weighs approximately 6405 kg (14,125 lb).

NOTE: Boom assembly must be rotated 180° (upside down) before performing any assembly or disassembly procedures.

CAUTION

A rollover fixture with webbing is recommended to rotate the boom sections. Chains are not recommended. If a rollover fixture is not available, rotate the sections using adequate support with webbing.

A secure fixture that will prevent damage to the boom is recommended to stabilize and hold the boom from moving during removal of the boom section(s).

When adjusting the extend and retract cables, hold the cable end and turn the nut. Do not turn the cable. Turning the cable while adjusting will result in damage or failure of the cable.

Refer to these procedures and Figure 4-16 when disassembling the boom.

1. Remove boom from crane. Refer to procedures outlined under *Removing the Boom*, page 4-18.
2. Position boom assembly upside down on adequate supports.
3. Put a chain or strap around the front tips of teles 3, 2, and 1 to prevent them from separating during disassembly.
4. Cut a section of angle-iron measuring 240 mm (9-1/2 in) in length. Cover edges of angle-iron with edge guard. Using zip-ties, attach angle-iron to telescope cylinder chrome tube.

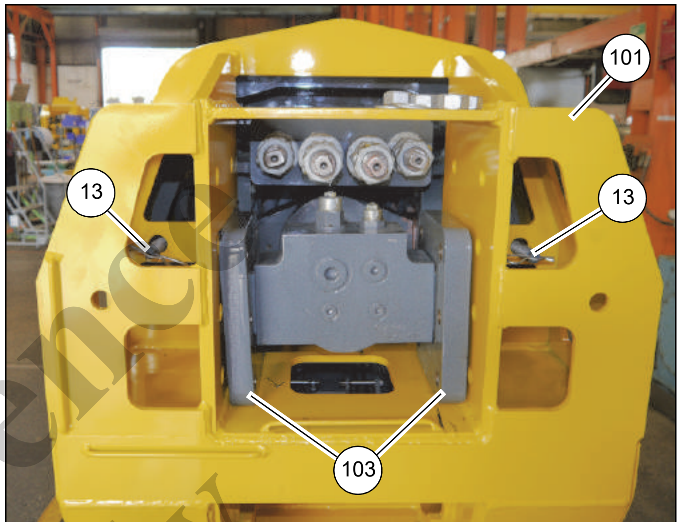
   Because of hydraulic oil pressure that may be held in the telescope cylinder by the check valves, the telescope cylinder can suddenly retract with much force when the trunnion bolts are removed. If the telescope cylinder were to retract, damage to the check valves in the top of the telescope cylinder will occur. The section of angle-iron will stop the telescope cylinder from retracting.

CAUTION

Component damage hazard!

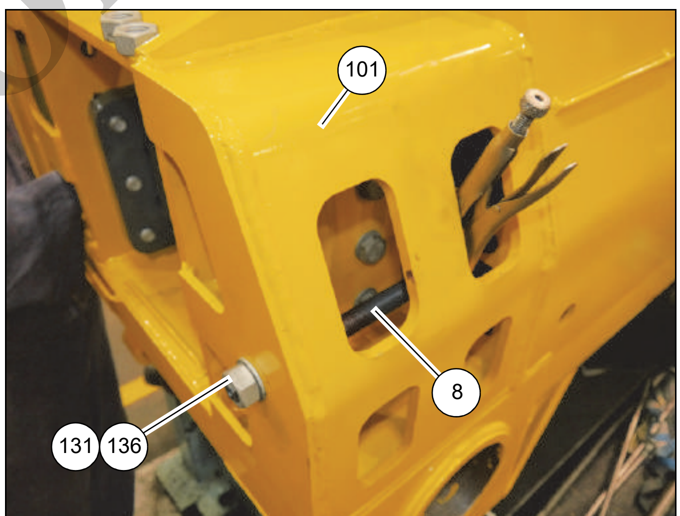
Make sure telescope cylinder is blocked in a manner that prevents it from suddenly retracting when the trunnion bolts are removed. Damage to the telescope cylinder can occur.

5. Remove bolts (123) and washers (136) attaching trunnion plates (103) to base (101) (see Figure 4-17).



9688-118 **FIGURE 4-17**

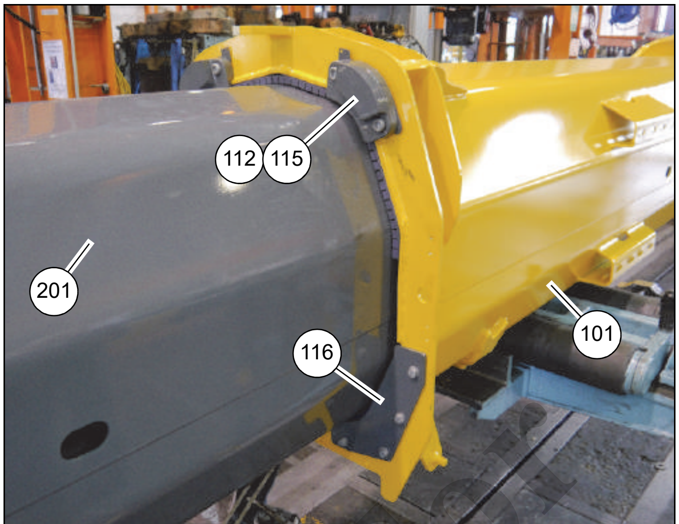
6. Remove two nuts (131) and washer (136) from end of each extend cable (8) at rear of base (101) (see Figure 4-18).



9688-119 **FIGURE 4-18**

7. Pull tele 1 (201) out of base (101) several feet.

8. Remove bolts (126), washers (132), lock washers (133), and nuts (141) attaching left and right stop plates (116) to base (101). Remove bolts (125), washers (135), and nuts (142) attaching left and right stop blocks (115) and shims (112) to base (101) (see Figure 4-19)



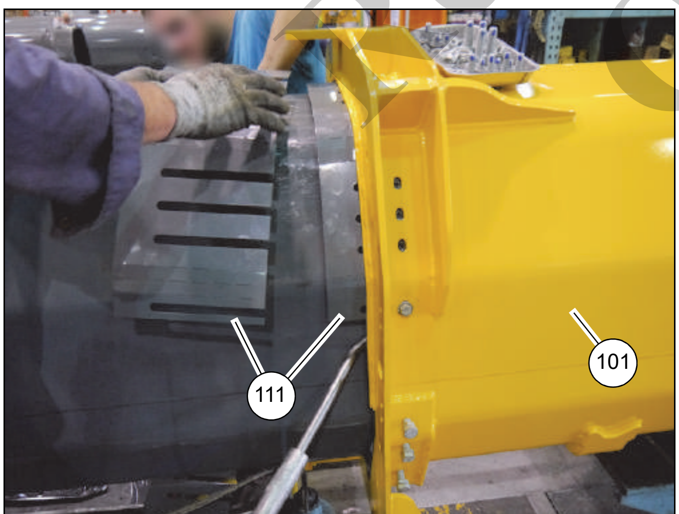
9688-117

FIGURE 4-19

9. Remove bolts (122) and washers (134) attaching wear pads (106, 107, 108), shims (111), and bars (113, 114) in place.

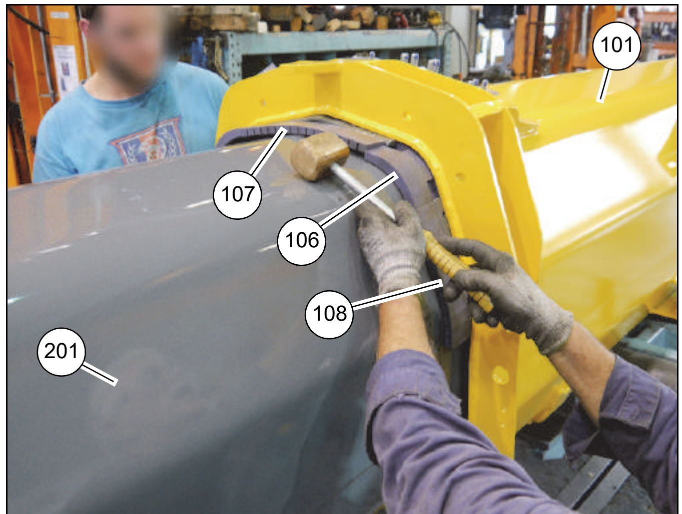
10. Remove bolts (127) and nuts (143) used to adjust the left and right wear pads (109, 110).

11. Remove shims (111), wear pads (106, 107, 108), and bars (113, 114) from between base (101) and tele 1 (201) (see Figure 4-20 and Figure 4-21).



9688-116

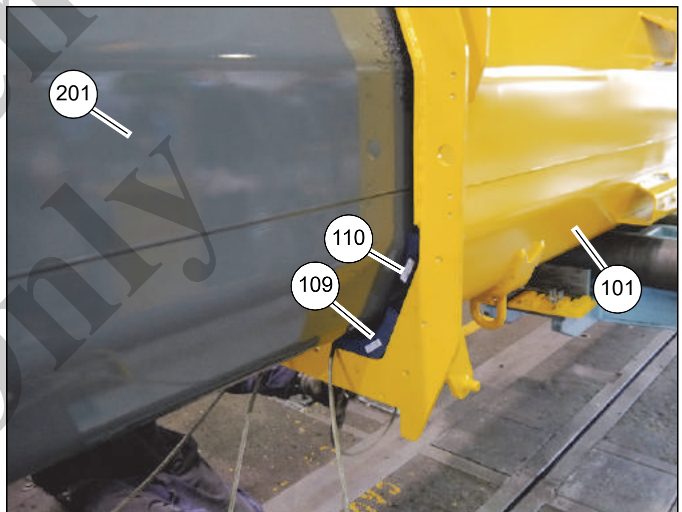
FIGURE 4-20



9688-114

FIGURE 4-21

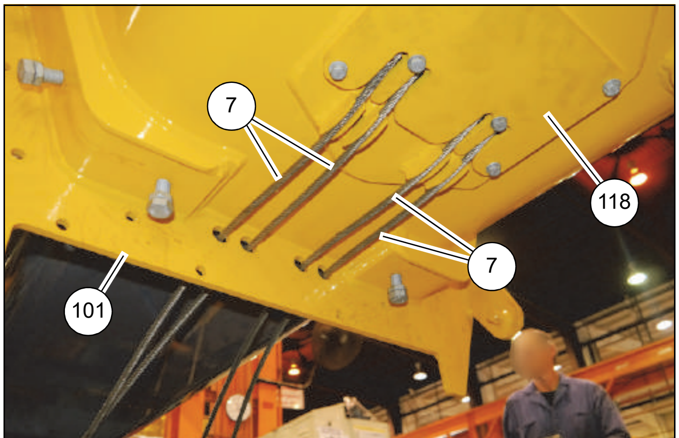
12. Slightly raise tele 1 (201), then remove left and right side wear pads (109, 110) from between base (101) and tele 1 (201) (see Figure 4-22).



9688-62

FIGURE 4-22

13. Remove two nuts (131) and one washer (136) from each of the four retract cables (7) at front of base (101) (see Figure 4-23).



9688-113 **FIGURE 4-23**

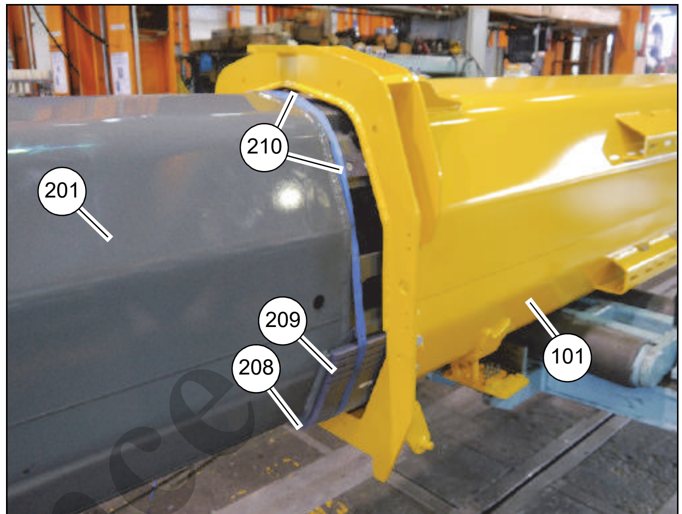
14. Remove four bolts (146) and washers (138) attaching cable mount weldment (118) to bottom of base (101) (see Figure 4-23).

15. Remove two bolts (146) and washers (138) attaching cable retainer plate (119) to cable mount weldment (118) (see Figure 4-23 and Figure 4-24).

9688-112 **FIGURE 4-24**

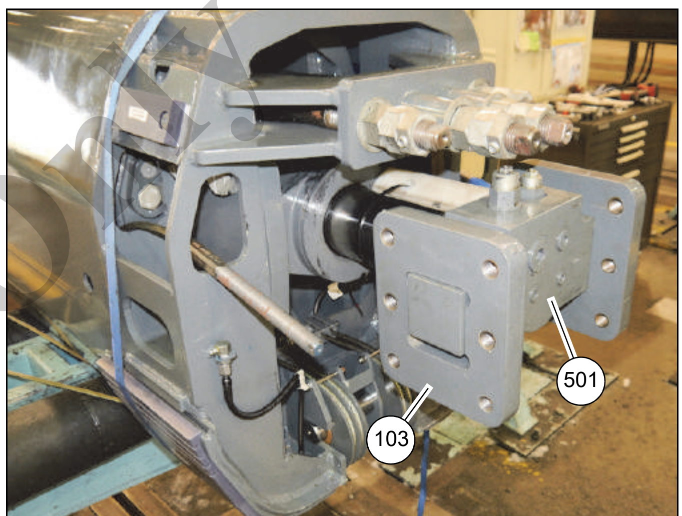
16. Pull ends of four retract cables (7) back through holes in tip of base (101) (see Figure 4-24). Route four retract cables (7) back up through base (101) and out between tele 1 (201) and base (101).

17. Pull tele 1 (201) out of base (101) (see Figure 4-25).



9688-110 **FIGURE 4-25**

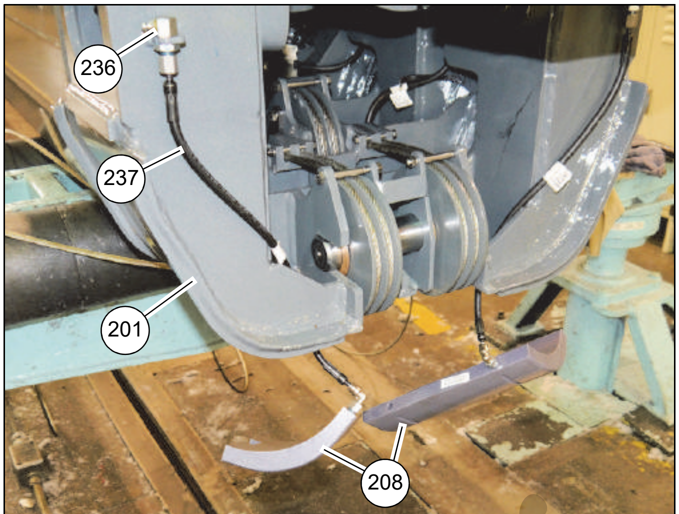
18. Remove trunnion blocks (103) from rear of telescope cylinder (501) (see Figure 4-26).



9688-108 **FIGURE 4-26**

19. Rotate end of telescope cylinder 180° so that the two holding valve cartridges point down.

20. Remove wear pads (208, 209) and shims (213) from bottom rear of tele 1 (201) (see Figure 4-27).

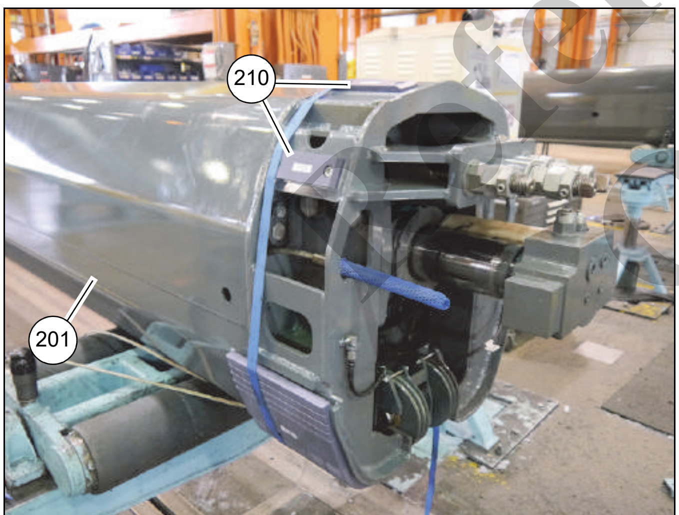


9688-105

FIGURE 4-27

21. Remove grease hoses (237) and grease fittings (236) from left and right sides of rear of tele 1 (201) (see Figure 4-27).

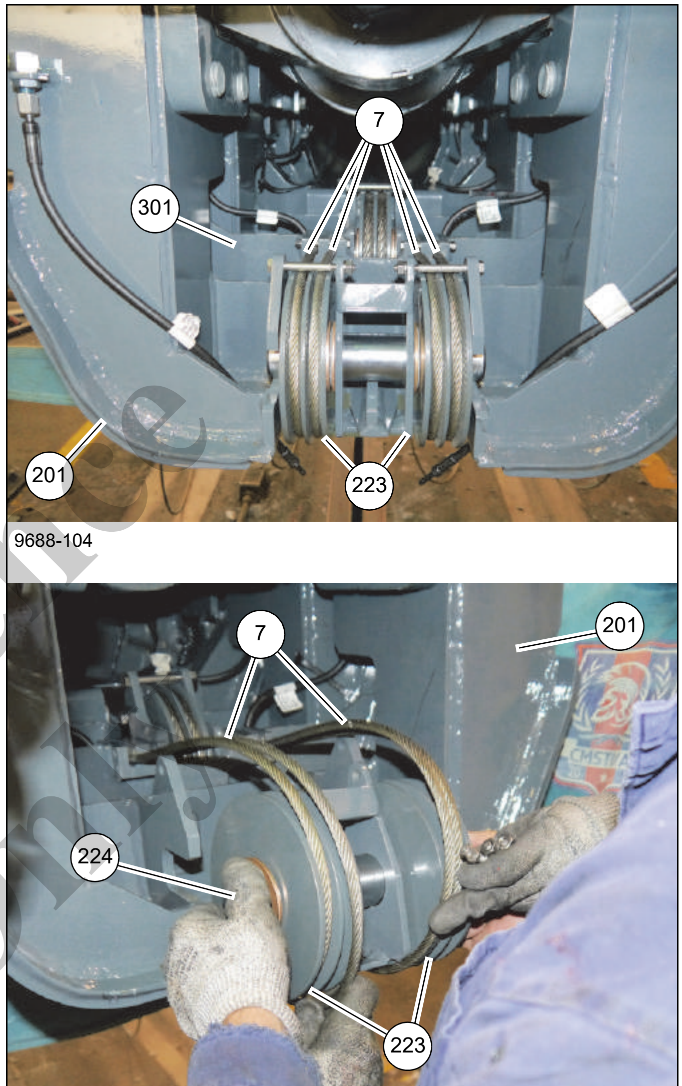
22. Remove two bolts (247) attaching each of the four wear pads (210) and shims (214, 215) to rear of tele 1 (201) (see Figure 4-28).



9688-107

FIGURE 4-28

23. Remove bolts (246), lock washers (257), and nuts (232) retaining retract cables (7) on sheaves (223). Remove two bolts (342), lock washers (351), and nuts (326) securing the ends of the four retract cables (7) in the cable keepers at rear of tele 2 (301) (see Figure 4-29).



9688-103

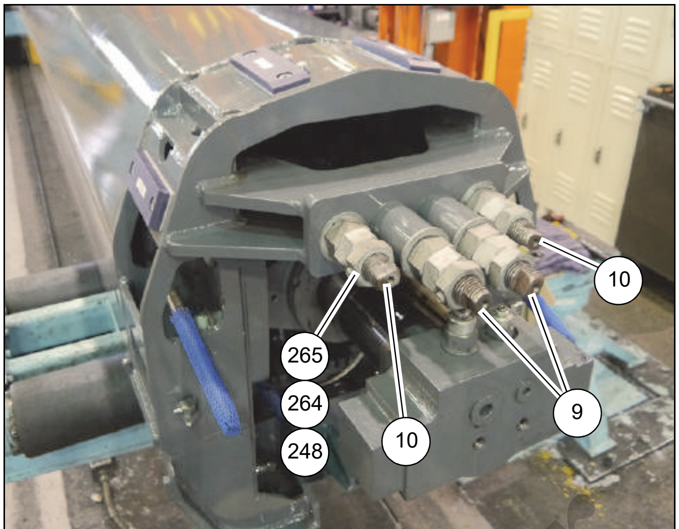
FIGURE 4-29

24. Remove the ends of three of the four retract cables (7) from the cables keepers in the rear of tele 2 (301). Note: the fourth cable end at the left center position cannot be removed due to interference with shaft (322).

25. Remove shaft/sheave assembly (224/223) from rear of tele 1 (201) (see Figure 4-29).

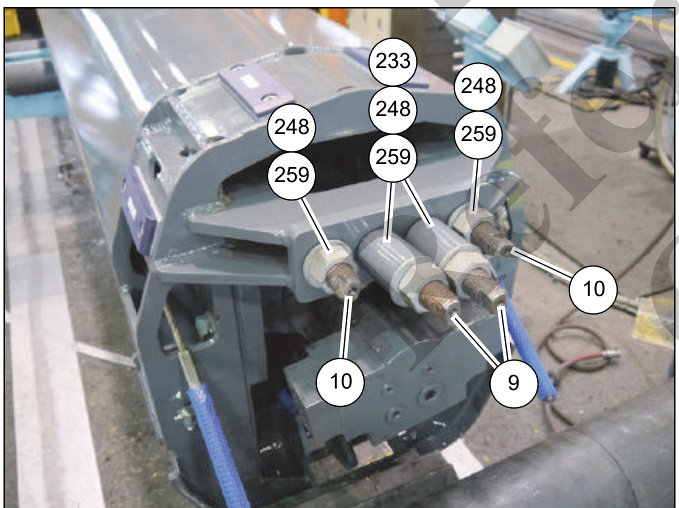
26. Coil the one remaining retract cable (7) and place it inside the tele sections.

27. Remove nuts (264) with set screws (265) from ends of the four extend cables (9, 10) (see Figure 4-30).



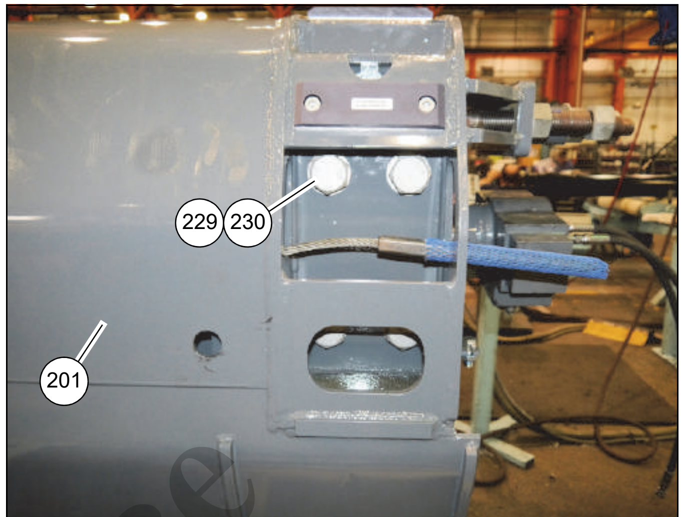
9688-99 **FIGURE 4-30**

28. Remove the two nuts (248) and washer (259) from each of the outside extend cables (10) Remove the two nuts (248), washer (259), and spacer (233) from each of the inside extend cables (9) (see Figure 4-31).



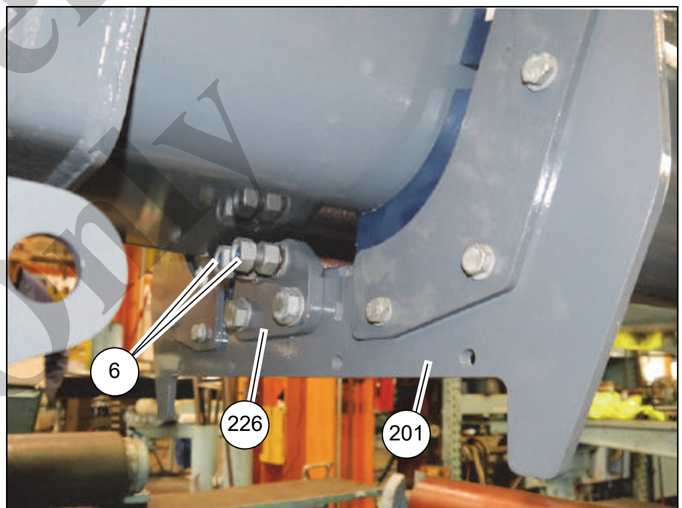
9688-97 **FIGURE 4-31**

29. Remove bolts (230) and washers (229) attaching trunnion plates (227) to the left and right sides of tele 1 (201 (see Figure 4-32).



9688-98 **FIGURE 4-32**

30. Remove nuts (262) and washers (266) from ends of the two retract cables (6) (see Figure 4-33).



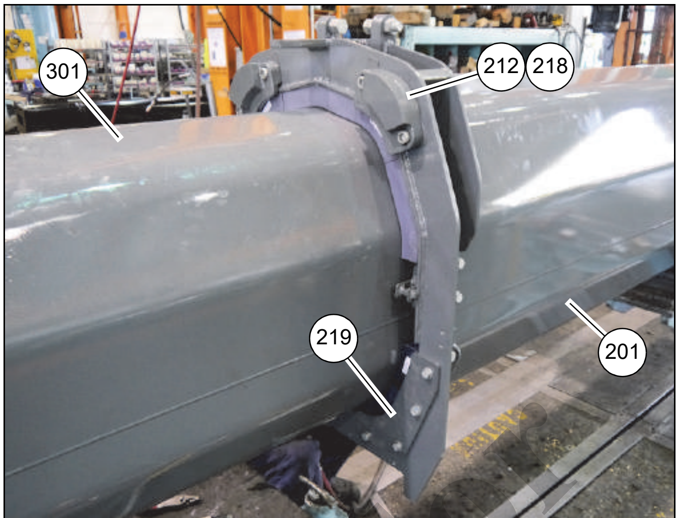
9688-95 **FIGURE 4-33**

31. Remove two bolts (245), washers (255), and nuts (262) attaching the plate (226) to front of tele 1 (201) (see Figure 4-33).

32. Put a chain or strap around the front tips of teles 3 and 2 to prevent them from separating during disassembly.

33. Pull tele 2 (301) out of tele 1 (201) several feet.

34. Remove bolts (242), washers (251), lock washers (252), and nuts (260) attaching left and right stop plates (219) to tele 1 (201). Remove bolts (240), washers (254), and nuts (261) attaching left and right stop blocks (218) and shims (212) to tele 1 (201) (see Figure 4-34).



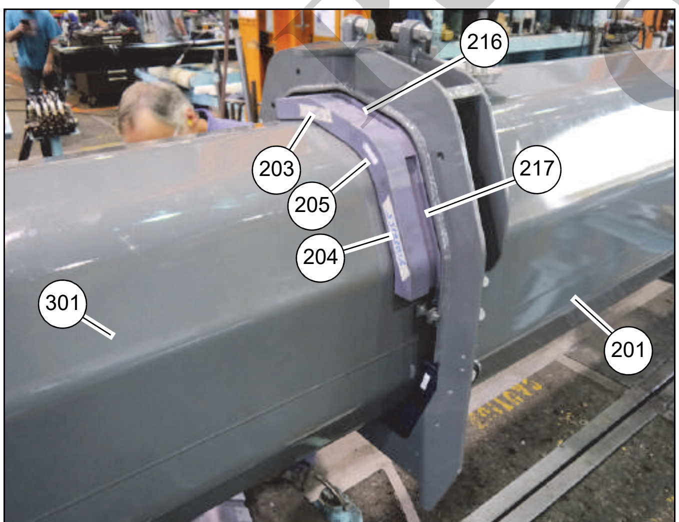
9688-93

FIGURE 4-34

35. Remove bolts (239) and washers (253) attaching wear pads (203, 204, 205), shims (211), and bars (216, 217) in place.

36. Remove bolts (243) and nuts (263) used to adjust the left and right wear pads (206).

37. Remove shims (211), wear pads (203, 204, 205), and bars (216, 217) from between tele 1 (201) and tele 2 (301) (see Figure 4-35).



9688-90

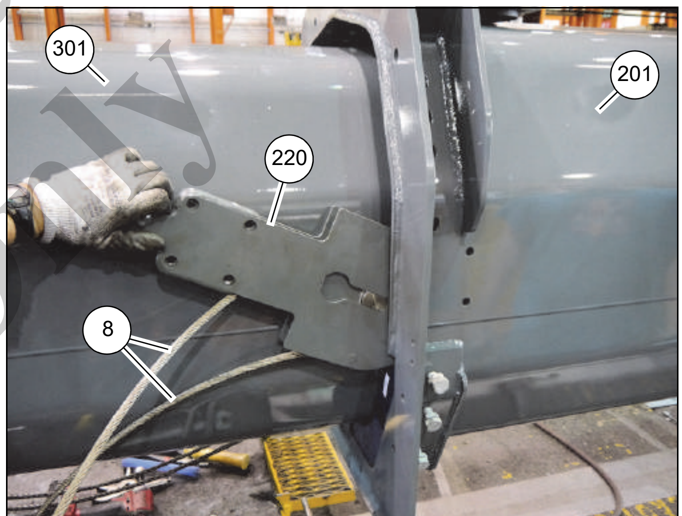
FIGURE 4-35

38. Slightly raise tele 2 (301), then remove left and right side wear pads (206) from between tele 1 (201) and tele 2 (301) (see Figure 4-36).

9688-87

FIGURE 4-36

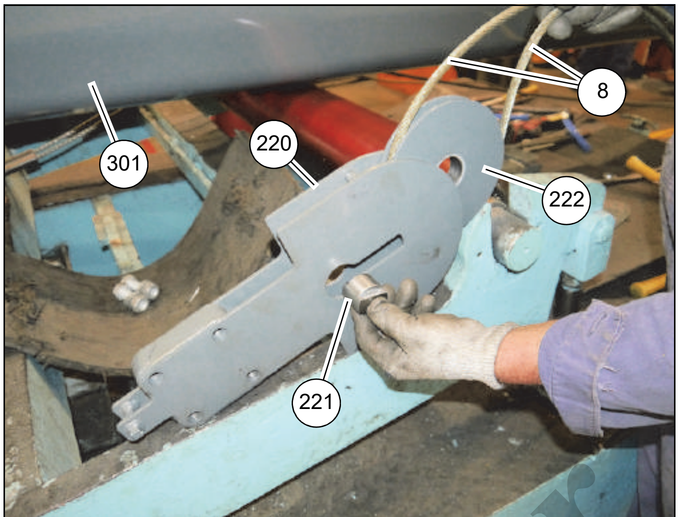
39. Remove bolts (244) and washers (253) attaching sheave mount weldments (220) to inside of tele 1 (201) (see Figure 4-37).



9688-88

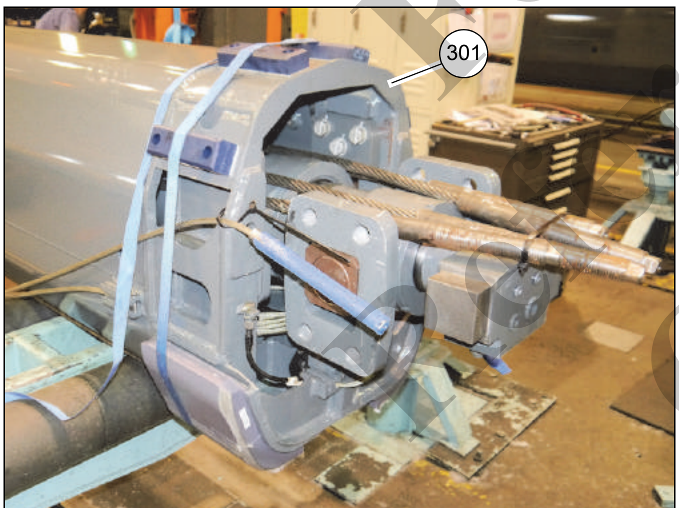
FIGURE 4-37

40. Remove shaft/sheave (221/222) assemblies from sheave mount weldments (220). Remove extend cables (8) from sheaves (222) (see Figure 4-38).



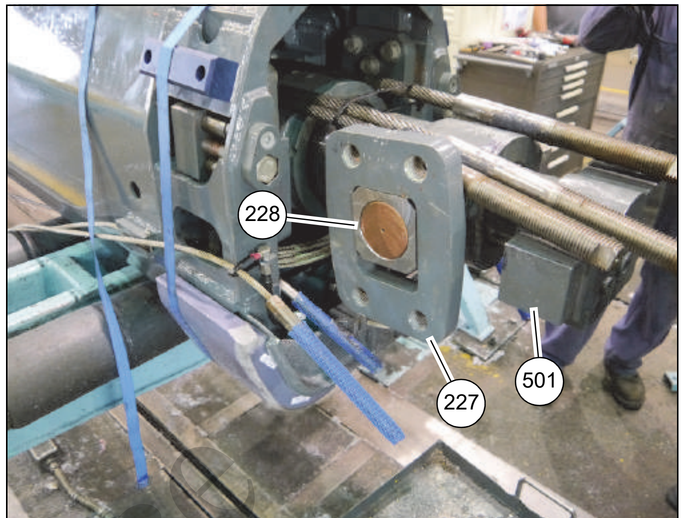
9688-78 **FIGURE 4-38**

41. Pull tele 2 (301) out of tele 1 (201) (see Figure 4-39).



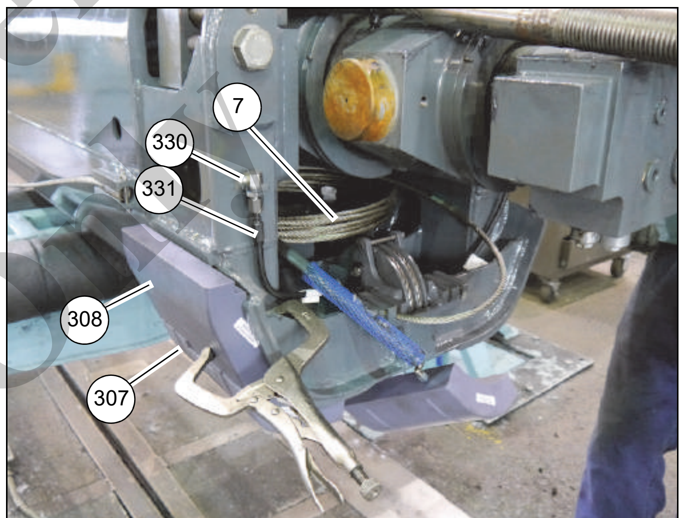
9729-27 **FIGURE 4-39**

42. Remove trunnion plate (227) from left and right side blocks (228). Remove block (228) from left and right sides of telescope cylinder (501) (see Figure 4-40).



9688-84 **FIGURE 4-40**

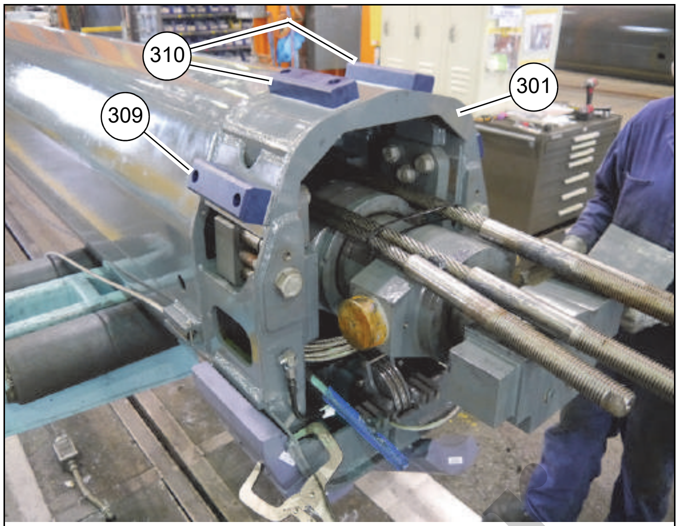
43. Remove wear pads (307, 308) and shims (313) from bottom rear of tele 2 (301) (see Figure 4-41).



9688-80 **FIGURE 4-41**

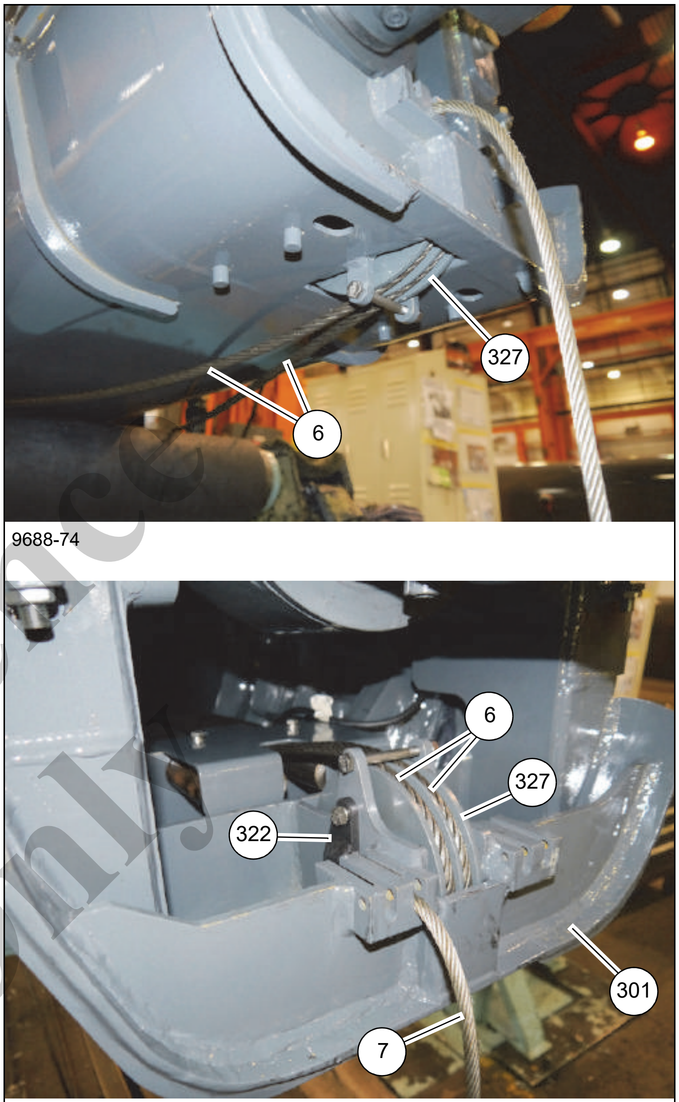
44. Remove grease hoses (331) and grease fittings (330) from left and right sides of rear of tele 2 (301) (see Figure 4-41).

45. Remove two bolts (337) attaching each of the four wear pads (309, 310) and shims (314, 315) to rear of tele 2 (301) (see Figure 4-42).



9688-81 **FIGURE 4-42**

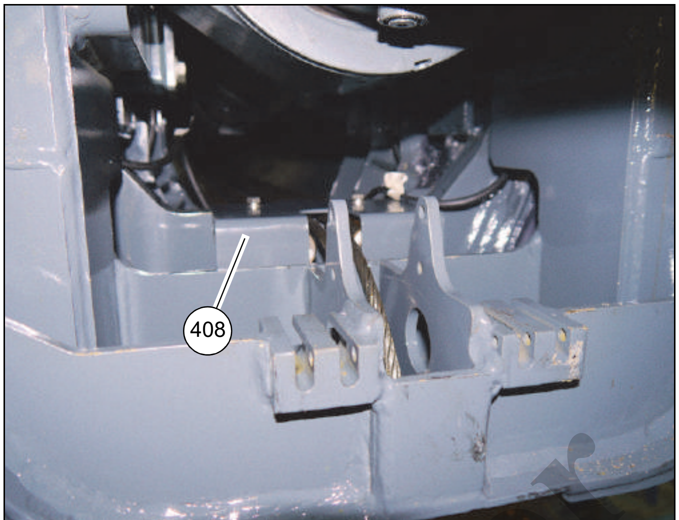
46. Remove bolts (340), lock washers (350), and nuts (357) at top and bottom of sheave assembly (327) which retain the two retract cables (6) on sheave assembly (327) (see Figure 4-43).



9688-73 **FIGURE 4-43**

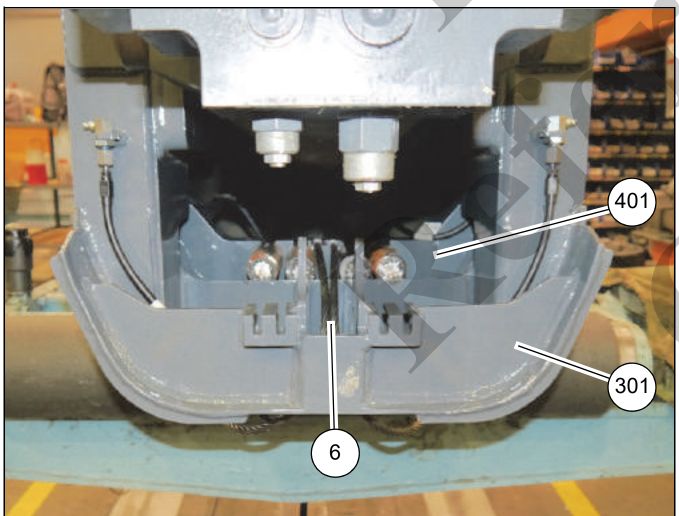
47. Remove bolts (339) attaching shaft weldment (322) to tele 2 (301). Remove shaft weldment (322), thrust washers (349), and sheave assembly (327) from rear of tele 2 (301) (see Figure 4-43).

48. Remove bolts (410), lock washers (409), and flat washers (419) attaching cover plate (408) over the four extend cables (9, 10) and the two retract cables (6) (see Figure 4-44).



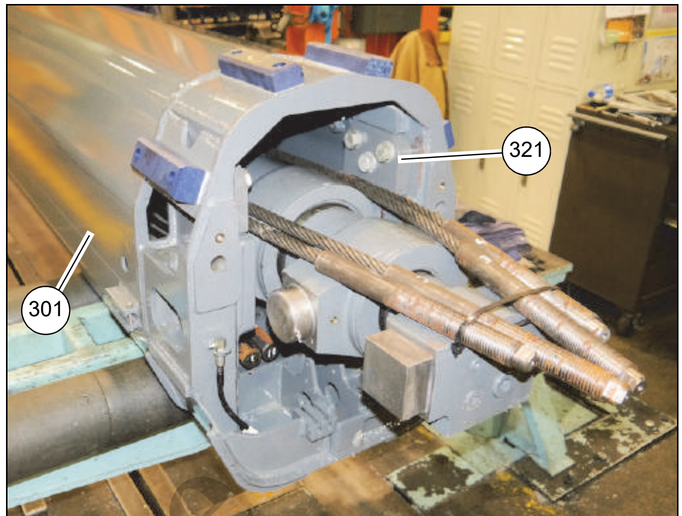
9688-72 **FIGURE 4-44**

49. Remove anchor ends of two retract cables (6) from rear of tele 3 (401) (see Figure 4-45).



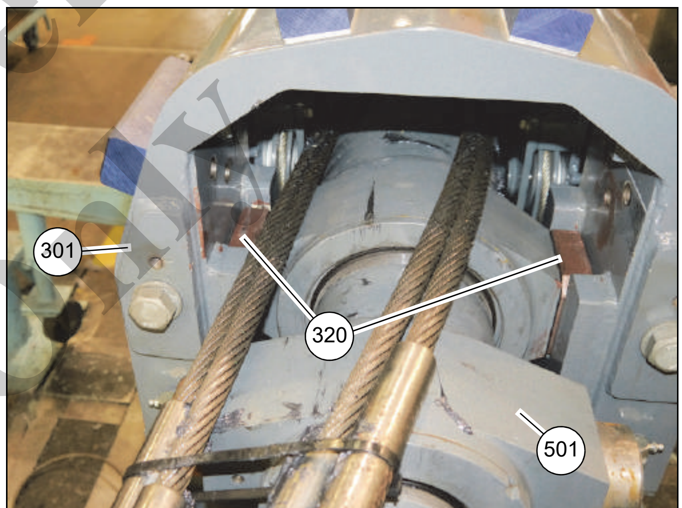
9729-23 **FIGURE 4-45**

50. Remove bolts (324) and washers (323) attaching plates (321) to inside of tele 2 (301) (see Figure 4-46).



9729-22 **FIGURE 4-46**

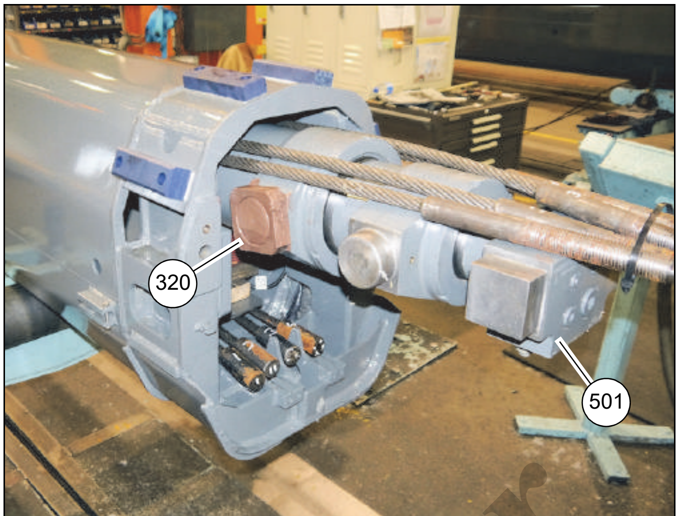
51. Lift rear of telescope cylinder (501) so that trunnion blocks (320) are lifted out of slots in rear of tele 2 (301) (see Figure 4-47).



9688-71 **FIGURE 4-47**

Manitowoc Crane Care

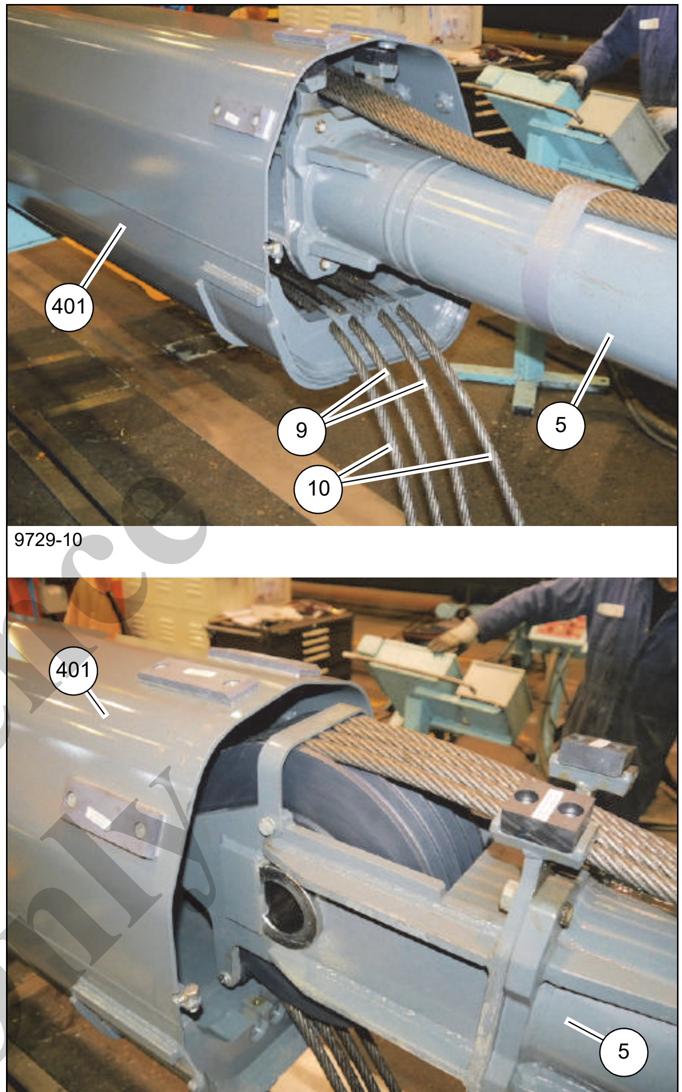
52. Pull telescope cylinder (501) out of rear of tele 2 (301). Remove trunnion blocks (320) from left and right sides of telescope cylinder (501) (see Figure 4-48).



9729-20

FIGURE 4-48

53. Remove telescope cylinder assembly (5) from tele 3 (401) (see Figure 4-49).

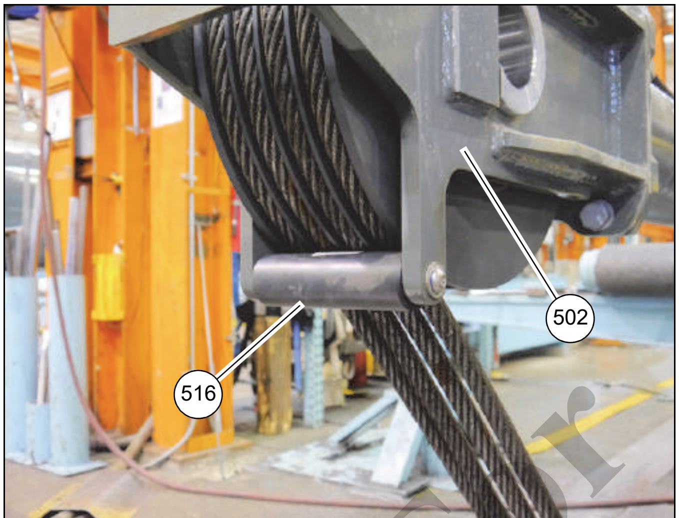


9729-9

FIGURE 4-49

54. Set telescope cylinder assembly (5) on to adequate supports.

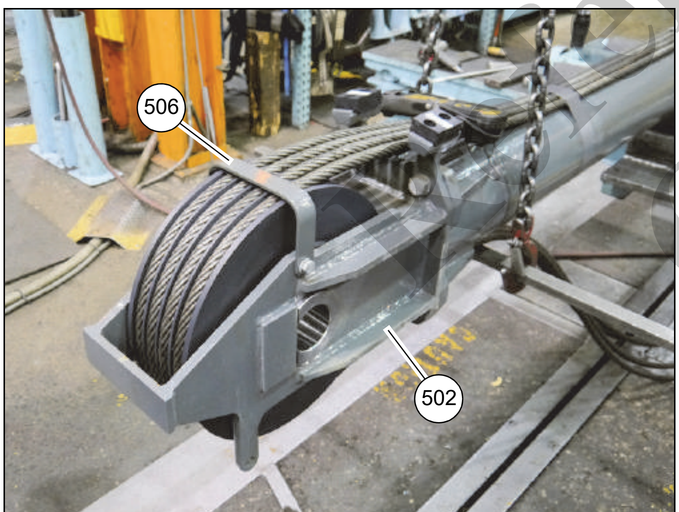
55. Remove bar (517), bolts (519) and washer (515) attaching roller (516) to sheave mount weldment (502) (see Figure 4-50).



9729-8

FIGURE 4-50

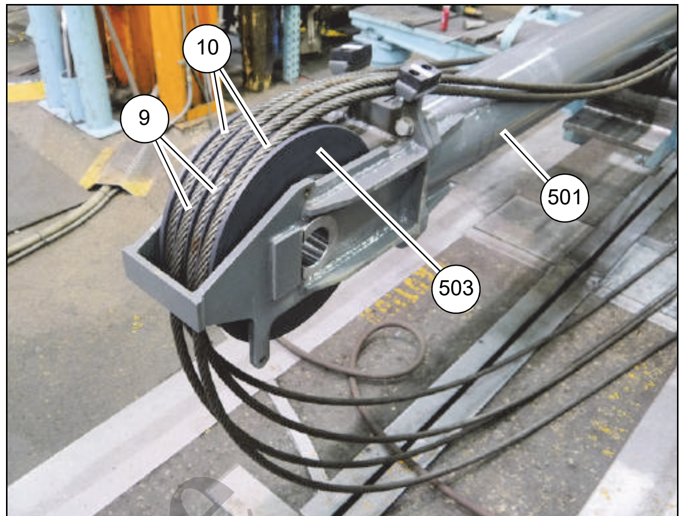
56. Remove two bolts (512) and washers (513) attaching cable keeper plate (506) to sheave mount weldment (502) (see Figure 4-51).



9729-7

FIGURE 4-51

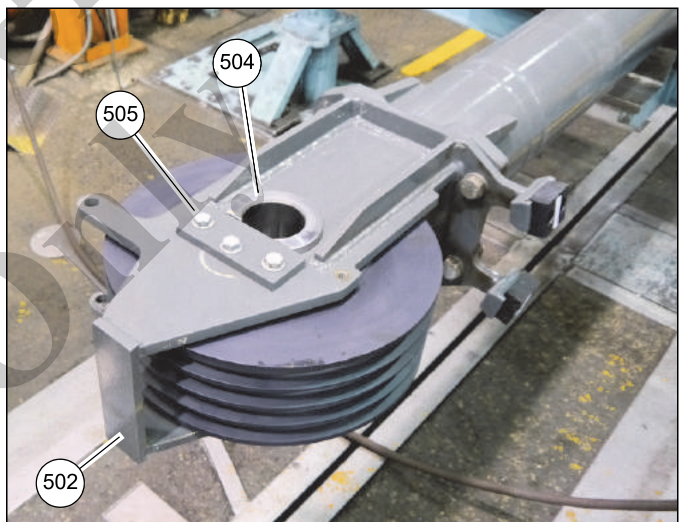
57. Remove the four extend cables (9, 10) from around sheave (503) (Figure 4-52).



9729-6

FIGURE 4-52

58. Remove three bolts (511) and washers (515) attaching plate (505) to side of sheave mount weldment (502) (see Figure 4-53).



9729-5

FIGURE 4-53

Manitowoc Crane Care

59. Remove shaft (504) from sheave mount weldment (502). Remove sheave (503) and two spacers (514) from sheave mount weldment (502) (see Figure 4-54).

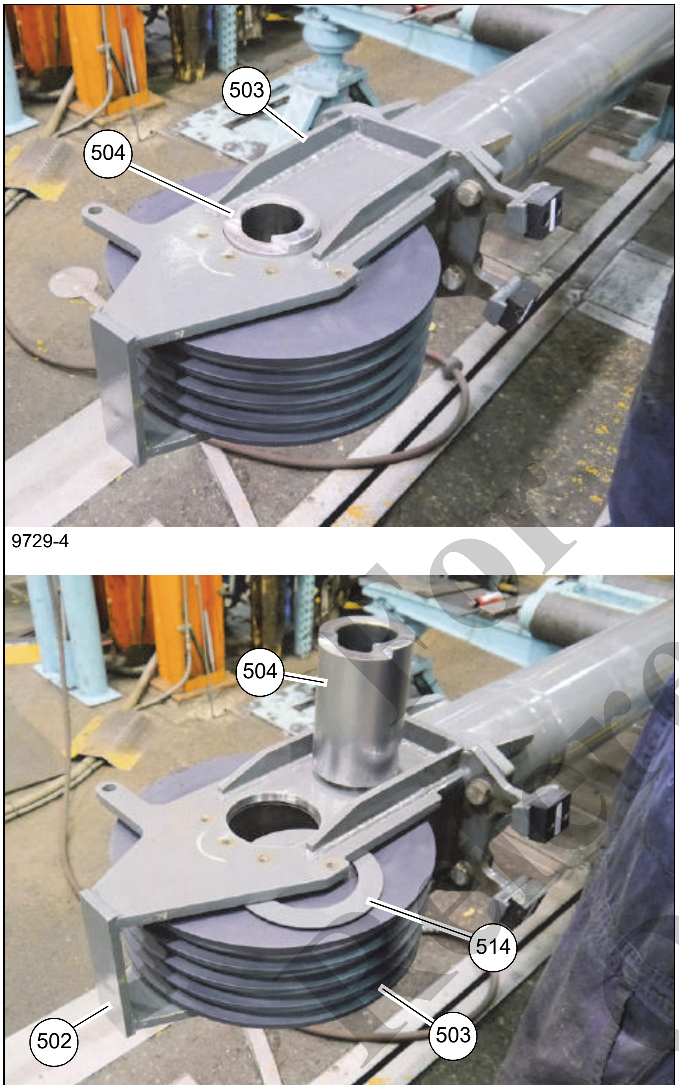


FIGURE 4-54

60. Remove bolts (508) attaching wear pads (507) to sheave mount weldment (502) (see Figure 4-55).

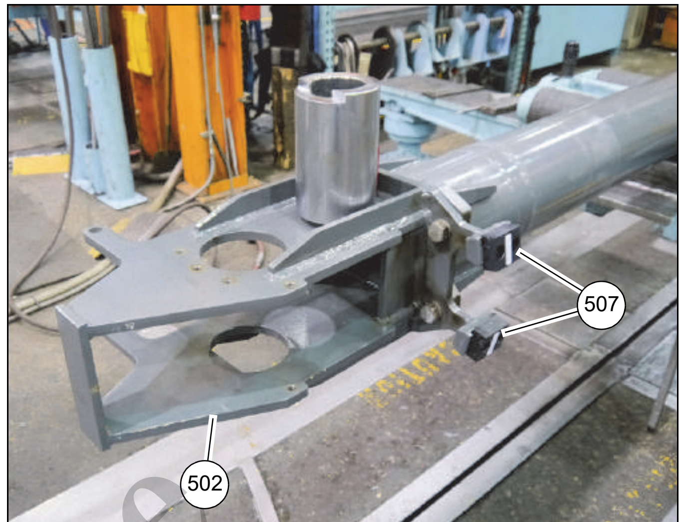


FIGURE 4-55

61. Remove four bolts (510) and washers (509) attaching sheave mount weldment (502) to front of telescope cylinder (501) (see Figure 4-56).

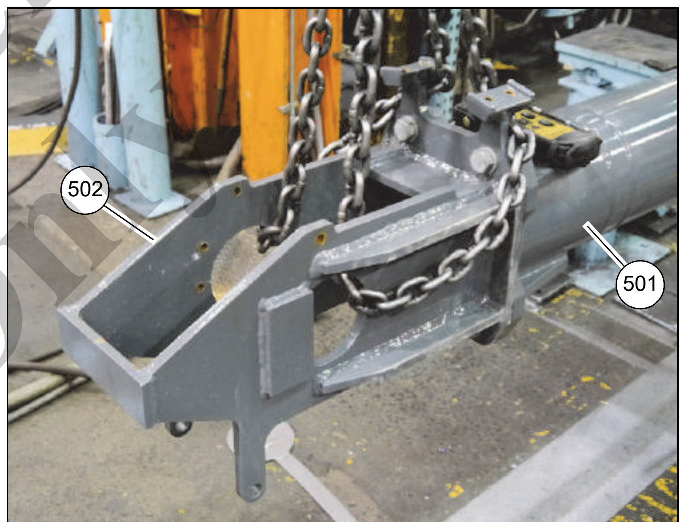


FIGURE 4-56

4

Assembling the 4-Section Boom

NOTE: Boom assembly must be rotated 180° (upside down) before performing any assembly or disassembly procedures.

CAUTION

A rollover fixture with webbing is recommended to rotate the boom sections. Chains are not recommended. If a rollover fixture is not available, rotate the sections using adequate support with webbing.

A secure fixture that will prevent damage to the boom is recommended to stabilize and hold the boom from moving during removal of the boom section(s).

When adjusting the extend and retract cables, hold the cable end and turn the nut. Do not turn the cable. Turning the cable while adjusting will result in damage or failure of the cable.

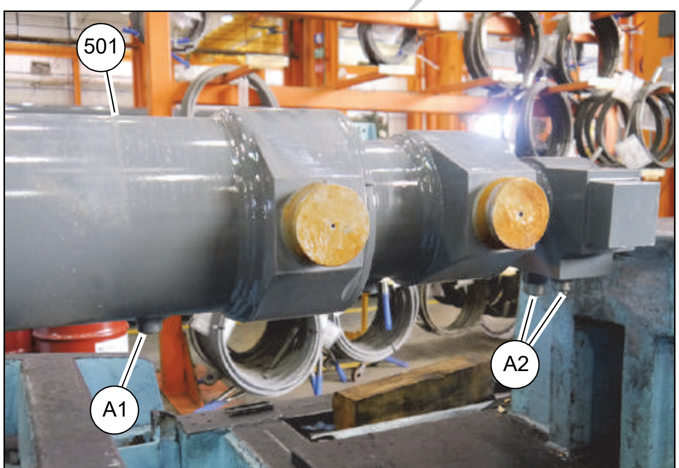
NOTE: Apply medium strength thread locking adhesive/sealant and primer to the threads of all attaching hardware except cable ends and cable lock nuts (131, 262, 248).

NOTE: Apply multipurpose grease (MPG) to all wear surfaces.

NOTE: Use standard Grade 5 and 8 torque values specified in Section 1 of this manual unless otherwise specified.

Use the following procedures and refer to Figure 4-16 when assembling the boom.

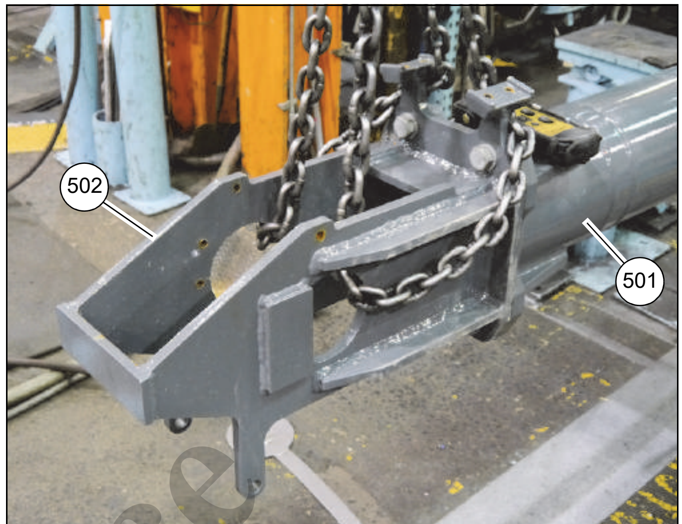
1. Position telescope cylinder (501) up side down on adequate supports. Make sure vent plug (A1) at rear of cylinder points down and that the two holding valve cartridges (A2) point down (see Figure 4-57).



9688-1

FIGURE 4-57

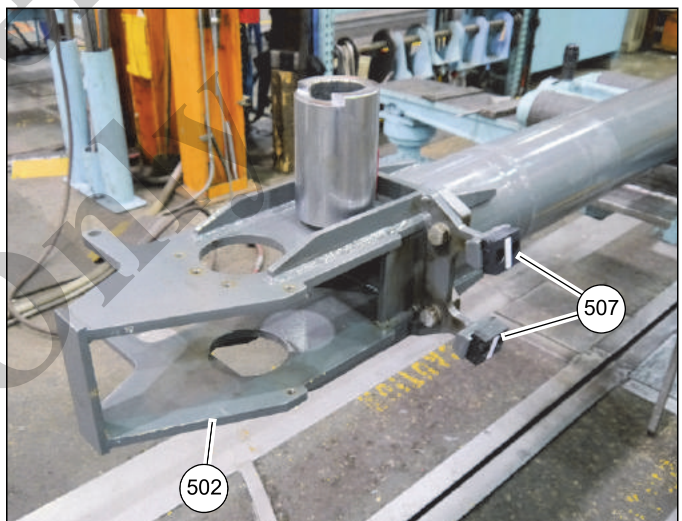
2. Install sheave mount weldment (502) to front of telescope cylinder (501) using four bolts (510) and washers (509) (see Figure 4-58).



9729-1

FIGURE 4-58

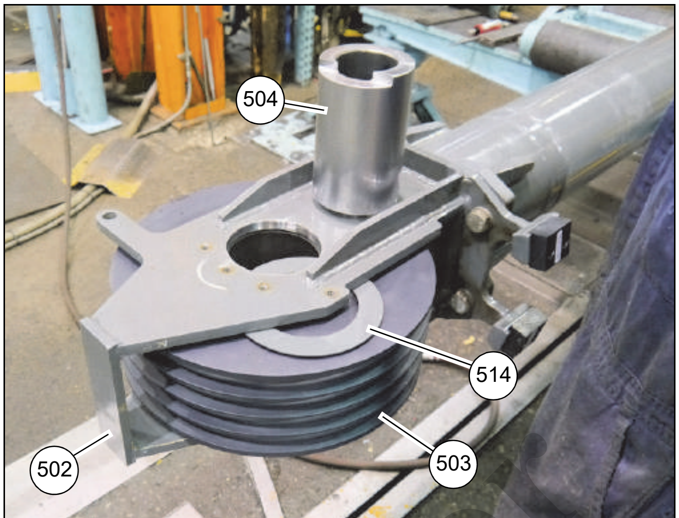
3. Install wear pads (507) to sheave mount weldment (502) using bolts (508) (see Figure 4-59).



9729-2

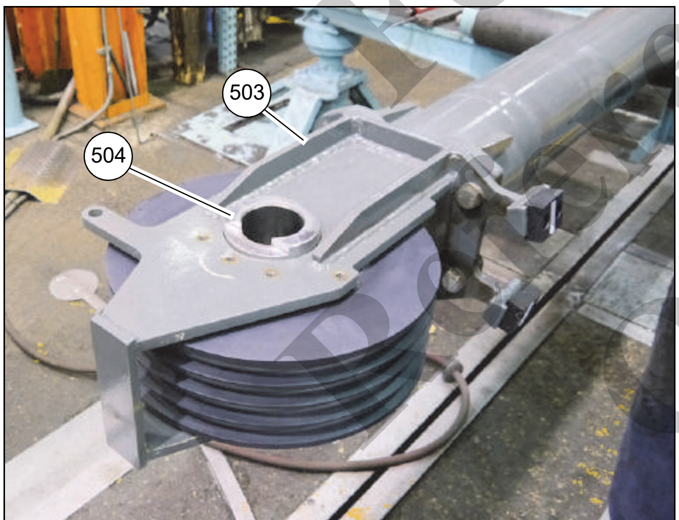
FIGURE 4-59

4. Install sheave (503) and two spacers (514) into sheave mount weldment (502) and secure with shaft (504) (see Figure 4-60 and Figure 4-61). Install one spacer (514) on each side of sheave.



9729-3

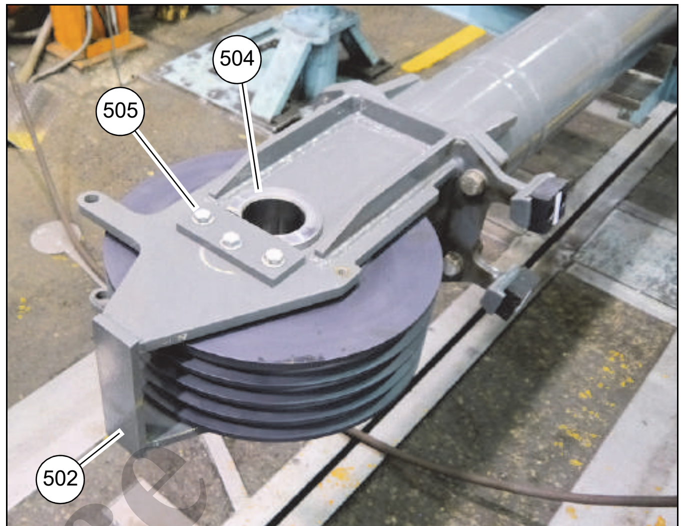
FIGURE 4-60



9729-4

FIGURE 4-61

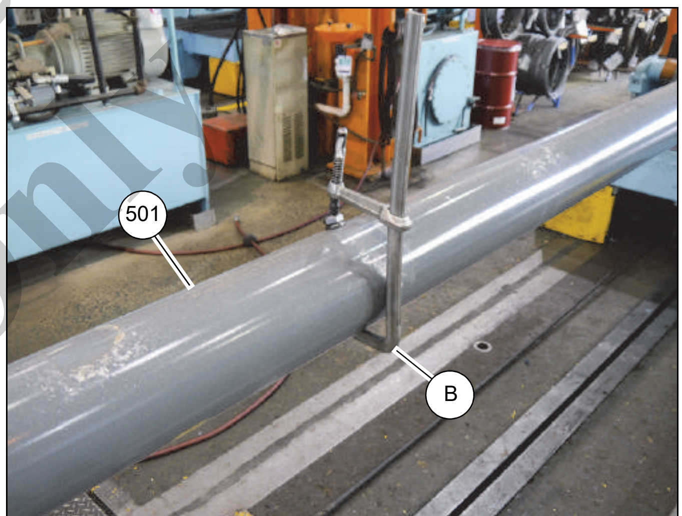
5. Using three bolts (511) and washers (515), install plate (505) to side of sheave mount weldment (502) to secure shaft (504) in place (see Figure 4-62).



9729-5

FIGURE 4-62

6. Install clamp (B) at mid-point of telescope cylinder (501) to assist with installation of the four extend cables (see Figure 4-63).



9688-6

FIGURE 4-63

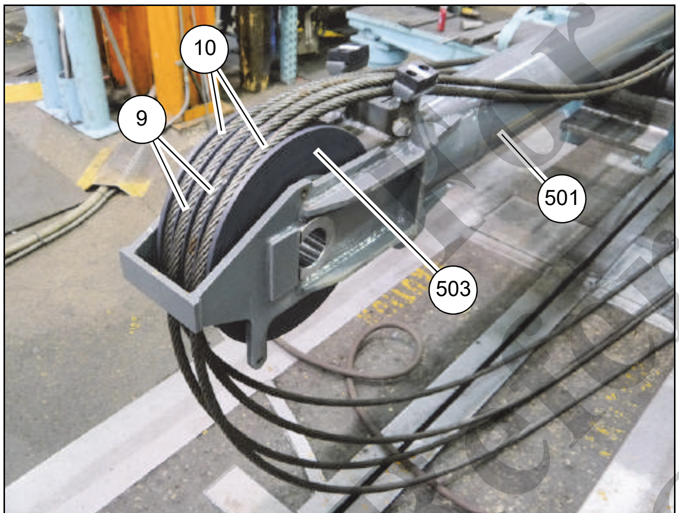
7. Lay out four extend cables (qty 2 - 9, qty 2 - 10) on ground alongside telescope cylinder (501), making sure threaded ends of the cables are toward the sheave. The longer cables (9) will be installed in the two center sheave grooves and the two shorter cables (10) will be installed in the outside sheave grooves — lay out cables accordingly. Do not cross cables.

4

8. Route the two longer cables (9) up and around sheave (503) and back to rear of telescope cylinder (501) (see Figure 4-64). Pass cables through clamp at mid-point of the telescope cylinder (see Figure 4-65). Make sure cables (9) are installed in the two inside sheave grooves and that they do not cross one another.

Route the two shorter cables (10) up and around sheave (503) and back to rear of the telescope cylinder (501). Pass cables through clamp at mid-point of the telescope cylinder. Make sure cables are installed in the two outside sheave grooves and that they do not cross one another.

Using a strap (C), secure the four cables (9, 10) in place at rear of the telescope cylinder (501) such that the two inside cables (9) hang over the end of the cylinder farther than the two outside cables (10) (see Figure 4-66).

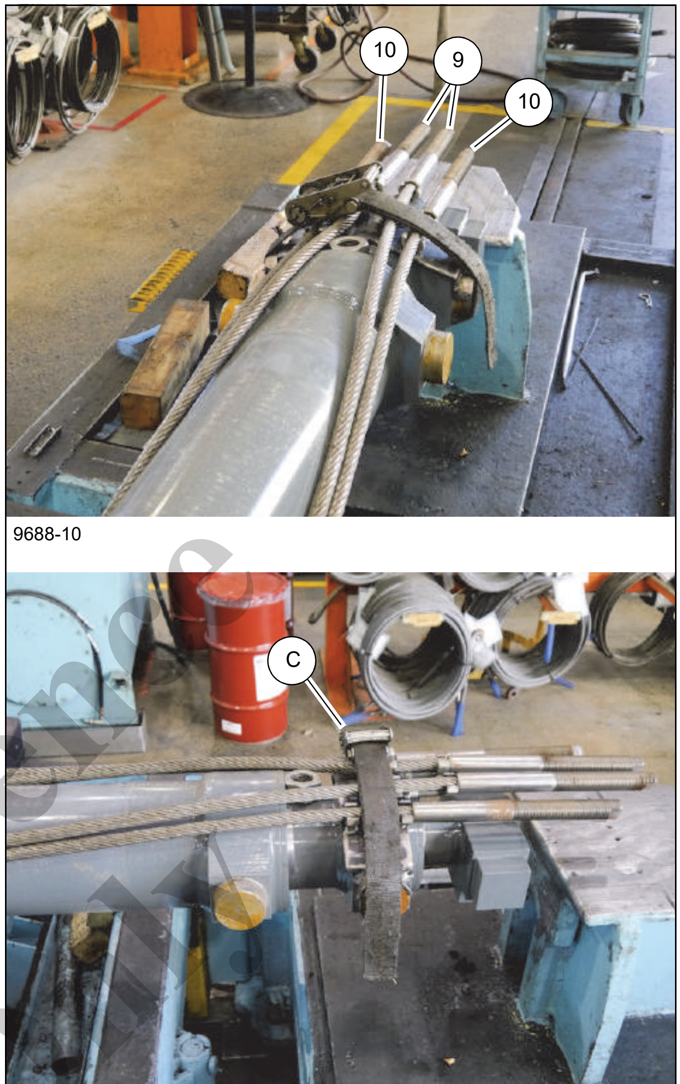


9729-6

FIGURE 4-64


9688-9

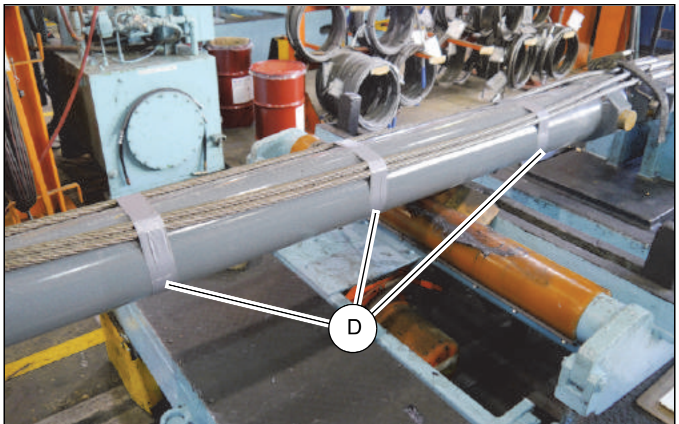
FIGURE 4-65



9688-11

FIGURE 4-66

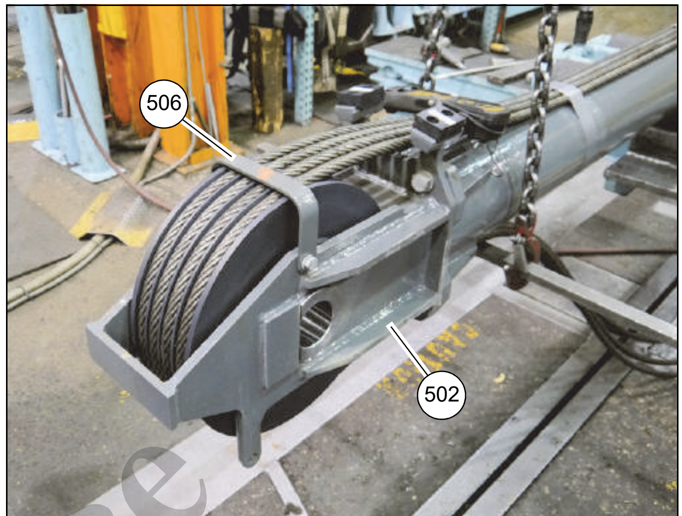
9. Using duct tape or similar (D), secure the four extend cables (9, 10) to top of telescope cylinder (501). cables do not cross one another.(see Figure 4-67).



9688-12

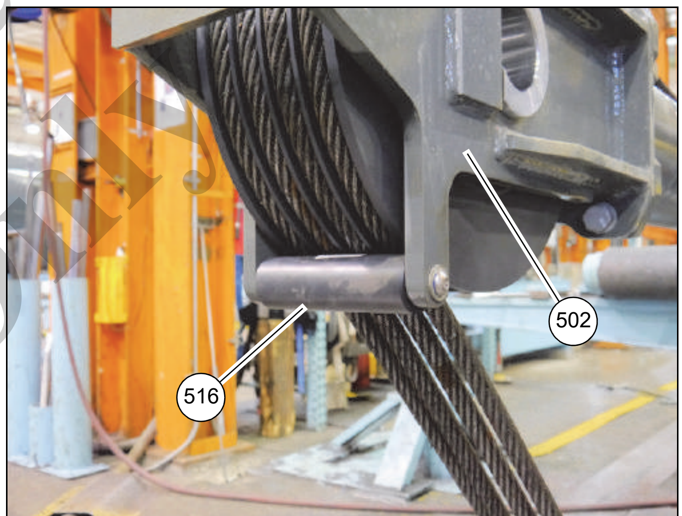
9688-13 **FIGURE 4-67**

10. Install cable keeper plate (506) on to sheave mount weldment (502) using two bolts (512) and washers (513) (see Figure 4-68).



9729-7 **FIGURE 4-68**

11. Install roller (516) on to sheave mount weldment (502) using bar (517), bolts (519) and washer (515) (see Figure 4-69).

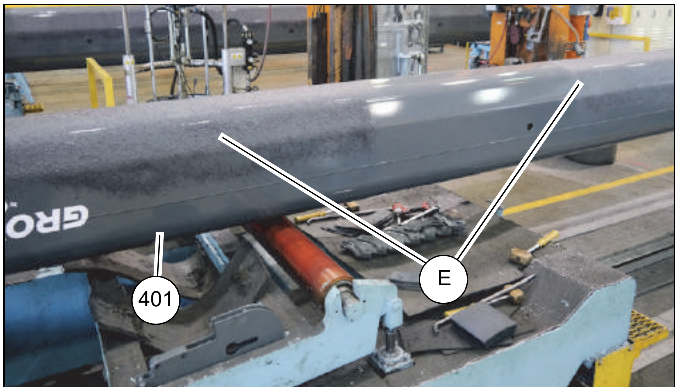


9729-8 **FIGURE 4-69**

12. Position tele 3 (401) upside down on adequate supports in front of telescope cylinder assembly (5).

13. Apply multipurpose grease to inside top and bottom of tele 3 (401).

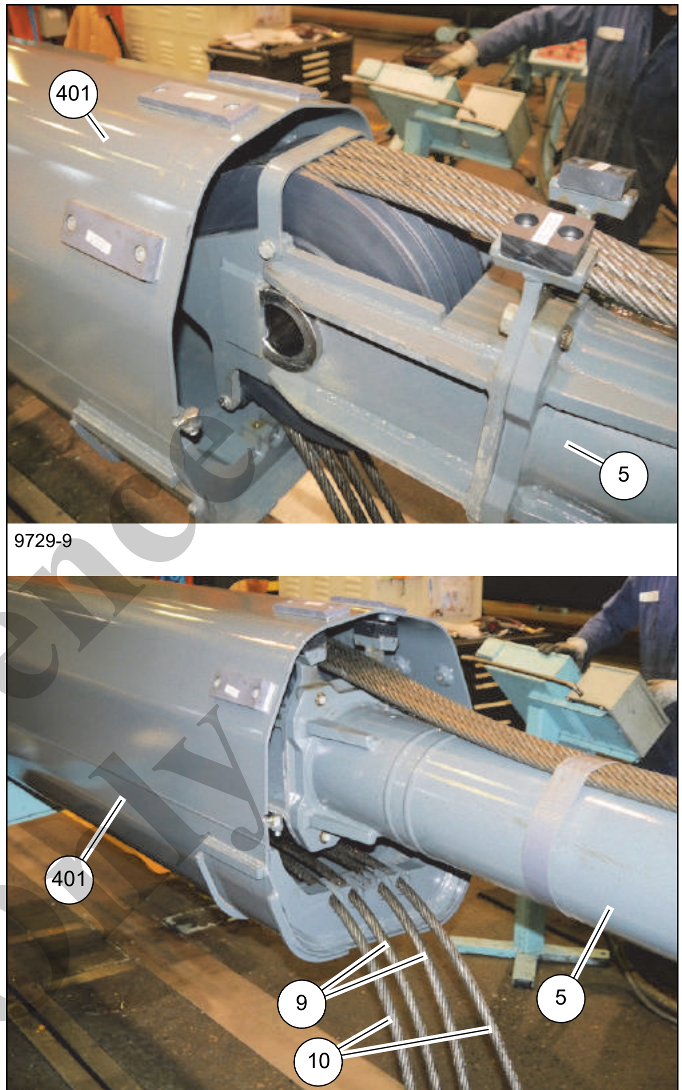
14. Spray multipurpose grease (E) on outside of tele 3 (401). Measuring approximately 1/4 of the distance of the boom from the tip, leave a 5 ft. wide strip of boom free of grease to install wear pads (Figure 4-70).



9688-21

FIGURE 4-70

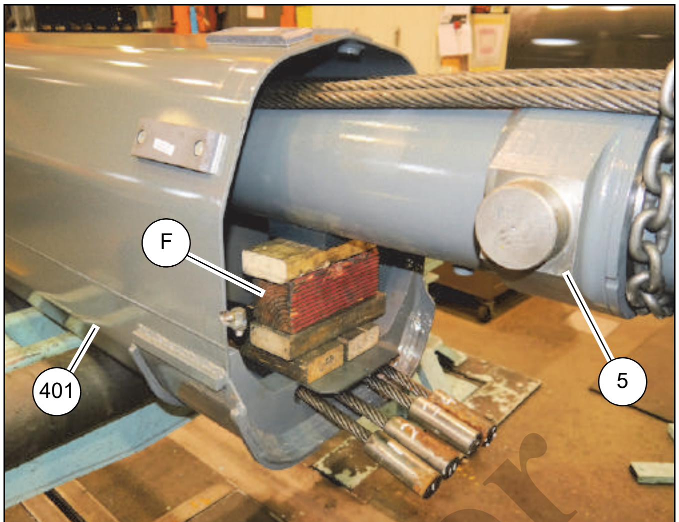
15. Lift the telescope cylinder assembly (5) and insert it in to tele 3 (401), making sure the four extend cables (9, 10) sit down in to the four cable keepers at rear of tele 3 (401) (see Figure 4-71).



9729-10

FIGURE 4-71

16. Insert telescope cylinder assembly (5) in to tele 3 (401) until the ends of the extend cables (9, 10) underneath the telescope cylinder assembly (5) are hanging out of tele 3 (401) by approximately 1 foot (see Figure 4-72).

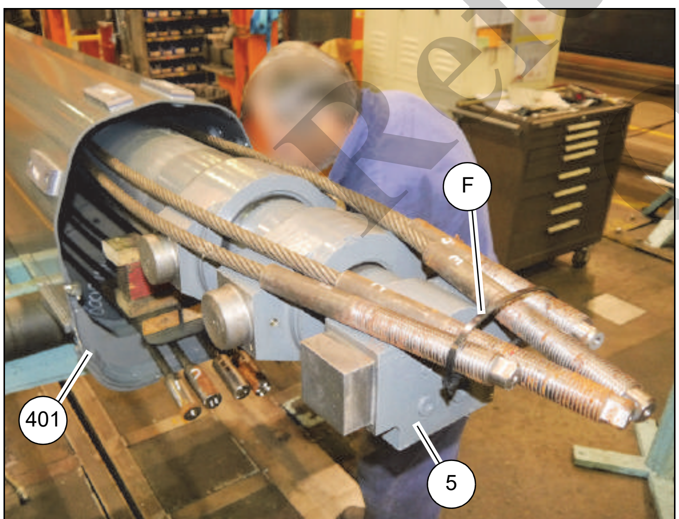


9729-11

FIGURE 4-72

17. Set telescope cylinder assembly (5) on to blocks of wood (F) measuring 9 inches in height (see Figure 4-72).

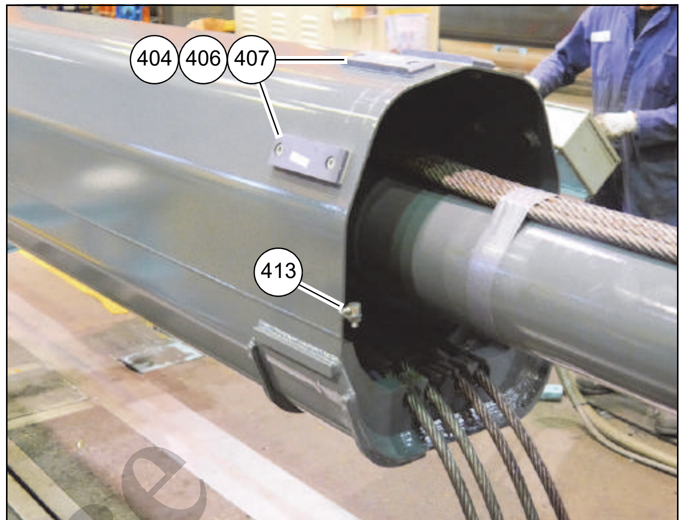
18. Using a zip-tie (G), secure ends of the four extend cables (9, 10) together above telescope cylinder assembly (5) (see Figure 4-73).



9729-12

FIGURE 4-73

19. Install four wear pads (404) with shims (406, 407) to rear of tele 3 (401) using two bolts (416) for each wear pad (see Figure 4-74).



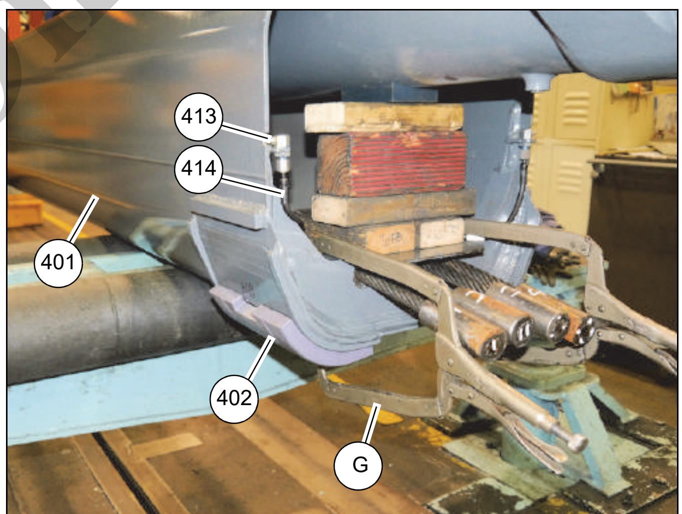
9729-13

FIGURE 4-74

20. Install grease fittings (413) to rear of tele 3 (401) using nuts (417) (see Figure 4-74). Orient grease fittings such that they point outward.

21. Attach grease hoses (414) to grease fittings (413) at rear of tele 3 (401). Route end of each grease hose (414) down through hole in bottom of tele 3 (401) (see Figure 4-75).

    Attach each grease hose (414) to wear pad (402) using adapter (411) and elbow (412) (see Figure 4-75).

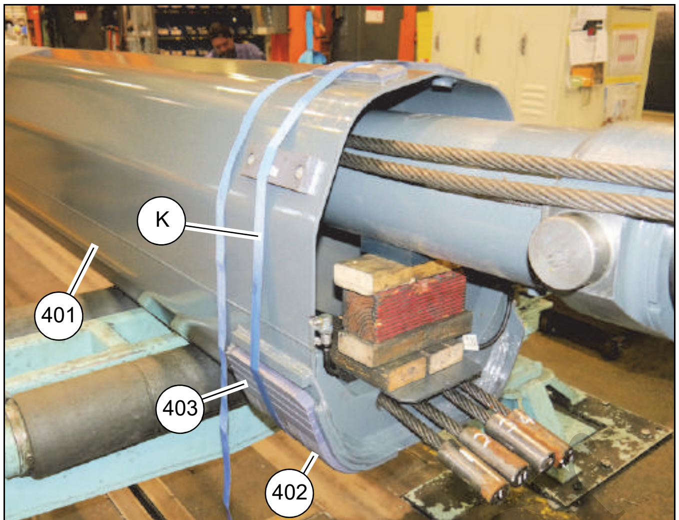


9729-14

FIGURE 4-75

22. Install shims (405) and wear pads (402) to bottom rear of tele 3 (401). Secure wear pads (402) in place using clamp (G) (see Figure 4-75).

23. Install wear pads (403) to bottom rear of tele 3 (401). Secure wear pads (402, 403) in place using strap (K) (see Figure 4-76). Note: Install strap around wear pads such that it is offset toward the front of tele 3 as shown.



9729-15

FIGURE 4-76

24. Apply multipurpose grease to inside top and bottom of tele 3 (401).

25. Position tele 2 (301) upside down on adequate supports in back of tele 3 (401) (see Figure 4-77).

9729-16

FIGURE 4-77

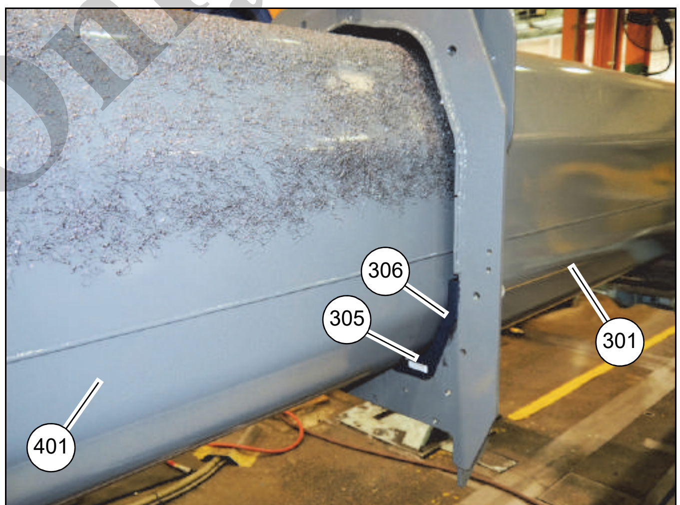
26. Insert tele 3 (401) into tele 2 (301) until the wear pads (402, 403, 404) at rear of tele 3 (401) are just inside tele 2 (301) (see Figure 4-78).

9729-17

FIGURE 4-78

27. Remove strap holding wear pads (402, 403) in place, then insert tele 3 (401) in to tele 2 (301) approximately 3 or 4 feet.

28. Slightly raise tele 3 (401), then install wear pads (305, 306) in the left and right bottom corners between tele 3 (401) and tele 2 (301) (see Figure 4-79). Install wear pad adjusting bolts (335) and nuts (356) on each side of tele 2 (301), but do not tighten.

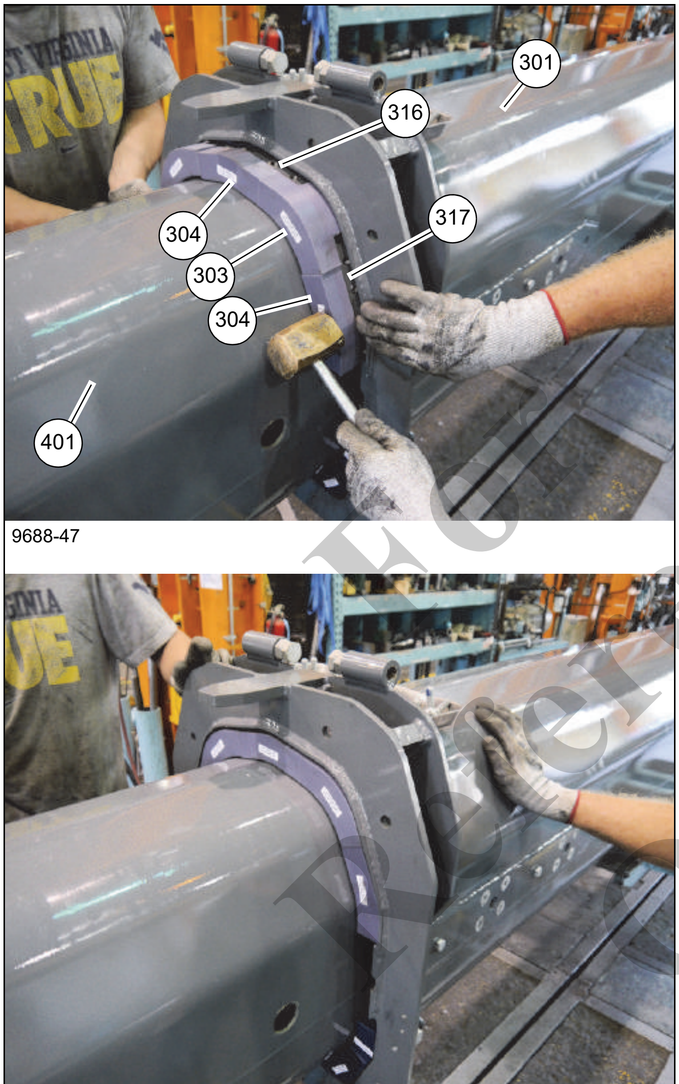


9729-18

FIGURE 4-79

29. Continue to insert tele 3 (401) into tele 2 (301) until tip of tele 2 is at the area of tele 3 which is free of grease.

30. Set wear pads (303, 304) with bars (316, 317) on top of tele 3 (401) and tap into place between tele 3 (401) and tele 2 (301) (see Figure 4-80)



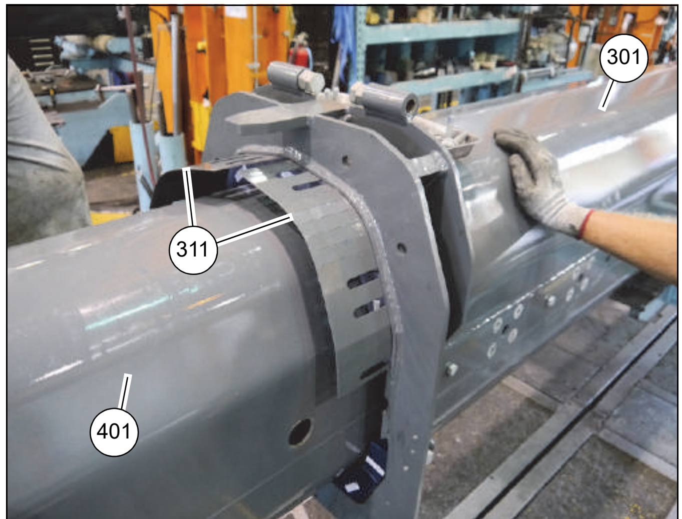
9688-47

9688-48

FIGURE 4-80

31. Install bolts (332) with washers (347) through tip of tele 2 (301) and into bars (316, 317) holding wear pads (303, 304) – do not tighten bolts (see Figure 4-80).

32. Install two shims (311) (per side) between wear pads (303, 304) and tele 2 (301) by gently tapping them with a rubber mallet or block of wood (see Figure 4-81).

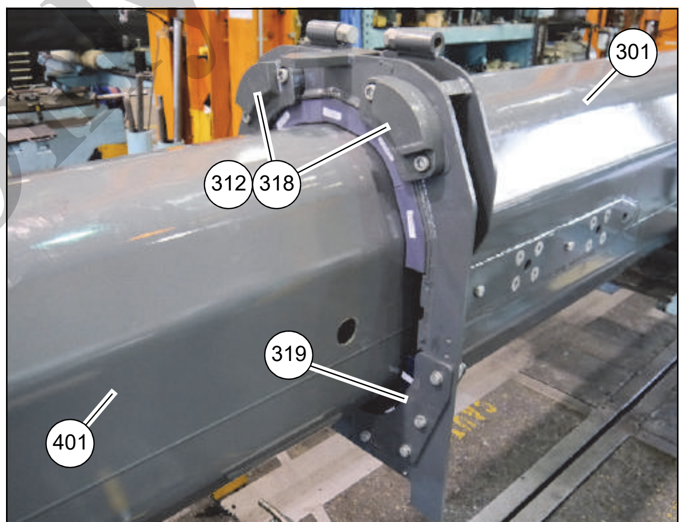


9688-49

FIGURE 4-81

33. Secure wear pads (303, 304) and shims (311) in place by tightening bolts (332) passing through holes in tele 2 (301) and into bars (316, 317).

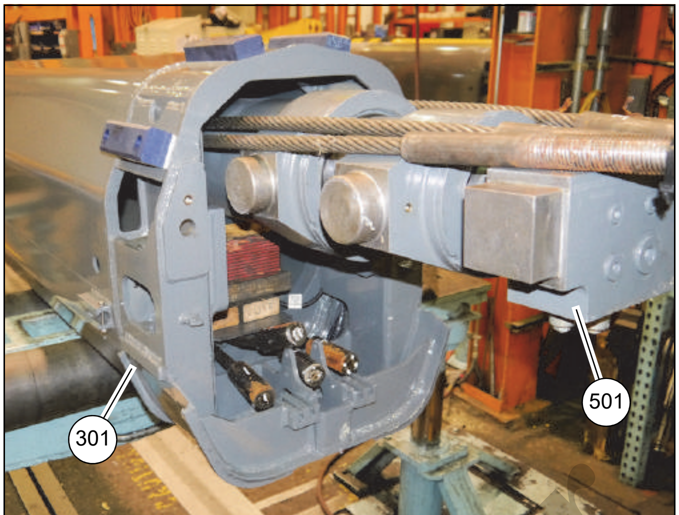
34. Install top left and right side shims (312) and stop blocks (318) on to front of tele 2 (301) using bolts (333), washers (348), and nuts (354) (see Figure 4-82). Install bottom left and right side stop plates (319) on to front of tele 2 (301) using bolts (336), washers (353), lock washers (346), and nuts (344) (see Figure 4-82).



9688-50

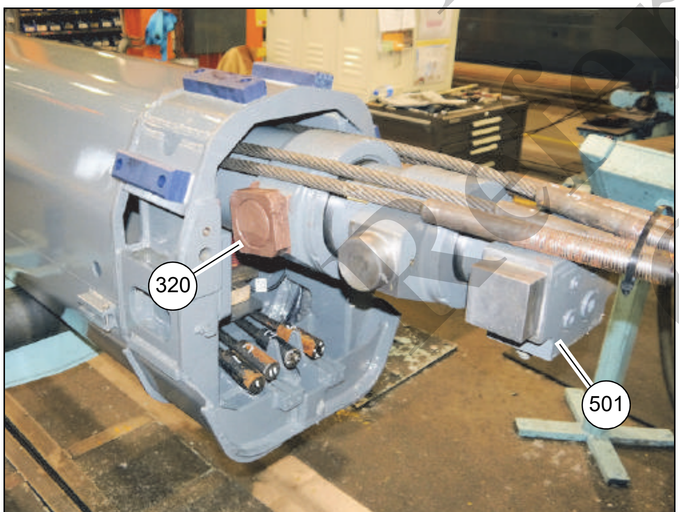
FIGURE 4-82

35. Insert tele 3 (401) into tele 2 (301) while making sure the telescope cylinder (501) passes through the rear of tele 2 (301) without hitting it (see Figure 4-83).



9729-19 **FIGURE 4-83**

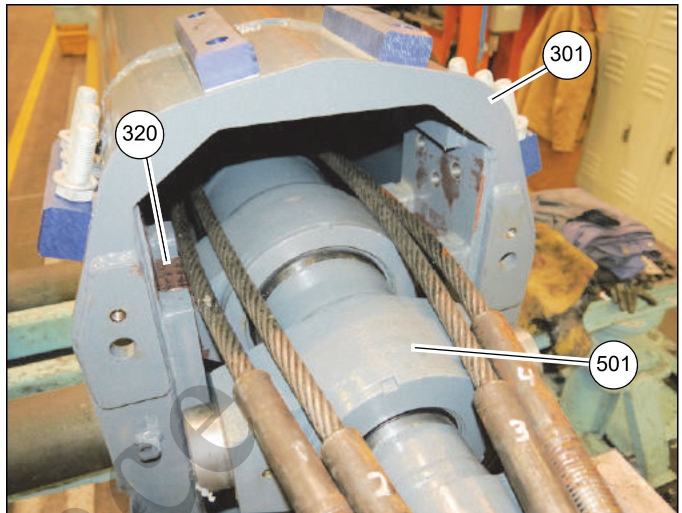
36. Apply anti-seize compound to trunnion blocks (320) and to trunnion on telescope cylinder (501), then install trunnion blocks (320) onto left and right sides of telescope cylinder (501) (see Figure 4-84).



9729-20 **FIGURE 4-84**

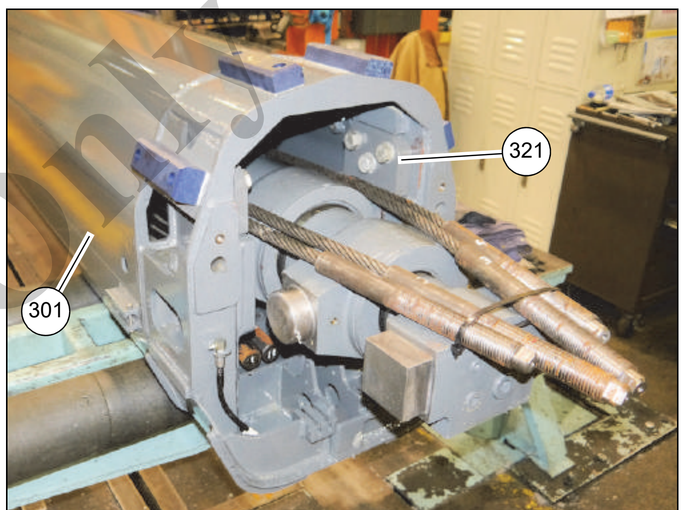
37. Lift telescope cylinder (501) and then remove blocks of wood supporting the cylinder.

38. Insert telescope cylinder (501) in to tele 2 (301) until trunnion blocks (320) on rear of telescope cylinder (501) align with corresponding slots in rear of tele 2 (301). Lower telescope cylinder (501) ensuring the trunnion blocks (320) drop into the slots (see Figure 4-85).



9729-21 **FIGURE 4-85**

39. Install plates (321) to the inside left and right sides of tele 2 (301) using bolts (324) and washers (323) (see Figure 4-86).



9729-22 **FIGURE 4-86**

40. Make sure the four extend cables (9, 10) are seated in the cables holders at rear of tele 3 (401) (see Figure 4-87).

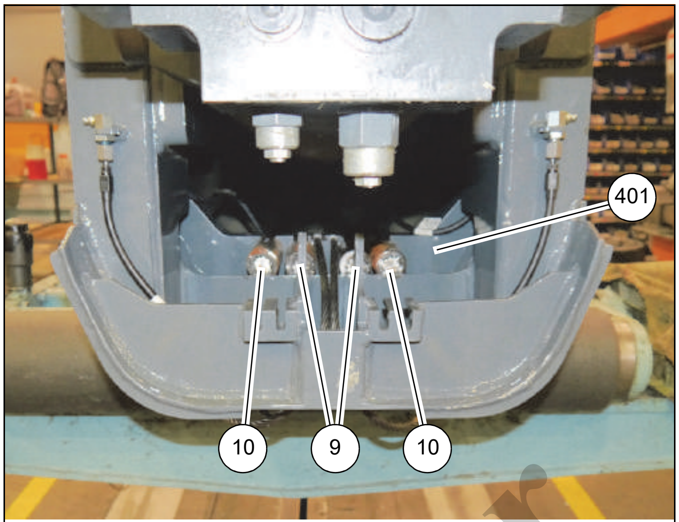


FIGURE 4-87

41. Install the anchor ends of two retract cables (6) up through hole in rear of tele 2 (301) and secure them in to center cable keepers on tele 3 (401) (see Figure 4-88). Route threaded ends of retract cables (6) to front of tele 2 (301).

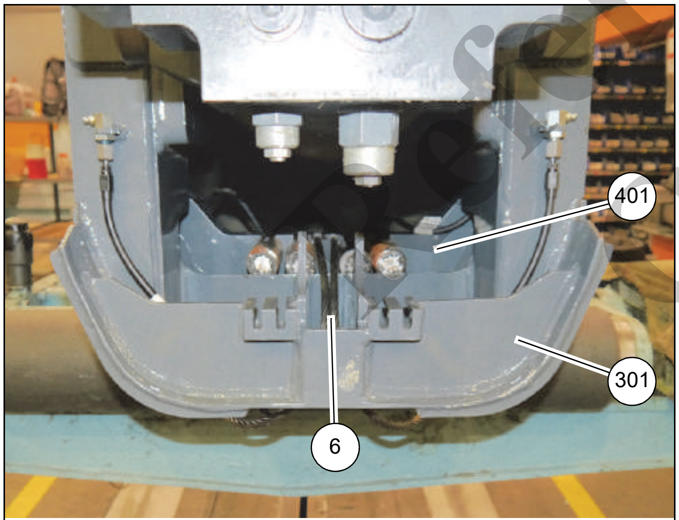


FIGURE 4-88

42. Install cover plate (408) over the four extend cables (9, 10) and the two retract cables (6) using bolts (410), lock washers (409), and flat washers (419) (see Figure 4-89).

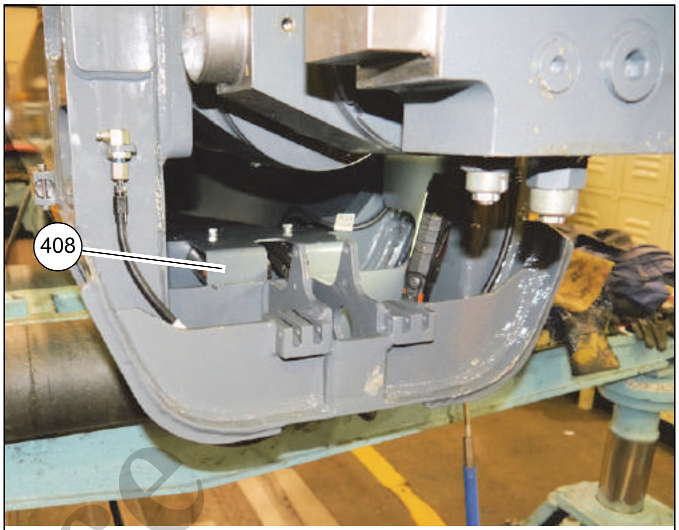


FIGURE 4-89

43. Install two extend cables (8) in to cable holder on left and right sides of tele 2 (301) (see Figure 4-90). Secure cable ends in place using bolts (341), lock washers (351), and nuts (326).

Route opposite ends of extend cables (8) to front of tele 2 (301).

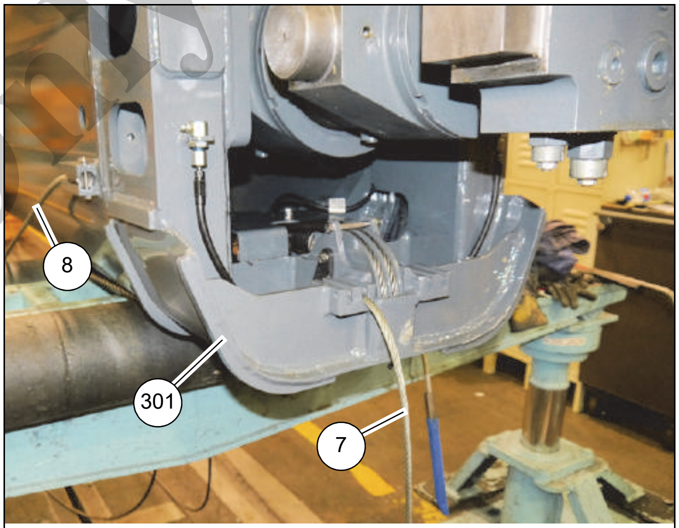


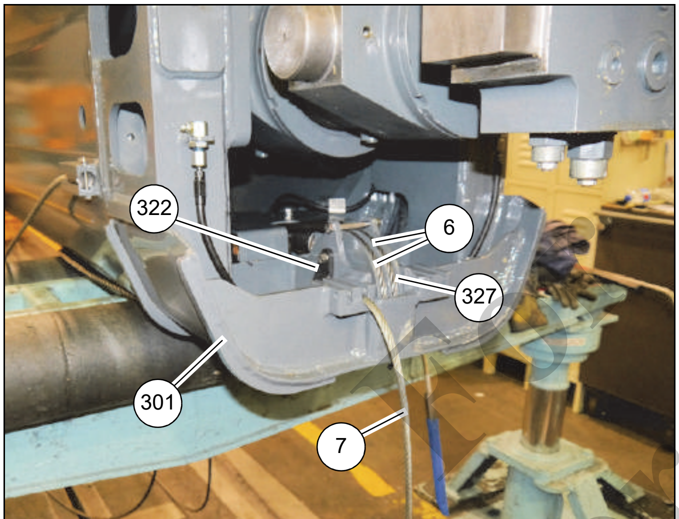
FIGURE 4-90

44. Install cable end of one retract cable (7) in to the left center cable keeper at rear of tele 2 (301) (see Figure 4-90).

45. Install sheave assembly (327) in to rear of tele 2 (301) ensuring the two retract cables (6) wrap around the sheave assembly (327) (see Figure 4-91).

    Secure sheave assembly (327) to tele 2 (301) by installing shaft weldment (322) through tele 2 (301) and sheave assembly (327) while making sure a thrust washer (349) is installed on each side of the sheave assembly (327) (Figure 4-91).

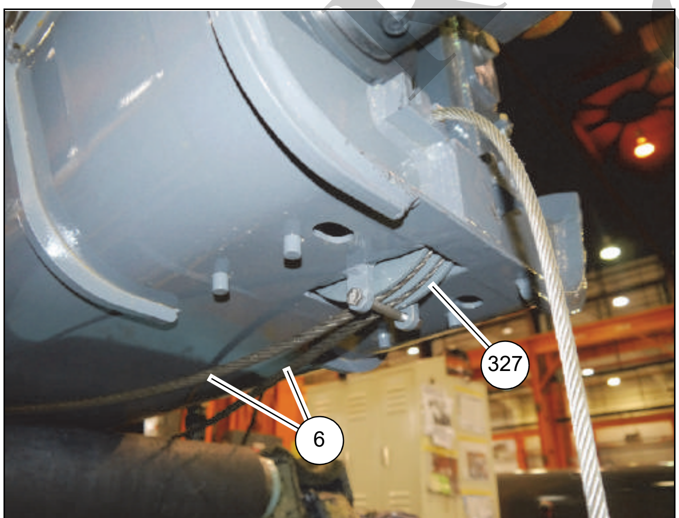
    Secure shaft weldment (322) in place using bolt (339) and washer (350) (see Figure 4-91).



9729-25

FIGURE 4-91

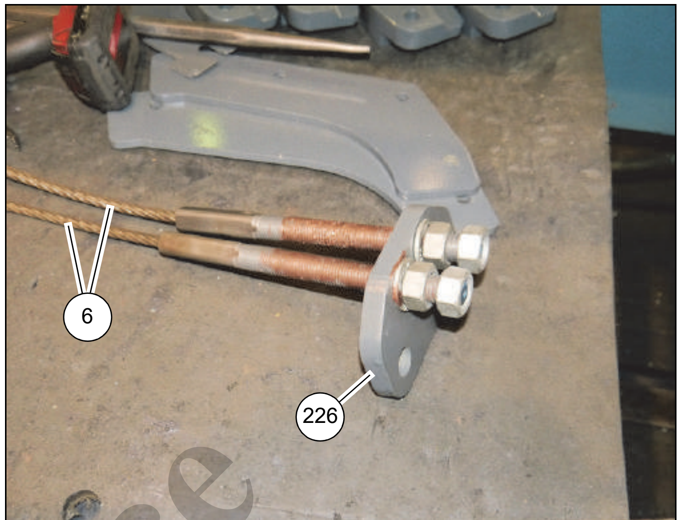
46. Install bolts (340), lock washers (350), and nuts (357) at top and bottom of sheave assembly (327) to retain the two retract cables (6) on sheave assembly (327) (see Figure 4-92).



9688-74

FIGURE 4-92

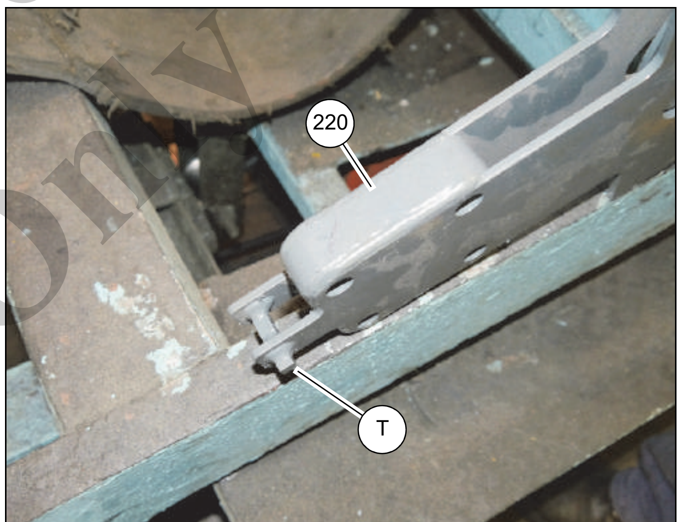
47. Install threaded ends of two retract cables (6) in to holes in plate (226). Secure each cable end with two nuts (262) and one washer (266) (Figure 4-93).



9688-75

FIGURE 4-93

48. Place a sheave mount weldment (220) at the front left and right sides of tele 2 (301). Position the sheave mount weldments (220) with the square pin (T) to the front of tele 2 (301) and away from it (Figure 4-94).

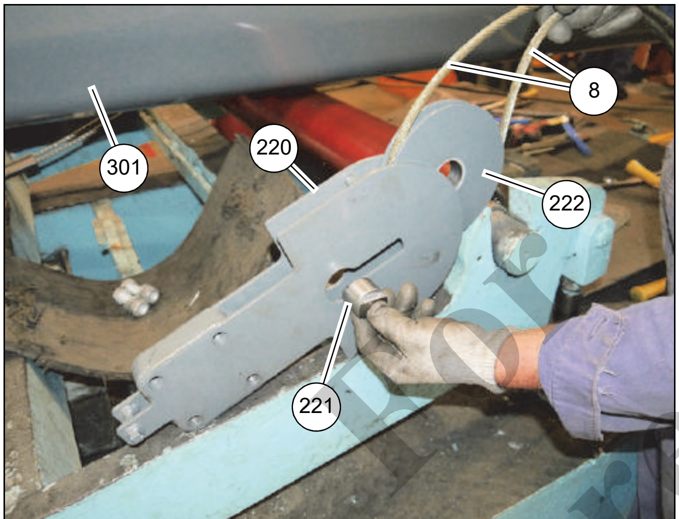


9688-77

FIGURE 4-94

49. Install extend cable (8) around sheave (222), ensuring the loose end of cable wraps around top of sheave first and then exits at the bottom of the sheave (222) and back to rear of tele 2 (301) (see Figure 4-95).

Install sheave (222) with retract cable (8) into sheave mount weldment (220) until shaft (221) can be installed through the sheave mount weldment (220) and sheave (222). Pull retract cable (8) toward rear of tele 2 (301) to seat the shaft/sheave assembly into the sheave mount weldment (220) (see Figure 4-95).

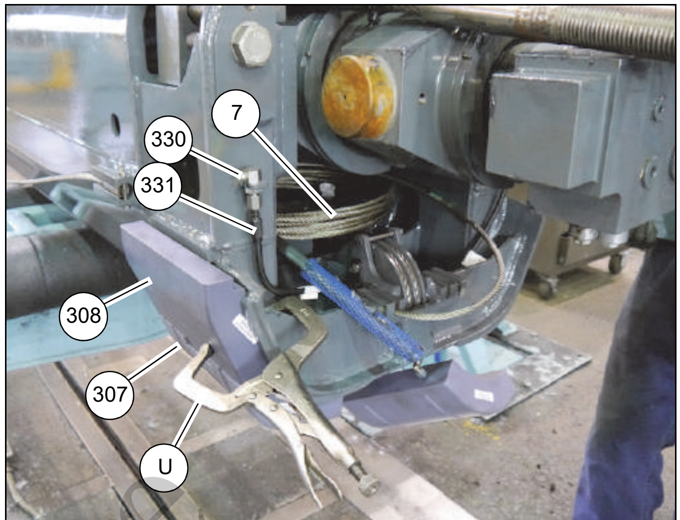


9688-78

9688-79

FIGURE 4-95

50. Coil the one retract cable (7) and place it inside the tele sections (Figure 4-96).



9688-80

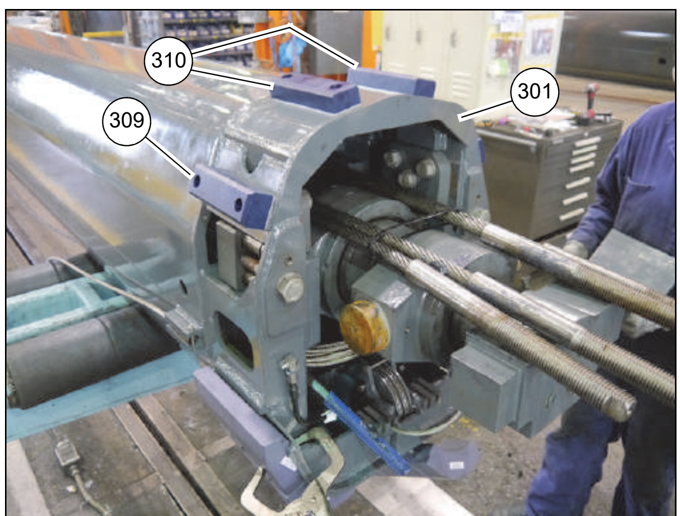
FIGURE 4-96

51. Install grease fittings (330) to rear of tele 2 (301) using nuts (338) (see Figure 4-96). Orient grease fittings such that they point outward.

52. Attach grease hoses (331) to grease fittings (330) at rear of tele 2 (301). Route end of each grease hose down through hole in bottom of tele 2 (301) (see Figure 4-96).

53. Attach each grease hose (331) to wear pad (307) using elbow (329) and adapter (328), then install a set of wear pads (307, 308) and three shims (313) to the left and right sides of tele 2 (301). Secure wear pads in place with clamps (U) (see Figure 4-96).

54. Install four wear pads (qty 2 - 309, qty 2 - 310) with shims (314, 315) to rear of tele 2 (301) using two bolts (337) for each wear pad. (see Figure 4-97).

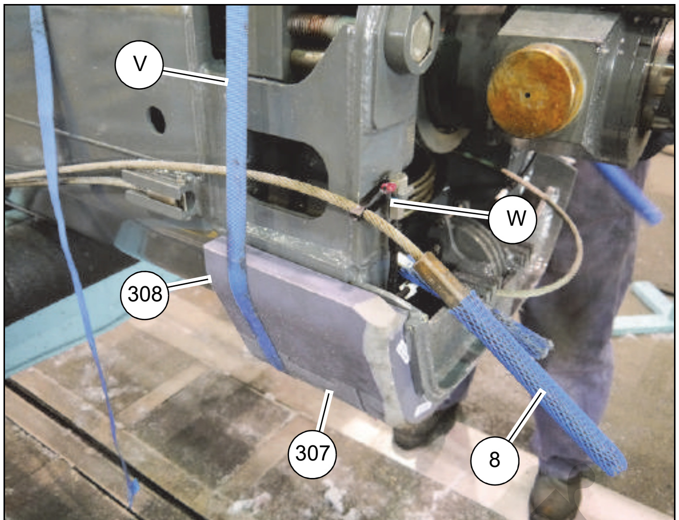


9688-81

FIGURE 4-97

4

55. Secure wear pads (307, 308) in place using strap (V). Note: Install strap around wear pads such that it is offset toward the front of tele 2 as shown. (see Figure 4-98).



9688-82

FIGURE 4-98

56. Using zip-ties (W), secure ends of left and right extend cables (8) to sides of tele 2 (301) to ease installation in to tele 1 (201) (see Figure 4-98).

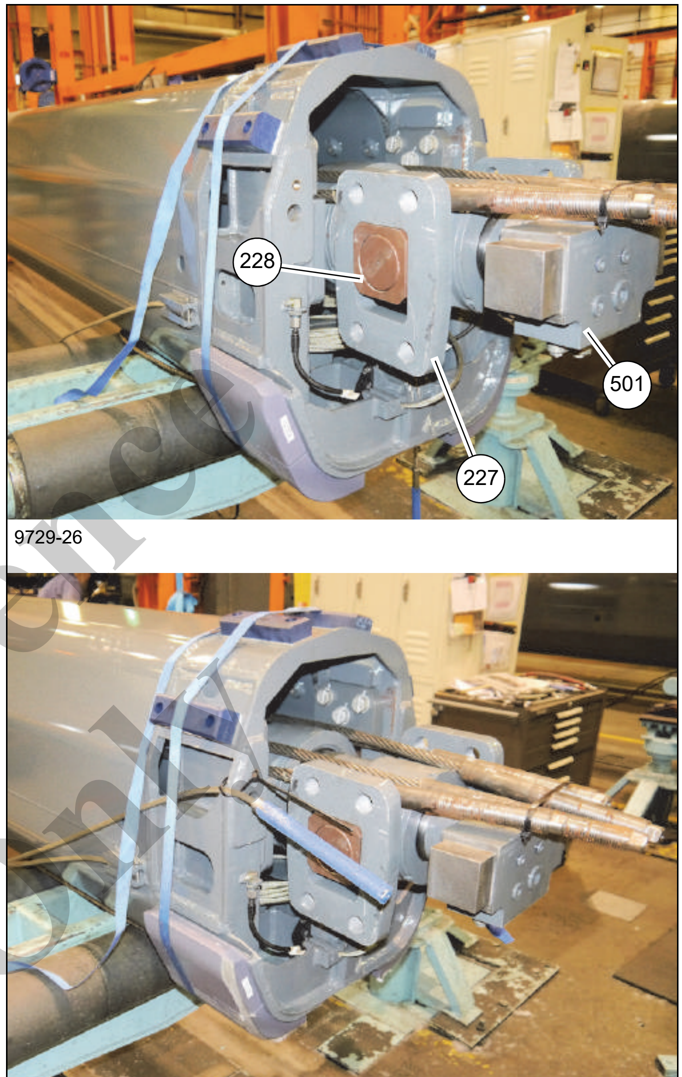
57. Position tele 1 (201) upside down on adequate supports in back of tele 2 (301).

58. Apply multipurpose grease to inside top and bottom of tele 1 (201).

59. Spray multipurpose grease on outside of tele 2 (301). Measuring approximately 1/4 of the distance of the boom from the tip, leave a 5 ft. wide strip of boom free of grease to install wear pads.

60. Apply an anti-seize compound to trunnion of telescope cylinder (501), then install a block (228) to left and right sides of telescope cylinder trunnion (see Figure 4-99).

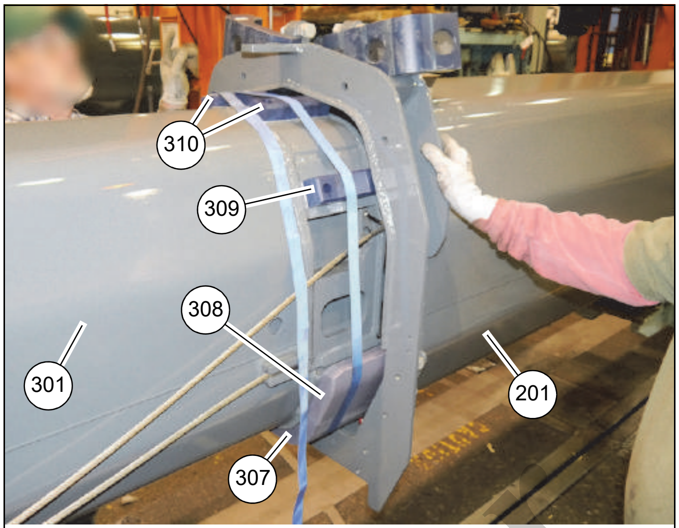
Install a trunnion plate (227) on to each block (228) (see Figure 4-99).



9729-27

FIGURE 4-99

61. Insert tele 2 (301) into tele 1 (201) until wear pads (307, 308, 309, 310) at rear of tele 2 (301) are just inside tele 1 (201) (see Figure 4-100).



9729-28

FIGURE 4-100

62. Remove strap holding wear pads (307, 308) in place, then insert tele 2 (301) in to tele 1 (201) until all wear pads are inside tele 2 (see Figure 4-101).

9729-29

FIGURE 4-101

63. Slightly raise tele 2 (301), then install wear pads (305, 306) in the left and right bottom corners between tele 2 (301) and tele 1 (201) (see Figure 4-102). Install wear pad adjusting bolts (335) and nuts (356) on each side of tele 1 (201), but do not tighten.

9688-87

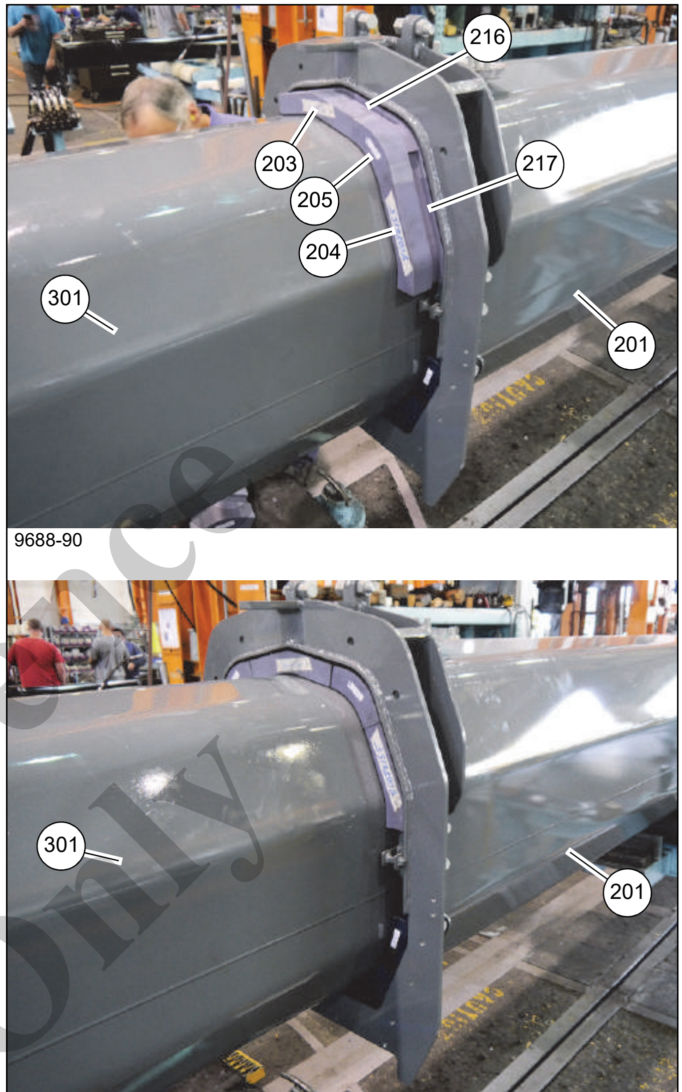
FIGURE 4-102

64. Continue to insert tele 2 (301) into tele 1 (201) until tip of tele 1 (201) is at the area of tele 2 (301) which is free of grease.

65. Lift sheave mount weldment (220) in to place next to tele 2 (301). Reach in to rear of tele 1 (201) and begin to pull the extend cable (8), which was attached to outside of tele 2 (301) using zip-ties, to the rear of tele 1 (201). Route extend cable (8) through hole in rear of tele 1 (201) (left and right sides) (see Figure 4-103). Make sure cables are not twisted. Pull extend cable (8) out rear of tele 1 (201) until bolt holes in sheave mount weldment (220) align with holes at front of tele 1 (201). Secure sheave mount weldments (220) to inside of tele 1 (201) using bolts (244) and washers (253) (see Figure 4-103).

9688-88
9688-89
FIGURE 4-103

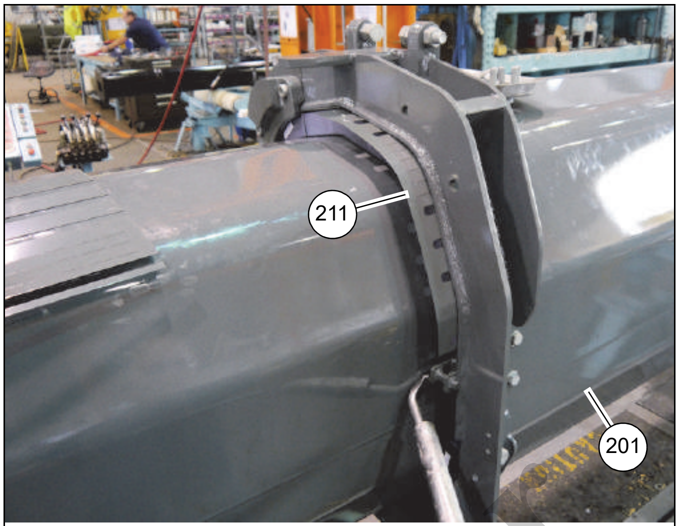
66. Set wear pads (203, qty 2 - 204, qty 2 - 205) with bars (216, qty 2 - 217) on top of tele 2 (301) and tap into place between tele 2 (301) and tele 1 (201) (see Figure 4-104)



9688-90
9688-91
FIGURE 4-104

67. Install bolts (239) with nuts (253) through tip of tele 1 (201) and into bars (216, 217) holding wear pads (203, 204, 205) – do not tighten bolts.

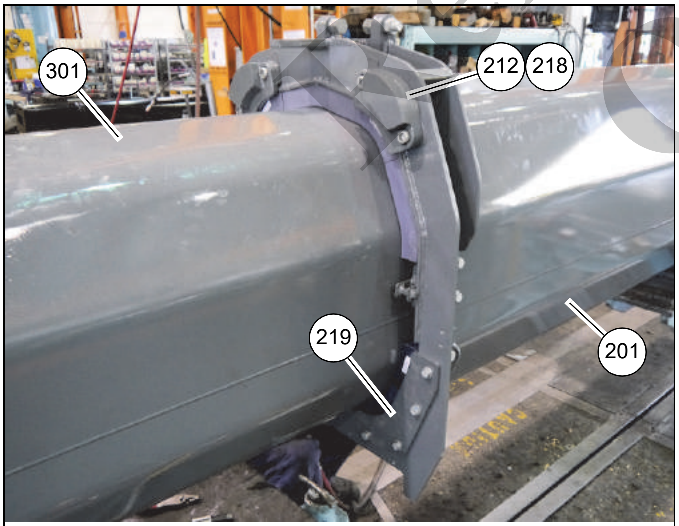
68. Install two shims (211) between wear pads (203, 204, 205) and tele 1 (201) by gently tapping them with a rubber mallet or block of wood (see Figure 4-105).



9688-92 FIGURE 4-105

69. Secure wear pads (203, 204, 205) and shims (211) in place by tightening bolts (239) passing through holes in tele 1 (201) and into bars (216, 217).

70. Install top left and right side shims (212) and stop blocks (218) on to front of tele 1 (201) using bolts (240), washers (254) and nuts (261) (see Figure 4-106). Install bottom left and right side stop plates (219) on to front of tele 1 (201) using bolts (242), washers (251), lock washers (252), and nuts (260) (see Figure 4-106).

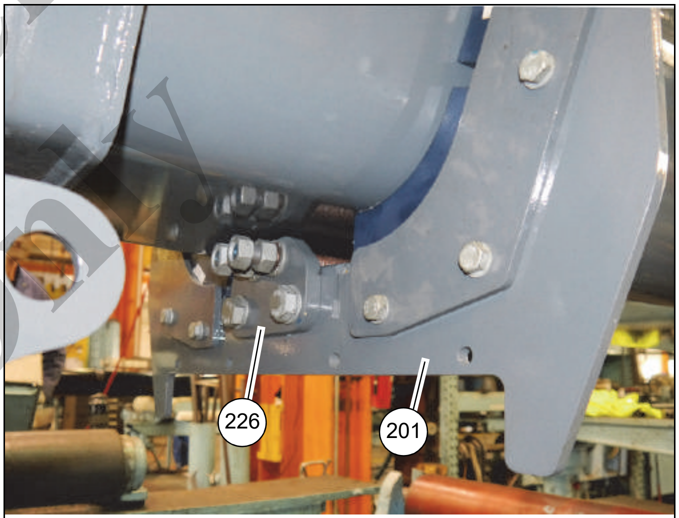


9688-93 FIGURE 4-106

71. Insert tele 2 (301) in to tele 1 (201) until tele 2 is within 0.45 m (1-1/2 ft) of being fully inserted (Figure 4-107).

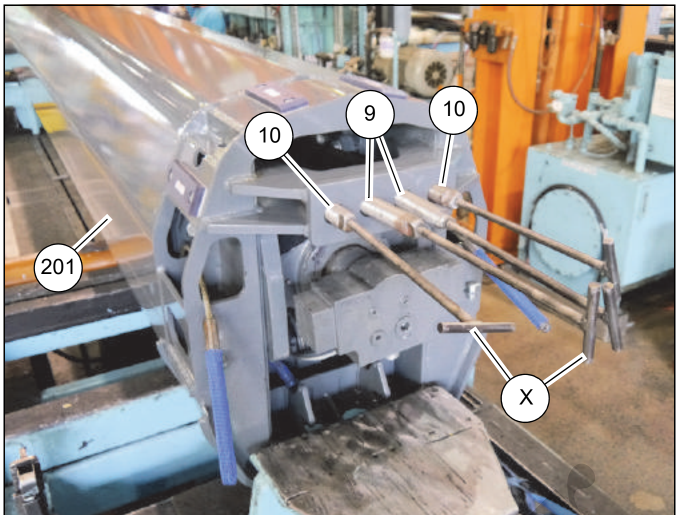
9688-94 FIGURE 4-107

72. Install plate (226) on to front end of tele 1 (201) using two bolts (245), washers (255), and nuts (262) (Figure 4-108).



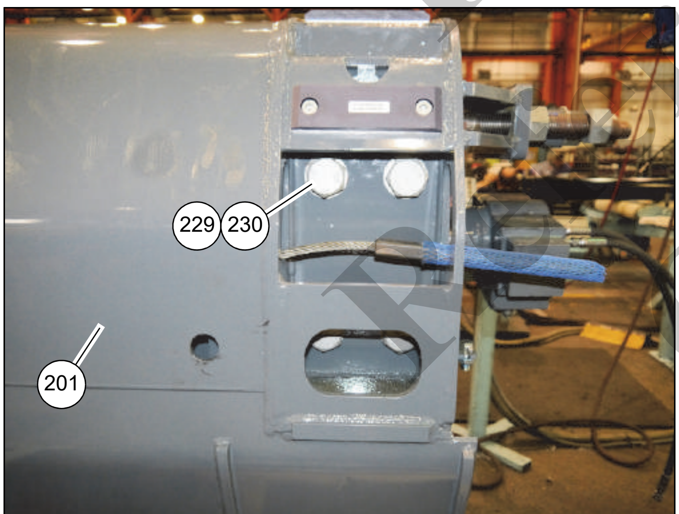
9688-95 FIGURE 4-108

73. Using threaded rods (X) or similar, pull four extend cables (9, 10) through holes in rear of tele 1 (201) (Figure 4-109). Fully insert tele 2 (301) into tele 1 (201).



9688-96 **FIGURE 4-109**

74. Secure each trunnion plate (227) to tele 1 (201) using four bolts (230) and washers (229) (left and right sides) (see Figure 4-110).

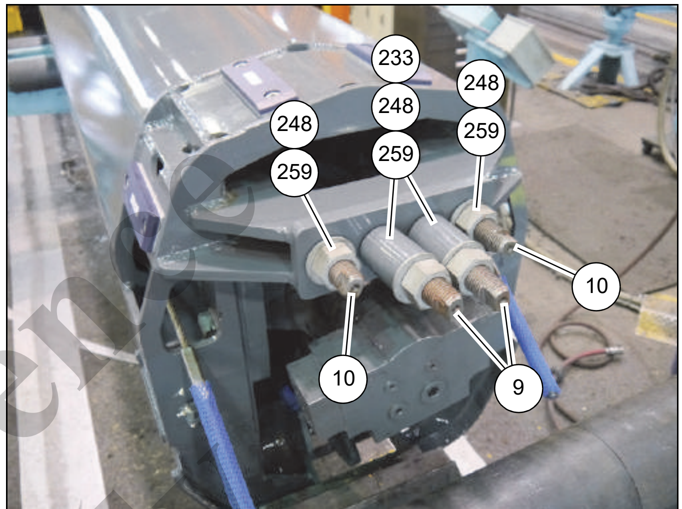


9688-98 **FIGURE 4-110**

75. Apply anti-seize compound to the threaded ends of the four extend cables (9, 10).

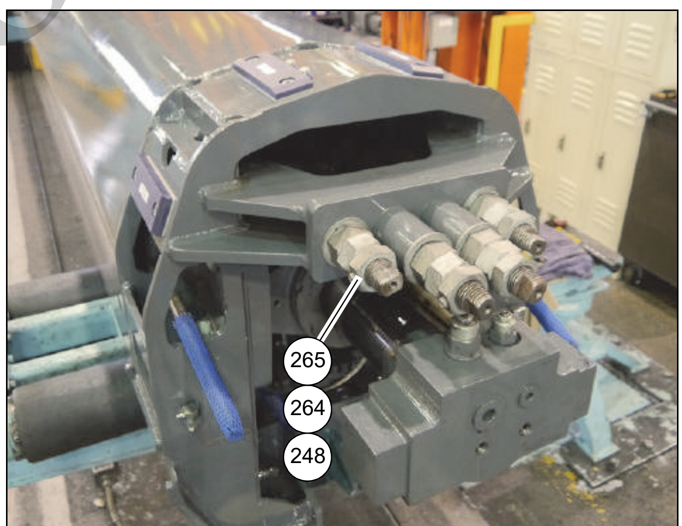
76. Install a washer (259) and nut (248) on to the threaded ends of the two outside extend cables (10). Turn nut (248) until a distance of 102 mm (4 in) is measured from the washer to the tip of the cable end (Figure 4-111). Note: When installing the nut, hold cable by its flats to prevent the cable from turning.

Install a spacer (233), washer (259), and nut (248) on to the threaded ends of the two inside extend cables (9). Turn nuts (248) until a distance of 102 mm (4 in) is measured from the washer to the tip of the cable end (Figure 4-111). Note: When installing the nut, hold cable by its flats to prevent the cable from turning.



9688-97 **FIGURE 4-111**

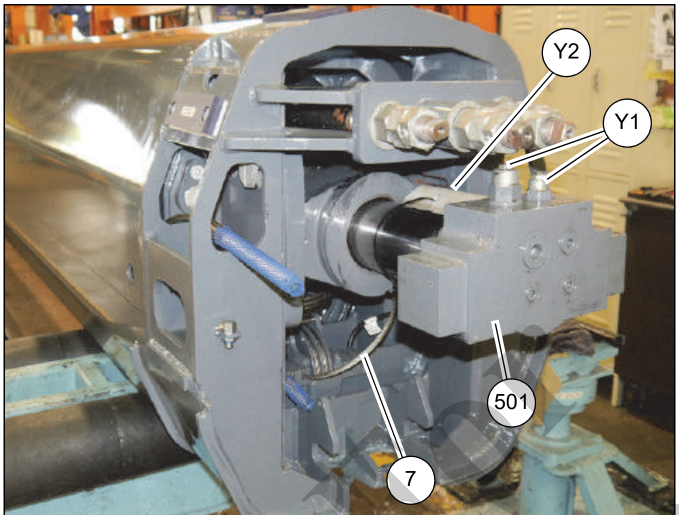
77. After cleaning threads of anti-seize compound, install jam nuts (248) on to each extend cable (9, 10) using a thread locking compound followed by nuts (264) with set screws (265) (see Figure 4-112).



9688-99 **FIGURE 4-112**

78. Rotate end of telescope cylinder (501) until the two holding valve cartridges (Y1) point up.

Pull telescope cylinder (501) out approximately 240 mm (9-1/2 in). Cut a section of angle-iron measuring 240 mm (9-1/2 in) in length. Cover edges of angle-iron with edge guard. Using zip ties, attach angle-iron (Y2) to telescope cylinder chrome tube (see Figure 4-113).

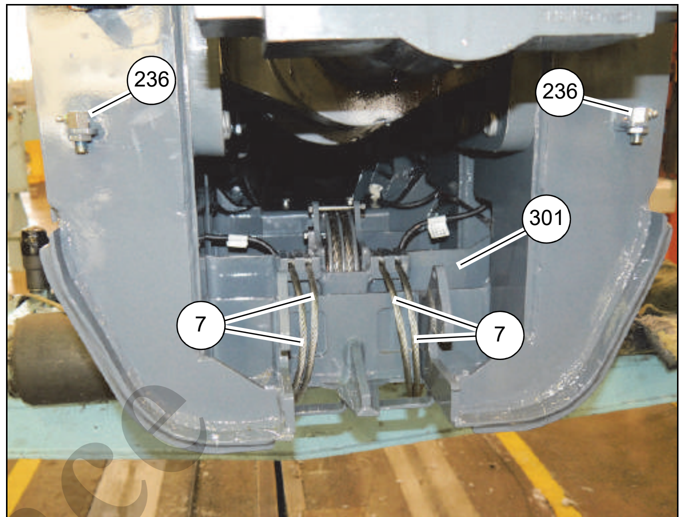


9688-100

FIGURE 4-113

79. Pull the one coiled retract cable (7) out of rear of teles and route up toward front of teles (see Figure 4-113).

80. Install cable ends of remaining three retract cables (7) into cable keepers at rear of tele 2 (301) (see Figure 4-114). Route all cables to the front of teles. Secure cable ends in place using two bolts (342), lock washers (351), and nuts (326).

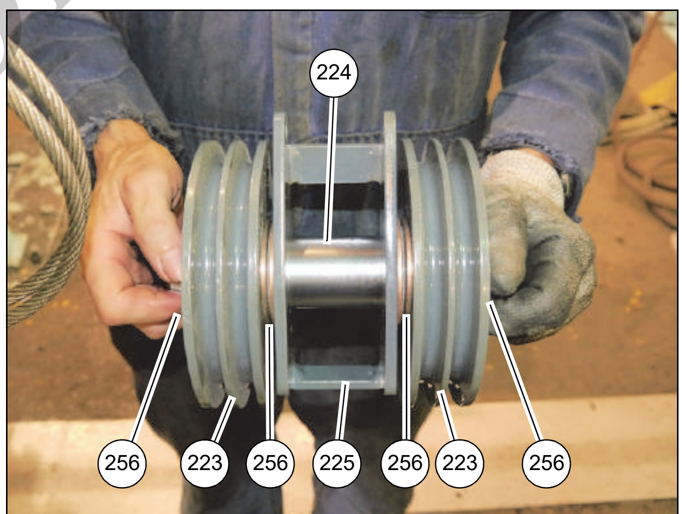


9688-101

FIGURE 4-114

81. Install grease fittings (236) to rear of tele 1 (201) using nuts (250). Orient grease fittings such that they point outward (see Figure 4-114).

82. Assemble sheave assembly by installing the following components on to shaft (224) in the following order - one thrust washer (256), one sheave assembly (223), one thrust washer (256), guard weldment (225), one thrust washer (256), one sheave weldment (223), and one thrust washer (256) (see Figure 4-115).

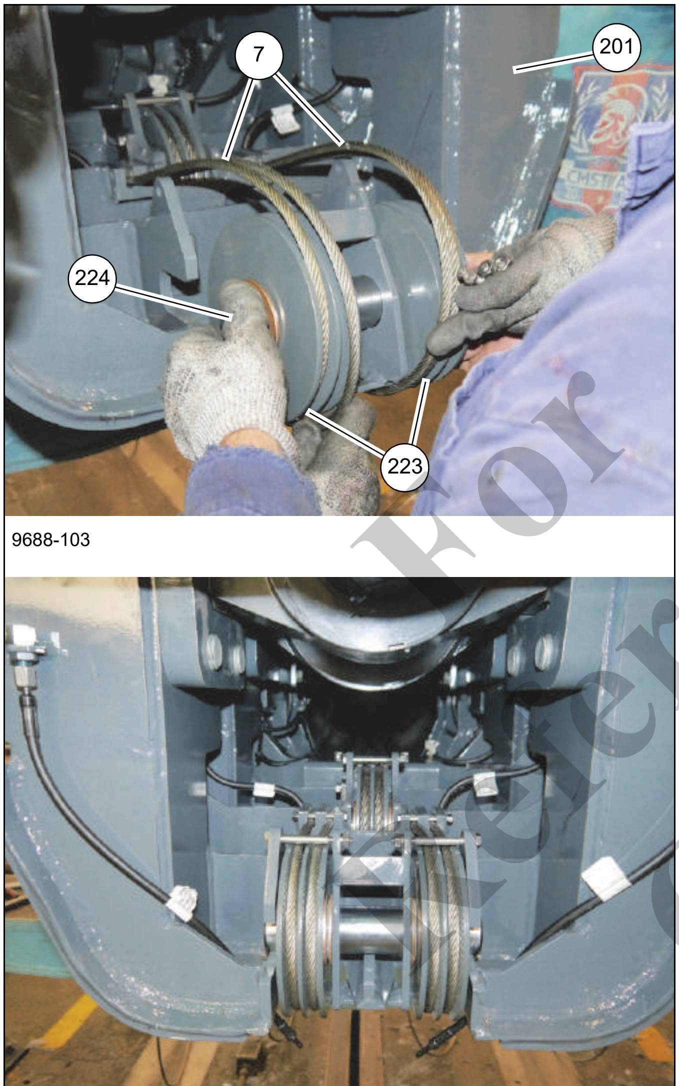


9688-102

FIGURE 4-115

4

83. Install shaft (224) of sheave assembly into rear of tele 1 (201), ensuring the four retract cables (7) wrap around the sheaves (223) (see Figure 4-116). Install bolts (246), lock washers (257), and nuts (232) at top of each sheave assembly to retain the retract cables (7) on the sheaves (223).



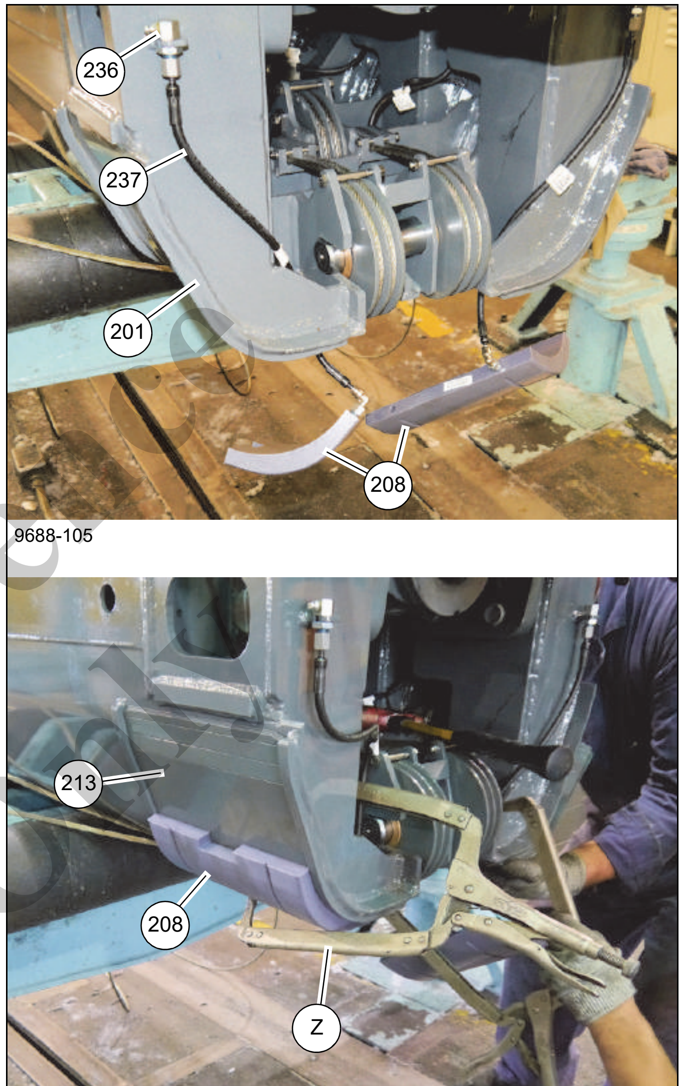
9688-103

9688-104

FIGURE 4-116

84. Attach grease hoses (237) to grease fittings (236) at rear of tele 1 (201). Route end of each grease hose down through hole in bottom of tele 1 (201) (see Figure 4-117).

Attach grease hoses (237) to wear pads (208) using elbows (235) and adapters (234), then secure shims (213) and wear pads (208, 209) to bottom rear of tele 1 (201) with clamp (Z) (see Figure 4-117).



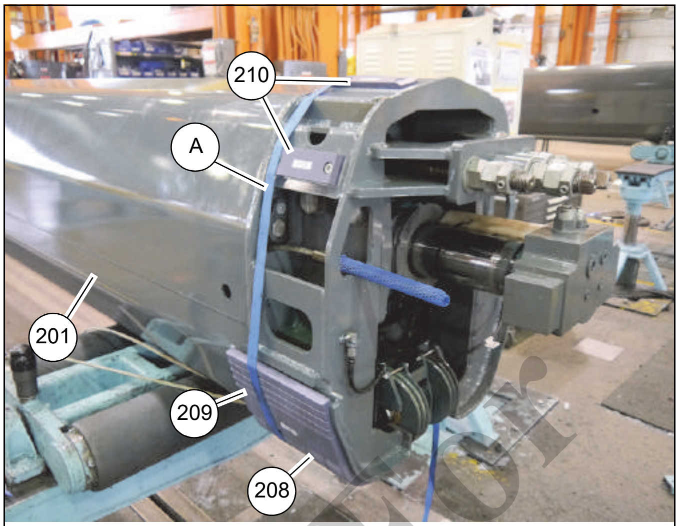
9688-105

9688-106

FIGURE 4-117

85. Install four wear pads (210) with shims (214, 215) to top rear of tele 1 (201) using two bolts (247) for each wear pad (see Figure 4-118).

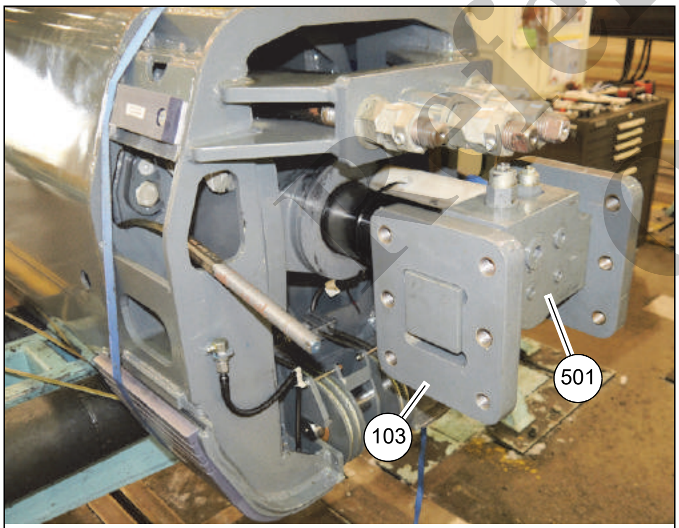
    Secure wear pads (208, 209) in place using strap (A). Note: Install strap around wear pads (208, 209) such that it is offset toward the front of tele 1 as shown.



9688-107

FIGURE 4-118

86. Install trunnion plates (103) on to rear of telescope cylinder (501) (see Figure 4-119).



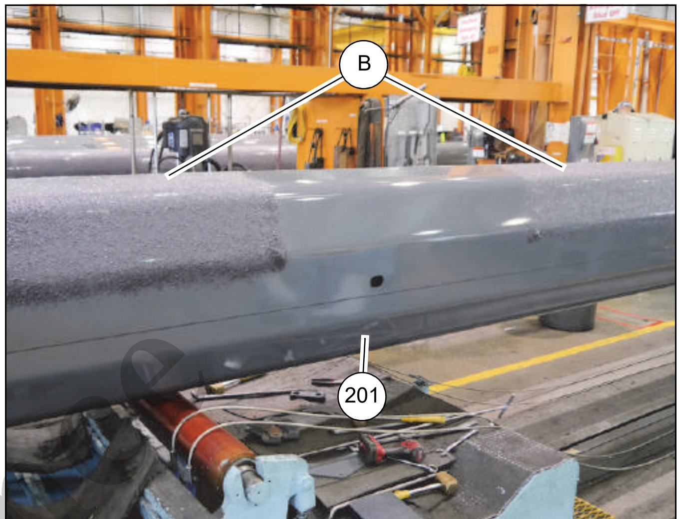
9688-108

FIGURE 4-119

87. Position base (101) upside down on adequate supports in back of tele 1 (201).

88. Apply multipurpose grease to inside top and bottom of base (101).

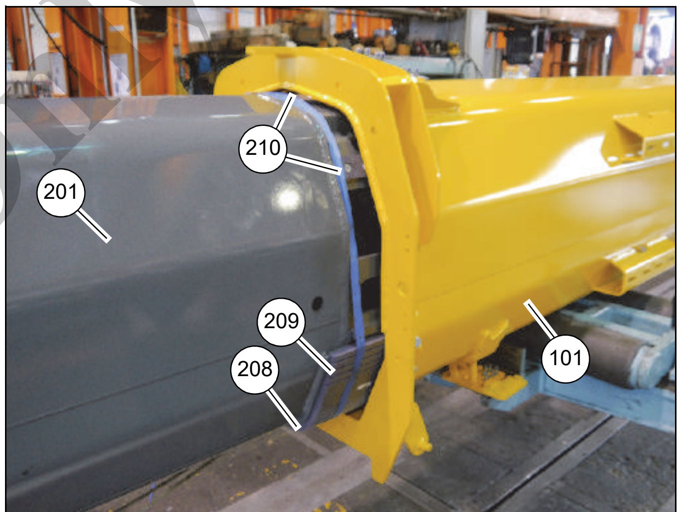
89. Spray multipurpose grease (B) on outside of tele 1 (201). Measuring approximately 1/4 of the distance of the boom from the tip, leave a 5 ft. wide strip of boom free of grease to install wear pads (see Figure 4-120).



9688-109

FIGURE 4-120

90. Insert tele 1 (201) into base (101) until wear pads (208, 209, 210) at rear of tele 1 (201) are just inside base (101) (see Figure 4-121).



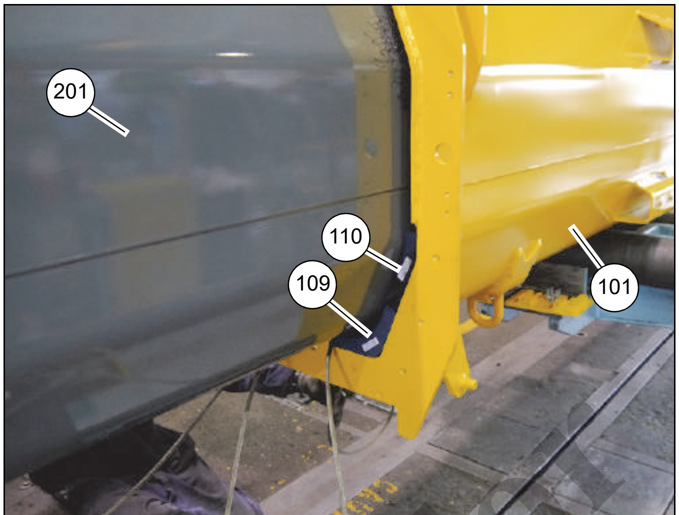
9688-110

FIGURE 4-121

91. Remove strap holding wear pads (208, 209) in place, then insert tele 1 (201) in to base (101) until all wear pads are inside base.

4

92. Slightly raise tele 1 (201), then install wear pads (109, 110) in the left and right bottom corners between tele 1 (201) and base (101) (see Figure 4-122). Install wear pad adjusting bolts (127) and nuts (143) on each side of base (101), but do not tighten.



9688-62

FIGURE 4-122

93. Continue to insert tele 1 (201) into base (101) until tip of base is at the area of tele 1 (201) which is free of grease.

94. Pull four retract cables (7) back through tip of tele 1 (201) and base (101) and route cable ends down through hole in tip of base (101) and then through four holes at front of base (101) (see Figure 4-123) Make sure cables do not cross one another.

9688-112

FIGURE 4-123

95. Install cable retainer plate (119) above the four retract cables (7), ensuring the cables seat in to grooves (see Figure 4-123).

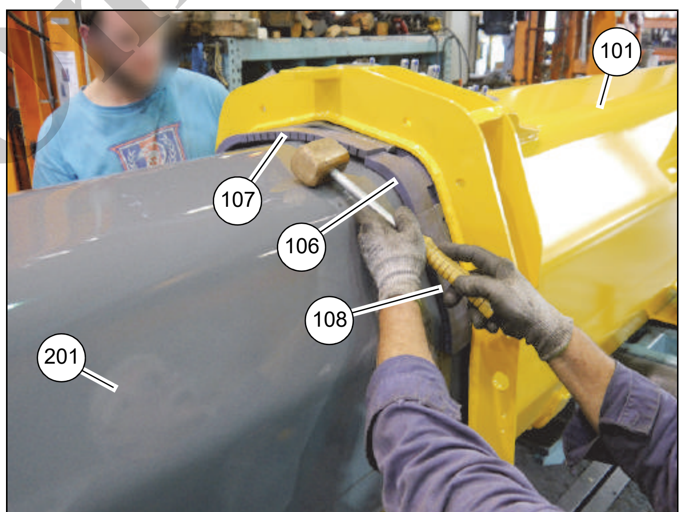
96. Attach cable retainer plate (119) to cable mount weldment (118) using two bolts (146) and washers (138), then attach cable mount weldment (118) to bottom of base (101) using four bolts (146) and washers (138) (see Figure 4-124).

9688-113

FIGURE 4-124

97. Apply anti-seize compound to threaded ends of the four retract cables (7), then install two nuts (131) with one washer (136) on to the threaded end of each cable (7).

98. Set wear pads (qty 2 - 106, 107, qty 2 - 108) with bars (113, qty 2 -114) on top of tele 1 (201) and tap into place between tele 1 (201) and base (101) (see Figure 4-125).

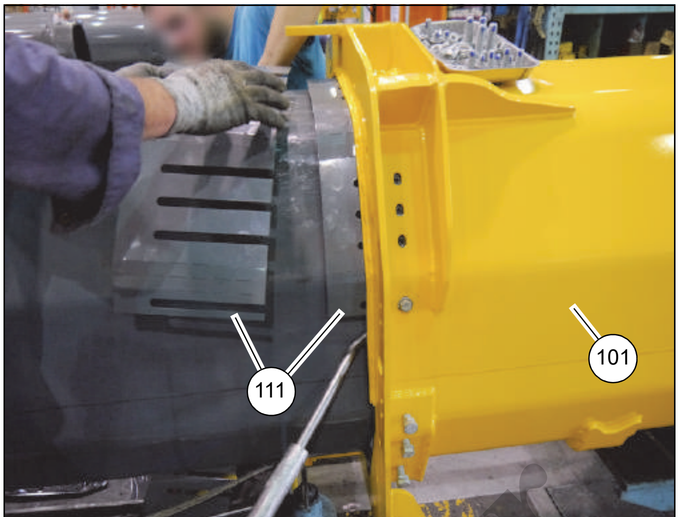


9688-114

FIGURE 4-125

99. Install bolts (122) with washers (134) through tip of base and into bars (113, 114) holding wear pads (106, 107, 108) – do not tighten bolts.

100. Install two shims (111) between wear pads (106, 107, 108) and base (101) by gently tapping them with a rubber mallet or block of wood (see Figure 4-126).

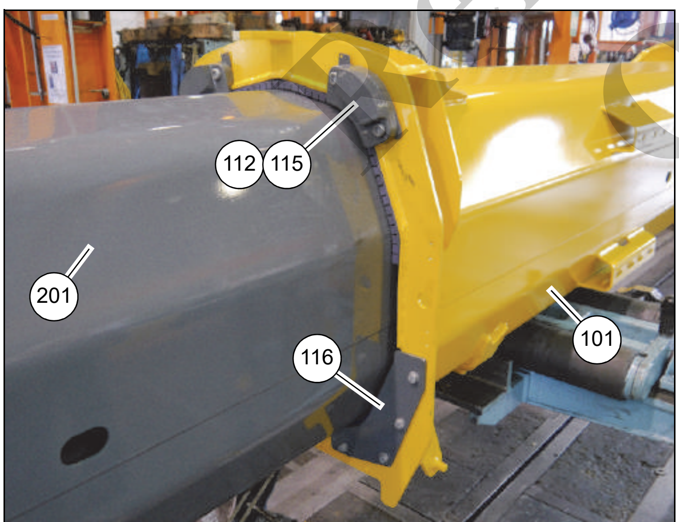


9688-116

FIGURE 4-126

101. Secure wear pads (106, 107, 108) and shims (111) in place by tightening bolts (122) passing through holes in base (101) and into bars (113, 114).

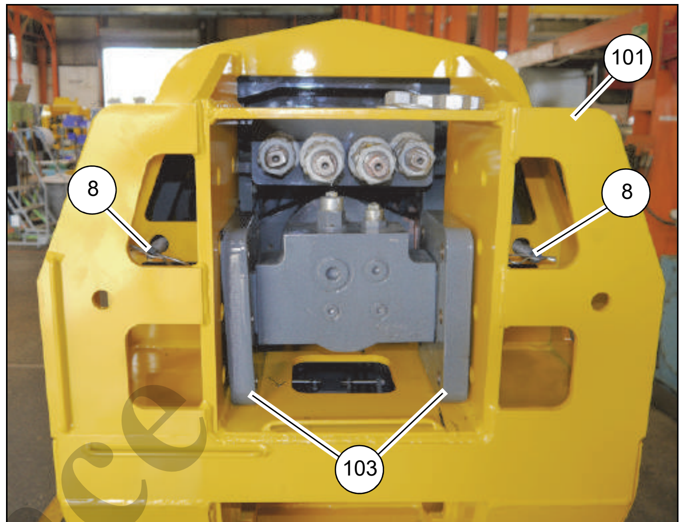
102. Install top left and right side shims (112) and stop blocks (115) on to front of base (101) using bolts (125), washers (135), and nuts (142) (see Figure 4-127). Install bottom left and right side stop plates (116) on to front of base (101) using bolts (126), washers (132), lock washers (133), and nuts (141).



9688-117

FIGURE 4-127

103. Insert tele 1 (201) into base (101) until holes in trunnion plates (103) on rear of telescope cylinder (501) align with holes in rear of base (101). At same time, make sure two extend cables (8) pass through holes in rear of base (101) (see Figure 4-128).

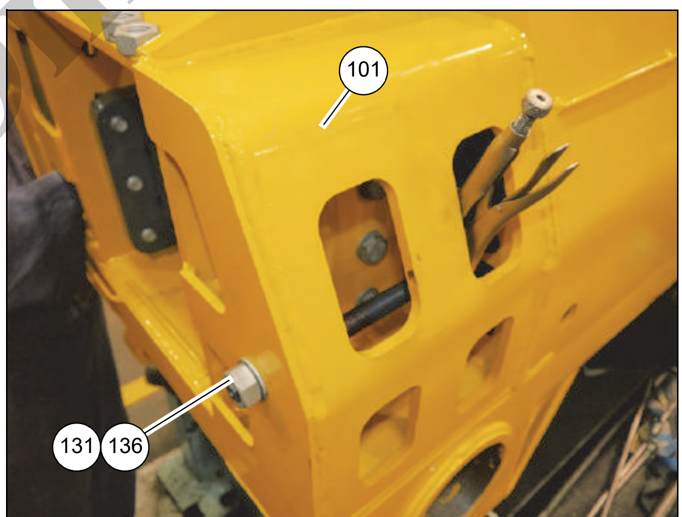


9688-118

FIGURE 4-128

104. Secure trunnion plates (103) to base (101) using bolts (123) and washers (136).

105. Apply anti-seize compound to the threaded ends of extend cables (8), then install a washer (136) and two nuts (131). Thread nuts on to cable ends until a measurement of 45 mm (1-3/4 in) is attained between bottom of washer and cable end (see Figure 4-129).



9688-119

FIGURE 4-129

106. Remove block of wood that was placed against telescope cylinder chrome tube and held in place with zip-tie.

4

5-SECTION BOOM - DISASSEMBLING/ASSEMBLING

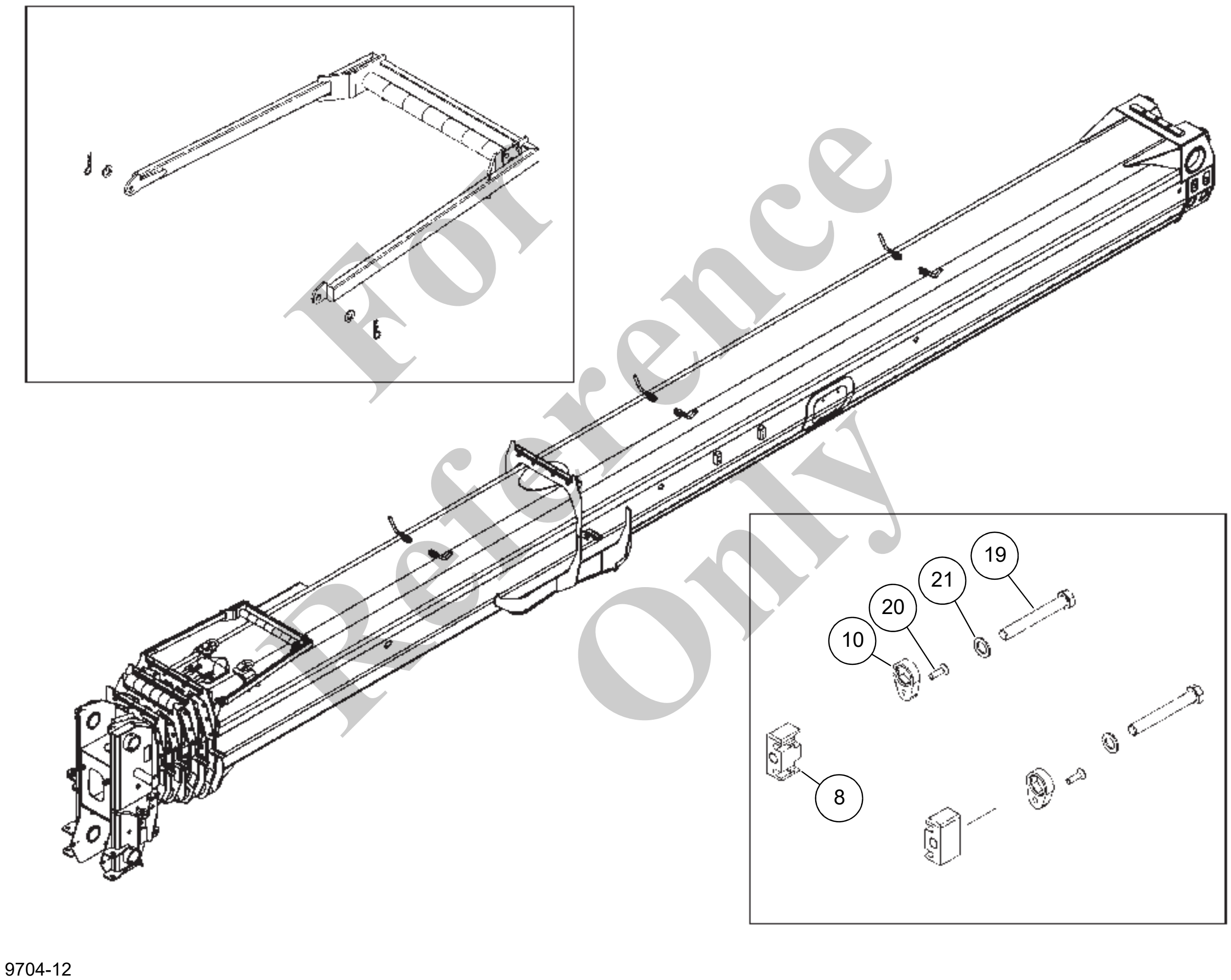


FIGURE 4-130

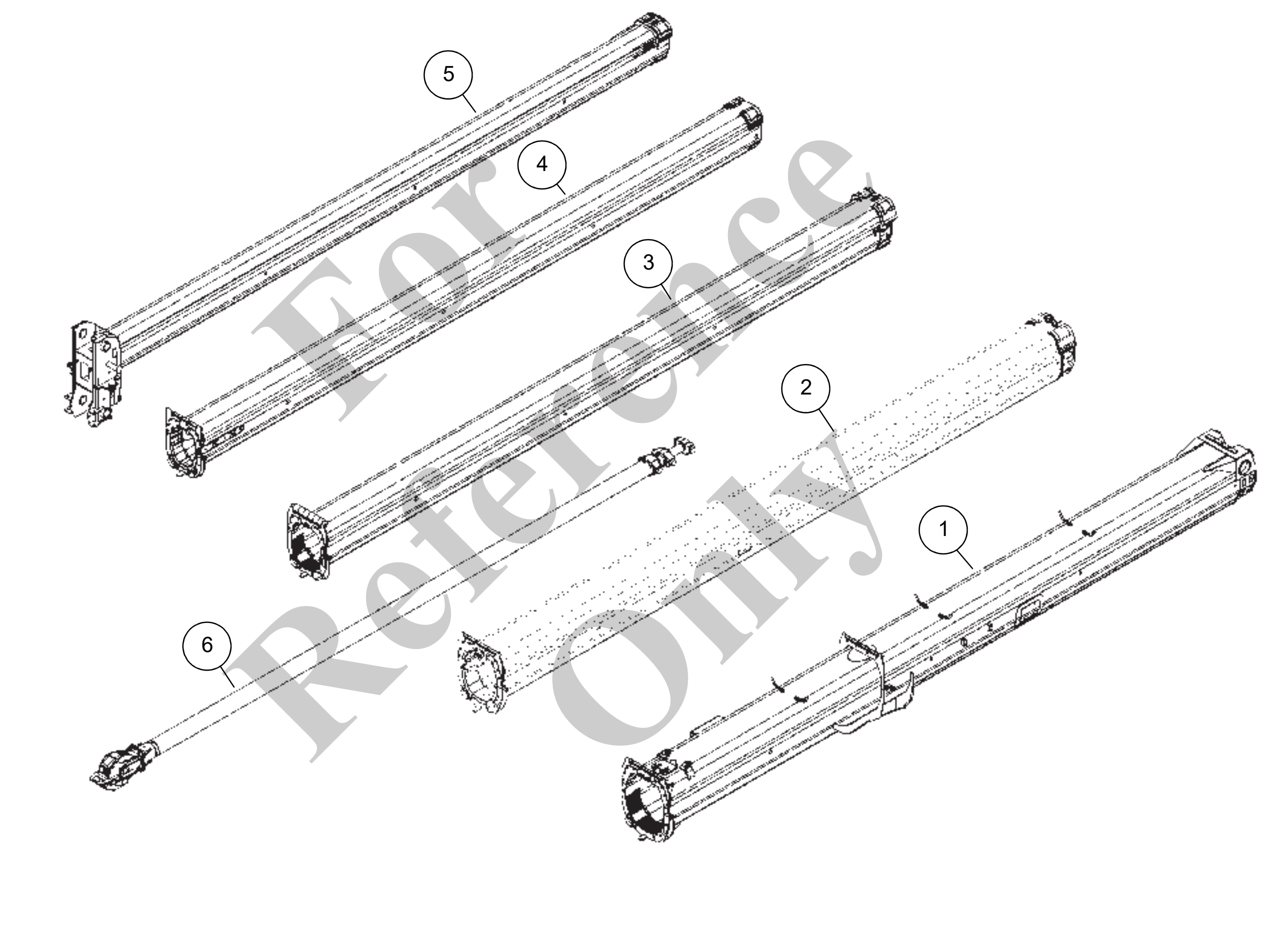


FIGURE 4-130 continued

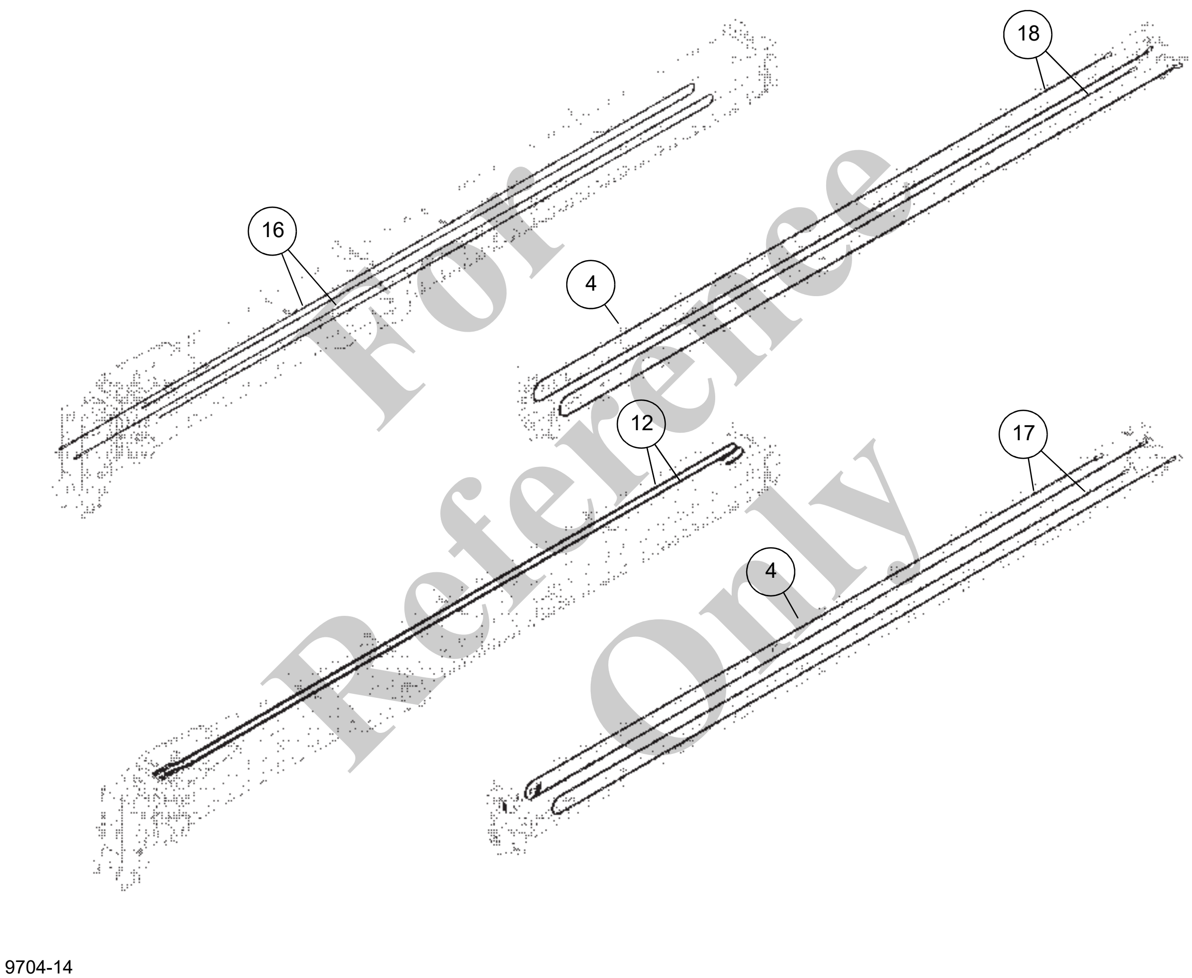


FIGURE 4-130 continued

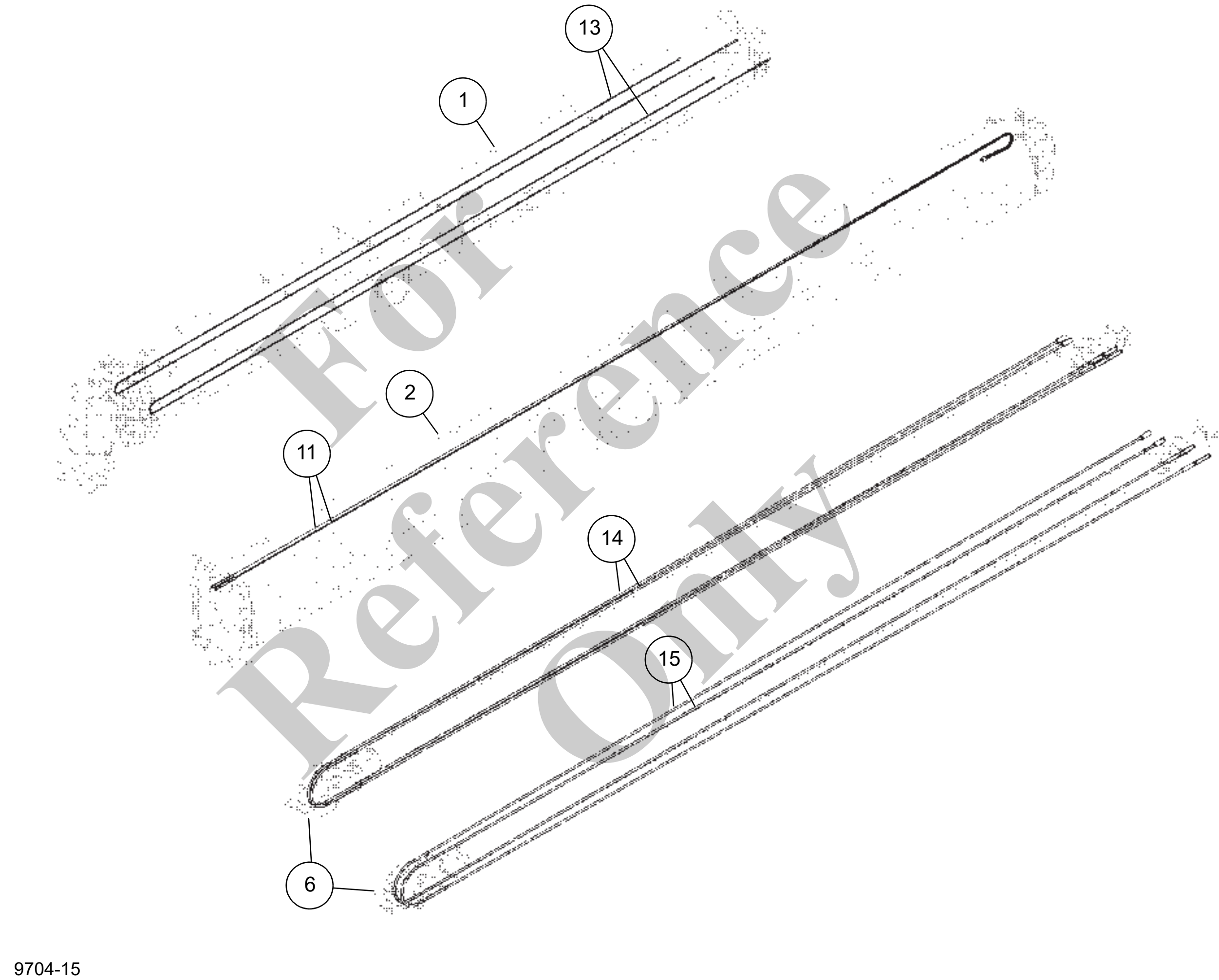


FIGURE 4-130 continued

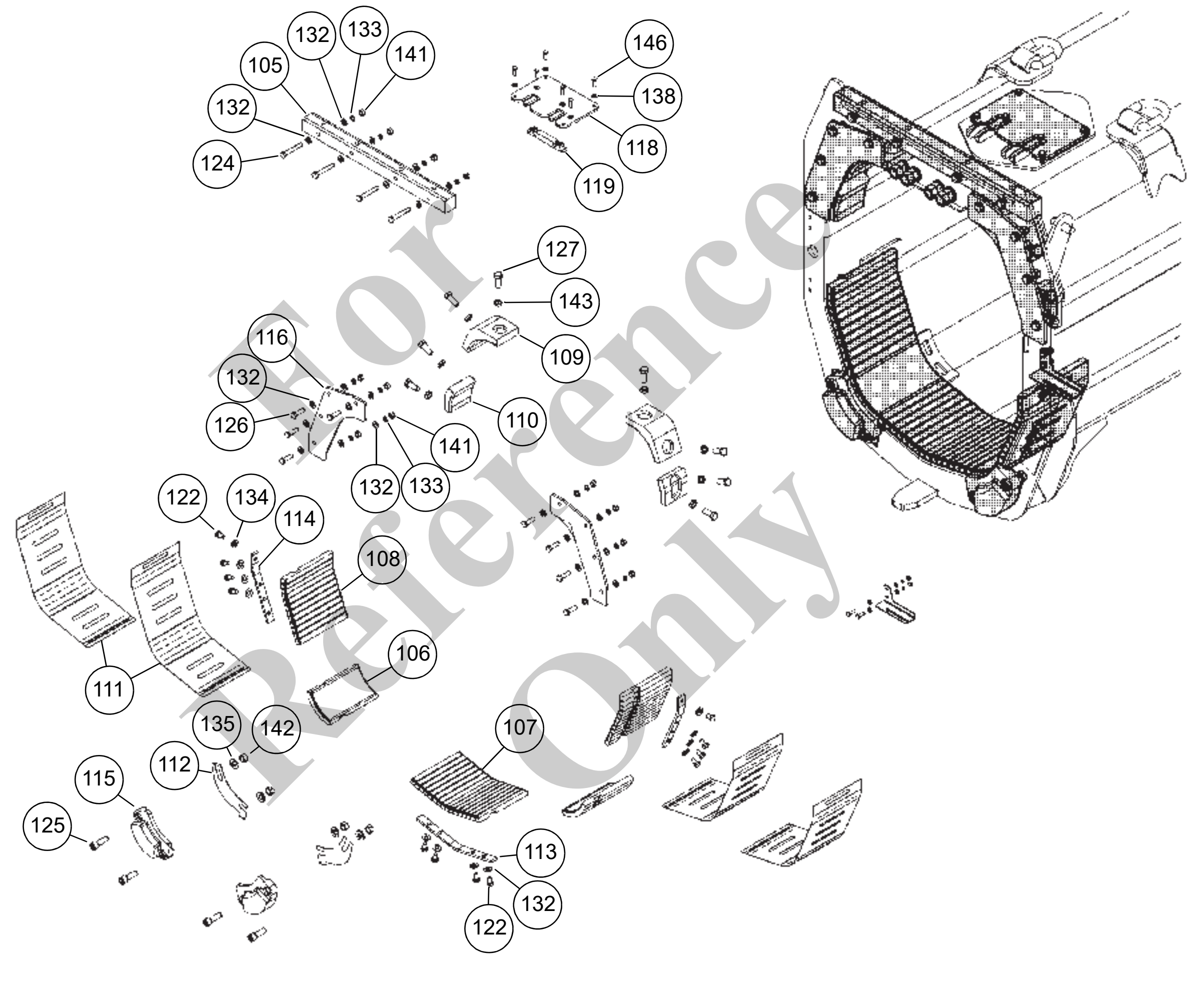


FIGURE 4-130 continued

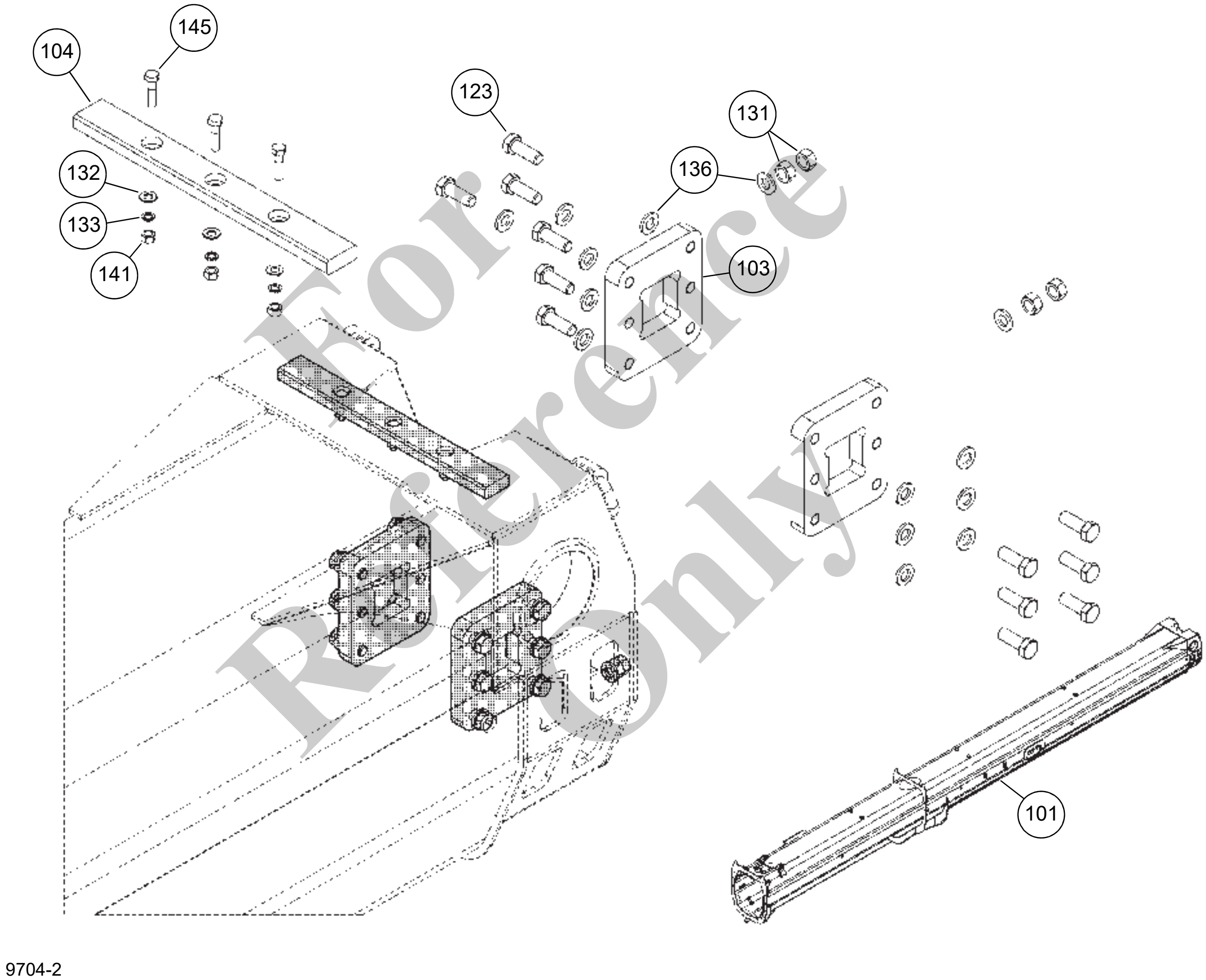


FIGURE 4-130 continued

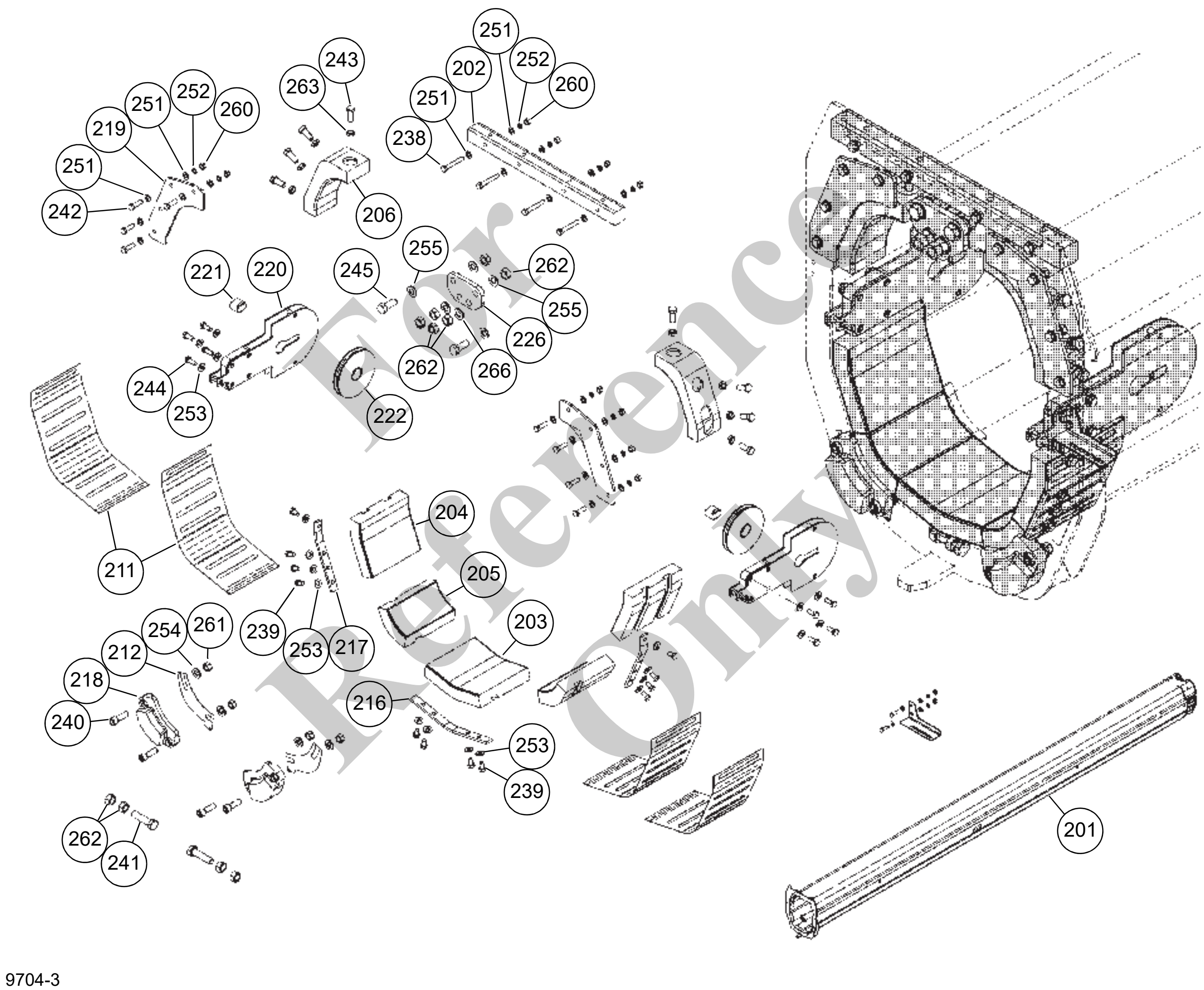


FIGURE 4-130 continued

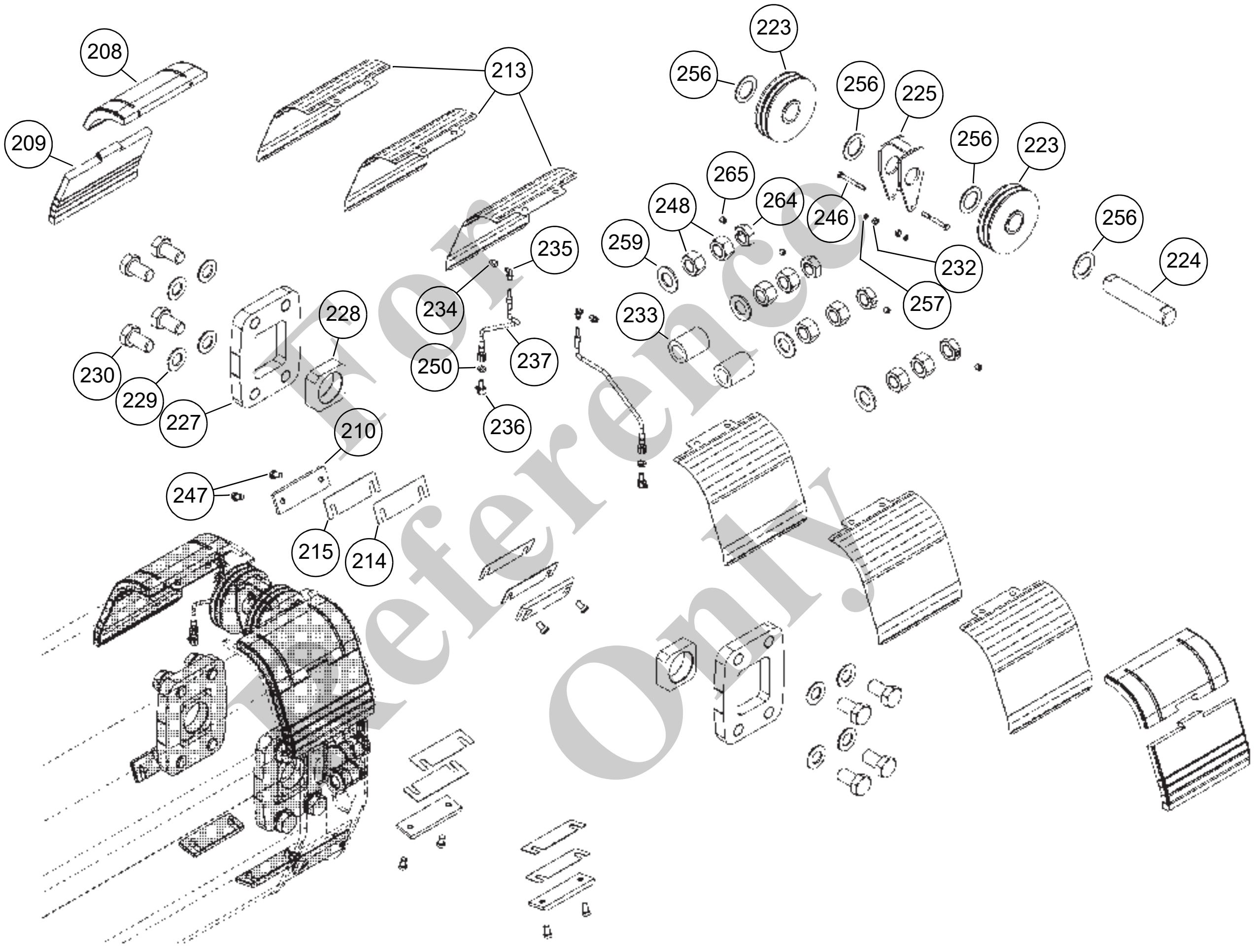


FIGURE 4-130 continued

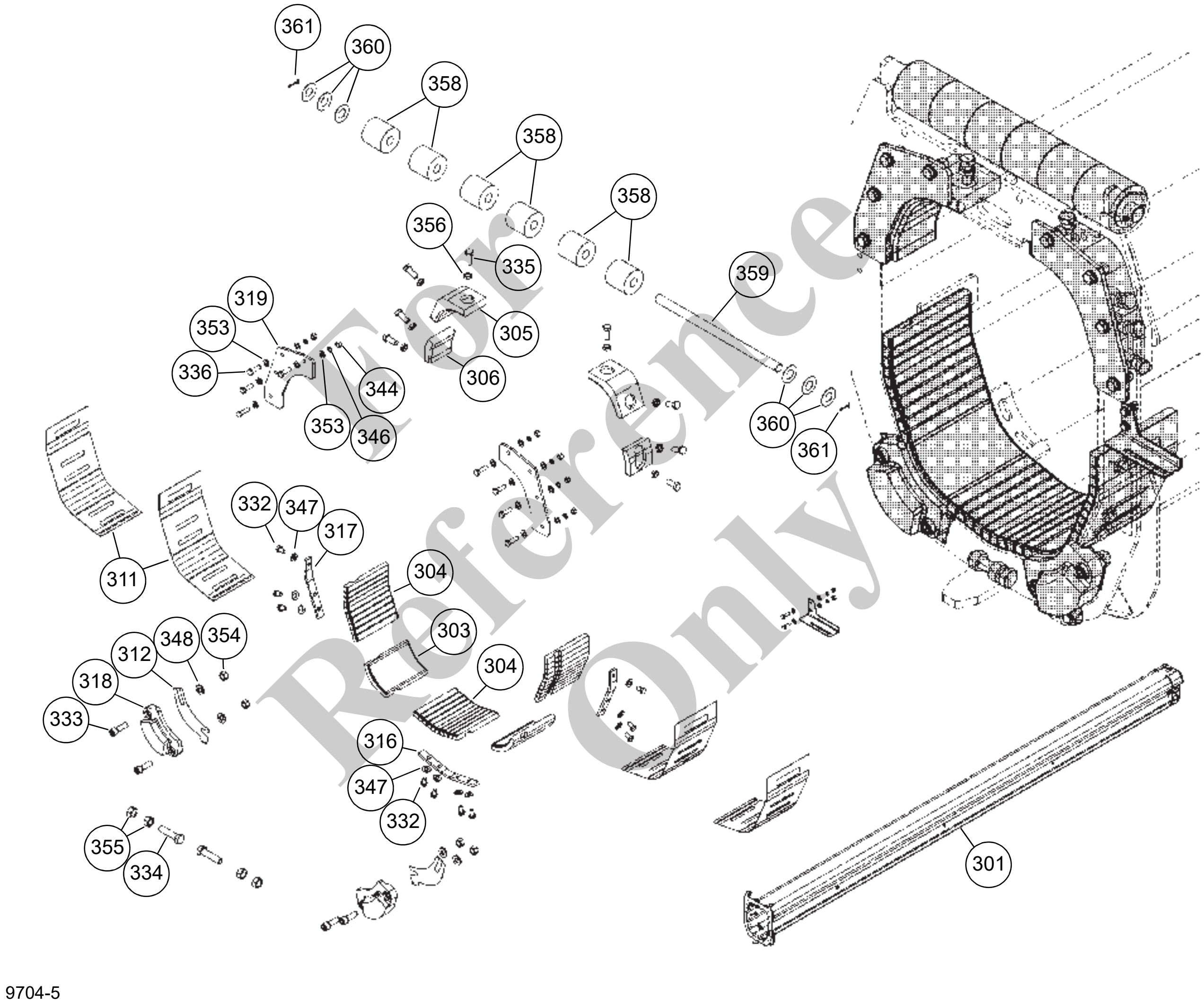


FIGURE 4-130 continued

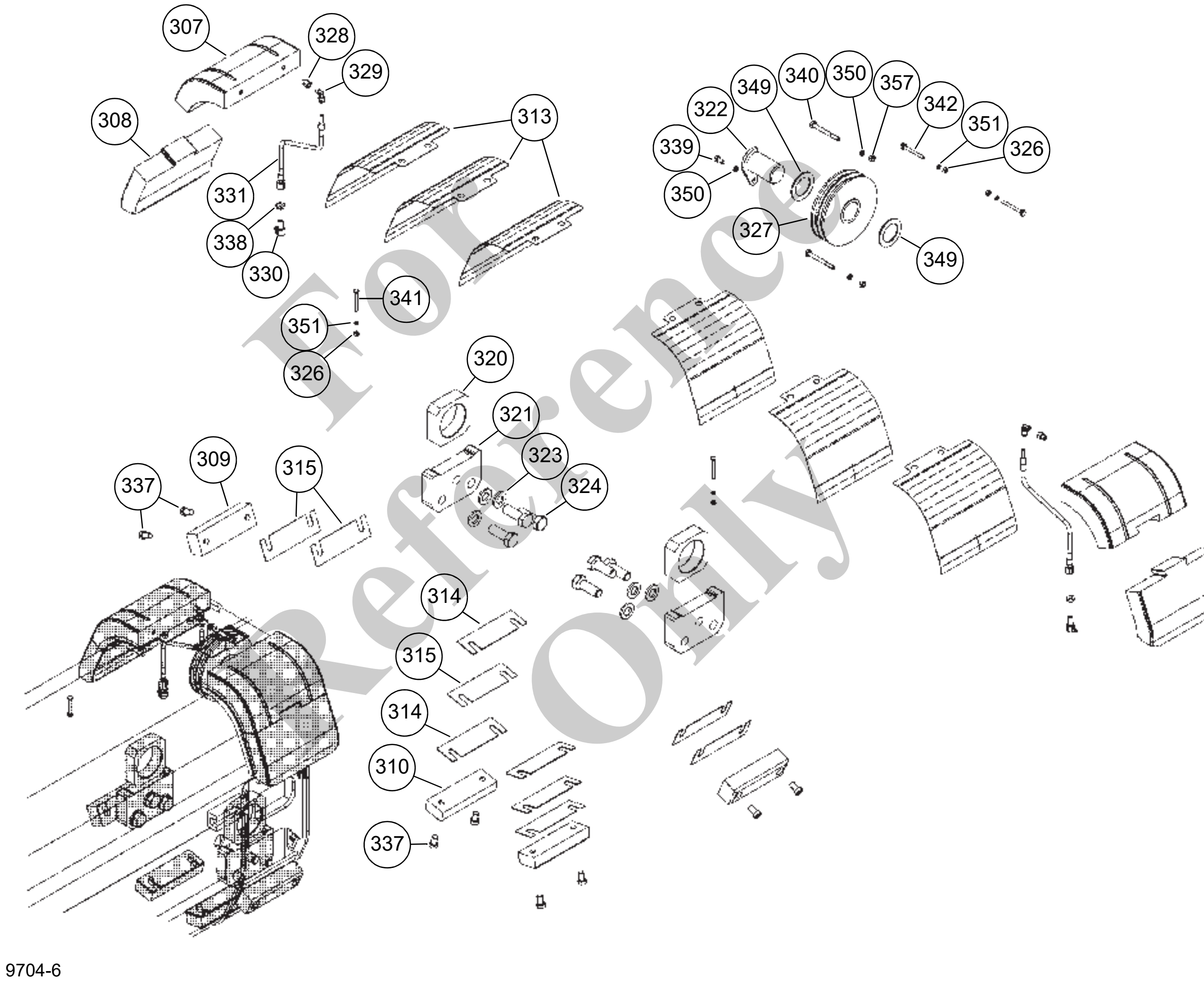


FIGURE 4-130 continued

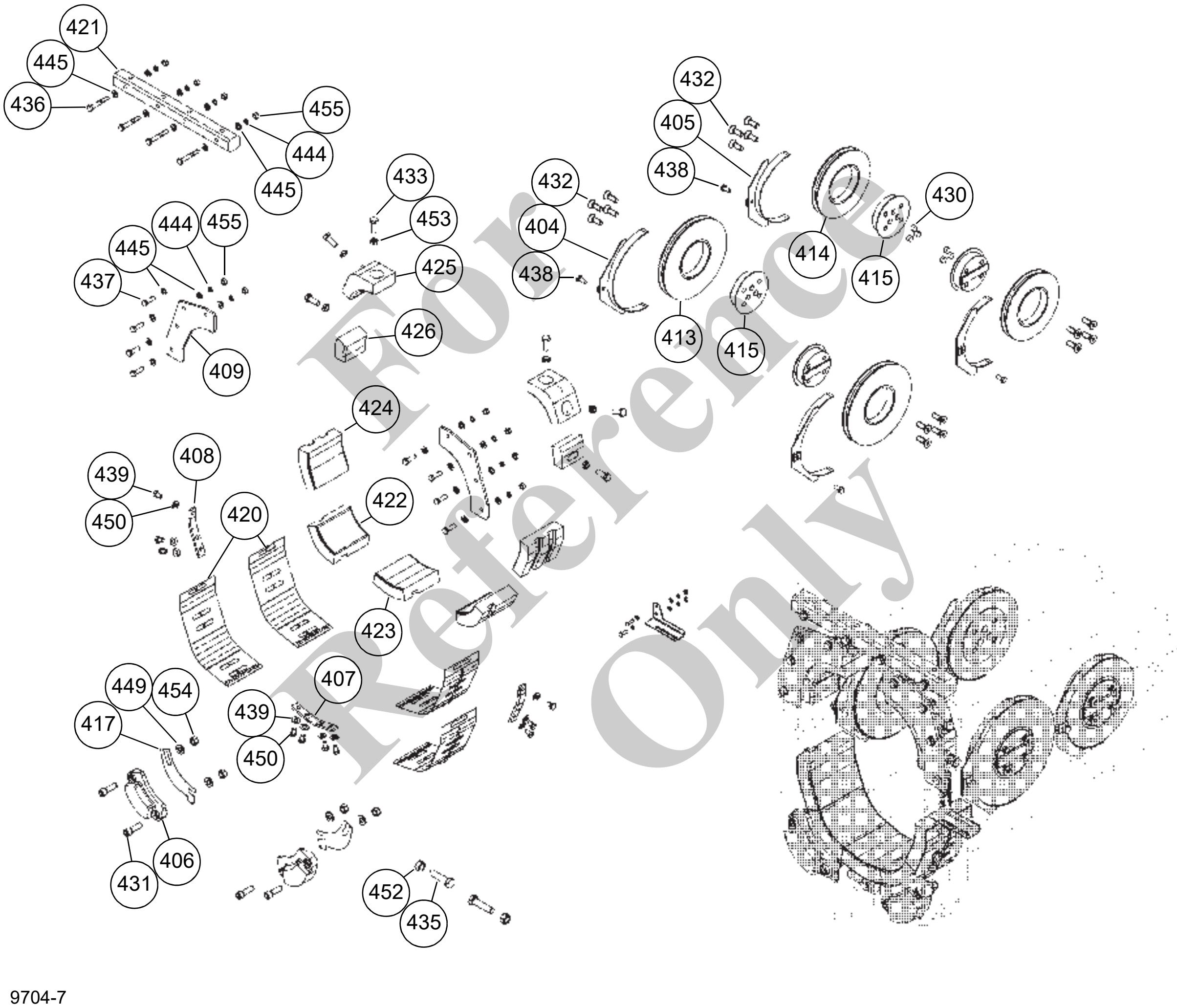


FIGURE 4-130 continued

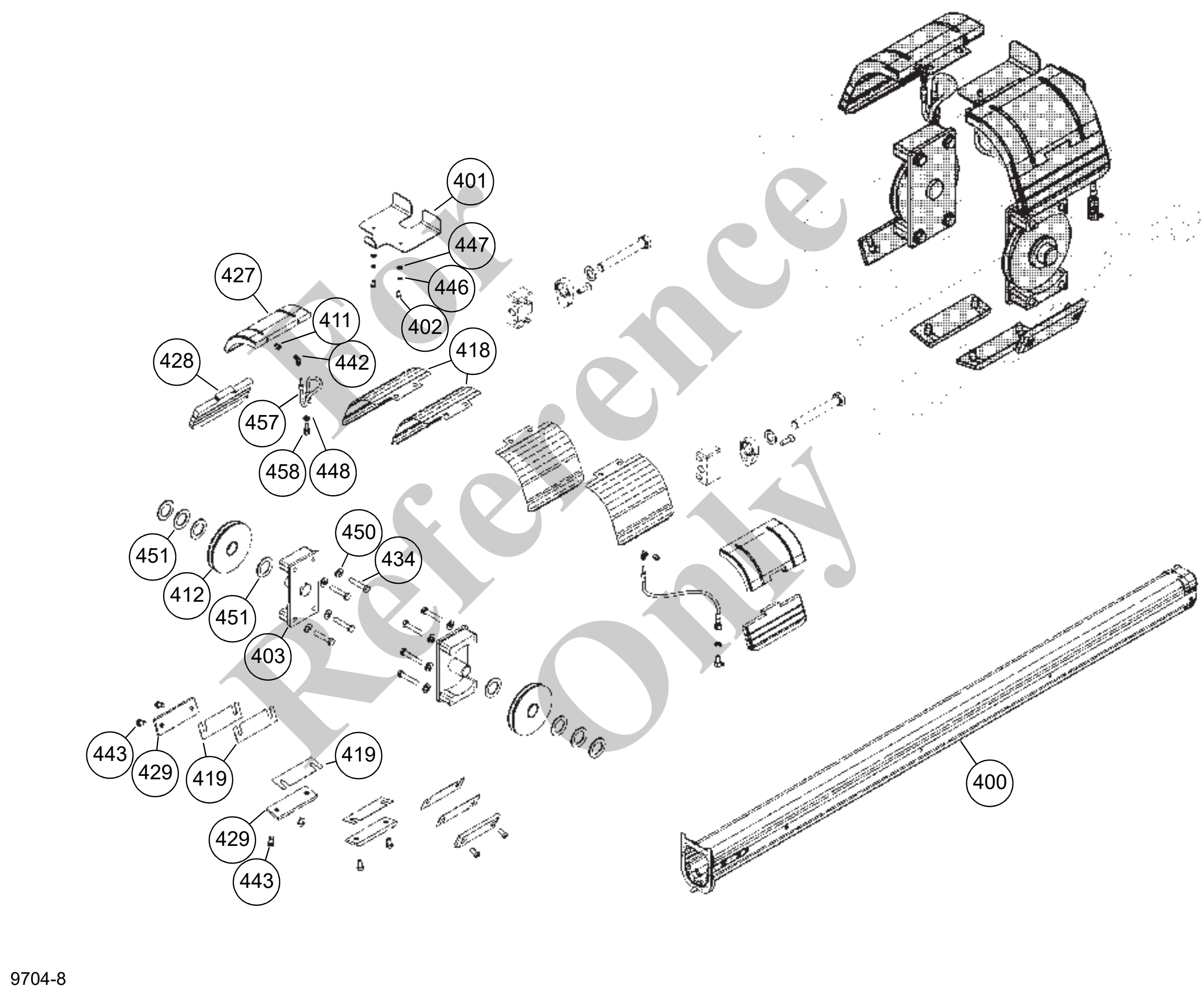


FIGURE 4-130 continued

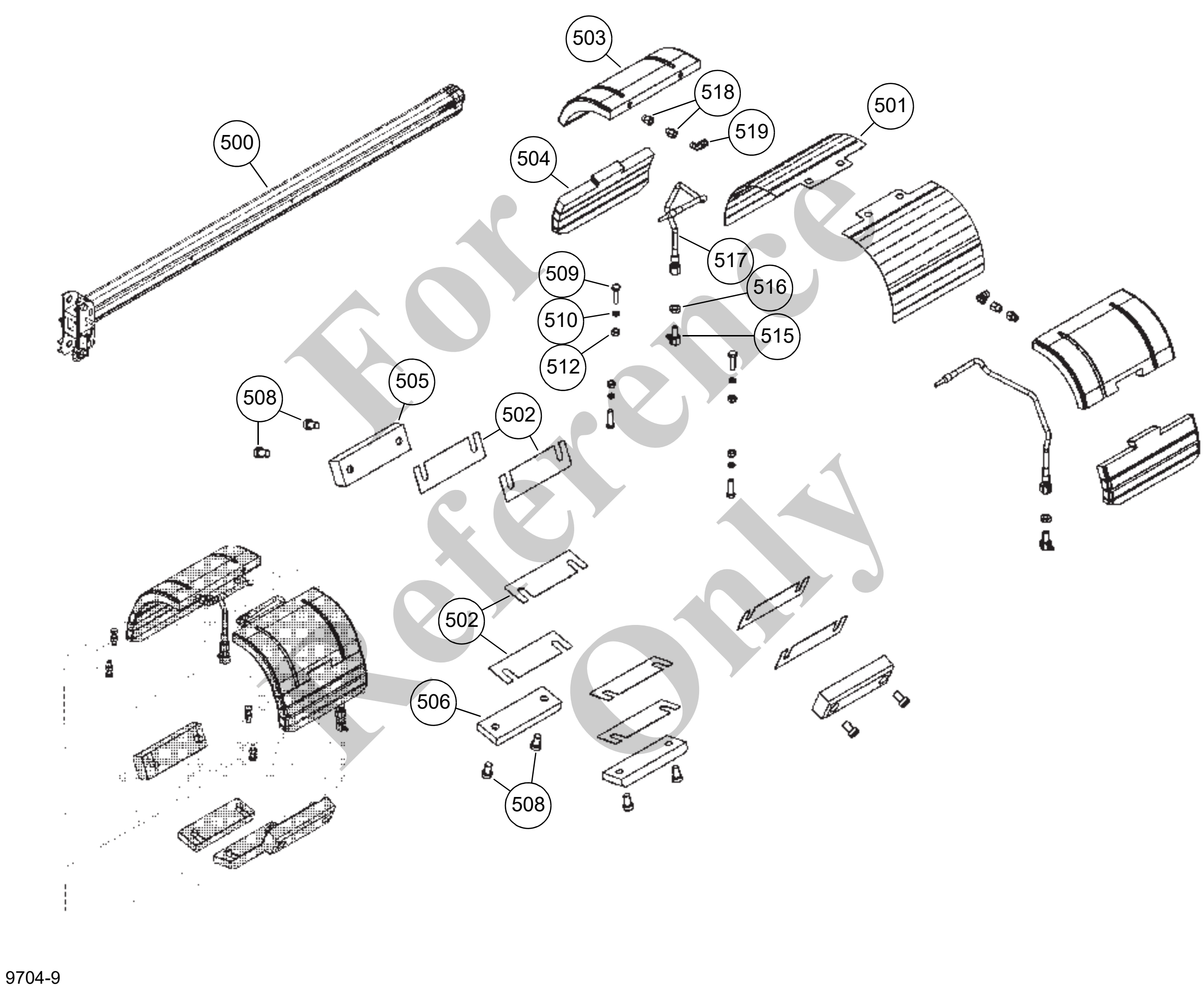


FIGURE 4-130 continued

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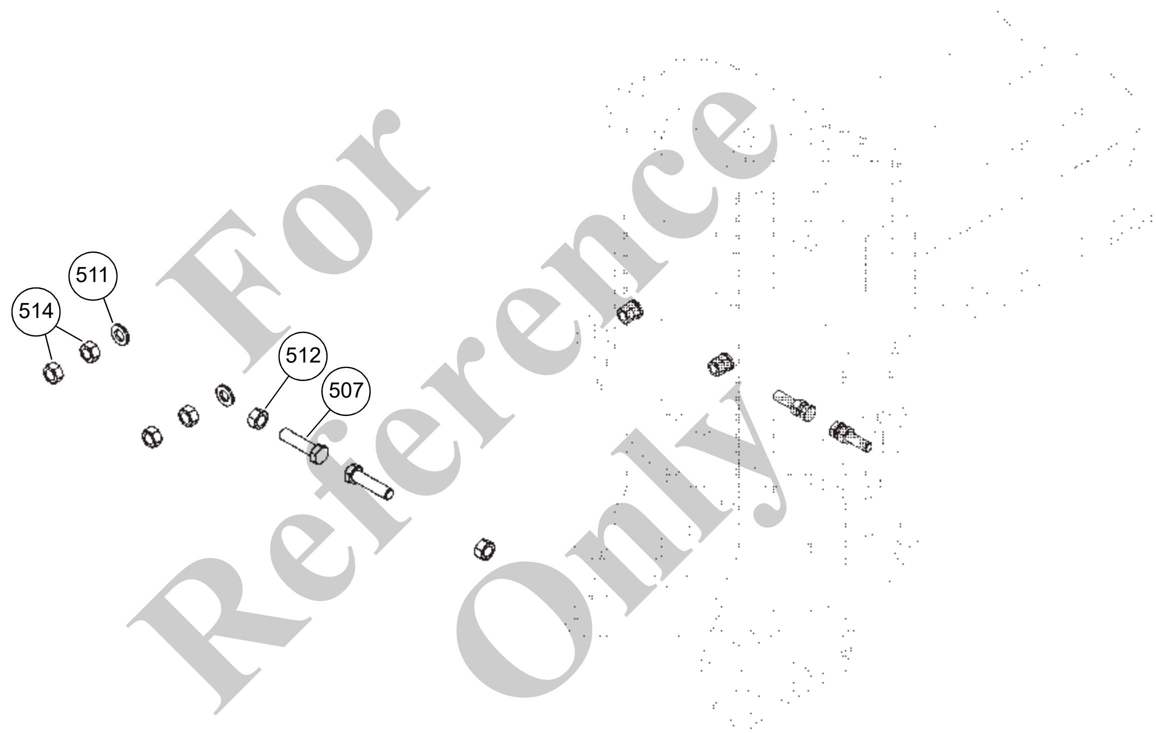


9704-10

FIGURE 4-130 continued

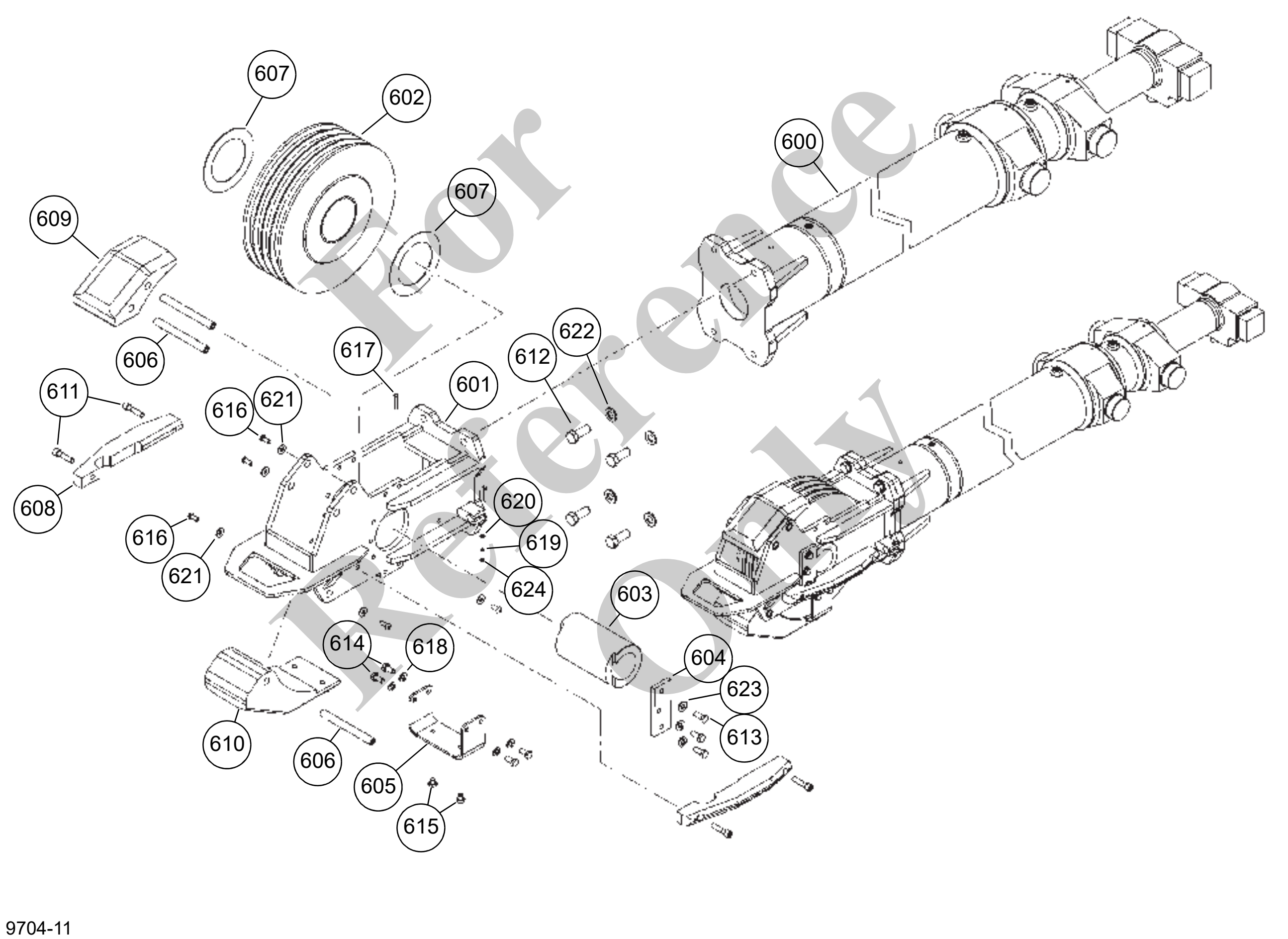


FIGURE 4-130 continued

ITEM	DESCRIPTION
1	BASE ASSEMBLY
2	TELE 1 ASSEMBLY
3	TELE 2 ASSEMBLY
4	TELE 3 ASSEMBLY
5	TELE 4 ASSEMBLY
6	CYLINDER ASSEMBLY
7	ASSEMBLY CABLE GUIDE
8	ANCHOR
10	PLATE
11	CABLE RETRACT
12	CABLE RETRACT
13	CABLE SYNCHRO
14	CABLE EXTEND
15	CABLE EXTEND
16	CABLE RETRACT
17	CABLE EXTEND TELE 4
18	CABLE EXTEND TELE 4
19	HHCS M24X180 10.9 ISO 4017
20	SFHCS M12X40-10.9 ISO 1064
21	F WASHER 1” HARD “
22	F WASHER 3/4”” HARD ASTM F-436-
23	HITCH PIN CLIP
101	BASE WELDMENT
102	BAR BENT KEEPER
103	PLATE TRUNNION
104	WEAR STRIP
105	PROTECTION STRIP
106	WEAR PAD
107	WEAR PAD
108	WEAR PAD
109	WEAR PAD ASSY
111	SHIM FRONT
112	SHIM
113	PLATE RETAINER
114	PLATE RETAINER
115	BLOCK STOP
116	RETAINER
117	COVER

ITEM	DESCRIPTION
118	WELDMENT CABLE MOUNT
119	PLATE CABLE RETAINER
120	BRACKET
121	SBCS M10X25 SS ISO 7380
122	HHCS M12X20 -10.9 ISO 4017
123	SCR CAP HEX HD M20 X 55 LG
124	HHCS M12X80 8.8 ISO 4014
125	SHCS M16X50 10.9 ISO 4762
126	HHCS M12X40 8.8 ISO 4017
127	HHCS M16X40 10.9 ISO 4014
128	HHCS M6X16 SS ISO 4017
129	HHCS FULL THREAD, 8 X 25 8.8
130	L WASHER, 8 ST DIN 7980
131	HEX NUT M20 8 ISO 4032
132	F WASHER, 12 ST ISO 7089
133	L WASHER, 12 ST DIN 7980
134	F WASHER 1/2” HARD ASTM F-436
135	F WASHER 5/8” HARD ASTM F-436
136	F WASHER 3/4” HARD ASTM F-436-
137	L WASHER 6 -HRC44-51 DIN 7980
138	F WASHER 5/16” HARD ANSI B27.2
139	F WASHER, 8 ST ISO 7089
140	HEX NUT, 8 8 ISO 4032
141	HEX NUT M12 8 ISO 4032
142	HEX NUT M16 8 ISO 4032
143	HEX JAM NUT, 16-8 ISO 4035
144	L WASHER, 10 ST DIN 7980
145	HHCS M12X45 8.8 ISO 4014
146	HHCS M8 X 25 -10.9 ISO 4017
201	TELE 1 WELDMENT
202	PROTECTION STRIP
203	WEAR PAD
204	WEAR PAD
205	WEAR PAD
206	WEAR PAD ASSY
208	WEAR PAD
209	WEAR PAD
210	SLIDER

ITEM	DESCRIPTION
211	SHIM FRONT
212	SHIM
213	SHIM REAR
214	FILL PLATE
215	FILL PLATE
216	PLATE RETAINER
217	PLATE RETAINER
218	BLOCK STOP
219	RETAINER
220	WELDMENT SHEAVE MOUNT
221	SHAFT
222	SHEAVE ASSEMBLY
223	SHEAVE ASSEMBLY
224	SHAFT
225	WELDMENT GUARD
226	PLATE
227	PLATE TRUNNION
228	BLOCK
229	F WASHER 1-1/8” HARD ASTM F-43
230	HHCS M30X55 10.9 ISO 4017
231	BRACKET
232	HEX NUT, 8 8 ISO 4032
233	BUSHING
234	ADAPTER 304-19509-1 M10X1/M10X
235	ELBOW, PUSH-IN 226-14123-3 WEK
236	PIPE UNION SV-06L/SW17 M12X1,
237	LUBRICANT HOSE
238	HHCS M12X80 8.8 ISO 4014
239	HHCS M12X20 -10.9 ISO 4017
240	SHCS M16X50 10.9 ISO 4762
241	HHCS M20X80 8.8 ISO 4017
242	HHCS M12X40 8.8 ISO 4017
243	HHCS M16X40 10.9 ISO 4014
244	HHCS M12X30 10.9 ISO 4017
245	HHCS M20X50 10.9 ISO 4014
246	HHCS M8X75 -8.8 ISO 4014
247	SHCS-LOW M12X20 8.8-A3C DIN 79
248	HEX NUT 1-1/4-7UNC SAE-8

ITEM	DESCRIPTION
249	HHCS FULL THREAD, 8 X 25 8.8
250	THIN NUT M12X1.5 5 DIN 80705
251	F WASHER, 12 ST ISO 7089
252	L WASHER, 12 ST DIN 7980
253	F WASHER 1/2” HARD ASTM F-436
254	F WASHER 5/8” HARD ASTM F-436
255	F WASHER, 20 ST ISO 7089
256	THRUST WASHER 1.75X2.6X0.13” B
257	L WASHER, 8 ST DIN 7980
258	F WASHER, 8 ST ISO 7089
259	F WASHER 1-1/4” HARD ASTM F-43
260	HEX NUT M12 8 ISO 4032
261	HEX NUT M16 8 ISO 4032
262	HEX NUT M20 8 ISO 4032
263	HEX JAM NUT, 16-8 ISO 4035
264	JAM NUT, 1 1/4-7 UNC P.L.
265	HSSS-L-FLAT 1/2-13UNCX0.50 ST
266	F WASHER 3/4”” HARD ASTM F-436-
301	TELE 2 WELDMENT
303	WEAR PAD
304	WEAR PAD
305	WEAR PAD ASSY
307	WEAR PAD
308	WEAR PAD
309	WEAR PAD
310	WEAR PAD
311	SHIM
312	SHIM
313	SHIM
314	FILL PLATE
315	FILL PLATE
316	PLATE
317	PLATE
318	BLOCK STOP
319	PLATE
320	BLOCK
321	PLATE
322	SHAFT WELD

ITEM	DESCRIPTION
323	F WASHER 3/4” HARD ASTM F-436-
324	SCR CAP HEX HD M20 X 55 LG
325	BRACKET
326	HEX NUT M6 8 ISO 4032
327	SHEAVE ASSEMBLY
328	ADAPTER
329	ELBOW, PUSH-IN
330	PIPE UNION
331	LUBRICANT HOSE
332	HHCS M12X20 -10.9 ISO 4017
333	SHCS M16X50 10.9 ISO 4762
334	HHCS M20X80 8.8 ISO 4017
335	HHCS M16X40 10.9 ISO 4014
336	HHCS M12X40 8.8 ISO 4017
337	SHCS-LOW M12X20 8.8-A3C DIN 79
338	THIN NUT M12X1.5 5 DIN 80705
339	HHCS M8X16 SS ISO 4017
340	HHCS M8X75 -8.8 ISO 4014
341	HHCS M6X50 SS ISO 4017
342	HHCS M6X60 8.8 ISO 4014
343	HHCS FULL THREAD, 8 X 25 8.8
344	HEX NUT M12 8 ISO 4032
346	L WASHER, 12 ST DIN 7980
347	F WASHER 1/2” HARD ASTM F-436
348	F WASHER 5/8” HARD ASTM F-436
349	THRUST WASHER 1.75X2.6X0.13” B
350	L WASHER, 8 ST DIN 7980
351	L WASHER 6 -HRC44-51 DIN 7980
352	F WASHER, 8 ST ISO 7089
353	F WASHER, 12 ST ISO 7089
354	HEX NUT M16 8 ISO 4032
355	HEX NUT M20 8 ISO 4032
356	HEX JAM NUT, 16-8 ISO 4035
357	HEX NUT, 8 8 ISO 4032
358	ROLLER
359	SHAFT
360	SHIM
361	COTTER PIN 0.13X1.75”” ST

ITEM	DESCRIPTION
400	TELE 3 WELDMENT
401	PLATE
402	HHCS M8X16 SS ISO 4017
403	WELDMENT
404	WELDMENT SHEAVE GUARD
405	WELDMENT SHEAVE GUARD
406	BLOCK STOP
407	PLATE
408	PLATE
409	PLATE
410	BRACKET
411	ADAPTER
412	SHEAVE ASSEMBLY
413	ASSY SHEAVE
414	ASSY SHEAVE
415	SHAFT
417	SHIM
418	SHIM
419	FILL PLATE
420	SHIM
421	WEAR PAD
422	WEAR PAD
423	WEAR PAD
424	WEAR PAD
425	WEAR PAD ASSY
427	WEAR PAD
428	WEAR PAD
429	SLIDER
430	PLUG
431	SHCS M16X50 10.9 ISO 4762
432	SFHCS M16X45 -10.9 ISO 10642
433	HHCS M16X40 10.9 ISO 4014
434	HHCS M12X65 -10.9 ISO 4017
435	HHCS M20X80 8.8 ISO 4017
436	HHCS M12X80 8.8 ISO 4014
437	HHCS M12X40 8.8 ISO 4017
438	HHCS FULL THREAD, 12 X 25 8.8
439	HHCS M12X20 -10.9 ISO 4017

ITEM	DESCRIPTION
440	HHCS FULL THREAD, 8 X 25 8.8
441	HHCS M6X60 8.8 ISO 4014
442	ELBOW, PUSH-IN
443	SHCS-LOW M12X20 8.8-A3C DIN 79
444	L WASHER, 12 ST DIN 7980
445	F WASHER, 12 ST ISO 7089
446	L WASHER, 8 ST DIN 7980
447	F WASHER, 8 ST ISO 7089
448	THIN NUT M12X1.5 5 DIN 80705
449	F WASHER 5/8” HARD ASTM F-436
450	F WASHER 1/2” HARD ASTM F-436
451	F WASHER 1-1/2”” HARD ASTM F-43
452	HEX NUT M20 8 ISO 4032
453	HEX JAM NUT, 16-8 ISO 4035
454	HEX NUT M16 8 ISO 4032
455	HEX NUT M12 8 ISO 4032
456	HEX NUT, 8 8 ISO 4032
457	LUBRICANT HOSE
458	PIPE UNION
500	TELE 4 WELDMENT
501	SHIM
502	FILL PLATE
503	WEAR PAD
504	WEAR PAD
505	WEAR PAD
506	WEAR PAD
507	HHCS M20X80 8.8 ISO 4017
508	SHCS-LOW M12X20 8.8-A3C DIN 79
509	HHCS M8X30 8.8 ISO 4017
510	L WASHER, 8 ST DIN 7980
511	F WASHER 3/4” HARD ASTM F-436-
512	HEX NUT M20 8 ISO 4032
514	HEX NUT, 8 8 ISO 4032
515	PIPE UNION
516	THIN NUT M12X1.5 5 DIN 80705
517	LUBRICANT HOSE
518	ADAPTER
519	ELBOW, PUSH-IN

ITEM	DESCRIPTION
600	CYL HYD
601	WELDMENT SHEAVE MOUNT
602	SHEAVE ASSEMBLY
603	SHAFT
604	PLATE
605	RETAINER
606	BAR
607	SPACER
608	WEAR PAD
609	WEAR PAD
610	WEAR PAD
611	SHCS M12X50 -12.9 ISO 4762
612	HHCS M20X50 10.9 ISO 4014
613	HHCS M12X30 10.9 ISO 4017
614	HHCS FULL THREAD, 12 X 25 8.8
615	HHCS M12X12 SS ISO 4017
616	SBCS M10X25 SS ISO 7380
617	HHCS M6X40 -8.8 ISO 4017
618	F WASHER, 12 ST ISO 7089
619	L WASHER 6 -HRC44-51 DIN 7980
620	F WASHER 6 -ST ISO 7089
621	F WASHER 3/8”” HARD ANSI B27.2
622	F WASHER 3/4”” HARD ASTM F-436-
623	F WASHER 1/2”” HARD ASTM F-436
624	HEX NUT M6 8 ISO 4032

Disassembling the 5-Section Boom

NOTE: 5-section boom weighs approximately 7300 kg (16,100 lb).

NOTE: Boom assembly must be rotated 180° (upside down) before performing any assembly or disassembly procedures.

CAUTION

A rollover fixture with webbing is recommended to rotate the boom sections. Chains are not recommended. If a rollover fixture is not available, rotate the sections using adequate support with webbing.

A secure fixture that will prevent damage to the boom is recommended to stabilize and hold the boom from moving during removal of the boom section(s).

When adjusting the extend and retract cables, hold the cable end and turn the nut. Do not turn the cable. Turning the cable while adjusting will result in damage or failure of the cable.

Refer to these procedures and Figure 4-130 when disassembling the boom.

1. Remove boom from crane. Refer to procedures outlined under *Removing the Boom*, page 4-18.
2. Position boom assembly upside down on adequate supports.
3. Put a chain or strap around the front tips of teles 4, 3, 2, and 1 to prevent them from separating during disassembly.
4. Cut a section of angle-iron measuring 240 mm (9-1/2 in) in length. Cover edges of angle-iron with edge guard. Using zip-ties, attach angle-iron to telescope cylinder chrome tube.

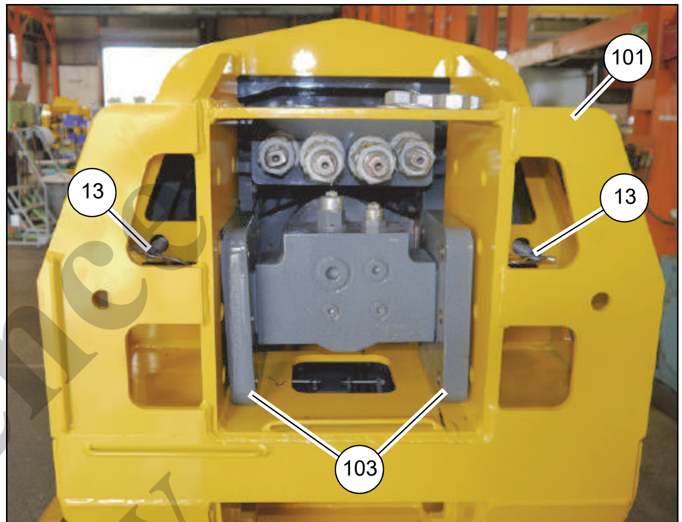
   Because of hydraulic oil pressure that may be held in the telescope cylinder by the check valves, the telescope cylinder can suddenly retract with much force when the trunnion bolts are removed. If the telescope cylinder were to retract, damage to the check valves in the top of the telescope cylinder will occur. The section of angle-iron will stop the telescope cylinder from retracting.

CAUTION

Component damage hazard!

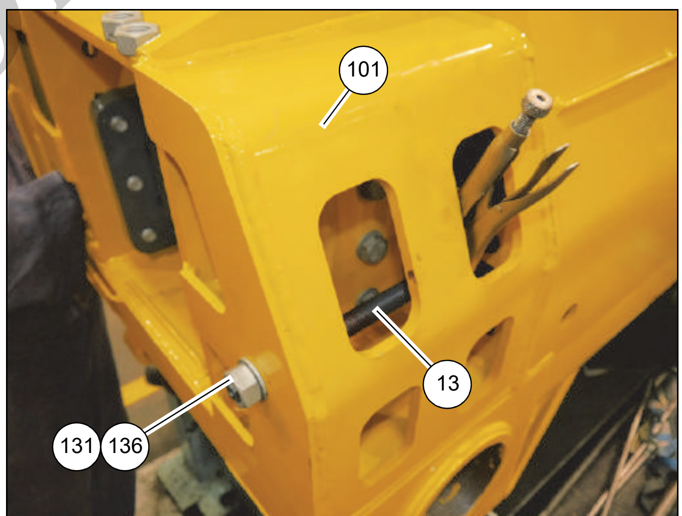
Make sure telescope cylinder is blocked in a manner that prevents it from suddenly retracting when the trunnion bolts are removed. Damage to the telescope cylinder can occur.

5. Remove bolts (123) and washers (136) attaching trunnion plates (103) to base (101) (see Figure 4-131).



9688-118 **FIGURE 4-131**

6. Remove two nuts (131) and washer (136) from end of each extend cable (13) at rear of base (101) (see Figure 4-132).

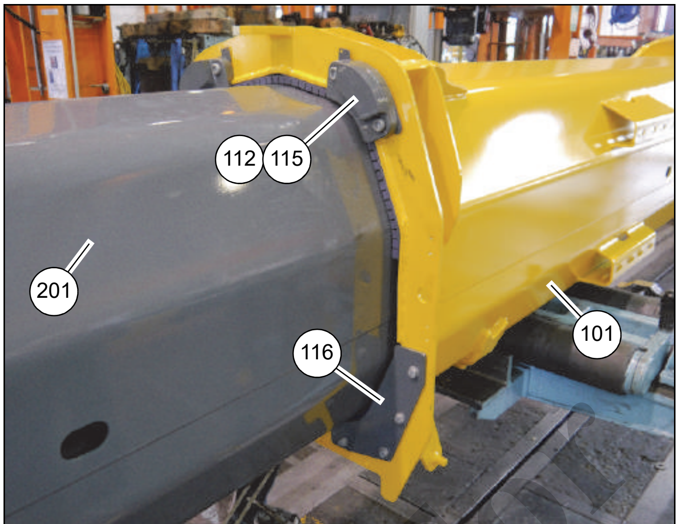


9688-119 **FIGURE 4-132**

7. Pull tele 1 (201) out of base (101) several feet.

4

8. Remove bolts (126), washers (132), lock washers (133), and nuts (141) attaching left and right stop plates (116) to base (101). Remove bolts (125), washers (135), and nuts (142) attaching left and right stop blocks (115) and shims (112) to base (101) (see Figure 4-133)



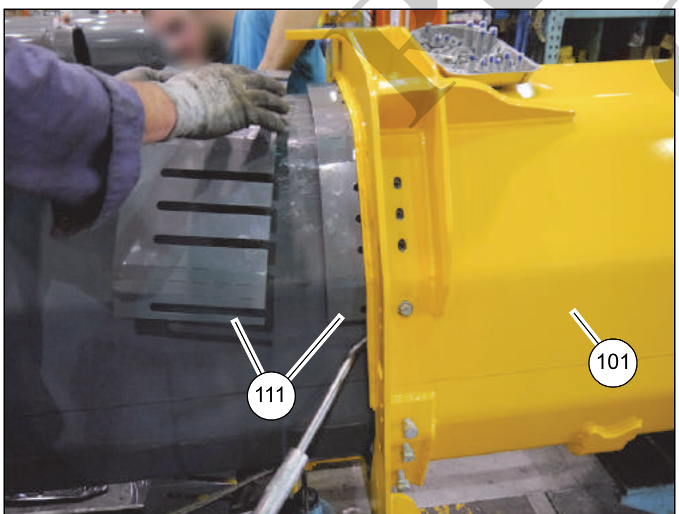
9688-117

FIGURE 4-133

9. Remove bolts (122) and washers (134) attaching wear pads (106, 107, 108), shims (111), and bars (113, 114) in place.

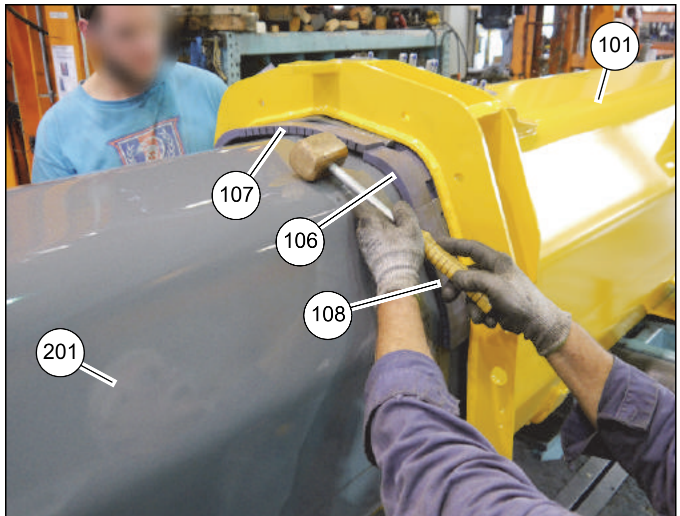
10. Remove bolts (127) and nuts (143) used to adjust the left and right wear pads (109, 110).

11. Remove shims (111), wear pads (106, 107, 108), and bars (113, 114) from between base (101) and tele 1 (201) (see Figure 4-134 and Figure 4-135).



9688-116

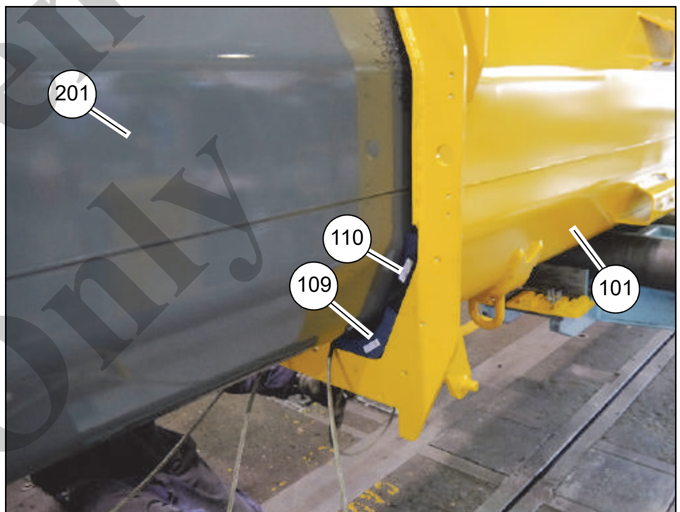
FIGURE 4-134



9688-114

FIGURE 4-135

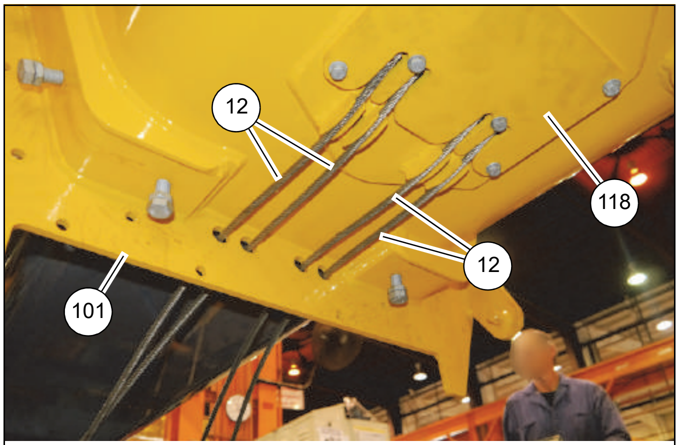
12. Slightly raise tele 1 (201), then remove left and right side wear pads (109, 110) from between base (101) and tele 1 (201) (see Figure 4-136).



9688-62

FIGURE 4-136

13. Remove two nuts (131) and one washer (136) from each of the four retract cables (12) at front of base (101) (see Figure 4-137).



9688-113 **FIGURE 4-137**

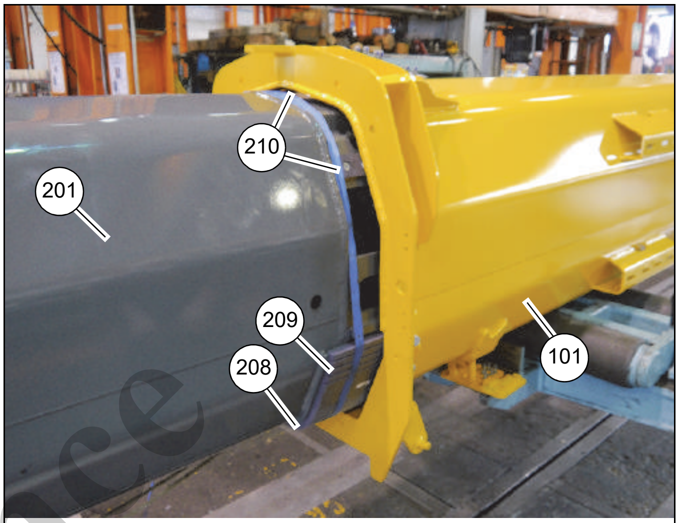
14. Remove four bolts (146) and washers (138) attaching cable mount weldment (118) to bottom of base (101) (see Figure 4-137).

15. Remove two bolts (146) and washers (138) attaching cable retainer plate (119) to cable mount weldment (118) (see Figure 4-137 and Figure 4-138).

9688-112 **FIGURE 4-138**

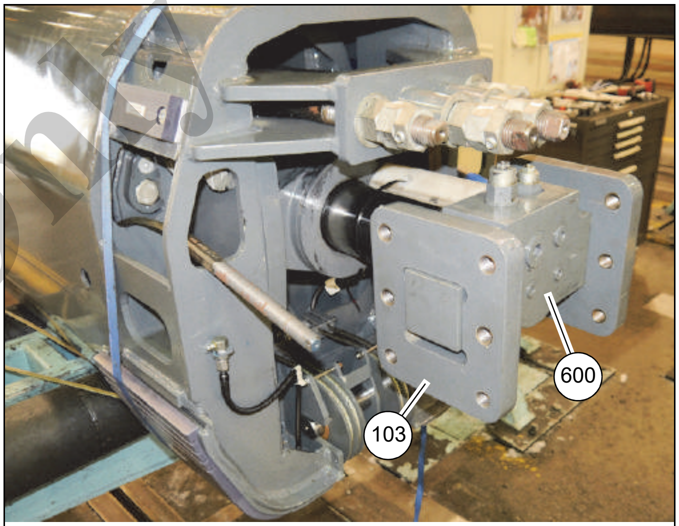
16. Pull ends of four retract cables (12) back through holes in tip of base (101) (see Figure 4-138). Route four retract cables (12) back up through base (101) and out between tele 1 (201) and base (101).

17. Pull tele 1 (201) out of base (101) (see Figure 4-139).



9688-110 **FIGURE 4-139**

18. Remove trunnion blocks (103) from rear of telescope cylinder (600) (see Figure 4-140).

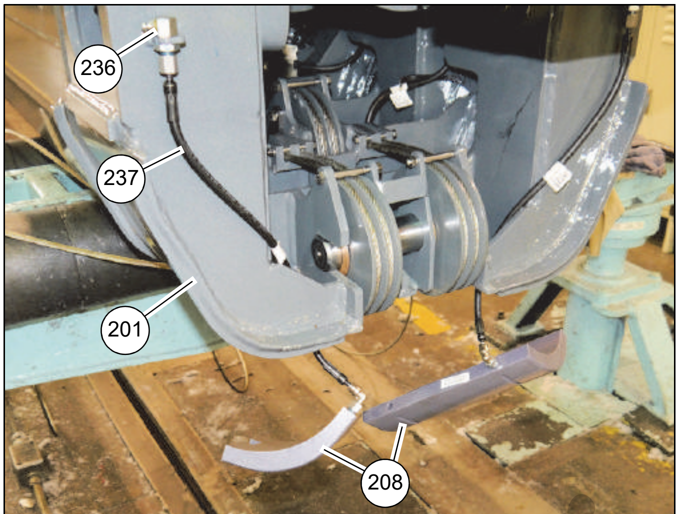


9688-108 **FIGURE 4-140**

19. Rotate end of telescope cylinder 180° so that the two holding valve cartridges point down.

4

20. Remove wear pads (208, 209) and shims (213) from bottom rear of tele 1 (201) (see Figure 4-141).

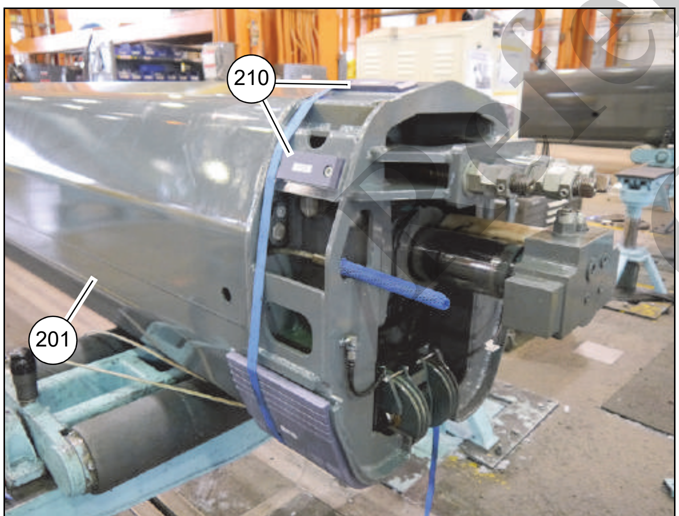


9688-105

FIGURE 4-141

21. Remove grease hoses (237) and grease fittings (236) from left and right sides of rear of tele 1 (201) (see Figure 4-141).

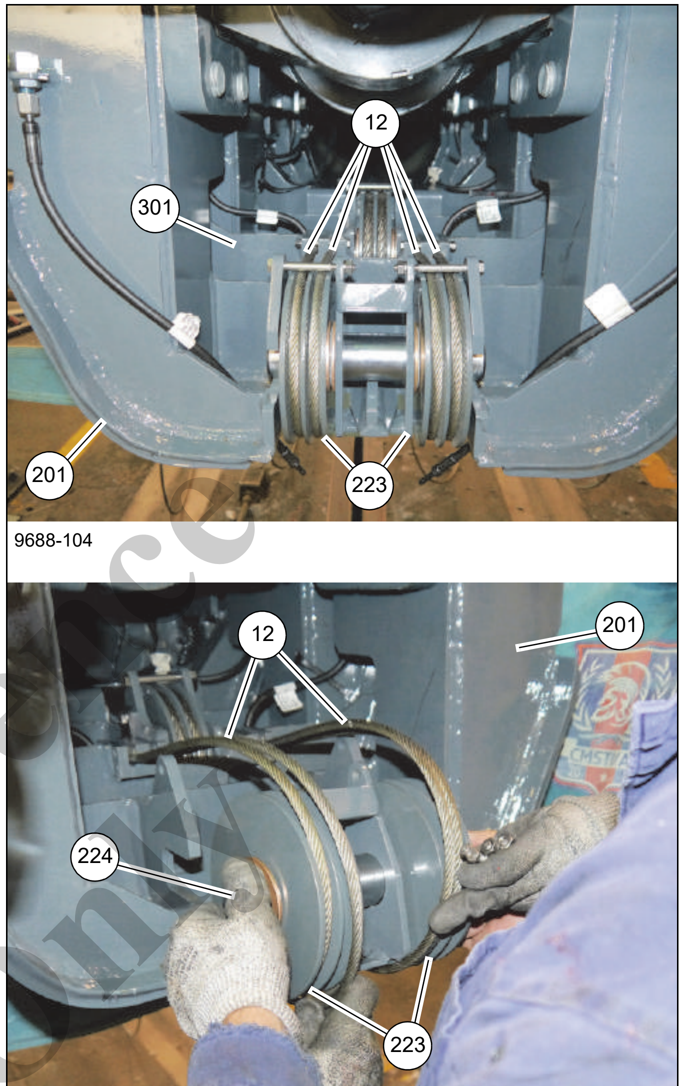
22. Remove two bolts (247) attaching each of the four wear pads (210) and shims (214, 215) to rear of tele 1 (201) (see Figure 4-142).



9688-107

FIGURE 4-142

23. Remove bolts (246), lock washers (257), and nuts (232) retaining retract cables (12) on sheaves (223). Remove two bolts (342), lock washers (351), and nuts (326) securing the ends of the four retract cables (12) in the cable keepers at rear of tele 2 (301) (see Figure 4-143).



9688-103

FIGURE 4-143

24. Remove the ends of three of the four retract cables (12) from the cables keepers in the rear of tele 2 (301). Note: the fourth cable end at the left center position cannot be removed due to interference with shaft (322).

25. Remove shaft/sheave assembly (224/223) from rear of tele 1 (201) (see Figure 4-143).

26. Coil the one remaining retract cable (12) and place it inside the tele sections.

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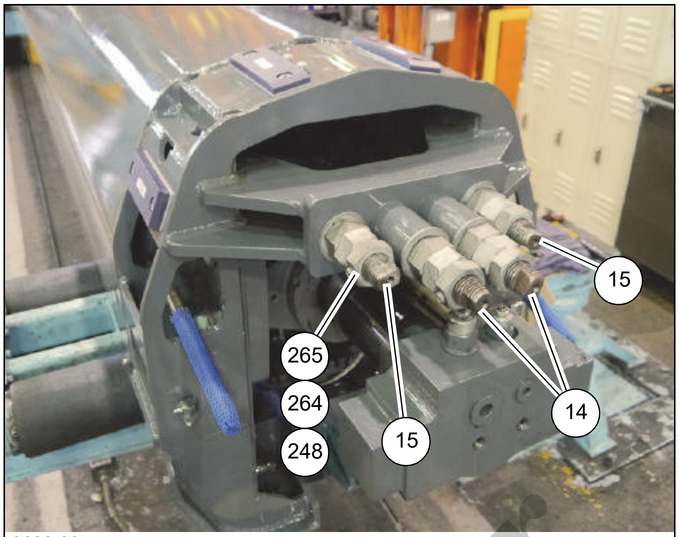
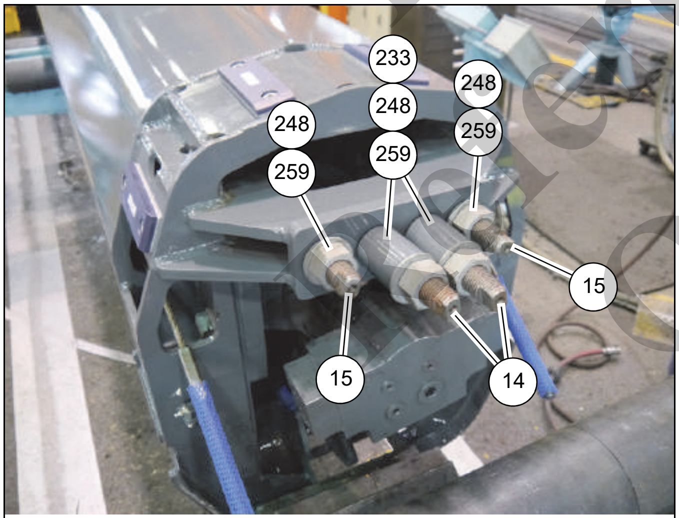
27. Remove nuts (264) with set screws (265) from ends of the four extend cables (14,15) (see Figure 4-144).



9688-99

FIGURE 4-144

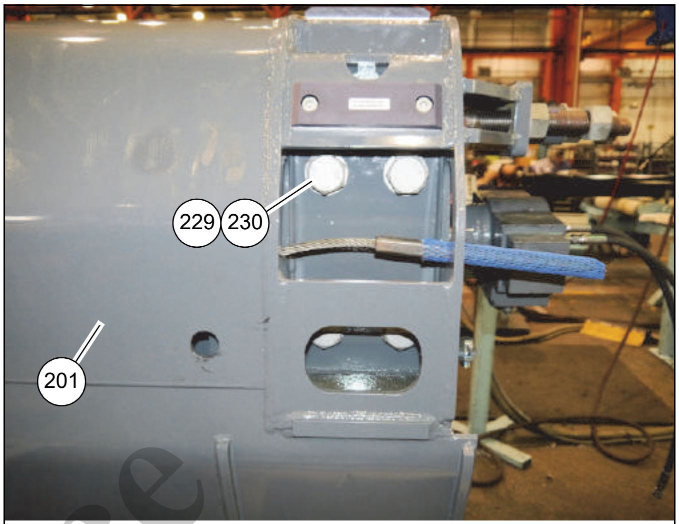
28. Remove the two nuts (248) and washer (259) from each of the outside extend cables (15) Remove the two nuts (248), washer (259), and spacer (233) from each of the inside extend cables (14) (see Figure 4-145).



9688-97

FIGURE 4-145

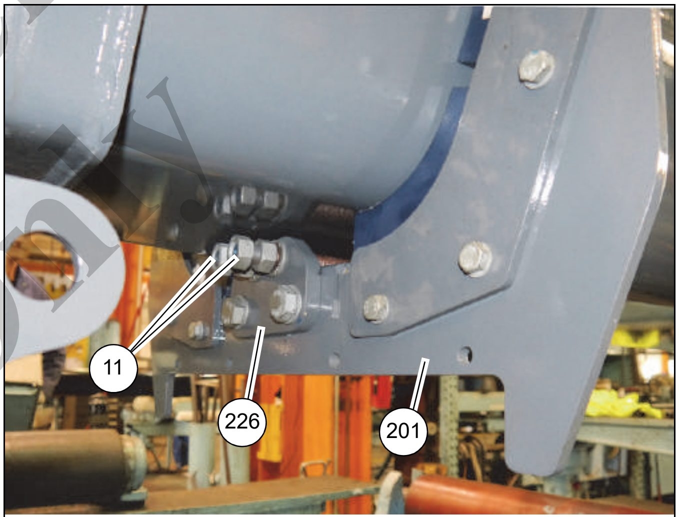
29. Remove bolts (230) and washers (229) attaching trunnion plates (227) to the left and right sides of tele 1 (201 (see Figure 4-146).



9688-98

FIGURE 4-146

30. Remove nuts (262) and washers (266) from ends of the two retract cables (11) (see Figure 4-147).



9688-95

FIGURE 4-147

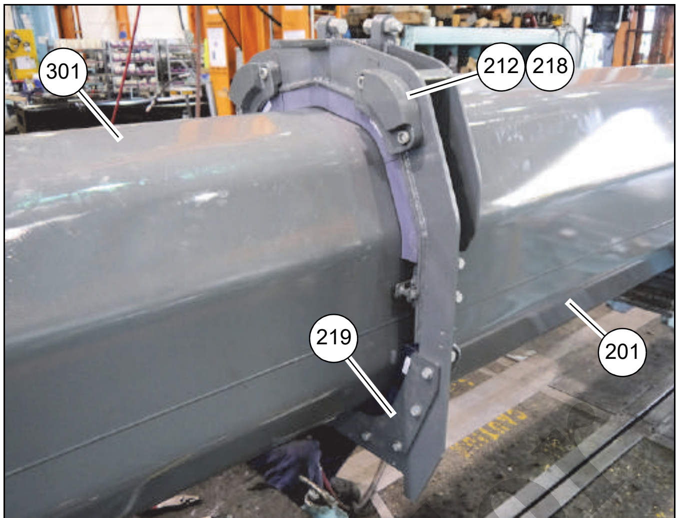
31. Remove two bolts (245), washers (255), and nuts (262) attaching the plate (226) to front of tele 1 (201) (see Figure 4-147).

32. Put a chain or strap around the front tips of teles 4, 3, and 2 to prevent them from separating during disassembly.

33. Pull tele 2 (301) out of tele 1 (201) several feet.

4

34. Remove bolts (242), washers (251), lock washers (252), and nuts (260) attaching left and right stop plates (219) to tele 1 (201). Remove bolts (240), washers (254), and nuts (261) attaching left and right stop blocks (218) and shims (212) to tele 1 (201) (see Figure 4-148).

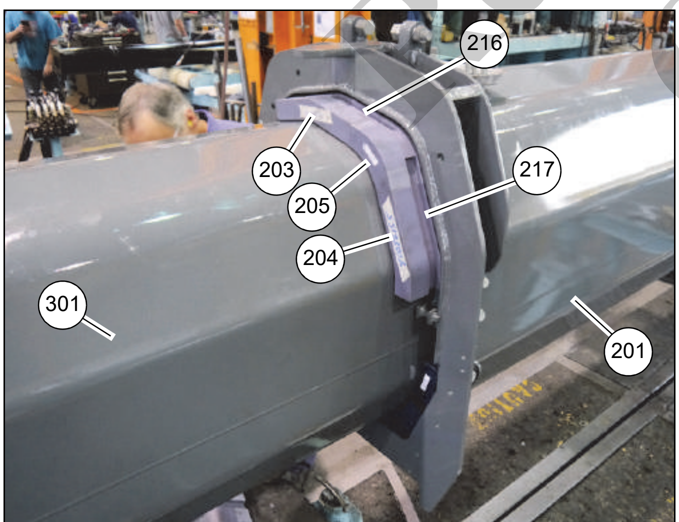


9688-93 **FIGURE 4-148**

35. Remove bolts (239) and washers (253) attaching wear pads (203, 204, 205), shims (211), and bars (216, 217) in place.

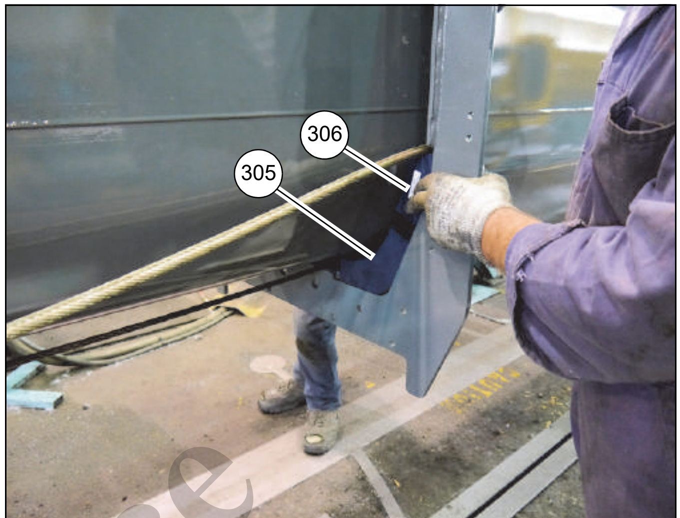
36. Remove bolts (243) and nuts (263) used to adjust the left and right wear pads (206).

37. Remove shims (211), wear pads (203, 204, 205), and bars (216, 217) from between tele 1 (201) and tele 2 (301) (see Figure 4-149).



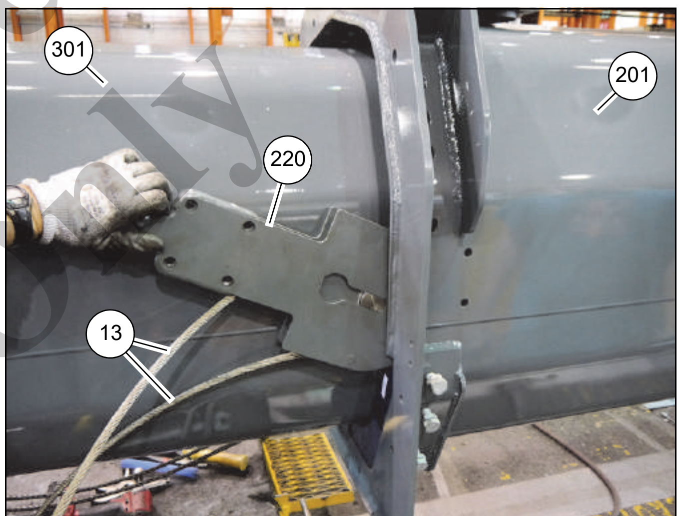
9688-90 **FIGURE 4-149**

38. Slightly raise tele 2 (301), then remove left and right side wear pads (206) from between tele 1 (201) and tele 2 (301) (see Figure 4-150).



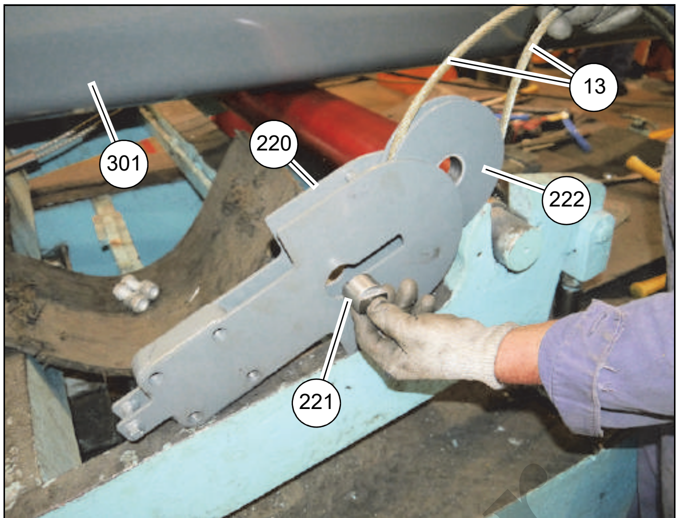
9688-87 **FIGURE 4-150**

39. Remove bolts (244) and washers (253) attaching sheave mount weldments (220) to inside of tele 1 (201) (see Figure 4-151).



9688-88 **FIGURE 4-151**

40. Remove shaft/sheave (221/222) assemblies from sheave mount weldments (220). Remove extend cables (13) from sheaves (222) (see Figure 4-152).

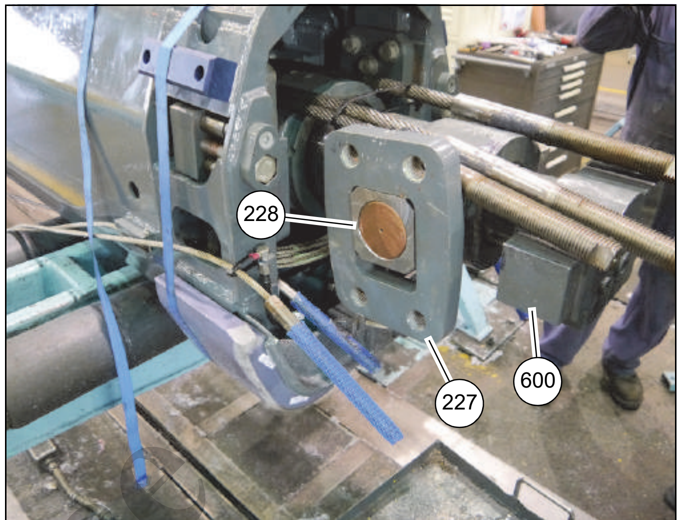


9688-78 FIGURE 4-152

41. Pull tele 2 (301) out of tele 1 (201) (see Figure 4-153).

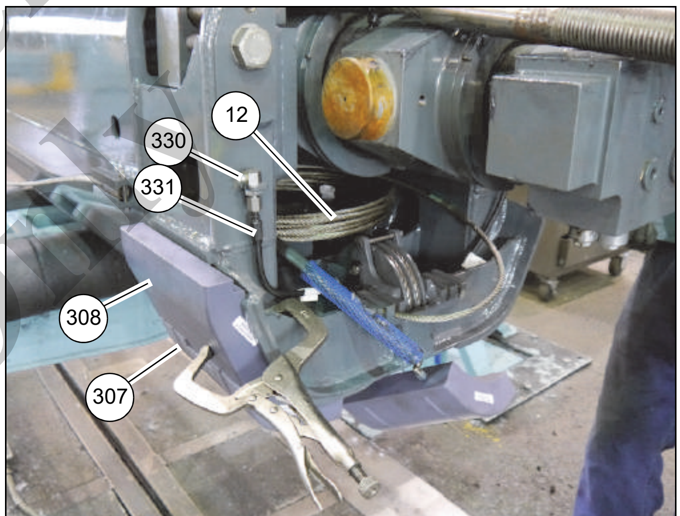
9688-85 FIGURE 4-153

42. Remove trunnion plate (227) from left and right side blocks (228). Remove block (228) from left and right sides of telescope cylinder (600) (see Figure 4-154).



9688-84 FIGURE 4-154

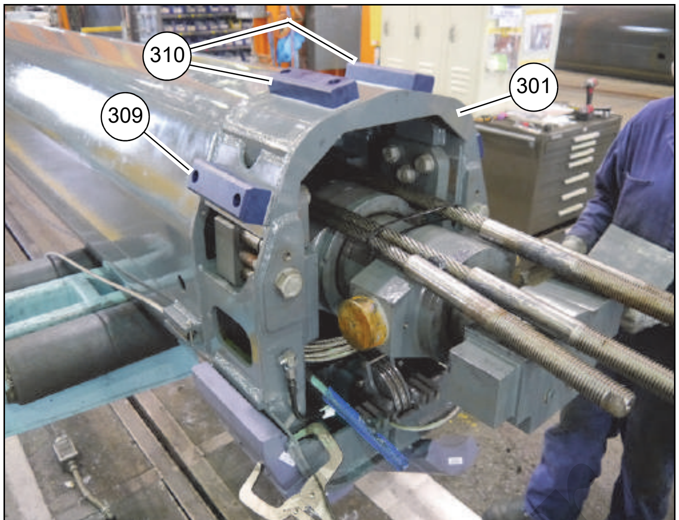
43. Remove wear pads (307, 308) and shims (313) from bottom rear of tele 2 (301) (see Figure 4-155).



9688-80 FIGURE 4-155

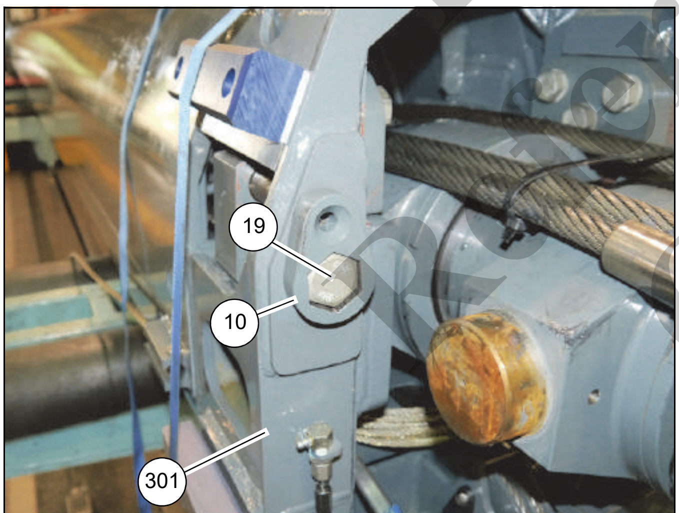
44. Remove grease hoses (331) and grease fittings (330) from left and right sides of rear of tele 2 (301) (see Figure 4-155).

45. Remove two bolts (337) attaching each of the four wear pads (309, 310) and shims (314, 315) to rear of tele 2 (301) (see Figure 4-156).



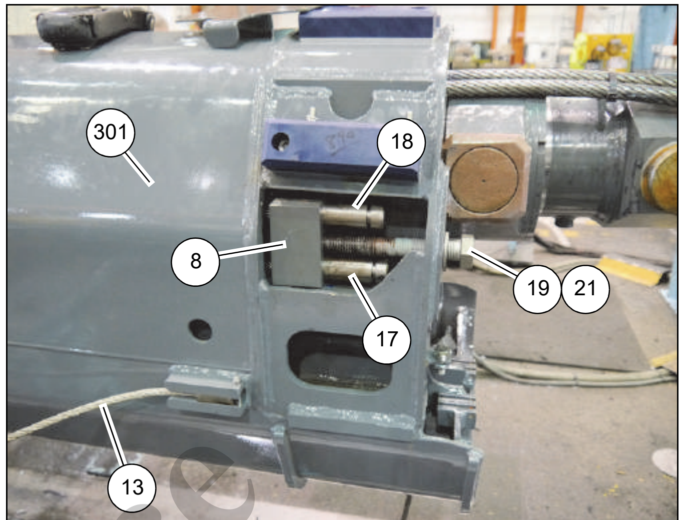
9688-81 **FIGURE 4-156**

46. Remove bolts (20) attaching bolt retainers (10) to rear of tele 2 (301). Remove bolt retainers (10) (see Figure 4-157).



9688-83 **FIGURE 4-157**

47. Remove bolts (19) and washers (21) from cable anchors (8) on left and right sides of tele 2 (301) (see Figure 4-158).

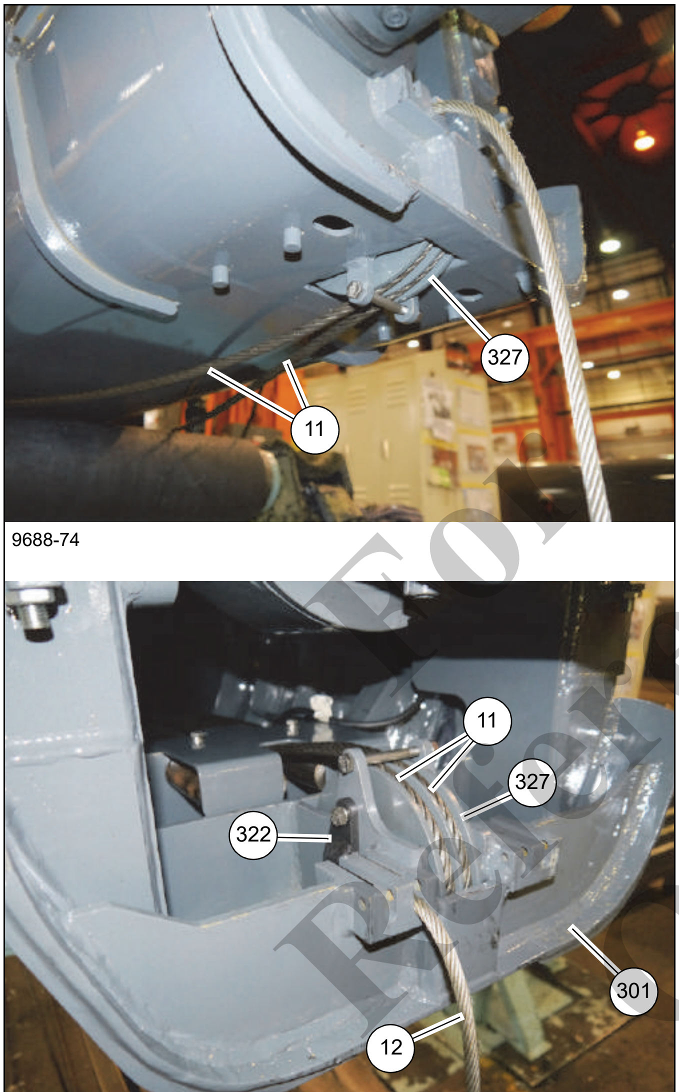


9688-67 **FIGURE 4-158**

48. Remove cable anchors (8) from the ends of cables (17, 18) (see Figure 4-158).

49. Remove bolts (341), lock washers (351), and nuts (326) securing cable ends of the two extend cables (13) to the left and right sides of tele 2 (301) (see Figure 4-158).

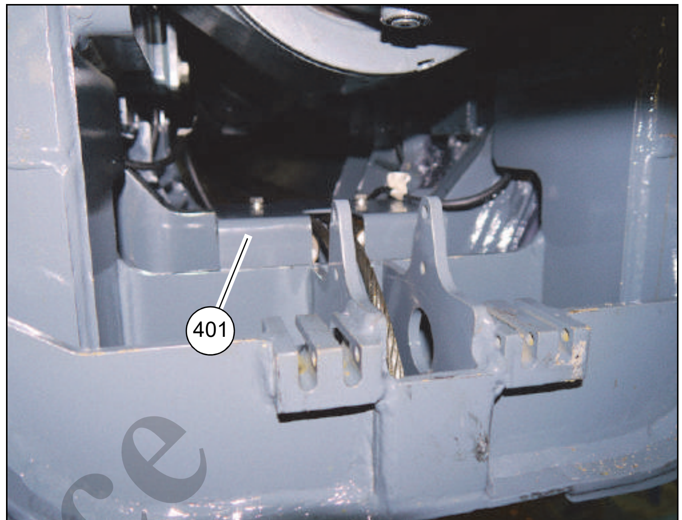
50. Remove bolts (340), lock washers (350), and nuts (357) at top and bottom of sheave assembly (327) which retain the two retract cables (11) on sheave assembly (327) (see Figure 4-159).



9688-73 **FIGURE 4-159**

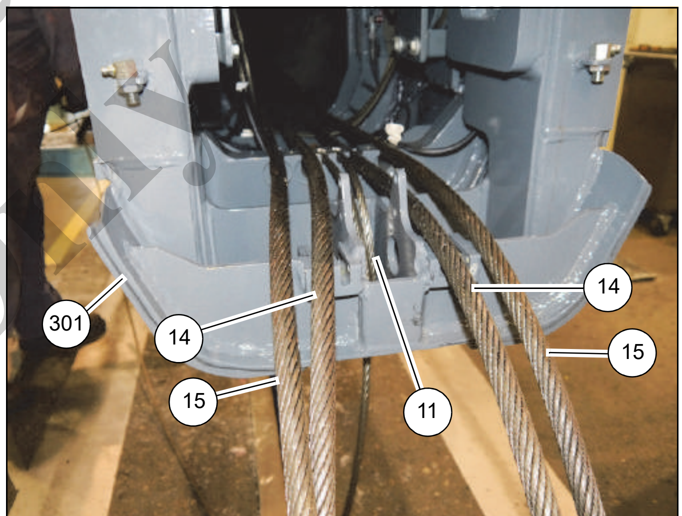
51. Remove bolts (339) attaching shaft weldment (322) to tele 2 (301). Remove shaft weldment (322), thrust washers (349), and sheave assembly (327) from rear of tele 2 (301) (see Figure 4-159).

52. Remove bolts (402), lock washers (446), and flat washers (447) attaching cover plate (401) over the four extend cables (14, 15) and the two retract cables (11) (see Figure 4-160).



9688-72 **FIGURE 4-160**

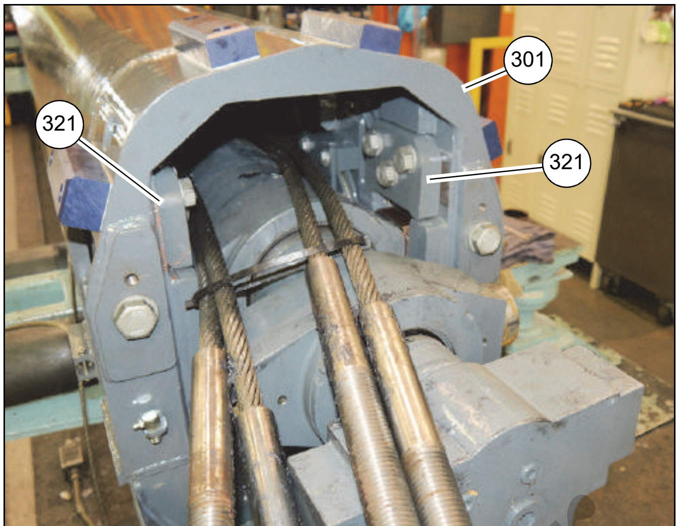
53. Remove anchor ends of two retract cables (11) from rear of tele 3 (400) (see Figure 4-161).



9688-70 **FIGURE 4-161**

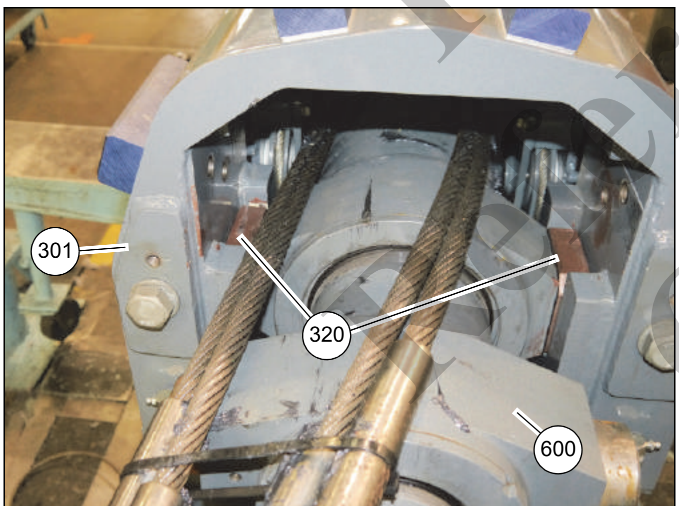
4

54. Remove bolts (323) and washers (323) attaching plates (321) to inside of tele 2 (301) (see Figure 4-162).



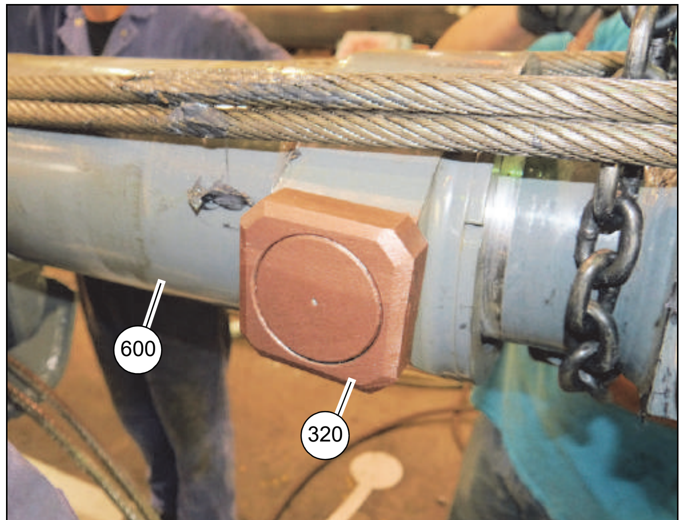
9688-76 **FIGURE 4-162**

55. Lift rear of telescope cylinder (600) so that trunnion blocks (320) are lifted out of slots in rear of tele 2 (301) (see Figure 4-163).



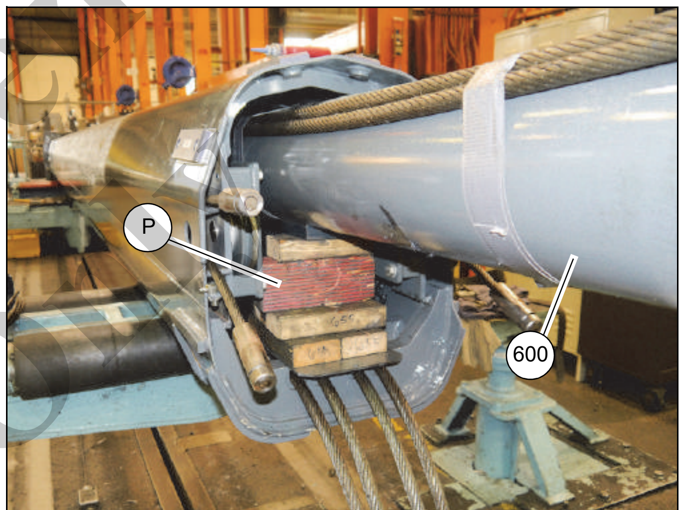
9688-71 **FIGURE 4-163**

56. Pull telescope cylinder (600) out of rear of tele 2 (301). Remove trunnion blocks (320) from left and right sides of telescope cylinder (600) (see Figure 4-164).



9688-69 **FIGURE 4-164**

57. Place blocks of wood or similar (P) measuring approximately 8-1/2 inches in height under telescope cylinder (600) (see Figure 4-165).

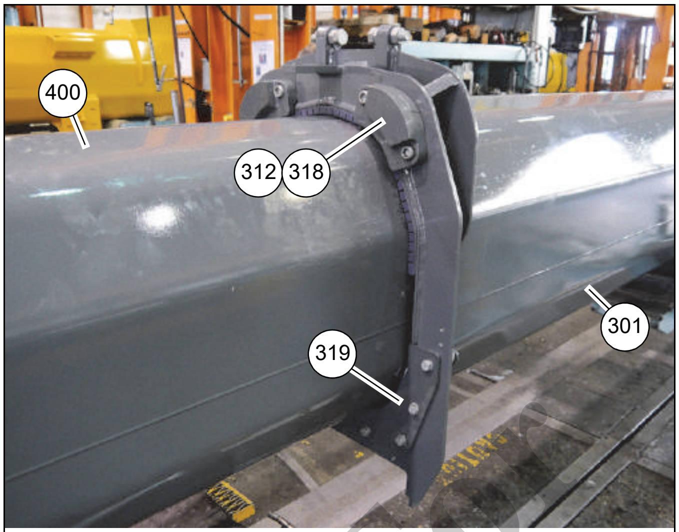


9688-54 **FIGURE 4-165**

58. Put a chain or strap around the front tips of teles 4 and 3 to prevent them from separating during disassembly.

59. Pull tele 3 (400) out of tele 2 (301) several feet.

60. Remove bolts (336), washers (353), lock washers (346), and nuts (344) attaching left and right stop plates (319) to tele 2 (301). Remove bolts (333), washers (348), and nuts (354) attaching left and right stop blocks (318) and shims (312) to tele 2 (301) (see Figure 4-166).



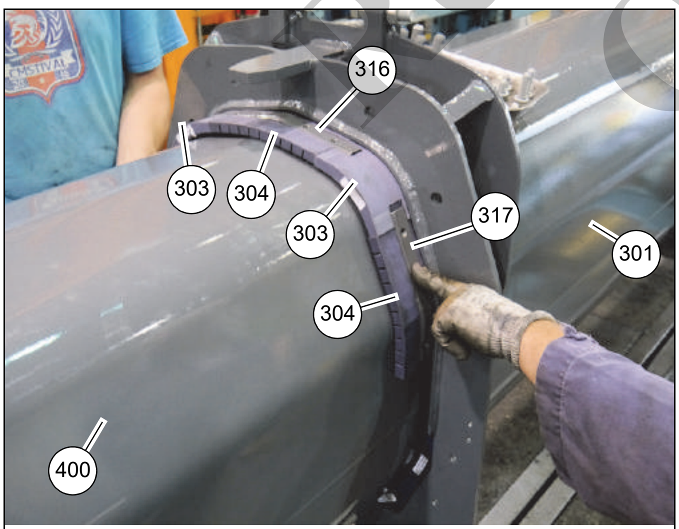
9688-63

FIGURE 4-166

61. Remove bolts (332) and washers (347) attaching wear pads (303, 304), shims (311), and bars (316, 317) in place.

62. Remove bolts (335) and nuts (356) used to adjust the left and right wear pads (305, 306).

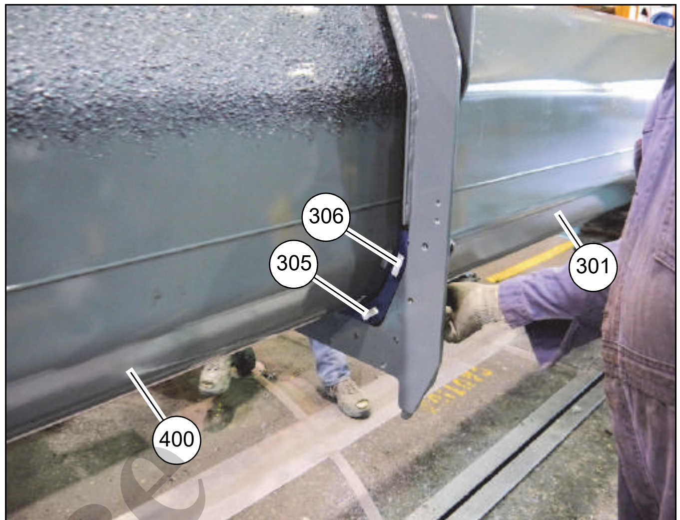
63. Remove shims (311), wear pads (303, 304), and bars (316, 317) from between tele 2 (301) and tele 3 (400) (see Figure 4-167).



9688-60

FIGURE 4-167

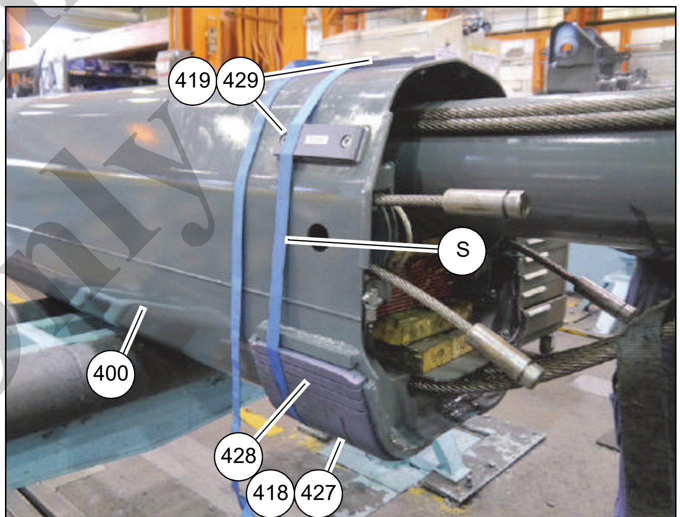
64. Slightly raise tele 3 (400), then remove left and right side wear pads (305, 306) from between tele 2 (301) and tele 3 (400) (see Figure 4-168).



9688-62

FIGURE 4-168

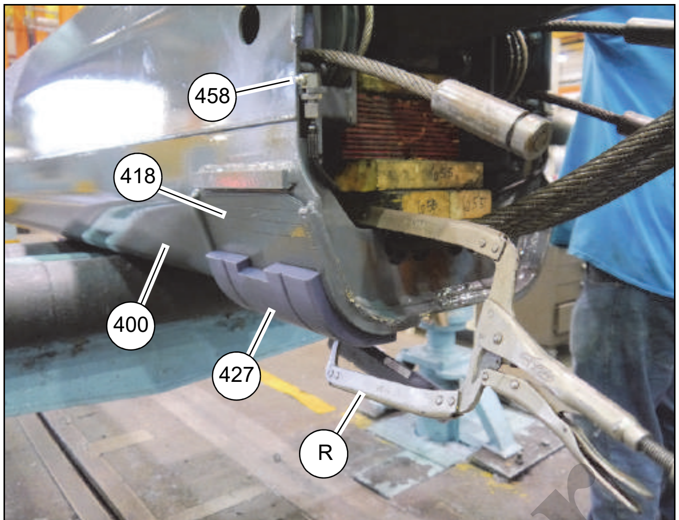
65. Pull tele 3 (400) out of tele 2 (301) (see Figure 4-169).



9688-57

FIGURE 4-169

66. Remove wear pads (427, 428) and shims (418) from bottom rear of tele 3 (400) (see Figure 4-169 and Figure 4-170)

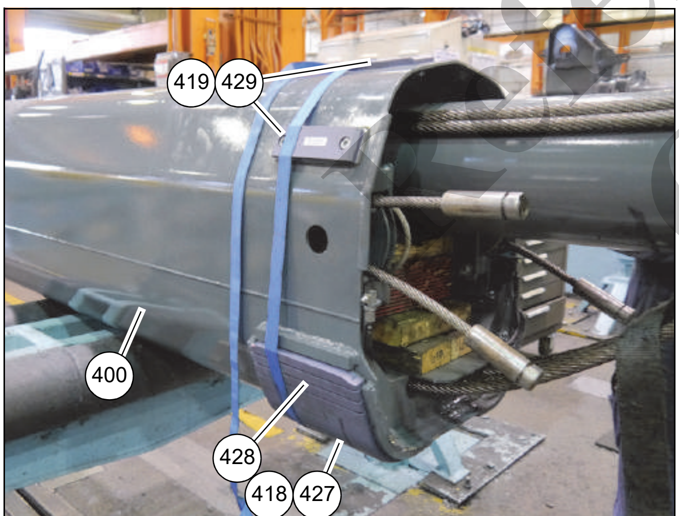


9688-56

FIGURE 4-170

67. Remove grease hoses (457) and grease fittings (458) from left and right sides of rear of tele 3 (400) (see Figure 4-170).

68. Remove two bolts (443) attaching each of the four wear pads (429) and shims (419) to rear of tele 3 (400) (see Figure 4-171).

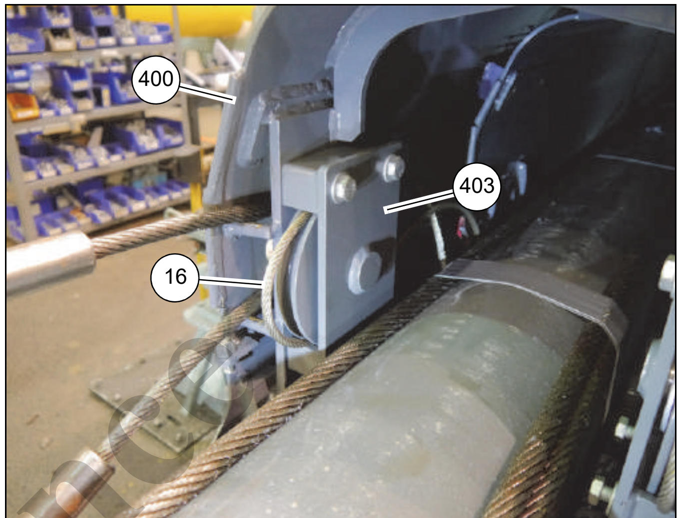


9688-57

FIGURE 4-171

69. Lift telescope cylinder (600) and then remove blocks of wood supporting the cylinder.

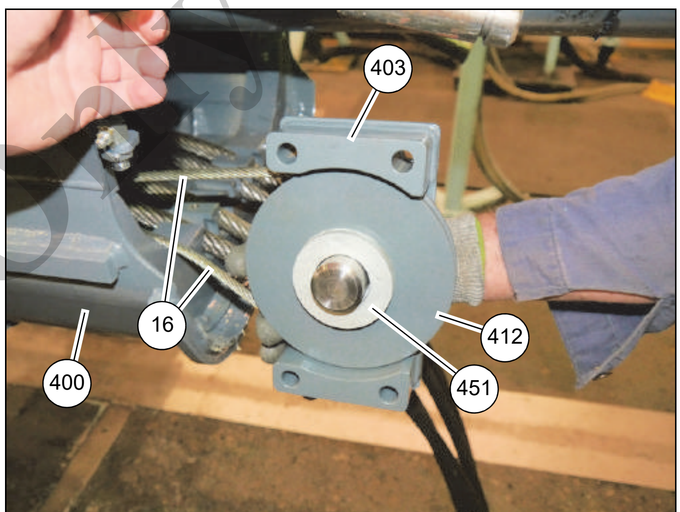
70. Remove four bolts (434) and washers (450) attaching left and right sheave weldments (403) to inside of tele 3 (400) (see Figure 4-172). Note: Raise and lower telescope cylinder as needed to access bolts.



9688-53

FIGURE 4-172

71. Remove hardened washers (451) and sheave (412) from sheave weldment (403) (see Figure 4-173).

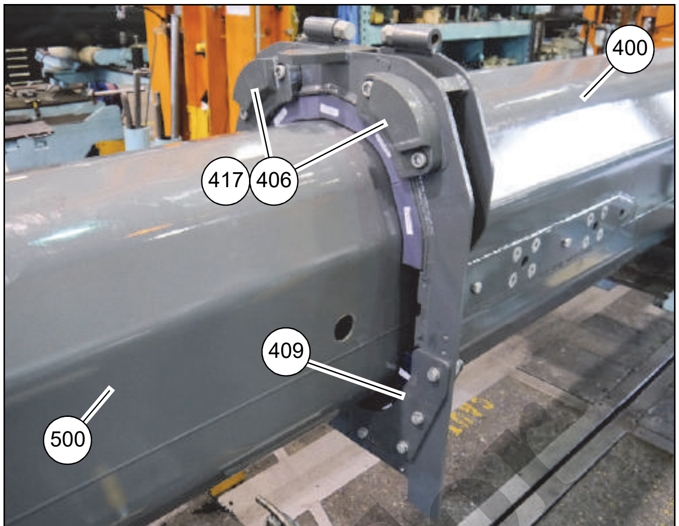


9688-52

FIGURE 4-173

72. Pull tele 4 (500) out of tele 3 (401) several feet.

73. Remove bolts (437), washers (445), lock washers (444), and nuts (455) attaching left and right stop plates (409) to tele 3 (400). Remove bolts (431), washers (449), and nuts (454) attaching left and right stop blocks (406) and shims (417) to tele 3 (400) (see Figure 4-174).



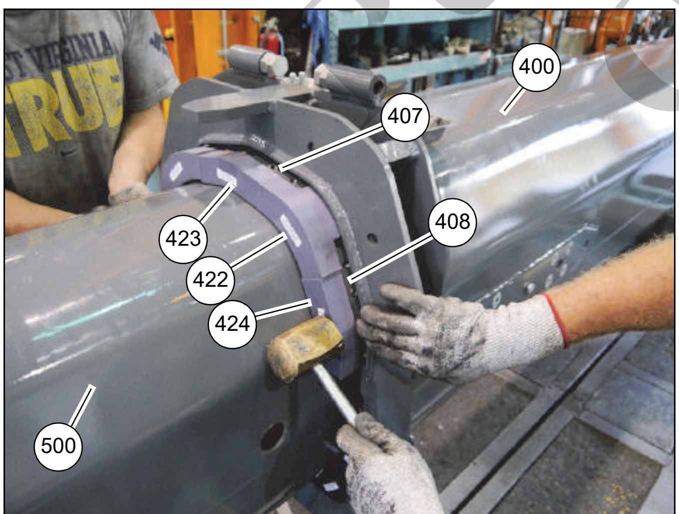
9688-50

FIGURE 4-174

74. Remove bolts (439) and washers (450) attaching wear pads (422, 423, 424), shims (420), and bars (407, 408) in place.

75. Remove bolts (443) and nuts (453) used to adjust the left and right wear pads (425, 426).

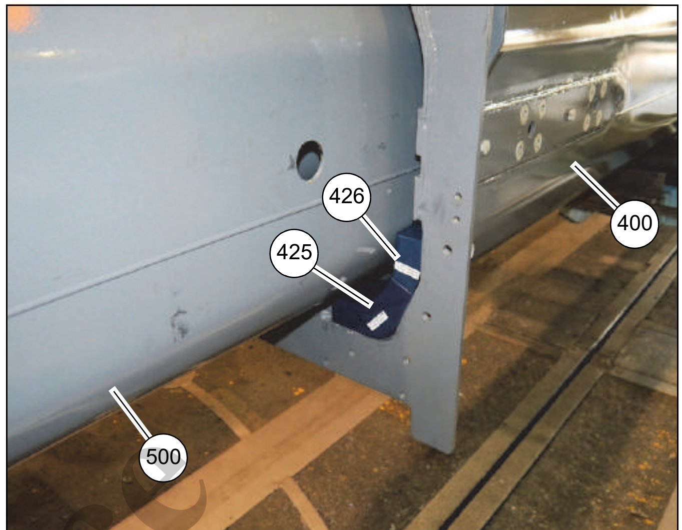
76. Remove shims (420), wear pads (422, 423, 424), and bars (407, 408) from between tele 3 (400) and tele 4 (500) (see Figure 4-175).



9688-47

FIGURE 4-175

77. Slightly raise tele 4 (500), then remove left and right side wear pads (425, 426) from between tele 3 (400) and tele 4 (500) (see Figure 4-176).



9688-46

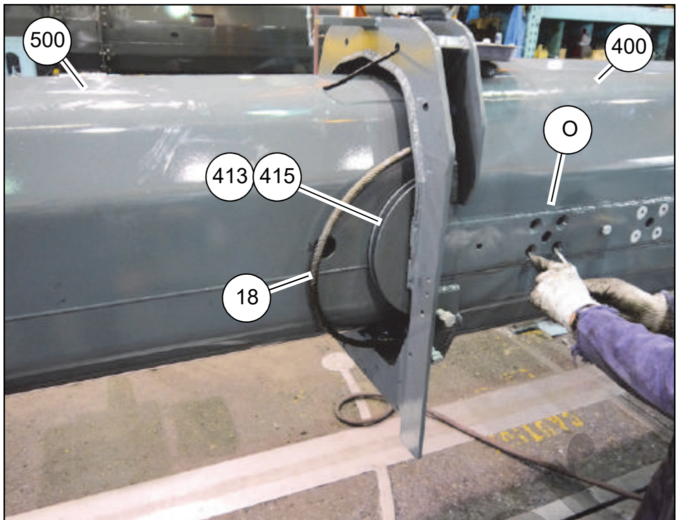
FIGURE 4-176

78. Remove bolt (438) attaching sheave guard weldment (404) between tele 4 (500) and tele 3 (400). Remove sheave guard weldment (404) (see Figure 4-177).

9688-43

FIGURE 4-177

79. Remove four bolts (432) attaching shaft/sheave (413, 415) assembly to tele 3 (400). Pull shaft/sheave (413, 415) assembly out from between tele 3 (400) and tele 4 (500) (see Figure 4-178).

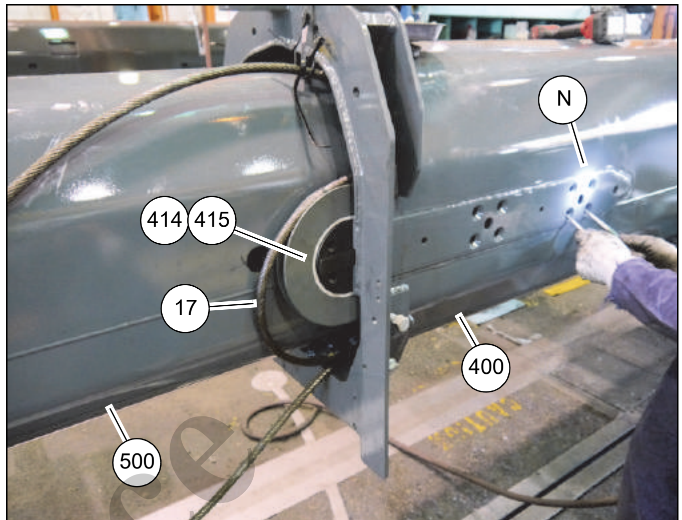


9688-44 **FIGURE 4-178**

80. Remove bolt (438) attaching sheave guard weldment (405) between tele 4 (500) and tele 3 (400). Remove sheave guard weldment (40) (see Figure 4-179).

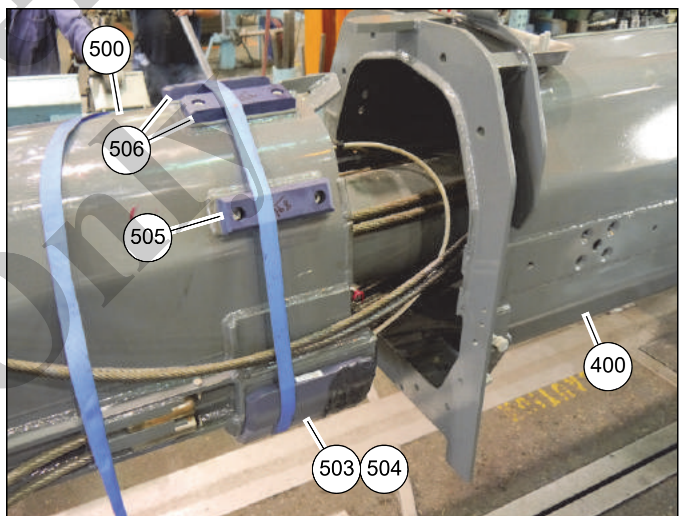
9688-43 **FIGURE 4-179**

81. Remove four bolts (432) attaching shaft/sheave (414, 415) assembly to tele 3 (400). Pull shaft/sheave (414, 415) assembly out from between tele 3 (400) and tele 4 (500) (see Figure 4-180).



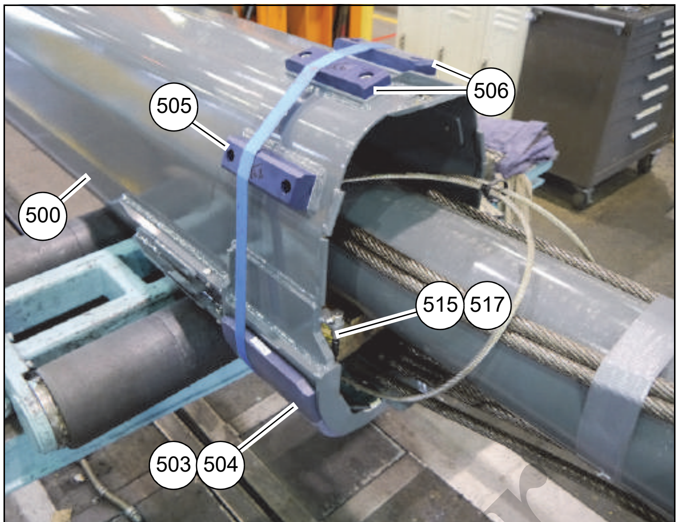
9688-42 **FIGURE 4-180**

82. Pull tele 4 (500) out of tele 3 (400) (see Figure 4-181).



9688-38 **FIGURE 4-181**

83. Remove wear pads (503, 504) and shims (501) from bottom rear of tele 4 (500) (see Figure 4-181 and Figure 4-182).



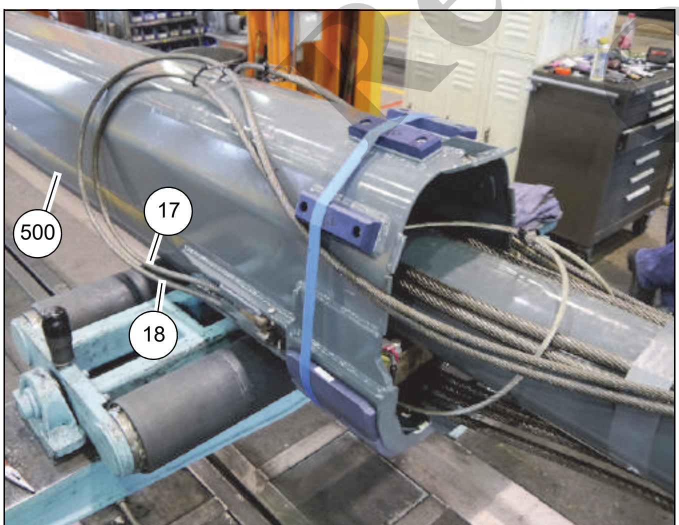
9688-34

FIGURE 4-182

84. Remove grease hoses (517) and grease fittings (515) from left and right sides of rear of tele 4 (500) (see Figure 4-182).

85. Remove two bolts (508) attaching each of the four wear pads (505, 506) and shims (502) to rear of tele 4 (500) (see Figure 4-182).

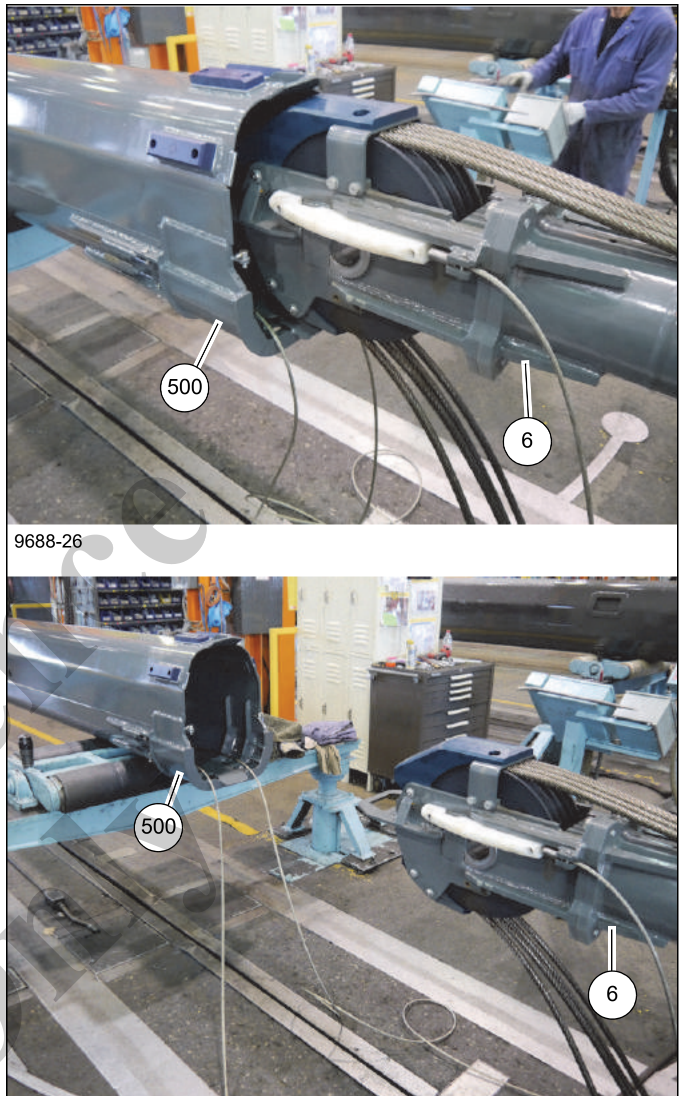
86. Remove bolts (509), lock washers (510), and nuts (512) securing cable ends of the extend cables (17, 18) into pockets at rear of tele 4 (500) (see Figure 4-183)



9688-35

FIGURE 4-183

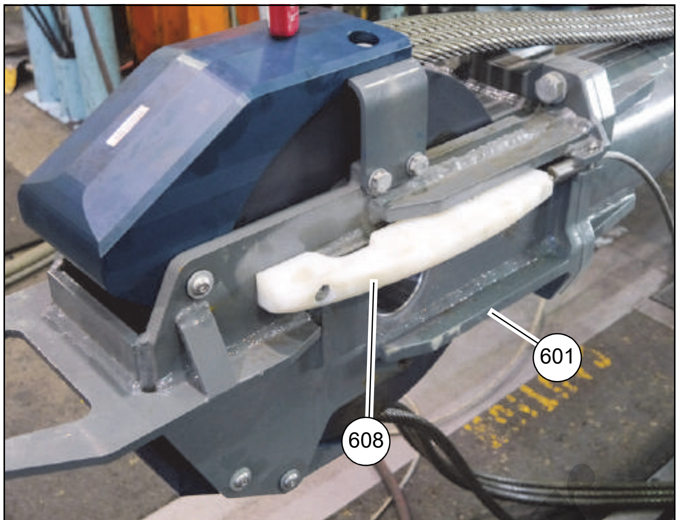
87. Remove telescope cylinder assembly (6) from tele 4 (500) (see Figure 4-184).



9688-25

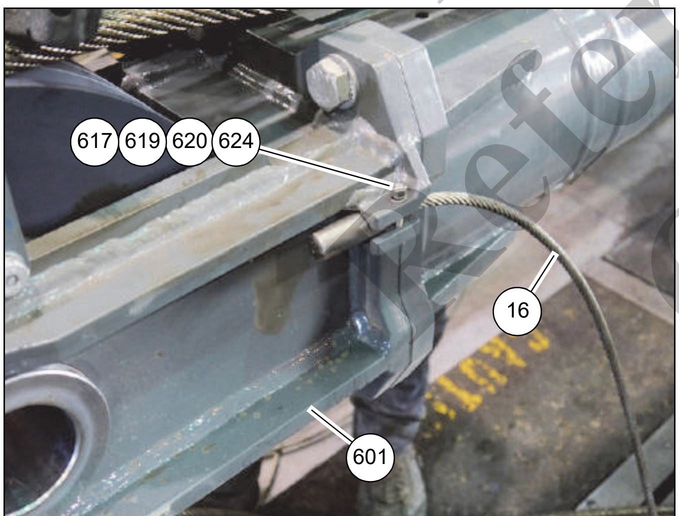
FIGURE 4-184

88. Remove bolts (611) attaching wear pad (608) to each side of sheave mount weldment (601) (see Figure 4-185).



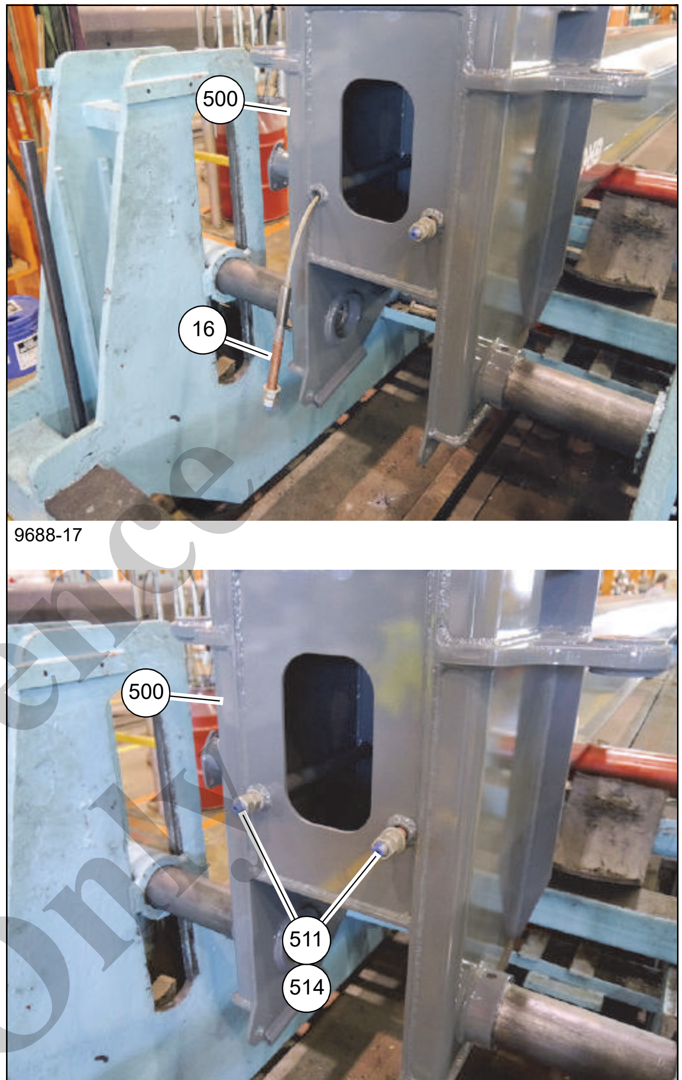
9688-24 **FIGURE 4-185**

89. Remove bolt (617), flat washer (620), lock washer (619), and nut (624) securing each retract cable (16) in place on side of sheave mount weldment (601) (see Figure 4-186).



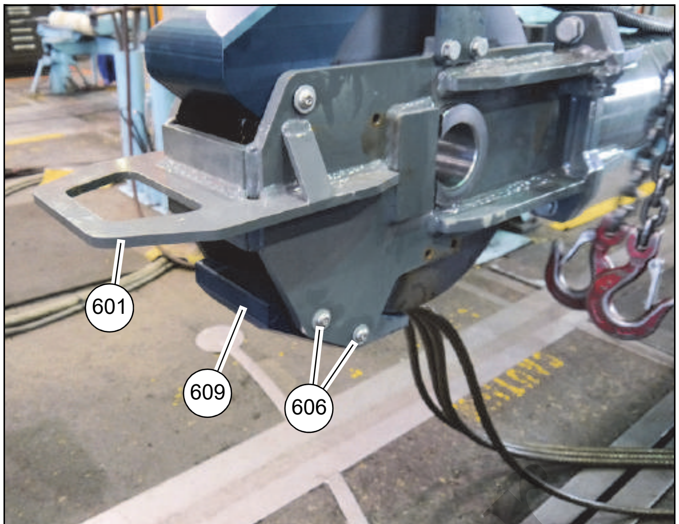
9688-23 **FIGURE 4-186**

90. At front of tele 4 (500), remove two nuts (514) and one washer (511) from the ends of each of the two retract cables (16) (see Figure 4-187).



9688-18 **FIGURE 4-187**

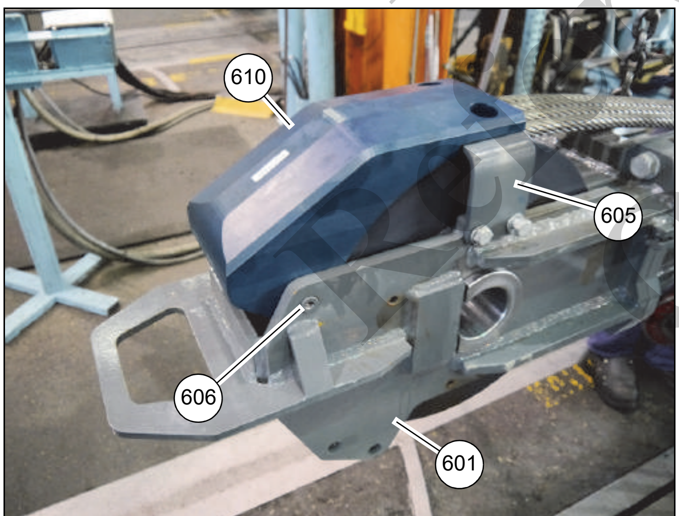
91. Remove bars (606), bolts (616), and washers (621) attaching bottom wear pad (609) to sheave mount weldment (601) (see Figure 4-188).



9688-16

FIGURE 4-188

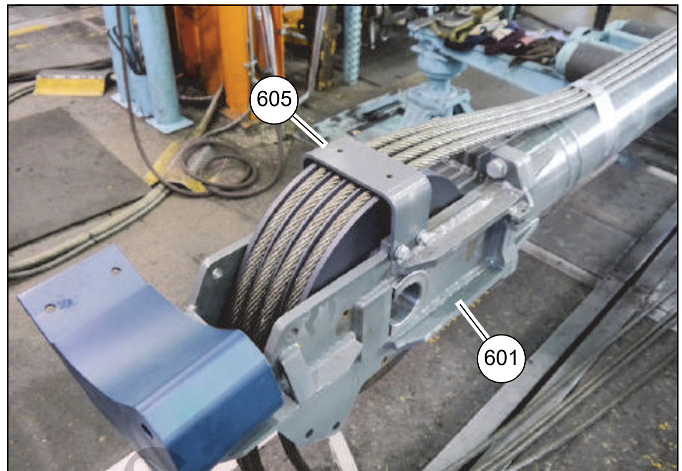
92. Remove bar (606), bolts (616) and washer (621) attaching top wear pad (610) to sheave mount weldment (601). Remove bolts (615) attaching top wear pad (610) to cable retainer (605) (see Figure 4-189).



9688-15

FIGURE 4-189

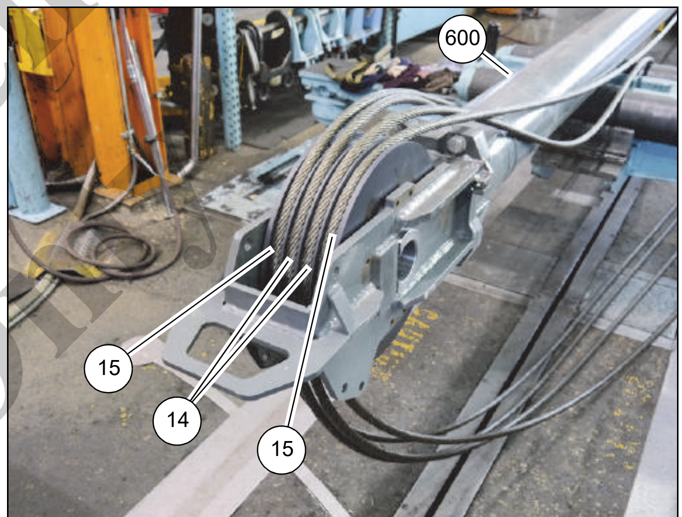
93. Remove four bolts (614) and washers (618) attaching cable retainer (605) to sheave mount weldment (601) (see Figure 4-190).



9688-14

FIGURE 4-190

94. Remove the four extend cables (14, 15) from around sheave (602) (Figure 4-191).



9688-8

FIGURE 4-191

4

95. Remove three bolts (613) and washers (623) attaching plate (604) to side of sheave mount weldment (601) (see Figure 4-192).

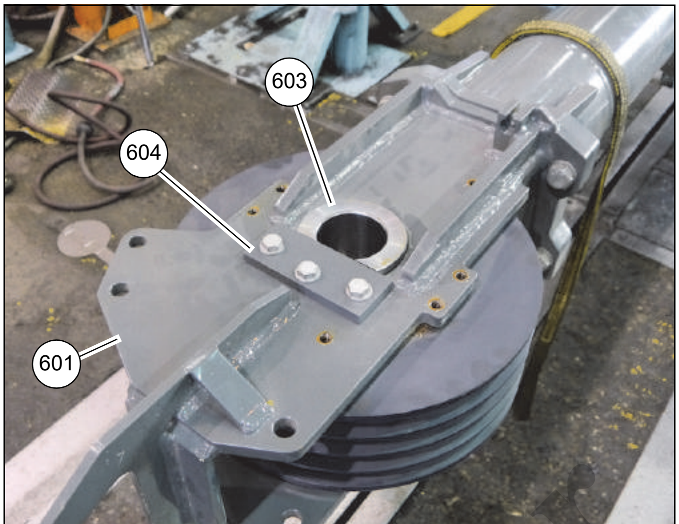


FIGURE 4-192

96. Remove shaft (603) from sheave mount weldment (601). Remove sheave (602) and two spacers (607) from sheave mount weldment (601) (see Figure 4-193 and Figure 4-194).

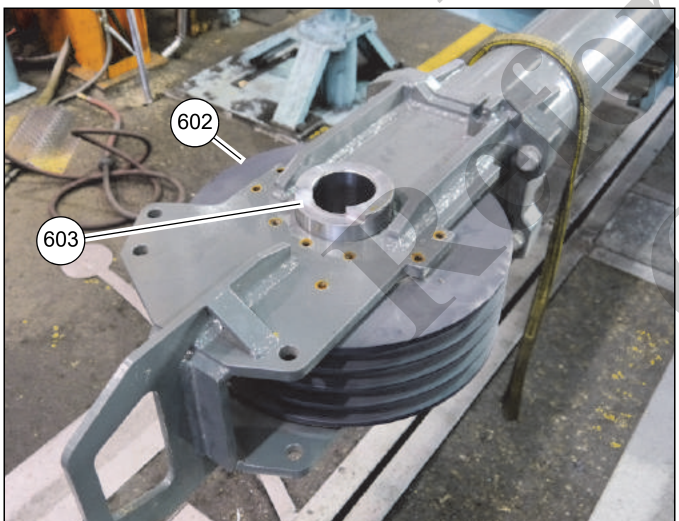


FIGURE 4-193

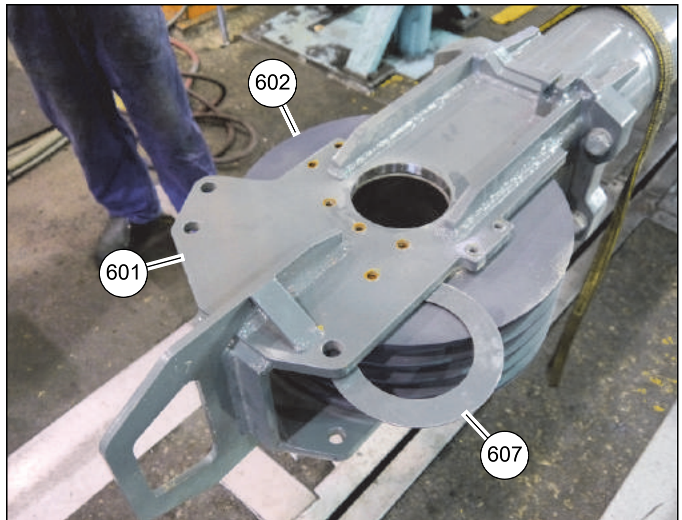


FIGURE 4-194

97. Remove four bolts (612) and washers (622) attaching sheave mount weldment (601) to front of telescope cylinder (600) (see Figure 4-195).

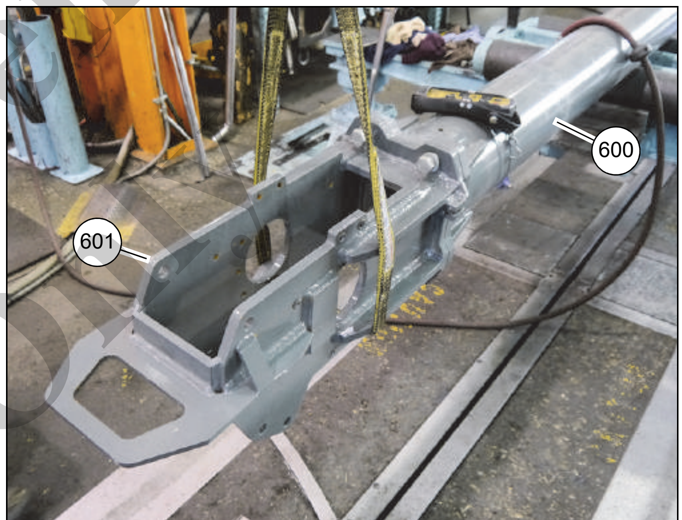


FIGURE 4-195

Assembling the 5-Section Boom

NOTE: Boom assembly must be rotated 180° (upside down) before performing any assembly or disassembly procedures.

CAUTION

A rollover fixture with webbing is recommended to rotate the boom sections. Chains are not recommended. If a rollover fixture is not available, rotate the sections using adequate support with webbing.

A secure fixture that will prevent damage to the boom is recommended to stabilize and hold the boom from moving during removal of the boom section(s).

When adjusting the extend and retract cables, hold the cable end and turn the nut. Do not turn the cable. Turning the cable while adjusting will result in damage or failure of the cable.

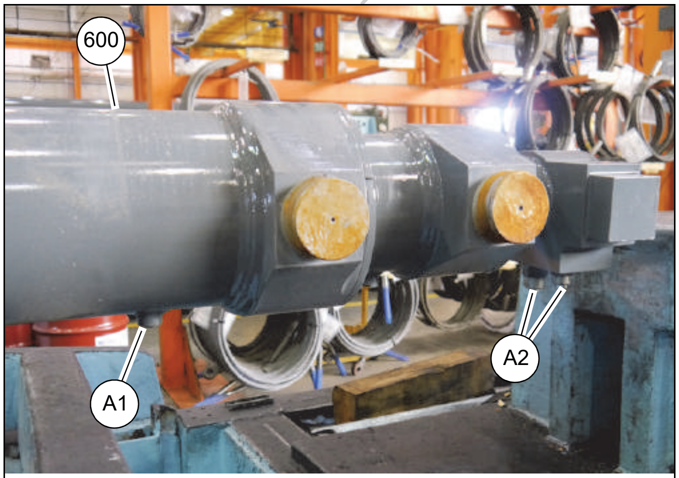
NOTE: Apply medium strength thread locking adhesive/sealant and primer to the threads of all attaching hardware except cable ends and cable lock nuts (131, 262, 248, 514).

NOTE: Apply multipurpose grease (MPG) to all wear surfaces.

NOTE: Use standard Grade 5 and 8 torque values specified in Section 1 of this manual unless otherwise specified.

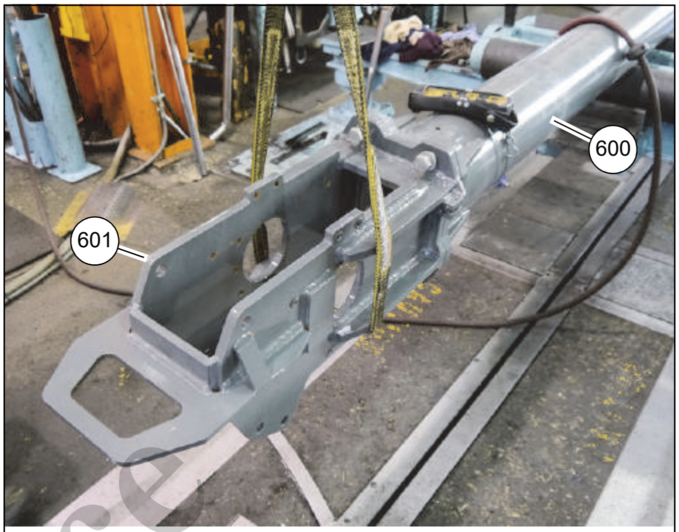
Use the following procedures and refer to FIGURE 4-130 continued when assembling the boom.

1. Position telescope cylinder (600) up side down on adequate supports. Make sure vent plug (A1) at rear of cylinder points down and that the two holding valve cartridges (A2) point down (see Figure 4-196).



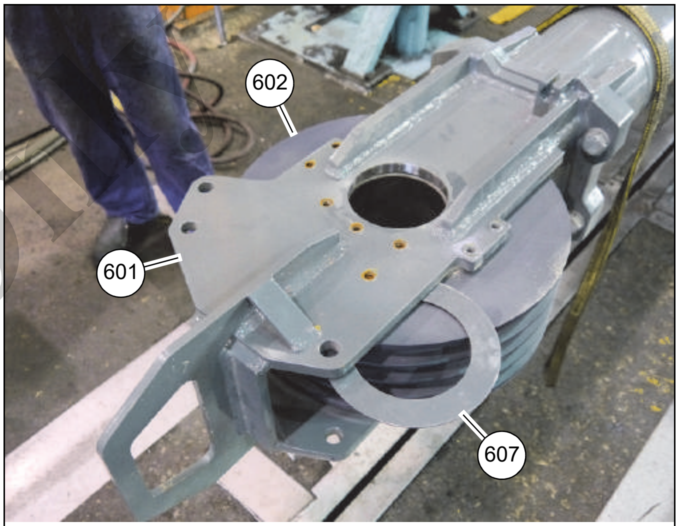
9688-1 **FIGURE 4-196**

2. Install sheave mount weldment (601) to front of telescope cylinder (600) using four bolts (612) and washers (622) (see Figure 4-197).

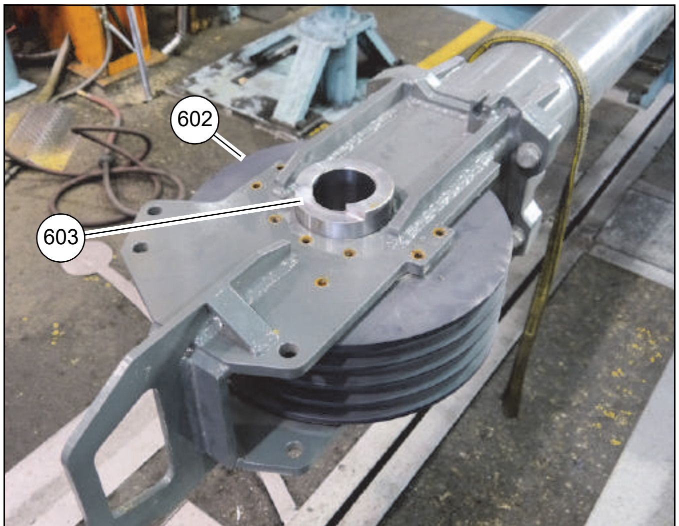


9688-2 **FIGURE 4-197**

3. Install sheave (602) and two spacers (607) into sheave mount weldment (601) and secure with shaft (603) (see Figure 4-198 and Figure 4-199). Install one spacer (607) on each side of sheave.

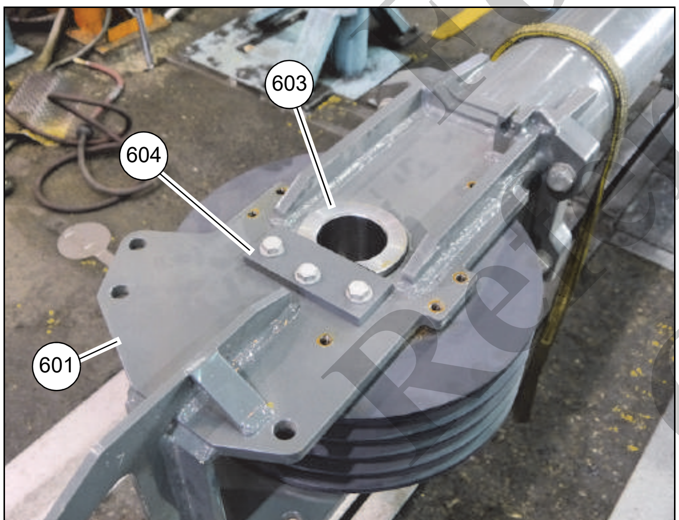


9688-3 **FIGURE 4-198**



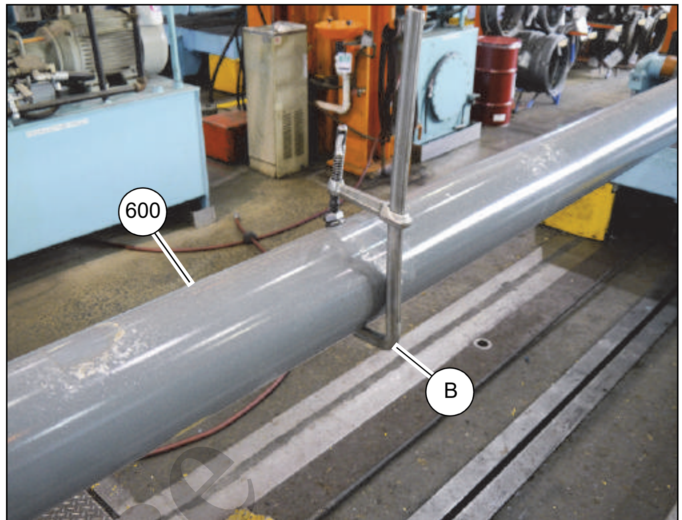
9688-4 **FIGURE 4-199**

4. Install plate (604) using three bolts (613) and washers (623) to side of sheave mount weldment (601) to secure shaft (603) in place (see Figure 4-200).



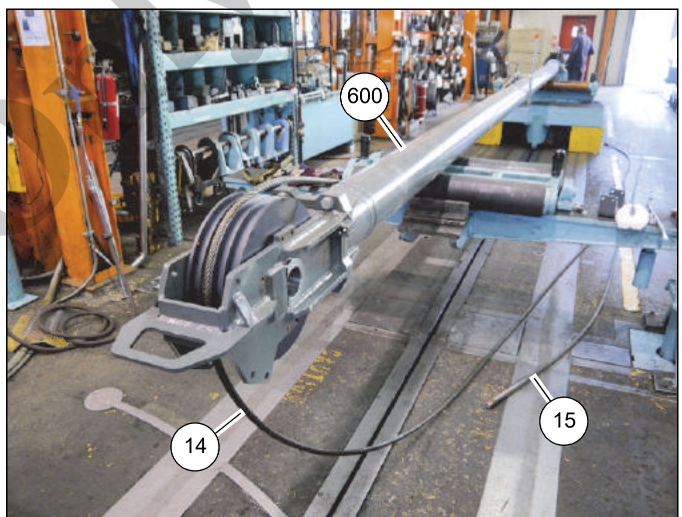
9688-5 **FIGURE 4-200**

5. Install clamp (B) at mid-point of telescope cylinder (600) to assist with installation of the four extend cables (see Figure 4-201).



9688-6 **FIGURE 4-201**

6. Lay out four extend cables (qty 2 - 14, qty 2 - 15) on ground alongside telescope cylinder (600), making sure threaded ends of the cables are toward the sheave. The longer cables (14) will be installed in the two center sheave grooves and the two shorter cables (15) will be installed in the outside sheave grooves — lay out cables accordingly. Do not cross cables. (see Figure 4-202).

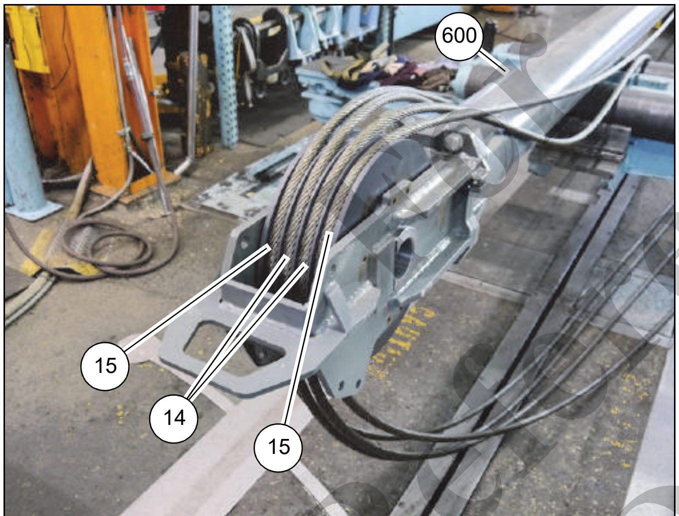


9688-7 **FIGURE 4-202**

7. Route the two longer cables (14) up and around sheave (602) and back to rear of telescope cylinder (600) (see Figure 4-203). Pass cables through clamp at mid-point of the telescope cylinder (see Figure 4-204). Make sure cables (14) are installed in the two inside sheave grooves and that they do not cross one another.

   Route the two shorter cables (15) up and around sheave (602) and back to rear of the telescope cylinder (600). Pass cables through clamp at mid-point of the telescope cylinder. Make sure cables are installed in the outside sheave grooves and that they do not cross one another.

   Using a strap (C), secure the four cables (14, 15) in place at rear of the telescope cylinder (600) such that the two inside cables (14) hang over the end of the cylinder farther than the two outside cables (15) (see Figure 4-205).

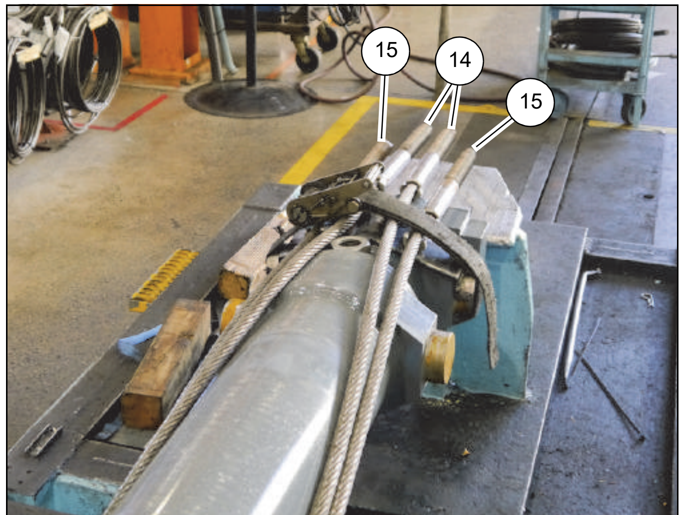


9688-8

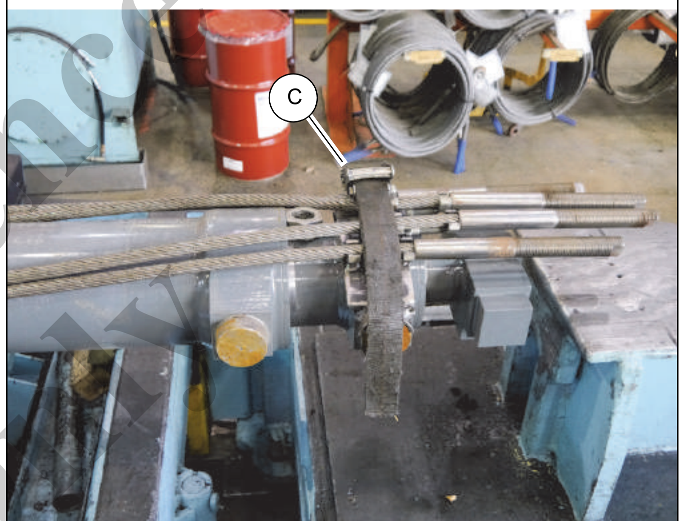
FIGURE 4-203


9688-9

FIGURE 4-204



9688-10



9688-11

FIGURE 4-205

4

8. Using duct tape (D), secure the four extend cables (14, 15) to top of telescope cylinder (600). Make sure cables do not cross one another (see Figure 4-206).

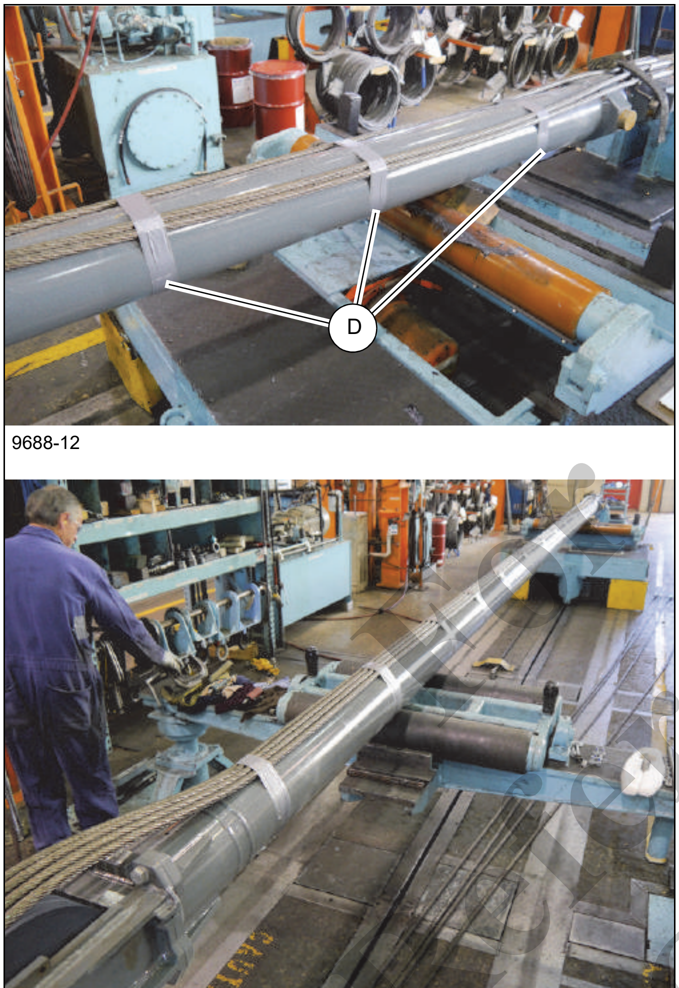
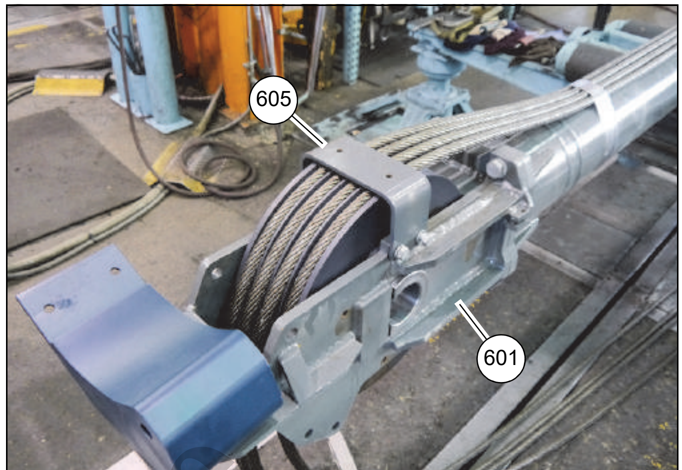


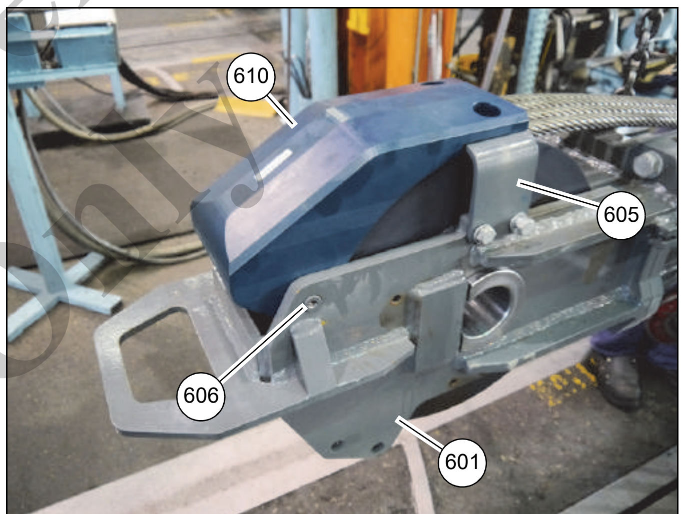
FIGURE 4-206

9. Install cable retainer (605) onto sheave mount weldment (601) using four bolts (614) and washers (618) (see Figure 4-207).



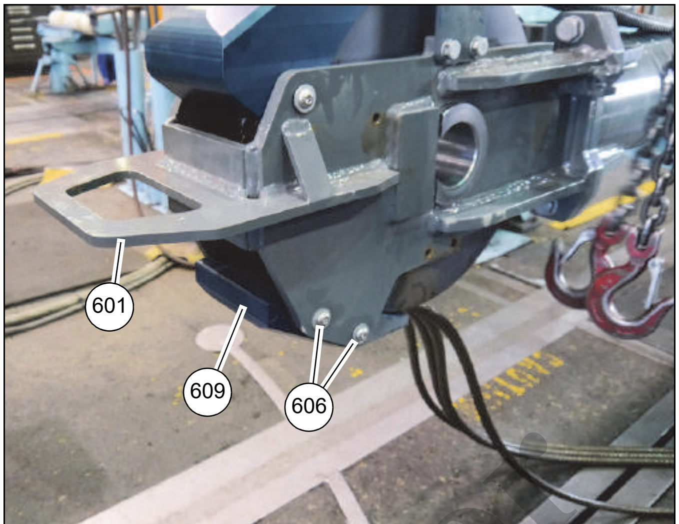
9688-14 **FIGURE 4-207**

10. Install top wear pad (610) to sheave mount weldment (601) using bar (606), bolts (616) and washer (621) and to cable retainer (605) using bolts (615) (see Figure 4-208).



9688-15 **FIGURE 4-208**

11. Install bottom wear pad (609) to sheave mount weldment (601) using bars (606), bolts (616), and washers (621) (see Figure 4-209). Lift cables using a suitable crane and sling to ease installation.

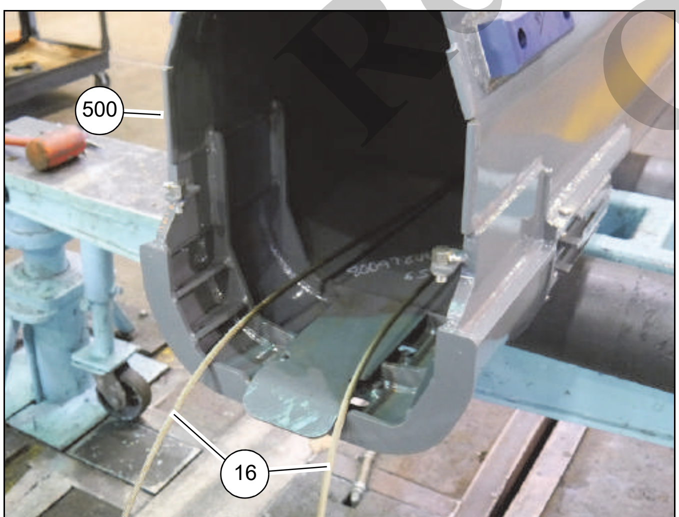


9688-16

FIGURE 4-209

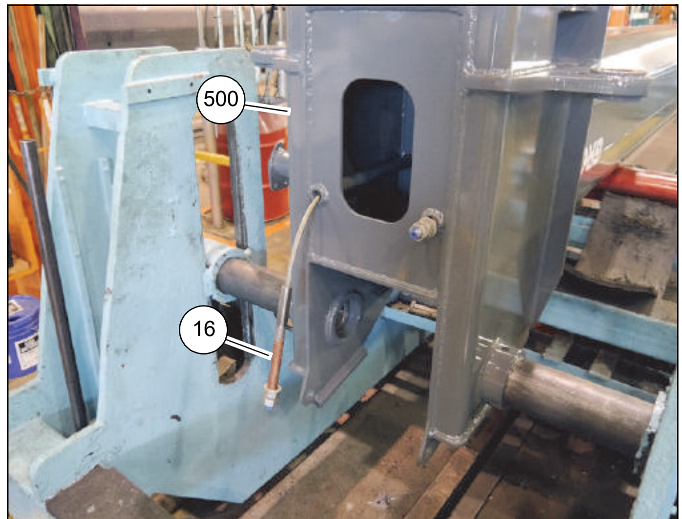
12. Position tele 4 (500) upside down on adequate supports in front of telescope cylinder assembly (6).

13. Route threaded ends of the two retract cables (16) through tele 4 (500) (see Figure 4-210). Apply an anti-seize compound to threaded ends of cables, then secure each retract cable (16) to front of tele 4 (500) using a washer (511) and two nuts (514) (see Figure 4-211). Pull the two cables out the rear of tele 4, removing any slack in cables.

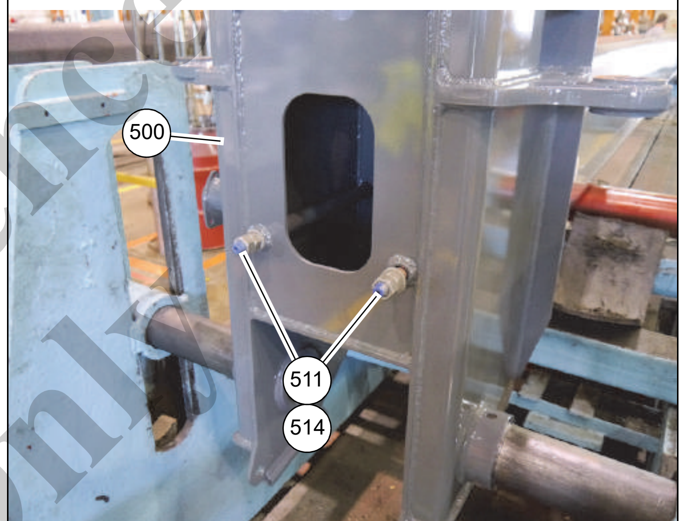


9688-19

FIGURE 4-210



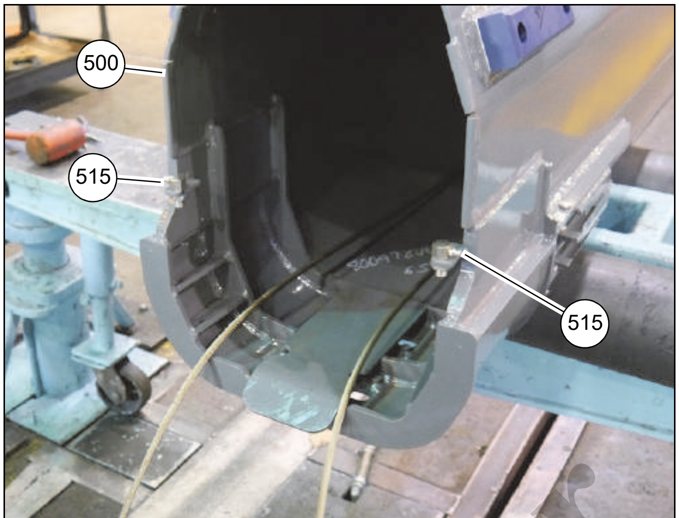
9688-17



9688-18

FIGURE 4-211

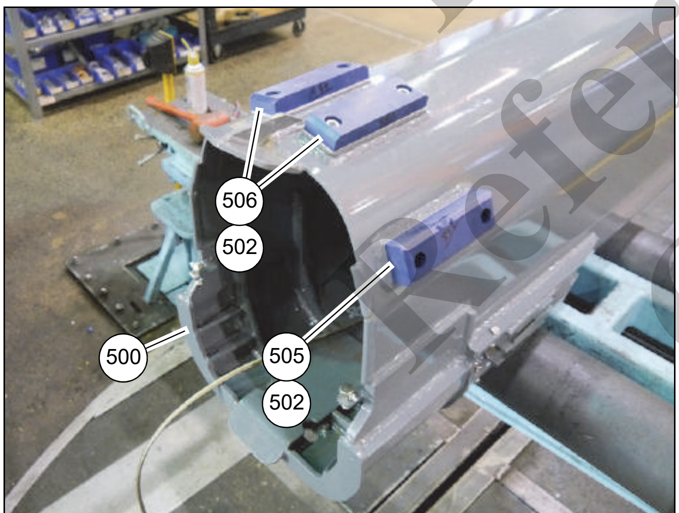
14. Install grease fittings (515) to rear of tele 4 (500) using nuts (516) (see Figure 4-212). Orient grease fittings such that they point outward.



9688-19

FIGURE 4-212

15. Install four wear pads (qty 2 - 505, qty 2 - 506) with shims (502) to rear of tele 4 (500) using two bolts (508) for each wear pad (see Figure 4-213).

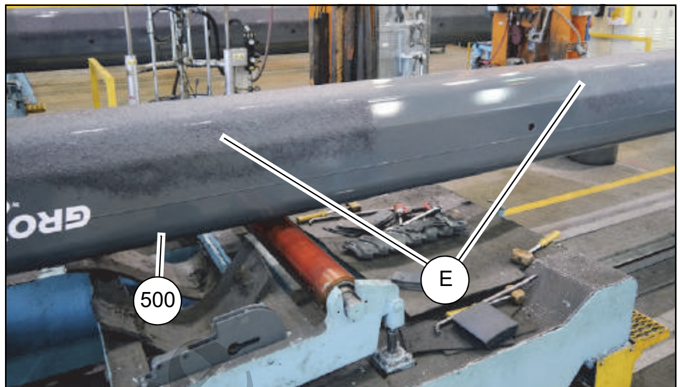


9688-20

FIGURE 4-213

16. Apply multipurpose grease to inside top and bottom of tele 4 (500).

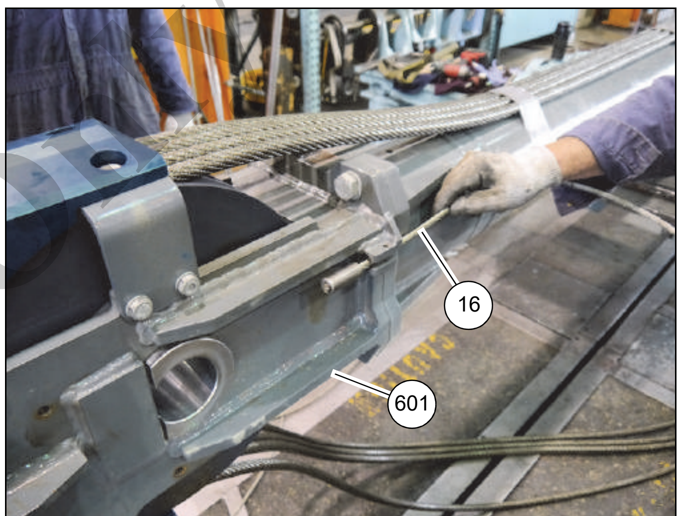
17. Spray multipurpose grease (E) on outside of tele 4 (500). Measuring approximately 1/4 of the distance of the boom from the tip, leave a 5 ft. wide strip of boom free of grease to install wear pads (Figure 4-214).



9688-21

FIGURE 4-214

18. Route the two retract cables (16) exiting the rear of tele 4 (500) along each side of the telescope cylinder assembly (6) and then loop them back to tip of telescope cylinder. Install the cable anchors in to their respective pockets on the sides of the sheave mount weldment (601) (see Figure 4-215).



9688-22

FIGURE 4-215

19. Secure each cable anchor in place using bolt (617), flat washer (620), lock washer (619), and nut (624) (see Figure 4-216).

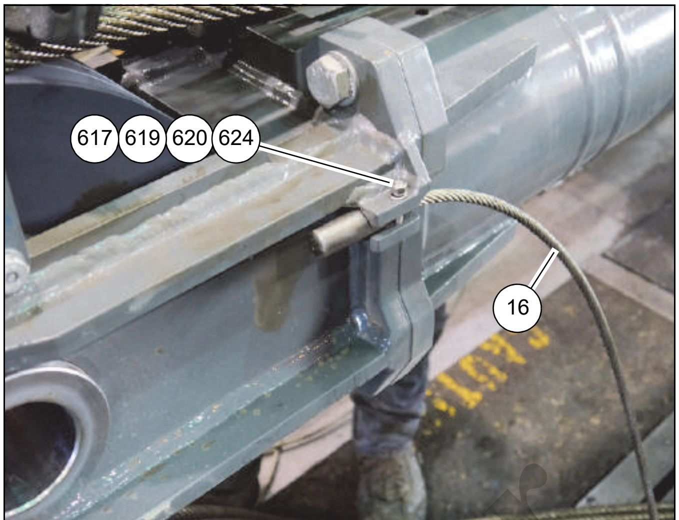


FIGURE 4-216

20. Install wear pad (608) on to each side of sheave mount weldment (601) using bolts (611) (see Figure 4-217).

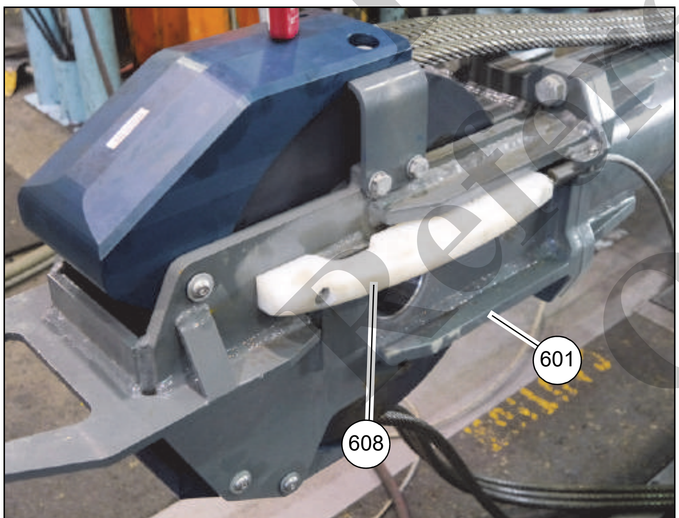


FIGURE 4-217

21. Lift the telescope cylinder assembly (6) and insert it into tele 4 (500) (see Figure 4-218).

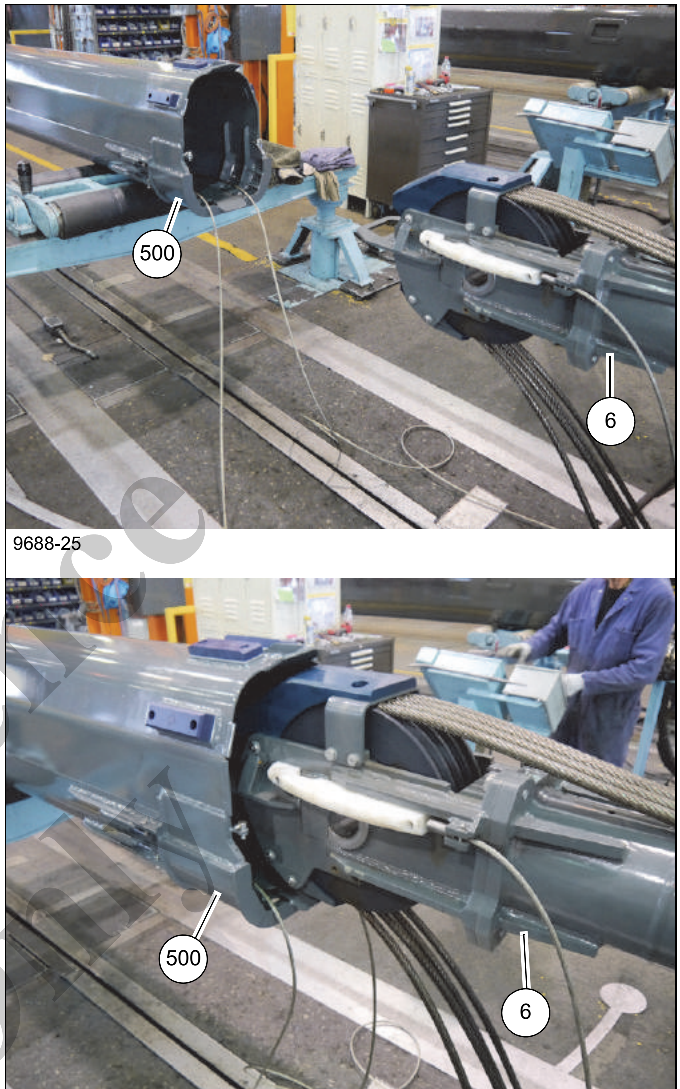
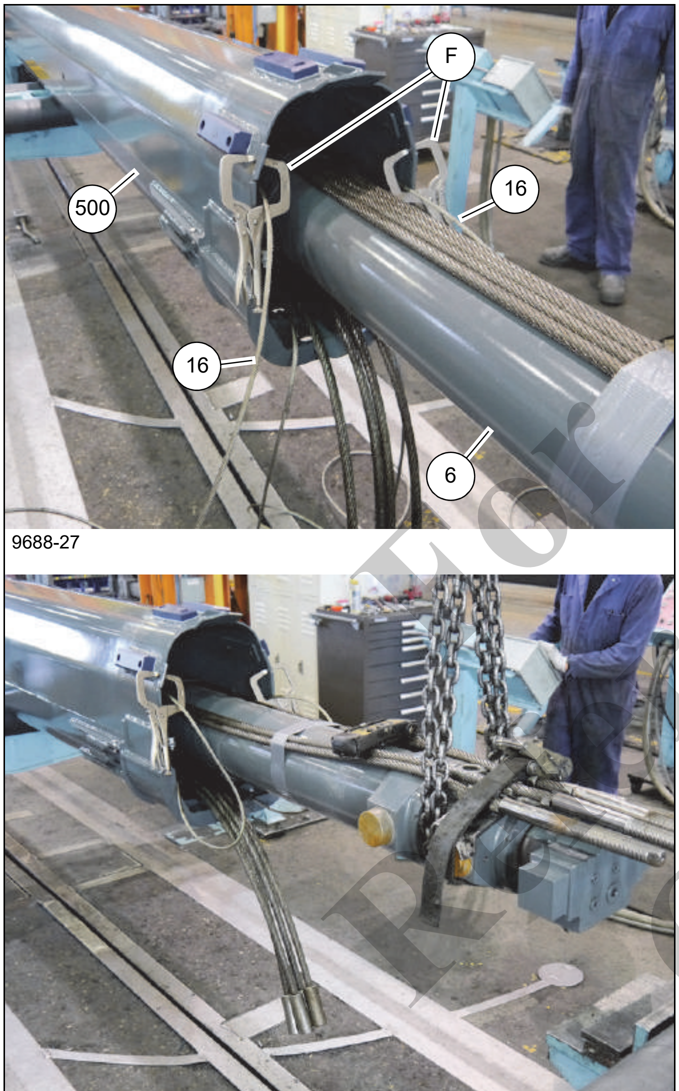


FIGURE 4-218

22. Fully insert telescope cylinder assembly (6) into tele 4 (500). Use clamps (F) to hold the two retract cables (16) up out of the way to prevent entanglement while inserting telescope cylinder into tele 4 (see Figure 4-219),

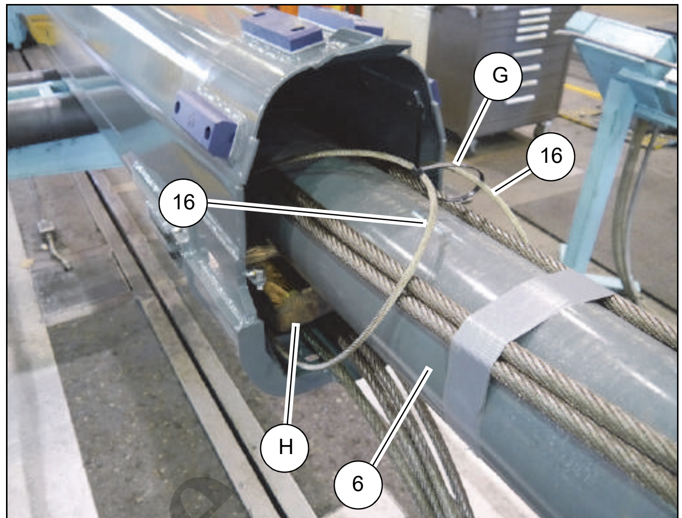


9688-27

9688-28

FIGURE 4-219

23. Using a zip-tie (G), secure tops of the two retract cables (16) together, then remove clamps (see Figure 4-220).

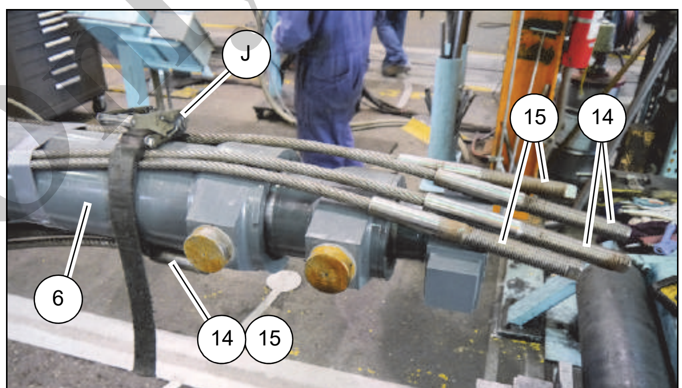


9688-29

FIGURE 4-220

24. Place three 2 in x 4 in blocks of wood (H) underneath the telescope cylinder assembly (6). Lower telescope cylinder onto the blocks of wood (see Figure 4-220).

25. Remove strap (J) securing the four extend cables (14, 15) to the top of telescope cylinder assembly (6), then use the strap to secure the four extend cables (14, 15) to the top and bottom of telescope cylinder assembly (6) (see Figure 4-221).

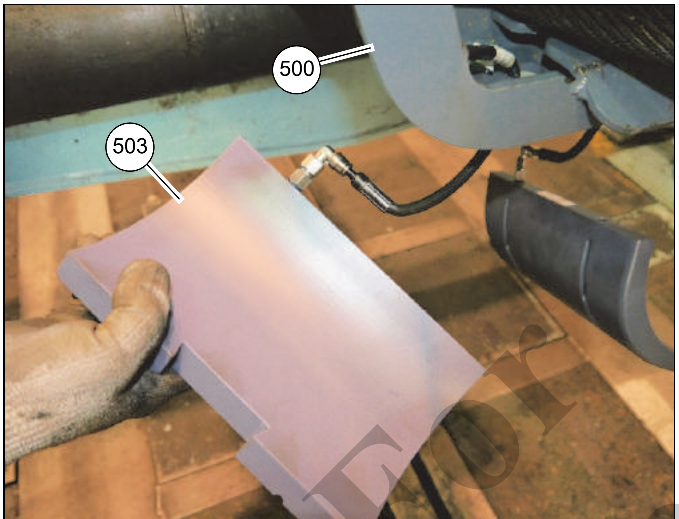


9688-30

FIGURE 4-221

26. Attach grease hoses (517) to grease fittings (515) at rear of tele 4 (500). Route end of each grease hose (517) down through hole in bottom of tele 4 (500) (see Figure 4-222).

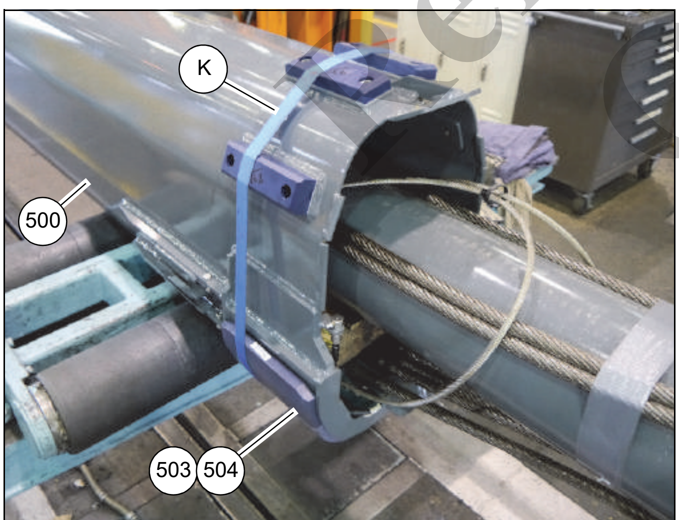
Attach each grease hose (517) to wear pad (503) using two adapters (518) and an elbow (519) (see Figure 4-222).



9688-33

FIGURE 4-222

27. Install shims (501) and wear pads (503, 504) to bottom rear of tele 4 (500). Secure wear pads (503, 504) in place using strap (K) (seeFigure 4-223). Note: Install strap around wear pads such that it is offset toward the front of tele 4 as shown.

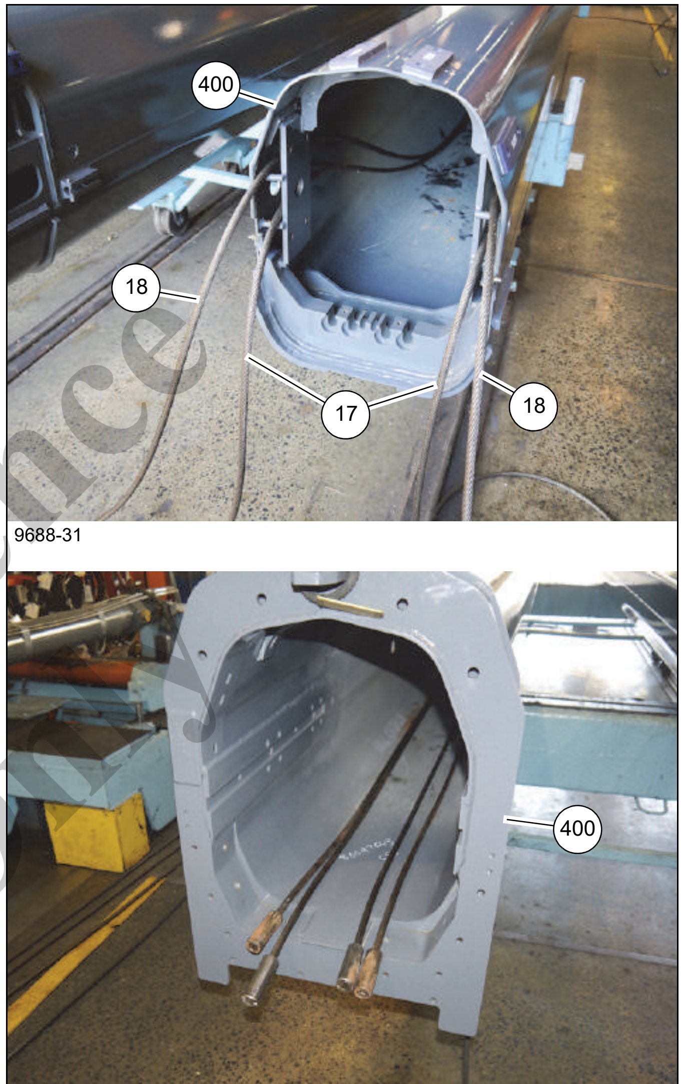


9688-34

FIGURE 4-223

28. Position tele 3 (400) upside down on adequate supports in back of tele 4 (500).

29. Route four extend cables (17, 18) through rear of tele 3 (400) and up to front of tele 3. Route the longer extend cables (18) through holes at top of tele 3 and the shorter extend cables (17) through holes at bottom of tele 3 (see Figure 4-224).



9688-31

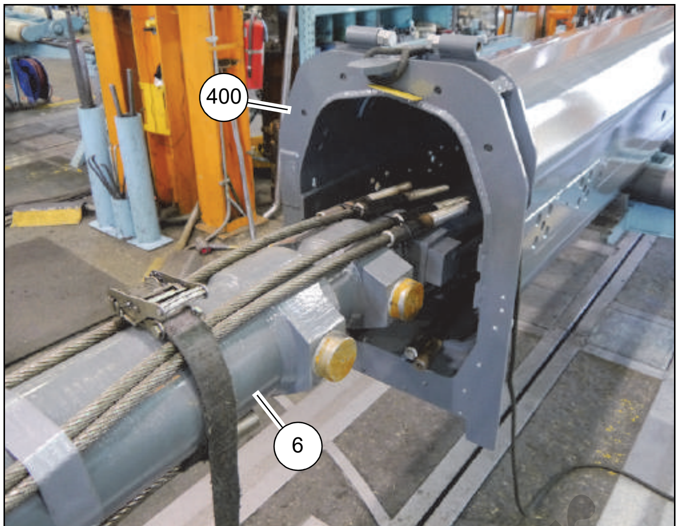
9688-32

FIGURE 4-224

30. Apply multipurpose grease to inside top and bottom of tele 3 (400).

4

31. Slightly insert telescope cylinder assembly (6) into front of tele 3 (400) (see Figure 4-225).



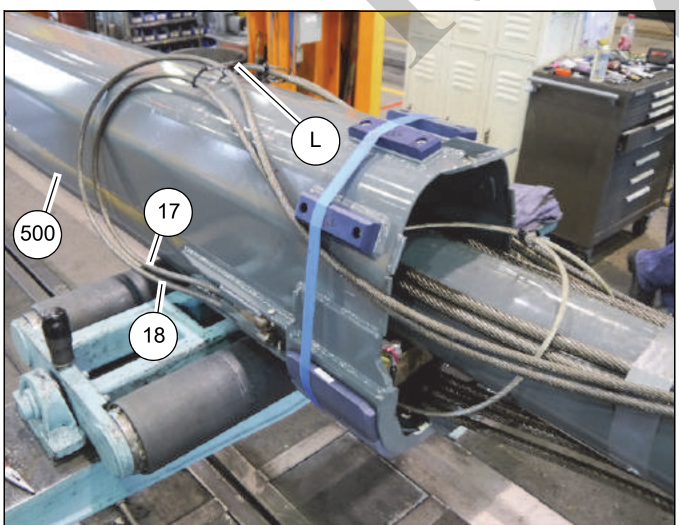
9688-36

FIGURE 4-225

32. Pull the four extend cables (17, 18) out of the front of tele 3 (400) and past the rear of tele 4 (500), then loop extend cables back toward rear of tele 4, making sure cables do not cross one another (see Figure 4-226).

Install cable ends of the longer extend cables (18) into bottom pockets at rear of tele 4 (500) and install cable ends of the shorter extend cables (17) into top pockets (as oriented) (see Figure 4-226) Secure cable ends in place using bolts (509), lock washers (510), and nuts (512).

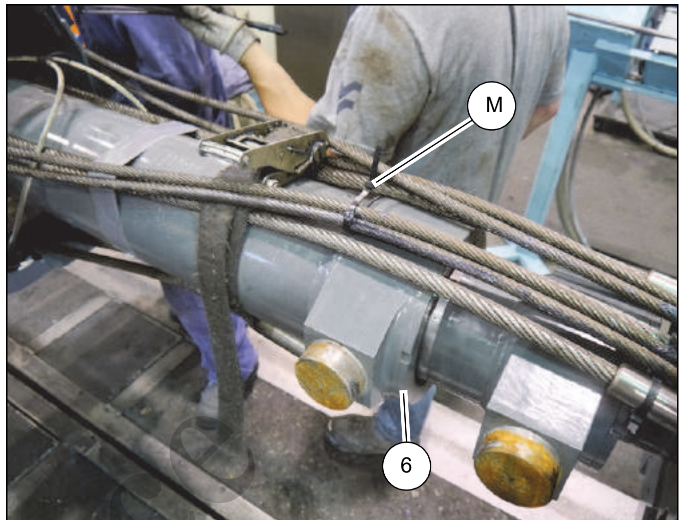
Using one zip-tie (L) per pair of cables, secure each pair of long and short extend cables (17, 18) together above rear of tele 4 (500).



9688-35

FIGURE 4-226

33. Using one zip-tie (M), secure the long and short extend cables (17, 18) together above the telescope cylinder assembly (6) (see Figure 4-227). Make sure cables do not cross one another.

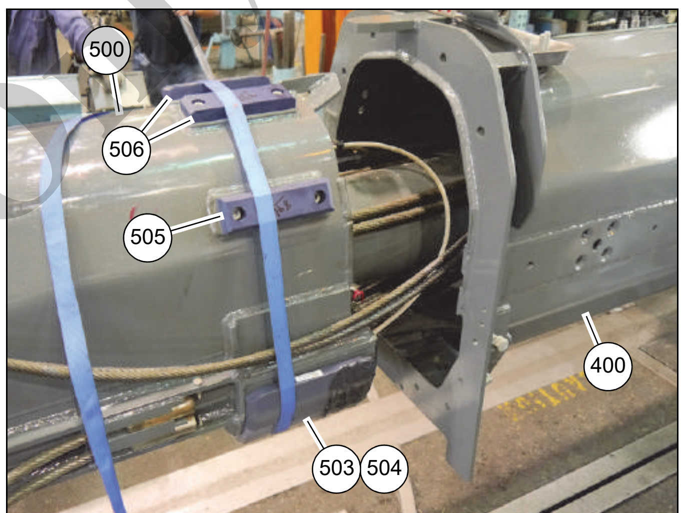


9688-37

FIGURE 4-227

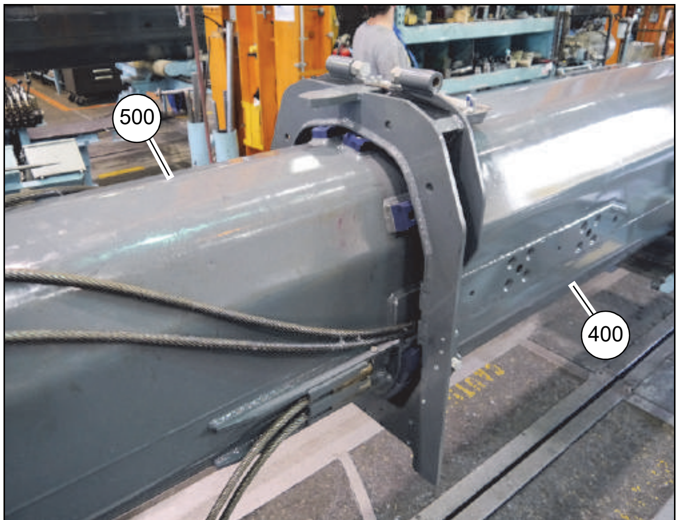
34. Insert tele 4 (500)/telescope cylinder assembly (6) into tele 3 (400) while pulling the four extend cables (17, 18) out the rear of tele 3 (400) (see Figure 4-228).

Continue to insert tele 4 into tele 3 until the wear pads (503, 504, 505, 506) at rear of tele 4 (500) are just inside tele 3 (400) (see Figure 4-229).



9688-38

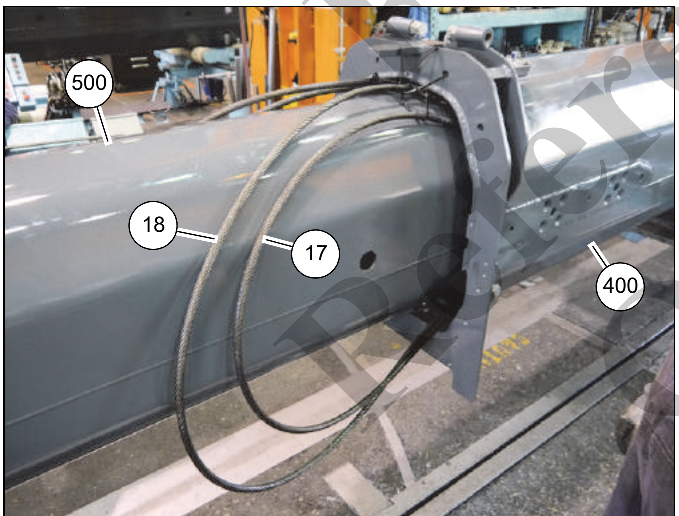
FIGURE 4-228



9688-39

FIGURE 4-229

35. Remove strap holding wear pads (503, 504) in place, then insert tele 4 (500) into tele 3 (400) until loops in extend cables (17, 18) are approximately 3 or 4 feet from the tip of tele 3 (400) (see Figure 4-230)

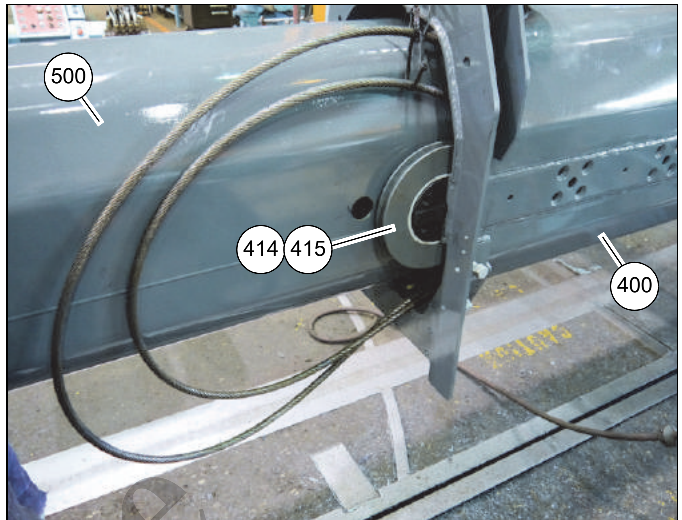


9688-40

FIGURE 4-230

36. Install three plugs (430) into back of each of the four shafts (415). Install a shaft (415) into the four sheaves (qty 2 - 413, qty 2 - 414).

37. Install shaft/sheave (414, 415) assembly between tele 4 (500) and tele 3 (400) (see Figure 4-231).

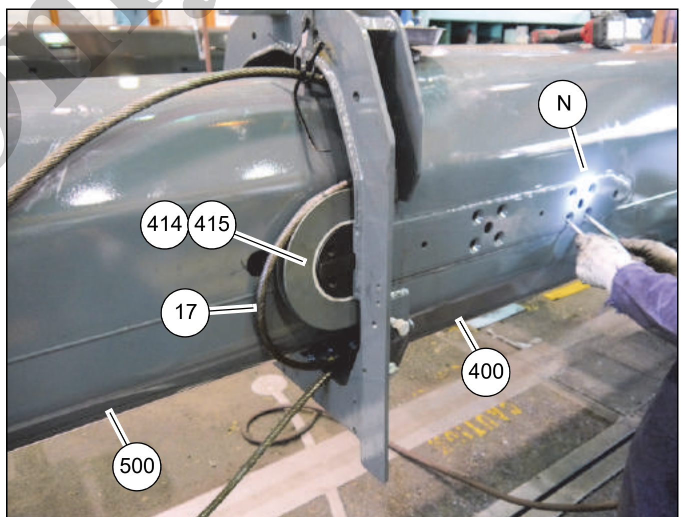


9688-41

FIGURE 4-231

38. Working at the rear of tele 3 (400), pull shorter extend cable (17) until cable begins to pull the shaft/sheave (414, 415) assembly into the front of tele 3 (400) (see Figure 4-232).

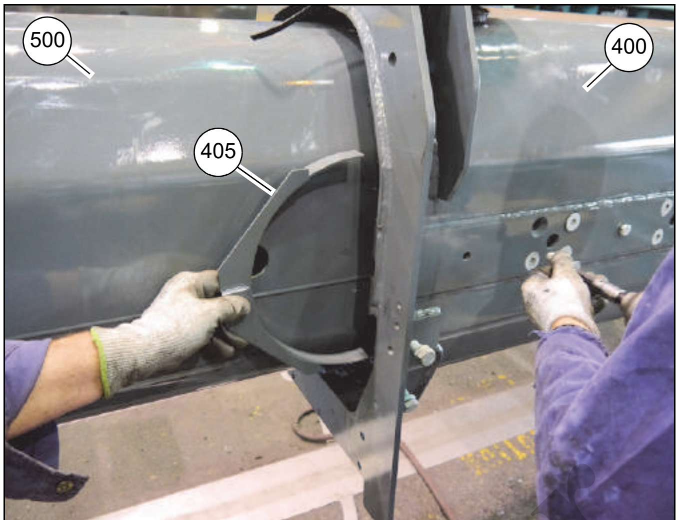
Continue to pull extend cable (17) until bolt holes in shaft (415) align with holes (N) in tele 3 (400) (see Figure 4-232). Secure shaft/sheave (414, 415) assembly to tele 3 (400) using four flat head screws (432).



9688-42

FIGURE 4-232

39. Install sheave guard weldment (405) between tele 4 (500) and tele 3 (400) and secure in place using bolt (438) (see Figure 4-233).

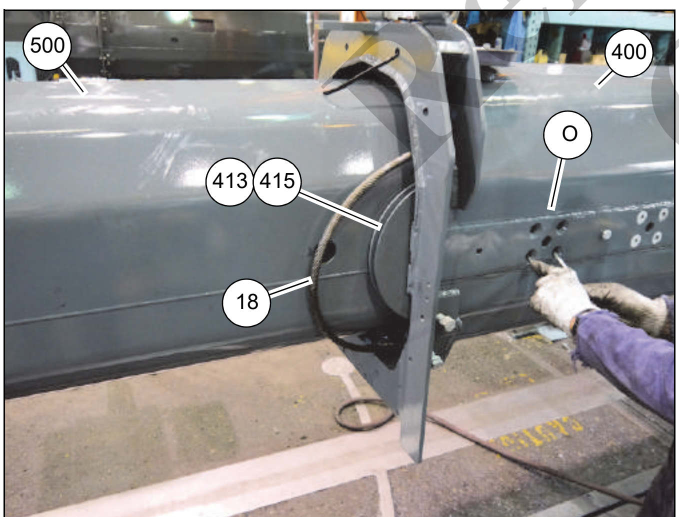


9688-43

FIGURE 4-233

40. Working at the rear of tele 3 (400), pull longer extend cable (18) until cable begins to pull the shaft/sheave (413, 415) assembly into the tip of tele 3 (400) (see Figure 4-234).

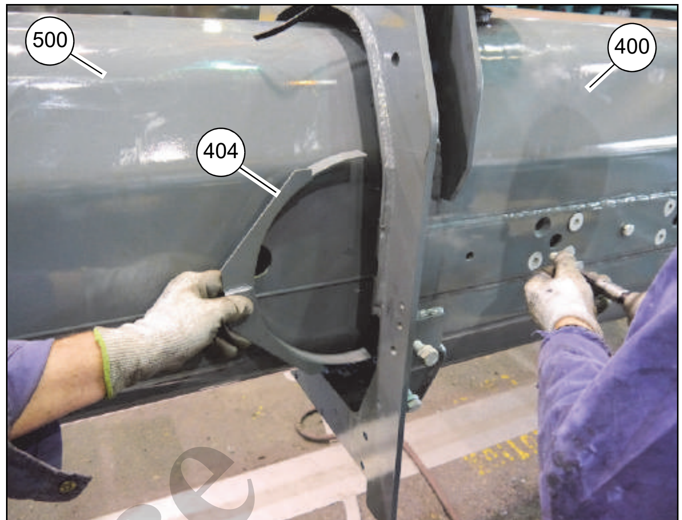
Continue to pull extend cable (18) until bolt holes in shaft/sheave (413, 415) assembly align with holes (O) in tele 3 (400) (see Figure 4-234). Secure shaft/sheave (413, 415) assembly to tele 3 (400) using four bolts (432).



9688-44

FIGURE 4-234

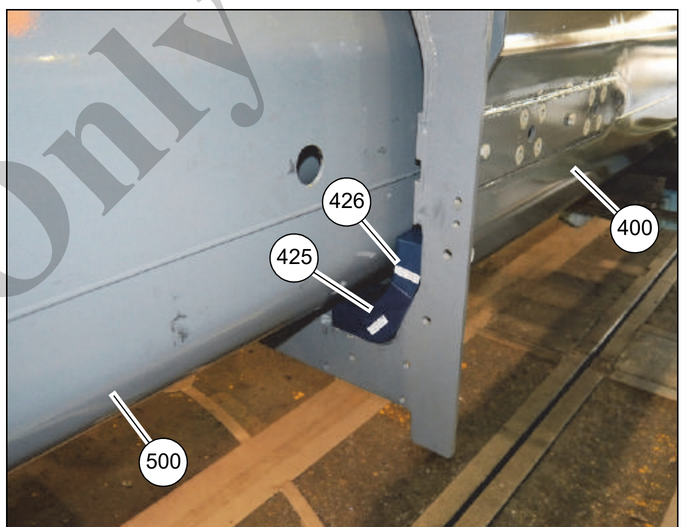
41. Install sheave guard weldment (404) between tele 4 (500) and tele 3 (400) and secure in place using bolt (438) (see Figure 4-235).



9688-43

FIGURE 4-235

42. Slightly raise tele 4 (500), then install wear pads (425, 426) in the left and right bottom corners between tele 4 (500) and tele 3 (400) (see Figure 4-236). Install wear pad adjusting bolts and nuts (433, 453) on each side of tele 3 (400), but do not tighten.



9688-46

FIGURE 4-236

43. Continue to insert tele 4 (500) into tele 3 (400) until tip of tele 3 is at the area of tele 4 which is free of grease.

44. Set wear pads (qty 2 - 422, 423. qty 2 - 424) with bars (407, qty 2 - 408) on top of tele 4 (500) and tap into place between tele 4 (500) and tele 3 (400) (see Figure 4-237)

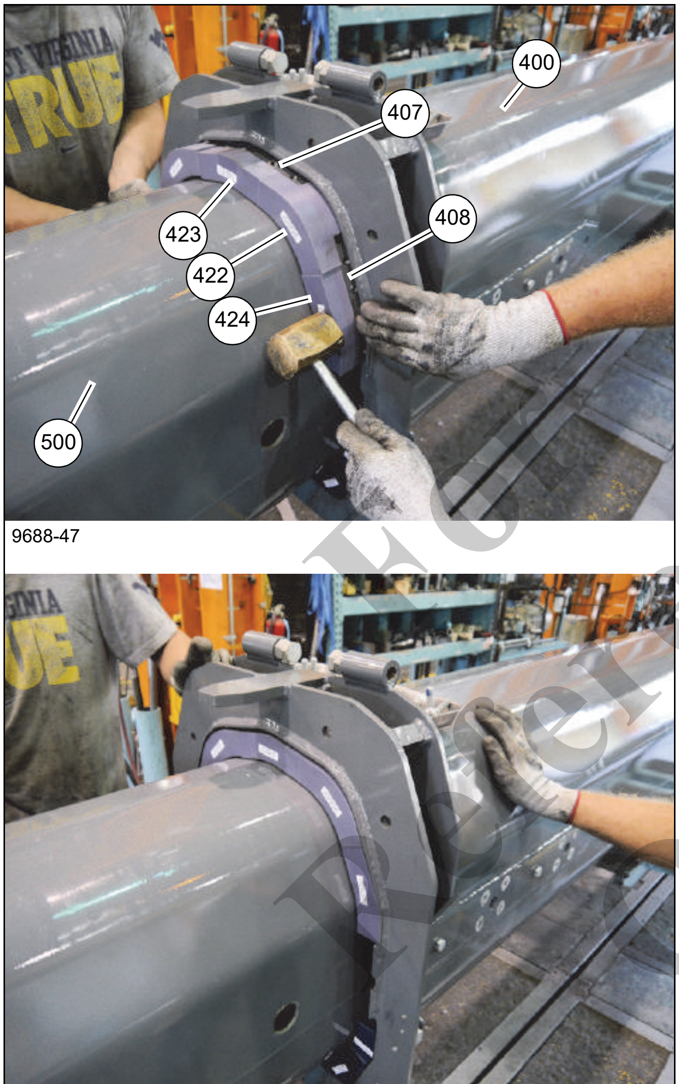
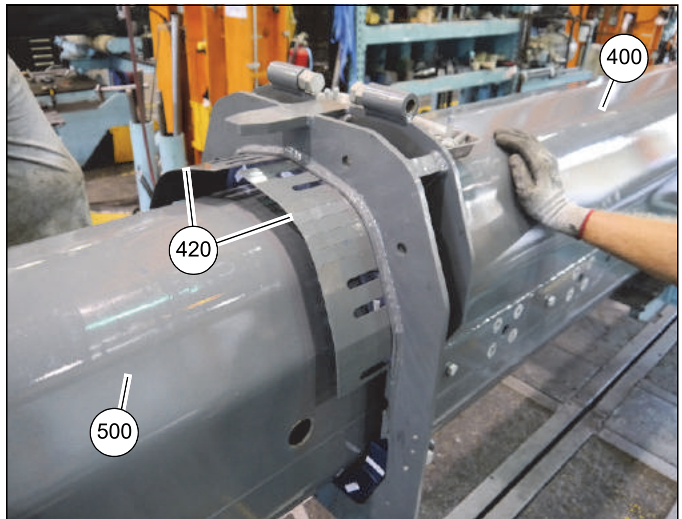


FIGURE 4-237

45. Install bolts (439) with washers (450) through tip of tele 3 (400) and into bars (407, 408) holding wear pads (422, 423. 424) – do not tighten bolts (see Figure 4-237).

46. Install two shims (420) (per side) between wear pads (422, 423. 424) and tele 3 (400) by gently tapping them with a rubber mallet or block of wood (see Figure 4-238).

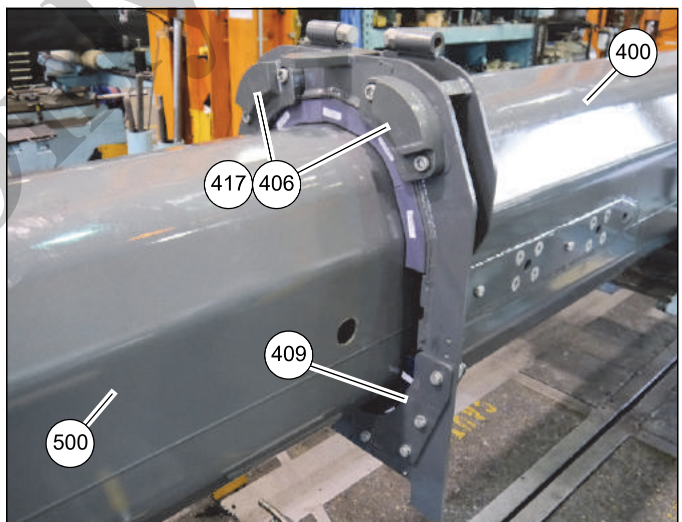


9688-49

FIGURE 4-238

47. Secure wear pads (422, 423, 424) and shims (420) in place by tightening bolts (439) passing through holes in tele 3 (400) and into bars (407, 408).

48. Install top left and right side shims (417) and stop blocks (406) on to front of tele 3 (400) using bolts (431), washers (449), and nuts (454) (see Figure 4-239). Install bottom left and right side stop plates (409) on to front of tele 3 (400) using bolts (437), washers (445), lock washers (444), and nuts (455) (see Figure 4-239).

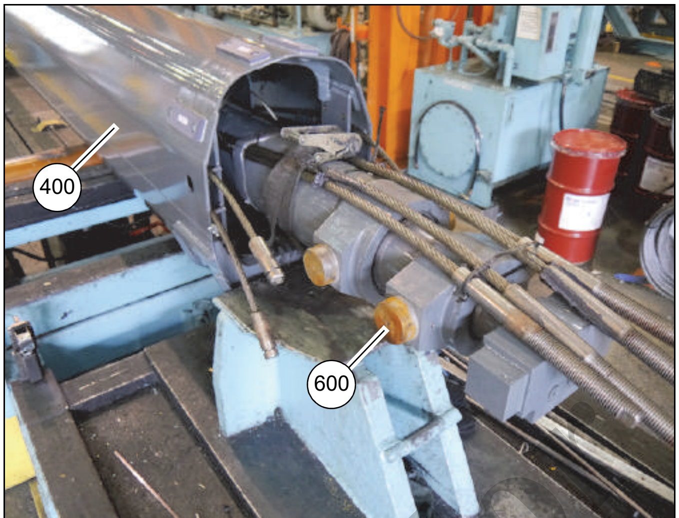


9688-50

FIGURE 4-239

4

49. Insert tele 4 (500) into tele 3 (400) while making sure the telescope cylinder (600) passes through the rear of tele 3 (400) without hitting it (see Figure 4-240). Note: Insert tele 4 into tele 3 until loops of retract cables (16) protrude 1 to 1-1/2 feet out rear of tele 3 (400).

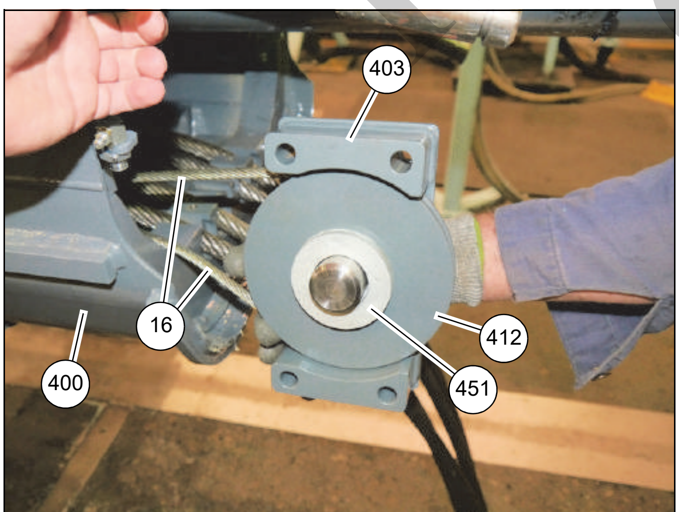


9688-51 **FIGURE 4-240**

50. Remove strap securing extend cables (14, 15) to rear of telescope cylinder (600).

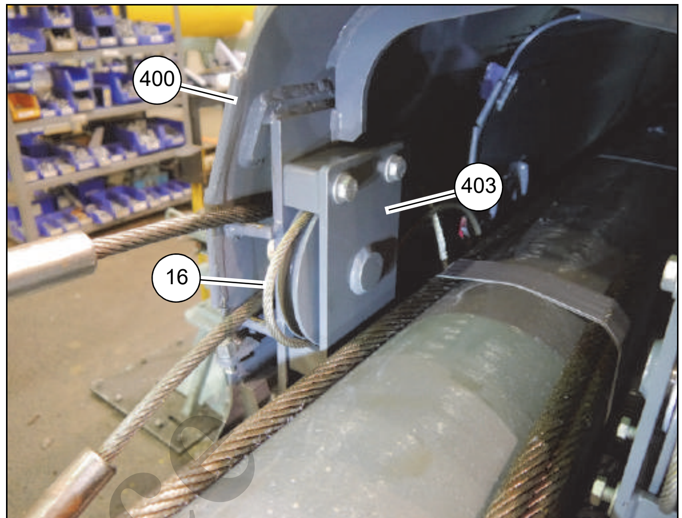
51. Remove wood blocks from underneath telescope cylinder (600).

52. Working at rear of tele 3 (400), install one hardened washer (451) on to shaft of sheave weldment (403). Wrap retract cable (16) around sheave (412), then install sheave (412) on to shaft of the sheave weldment (403). Install three more hardened washers (451) onto shaft (see Figure 4-241).



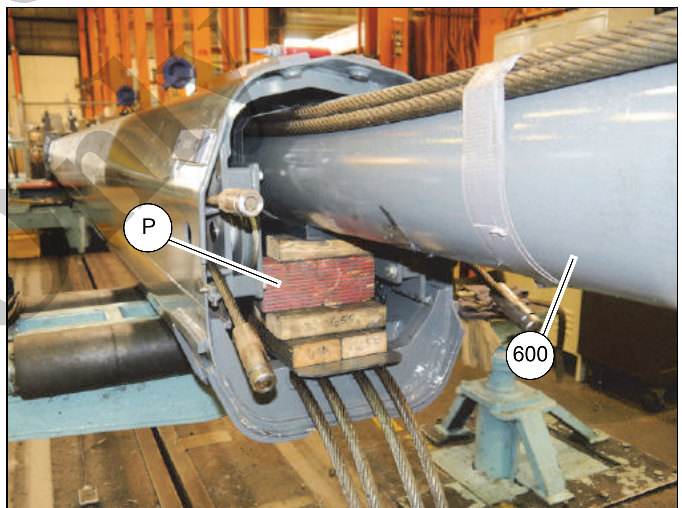
9688-52 **FIGURE 4-241**

53. Install sheave weldment (403) to inside of tele 3 (400) using four bolts (434) and washers (450) (left and right sides) (see Figure 4-242). Note: Raise and lower telescope cylinder as needed to access bolts.



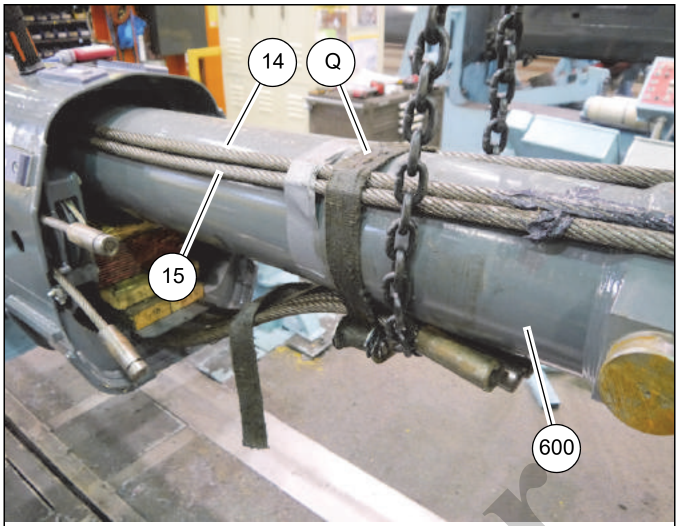
9688-53 **FIGURE 4-242**

54. Place blocks of wood or similar (P) measuring approximately 8-1/2 inches in height under telescope cylinder (600) (see Figure 4-243).



9688-54 **FIGURE 4-243**

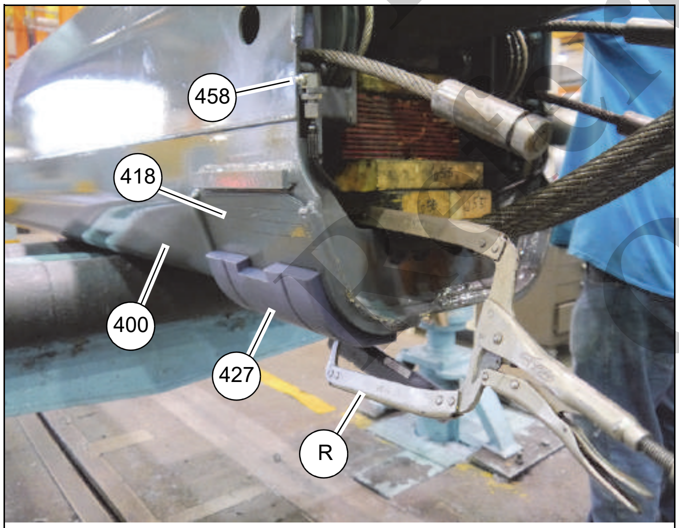
55. Using strap (Q), secure the four extend cables (14, 15) to top and bottom of telescope cylinder (600) (see Figure 4-244).



9688-55

FIGURE 4-244

56. Install grease fittings (458) to rear of tele 3 (400) using nuts (448) (see Figure 4-245). Orient grease fittings such that they point outward.



9688-56

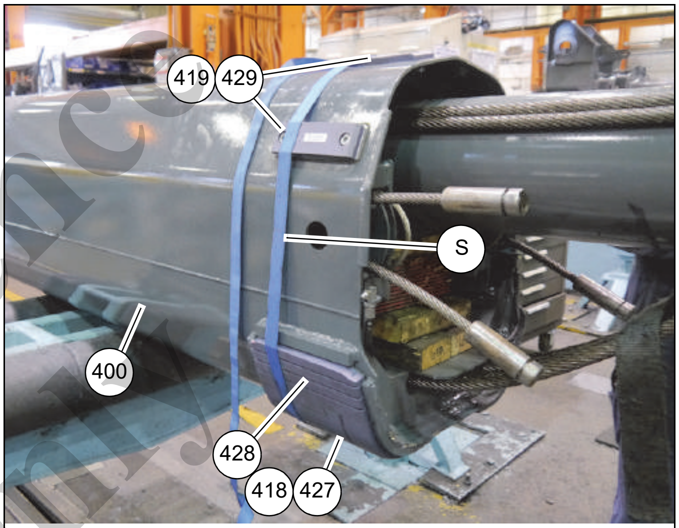
FIGURE 4-245

57. Attach grease hoses (457) to grease fittings (458) at rear of tele 3 (400). Route end of each grease hose (457) down through hole in bottom of tele 3 (400).

Attach each grease hose (457) to wear pad (427) using elbow (442) and adapter (411), then secure shims (418) and wear pads (427) to bottom rear of tele 3 (400) with clamp (R) (see Figure 4-245).

58. Install four wear pads (429) with shims (419) to top rear of tele 3 (400) using two bolts (443) for each wear pad (see Figure 4-246).

Install wear pads (428) to bottom rear of tele 3 (400). Secure wear pads (427, 428) in place using strap (S) (seeFigure 4-246). Note: Install strap around wear pads such that it is offset toward the front of tele 3 (400) as shown.



9688-57

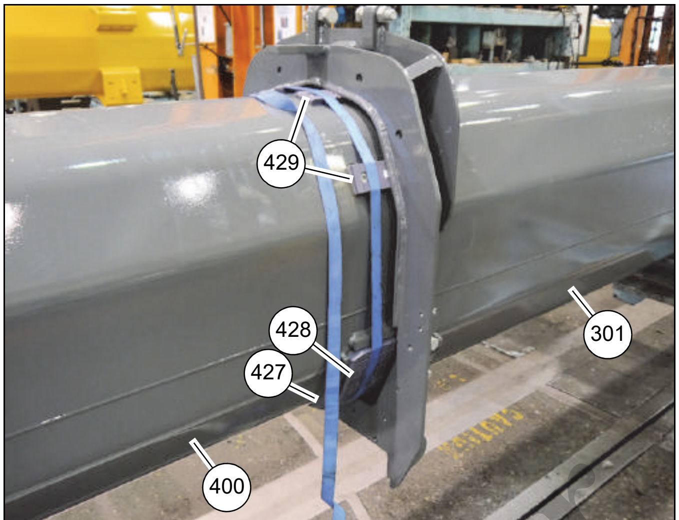
FIGURE 4-246

59. Position tele 2 (301) upside down on adequate supports in back of tele 3 (400).

60. Apply multipurpose grease to inside top and bottom of tele 2 (301).

61. Spray multipurpose grease on outside of tele 3 (400). Measuring approximately 1/4 of the distance of the boom from the tip, leave a 5 ft. wide strip of boom free of grease to install wear pads.

62. Insert tele 3 (400) into tele 2 (301) until wear pads (427, 428, 429) at rear of tele 3 (400) are just inside tele 2 (301) (see Figure 4-247).

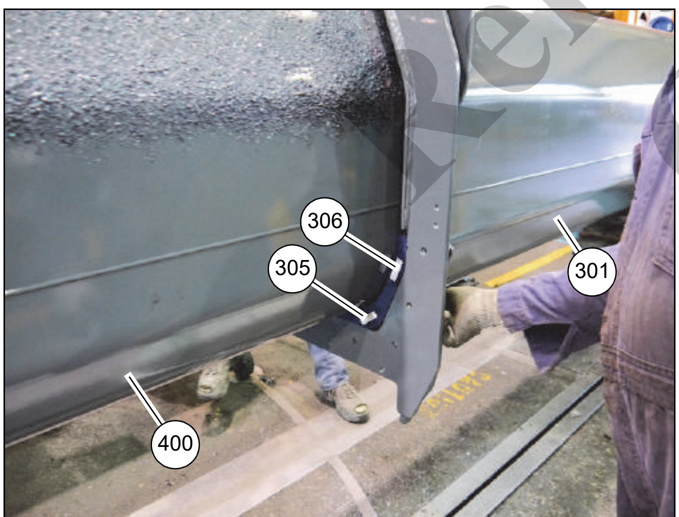


9688-59

FIGURE 4-247

63. Remove strap holding wear pads (427, 428) in place, then insert tele 3 (400) in to tele 2 (301) until all wear pads (427, 428, 429) are inside tele 2 (301).

64. Slightly raise tele 3 (400), then install wear pads (305, 306) in the left and right bottom corners between tele 3 (400) and tele 2 (301) (see Figure 4-248). Install wear pad adjusting bolts (335) and nuts (356) on each side of tele 2 (301), but do not tighten.

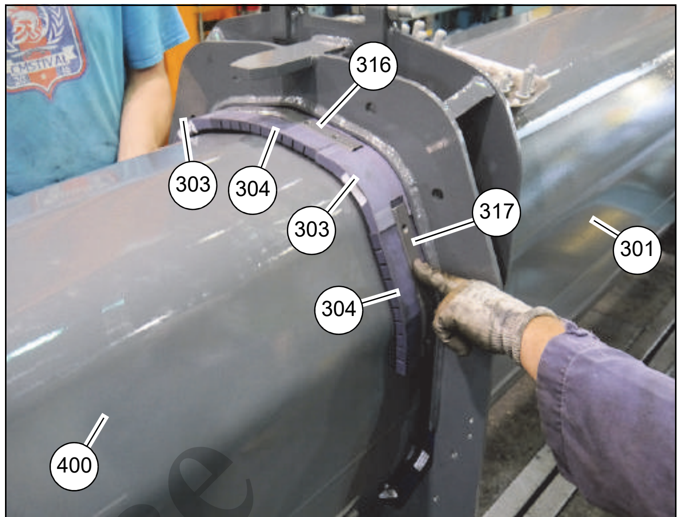


9688-62

FIGURE 4-248

65. Continue to insert tele 3 (400) into tele 2 (301) until tip of tele 2 (301) is at the area of tele 3 (400) which is free of grease.

66. Set wear pads (qty 2 - 303, qty 3 - 304) with bars (316, qty 2 - 317) on top of tele 3 (400) and tap into place between tele 3 (400) and tele 2 (301) (see Figure 4-249)

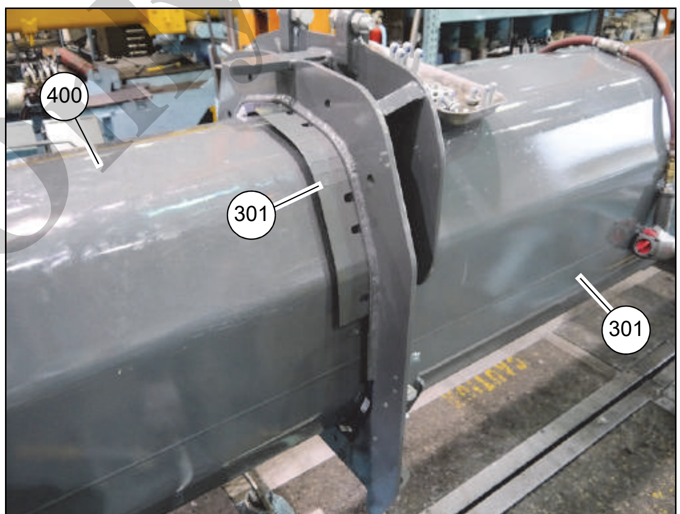


9688-60

FIGURE 4-249

67. Install bolts (332) and washers (347) through tip of tele 2 (301) and into bars (316, 317) holding wear pads (303, 304) – do not tighten bolts.

68. Install two shims (311) (per side) between wear pads (303, 304) and tele 2 (301) by gently tapping them with a rubber mallet or block of wood (see Figure 4-250).

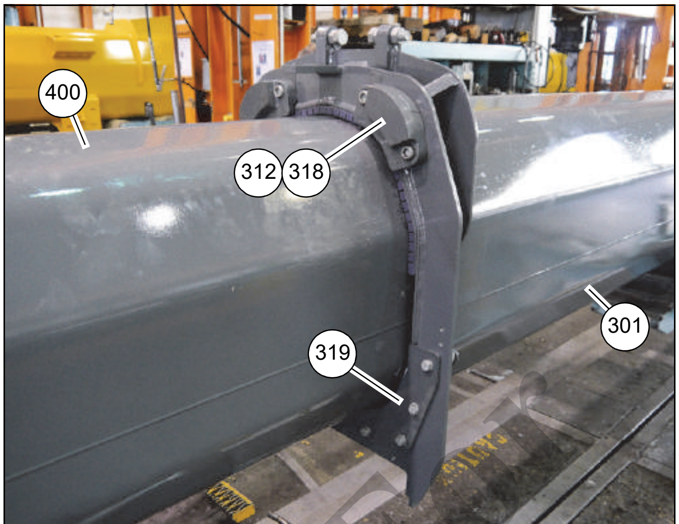


9688-61

FIGURE 4-250

69. Secure wear pads (303, 304) and shims (311) in place by tightening bolts (332) passing through holes in tele 2 (301) and into bars (316, 317).

70. Install top left and right side shims (312) and stop blocks (318) on to front of tele 2 (301) using bolts (333), flat washers (348), and nuts (354) (see Figure 4-251). Install bottom left and right side stop plates (319) on to front of tele 2 (301) using bolts (336), washers (353), lock washers (346), and nuts (344).



9688-63

FIGURE 4-251

71. Insert tele 3 (400) into tele 2 (301) while making sure the telescope cylinder (600) passes through the rear of tele 2 (301) without hitting it (see Figure 4-252). Also, the two extend cables (17, 18) on the left and right sides pass through holes in rear of tele 2 (301) (see Figure 4-253).

9688-64

FIGURE 4-252

9688-65

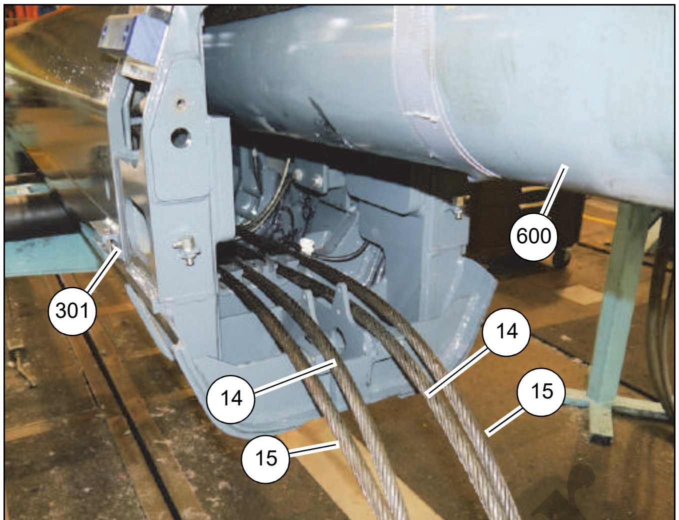
9688-66

FIGURE 4-253

72. Remove strap securing four extend cables (14, 15) to top and bottom of telescope cylinder (600).

73. Lift telescope cylinder (600) and then remove blocks of wood supporting the cylinder.

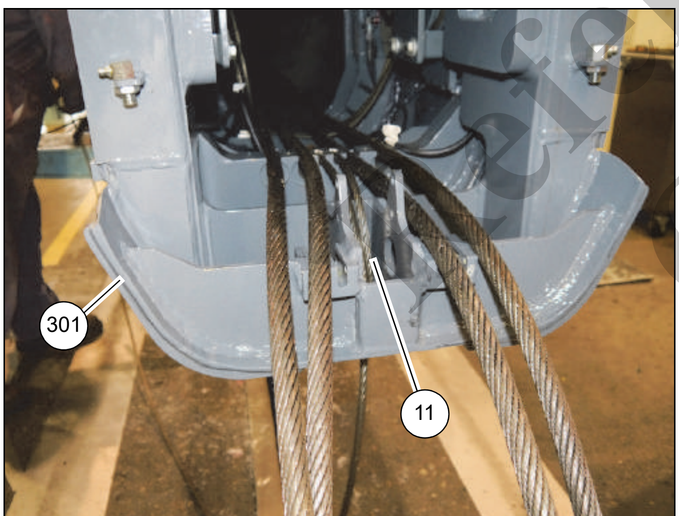
74. Make sure four extend cables (14, 15) pass through cable keepers in bottom rear of tele 3 (400) (see Figure 4-254).



9688-68

FIGURE 4-254

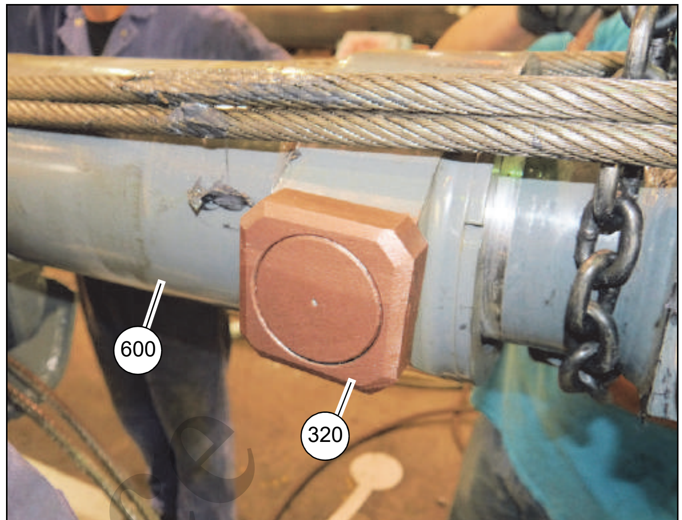
75. Install the anchor ends of two retract cables (11) up through hole in rear of tele 2 (301) and secure them in to center cable keepers on tele 3 (400) (see Figure 4-255). Route threaded ends of retract cables (11) to front of tele 2 (301).



9688-70

FIGURE 4-255

76. Apply anti-seize compound to trunnion blocks (320) and to trunnion on telescope cylinder (600), then install trunnion blocks (320) onto left and right sides of telescope cylinder (600) (see Figure 4-256).

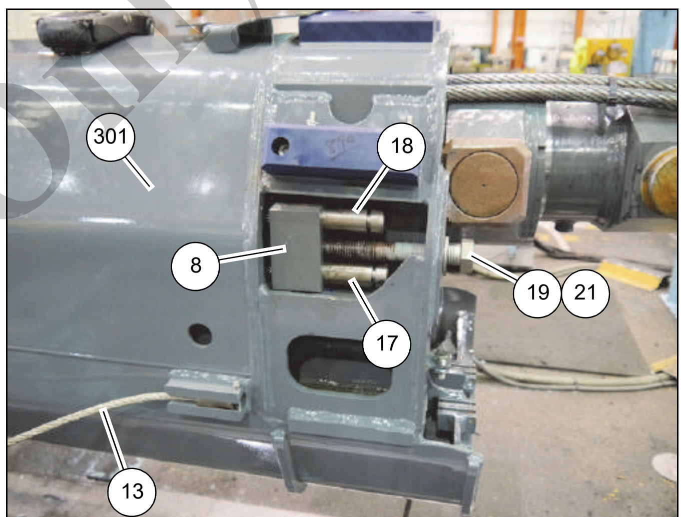


9688-69

FIGURE 4-256

77. Install two extend cables (13) in to cable holder on left and right sides of tele 2 (301) (see Figure 4-257). Secure cable ends in place using bolts (341), lock washers (351), and nuts (326).

Route opposite ends of extend cables (13) to front of tele 2 (301).



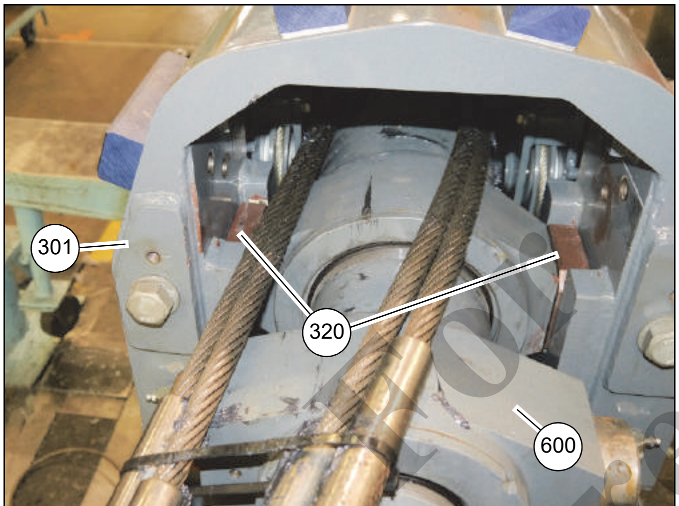
9688-67

FIGURE 4-257

78. Install cable anchor (8) in to the left and right sides of tele 2 (301), making sure cable ends of the two extend cables (17, 18) are seated into each cable anchor (8) (see Figure 4-257).

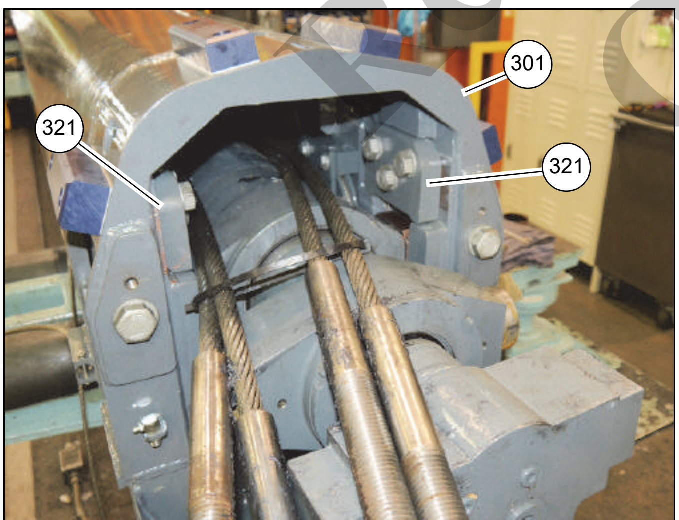
79. Apply anti-seize compound to threads of bolts (19), then install the bolts (19) with washer (21) through the rear of tele 2 (301) and in to cable anchors (8) (see Figure 4-257). Install bolts (19) until bolt tips are flush with cable anchors (8) (see Figure 4-257).

80. Insert telescope cylinder (600) in to tele 2 (301) until trunnion blocks (320) on rear of telescope cylinder (600) align with corresponding slots in rear of tele 2 (301). Lower telescope cylinder (600) ensuring the trunnion blocks (320) drop into the slots (see Figure 4-258).



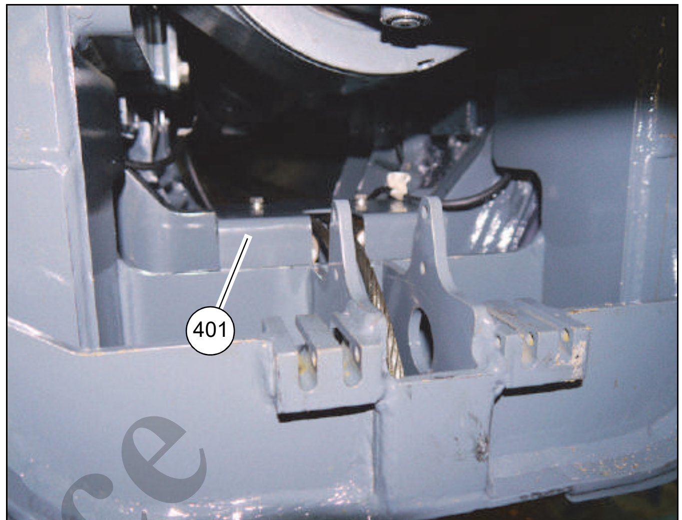
9688-71 **FIGURE 4-258**

81. Install plates (321) to the inside left and right sides of tele 2 (301) using bolts (324) and washers (323) (see Figure 4-259).



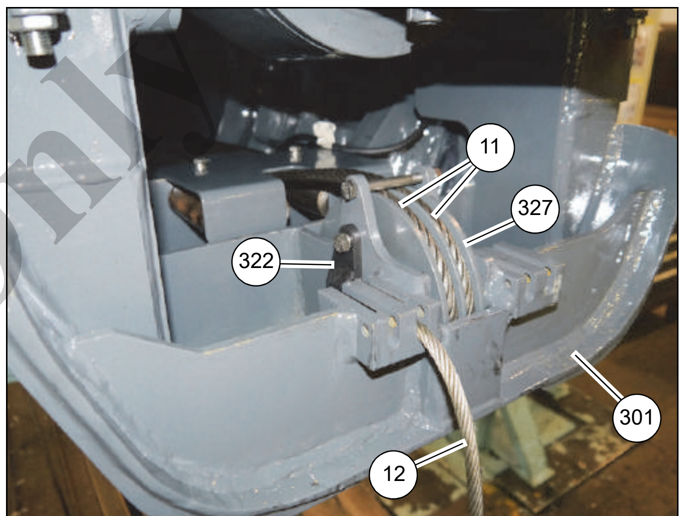
9688-76 **FIGURE 4-259**

82. Install cover plate (401) over the four extend cables (14, 15) and the two retract cables (11) using bolts (402), lock washers (446), and flat washers (447) (see Figure 4-260).



9688-72 **FIGURE 4-260**

83. Install cable end of one retract cable (12) in to the left center cable keeper at rear of tele 2 (301) (see Figure 4-261).



9688-73 **FIGURE 4-261**

84. Install sheave assembly (327) in to rear of tele 2 (301) ensuring the two retract cables (11) wrap around the sheave assembly (327) (see Figure 4-261).

Secure sheave assembly (327) to tele 2 (301) by installing shaft weldment (322) through tele 2 (301) and sheave assembly (327) while making sure a thrust

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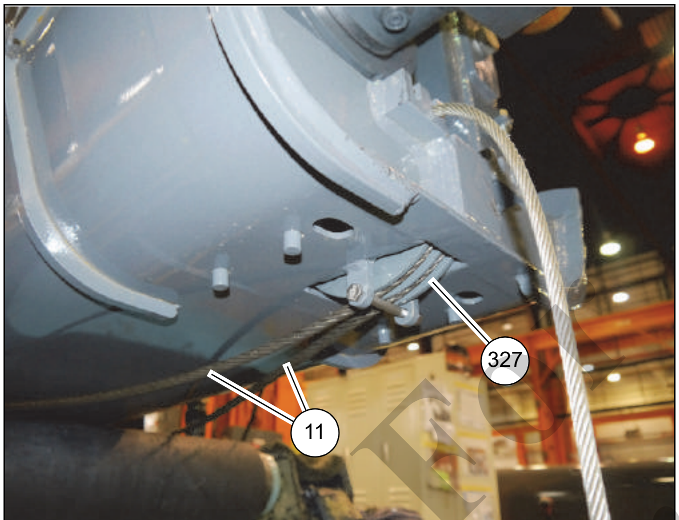
washer (349) is installed on each side of the sheave assembly (327) (Figure 4-261).

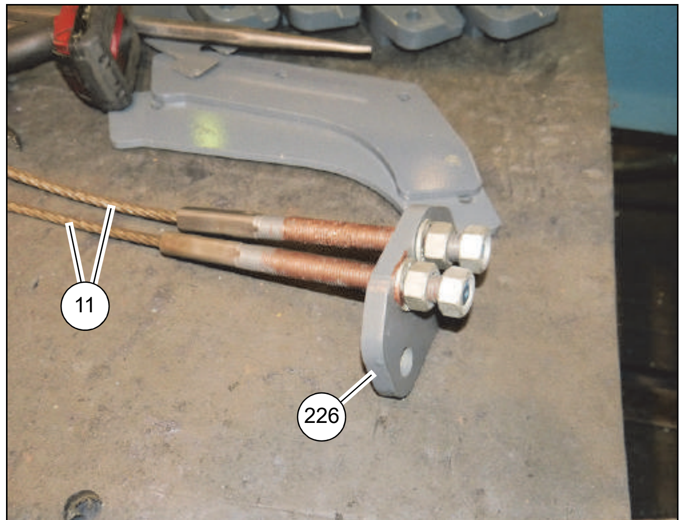
Secure shaft weldment (322) in place using bolt (339) (see Figure 4-261).

85. Install bolts (340), lock washers (350), and nuts (357) at top and bottom of sheave assembly (327) to retain the two retract cables (11) on sheave assembly (327) (see Figure 4-261 and Figure 4-262).



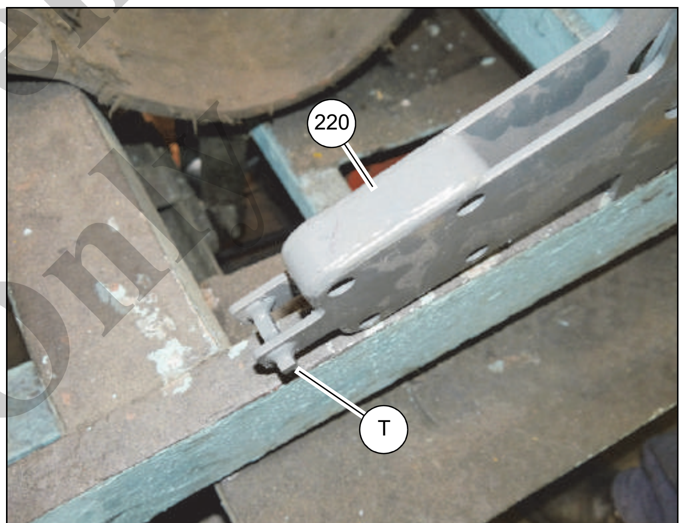
9688-74 **FIGURE 4-262**

86. Install threaded ends of two retract cables (11) in to holes in plate (226). Secure each cable end with two nuts (262) and one washer (266) (Figure 4-263).



9688-75 **FIGURE 4-263**

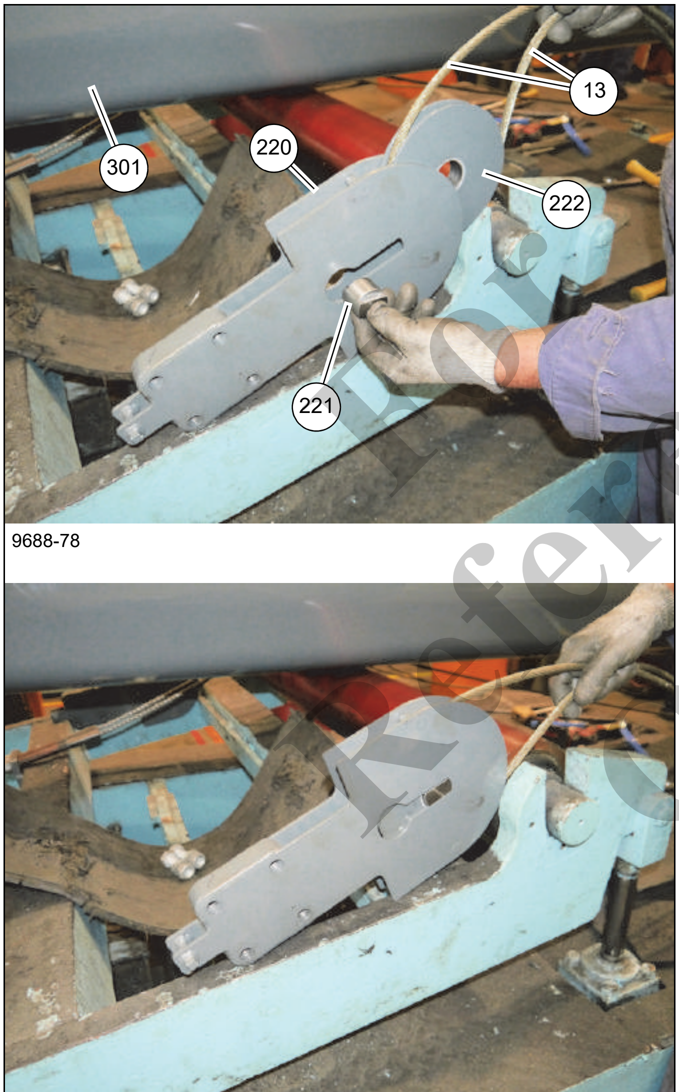
87. Place a sheave mount weldment (220) at the front left and right sides of tele 2 (301). Position the sheave mount weldments (220) with the square pin (T) to the front of tele 2 (301) and away from it (Figure 4-264).



9688-77 **FIGURE 4-264**

88. Install extend cable (13) around sheave (222), ensuring the loose end of cable wraps around top of sheave first and then exits at the bottom of the sheave (222) and back to rear of tele 2 (301) (see Figure 4-265).

Install sheave (222) with retract cable (13) into sheave mount weldment (220) until shaft (221) can be installed through the sheave mount weldment (220) and sheave (222). Pull retract cable (13) toward rear of tele 2 (301) to seat the shaft/sheave assembly into the sheave mount weldment (220) (see Figure 4-265).

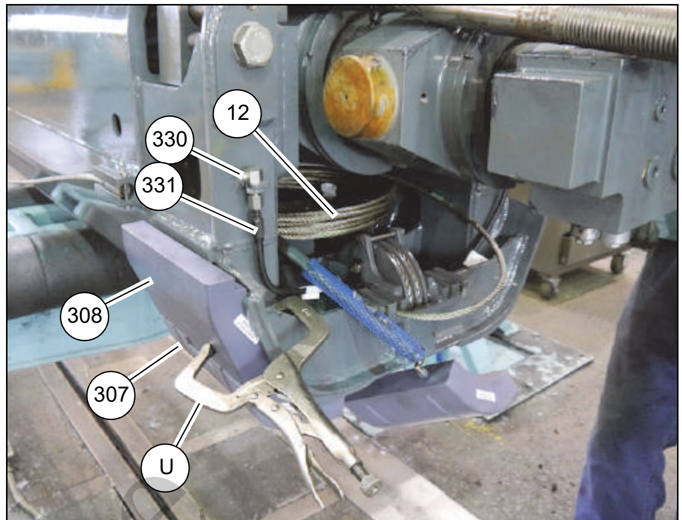


9688-78

9688-79

FIGURE 4-265

89. Coil the one retract cable (12) and place it inside the tele sections (Figure 4-266).



9688-80

FIGURE 4-266

90. Install grease fittings (330) to rear of tele 2 (301) using nuts (338) (see Figure 4-266). Orient grease fittings such that they point outward.

91. Attach grease hoses (331) to grease fittings (330) at rear of tele 2 (301). Route end of each grease hose down through hole in bottom of tele 2 (301) (see Figure 4-266).

92. Attach each grease hose (331) to wear pad (307) using elbow (329) and adapter (328), then install a set of wear pads (307, 308) and three shims (313) to the left and right sides of tele 2 (301). Secure wear pads in place with clamps (U) (see Figure 4-266).

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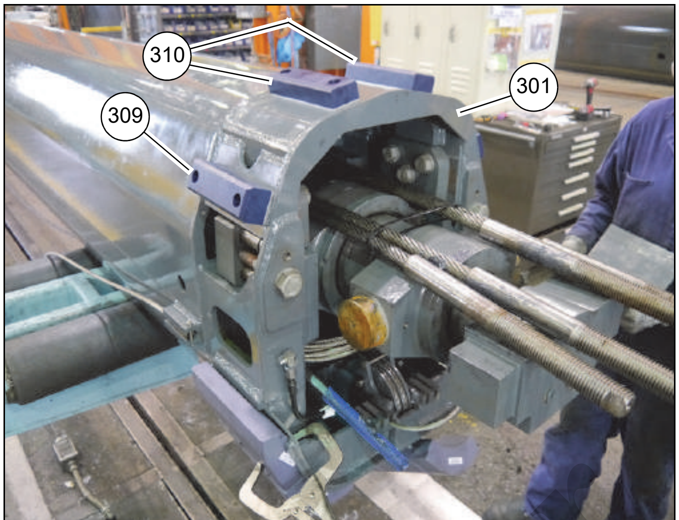
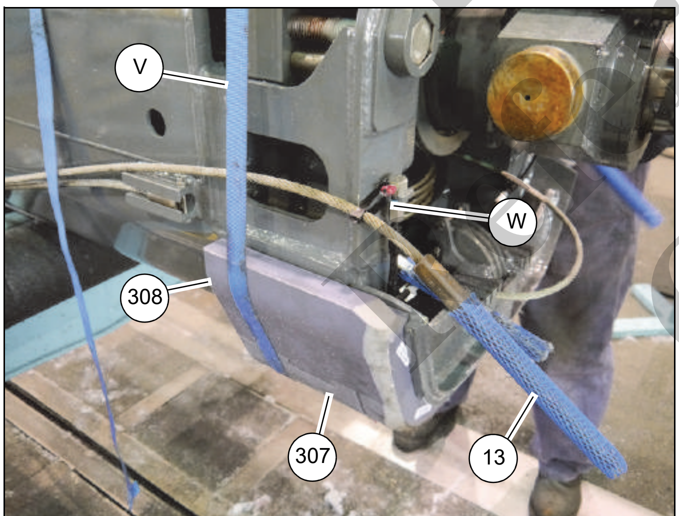
93. Install four wear pads (qty 2 - 309, qty 2 - 310) with shims (314, 315) to rear of tele 2 (301) using two bolts (337) for each wear pad. (see Figure 4-267).



9688-81 **FIGURE 4-267**

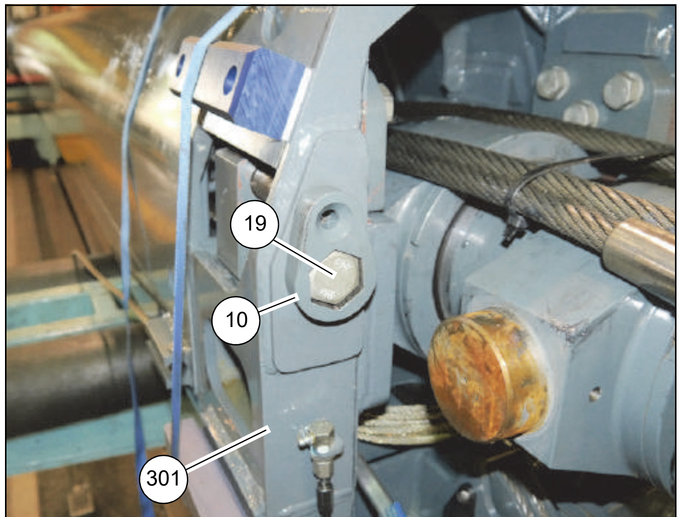
94. Secure wear pads (307, 308) in place using strap (V). Note: Install strap around wear pads such that it is offset toward the front of tele 2 as shown. (see Figure 4-268).



9688-82 **FIGURE 4-268**

95. Using zip-ties (W), secure ends of left and right extend cables (13) to sides of tele 2 (301) to ease installation in to tele 1 (201) (see Figure 4-268).

96. Install bolt retainer (10) over head of bolt (19) on left and right sides of tele 2 (301). Secure each bolt retainer (10) in place using a bolt (20) (see Figure 4-269).



9688-83 **FIGURE 4-269**

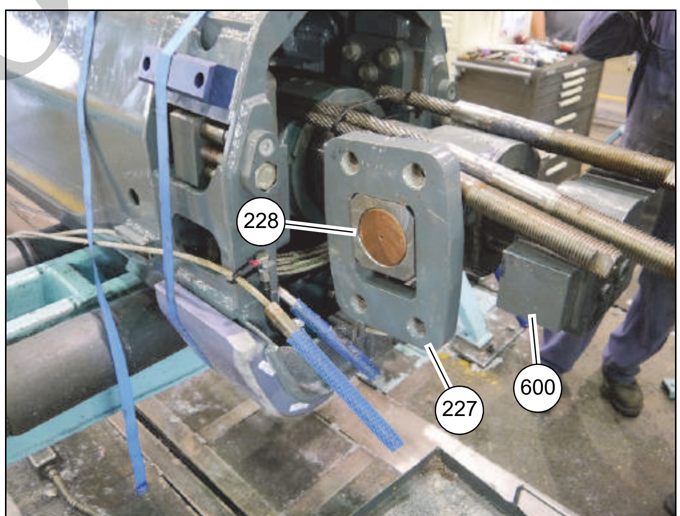
97. Position tele 1 (201) upside down on adequate supports in back of tele 2 (301).

98. Apply multipurpose grease to inside top and bottom of tele 1 (201).

99. Spray multipurpose grease on outside of tele 2 (301). Measuring approximately 1/4 of the distance of the boom from the tip, leave a 5 ft. wide strip of boom free of grease to install wear pads.

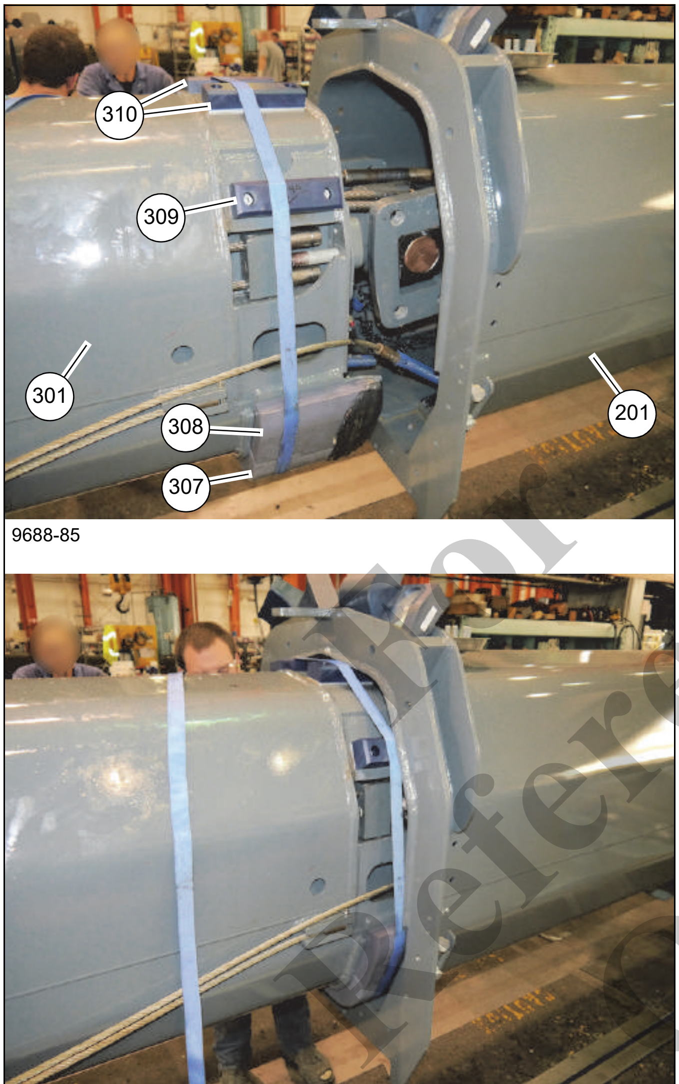
100. Apply an anti-seize compound to trunnion of telescope cylinder (600), then install a block (228) to left and right sides of telescope cylinder trunnion (see Figure 4-270).

Install a trunnion plate (227) on to each block (228) (see Figure 4-270).



9688-84 **FIGURE 4-270**

101. Insert tele 2 (301) into tele 1 (201) until wear pads (307, 308, 309, 310) at rear of tele 2 (301) are just inside tele 1 (201) (see Figure 4-271).



9688-85

9688-86

FIGURE 4-271

102. Remove strap holding wear pads (307, 308) in place, then insert tele 2 (301) in to tele 1 (201) until all wear pads are inside tele 2.

103. Slightly raise tele 2 (301), then install wear pads (305, 306) in the left and right bottom corners between tele 2 (301) and tele 1 (201) (see Figure 4-272). Install wear pad adjusting bolts (335) and nuts (356) on each side of tele 1 (201), but do not tighten.

9688-87

FIGURE 4-272

104. Continue to insert tele 2 (301) into tele 1 (201) until tip of tele 1 (201) is at the area of tele 2 (301) which is free of grease.

105. Lift sheave mount weldment (220) in to place next to tele 2 (301). Reach in to rear of tele 1 (201) and begin to pull the extend cable (13), which was attached to outside of tele 2 (301) using zip-ties, to the rear of tele 1 (201). Route extend cable (13) through hole in rear of tele 1 (201) (left and right sides) (see Figure 4-273). Make sure cables are not twisted. Pull extend cable (13) out rear of tele 1 (201) until bolt holes in sheave mount weldment (220) align with holes at front of tele 1 (201). Secure sheave mount weldments (220) to inside of tele 1 (201) using bolts (244) and washers (253) (see Figure 4-273).

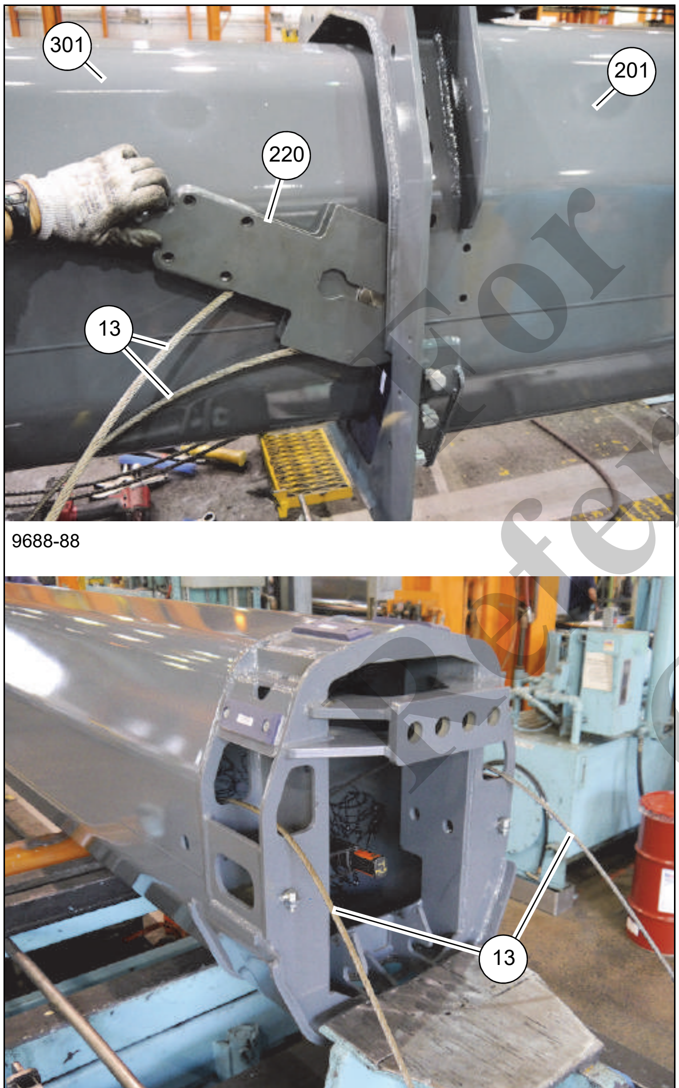


FIGURE 4-273

106. Set wear pads (203, qty 2 - 204, qty 2 - 205) with bars (216, qty 2 - 217) on top of tele 2 (301) and tap into place between tele 2 (301) and tele 1 (201) (see Figure 4-274)

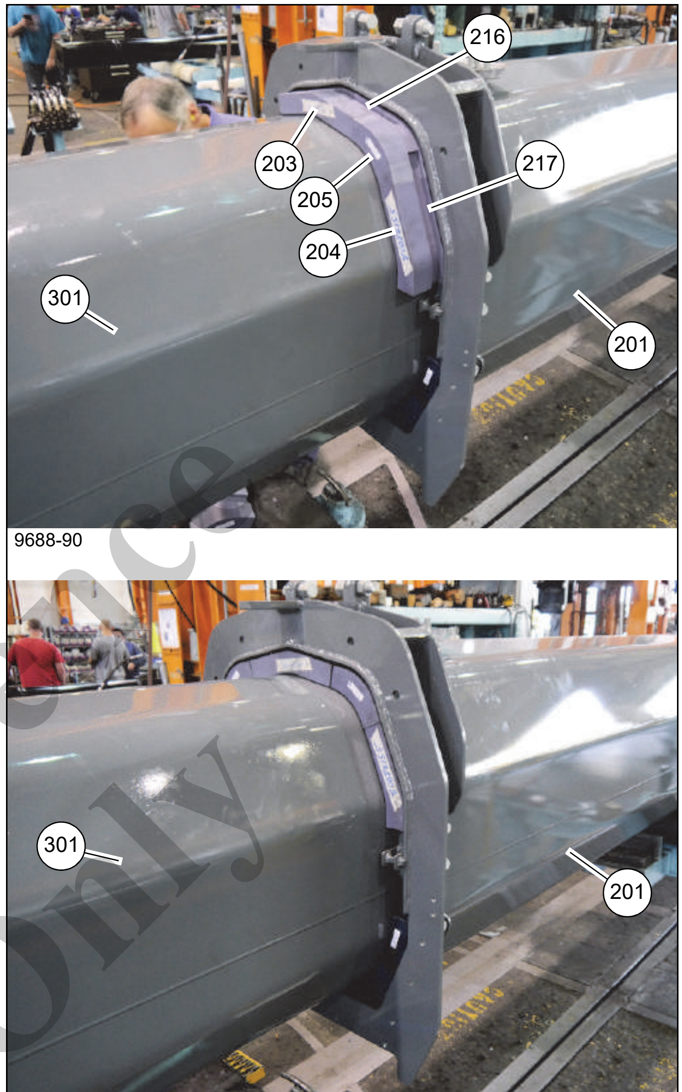
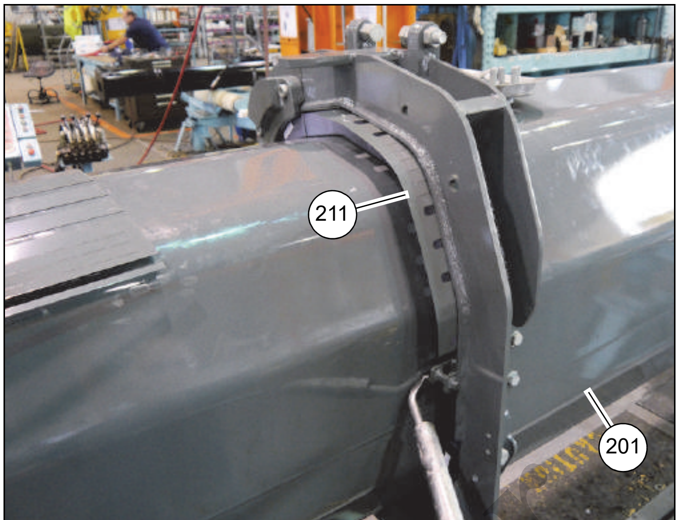


FIGURE 4-274

107. Install bolts (239) with nuts (253) through tip of tele 1 (201) and into bars (216, 217) holding wear pads (203, 204, 205) – do not tighten bolts.

108. Install two shims (211) between wear pads (203, 204, 205) and tele 1 (201) by gently tapping them with a rubber mallet or block of wood (see Figure 4-275).

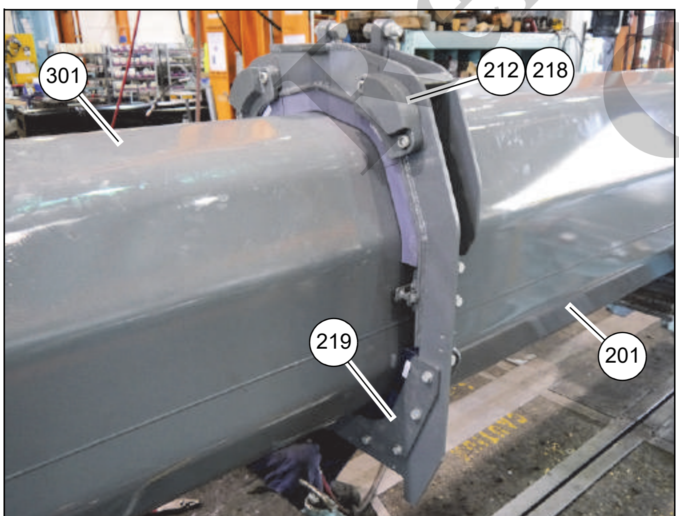


9688-92

FIGURE 4-275

109. Secure wear pads (203, 204, 205) and shims (211) in place by tightening bolts (239) passing through holes in tele 1 (201) and into bars (216, 217).

110. Install top left and right side shims (212) and stop blocks (218) on to front of tele 1 (201) using bolts (240), washers (254) and nuts (261) (see Figure 4-276). Install bottom left and right side stop plates (219) on to front of tele 1 (201) using bolts (242), washers (251), lock washers (252), and nuts (260) (see Figure 4-276).



9688-93

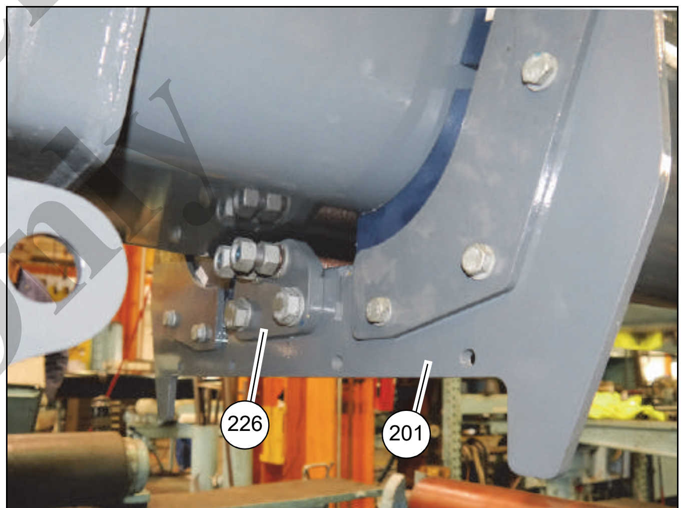
FIGURE 4-276

111. Insert tele 2 (301) in to tele 1 (201) until tele 2 is within 0.45 m (1-1/2 ft) of being fully inserted (Figure 4-277).

9688-94

FIGURE 4-277

112. Install plate (226) on to front end of tele 1 (201) using two bolts (245), washers (255), and nuts (262) (Figure 4-278).

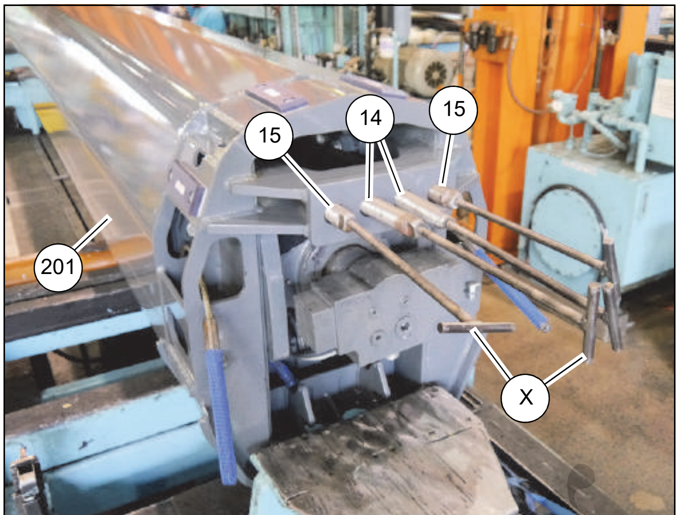


9688-95

FIGURE 4-278

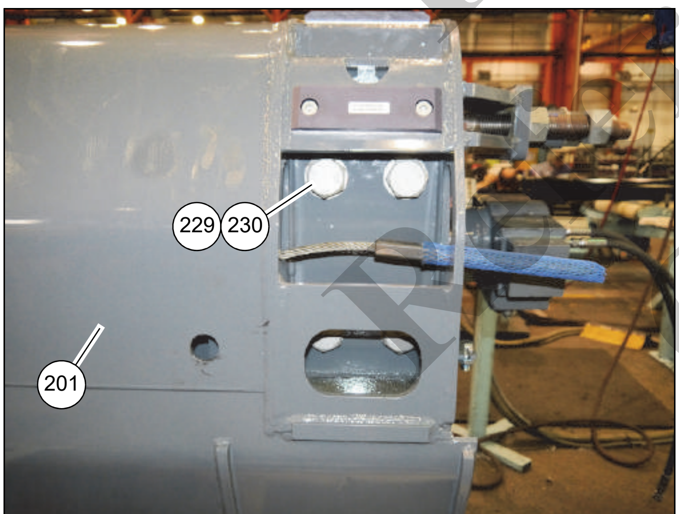
4

113. Using threaded rods (X) or similar, pull four extend cables (14, 15) through holes in rear of tele 1 (201) (Figure 4-279). Fully insert tele 2 (301) into tele 1 (201).



9688-96 **FIGURE 4-279**

114. Secure each trunnion plate (227) to tele 1 (201) using four bolts (230) and washers (229) (left and right sides) (see Figure 4-280).

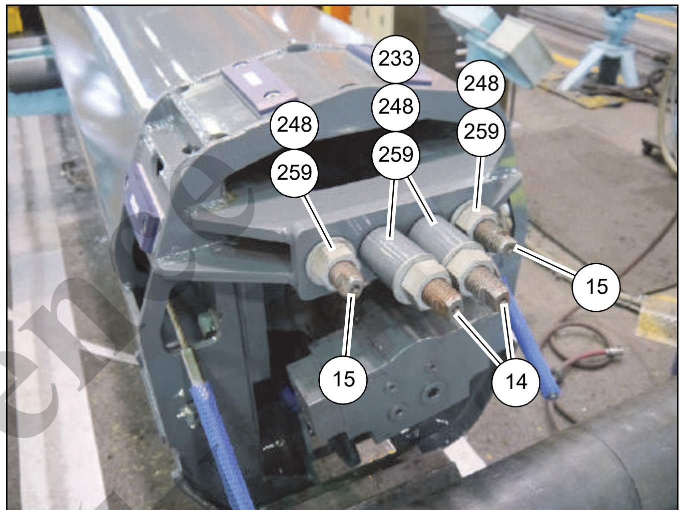


9688-98 **FIGURE 4-280**

115. Apply anti-seize compound to the threaded ends of the four extend cables (14, 15).

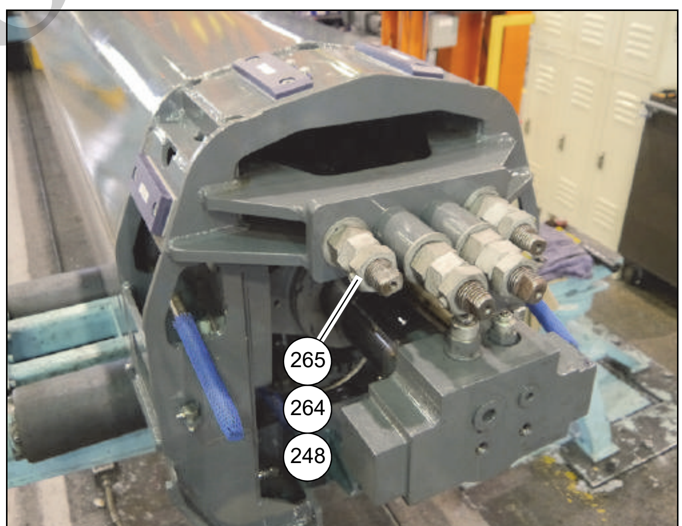
116. Install a washer (259) and nut (248) on to the threaded ends of the two outside extend cables (15). Turn nut (248) until a distance of 102 mm (4 in) is measured from the washer to the tip of the cable end (Figure 4-281). Note: When installing the nut, hold cable by its flats to prevent the cable from turning.

Install a spacer (233), washer (259), and nut (248) on to the threaded ends of the two inside extend cables (14). Turn nuts (248) until a distance of 102 mm (4 in) is measured from the washer to the tip of the cable end (Figure 4-281). Note: When installing the nut, hold cable by its flats to prevent the cable from turning.



9688-97 **FIGURE 4-281**

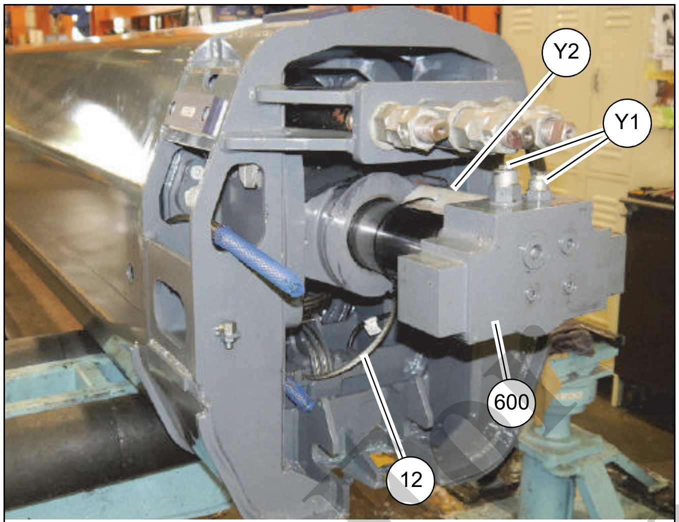
117. After cleaning threads of anti-seize compound, install jam nuts (248) on to each extend cable (14, 15) using a thread locking compound followed by nuts (264) with set screws (265) (see Figure 4-282).



9688-99 **FIGURE 4-282**

118. Rotate end of telescope cylinder (600) until the two holding valve cartridges (Y1) point up.

Pull telescope cylinder (600) out approximately 240 mm (9-1/2 in). Cut a section of angle-iron measuring 240 mm (9-1/2 in) in length. Cover edges of angle-iron with edge guard. Using zip-ties, attach angle-iron (Y2) to telescope cylinder chrome tube (see Figure 4-283).

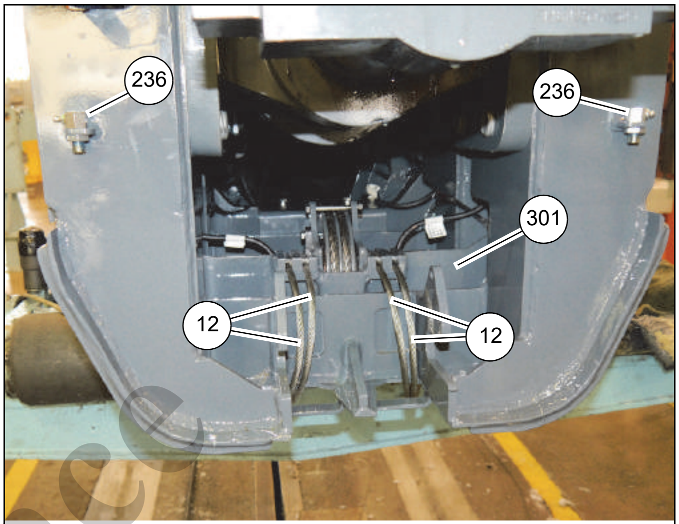


9688-100

FIGURE 4-283

119. Pull the one coiled retract cable (12) out of rear of teles and route up toward front of teles (see Figure 4-283).

120. Install cable ends of remaining three retract cables (12) into cable keepers at rear of tele 2 (301) (see Figure 4-284). Route all cables to the front of teles. Secure cable ends in place using two bolts (342), lock washers (351), and nuts (326).

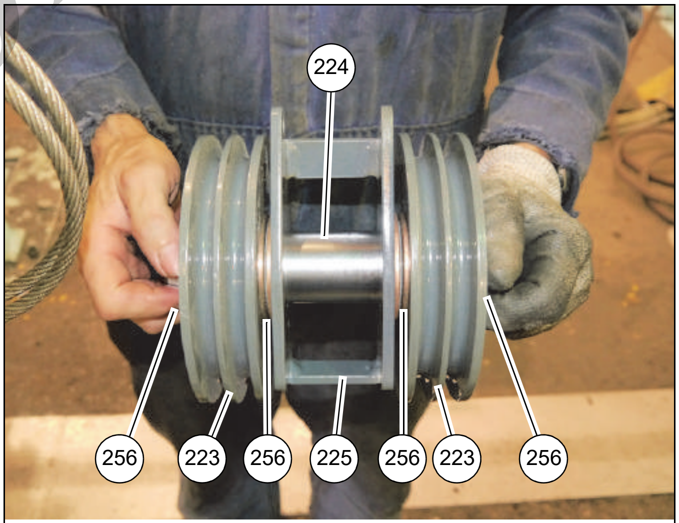


9688-101

FIGURE 4-284

121. Install grease fittings (236) to rear of tele 1 (201) using nuts (250). Orient grease fittings such that they point outward (see Figure 4-284).

122. Assemble sheave assembly by installing the following components on to shaft (224) in the following order - one thrust washer (256), one sheave assembly (223), one thrust washer (256), guard weldment (225), one thrust washer (256), one sheave weldment (223), and one thrust washer (256) (see Figure 4-285).



9688-102

FIGURE 4-285

123. Install shaft (224) of sheave assembly into rear of tele 1 (201), ensuring the four retract cables (12) wrap around the sheaves (223) (see Figure 4-286). Install bolts (246), lock washers (257), and nuts (232) at top of each sheave assembly to retain the retract cables (12) on the sheaves (223).

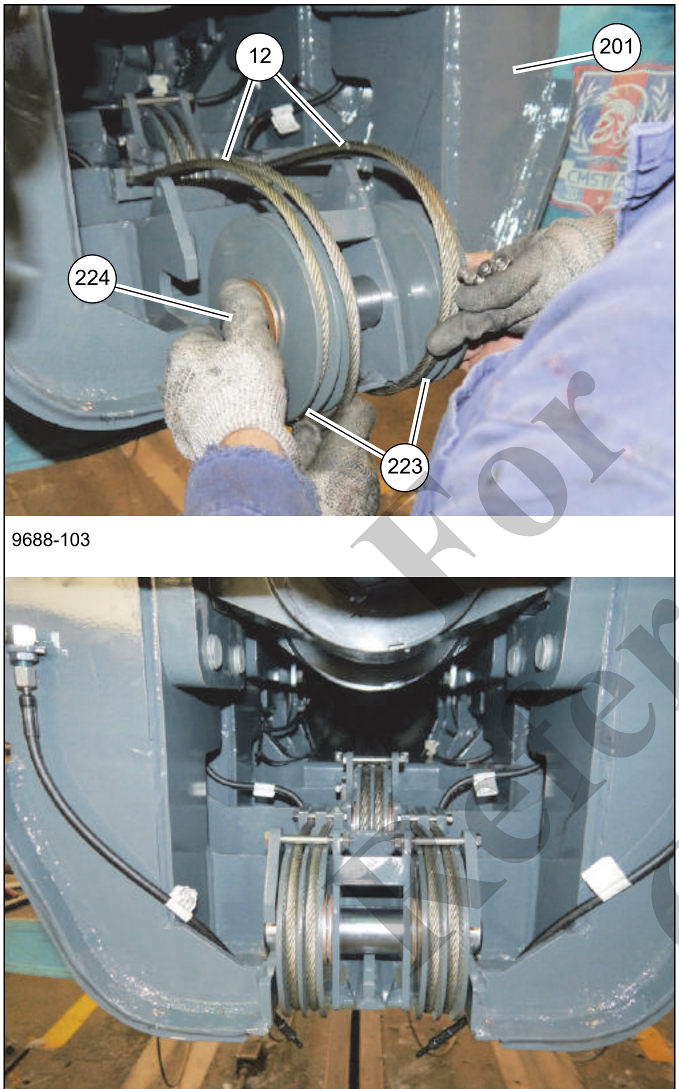


FIGURE 4-286

124. Attach grease hoses (237) to grease fittings (236) at rear of tele 1 (201). Route end of each grease hose down through hole in bottom of tele 1 (201) (see Figure 4-287).

Attach grease hoses (237) to wear pads (208) using elbows (235) and adapters (234), then secure shims (213) and wear pads (208, 209) to bottom rear of tele 1 (201) with clamp (Z) (see Figure 4-287).

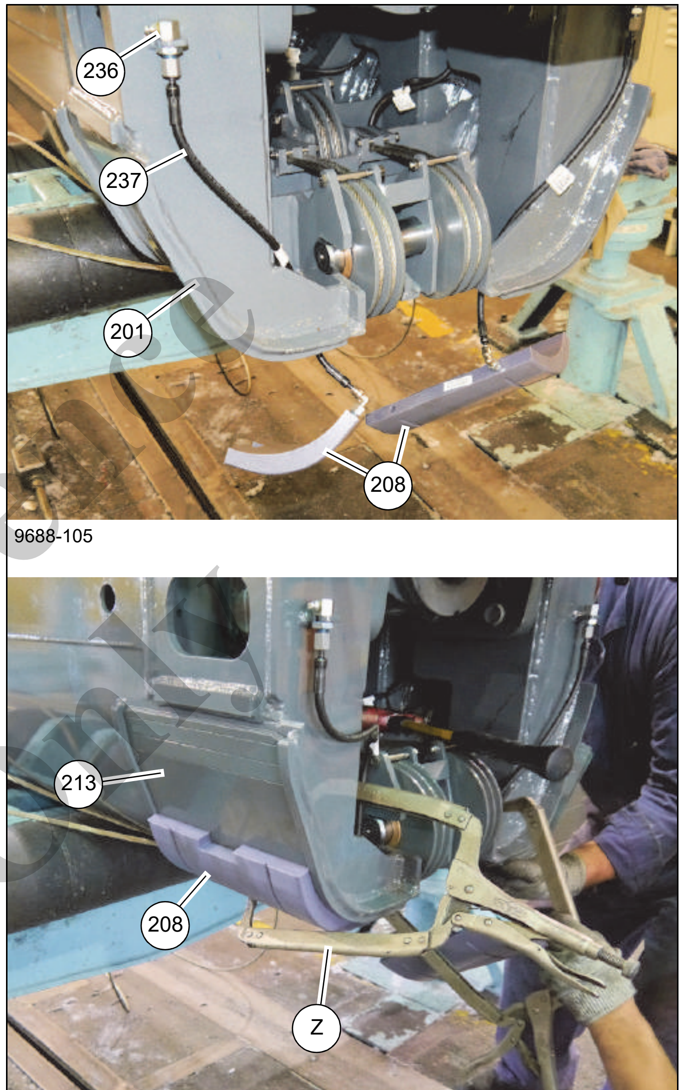
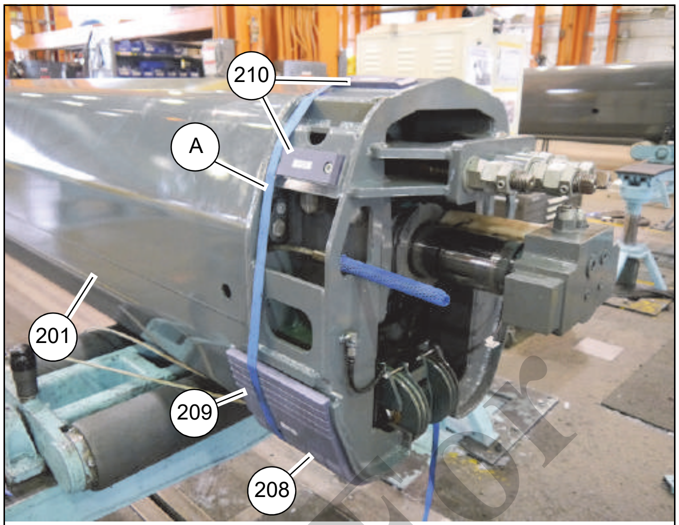


FIGURE 4-287

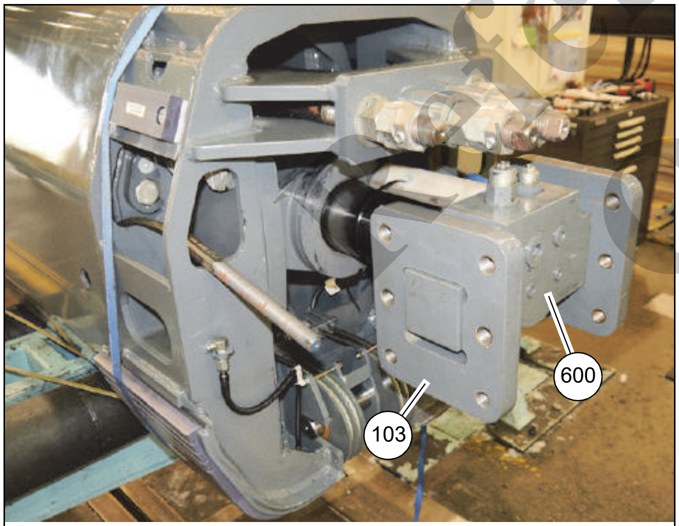
125. Install four wear pads (210) with shims (214, 215) to top rear of tele 1 (201) using two bolts (247) for each wear pad (see Figure 4-288).

Secure wear pads (208, 209) in place using strap (A). Note: Install strap around wear pads (208, 209) such that it is offset toward the front of tele 1 as shown.



9688-107 FIGURE 4-288

126. Install trunnion plates (103) on to rear of telescope cylinder (600) (see Figure 4-289).

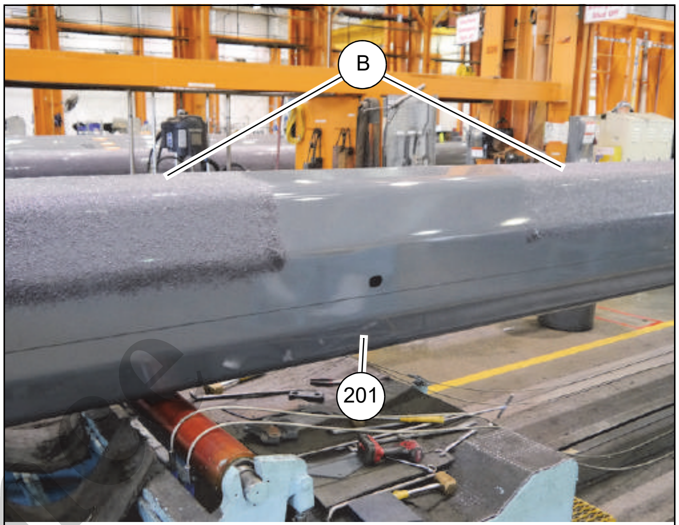


9688-108 FIGURE 4-289

127. Position base (101) upside down on adequate supports in back of tele 1 (201).

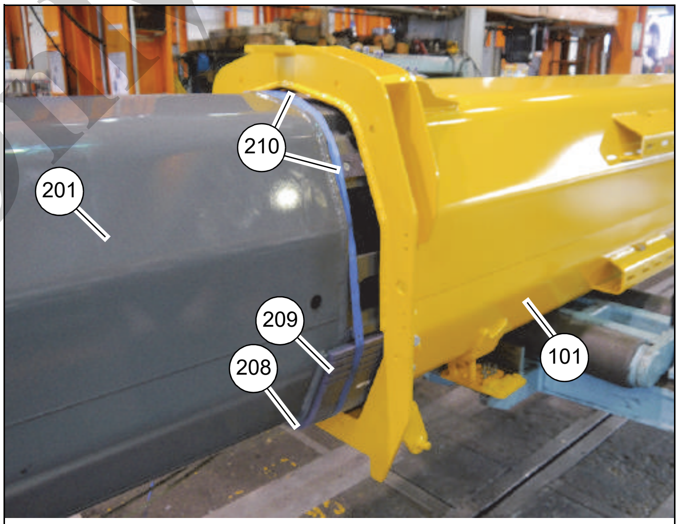
128. Apply multipurpose grease to inside top and bottom of base (101).

129. Spray multipurpose grease (B) on outside of tele 1 (201). Measuring approximately 1/4 of the distance of the boom from the tip, leave a 5 ft. wide strip of boom free of grease to install wear pads (see Figure 4-290.



9688-109 FIGURE 4-290

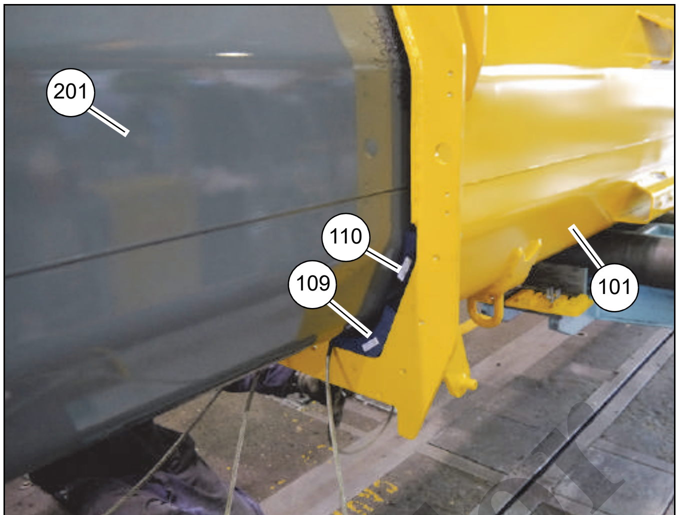
130. Insert tele 1 (201) into base (101) until wear pads (208, 209, 210) at rear of tele 1 (201) are just inside base (101) (see Figure 4-291).



9688-110 FIGURE 4-291

131. Remove strap holding wear pads (208, 209) in place, then insert tele 1 (201) in to base (101) until all wear pads are inside base.

132. Slightly raise tele 1 (201), then install wear pads (109, 110) in the left and right bottom corners between tele 1 (201) and base (101) (see Figure 4-292). Install wear pad adjusting bolts (127) and nuts (143) on each side of base (101), but do not tighten.



9688-62

FIGURE 4-292

133. Continue to insert tele 1 (201) into base (101) until tip of base is at the area of tele 1 (201) which is free of grease.

134. Pull four retract cables (12) back through tip of tele 1 (201) and base (101) and route cable ends down through hole in tip of base (101) and then through four holes at front of base (101) (see Figure 4-293). Make sure cables do not cross one another.

9688-112

FIGURE 4-293

135. Install cable retainer plate (119) above the four retract cables (12), ensuring the cables seat in to grooves (see Figure 4-293).

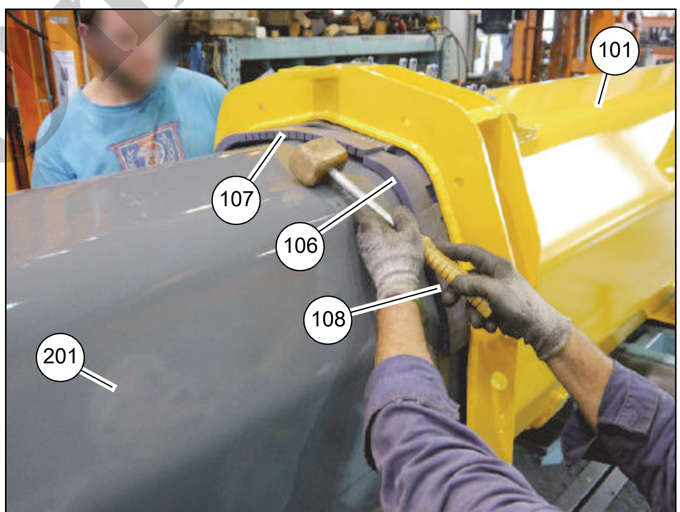
136. Attach cable retainer plate (119) to cable mount weldment (118) using two bolts (146) and washers (138), then attach cable mount weldment (118) to bottom of base (101) using four bolts (146) and washers (138) (see Figure 4-294).

9688-113

FIGURE 4-294

137. Apply anti-seize compound to threaded ends of the four retract cables (12), then install two nuts (131) with one washer (136) on to the threaded end of each cable (12).

138. Set wear pads (qty 2 - 106, 107, qty 2 - 108) with bars (113, qty 2 -114) on top of tele 1 (201) and tap into place between tele 1 (201) and base (101) (see Figure 4-295).

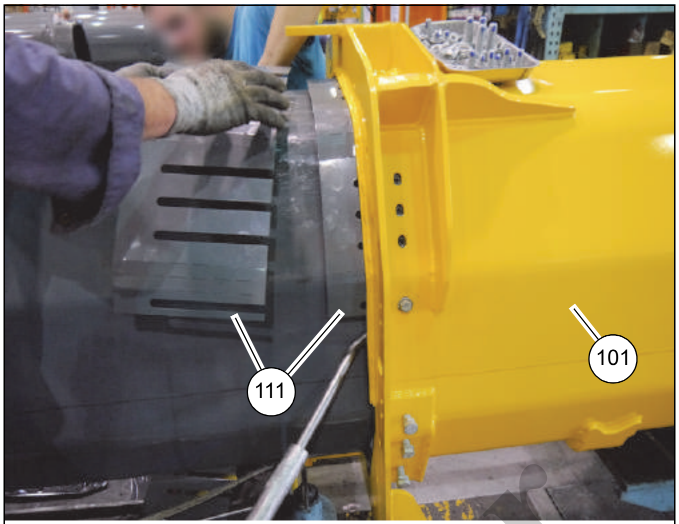


9688-114

FIGURE 4-295

139. Install bolts (122) with washers (134) through tip of base and into bars (113, 114) holding wear pads (106, 107, 108) – do not tighten bolts.

140. Install two shims (111) between wear pads (106, 107, 108) and base (101) by gently tapping them with a rubber mallet or block of wood (see Figure 4-296).

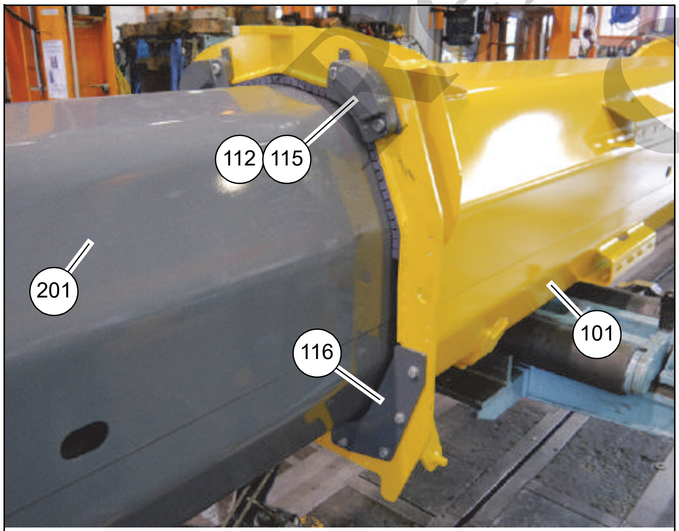


9688-116

FIGURE 4-296

141. Secure wear pads (106, 107, 108) and shims (111) in place by tightening bolts (122) passing through holes in base (101) and into bars (113, 114).

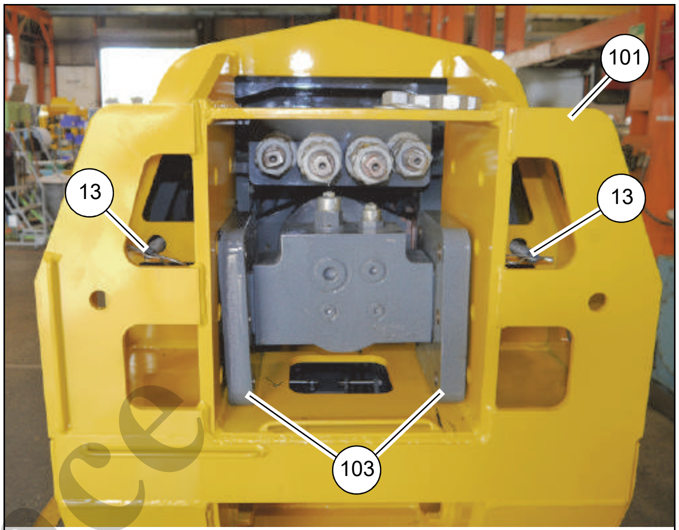
142. Install top left and right side shims (112) and stop blocks (115) on to front of base (101) using bolts (125), washers (135), and nuts (142) (see Figure 4-297). Install bottom left and right side stop plates (116) on to front of base (101) using bolts (126), washers (132), lock washers (133), and nuts (141).



9688-117

FIGURE 4-297

143. Insert tele 1 (201) into base (101) until holes in trunnion plates (103) on rear of telescope cylinder (600) align with holes in rear of base (101). At same time, two extend cables (13) pass through holes in rear of base (101) (see Figure 4-298).

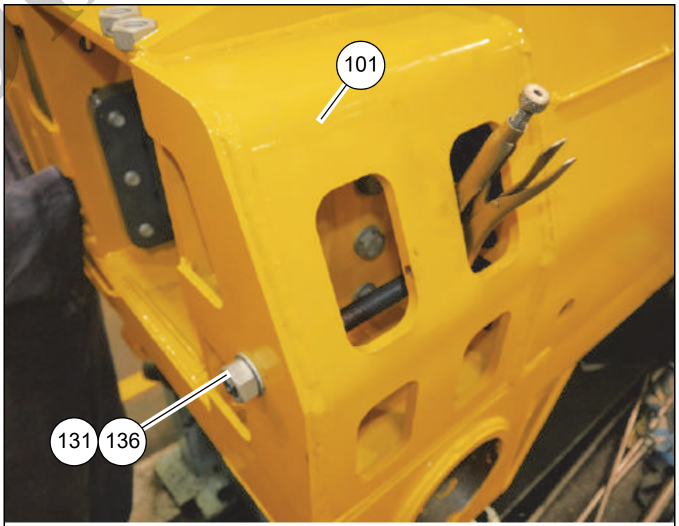


9688-118

FIGURE 4-298

144. Secure trunnion plates (103) to base (101) using bolts (123) and washers (136).

145. Apply anti-seize compound to the threaded ends of extend cables (13), then install a washer (136) and two nuts (131) (see Figure 4-299). Thread nuts on to cable ends until a measurement of 45 mm (1-3/4 in) is attained between bottom of washer and cable end (seeFigure 4-299).



9688-119

FIGURE 4-299

146. Remove block of wood that was placed against telescope cylinder chrome tube and held in place with zip-tie.

EXTEND AND RETRACT CABLES - TENSIONING

Tensioning the 4-Section Boom Extend and Retract Cables

The boom extend and retract cables must be tensioned after the boom has been rebuilt and any time the cables appear to be loose.

Perform the following procedure to tension the extend and retract cables:

CAUTION

When adjusting cables, use two wrenches. Hold the “flat” on the cable and turn the adjusting nut.

Do not allow the cables to twist. Cable failure could result.

- When tightening or loosening the cables, secure the cables using the flats at the front of the cable ends to prevent the cables from twisting.
- Make sure all tensioning nuts thread on and off of the threaded studs by hand; weld spalls or thread damage will adversely affect torque values.

WARNING

To prevent serious injury or death, always wear personal protective equipment, including a hard hat, eye protection, gloves and metatarsal boots.

CAUTION

Possible Cable Damage!

Use of an impact wrench to tighten the cable tensioning nuts can cause the extend and retract cables to twist, resulting in cable failure.

Do not use an impact wrench when tensioning the extend and retract cable.

1. Fully retract the boom and position the boom to horizontal.
2. Extend the boom approximately 25 mm (1 in) to relieve tension on the retract cables.
3. Adjust the retract cables at the front of tele 1 and tele 2 to remove the slack from the cables.
4. Retract the boom approximately 25 mm (1 in) to relieve tension on the extend cables.
5. Adjust the extend cables at the rear of the base section and tele 1 to remove the slack from the cables. Make sure the extend cables are tightened enough to lift the cables off of the bottom of tele 2 and tele 3 by at least 25 mm (1 in).
6. Adjust the retract cables for tele 3 such that the stop block for tele 3 makes contact 3 to 4 mm (0.12 to 0.16 in) before the stop block for tele 2. This adjustment also tightens the extend cables for tele 3.

   If the stop block on tele 3 cannot be adjusted properly without excessive thread protruding from tele 2, loosen the tension on the tele 3 retract cables by approximately 25 mm (1 in) and loosen the tension on the tele 3 extend cables by approximately 25 mm (1 in). Tighten the tele 3 retract cables until the stop block for tele 3 makes contact 3 to 4 mm (0.12 to 0.16 in) before the stop block for tele 2.
7. Adjust the retract cables for tele 2 such that tele 1 and tele 2 make contact on the next inner sections stop block at the same time. This adjustment also tightens the extend cables for tele 2.

   If the stop blocks cannot be adjusted properly without excessive thread protruding from tele 1, loosen the tension on the tele 2 retract cables by approximately 25 mm (1 in) and loosen the tension on the tele 2 extend cables by approximately 25 mm (1 in). Tighten the tele 2 retract cables until the tele 1 and tele 2 make contact on the next inner sections stop block at the same time.
8. If the retract cables still cannot be adjusted properly, remove tension in all cables and return to step 2.
9. Lock all cable adjustments in place with their related locknuts.

Tensioning the 5-Section Boom Extend and Retract Cables

The boom extend and retract cables must be tensioned after the boom has been rebuilt and any time the cables appear to be loose.

Perform the following procedure to tension the extend and retract cables:

CAUTION

When adjusting cables, use two wrenches. Hold the “flat” on the cable and turn the adjusting nut.

Do not allow the cables to twist. Cable failure could result.

- When tightening or loosening the cables, secure the cables using the flats at the front of the cable ends to prevent the cables from twisting.
- Make sure all tensioning nuts thread on and off of the threaded studs by hand; weld spalls or thread damage will adversely affect torque values.

WARNING

To prevent serious injury or death, always wear personal protective equipment, including a hard hat, eye protection, gloves and metatarsal boots.

CAUTION

Possible Cable Damage!

Use of an impact wrench to tighten the cable tensioning nuts can cause the extend and retract cables to twist, resulting in cable failure.

Do not use an impact wrench when tensioning the extend and retract cable.

1. Fully retract the boom and position the boom to horizontal.
2. Extend the boom approximately 25 mm (1 in) to relieve tension on the retract cables.
3. Adjust the retract cables at the front of the base, tele 2 and tele 4 to remove the slack from the cables.
4. Extend the boom until the back end of tele 1 is accessible through the hole in the base section.
5. Retract the boom approximately 25 mm (1 in) to relieve tension on the extend cables.
6. Adjust the extend cables at the rear of the base section and tele 1 to remove the slack from the cables. Make sure the extend cables are tightened enough to lift the cables off of the bottom of tele 2, tele 3, and tele 4 by at least 25 mm (1 in).
7. Extend the boom until the rear sides of tele 2 are accessible through the openings in the side of tele 1.
8. Remove plates (10, Figure 4-130) to gain access to the adjusting bolts (19, Figure 4-130).
9. Retract the boom approximately 25 mm (1 in) to relieve tension on the extend cables.
10. Adjust the extend cables at the rear of tele 2 using adjusting bolts (19, Figure 4-130) to remove the slack from the cables. Reinstall plates (10, Figure 4-130) to prevent adjusting bolts (19) from loosening.
11. Adjust the retract cables for tele 4 such that the stop block for tele 4 makes contact 3 to 4 mm (0.12 to 0.16 in) before the stop block for tele 3. This adjustment also tightens the extend cables for tele 4.

    If the stop block on tele 4 cannot be adjusted properly without excessive thread protruding from tele 4, loosen the tension on the tele 4 retract cables by approximately 25 mm (1 in) and loosen the tension on the tele 4 extend cables (by approximately 25 mm (1 in). Tighten the tele 4 retract cables until the stop block for tele 4 makes contact 3 to 4 mm (0.12 to 0.16 in) before the stop block for tele 3.
12. Adjust the retract cables for tele 3 such that the stop block for tele 3 makes contact 3 to 4 mm (0.12 to 0.16 in) before the stop block for tele 2. This adjustment also tightens the extend cables for tele 3.

    If the stop block on tele 3 cannot be adjusted properly without excessive thread protruding from tele 1, loosen the tension on the tele 3 retract cables by approximately 25 mm (1 in) and loosen the tension on the tele 3 extend cables by approximately 25 mm (1 in). Tighten the tele 3 retract cables until the stop block for tele 3 makes contact 3 to 4 mm (0.12 to 0.16 in) before the stop block for tele 2.
13. Adjust the retract cables for tele 2 such that tele 1 and tele 2 make contact on the next inner sections stop block at the same time. This adjustment also tightens the extend cables for tele 2.

    If the stop blocks cannot be adjusted properly without excessive thread protruding from the base section, loosen the tension on the tele 2 retract cables by approximately 25 mm (1 in) and loosen the tension on the tele 2 extend cables by approximately 25 mm (1 in). Tighten the tele 2 retract cables until the tele 1 and tele 2 make contact on the next inner sections stop block at the same time.
14. If the retract cables still cannot be adjusted properly, remove tension in all cables and return to step 2.
15. Lock all cable adjustments in place with their related locknuts.

Extend and Retract Cable Maintenance

Do not attempt to work on the boom without experienced supervision.

DANGER

Never handle wire rope with bare hands. Injury to hands could result.

DANGER

To prevent serious injury or death, always wear personal protective equipment; i.e., a hard hat, eye protection, gloves and metatarsal boots.

The following information is taken from a National Consensus standard as referenced by Federal Government Agencies.

All wire rope will eventually deteriorate to a point where it is no longer usable. Wire rope shall betaken 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, bird caging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than:
- 0.4 mm (0.016-in) for diameters up to and including 8 mm (0.3125-in).
- 0.79 mm (0.031-in) for diameters 10 and 13 mm (0.375 and 0.5-in) inclusive.
- 1.19 mm (0.047-in) for diameters 14 to 19 mm (0.5625 to 0.75-in) inclusive.
- 1.59 mm (0.063-in) for diameters 22 to 29 mm (0.875 to 1.125 in) inclusive.
- 2.38 mm (0.094-in) for diameters 32 to 38 mm (1.25 to 1.5 in) inclusive.
- 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.

BOOM MAINTENANCE

Functional Test Of The Boom

1. Activate the hydraulic system and check for proper operation and any leaks.
2. Make sure the boom will extend and retract properly.
3. Make sure the lift cylinder will not allow the boom to drift down until the operator lowers it.
4. Make sure all electrical components disconnected during removal are operating properly.

Boom Inspection

Do not attempt to work on the boom without experienced supervision.

DANGER

To prevent serious injury or death, always wear personal protective equipment; i.e., a hard hat, eye protection, gloves and metatarsal boots.

1. Visually inspect telescoping sections for adequate lubrication of all wear surfaces.
2. Observe extended sections for evidence of cracks, warping, or other damage.
3. Periodically check security of boom wear pads.
4. Check boom nose sheaves for security and freedom of movement.

Boom Alignment And Servicing

Do not attempt to work on the boom without experienced supervision.

DANGER

To prevent serious injury or death, always wear personal protective equipment; i.e., a hard hat, eye protection, gloves and metatarsal boots.

Boom alignment is achieved by adjustment of the wear pads located at various points in the boom assembly. Adjustment of the wear pads is as follows:

1. Fully extend the boom horizontally.
2. Lubricate the boom bottom plates (sides and bottom).
3. Shim the front lower side wear pads to within 1.52 mm (0.06 in) from side plate of next inner boom section, then shim the front upper wear pads in the same manner. Use equal number of shims on each side.

CAUTION

When extending and retracting the boom during alignment, movement should be stopped if a restriction is encountered. re-shim wear pads as necessary to provide free travel of the affected boom section(s).

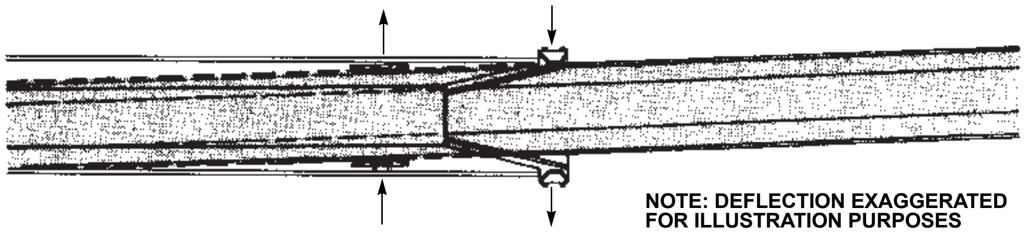
4. Retract and extend the boom; check for the high point where the boom has brushed the wear pads at the widest point.
5. Retract the boom sections to align the high point on the boom section with the adjacent wear pads.
6. Add or subtract shims as necessary.

Table 4-1

Example	
If the boom deflects to the left:	
1	The forward left wear pad would be shimmed in.
2	The rear left adjustable wear pad would be adjusted out, away from the internal boom section.
3	The forward right wear pad will be shimmed out.
4	The right rear adjustable pad adjusted in

7. Attach a weight and extend the boom full length. Check for side deflection.

4



Boom Alignment

FIGURE 4-300

TELESCOPE CIRCUIT TROUBLESHOOTING

Table 4-2

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Erratic operation of extending telescoping cylinder.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	b. Damaged relief valves.	**b.** Repair or replace relief valves.
	c. Air in telescope cylinder.	**c.** Bleed by lowering telescope cylinder below horizontal.
	d. Low engine rpm.	**d.** Increase engine rpm to recommended setting.
	e. Lack of lubrication on boom sections.	**e.** Properly lubricate all boom sections.
	f. Extremely tight boom extension sheaves.	**f.** Inspect and properly lubricate boom extension sheaves.
	g. Improper boom alignment caused from side loading.	**g.** Reduce and properly hoist load.
	h. Worn boom wear pads.	**h.** Replace wear pads and properly lubricate.
	i. Distorted boom section.	**i.** Replace distorted section.
	j. Damaged telescope cylinder.	**j.** Repair or replace cylinder.
	k. Clogged, broken, or loose hydraulic lines or fittings.	**k.** Clean, tighten, or replace lines or fittings.
	l. Damaged control valve.	**l.** Repair or replace control valve.
2. Erratic operation of retracting telescoping cylinder.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	b. Damaged relief valve.	**b.** Repair or replace relief valve.
	c. Air in cylinder.	**c.** Bleed by lowering telescoping cylinder below horizontal and cycle telescope cylinder.
	d. Low engine rpm.	**d.** Increase engine rpm to recommended setting.
	e. Lack of lubrication.	**e.** Properly lubricate all boom sections.
	f. Check valve malfunctioning.	**f.** Repair or replace check valve.
	g. Improper boom alignment caused from side loading.	**g.** Reduce and properly hoist load.
	h. Extremely tight boom retraction sheave.	**h.** Inspect and properly lubricate.
	i. Distorted boom section.	**i.** Replace distorted section.
	j. Worn boom wear pads.	**j.** Replace wear pads and properly lubricate.
	k. Bent cylinder rod(s).	**k.** Replace cylinder rod(s) and all cylinder seals.
	l. Scored cylinder barrel.	**l.** Repair or replace cylinder barrel.
	m. Damaged piston seals.	**m.** Replace all cylinder seals.
	n. Loose or damaged piston(s).	**n.** Replace all seals and re-torque or replace piston(s).

SYMPTOM	PROBABLE CAUSE	SOLUTION
3. Telescope cylinder will not extend.	No pilot pressure to shift the control valve spool because of:	
	a. Defective pilot solenoid valve.	**a.** Replace valve.
	b. Defective electrical circuit to pilot solenoid valve.	**b.** Repair electrical circuit.
	c. Defective control handle.	**c.** Replace control handle.
	d. Telescope extend is locked out by RCL.	**d.** Reduce radius by retracting telescope cylinder or booming up.
	e. Low hydraulic oil level.	**e.** Replenish oil to proper level.
	f. Relief valve malfunctioning.	**f.** Repair or replace relief valve.
	g. Excessive load.	**g.** Reduce load.
	h. Clogged hose and fittings.	**h.** Replace hose or fittings. (Refer to parts manual).
	i. Broken valve spool.	**i.** Replace valve.
	j. Damaged piston seals.	**j.** Replace all cylinder seals.
	k. Damaged piston(s).	**k.** Replace piston(s) and all cylinder seals.
	l. Bent boom section(s).	**l.** Replace damaged boom section(s).
	m. Broken hydraulic pump coupling.	**m.** Replace broken hydraulic pump coupling.
	n. Worn or damaged hydraulic pump section.	**n.** Repair or replace pump section.

SYMPTOM	PROBABLE CAUSE	SOLUTION
4. Telescope cylinder will not retract.	No pilot pressure to shift the control valve spool because of:	
	a. Defective pilot solenoid valve.	**a.** Replace valve.
	b. Defective electrical circuit to pilot solenoid valve.	**b.** Repair electrical circuit.
	c. Defective control handle.	**c.** Replace control handle.
	d. Low hydraulic oil level.	**d.** Replenish oil to proper level.
	e. Relief valve damaged.	**e.** Repair or replace relief valve.
	f. Excessive load.	**f.** Reduce load. (Refer to load chart).
	g. Inoperative check valve.	**g.** Replace check valve.
	h. Clogged hose and fittings.	**h.** Replace hose or fittings. (Refer to Manitowoc Crane Care Parts Manual).
	i. Broken valve spool.	**i.** Replace valve section.
	j. Broken piston(s).	**j.** Replace piston(s) and all cylinder seals.
	k. Damaged piston seals.	**k.** Replace all cylinder seals.
	l. Bent boom section(s).	**l.** Replace damaged boom section(s).
	m. Broken hydraulic pump coupling.	**m.** Replace broken hydraulic pump coupling.
	n. Worn or damaged hydraulic pump.	**n.** Repair or replace pump.
	o. Broken hydraulic pump shaft.	**o.** Replace pump shaft.

4

LIFT CIRCUIT TROUBLESHOOTING

Table 4-3

Symptom	Probable Cause	Solution
1. Boom raises erratically.	**a.** Low hydraulic oil.	**a.** Replenish hydraulic oil to proper level.
	b. Low engine rpm.	**b.** Increase engine rpm to recommended setting.
	c. Main relief valve damaged.	**c.** Replace relief valve.
	d. Air in cylinder rod.	**d.** Bleed cylinder rod.
	e. Bent boom pivot shaft.	**e.** Replace pivot shaft.
2. Boom lowers erratically.	**a.** Low hydraulic oil.	**a.** Replenish hydraulic oil to proper oil level.
	b. Low engine rpm.	**b.** Increase engine rpm to recommended level.
	c. Circuit and/or relief valve inoperative.	**c.** Repair or replace relief valve.
	d. Air in hydraulic cylinder.	**d.** Bleed air from cylinder.
	e. Damaged hydraulic pump section.	**e.** Repair or replace pump section.
3. Boom raises slowly.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	b. Low engine rpm.	**b.** Increase and maintain engine rpm.
	c. Damaged relief valve.	**c.** Repair or replace relief valve.
	d. Extremely cold hydraulic oil.	**d.** Operate unit to bring oil to operating temperature.
	e. Improper hose or fittings, installed.	**e.** Replace hose or fittings. (Refer to Manitowoc Crane Care Parts Manual).
	f. Operating two functions with in the same control valve bank assembly.	**f.** Feather controls to obtain desired speed of both functions.
	g. Restriction in return hose.	**g.** Replace return hose.
	h. Cylinder piston seals leaking.	**h.** Replace all cylinder seals.
	i. Scored cylinder barrel.	**i.** Hone or replace barrel.
	j. Worn hydraulic pump section.	**j.** Repair or replace pump section.
	k. Software settings.	**k.** Refer to *Adjusting Electronic Joysticks*, page 3-17.

Symptom	Probable Cause	Solution
4. Boom lowers slowly.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	b. Low engine rpm.	**b.** Increase rpm to recommended level.
	c. Damaged relief valve.	**c.** Repair or replace relief valve.
	d. Operating two functions within the same control valve bank assembly.	**d.** Feather controls to obtain desired speed of both functions.
	e. Extremely cold hydraulic oil.	**e.** Operate unit to bring oil to operating temperature.
	f. Improper hose or fittings installed.	**f.** Replace hose or fittings. (Refer to Manitowoc Crane Care Parts Manual).
	g. Restriction in return hose.	**g.** Replace return hose.
	h. Cylinder piston seals worn.	**h.** Replace all cylinder seals.
	i. Scored cylinder barrel.	**i.** Hone or replace barrel.
	j. Worn hydraulic pump section.	**j.** Repair or replace pump section.
	k. Piston rod broken (loose from piston).	**k.** Replace piston rod and all cylinder seals.
5. Boom will not raise.	No pilot pressure to shift the control valve spool because of:	
	a. Defective pilot solenoid valve.	**a.** Replace valve.
	b. Defective electrical circuit to pilot solenoid valve.	**b.** Repair electrical circuit.
	c. Defective control handle.	**c.** Replace control handle
	d. Low hydraulic oil.	**d.** Replenish hydraulic oil to proper level.
	e. Main relief valve or circuit relief valve damaged.	**e.** Repair or replace relief valve.
	f. Excessive load.	**f.** Reduce load as required.
	g. Worn or damaged hydraulic pump section.	**g.** Repair or replace pump section.
	h. Broken pump shaft.	**h.** Replace pump shaft and seals.
	i. Broken pump drive coupling.	**i.** Replace drive coupling.
	j. Broken control valve spool.	**j.** Replace control valve.

Symptom	Probable Cause	Solution
6. Boom will not lower.	No pilot pressure to shift the control valve spool and unseat the holding valve because of:	
	a. Defective pilot solenoid valve.	**a.** Replace valve
	b. Defective electrical circuit to pilot solenoid valve.	**b.** Repair electrical circuit.
	c. Defective control handle.	**c.** Replace control handle.
	d. Defective pilot supply valve in Accessory Manifold	**d.** Replace valve.
	e. Boom down is locked out by RCL.	**e.** Reduce radius by retracting telescope cylinder or booming up.
	f. Low hydraulic oil.	**f.** Replenish hydraulic oil to proper level.
	g. Main relief valve or circuit relief valve damaged.	**g.** Repair or replace relief valve.
	h. Worn or damaged hydraulic pump section.	**h.** Repair or replace pump section.
	i. Broken pump shaft.	**i.** Replace pump shaft and seals.
	j. Broken pump drive coupling.	**j.** Replace drive coupling.
	k. Broken control valve spool.	**k.** Replace control valve.
	l. Defective hold valve	**l.** Repair or replace hold valve

LIFT CYLINDER - REMOVING/INSTALLING

Removing the Lift Cylinder

NOTE: Refer to Figure 4-301 and Figure 4-302 for removal and installation of lift cylinder.

1. Extend and set the outriggers and level the crane.
2. Elevate the boom slightly so that the lift cylinder is extended approximately 1 ft (0.3 m).

DANGER

Ensure the lifting device is capable of supporting the boom assembly. Death or serious injury may result if the lifting device cannot support the load.

3. Ensure the boom is fully supported by placing blocking or cribbing under the boom. Rest the boom on the blocking or cribbing.

NOTE: Lift cylinder weighs 585 kg (1290 lb).

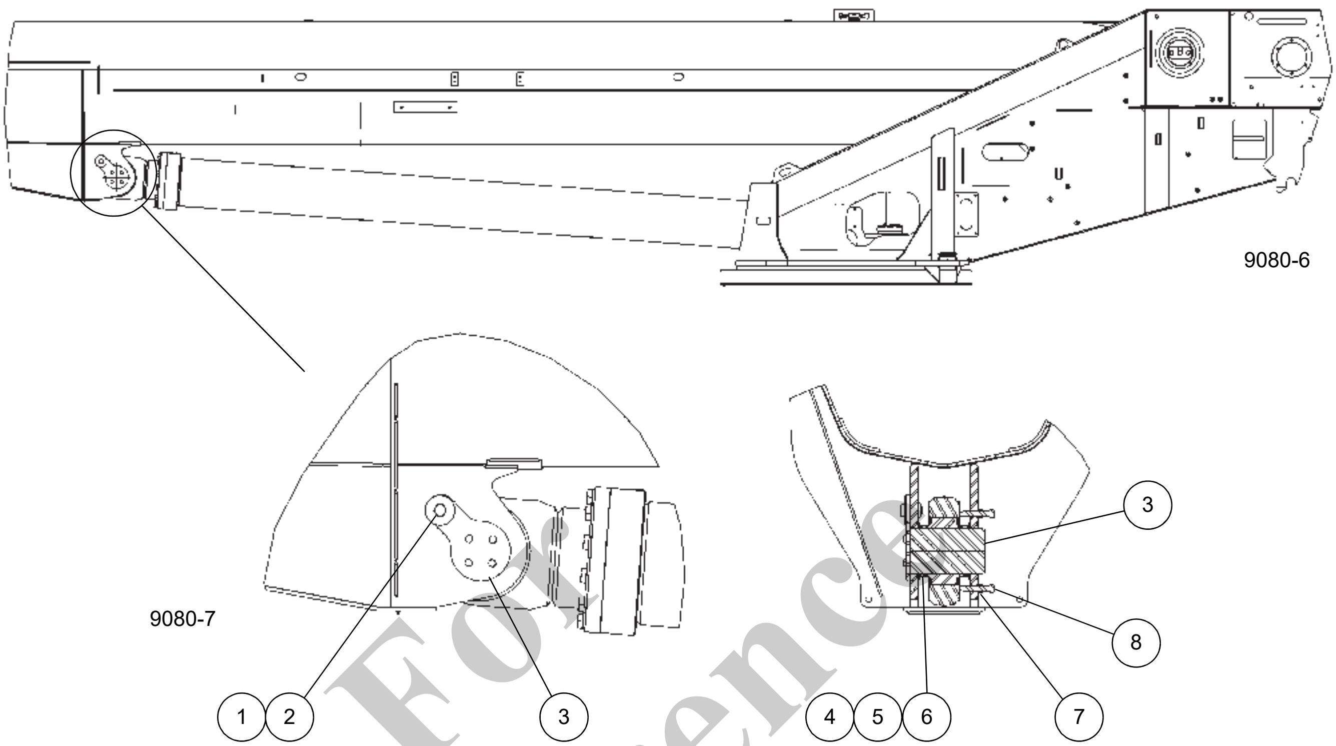
4. Attach an adequate lifting/supporting device to the lift cylinder.
5. Remove the capscrews, washers, and end plate securing the upper lift cylinder shaft to the side of the attachment fitting on the boom. Loosen the set screws on the opposite side.
6. Remove the capscrews, lock washers, flat washers, and end plate securing the lift cylinder lower pivot shaft to the turntable.
7. Remove the upper lift cylinder shaft, spacers, and shims, noting position of each. Activate the hydraulic system and retract the lift cylinder enough to clear the upper attach point.
8. Tag and disconnect all the hydraulic lines to the cylinder. Cap or plug all openings with high pressure fittings.
9. Remove the lower lift cylinder shaft and spacers, noting position of each.
10. Move the lift cylinder to a clean work area.

Installing the Lift Cylinder

NOTE: Refer to Figure 4-301 and Figure 4-302 for removal and installation of lift cylinder.

NOTE: Lift cylinder weighs 585 kg (1290 lb).

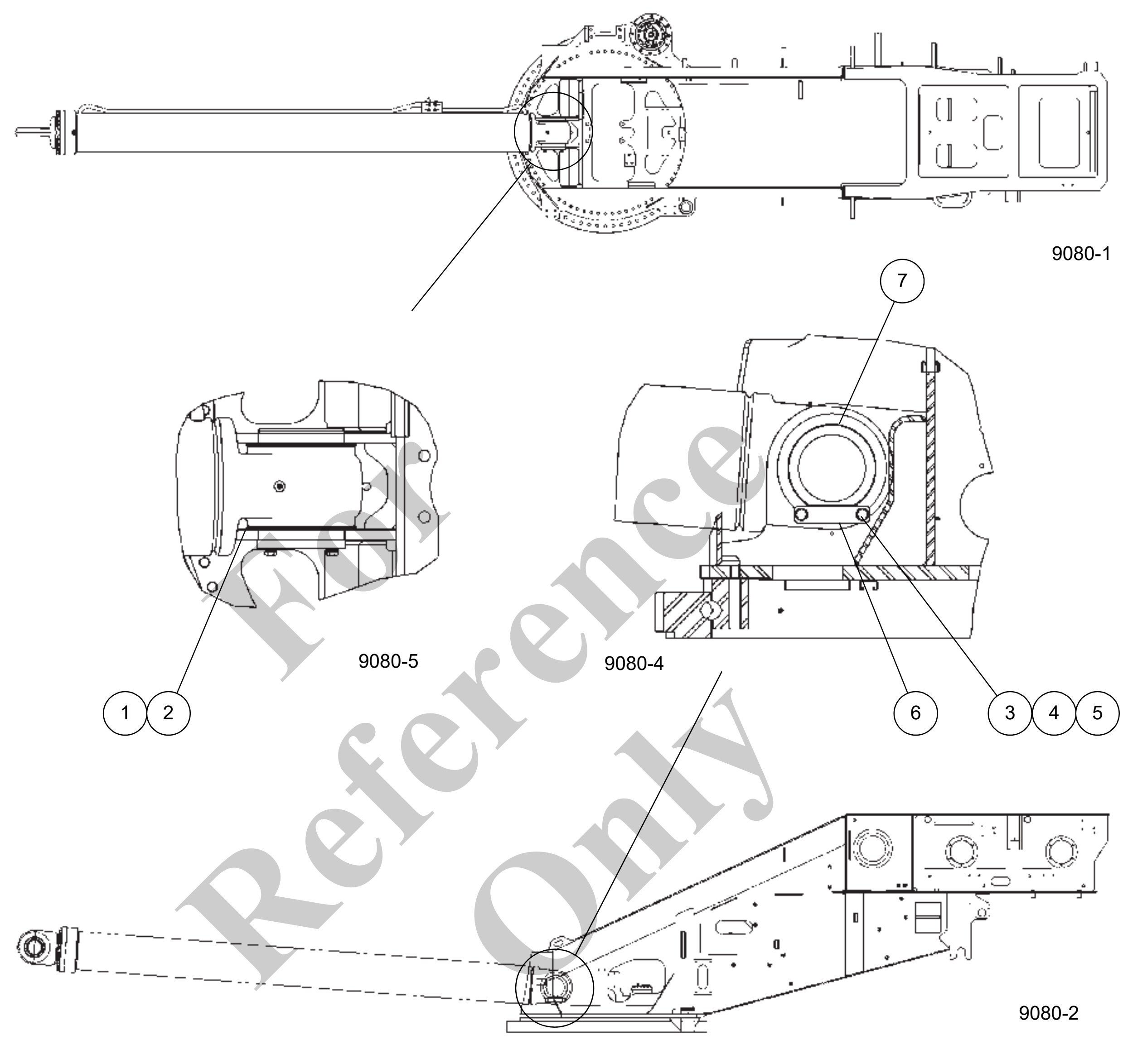
1. Attach an adequate lifting device to the lift cylinder and position the cylinder over the attach fitting on the turntable.
2. Lower the lift cylinder into the attach fittings on the turntable and align the lift cylinder bushing with the attach fitting holes.
3. Install the lift cylinder lower pivot shaft and spacers following positions noted during disassembly.
4. Secure pivot shaft in place using end plate, flat washers, lock washers, and capscrews.
5. Connect the extend and retract hoses, as tagged during disassembly, to the lift cylinder.
6. Activate the crane's hydraulic system and align the lift cylinder rod end with the attach point on the boom. Install the upper pivot shaft through the cylinder and boom attach points, inserting the spacers and shims as noted during disassembly. Shut down the engine.
7. Install end plate, washers, and capscrews which secure upper pivot shaft to the side of the attachment fitting on the boom.
8. Evenly tighten the setscrews on the opposite side until both setscrews make contact with the cylinder, then loosen both setscrews until a gap of 2 mm (0.08 in) is attained between end of setscrews and cylinder. Secure setscrews with nuts.
9. Remove the lifting and supporting devices from the boom and lift cylinders. Activate the hydraulic system and check the lift cylinders for proper operation and any leaks.



Item	Description
1	Flat Washer
2	Capscrew
3	Lift Cylinder Foot Pin
4	Shim - 1 mm

Item	Description
5	Shim - 2 mm
6	Spacer
7	Nut
8	Setscrew

FIGURE 4-301



Item	Description
1	Spacer
2	Spacer
3	Flat Washer
4	Lock Washer

Item	Description
5	Capscrew
6	Pivot Pin Plate
7	Cylinder Pivot Pin

FIGURE 4-302

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SECTION 5
HOIST AND COUNTERWEIGHT

SECTION CONTENTS

5

DESCRIPTION

One hoist is available, the GHP15 (Figure 5-1). The hoist incorporates one dual displacement piston motor which drives a reduction unit within the hoist. The hoist utilizes planetary reduction with a multi-disc automatic brake that is spring applied and hydraulically released. An overrunning clutch allows the hoist to be raised without releasing the brake while at the same time holding the load until there is sufficient pressure to release the brake when hoisting down. The hoist motor controls both speed and torque of the hoist.

There are two modes in which the hoist operates. One mode is high speed. The pilot solenoid valve shifts the selector spool on the motor to provide minimum motor displacement. This gives high line speed and low torque.

The second mode is low speed. The pilot solenoid valve shifts the selector spool on the motor to provide maximum motor displacement. This gives low line speeds and high torque.

The hoist on CE cranes is equipped with a 3rd wrap indicator system, which consists of a tapered follower roller and an electric switch. When the cable on the hoist drum reaches three wraps of remaining cable, the tapered follower moves closer to the drum by way of springs and actuates the switch. When the switch is actuated, the crane control system stops the hoist operation, displays the 3rd wrap indicator on the ODM (Operator Display Monitor), and sounds the warning buzzer.

THEORY OF OPERATION

The hoist assembly is controlled by electronic remote controllers located in the cab. When the control lever in the cab is moved from neutral, it causes the hoist section of the directional control valve to shift the valve spool to route hydraulic flow to the hoist motor control valve. The hoist motor control valve is used to stop or slow the hoist when the load is trying to drive the hoist down too quickly. The motor control valve is piloted open by the hoist down pressure. If the load lowers faster than the flow of oil in the hoist down line, the pilot pressure decreases and the motor control valve partially closes to restrict the oil leaving the motor until a balance occurs. This results in the load lowering at a uniform speed based on the position of the hoist control lever.

During stopping, when the hoist down flow ceases, the pilot pressure holding the motor control valve open decays to zero and the motor control valve spool closes, thus blocking all flow of oil out of the hoist motor. This same pressure decay allows the spring applied pressure released hoist brake to apply when the load is fully stopped. This brake acts as a “parking brake” and holds the load in the stopped position.

MAINTENANCE

Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential at ambient temperatures below 4°C (+40°F).

The prime mover should be run at its lowest recommended RPM with the hydraulic hoist control valve in neutral allowing sufficient time to warm up the system. The hoist should then be operated at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil, and to circulate gear lubricant through the planetary gear sets.

DANGER

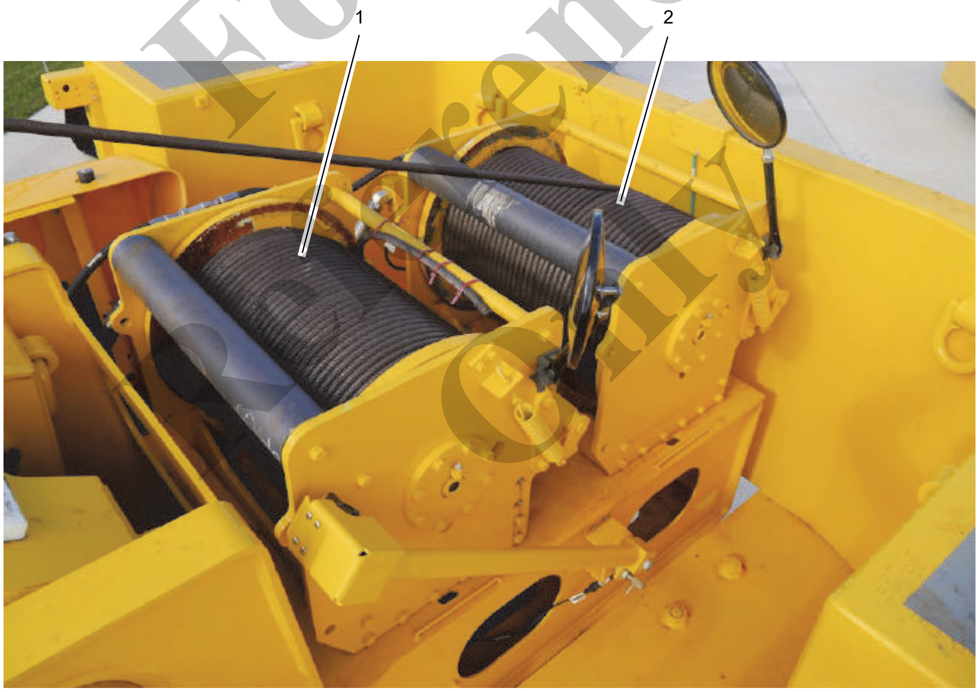
Failure to properly warm up the hoist, particularly under low ambient temperature conditions, may result in temporary brake slippage due to high back pressures attempting to release the brake, which could result in property damage, severe personal injury or death.

Removal

1. If the CE option is provided, remove the hoist covers.
2. Remove all cable from the hoist drum.
3. Tag and disconnect the hydraulic lines to the hoist. Cap or plug all lines and openings.
4. Tag and disconnect the electrical wires to the hoist rotation indicator sensor.
5. Tag and disconnect the electrical wires to the hoist hi-speed solenoid valve.
6. Remove the hoist mounting nuts, capscrews, washers, and shims (if shims are used, mark their location).

NOTE: The GHP15 hoist assembly, less the cable, weighs approximately 400 kg (881 lb).

7. Using an adequate lifting device, remove the hoist from the crane.



Item	Description
1	Main Hoist
2	Auxiliary Hoist

FIGURE 5-1

Installation

1. Ensure the mounting plate and hoist pads are clean and free from debris and the hoist has not been damaged during handling.
2. With the hoist supported by a suitable lifting device, position the hoist on the mount.
3. Check the hoist to boom alignment according to *Hoist to Boom Alignment*, page 5-7.

4. Place a level across the top of the boom base section near the boom pivots.
5. Place a level across the top of the hoist drum and determine if the hoist is sitting in the same plane in relation to the level positioned between the boom pivot shaft bushings.
6. With the hoist level, check to determine if all the hoist mounting pads are in contact with the mounting plate by rocking the hoist.
7. Keeping the hoist level, use a feeler gauge to determine the amount of gap existing between the pads and the mounting plate.
8. Add shims to satisfy any existing gaps. Altering the shim thickness to fit a tapering gap is acceptable. Install the capscrews, washers and nuts and torque see *Fasteners and Torque Values*, page 1-19.
9. Remove the lifting device from the hoist.
10. Connect the hydraulic lines to the hoist ensuring the proper lines are connected to the correct ports as marked during removal.
11. Connect the electrical wires to the hoist hi speed solenoid valve as marked during removal.
12. Connect the electrical wires to the hoist rotation indicator sensor as tagged during removal.
13. Install the cable, following the procedures outlined under *Installing Cable on the Hoist* in the Operator Manual.

Functional Check

1. Attach a test weight to the hook and raise and lower the load several times.
2. Check the hoist for smooth operation of the hoist motor and brake system.
3. Ensure the hydraulic connections are secure and free from leaks.

5

HOIST MAINTENANCE AND INSPECTION

It is extremely important that maintenance staff involved with the crane inspections be made aware of the possibility that deterioration of internal critical components within the hoist can occur. Hoists incorporate planetary gears, multi-disc brake assemblies and sprag clutches which do not have an infinite service life span. Although these components have been designed to achieve long service life, reliability can be substantially reduced by a variety of influencing factors such as:

- High cycle operation
- Operating in high ambient temperatures
- High external contamination, such as dusty or sandy conditions
- Type of lubricant used
- Level of maintenance

The following routine servicing points must be carried out in accordance with manufacturer's instructions:

Usage and Inspection

Inspection procedures for hoists are divided into five general categories based upon their usage or duty cycle, which in turn determines appropriate intervals for inspections. The usage categories must be assigned by the crane user on a consistent crane-by-crane basis. The five crane/hoist usage categories are as follows:

- **Idled** - The crane/hoist has not been used for three months.
- **Infrequent Usage** - The crane/hoist is used less than ten hours per month based on a three month average
- **Moderate Usage** - Crane/hoist used 10 - 50 hours per month based on a three month average.
- **Heavy Usage** - Crane/hoist used 50 - 200 hours per month.
- **Severe Duty -** Crane/hoist is operated more than 200 hours per month OR where 50% of the lifts exceed 75% of the rated capacity for the hoist.

NOTE: For idled units with unknown maintenance and repair history, it is highly recommended that the hoist undergo a tear down inspection prior to being placed into service.

The following chart lists the inspections that are required for each type of usage category:

INSPECTION / USAGE CATEGORY	PRE-USE DAILY INSPECTION	QUARTERLY INSPECTION	SEMI-ANNUAL INSPECTION	ANNUAL INSPECTION
IDLED Not used for 3 months or longer	REQUIRED BEFORE PLACED IN SERVICE	REQUIRED BEFORE PLACED IN SERVICE	REQUIRED BEFORE PLACED IN SERVICE	—
INFREQUENT USAGE less than ten hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
MODERATE USAGE 10-50 hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
HEAVY USAGE 50-200 hours per month	REQUIRED	REQUIRED MONTHLY	REQUIRED QUARTERLY (3 months)	REQUIRED SEMI-ANNUALLY (6 months)
SEVERE USAGE 200+ hours per month or 50% of lifts exceed 75% rated capacity	REQUIRED	REQUIRED	REQUIRED QUARTERLY (3 months)	REQUIRED SEMI-ANNUALLY (6 months)

Pre-Use or Daily Inspection

Must include but is not limited to the following inspections that will be performed prior to placing the crane into service and then as necessary during extended operation. This inspection must be performed by a qualified crane operator or qualified crane technician.

1. Check for external oil leaks and repair as necessary. This is extremely important due to the accelerated wear that will result from insufficient lubricating oil in the hoist. Hoists with a sight glass; check oil level daily. Hoists without a sight glass; check oil level monthly if no external oil leaks are detected. Lubricant level must be maintained between the minimum and maximum levels; midway up sight glass or at bottom of level plug port as equipped. Use **ONLY** the recommended type of lubricant. Refer to the machine's lubrication chart.
2. Check hydraulic fittings and hoses for chaffing, deterioration or corrosion and repair as necessary.
3. Visually inspect for corroded, loose or missing bolts, pins or other fasteners and replace or tighten as necessary.
4. Visually inspect rotation indicator transmitters, anti-two-blocking switches and other safety equipment and repair as necessary.

Quarterly Inspection (every three months)

Must include but is not limited to the following inspections that must be performed by a qualified crane operator or qualified crane technician.

1. Perform the pre-use inspection.
2. Inspect for corrosion of fasteners, hoist base, drum, etc. and repair/replace as required to maintain the structural integrity of the hoist.

Semi-Annual Inspections (every six months)

1. Perform the pre-use and quarterly inspections.
2. Take a sample of the lubricant from the hoist gear cavity as described on this page and analyze it for wear metals content, correct viscosity, lubricant deterioration, moisture and other contaminants. If the oil sample contains a high amount of metallic particles, the hoist must be taken out of service to undergo a tear down inspection.

NOTE: Oil analysis alone cannot detect nor warn against a fatigue failure.

Annual Inspection

This inspection must be carried out by a qualified crane technician. The annual inspection **MUST** include, but not be limited, to the following:

1. Perform the pre-use/daily, quarterly and semi-annual inspections.
2. Change the lubricating oil in the hoist gear cavity after an oil sample has been taken as described on this page. Refill the hoist to the proper level with recommended lubricant. Refer to the machine's lubrication chart.

WARNING

Possible equipment damage and/or personal injury!

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

PREVENTIVE MAINTENANCE AND OIL SAMPLING

WARNING

Risk of personal injury!

Hot oil may cause personal injury and/or burns to unprotected skin. Make certain the oil has cooled to a safe temperature (typically less than 43°C or 110°F) before taking an oil sample, changing oil or servicing the hoist.

Oil Change

The hoist gear oil must be changed after the first 300 operating hours then on an annual basis, at a minimum thereafter. In severe duty applications, the gear oil should be changed every six months. Use the recommended lubricants. Refer to the machine's lubrication chart.

Gear Oil Sampling and Analysis

Proper gear oil sampling and analysis is a vital part of a comprehensive preventive maintenance program. Information obtained from the oil analysis allows the maintenance technician to substitute preventive maintenance for more costly unscheduled down time or a far more dangerous failure. Early detection of accelerated component wear allows the scheduling of corrective maintenance.

Prepare the hoist by cleaning the drain plug area and drain extension tube in order to obtain an uncontaminated sample. Operate the hoist in both directions for one or two minutes to thoroughly mix the gear oil then take the sample from the midstream flow of the oil to obtain an accurate representation of the oil condition. After taking the oil sample continue with the oil change or refill the hoist gear cavity to the proper level with recommended lubricant. Iron contaminant levels will be on the high side of “normal” during initial break-in.

Equally important as the level of contamination is the change in level of contamination. An effective oil analysis program should provide the technician with a view of the progression of wear or a trend. If a sample shows a sudden rise in contaminant level action should be taken to determine what has changed.

NOTE: Oil analysis alone cannot detect nor warn against a fatigue failure.

BRAKE TEST PROCEDURE FOR GHP15 HOISTS

The above model planetary hoists have a spring applied, hydraulically released, multiple disc brake inside the hoist housing. This brake holds a suspended load when the directional control valve is in neutral, or when hydraulic power is lost. An over-running brake clutch assembly permits the power train and drum to rotate in the direction to lift a load, while the brake remains fully applied. A load cannot be lowered, however, without applying hydraulic pressure to the release port and releasing the brake.

Brake Test Procedure (To be performed with no load on the hoist)

1. Remove and cap or plug the brake release line from fitting in the hoist brake release port.
2. With the hydraulic power unit running, move the directional control valve handle slowly to the full open, lowering position.
3. Increase the engine speed, if necessary, to bring system pressure up to the relief valve setting. The hoist drum should remain stationary
4. If the hoist drum rotates, the hoist should be disassembled and the brake components should be examined for wear. In addition, the brake springs should be measured for the correct free length in those hoist using helical compression springs.
5. Replace any parts showing excessive wear and any spring whose length is shorter than the minimum shown in the applicable hoist Service Manual.
6. Reassemble the brake and hoist, then repeat the above steps.
7. When testing is complete, reattach the brake release line to the brake release port.

Contact CraneCARE with any questions.

General guidelines for iron contaminant level

PPM	Condition of Oil
100-500	**Normal -** Acceptable level; little significant contamination
500-800	**Caution - Abnormal sample. Change oil and retake sample after 50 hours of operation. If second sample is above 500 ppm, remove hoist from service and perform tear-down inspection to determine source of contamination.**
Over 800	**Unacceptable - Remove hoist from service and perform tear-down inspection to determine the source of contamination.**

HOIST TO BOOM ALIGNMENT

Preparation

Boom alignment must be completed before attempting hoist alignment. If the hoist is not properly aligned, the cable can be damaged or fine control could be affected.

The crane must be set on outriggers fully extended and the crane must be leveled. The boom must be over the front.

Tools Required

- Two foot square
- Mason cord
- Chalk
- Protractor

Procedure

The hoist mounting location will determine the alignment procedure used. Shift one side of the hoist back or forward to align the hoist with the boom sheave for cranes that have the hoist mounted either directly to the boom or on a mount attached to the boom. It may be necessary to shim under one side of the hoist to make it level.

The hoist must be checked in two directions, one at 0 degree and the other is above 45 degree boom angle on any crane that the hoist is not mounted directly to the boom, stationary mounted.

Check the hoist at 0 degree to see if the hoist is aligned to the boom nose sheave. The main hoist is aligned to the right hand sheave and the auxiliary hoist is aligned to the center sheave (Figure 5-2).

NOTE: The hoist cable will have gaps in it during spooling if the alignment is not correct.

NOTE: The hoist is not level if the cable is piling up on one side of the drum.

1. The boom must be extended one half of full extension on all hoist alignments. This length is used because when the main hoist cable is positioned on the top right hand boom nose sheave, the cable must leave the center of the drum at a 90 degree angle. The boom has the ability to extend, retract, and change the angle of departure from the drum. Extend the boom half way to provide a center point of adjustment to check the fleet angle of the cable.
2. All the cable must be removed from the hoist drum to check the fleet angle. Using mason cord or cat gut fishing line you will be able to pull the line tight to make an accurate measurement of the fleet angle. Find the centerline of the hoist drum by using a square and drawing a line horizontal on the drum. Put a line vertical to the horizontal line in the absolute center of the drum by using a tape measure. With the boom at 0 degree, tie the line tight to the boom nose and have it in the center of the right hand boom nose sheave.

NOTE: If this special equipment is not available, sufficient accuracy in locating a centerline may be obtained by using a steel square against the machine's inner surfaces of both flanges. It is advisable to avoid using any cast surfaces in this procedure unless a check from both flanges indicates that the resultant line is straight.

3. Tie the line around the hoist drum so that the line is very tight and the line is crossing the absolute center of the drum at the centerline mark you put on the drum.
4. Using a protractor, lay it on the vertical line on the hoist drum so the string line is in the center of the protractor. The string line will be at the 90 degree mark on the protractor if the hoist is straight with the boom nose sheave. If it is not at the 90 degree mark, the hoist mounting bolts will have to be loosened and the hoist moved so it is.

NOTE: This test is for cable leaving gaps while spooling.

CAUTION

Do not alter holes or stop blocks on the crane mounting plate, as very small adjustments result in large angular changes. Extreme care should be taken to avoid over-correction.

5. Elevate the boom above 45 degree boom angle to check if the hoist is level. Reposition the hoist drum and tighten the cord so you can have the cord in the center of the protractor at the 90 degree mark. If the cord is not at the 90 degree mark, the hoist will have to be shimmed until the cord is at the 90 degree mark.

NOTE: This test is for cable piling up on one side of the hoist drum.

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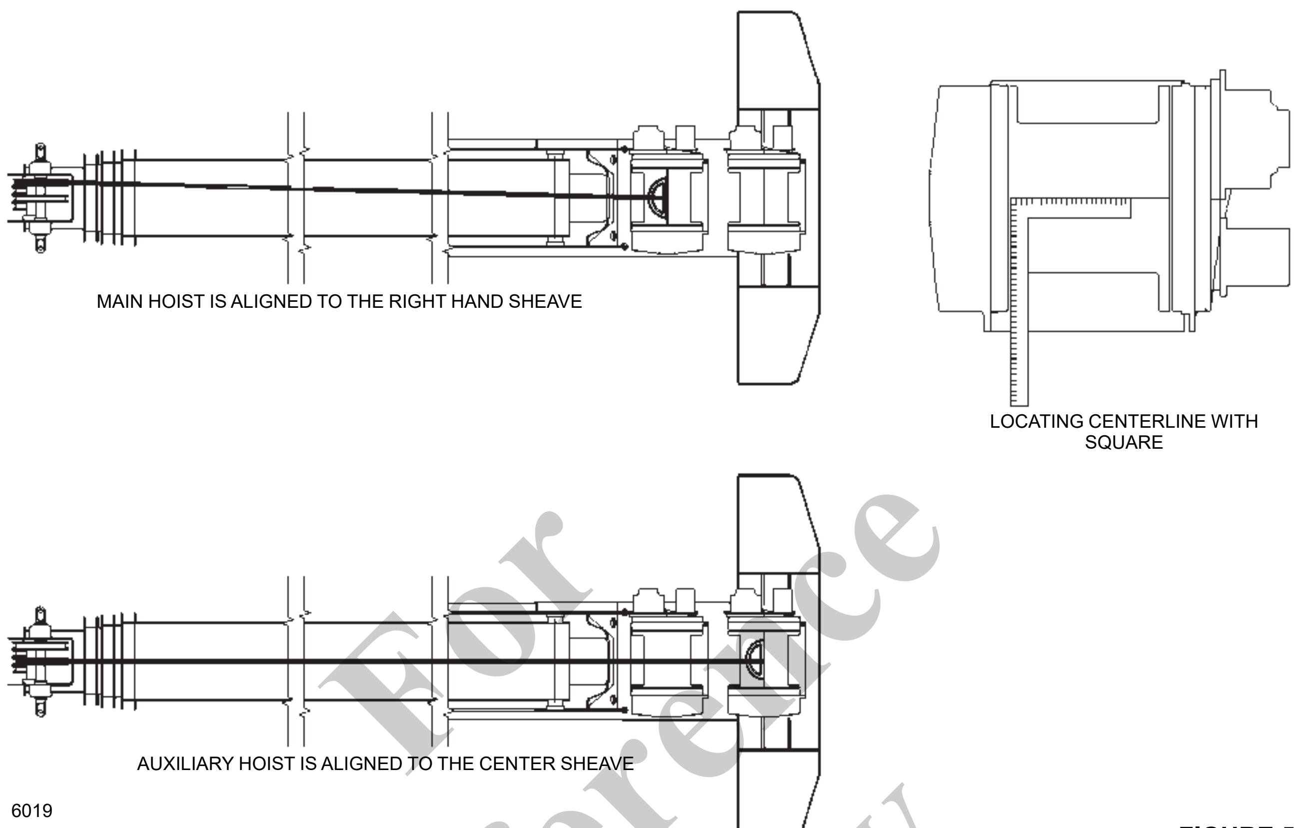


FIGURE 5-2

PISTON MOTOR AND CONTROL VALVE

Description

The piston motor is a bent axis, bidirectional, variable displacement hydraulic motor. The motor is bolted to the hoist and is geared directly to the hoist planetary.

The motor control valve is bolted to the motor.

Maintenance

Removal

1. Thoroughly clean the external surfaces of the drum and motor with steam or clean solvent and blow dry.
2. Tag and disconnect the electrical connections to the hoist motor and the motor control valve.
3. Tag and disconnect the hydraulic lines connected to the hoist motor and the motor control valve.
4. Remove the capscrews and lockwashers that secures the motor and motor control valve to the hoist.

NOTE: The GHP15 hoist motor weighs approximately 28 kg (62 lb).

5. Place the motor and motor control valve in a clean, dry suitable work area.

Installation

NOTE: Care must be taken to assure the primary thrust plate remains properly located in its counterbore when the motor is re-installed. If the winch is operated with the primary thrust plate wedged between the primary gears and the planet carrier, or with a thrust washer out of position severe damage to internal winch components could result.

1. Install a new O-ring on the motor pilot then lubricate with petroleum jelly or gear oil. Engage the motor shaft with the brake clutch inner race and lower into place.
2. Apply Loctite No. 243 to the mounting bolts, and install the bolts and lockwashers. Torque the bolts to 102 N-m (75 lb-ft).
3. Connect the hydraulic lines as tagged during removal.
4. Connect the electrical connections as tagged during removal.
5. Fill the drum with oil. Refer to Section 9 - LUBRICATION in this manual.

IDLER DRUM AND CABLE FOLLOWER

Description

The main and auxiliary hoists are equipped with an idler drum on the forward side of the hoist. The main hoist idler drum is used to keep the hoist cable from coming in contact with the boom. When the crane is also equipped with an auxiliary hoist, the idler drum on the auxiliary hoist is used to keep the hoist cable from coming in contact with the main hoist. The cable follower is mounted on the rear side of it's respective hoist. The cable follower applies a downward spring pressure against the cable onto the hoist drum, to ensure that the cable will be uniformly wound onto the hoist drum, and also prevent cable from jumping under abnormal line conditions.

Maintenance

Idler Drum

Removal and Disassembly

1. Remove the bolt, washer, and lockwasher from the right side of the idler roller Figure 5-3.
2. Support the idler roller and withdraw the shaft from the left side. Take care not to lose the dowel pin on the end.
3. Remove the roller from between the side plates.

Cleaning and Inspection

1. Clean all rust and dirt from the shaft.
2. Inspect the shaft and roller for cracks, scoring, or grooving. Replace if necessary.

Assembly and Installation

1. Position the roller between the side plates
2. Install the shaft through the left side plate and the roller. Ensure the flat on the shaft end aligns with the stop welded on the side plate, align the dowel pin.
3. Secure the shaft to the right side plate with a bolt, washer and lockwasher. Apply Loctite 243 to the bolt threads.

Cable Follower

Removal and Disassembly

1. Loosen the adjusting nuts and remove the tension spring and adjusting rod from both sides of the hoist (see Figure 5-3).
2. Remove the tack welds from the bolt heads securing the arm to the cable follower roller.
3. Support the cable follower roller and remove the bolts and washers securing the arms to the angles on each end of the roller. Remove the cable follower roller.
4. Disassemble the cable follower roller as follows.
   a. Remove the two bolts and washers securing the angle to the right side of the shaft.
   b. Remove the shims and roller from the shaft.
   c. If necessary, remove the bearing and bearing housing from both ends of the roller.
5. Remove the bolt and locknut securing the arm to the spring attaching lever on each side of the hoist. Remove arms and levers from the side plates.

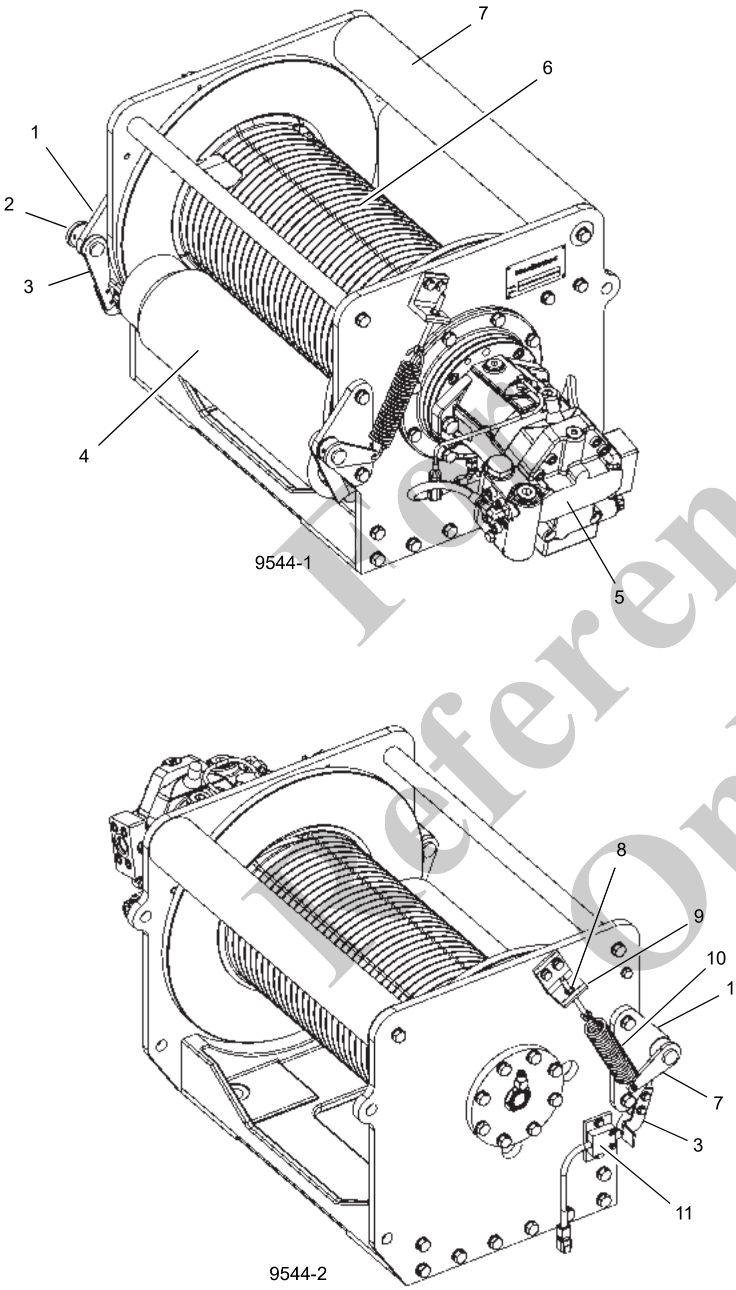
NOTE: Be sure to mark each arm and lever as to what side (left or right) they were removed from. This will be helpful during installation.

Cleaning and Inspection

1. Clean all grease from the shaft, bearing, and roller.
2. Check the shaft, roller, and bearings for cracks, scoring, or grooving. Replace if necessary.
3. Check the spring tension. If the springs will not provide sufficient tension when adjusted, replace them.

Assembly and Installation

1. Install the left arm through the bushing on the left side plate. Install left spring attaching lever on the arm and secure with a bolt and locknut. Apply Loctite 243 to the bolt threads.
2. Repeat step 2 on the right side.
3. Assemble the cable follower roller as follows.
   a. Apply high strength retaining compound Loctite 680 to the bearing housings and the bearings. Install them in both ends of the roller.
   b. Install the shaft into the roller with a least one shim on each end.
   c. Position the angle on the right side of the shaft and secure with two bolts and washers. Apply Loctite 243 to the bolt threads.
4. Position the cable follower roller on the arms and secure with four bolts and washers. Center the roller between the hoist drum flanges and tighten the bolts. Tack weld the bolt heads.
5. Attach one end of the tension springs to the levers on each side. Install the adjusting rod through the lug on each side plate and connect to the other end of the spring. Install the adjusting nuts on each rod and tighten enough to take the slack out of the springs.
6. Using a grease gun, apply grease to the fittings on each side plate bushing.
7. Adjust the roller as follows.



Item	Description
1	Pivot Bracket
2	Lever
3	Arm
4	Follower Roller
5	Hydraulic Motor
6	Drum
7	Idler Roller
8	Nut
9	Bracket
10	Spring
11	3rd Wrap Indicator Switch

FIGURE 5-3

a. With one layer of cable on the hoist drum, adjust the bolts on the front of each side plate (that push against each arm) so the roller applies pressure on the layer of cable, and does not interfere with filler/ riser protrusions on the hoist drum flanges. Tighten jam nuts to secure setting.

b. With a full drum of cable, the adjusting spring length from eye to eye should not exceed 25.7 cm (10.12 in). Adjust rods as necessary and tighten jam nuts to secure this setting.

Complete Assembly

Removal

1. Remove all tension from the springs on each side by loosening the nuts and jam nuts.
2. Support the weight of the assembly and remove the two bolts and washers securing each side plate to the hoist. Remove the idler drum and cable follower assembly from the hoist.
3. If necessary to completely disassemble or remove any part of the assembly, refer to the applicable paragraphs in this Sub-section.

Installation

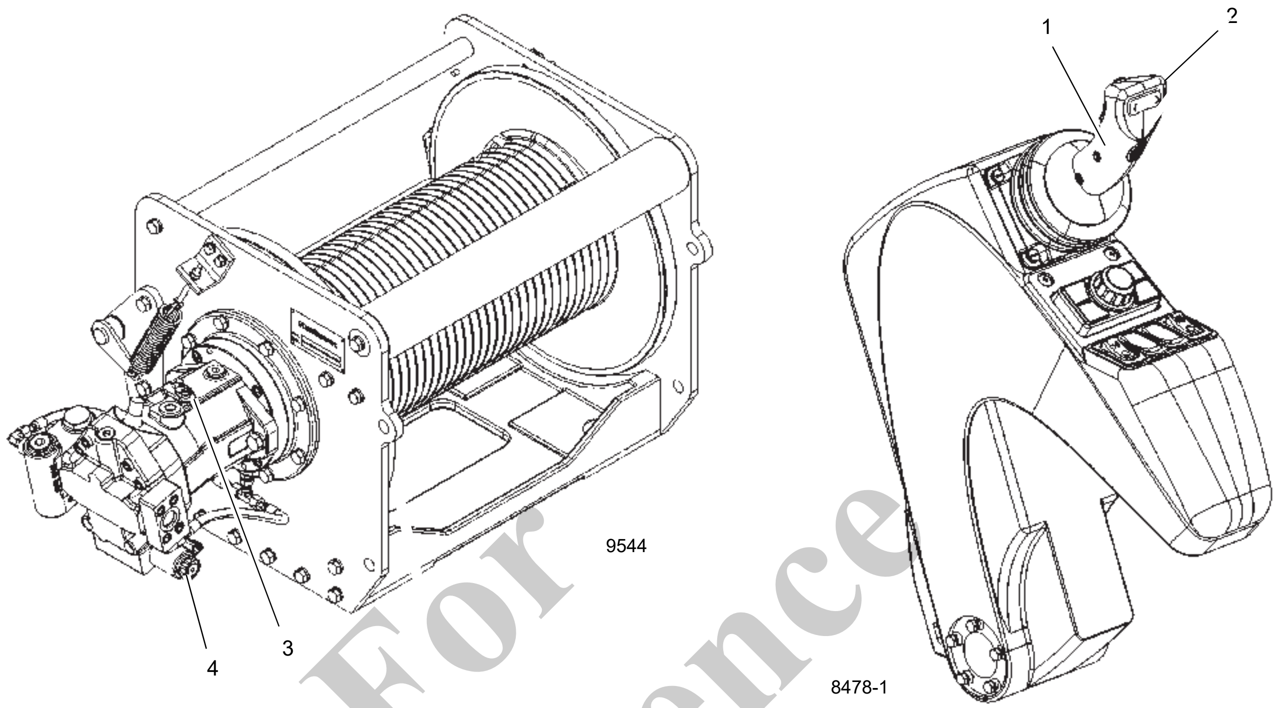
1. Position the idler drum and cable roller assembly on the hoist and secure each side plate to the hoist with two bolts and washers.
2. Adjust the tension on the cable follower. Refer to instructions in paragraph titled CABLE FOLLOWER - Assembly and Installation in this Sub-Section.

HOIST DRUM ROTATION INDICATOR SYSTEM

Description

The hoist drum rotation indicator system (Figure 5-4) is an electrically operated system that provides the operator with a touch indication of drum rotation so the operator will know if and at what speed the hoist drum is rotating, even under the most distracting conditions. The main screen of the Operator Display Module (ODM) will also illuminate a hoist up or hoist down indicator light to show the direction of hoist motion.

The rotation indicator system consists of the rotation indicator sensor and rotation indicator solenoid. The rotation sensor is located on the hoist motor. The pulsing solenoid is located in the applicable hoist control lever handle. Actuation of the rotation indicator and illumination of the direction lights is controlled by the Can-Bus system from input supplied by the rotation indicator sensor. The rotation indicator will cease operation at high line speeds to prevent damage to the solenoid.



Hoist

Controller

FIGURE 5-4

Item	Description
1	Rotation Indicator
2	Controller
3	Rotation Sensor Connection
4	Two Speed Solenoid Connection

COUNTERWEIGHT REMOVAL

Fixed Counterweight Description

The counterweight is attached to the rear of the turntable and weighs 5580 kg (12,300 lb). For cranes without an auxiliary hoist, an additional 637 kg (1400 lb) counterweight is bolted to the hoist mounting area in lieu of the auxiliary hoist.

Fixed Counterweight Removal

DANGER

Death or serious injury could result from being crushed by a falling counterweight.

NOTE: Use of a forklift to remove/install the fixed counterweight is not recommended.

Refer to Figure 5-5 for counterweight removal.

1. Fully extend and set the outriggers.

NOTE: Turntable lock pin can only be engaged with boom over front.

2. Rotate the superstructure so the counterweight is over the front of the carrier to gain additional clearance.

NOTE: The counterweight weighs approximately 5580 kg (12,300 lb).

3. Lower and fully retract the boom
4. Engage the 360° swing lock (if equipped).
5. Shut down crane.

CAUTION

When lifting/handling the counterweight, keep the chains/ straps vertical to minimize side pull on the lifting lugs.

6. Attach an adequate lifting device to the four lifting lugs on the counterweight.
7. Remove the four bolts and washers securing the counterweight to the superstructure. Slightly lift counterweight off of superstructure. Without raising or lowering the height of the counterweight, move the counterweight rearward until it clears the tail of the superstructure. Move counterweight far enough from crane to allow the superstructure to clear during repositioning.
8. Rotate superstructure to the normal travel position.

Fixed Counterweight Installation

1. Fully extend and set the outriggers.
2. Rotate the superstructure so the counterweight will be over the front of the carrier to gain additional clearance.
3. Shut down crane.

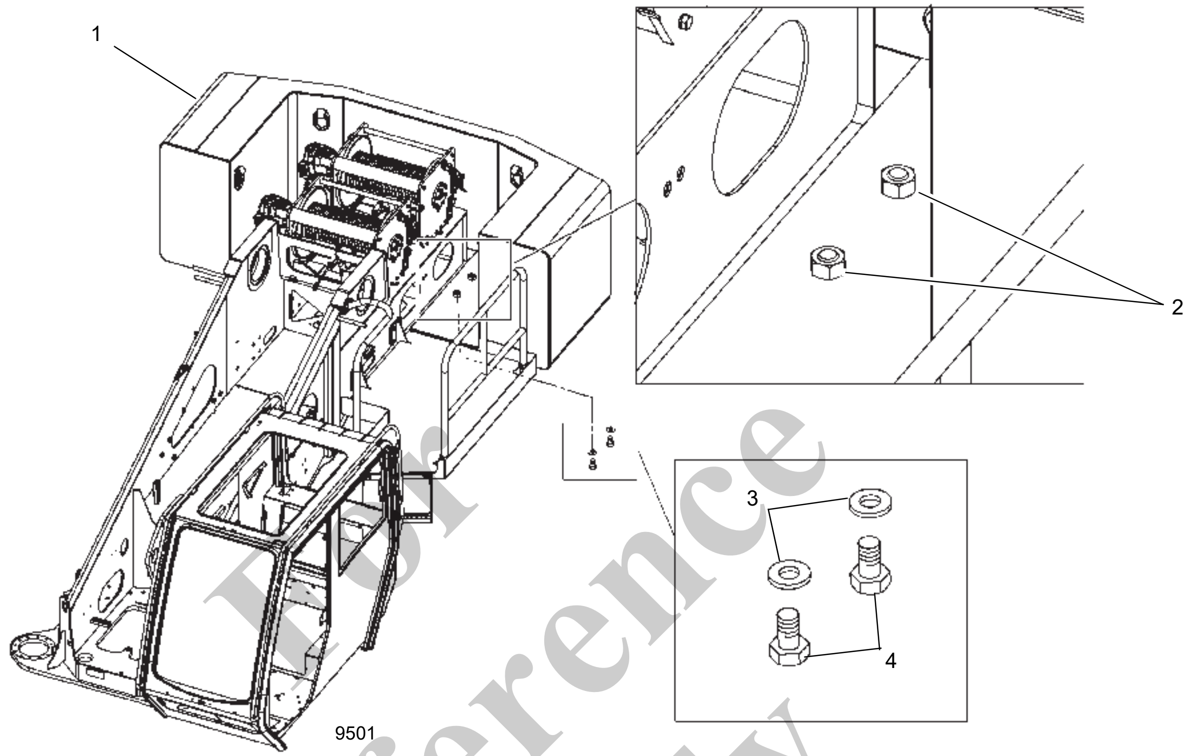
CAUTION

When lifting/handling the counterweight, keep the chains/ straps vertical to minimize side pull on the lifting lugs.

NOTE: The counterweight weighs approximately 5580 kg (12,300 lb).

NOTE: Use of a forklift to remove/install the fixed counterweight is not recommended.

4. Attach an adequate lifting device to the four lifting lugs on the counterweight.Lift the counterweight into place on the superstructure, aligning the securing nuts in the bottom of the counterweight with the holes in the superstructure.
5. Secure the counterweight to the superstructure using four bolts and washers. Tighten bolts following torque specifications found under *Fasteners and Torque Values*, page 1-19.
6. Remove the lifting device from the counterweight.



Item	Description
1	Counterweight
2	Nut
3	Washer
4	Bolt

FIGURE 5-5

SECTION 6
SWING SYSTEM

SECTION CONTENTS

INTRODUCTION

Description

The swing system consists of an electric remote controller, a swing enable switch, a free swing button switch, a directional control valve, the swing drive, the swing brake assembly, the brake pedal and power brake valve, and a swing brake release solenoid valve.

The purpose of the swing system is to allow the crane superstructure to rotate atop the carrier frame. The superstructure swing system provides full 360 degree continuous rotation in both directions.

The swing brake is applied when the Swing Controller is in the center position and is automatically released when the Swing Controller is actuated. Swing is activated using the Swing Enable Switch and the controller in the cab. When the Swing Controller is actuated, hydraulic pressure is routed to the swing motor to drive the gearbox in the appropriate direction. As the gearbox rotates, the pinion gear meshes with the teeth on the swing bearing and rotates the superstructure. Swing speed is controlled by the controller. The maximum rotation speed is 1.5 rpm with no load. Positioning the controller to the left or right actuates a control valve through electric signal to provide 360 degree continuous rotation in the desired direction. Upon moving the controller to the center position, the crane control system will gradually reapply the swing brake until it is its fully applied. The operator can apply the swing brake manually by pressing the Swing Brake Foot Pedal. The Free Swing Button is located on the upper front of the left controller. Pressing and holding the Free Swing Button releases the swing brake and allows the boom to be centered over the load prior to lifting.

The crane is equipped with a pin type turntable lock as standard and an optional 360 degree positive swing lock. The 360 degree positive swing lock meshes with the swing gear teeth at any point of rotation. The pin type turntable lock will only lock the turntable in a straight ahead position over the front of machine. Both swing locks are operated from the cab.

Theory of Operation

Swing Drive

The hydraulic power for the swing drive (Figure 6-1) is supplied by the engine driven hydraulic pump. Oil flows from the pump to the hydraulic Port 5 swivel. Flow from the swivel is routed to the accessory manifold with swing directional control valve. Flow is routed to the front steering flow divider valve in the swing directional control valve. Bypass flow from the flow divider valve is used to supply the swing directional control valve.

When the electric remote control is positioned to select right or left swing, the flow through the control valve is directed to the swing motor. If the SWING selector switch is in the ON position, the superstructure will rotate in the desired direction. Shifting the control to neutral and depressing the brake pedal will stop the swing.

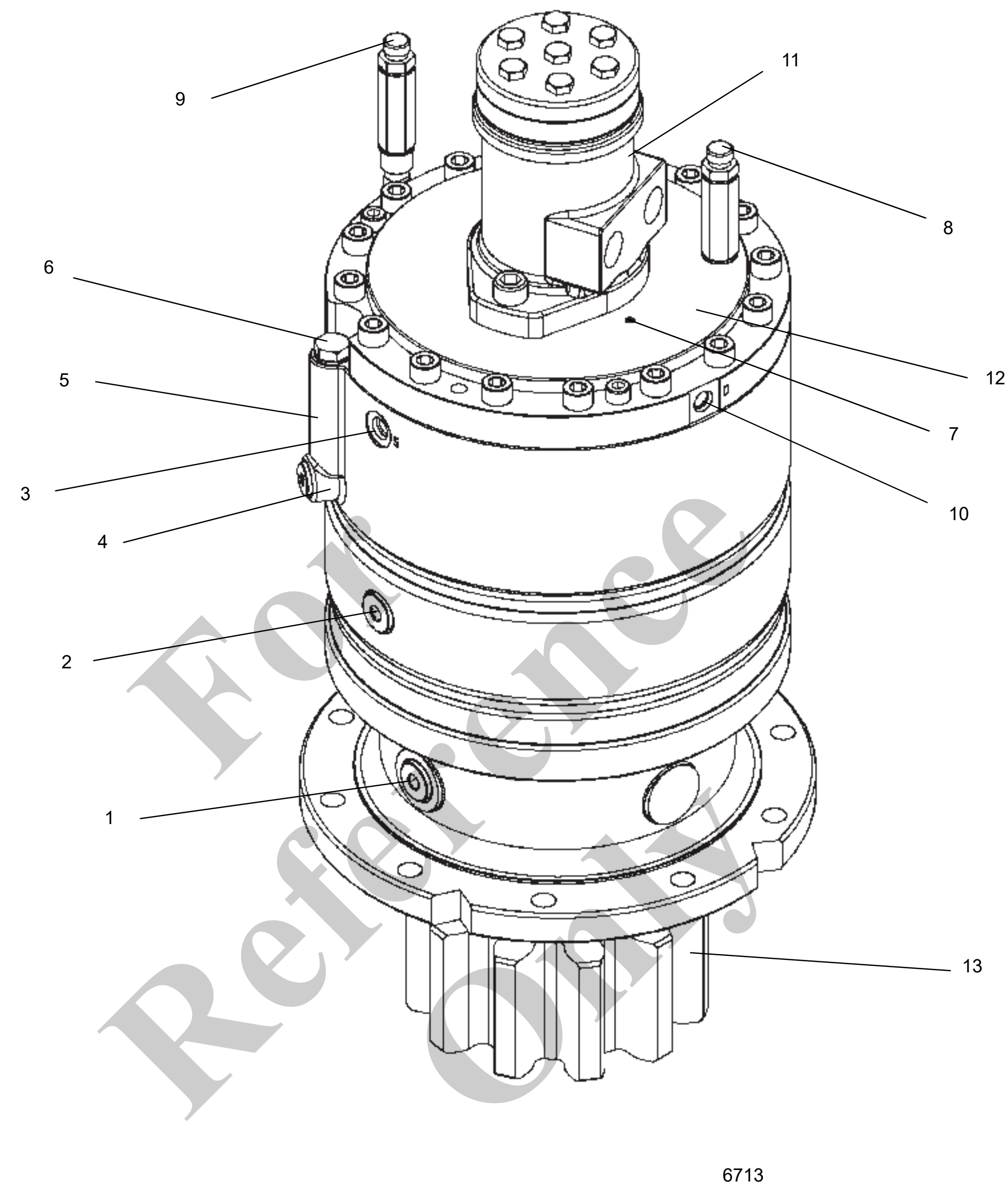


FIGURE 6-1

Item	Description
1	Drain Plug
2	Plug
3	Brake release Port
4	Drain Plug for Brake Housing
6	Fill Plug and Oil Level Indicator
8	Breather

Item	Description
9	Breather
10	Brake Apply Port
11	Motor
12	Gearbox and Brake
13	Pinion

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Superstructure swing operation erratic in either direction.	**a.** Damaged relief valve.	**a.** Replace relief valve.
	b. Swing brake dragging (not releasing properly).	**b.** Readjust and/or replace necessary parts.
	c. Low engine rpm.	**c.** Increase engine rpm to obtain smooth swing operation.
	d. Low hydraulic oil.	**d.** Replenish hydraulic oil to proper level.
	e. Improper movement of control to neutral.	**e.** Feather controls to neutral to maintain smooth stopping action.
	f. Insufficient lubricant on swing bearing.	**f.** Lubricate bearing properly. Refer to Section 9 - LUBRICATION.
	g. Crane not level.	**g.** Level crane using outriggers.
	h. Damaged swing motor.	**h.** Repair or replace swing motor.
	i. Excessive overload.	**i.** Reduce load. Refer to load capacity chart.
	j. Restricted or partly clogged hydraulic hose or fittings.	**j.** Replace hose or fittings.
	k. Pump cavitation in swing section.	**k.** Tighten suction hose or replace any damaged fitting. Check hydraulic tank level.
	l. Improperly torqued turntable bolts.	**l.** Torque turntable bolts evenly.
	m. Excessive preload on upper and lower pinion shaft bearing.	**m.** Adjust as necessary.
	n. Improperly torqued swing motor attachment bolts.	**n.** Torque swing motor attachment bolts.
	o. Malfunction of the swing box.	**o.** Remove swing box and make necessary repairs.
	p. Worn or damaged pump.	**p.** Repair or replace damaged pump.
	q. Damaged swing directional control valve.	**q.** Repair or replace swing directional control valve.
	r. Damaged swing pinion.	**r.** Replace pinion.
	s. Damaged turntable bearing.	**s.** Replace turntable bearing.
	t. Software settings.	**t.** Refer to *Adjusting Electronic Joysticks*, page 3-17.

Symptom	Probable Cause	Solution
2. Superstructure swing operation erratic in one direction only.	**a.** Crane not level.	**a.** Level crane using outriggers.
	b. Turntable bearing binding due to continuous limited swing. (Example: concrete pourer.)	**b.** Rotate machine 360 degrees in both directions several times and lubricate bearing.
	c. Restricted hose or fitting.	**c.** Replace hose or fitting.
	d. Damaged swing directional control valve.	**d.** Replace swing directional control valve.
	e. Damaged swing pinion.	**e.** Replace pinion.
	f. Damaged turntable bearing.	**f.** Replace turntable bearing.
	g. Software settings.	**g.** Refer to *Adjusting Electronic Joysticks*, page 3-17.
3. Superstructure will not swing in either direction.	**a.** Damaged relief valve.	**a.** Remove, clean, and repair or replace relief valve.
	b. Damaged swing motor.	**b.** Repair or replace swing motor.
	c. Swing brake not releasing properly.	**c.** Repair as necessary.
	d. Damaged hydraulic remote control valve.	**d.** Replace hydraulic remote control valve.
	e. Internal damage to swing box.	**e.** Remove swing box and repair.
	f. Worn or damaged hydraulic pump.	**f.** Replace pump section.
	g. Damaged swing directional control valve.	**g.** Replace swing directional control valve.
	h. Damaged swing pinion.	**h.** Replace pinion.
	i. Damaged turntable bearing.	**i.** Replace turntable bearing.
	j. Excessive overload.	**j.** Reduce load. Refer to load capacity chart.
	k. Software settings.	**k.** Refer to *Adjusting Electronic Joysticks*, page 3-17.
	l. Cold ambient temperatures.	**l.** Refer to the swing drive and turntable bearing warm-up procedures found under the sub-section titled *Crane Warm-Up Procedures* in Section 4 of the GRT655 Operator Manual.

Symptom	Probable Cause	Solution
4. Superstructure swing operation slow in either direction.	**a.** Damaged relief valve.	**a.** Adjust, repair or replace valve.
	b. Improperly adjusted swing brake.	**b.** Readjust.
	c. Damaged hydraulic remote control valve.	**c.** Replace hydraulic remote control valve.
	d. Improperly lubricated swing bearing.	**d.** Lubricate bearing per recommendations.
	e. Improper size hose and/or fittings installed.	**e.** Refer to the Parts Manual.
	f. Clogged or restricted hydraulic hoses or fittings.	**f.** Clean or replace damaged parts.
	g. Worn or damaged output shaft bearings	**g.** Replace bearings.
	h. Worn or damaged swing motor.	**h.** Repair or replace motor.
	i. Worn or damaged hydraulic pump.	**i.** Repair or replace pump.
	j. Crane not level.	**j.** Level crane.
	k. Damaged swing directional control valve.	**k.** Replace swing directional control valve.
	l. Software settings.	**l.** Refer to *Adjusting Electronic Joysticks*, page 3-17.
5. Superstructure swing operation slow in one direction only.	**a.** Crane not level.	**a.** Level crane.
	b. Damaged hydraulic remote control valve.	**b.** Replace hydraulic remote control valve.
	c. Damaged swing directional control valve.	**c.** Replace the swing directional control valve.
	d. Clogged or restricted hose.	**d.** Replace hose or fitting.
	e. Improperly torqued turntable bearing.	**e.** Torque turntable bearing.
	f. Software settings.	**f.** Refer to *Adjusting Electronic Joysticks*, page 3-17.
6. Swing brake operation erratic.	**a.** Improper brake adjustment.	**a.** Adjust brake.
	b. Air in swing brake system.	**b.** Bleed brake system.
	c. Brake pedal not fully retracted.	**c.** Check brake pedal return spring; repair or replace spring.
	d. Dirty or glazed brake disc.	**d.** Clean or replace disc.
	e. Malfunction of the glide swing power brake valve.	**e.** Repair or replace glide swing power brake valve.
	f. Kinked or bent lines and/or hoses and fittings.	**f.** Straighten or replace as required.
	g. Software settings.	**g.** Refer to *Adjusting Electronic Joysticks*, page 3-17.

Symptom	Probable Cause	Solution
7. Swing brake system will not operate.	**a.** Damaged swing brake release valve.	**a.** Replace release valve.
	b. Damaged glide swing power brake valve.	**b.** Repair or replace glide swing power brake valve.
	c. Internal damage to the swing brake assembly.	**c.** Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	**d.** Tighten or replace lines and fittings.
	e. Software settings.	**e.** Refer to *Adjusting Electronic Joysticks*, page 3-17.
8. Swing brake pedal is spongy.	**a.** Damaged glide swing power brake valve.	**a.** Repair or replace the glide swing power brake valve.
	b. Loose or restricted brake lines or fittings.	**b.** Tighten or replace brake lines and fittings.
	c. Software settings.	**c.** Refer to *Adjusting Electronic Joysticks*, page 3-17.
9. Swing brake drags.	**a.** Damaged glide swing power brake valve.	**a.** Repair or replace the glide swing power brake valve.
	b. Damaged swing brake release valve.	**b.** Replace release valve.
	c. Internal damage to the swing brake assembly.	**c.** Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	**d.** Tighten or replace brake lines and fittings.
	e. Software settings.	**e.** Refer to *Adjusting Electronic Joysticks*, page 3-17.
10. Superstructure swings slowly.	**a.** Insufficient hydraulic volume.	**a.** Check delivery of hydraulic pump. Ensure sufficient fluid is available to pump. Check pump drive speed.
	b. Damaged relief valve.	**b.** Adjust, repair, or replace valve.
	c. Damaged swing motor.	**c.** Repair or replace motor.
	d. Software settings.	**d.** Refer to *Adjusting Electronic Joysticks*, page 3-17.
11. Swing motor continues to operate when swing control is in neutral.	**a.** Hydraulic remote control valve sticking or valve otherwise damaged.	**a.** Repair or replace valve.
	b. Control valve sticking or valve otherwise damaged.	**b.** Repair or replace valve.
	c. Software settings.	**c.** Refer to *Adjusting Electronic Joysticks*, page 3-17.
12. Swing motor turning in wrong direction.	**a.** Improper port connections.	**a.** Reverse port connection.
	b. Software settings.	**b.** Refer to *Adjusting Electronic Joysticks*, page 3-17.

Symptom	Probable Cause	Solution
13. Swing motor noisy.	**a.** Air in system.	**a.** Refer to Section 2 - HYDRAULIC SYSTEM, for removal of air from the system.
	b. Motor binding.	**b.** Repair or replace motor.
	c. Software settings.	**c.** Refer to *Adjusting Electronic Joysticks*, page 3-17.

6

SWING MOTOR

Description

The swing motor is mounted on the swing brake housing and drives the swing gearbox through the brake assembly. The swing motor is a hydraulic gerotor type with low speed and high torque characteristics. It has only three moving parts, the commutator valve, the drive, and the gerotor star. The motor has two ports for connection to the hydraulic system.

Maintenance

Removal

1. Ensure the swing brake and swing lock are engaged.
2. Clean the port area around the motor. Tag and disconnect the hydraulic hoses from the motor assembly. Cap or plug all openings.

CAUTION

Pull straight up on the motor assembly to avoid damaging the splined shaft.

3. Remove the two screws securing the motor and lift the swing motor free of the flange. Remove and discard the O-ring from the groove in the swing brake.

Installation

CAUTION

Use care when engaging the swing motor drive gear, do not force the shaft to engage.

1. Install a new O-ring in the groove of the swing brake. Position the swing motor on the swing brake, engaging the shaft with the brake input shaft.
2. Apply Loctite 243 to the screw threads. Install the screws and secure the motor to the brake housing. Torque the screws 85 to 103 N-m (44 to 72 lb-ft).
3. Connect the hydraulic lines to the swing motor as tagged during removal.

Test

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

SWING GEARBOX AND BRAKE

Description

The swing gearbox and brake, used in conjunction with the swing motor, rotates and stops the superstructure. A pedal on the cab floor is used to activate the swing brake. The swing brake is automatically activated when the swing controller is returned to the neutral (center) position. The swing gearbox are bolted to the superstructure base plate, and its pinion gear meshes with the ring gear of the turntable bearing to rotate the turntable.

The swing gearbox utilizes double reduction planetary gearing. The multi-disc swing brake assembly is an integral part of the swing gearbox and is located between the swing motor and the swing gearbox. The brake mechanism is a disc pack that is hydraulically released and spring applied.

Maintenance

NOTE: The swing brake can be removed and disassembled independently of the swing gearbox.

Swing Brake

Removal

1. Engage the turntable lock pin.
2. Tag and disconnect the hydraulic lines connected to the swing motor and the brake. Cap and/or plug all openings.
3. Remove the swing motor from the swing brake according to the procedures found in this Section under SWING MOTOR - REMOVAL.

CAUTION

Use care when removing the capscrews securing the brake, as there is tension on the bolts due to internal brake springs.

4. Unscrew the screws securing the brake to the gearbox. Lift the brake using the brake flange, then remove the O-ring.
5. Cover the opening of the swing gearbox to ensure no dirt, dust, etc., gets into the gearbox.

Installation

1. Install a new o-ring onto the brake housing.
2. Apply Loctite 243 to the screws. Install brake onto gearbox and secure with the screws. Torque the screws 50 to 60 N-m (36.8 to 44.2 lb-ft).
3. Install the swing motor into the swing brake according to the procedures found in this Section under SWING MOTOR - INSTALLATION.
4. Fill brake housing with oil to the full mark on the dipstick.
5. Connect the hydraulic lines to the motor and brake.
6. Bleed all air from the brake assembly.

Gearbox

Removal

1. Engage the turntable lock pin.
2. Mark orientation of the swing drive gearbox housing to the turntable.
3. Tag and disconnect the hydraulic lines from the swing motor and swing brake. Cap and/or plug all openings
4. Unscrew the three screws securing the pinion gear cover. Remove the cover.

NOTE: The complete gearbox assembly with motor weighs approximately 170 kg (375 lb).

5. Attach a suitable lifting device to the swing gearbox. Remove the capscrews, flatwashers and bushings securing the gearbox to the mounting plate.

NOTE: Take note of the swing motor port orientation to ensure proper installation.

6. Remove the swing gearbox.
7. If necessary, remove the swing motor according to the procedures found in this Section under SWING MOTOR REMOVAL.
8. If necessary, remove the swing brake according to the procedures found in this Section under SWING BRAKE REMOVAL.
9. Cover the opening of the swing gearbox to ensure no dirt, dust, etc., gets into the gearbox.

Installation

1. If removed, install the swing brake according to the procedures found in this Section under SWING BRAKE INSTALLATION.
2. If removed, install the swing motor according to the procedures found in this Section under SWING MOTOR INSTALLATION.
3. Attach a suitable lifting device to the swing gearbox and lift and position the swing gearbox in place on the mounting plate.
4. Install the capscrews, flatwashers and bushings. Torque the capscrews 85 to 93 N-m (63 to 69 lb-ft).
5. Apply Loctite 243 to screws. Install the pinion gear on the output shaft. Install the cover and secure with three screws. Torque screws 50 N-m (36.8 lb-ft).
6. Connect the hydraulic lines to the swing brake.
7. Connect the hydraulic lines to the swing motor.

8. Service the gearbox as indicated under SERVICING.

Servicing

As with all highly stressed mechanisms, reasonable operating procedures are always required. Normal maintenance should only consist of proper lubrication and a periodic check of mounting bolt torque values. Lubrication consists of maintaining the gearbox oil level. Oil in a new gearbox should be drained and flushed out after approximately 250 hours of operation, and replaced with premium quality SSGL-5 after approximately 500 hours of operation or each year, whichever occurs first (refer to *Section 9 - Maintenance and Lubrication* for oil specification). Operation in high humidity or polluted air areas will require more frequent changes to minimize moisture or contaminate accumulation. Change the oil as follows.

1. Unscrew the drain plug. To ensure all oil has been removed, unscrew the filler and level plugs.
2. After oil is drained, replace the drain plug and any other plugs that were removed to drain the oil.
3. Flush the case with a light flushing oil.

NOTE: Cleaning of the gearbox with a solvent is recommended to prevent an accumulation of grit and grime. Avoid steam cleaning where moisture and dirt might be driven into the vent of the swing bearing.

4. To refill with oil, fill through filler plug until it begins to flow out of the level plug.
5. Tighten the level and filler plugs.

Checking The Oil Level

1. Check the oil level through level plug.
2. If no oil is visible on the level plug, add oil until the level is between min and max on the level plug.
3. Refer to *Section 9 - Maintenance and Lubrication*.

Testing

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

SWING BEARING

Description

The swing bearing is an anti-friction roller bearing that mates the Superstructure to the Carrier. The bearing inner race is bolted to the Superstructure and the outer race is bolted to the Carrier. The inner race contains two grease fittings for lubrication of the bearing which are hosed to two fittings at the front right side of the turntable center section.

Maintenance

General

The swing bearing is the most critical maintenance point of the crane. It is here, at the centerline of rotation, that stresses of loads are concentrated. In addition, the bearing provides the only attachment between the superstructure and carrier. Therefore, proper care of the bearing and periodic maintenance of the turntable-to-bearing attach bolts -IS A MUST -to ensure safe and efficient operation.

Torquing Turntable Bolts

General

DANGER

Failure to maintain proper torque of the turntable bearing attaching bolts will result in damage to the crane and possible injury to personnel.

Maintaining proper torque value for bolts is extremely important for structural strength, performance, and reliability of the crane. Variations in torque can cause distortion, binding, or complete separation of the superstructure from the carrier.

CAUTION

Repeated re-torquing may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 8 and metric grade 10.9), the serviceman must be aware of bolt classifications and that he is installing a high strength heat-treated tempered component and the bolt must be installed according to specifications. Special attention should be given to the existence of lubricant and plating that will cause variation from dry torque values. When a high strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification.

DANGER

It is mandatory that bearing attaching bolts be inspected for lack of torque and retorqued, as required, after the first 300 hours of crane operation. The bolts may loosen in service due to vibration, shock-loads, and temperature changes, therefore, periodic inspection should be accomplished every 500 hours thereafter, ensuring the bolts are properly torqued.

KNOW YOUR TORQUE WRENCH! 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.

If it is reported by the crane operator or suspected that the crane has been overloaded beyond the capacities specified above the bold line on the cranes' capacity chart, then all turntable bolts must be inspected for looseness and retorqued to specifications.

Turntable bolts should be torqued according to the procedures outlined in this section.

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

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

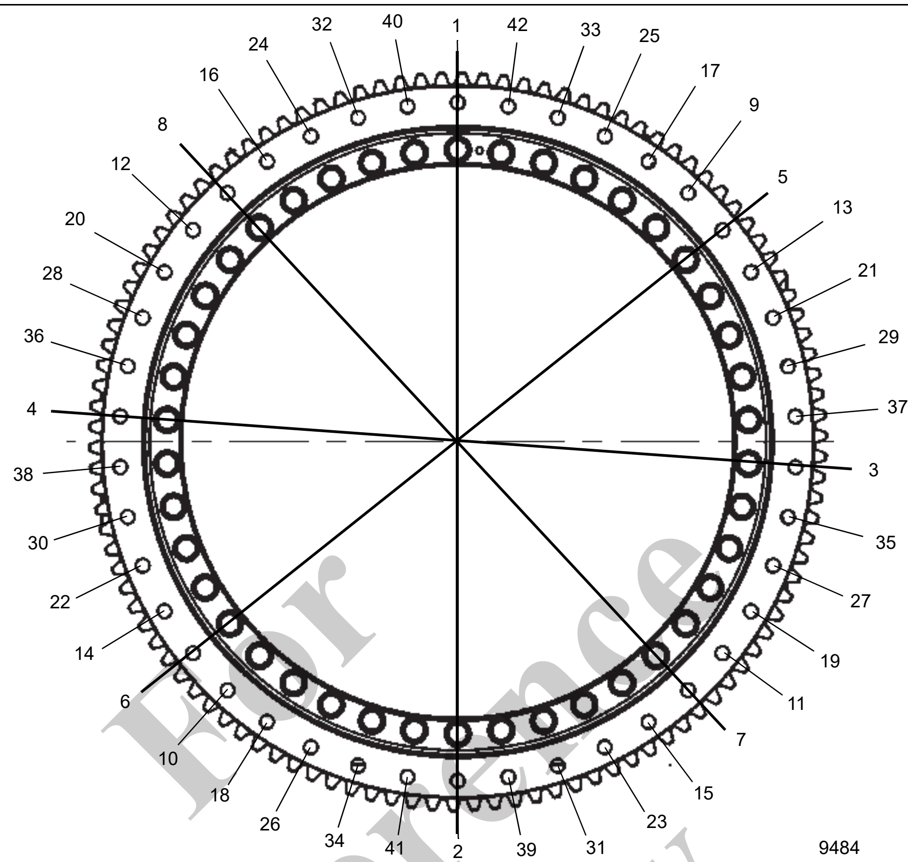


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FIGURE 6-2

The inner race of the bearing is secured to the turntable by 42, M24 x 150 mm, 10.9 bolts. The outer race of the bearing is secured to the carrier frame by 42, M24 x 150 mm, 10.9 bolts.

Torque Values

Torque all inner race turntable bolts Figure 6-2 to a final torque of 790 N-m (580 lb-ft).

Torque all outer race turntable bolts Figure 6-2 to a final torque of 790 N-m (580 lb-ft).

tools **Required**

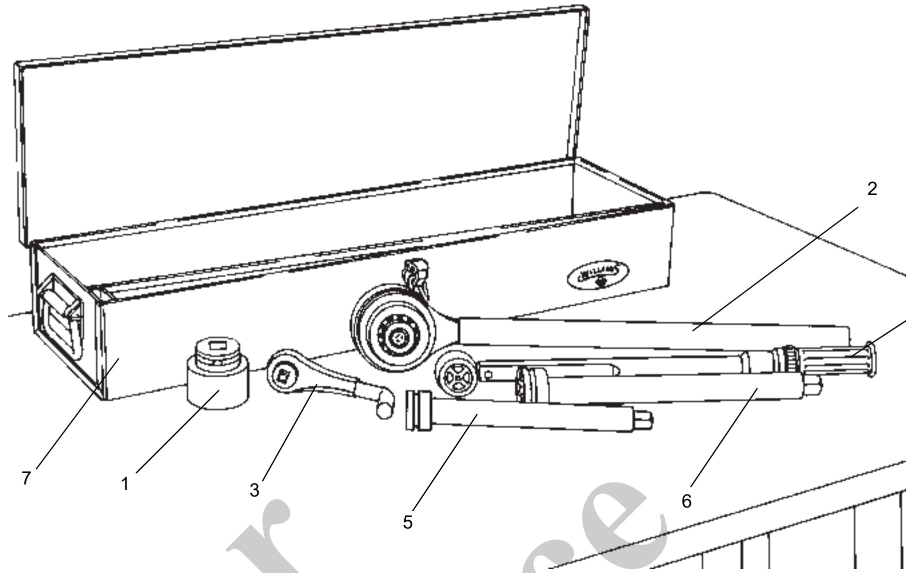
Figure 6-3 lists the complete set of special tools required to torque the turntable bolts.

Inner Race Torquing

1. Extend and set the outriggers. Fully elevate the boom.
2. Using a star pattern tighten the bolts to a torque of 630 N-m (465 lb-ft). Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Return to bolt 1 and tighten all bolts to a torque of 790 N-m (580 lb-ft). The same tools are used as in step 1.

Outer Race Torquing

1. Extend and set the outriggers. Fully elevate the boom.
2. Using a star pattern tighten the bolts to a torque of 630 N-m (465 lb-ft). Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Return to bolt 1 and tighten all bolts to a torque of 790 N-m (580 lb-ft). The same tools are used as in step 1.



Orders for special tools shall be referred to:

Manitowoc Crane Care
1565 Buchanan Trail East
Shady Grove, PA 17256-0021
Phone: (717) 597-8121
Fax: (717) 593-5929

Description	Grove Part Number	Quantity Required
1. 1 1/2” Socket 3/4” Drive	9-999-100143	1
2. 4 to 1 Torque Multiplier (1/2” Input 3/4” Output)	9-999-100134	1
3. Backlash Adapter	9-999-100141	1
4. 1/2” Drive Torque Wrench	9-999-100136	1
5. 10” Extension 3/4” Drive	9-999-100138	A/R
6. 13” Extension 3/4” Drive	9-999-100137	A/R
7. Tool Box (Optional)	9-999-100146	1

Special Turntable Bolt Torquing Tools

FIGURE 6-3

Removal

1. Fully extend and set the outriggers enough to take up the slack in the pads.

NOTE: Do not raise the machine on the outriggers.

2. Ensure the boom is in the travel position and the turntable lock pin is engaged.
3. Elevate the boom slightly and shut down the engine.
4. Retract the main hoist rope and auxiliary hoist rope (if equipped), then tie-off each rope at the related hoist.
5. Tag and disconnect the battery cables from the batteries.

NOTE: The GRT655 boom assembly weighs approximately 6800 kg (15,000 lb). The GRT655L boom assembly weighs approximately 7520 kg (16,575 lb). Removal of the swingaway boom extension will simplify boom removal, therefore, the above weight is for the boom without the swingaway boom extension attached. The lift cylinder weighs approximately 921 kg (2030 lb).

6. Remove the boom and lift cylinder following the procedures outlined in Section 4 - BOOM.

NOTE: The counterweight structure weighs approximately 5580 kg (12,300 lb).

7. Remove the counterweight following the procedures outlined in Section 5 - HOIST and COUNTERWEIGHT. If necessary, remove the hoists.
8. Tag and disconnect all water and oil lines from the bottom of the swivel. Cap or plug all lines and openings.
9. Locate the connectors and ground wire that joins the swivel wiring harness to the receptacles and ground stud on the carrier.
10. Disconnect the swivel wiring harness connectors from the carrier wiring receptacles. Remove the ground wire from the ground stud.
11. Remove the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.
12. Coil the wiring harness and secure it to the swivel to prevent damage to the harness during turntable removal.
13. Remove the linkage assembly that secures the bottom of the swivel to the carrier frame.

NOTE: The swivel assembly will be removed with the turntable.

DANGER

Ensure the lifting device is capable of fully supporting the weight of the superstructure. Ensure the superstructure will not tilt or slide during lifting and moving. Failure to do so may result in death or injury to personnel and damage to equipment.

NOTE: Refer to Table 1-1 - GRT655 Axle Weight Distribution Table, page 1-6 and Table 1-2 - GRT655L Axle Weight Distribution Table, page 1-8 for the weight of the superstructure with bearing. If a lifting device capable of lifting the entire superstructure is not available, the superstructure weight may be reduced by removing various components such as the hoist(s).

14. Attach a suitable lifting device to the two superstructure lifting lugs near the lower lift cylinder pivot shaft bushings and to the two boom pivot shaft bushings. If lifting with chains, be sure protective chain covers are used to prevent damage to the two boom pivot shaft bushings. Take in cable or chain to remove slack. Do not pull up on the superstructure.

DANGER

Ensure the superstructure is fully supported before proceeding.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be removed from the swing drive side and front side of the turntable.

15. Remove the 42 bolts and washers securing the turntable bearing outer race to the carrier.

DANGER

Ensure that any blocking material used is capable of fully supporting the weight of the superstructure and will not allow it to tilt or shift. Failure to do so may result in death or injury to personnel.

16. Carefully lift the superstructure, using care not to damage the swivel assembly. Set the superstructure and bearing on blocking that will not allow the superstructure to tilt or shift, or rest on the swivel. Ensure blocking is supporting the bearing and tail end of the superstructure. Leave the lifting device attached.

NOTE: If the same bearing is to be used again, mark the position of the bearing on the superstructure so it can be installed in the exact position it was before removal.

17. Remove the 42 bolts and washers securing the turntable bearing to the superstructure.

18. Using the lifting device, remove the superstructure from the bearing.

Inspection

Check the bearing teeth for chipping or cracking. If any evidence of these is found, replace the bearing. Ensure the bolt holes are free of dirt, oil, or foreign material.

Installation

DANGER

Anytime a turntable bolt has been removed, it must be replaced with a new bolt.

NOTE: If the same bearing is to be used again, align the marked teeth on the pinion shaft and the marked teeth on the bearing.

NOTE: Installation is in the travel position. Ensure the swing lock is disengaged before attempting to mate the bearing to the superstructure.

1. Using an appropriate lifting device, position the superstructure over the turntable bearing. If the same bearing is being used, position it as marked prior to removal.

If a new bearing is being installed, position the bearing so that its loading (filler) plug is as close as possible to 90° to the side of the crane, opposite the cab-side.

2. Install 42 new bolts and washers securing the bearing to the superstructure. Refer to Inner Race Torquing in this Sub-Section.

NOTE: If a new bearing is being installed, a new pinion gear must also be used. Align the high point (maximum eccentricity) on the bearing with the new pinion gear high point (Figure 6-4).

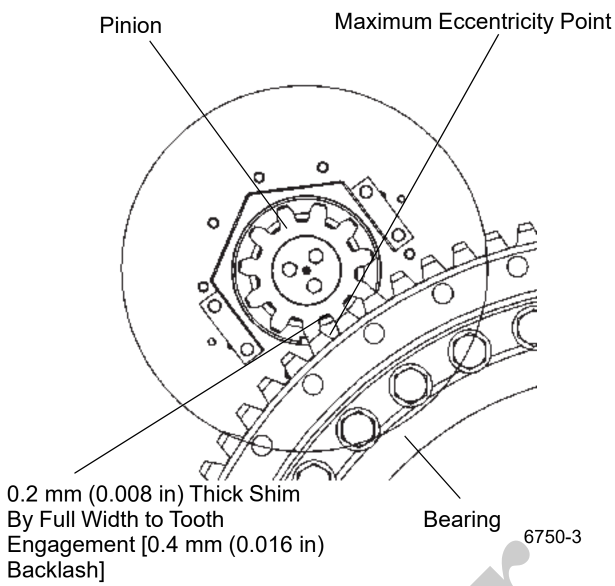


FIGURE 6-4

3. Orient ring gear such that its point of maximum eccentricity (“high point”) is located between the swing drives. Position swing drives so that pinion is centered within cutout in base plate and motor ports face towards the outboard side as shown.

4. Using an appropriate lifting device, lift the superstructure and align it over the carrier in the travel position.Carefully lower the superstructure into position on the carrier bearing plate, being careful not to damage the swivel assembly.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be installed from the swing drive side and front side of the turntable.

5. Install 42 new bolts and washers. Refer to Outer Race Torquing in this Sub-Section.

6.

CAUTION

Do Not Clamp Over Pinion.

- Using shims, set backlash by moving the swing drive assemblies toward the bearing in order to mesh the pinion with the ring gear teeth (see Figure 6-4).
- Check tooth engagement squareness and vertical tooth engagement.
- Remove backlash shims and recheck backlash.

7. Install the linkage assembly that secures the bottom of the swivel to the carrier frame.

8. Plug the swivel wiring harness connectors into the carrier receptacles. Secure the ground wire to the ground stud using a washer, lockwasher, and nut.

9. Install the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel.

10. Connect all water and hydraulic lines to the ports on the bottom of the swivel as tagged during removal.

11. Install the boom and lift cylinder following the procedures outlined in Section 4 - BOOM.

NOTE: The counterweight structure weighs approximately 5580 kg (12,300 lb).

12. Install the counterweight, and main and auxiliary hoists if removed, following the procedures outlined in Section 5 - HOIST and COUNTERWEIGHT.

13. Reconnect the batteries.

14. Check the slew potentiometer in the electrical swivel for proper orientation. Refer to *Slew Potentiometer Adjustment*, page 6-21.

Testing

Activate the crane and check for proper function.

NOTE: If the superstructure does not turn freely after bearing and pinion replacement, contact your local distributor.

SWIVELS

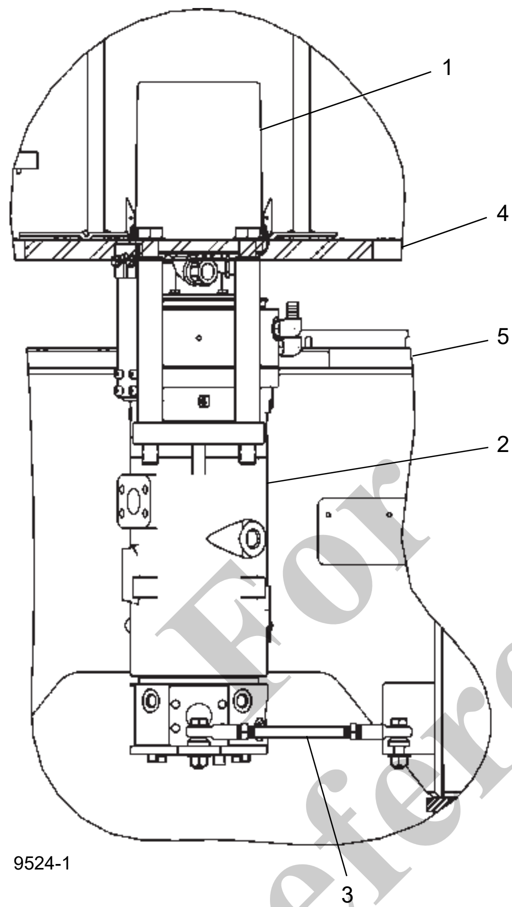
Description

The swivel assembly Figure 6-5 consists of a 10 port hydraulic swivel, a 2 port water swivel, a 2 port refrigerant swivel and a 20 conductor electrical slip ring. Solid connections cannot be used to transfer oil, heater hot water and electricity between the carrier and superstructure due to the continuous 360 degree swing. The use of swivels efficiently accomplishes this function.

The barrel portion of the hydraulic swivel is attached to the turntable base plate by four capscrews, washers and bushings. The spool portion of the swivel rides upon a thrust ring at the top of the swivel case. The spool portion is held stationary by a linkage assembly that is attached to the swivel and the carrier frame. This allows the spool to remain stationary with the carrier as the case rotates with the superstructure.

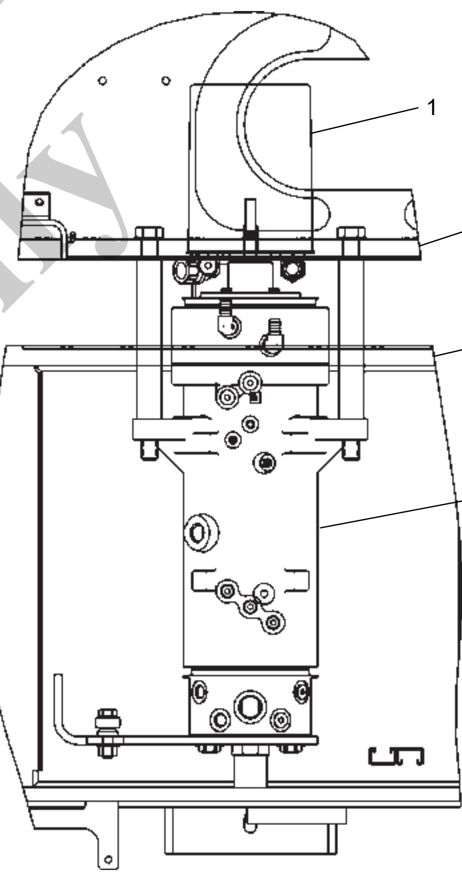
The spool portion of the water swivel is integral with the hydraulic swivel. The hydraulic and water swivel spools remain stationary with the carrier as the superstructure rotates. The water swivel case engages to hydraulic case by four dowel pins.

The electrical slip ring center or collector ring assembly is secured by setscrews to a center post which is bolted to the spool of the hydraulic swivel. This allows the collector ring assembly to remain stationary with the carrier. The outer portion or brush assembly is mounted on two studs which are located on the mounting plate assembly which is retained to the water swivel barrel by a bolt. This allows the brush assembly to rotate with the superstructure around the stationary collector core.



9524-1

Item	Description
1	Slip Ring Assembly
2	Hydraulic Swivel
3	Linkage Assembly
4	Turntable Base Plate
5	Carrier Top Plate



9524-3

FIGURE 6-5

Hydraulic Swivel

Description

Each of the ports on the spool and case of the swivel is stamped with the port number. The function of each port is described below.

Port #	Max Test Pressure kPa (bar) (psi)	Function
1	25000 (250) (3625)	Brake - Front
2	25000 (250) (3625)	Load Sense
3	25000 (250) (3625)	Brake - Rear
4	5000 (50) (725)	Dual Return
5	30000 (300) (4351)	Swing/Steer
6	32000 (320) (4641)	Lift/Tele/Hoist
7	25000 (250) (3625)	Front Steer - Left
8	25000 (250) (3625)	N/A
9	25000 (250) (3625)	Front Steer-Right
10	500 (5) (73)	Case Drain
11	500 (5) (73)	A/C
12	500 (5) (73)	A/C
A	500 (5) (73)	Heater Supply (Coolant)
B	500 (5) (73)	Heater Return (Coolant)

Theory of Operation

The hydraulic swivel allows oil to flow from the pumps to various crane functions on the superstructure. All oil is routed into the spool portion of the swivel where, through a series of internally drilled passages, oil is transferred to circumferential channels on the spool exterior. These channels correspond with a mating port on the outer case of the swivel. Each channel is separated by a series of nylon and O-ring seals that prevent transfer of oil and pressure. Return flow from the crane superstructure is accomplished in the same manner through another set of ports.

Engine coolant flows from the carrier mounted engine to the hot water heater in the operator cab through ports A and B of the swivel.

Refrigerant from the engine mounted compressor passes through port 12 of the swivel to the turntable mounted condenser that is cooled by an electric powered fan.The refrigerant goes from the condenser to the dryer, also mounted to the turntable, then onto the expansion valve and evaporator mounted under the operator’s seat in the cab. The refrigerant goes from the evaporator back down to the swivel where it passes through port 11 on its way back to the compressor.

Maintenance

Removal

1. Extend and set the outriggers. Ensure the crane is level and the boom is over the front.
2. Elevate the boom and note at what boom angle you have the most clearance between the lift cylinder and the turntable side plate. Shut down the engine.
3. Measure the distance from the top of the lift cylinder to the base of the boom section where the lift cylinder attaches. Cut two pieces of 10 x 10 cm (4 x 4 in) oak to fit.

NOTE: It might be necessary to raise the boom slightly to allow installation of the blocking.

NOTE: This blocking is to add extra support for the boom. Any seepage or leakage in the holding valves or internally in the cylinders will allow the boom to settle over a period of time.

4. Use the wood blocking to block between the barrel of the lift cylinder and the boom base section.

5. Evacuate A/C system and capture refrigerant. Refer to the sub-section *Air Conditioner (Optional)*, page 3-17 for evacuation time.
6. Tag and disconnect A/C lines from spool and case.
7. Tag and disconnect the hydraulic lines from the case of the hydraulic swivel. Cap or plug all lines and openings.
8. Tag and disconnect the hydraulic lines and water lines from the spool of the hydraulic swivel. Cap or plug all lines and openings.
9. Tag and disconnect the water lines from the case of the water swivel. Cap or plug all lines and openings.
10. Disconnect the swivel wiring harness connectors from the carrier receptacles and the yellow ground wire from the connector mounting bracket on the carrier frame. If necessary, remove the electrical swivel. Refer to *Electrical Slip Ring* in this Section.

NOTE: The hydraulic swivel weighs approximately 159 kg (350 lb). The hydraulic, water, and electrical swivel combined weigh approximately 172 kg (380 lb).

11. On the bottom of the swivel, remove the two bolts, washers, nuts, and spacers that secure the linkage assembly to the swivel and the carrier frame. Note the orientation of the spacers.

NOTE: It may be necessary to remove some drive line components to remove the swivel.

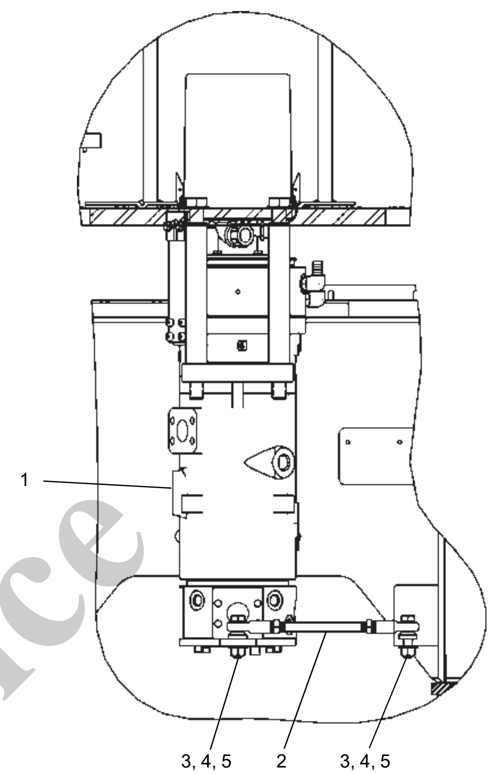


FIGURE 6-6

Item	Description
1	Swivel Assembly
2	Linkage Assembly
3	Hex Nut
4	Washer
5	Bolt

12. Position an adequate supporting device beneath the swivel.
13. Remove the capscrews, washers, and bushings securing the swivel barrel to the turntable base plate and lower the swivel to the ground.

Installation

NOTE: The hydraulic swivel weighs approximately 159 kg (350 lb). The hydraulic, water, and electrical swivel combined weigh approximately 172 kg (380 lb).

1. Raise the swivel into position.
2. Secure the hydraulic swivel to the turntable base plate with the bushings, capscrews and washers. Tighten the capscrews. Refer to *Fasteners and Torque Values*, page 1-19.

3. On the bottom of the swivel, install the linkage assembly onto the swivel and the carrier frame using the two bolts, washers, nuts, and spacers. Orient the spacers as noted during disassembly.
4. If removed, install the electrical swivel. Refer to *Electrical Slip Ring* in this Section. Connect the swivel wiring harness connectors to the carrier receptacles and the yellow ground wire to the mounting bracket on the carrier frame using the bolt and star washers taken off at removal. Spray ground stud with a terminal protector to help prevent corrosion.
5. Install the clamp, lockwasher, flat washer and capscrew to the bottom of the swivel retainer plate securing the wiring harness.
6. Connect the hydraulic lines and water lines to the spool of the hydraulic swivel as tagged during removal.
7. Connect the hydraulic lines to the hydraulic swivel case as tagged during removal.
8. Connect the water lines to the water swivel case as tagged during removal.
9. Connect the A/C lines to spool and case as tagged during removal.
10. Remove the blocking material from the lift cylinder.
11. Charge A/C system. Refer to the sub-section *Air Conditioner (Optional)*, page 3-17 for charge level and Pag oil requirements.
12. Activate all systems; cycle all functions and observe for proper operation and any leakage.

Electrical Slip Ring

Description

The slip ring assembly consists of a 20 conductor slip ring and cover assembly.

Each brush set incorporates two brushes, leads, and clips which are attached to a brush holder assembly. The brush set leads are formed into harnesses which are routed through the mounting plate on the slip ring. The collector ring leads are formed into one harness which is routed downward through the center of the hydraulic swivel. Extending from the base of the hydraulic swivel, the collector ring leads are also formed into connectors which plug into receptacles from the chassis power supply.

The slip ring cover is secured with a seal and bolts

The electrical slip ring assembly also incorporates a slew potentiometer. The potentiometer controls functions in the rated capacity limiter (RCL), working range limiter, and rear axle oscillation lockout systems.

Theory of Operation

The electrical slip ring is located on top of the water swivel and transfers electricity between the carrier and superstructure. Wiring harnesses transmit the electricity in the carrier and superstructure.

Maintenance

Removal

1. Perform steps 1 through 4 of HYDRAULIC SWIVEL - REMOVAL in this section.

CAUTION

Disconnect the batteries before performing any maintenance on the electrical system. Serious burns may result from accidental shorting or grounding of live circuits.

2. Disconnect the batteries. Refer to Section 3 - ELECTRIC SYSTEM.
3. Locate the connectors which join the collector ring harness to the receptacles for the carrier.
4. Tag the connectors and their receptacles with numbers. Disconnect the connectors from the chassis wiring receptacles.
5. Plug the connector into the carrier wiring receptacle, connect the wires as tag during removal. Install the yellow ground wire to the connector mounting bracket on the carrier frame using the bolt and star washers taken of at removal. Spray ground stud with a terminal protector to help prevent corrosion.
6. Connect the batteries.

CAUTION

It is imperative that the slew potentiometer be adjusted anytime work is done to the electrical swivel.

7. Activate all systems, cycle all functions, and observe for proper operation. Adjust the slew potentiometer following the procedures found under sub-section *Slew Potentiometer Adjustment*, page 6-21.

Preventive Maintenance

It is recommended that a normal inspection of the slip ring collector ring and brush assembly be established. An example of this could be at approximately 100 to 150 engine operating hours. When this time limit is reached, perform the following.

1. Check the collector ring and brush assembly for any corrosion, pitting, arcing, and wear.
2. Check the collector ring setscrews and ensure they are tight.
3. Check the brush and arm assembly springs. Ensure they are holding the brushes firmly against the collector rings.

Slew Potentiometer Adjustment

1. Rotate the superstructure over the front and engage the house lock pin.
2. Remove the electrical swivel cover.

CAUTION

Do not attempt to rotate the slotted shaft in the center of the slew potentiometer.

3. Disengage the house lock pin and swing the superstructure approximately 10 degrees to the right (clockwise). Slowly swing back to the left and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, step 3 must be repeated.

4. Loosen the three screws that secure the slew potentiometer to the mounting plate.
5. Rotate the body of the slew potentiometer until the slew angle indicates 0.0 ±0.1 degree.

NOTE: The slew angle indication in step 6 may not be obtainable due to limited wire length on the potentiometer, or the electrical terminals interference with one of the three mounting screws. If this occurs, reposition the collar set screwed to the potentiometer shaft and repeat steps 3 thru 5.

6

6. Tighten the three screws that secure the slew potentiometer to the mounting plate. Install the electrical swivel cover.
7. Disengage the house lock pin and swing approximately 10 degrees to the left (counterclockwise). Slowly swing back to the right and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, step 7 must be repeated.

8. If the angle indicated on the console does not exceed ±1.0 degree, proceed to step 10. If the indicated angle exceeds ±1.0 degree, return to step 3.
9. Disengage the house lock pin and swing approximately 10 degrees to the right (clockwise). Slowly swing back to the left and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, step 10 must be repeated.

10. If the angle indicated on the console does not exceed ±1.0 degree, proceed to step 12. If the indicated angle exceeds ±1.0 degree, return to step 3.
11. Disengage the house lock pin and swing approximately 10 degrees to the left (counterclockwise). Slowly swing back to the right and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, step 12 must be repeated.

12. Verify the angle indicated on the console does not exceed ±1.0 degree. If the indicated angle exceeds ±1.0 degree, return to step 3.

SECTION 7
POWER TRAIN

SECTION CONTENTS

ENGINE

Description

The engine is a Cummins QSB6.7 Tier 3 or Tier 4F diesel engine (Figure 7-1). This Service Manual does not include detailed information on the engine itself. A separate manual as prepared in detail by the engine manufacturer, is supplied with this Service Manual. However, a short description and maintenance of certain components of the fuel system, air intake system, exhaust system, and water cooling system is provided in this section.

The engine is electronically controlled by the Electronic Control Module (ECM), it is the control center of the system. It processes all of the inputs and sends commands to the fuel systems as well as vehicle and engine control devices.

Engine speed is controlled by the foot throttle pedal in the cab. It controls engine RPM which increases or decreases proportionately with the amount of foot pressure applied to the pedal. The foot throttle pedal is electrically connected to the superstructure control module which sends the signal to the engine ECM via the J1939 data link.

The engine and its components are enclosed in a hood assembly with a grill in the rear of the hood for adequate air circulation. Access to the engine is gained through a door assembly in the right side of the hood.

The air intake filter is mounted on the rear of the crane

DANGER

Do not spray starting fluid into the air inlet. The spray will contact the heater elements and could explode causing personal injury.

To aid in starting the engine in cold weather, the engine is equipped with electric air heating elements that are located in the engine’s intake air stream to aid in cold starting and reduce white smoke at start-up. In the preheat mode, the engine should not be cranked until the WAIT-TO-START lamp turns off. The WAIT-TO-START lamp is illuminated during the preheat time that takes place when the ignition switch is in the ON position during cold weather starting. The ECM checks intake manifold temperature to determine how long to energize the air heater before extinguishing the WAIT-TO-START lamp. Once the engine is started, the electric air heating element will be energized again for a time period determined by intake air temperature.

Maintenance

Engine Removal

CAUTION

Burn Hazard!

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

1. Set the outriggers and position the boom to over the side.
2. Open and remove the hood door assembly.
3. Disconnect the air filter tubing at the engine and air cleaner. Remove and lay aside.
4. Disconnect the exhaust tubing at the engine and muffler. Lay to the side.
5. Tag and disconnect the engine electrical harness connector from the carrier harness connector and battery cables.
6. Remove the start and grid heater relay panel and place to the side of the frame. Lay the relay panel with the harness on the engine. If a remote crank option is present, disconnect the remote crank harness connector from the engine harness and tie up excess harness so it is out of the way.
7. Drain the engine coolant system.
8. Drain the engine lubrication system.
9. Drain the transmission/torque converter oil system.
10. Evacuate A/C system and capture refrigerant. Refer to the sub-section *Air Conditioner (Optional)*, page 3-17 for evacuation time.
11. Remove the engine hood assembly and pump cover from the machine.
12. Disconnect and remove the drive shaft(s) between the transmission/torque converter and the axle(s). Refer to DRIVE LINES in this Section.
13. Tag and disconnect all lines from the radiator. Disconnect the coolant level sensor harness from the engine harness and tie up excess harness so it is out of the way. Remove the radiator. Refer to *Water Cooling System*, page 7-24.
14. Tag and disconnect all lines and tubing from the engine, transmission/torque converter, and all other components.

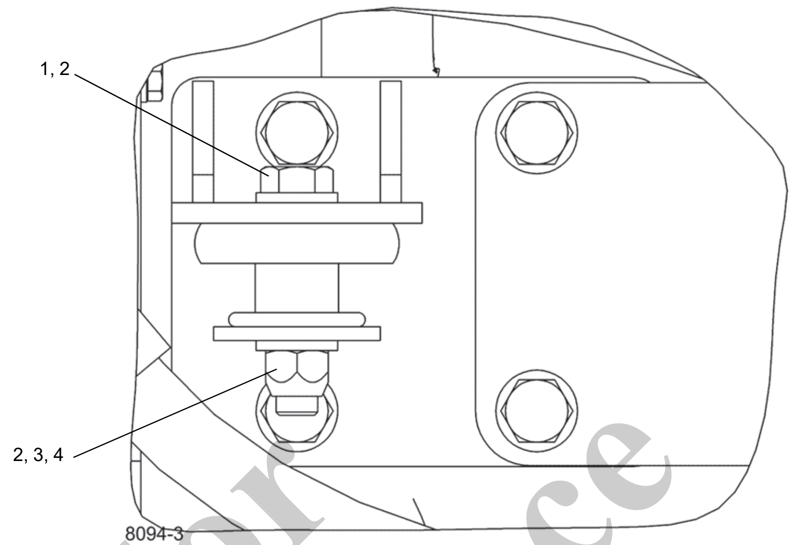
DANGER

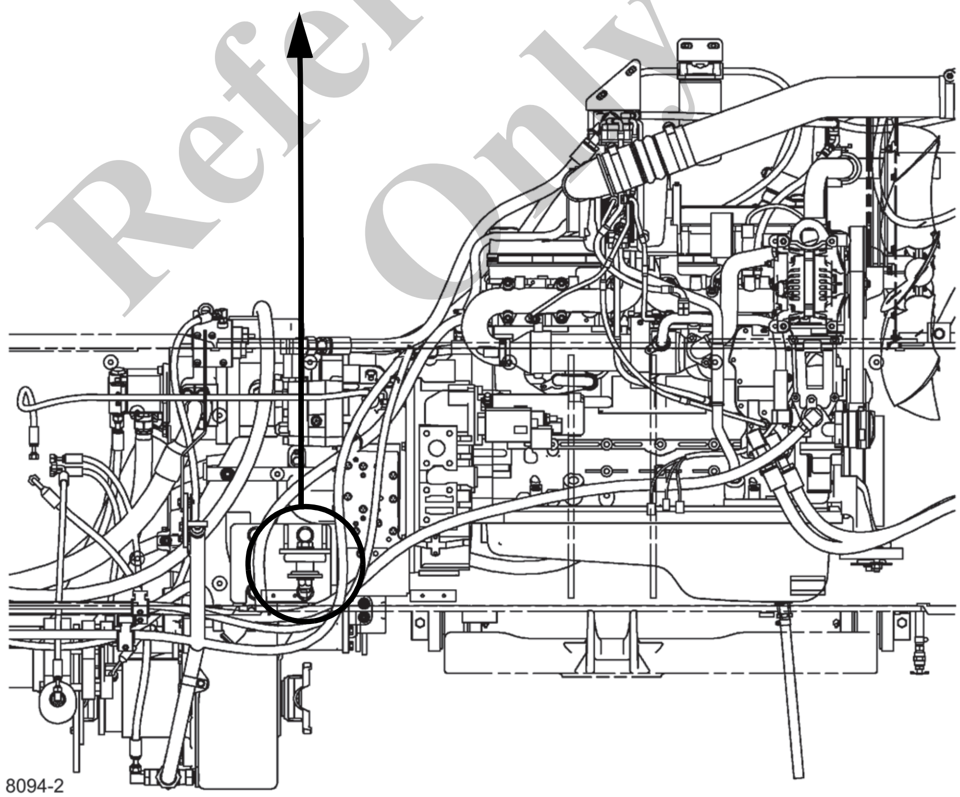
The lifting device must be able to support the combined weight of the engine and transmission.

NOTE: The engine and transmission/torque converter assembly weighs approximately 1027 kg (2265 lb).

15. Attach to the engine a lifting device capable of supporting the weight of the engine and transmission/torque converter.
16. With the lifting device supporting the weight of the engine, remove the capscrews, washers and locknuts securing the front of the engine to the frame.
17. Remove the capscrews, washers, nuts, insulator and mounting plate securing the rear of the engine to the frame.
18. Using the lifting device, lift the engine and transmission/torque converter as an assembly from the crane.
19. If a new engine is to be installed, remove all components, fittings, etc., from the old engine and install them on the new engine in the same locations.

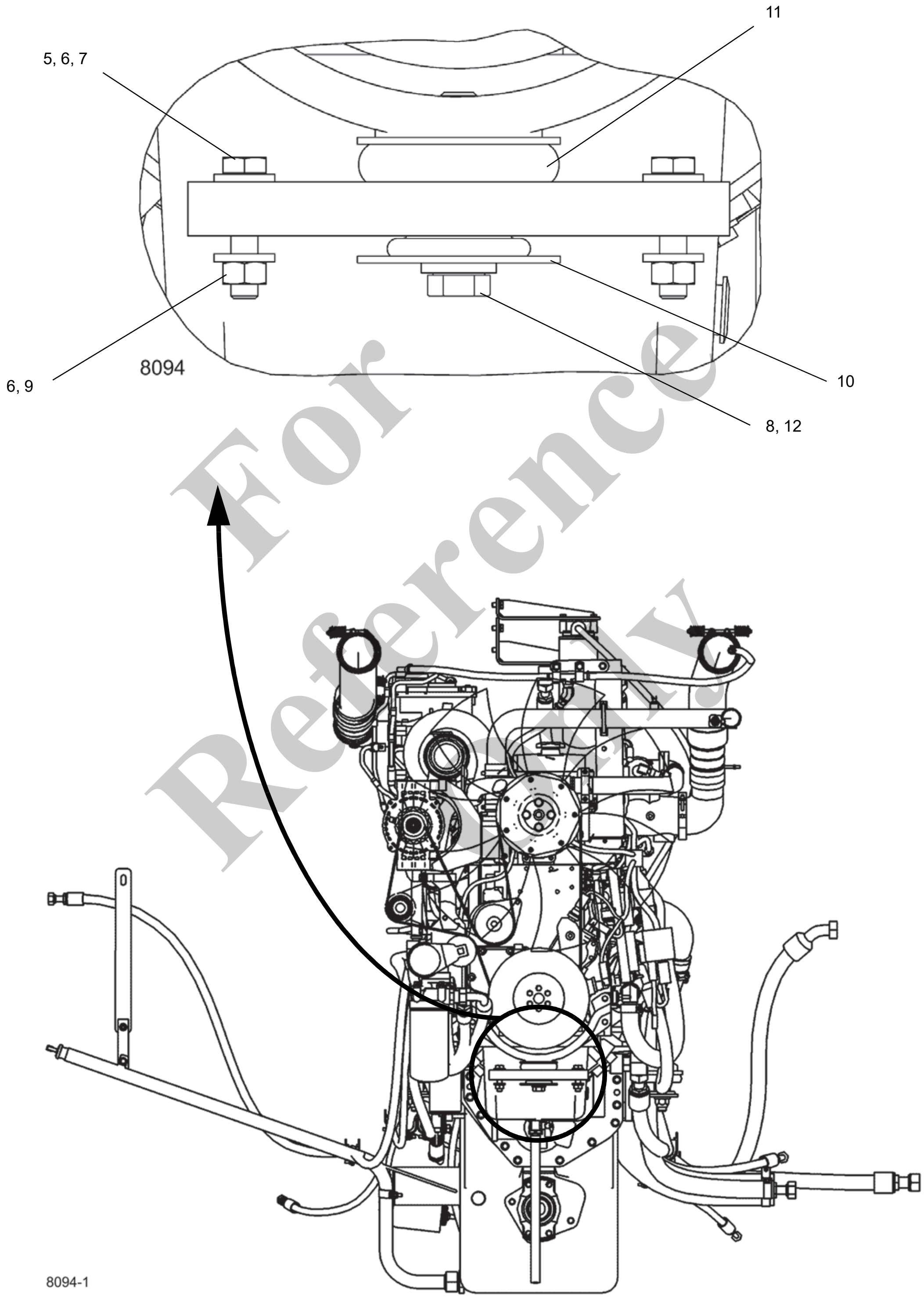
NOTE: Ensure that the same grade hardware, torque values, and Loctite as were installed by the factory are used.





View Of Engine

FIGURE 7-1



View Of Engine

FIGURE 7-1 continued

Figure 7-1 Item Numbers

Item	Description
1	Capscrew
2	Washer
3	Dockwasher
4	Locknut
5	Capscrew
6	Washer
7	Mounting Plate
8	Washer
9	Hex Nut
10	Dockwasher
11	Isolator
12	Capscrew

Engine Installation

DANGER

The lifting device must be able to support the combined weight of the engine and transmission.

NOTE: Use the same grade hardware, torque values, and Loctite that were used by the factory.

NOTE: Apply medium strength sealant (Loctite 243) to engine attaching hardware.

1. With all components and fittings installed on the new engine, lift the engine into the crane.
2. With the engine in position, install the mounting plate, insulator, nuts, washers and capscrews and secure rear of engine Figure 7-1. Torque M16 grade 10.9 capscrews see *Maintenance and Lubrication*, page 9-1.
3. At the front of the engine install the capscrews, washers and locknuts and secure the engine to the frame. Torque the M12 grade 8.8 bolts see *Fasteners and Torque Values*, page 1-19.
4. Remove the lifting device.
5. Connect all lines and tubing to the engine, torque converter, and all other components in accordance with the identification marks made during removal.

CAUTION

Do not apply sealant to the inside of the hydraulic suction hoses.

6. Install the radiator. Refer to RADIATOR - Installation in this Section. Connect all hoses and electrical harnesses to the radiator as tagged during removal.
7. Connect the drive shafts between the transmission/torque converter and the axles. Refer to DRIVE LINES in this Section.
8. Install the hood assembly. Install the pump cover.
9. Position the start and grid heater relay panel on the right side on the frame and secure with the hardware. If equipped with a remote crank option, reconnect to the engine harness.Connect the battery cables and engine electrical harness connector in accordance with the identification marks made during removal.
10. Connect the air filter tubing at the engine and the air filter. Connect the exhaust tubing to the engine and muffler.
11. Charge the A/C system. Refer to the sub-section *Air Conditioner (Optional)*, page 3-17 for charge level and Pag oil requirements.
12. Install the hood top door assembly.
13. Service the transmission, engine lubrication system, and engine cooling system. See *Maintenance and Lubrication*, page 9-1.
14. Start the engine. Check all hoses and fittings for leaks. Recheck all fluid levels.

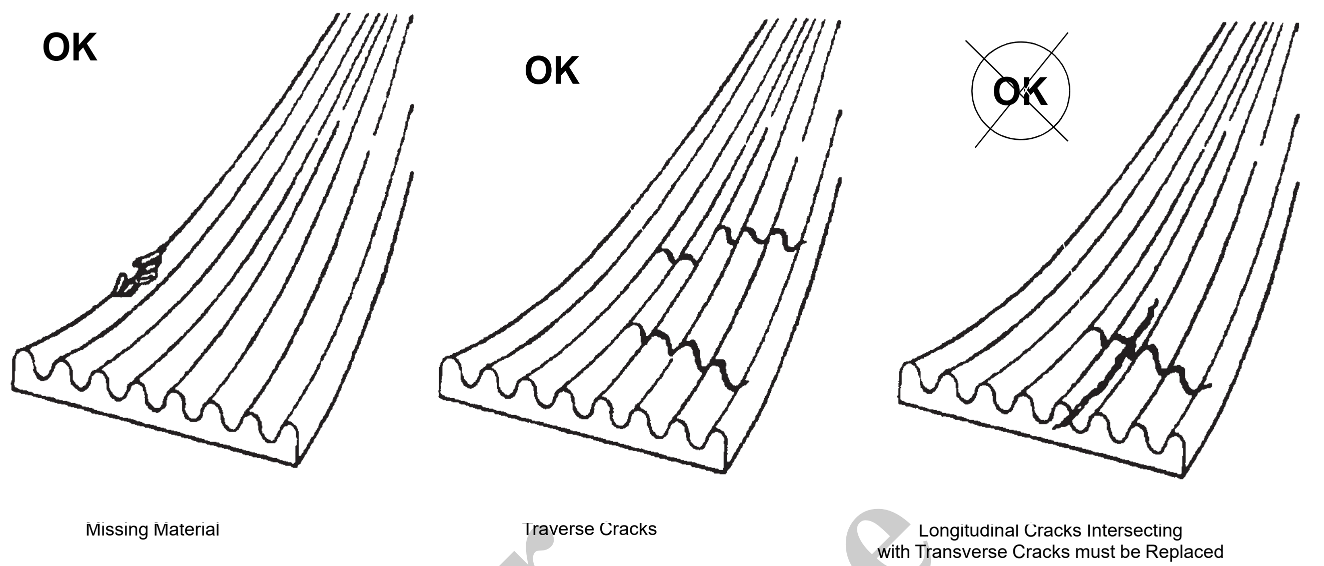


FIGURE 7-2

Engine Drive Belts

The proper operation of engine belt-driven components such as the alternator, fan, and water pump depend on the proper condition and tension of the engine drive belt.

NOTE: Belt tension is maintained with an automatic belt tension device.

The engine drive belt should be inspected visually on a daily basis. The drive belt should be inspected for cracks, frayed areas, and glazed or shiny surfaces Figure 7-2. A drive belt that is glazed or shiny indicates belt slippage.

Engine drive belt damage can be caused by various factors such as incorrect tension, incorrect belt size, misaligned engine pulleys, incorrectly installed belt, or by oil, grease, or hydraulic fluid on the belt.

Refer to the engine manufacturer's manual for any special tools or belt tension specifications.

FUEL SYSTEM

Description

The fuel system consists of the fuel tank, strainer, fuel cooler, lift pump, injection fuel pump, fuel-water separator filter and the fuel injectors. All components except the fuel tank are installed on the engine or supplied with the engine for remote mounting.

Fuel Tank

The fuel tank Figure 7-3 is a steel cylinder-type tank located on the left side of the machine. The fuel tank has a draw capacity of 220 L (58 gal). A connection on the bottom of the tank provides for fuel supply to the engine. Surplus fuel from the engine is provided to the bottom of the fuel tank below the fuel level. The tank is equipped with a non-vented filler cap, chain-attached to the tank, and a fuel quantity sender unit which provides a signal to a fuel quantity gauge on the instrument panel in the cab.

Injection Fuel Pump

The fuel oil is finely atomized as it is injected into the cylinder and ignited by the heat of the compression. It is metered also, before injection, to meet the load requirements imposed upon the engine. Surplus fuel, returning from the injectors, is bypassed back to the fuel tank or to the inlet side of the pump. The continuous flow of fuel through the injectors helps to cool the injectors and to purge air from the system.

Fuel Filter-Water Separator and Fuel Filter

The fuel filter-water separator removes impurities from the fuel and also removes water from the fuel before it reaches the engine. The filter is mounted on the left side of the machine near the fuel tank.

The fuel mixture passes through the outer wrap of the first stage of the filter paper, where large droplets of water are formed as it is stripped from the fuel. The water falls out into the void between the two paper elements and goes to a reservoir in the bottom of the housing, where it can be drained through a drain plug at the bottom of the housing.

Additionally, the fuel filter located on the inner right side of the frame, behind the engine, removes impurities from the fuel before it reaches the engine.

Electric Lift Pump

The ECM controls the electric lift pump located between the fuel tank and the injection pump. Whenever the keyswitch is turned to the ON position, the lift pump will be energized for a few seconds to make sure the low pressure fuel lines are fully primed. The electric lift pump shuts off after the engine is started.

Maintenance

NOTE: The entire fuel system must be maintained air tight to prevent loss of prime.

Fuel Tank

The fuel tank should be kept filled, especially overnight, to reduce condensation to a minimum. Refer to the applicable engine manual for the recommended schedule for draining any water or sediment from the tank.

Removal

1. Position a suitable container under the fuel tank and drain all fuel from the tank.
2. Tag and disconnect the lines from the bottom of the tank.
3. Disconnect the electrical lead from the fuel quantity sender unit.
4. Support the weight of the tank, loosen and remove the hardware securing the straps to the mounting brackets. Remove the tank and steps.
5. If a new tank is to be installed, remove the fittings, the fuel quantity sender, and steps from the tank and install them in the new tank.

Installation

1. Position the new tank on the mounting brackets and install the hardware on the two straps. Torque the capscrews, see *Fasteners and Torque Values*, page 1-19.
2. Connect the electrical lead to the fuel quantity sender unit.
3. Connect the two lines to the fittings on the bottom of the tank in accordance with the identification marks made during removal.
4. Service the tank.

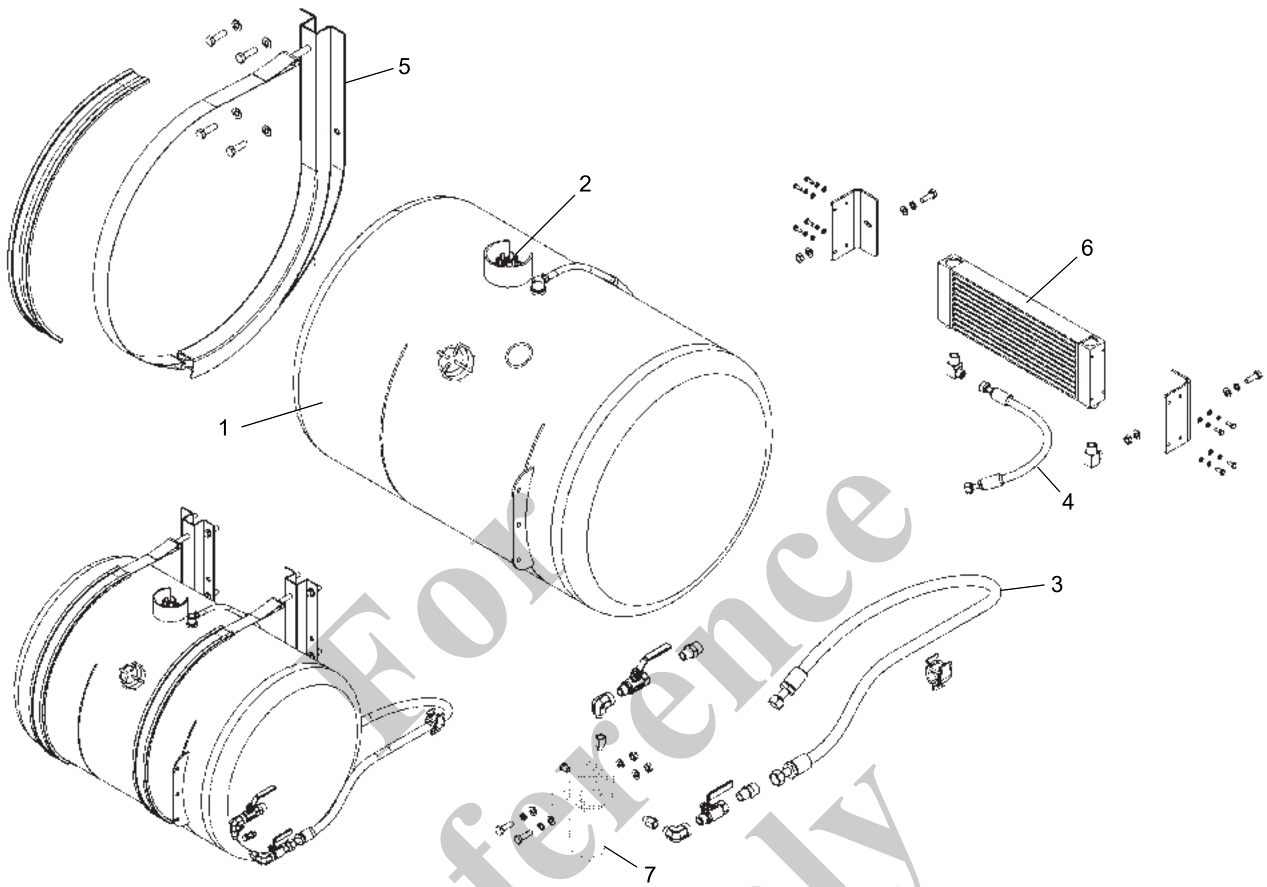
Fuel Filter-Water Separator

Draining

The fuel filter-water separator is located on the left side of the crane, immediately to the right of the fuel tank.

The sump of the fuel filter-water separator should be drained daily, 30 minutes after the engine is shut down, to remove any water and sediment. Adhere to the following procedure.

1. Open the drain plug.
2. Drain until fuel appears.
3. Close the drain plug.



Item	Description
1	Fuel Tank
2	Fuel Level Sensor
3	Fuel Supply
4	Fuel Return
5	Mounting Bracket
6	Fuel Cooler
7	Fuel Filter/Water Separator

FIGURE 7-3

AIR INTAKE AND EXHAUST SYSTEM

Description

The air intake system (Tier 4 - Figure 7-4 and Tier 3 - Figure 7-5) controls the quality and amount of air available for combustion. System components are the Air Cleaner, Turbocharger, Charge Air Cooler, Cylinder Head, and Exhaust Manifold. Inlet air is pulled through the Air Cleaner, compressed and heated in the compressor side of the Turbocharger. The air is pushed through the Charge Air Cooler to the Air Inlet Manifold. Cooling the inlet air increases combustion efficiency, lowers fuel consumption, and increases the horsepower. The air is forced into the cylinder head to fill the inlet ports. Air flow from the inlet port into the cylinder is controlled by the intake valves.

Each cylinder has two intake valves and two exhaust valves. When the intake valves open, cooled compressed air from the inlet port is pulled into the cylinder. The intake valves close and the piston begins to move up on the compression stroke. Fuel is injected into the cylinder and combustion starts. The piston is forced down and is on the exhaust stroke when it moves up again. The exhaust valves open and exhaust is expelled through the exhaust port into the exhaust manifold.

The exhaust gas from the exhaust manifold enters the turbine side of the turbocharger and causes the turbine to turn driving the compressor. Exhaust from the turbocharger passes through the exhaust system (Tier 4 - Figure 7-10 and Tier 3 - Figure 7-11).

The Air Cleaner is the dry-type with a replaceable element and is located on the left rear fender. A service indicator, designed to indicate red when servicing is required, is attached to the Air Cleaner.

On the Cummins QSB Engine there are electric air heating elements that are located in the engine's intake air stream. These elements heat the intake air when starting the engine in cold ambient conditions. Startability and white smoke control are enhanced by the use of the intake air heater. A Wait-to-Start Lamp is located on the ODM (Operator Display Module) to indicate when to crank the engine.

Air Intake

Air Cleaner Checks

Dust passing the air cleaner can cause rapid engine wear. All connections between the air cleaner and the engine must be tight and sealed. If these connections are well sealed, and there is still evidence of dust leakage, check the following places for possible trouble.

NOTE: Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

1. Inspect the air cleaner outlet tube for damage.
2. Ensure the element gasket washer is not damaged and the washer's rubber face seals against the element.
3. Inspect the element gasket for damage.
4. Check for structural failures and replace damaged parts.
5. Inspect the restriction indicator tap for leaks.

Check For Filter Restriction

As a dry cleaner element becomes loaded with dust, the vacuum on the engine side of the air cleaner (at the air cleaner outlet) increases.

The vacuum is generally measured as restriction in kilo-pascals or inches of water. The engine manufacturer places a recommended limit on the amount of restriction the engine will stand without loss in performance before the element must be cleaned or replaced. Cummins allows a vacuum of 6.2 kPa (25 inches of water) maximum with a dirty air cleaner at maximum governed RPM.

A service indicator (Tier 3 engines only) attached to the air cleaner housing will indicate when the filter needs to be replaced. Reset the indicator each time the air cleaner is serviced. If the indicator's accuracy is suspect, a water manometer is the most accurate and dependable method of measuring vacuum.

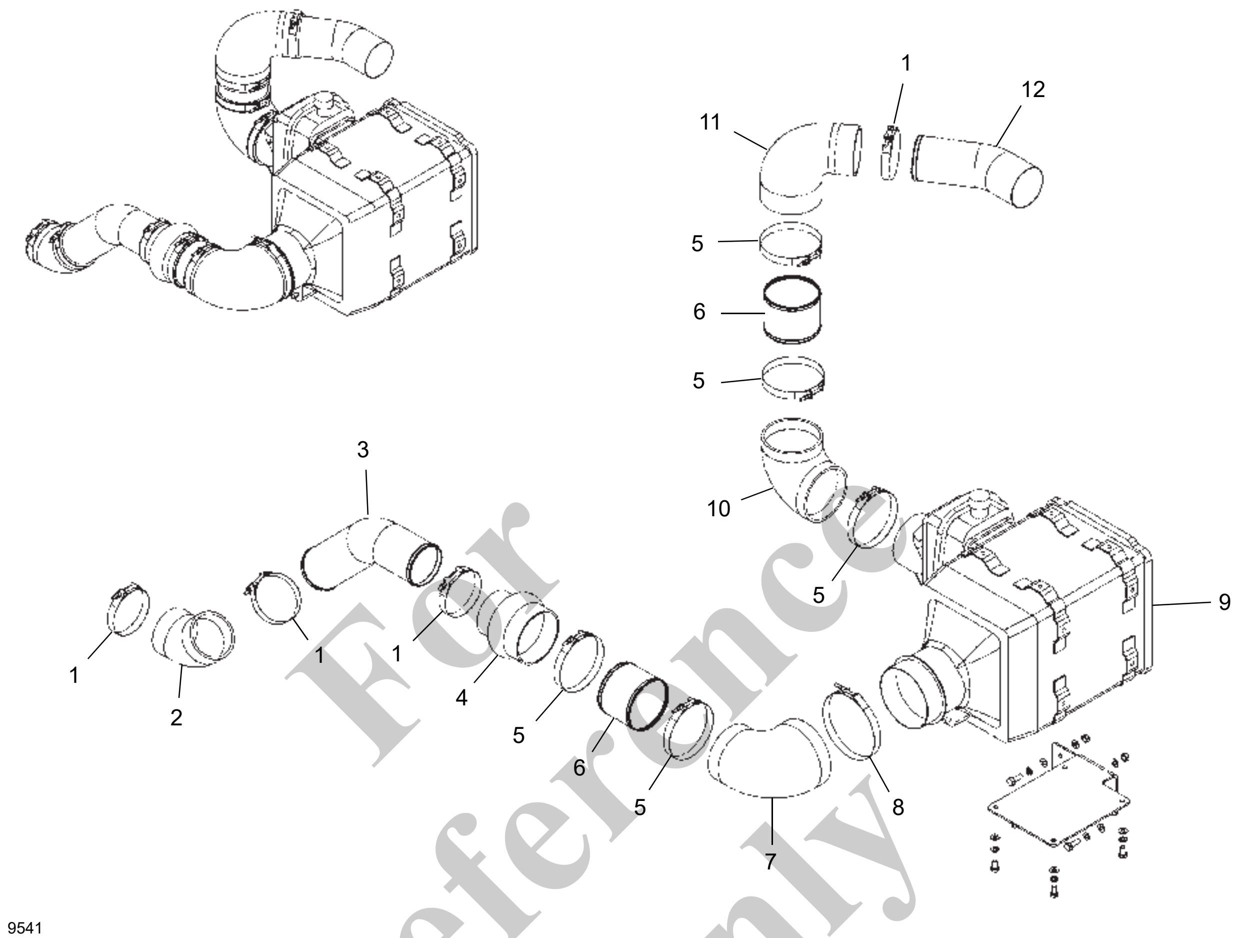
To use the manometer, hold it vertically and fill both legs approximately half full with water. One of the upper ends is connected to the restriction tap on the outlet side of the air cleaner by means of a flexible hose. The other end is left open to the atmosphere.

Maximum restriction in the air cleaner occurs at maximum air flow. On this turbocharged diesel engine, the maximum air flow occurs only at maximum engine power.

With the manometer held vertically and the engine drawing maximum air, the difference in the height of the water columns in the two legs, measured in inches or centimeters, is the air cleaner restriction. Restriction indicators are generally marked with the restriction at which the red signal flag locks up.

If the initial restriction on a new or clean filter reads above the maximum allowed for the engine, check the following items:

1. Ensure the air cleaner inlet is not plugged.
2. Inspect the air cleaner outlet to be sure it is not plugged by paper, rags, etc.
3. Ensure the correct size connections are used between the air cleaner and the engine.
4. Ensure all inlet accessories are the correct size and are not plugged by any foreign object.



Air Intake Installation - Tier 4

1	T-Bolt Clamp	7	90° Elbow
2	Adapter	8	Clamp
3	4” Air Intake Tube	9	Air Cleaner Assembly
4	Hump Reducer	10	90° Elbow
5	Clamp	11	Elbow
6	4” Air Intake Tube	12	4” Air Intake Tube

FIGURE 7-4

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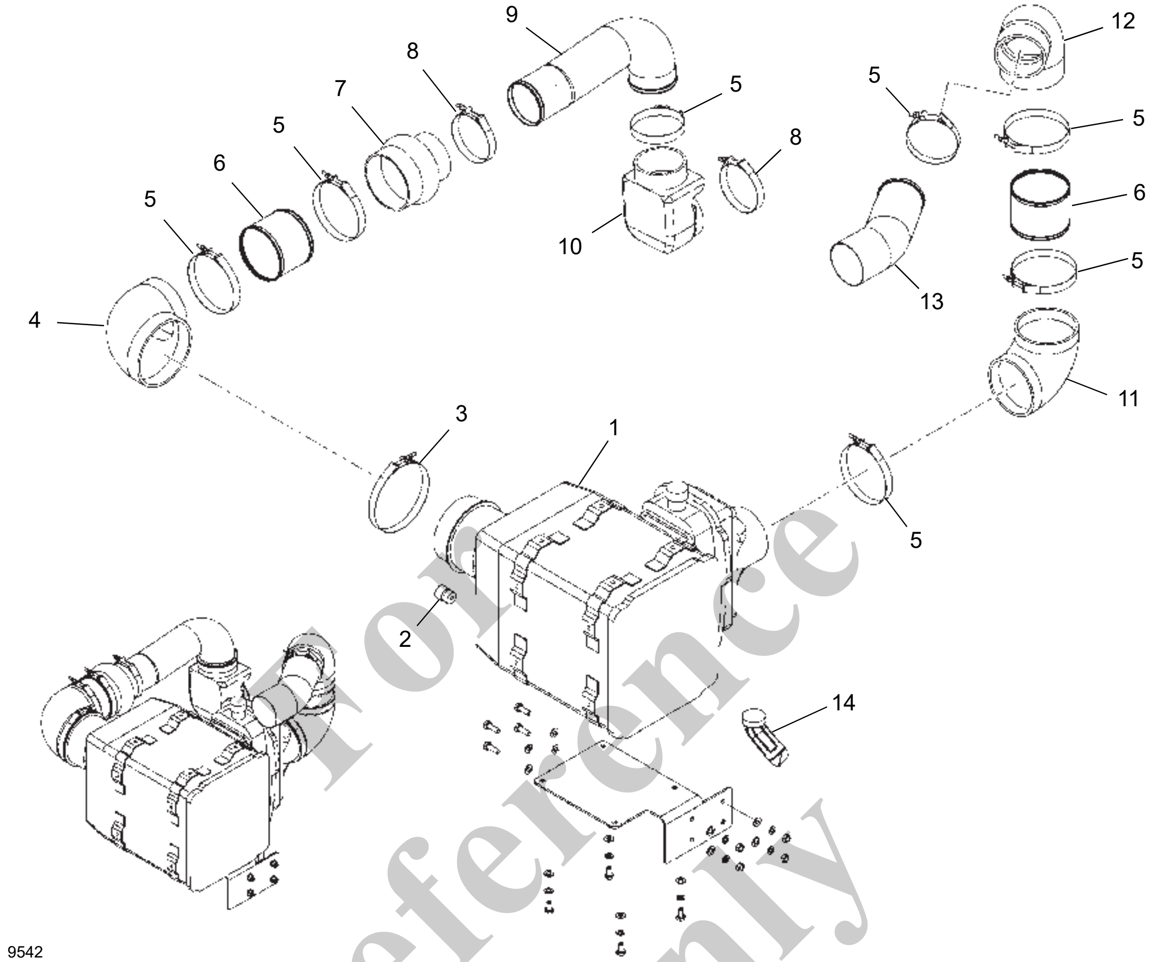
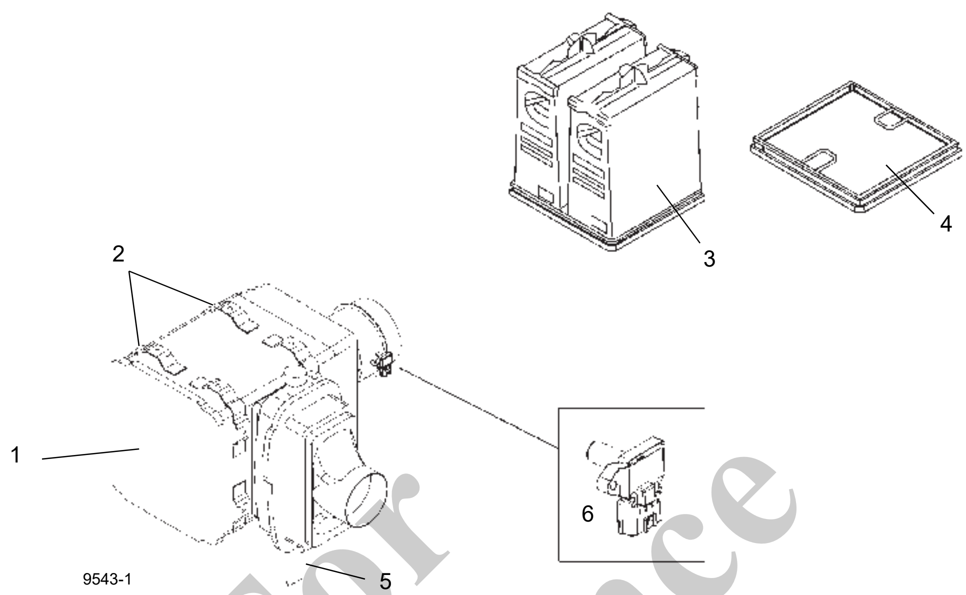


Air Intake Installation - Tier 3

1	Air Cleaner Assembly	8	T-Bolt Clamp
2	Service Indicator	9	Tube
3	Clamp	10	Elbow
4	90° Elbow	11	90° Elbow
5	Clamp	12	Elbow
6	4” Air Intake Tube	13	4” Air Intake Tube
7	Hump Reducer	14	Valve

FIGURE 7-5

7



1	Air Cleaner Assembly	4	Secondary Filter
2	Latch	5	Ejection Valve
3	Primary Filter	6	TBAP Sensor Assembly

Air Cleaner Assembly

FIGURE 7-6

Filter Element Replacement

CAUTION

Never service the air cleaner while the engine is running.

1. Lift the clips (1) (Figure 7-7) securing the cover to the air cleaner body and remove the cover.

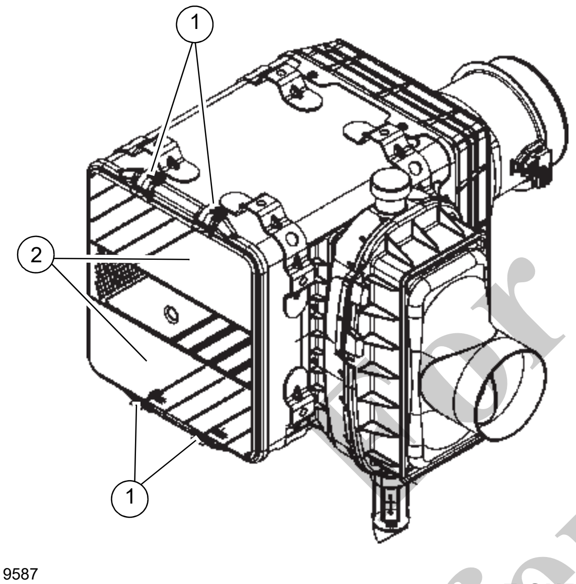


FIGURE 7-7

2. Remove primary filter (2) (Figure 7-7) from the air cleaner and inspect for foreign material and marks of dust.
3. Remove secondary filter (not shown) from the air cleaner every third primary filter change.
4. Thoroughly clean the sealing surface and inside of the air filter housing. Inspect all parts of the intake system and air cleaner.
5. Install new secondary filter (if necessary) and new primary filter.
6. Place the cover back on the air cleaner housing and secure with clips (1).
7. Check all connections and ducts for an air tight fit. Make sure that all clamps, bolts, and connections are tight. Check for holes in piping. Leaks in the air intake system may send dust directly to the engine.
8. Replace decking access plate.

Element Cleaning

It is not recommended that filter elements be cleaned. Cummins and most other manufacturers will not warrant a cleaned air filter.

Air Cleaner Body

Before installing the filter element, remove foreign material (leaves, lint or other foreign matter) that may have collected inside the air cleaner body. Inspect the inside of the body for dents or other damage that would interfere with air flow or with the fins on the element or inside the body. Repair any body dents, being careful not to damage the sealing surfaces. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube, taking care not to damage the sealing area on the tube.

Precleaner

The precleaner (1) (Figure 7-8) prevents large debris from entering the air cleaner and should be cleaned periodically, especially when working in severe dust conditions. Remove the top half of the precleaner by releasing the two latches on the sides of the precleaner. Remove all debris from inside precleaner and reassemble.

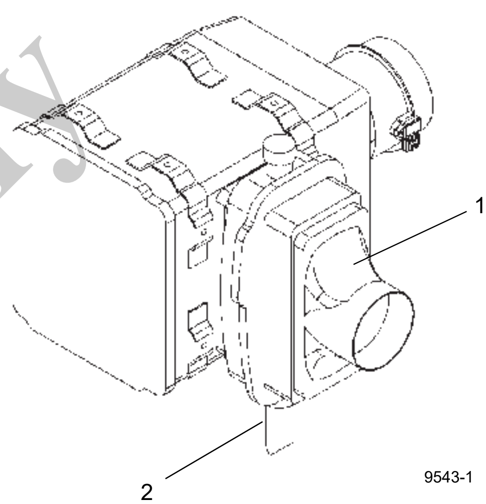


FIGURE 7-8

Vacuator Valve

Vacuator valves (2, Figure 7-8) (1, Figure 7-9) are designed to expel loose dust and dirt from the air cleaner body automatically, thus lengthening the element service life. The valve lips must point straight down and be kept free from debris to operate effectively. Mud and chaff can lodge in these lips periodically and hold them open during engine operation.

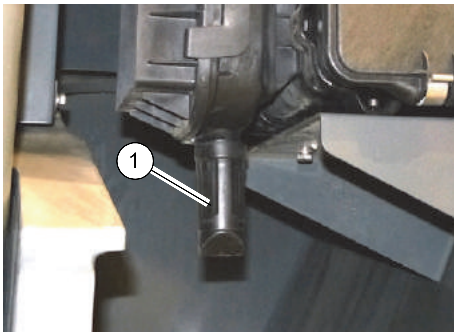


FIGURE 7-9

Check the condition of the valve and lips frequently and keep them clean. The valve lips should be open only when the engine is shut down. If the valve is turned outside in, check for a clogged air cleaner inlet. Malfunction of this valve does not reduce the air cleaner effectiveness, but does allow the element to get dirty faster and reduces serviceable life. If a valve is lost or damaged, replace it with a new valve of the same part number.

Duct Work

1. Check the intake pipe cap and screen for accumulation of leaves, trash, and other debris that could restrict air flow. Repair the screen or replace the cap if any large holes are found in the screen.
2. Check all mounting hardware for security to eliminate possible vibration of intake piping. Such vibration leads to early failure of hoses, clamps, and mounting parts, and can cause hoses to slip off the connecting pipes, allowing un-filtered air into the engine air intake.
3. Check hoses for cracks, chafing, or deterioration, and replace at the first sign of probable failure.

Charge-Air Cooler System

The charge-air cooler (CAC) (Figure 7-15) is used to cool engine air after it has passed through a turbocharger, but before it enters the engine. The charge-air cooler provides better horsepower, increased fuel efficiency, and reduces engine emissions.

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

The ducting consists of metal tubing, hose clamps and bellows. The recommended installation torque of the spring loaded clamps is 4.5 ±0.6 N-m (40 ±5 lb-in). Do not compress the spring completely, the bellows and/or clamp may be damaged from thermal expansion of the CAC tube.

Maintenance

Check the hose clamps for proper torque.

Inspect the bellows for cracks or holes.

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

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

Remove and Replace

Refer to the sub-section *Cooler Assembly*, page 7-34 for procedures to remove and replace the charge-air cooler.

Exhaust System

Tier 3 Exhaust System

CAUTION

Burn Hazard!

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

The Tier 3 exhaust system (Figure 7-11) is made of a muffler and various tubes, elbows, and clamps.

When removing and installing a muffler, tighten all hardware to specifications found under *Fasteners and Torque Values*, page 1-19, unless specified otherwise:

- Tighten V-band clamps to 13.5±1.5 N-m (10±1.10 ft-lb).

Tier 4 Exhaust System

CAUTION

Burn Hazard!

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

NOTE: Lift lugs on the diesel oxidation catalyst (8) are for lifting only the oxidation catalyst, not the entire aftertreatment system.

Removal

1. Remove the sheet metal guard to gain access to the muffler and diesel oxidation catalyst.
2. Remove clamp to free exhaust tailpipe from SCR device (3).
3. Disconnect DEF hose. Cap and plug all openings.
4. Tag and disconnect all electrical connections.
5. Loosen V-band clamps to free decomposition reactor tube, then remove decomposition reactor tube.
6. Remove exhaust clamps securing the exhaust tube to the mounting brackets.
7. Loosen V-band clamps to free exhaust tube from the diesel oxidation catalyst, then remove exhaust tube.
8. Loosen mounting bands to free diesel oxidation catalyst, then remove oxidation catalyst using its lifting lugs.
9. Loosen mounting bands to free SCR and remove SCR.
10. Inspect muffler, diesel oxidation catalyst, exhaust tailpipe, exhaust tubes, bellows, and attaching hardware. Repair or replace any of these parts if damaged or missing.

Installation

When assembling the muffler/diesel oxidation catalyst leave the clamps and mounting hardware loose until the assembly is together.

When installing exhaust system, tighten all hardware to specifications found under *Fasteners and Torque Values*, page 1-19, unless specified otherwise:

- Tighten V-band clamps (4, 5, 15, Figure 7-11) to 13.5±1.5 Nm (9.96±1.10 ft-lb).
- Tighten slip joint clamp (12) hardware to 9.6 to 11.3 N-m (7.1 to 8.3 ft-lb).
- Tighten mounting bands to 5.4 Nm (4.0 ft-lb).

1. Install diesel oxidation catalyst into the mounting bands.
2. Install SCR into the mounting bands.
3. Attach decomposition reactor tube to the SCR and diesel oxidation catalyst using the V-band clamps and gaskets.
4. Attach exhaust tube to the diesel oxidation catalyst using V-band clamp and gasket.
5. Secure exhaust tube to the mounting brackets using the exhaust clamps.
6. Connect electrical connections as tagged during disassembly.
7. Connect DEF hose.
8. Attach exhaust tailpipe to SCR.
9. Tighten all hardware and clamps.
10. Install sheet metal guard.

V-Band Clamps

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

After 1000 Hours, or One Year

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

2000 Hours or 2 Years

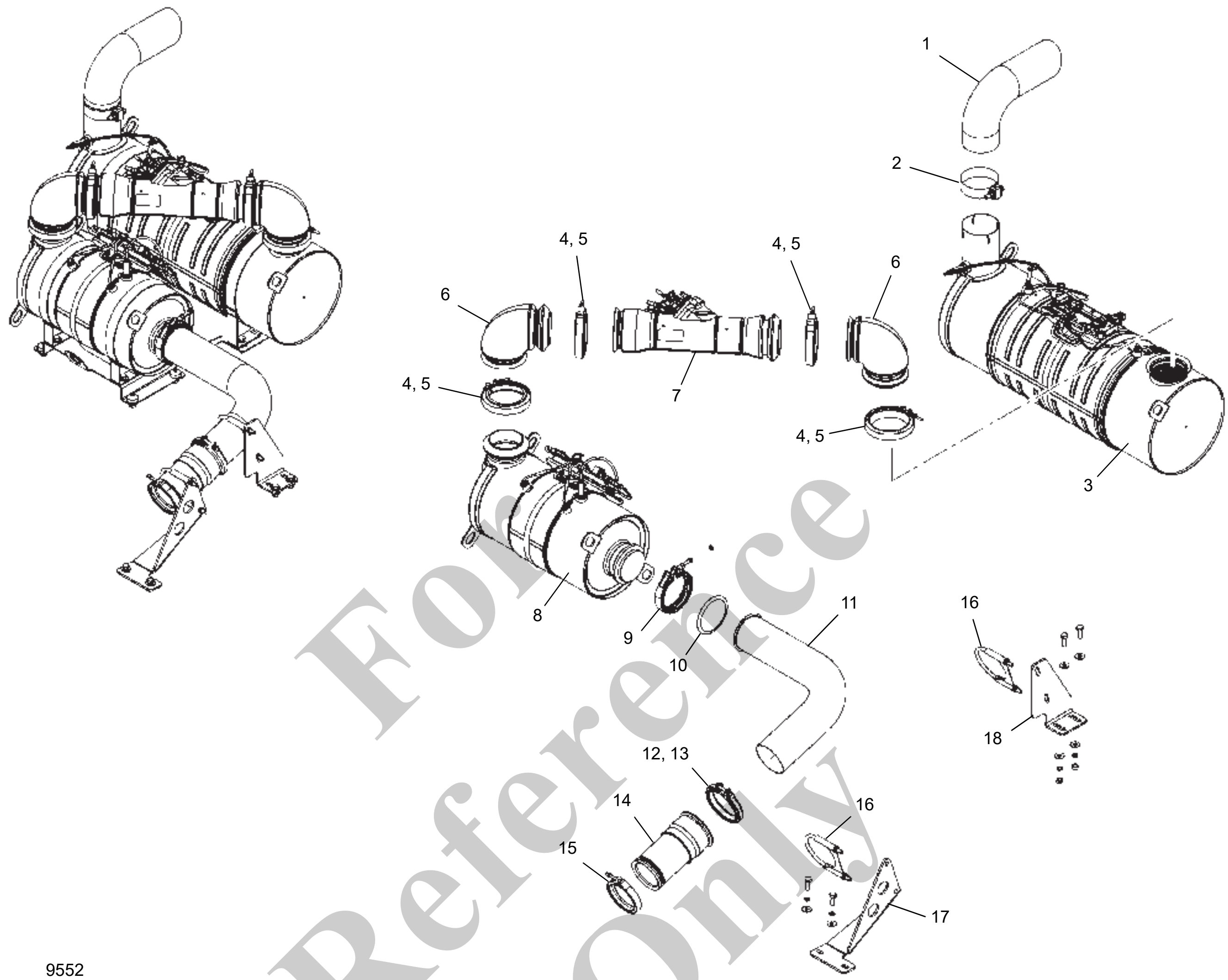
Tighten the V-clamps by 1½ turns of the nuts.

4000 Hours or 4 Years

Tighten the V-clamp by 1½ turns of the nuts.

5000 Hours or 5 Years

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

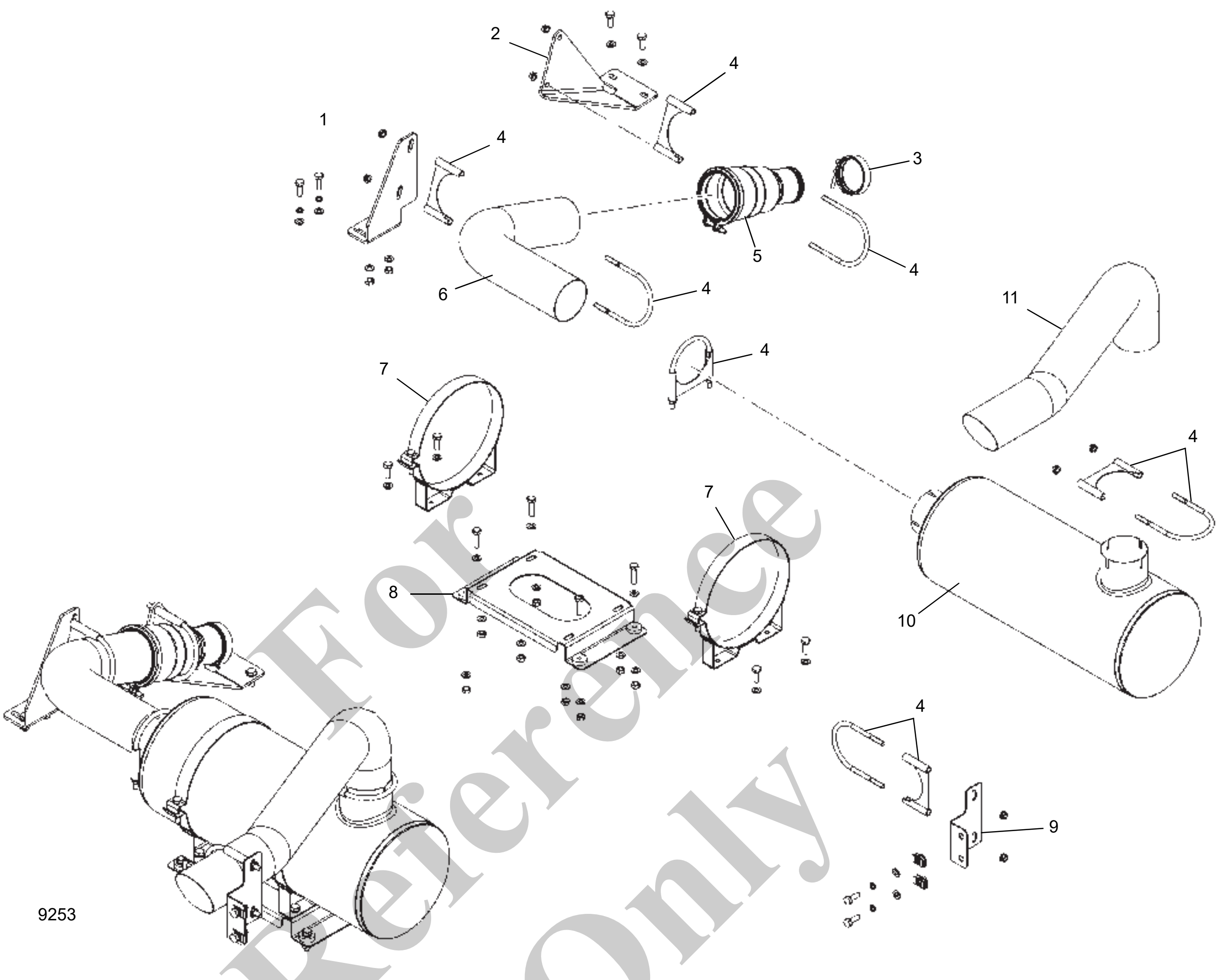


Exhaust System - Tier 4

Item	Description
1	Tube
2	4” Band Clamp
3	Selective Catalytic Reduction (SCR) Device
4	V-Band Clamp
5	Decomposition Pipe Gasket
6	Elbow
7	Decomposition Reactor Tube
8	Oxidation Catalyst
9	V-Band Clamp

Item	Description
10	Decomposition Pipe Gasket
11	Tube
12	Clamp
13	Decomposition Pipe Gasket
14	Exhaust Tube Weldment
15	V-Band Clamp
16	Muffler Clamp
17	Bracket
18	Bracket

FIGURE 7-10



Exhaust System - Tier 3

Item	Description
1	Bracket
2	Bracket
3	V-Band Clamp
4	Muffler Clamp
5	Tube Weldment
6	Tube

Item	Description
7	Mounting Band Clamp
8	Weldment
9	Bracket
10	Muffler
11	Tube

FIGURE 7-11

AFTERTREATMENT DIESEL EXHAUST FLUID (DEF) - TIER 4 ONLY

DEF Tank

Description

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

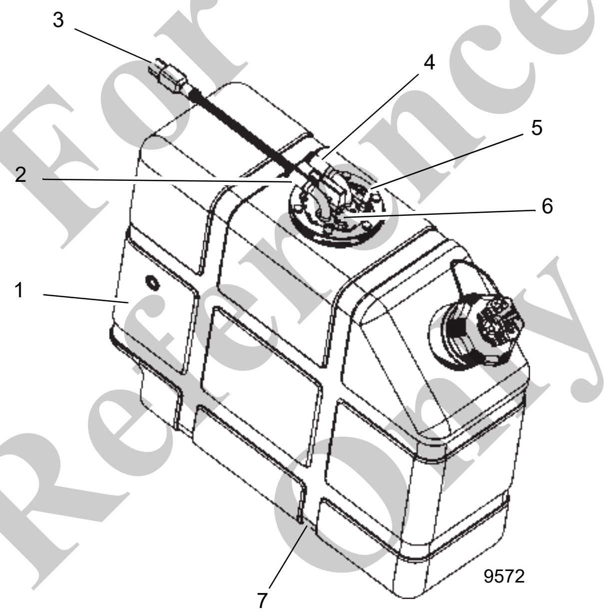
The DEF tank (Figure 7-12) incorporates a fluid level sending unit and a heating element to keep the DEF from freezing.

Removal

1. Tag and disconnect the electrical connectors on the DEF tank.
2. Tag and disconnect the fluid lines on the tank.
3. Remove the hardware holding the tank straps in place.
4. Remove the tank.

Installation

1. Place the DEF tank onto the location on the frame.
2. Place the tank straps around the tank and secure with hardware.
3. Connect the fluid lines as tagged during removal.
4. Connect the electrical connectors as tagged during removal.



Item	Description
1	DEF Tank
2	Coolant Outlet
3	Electrical Connector
4	Coolant Inlet
5	DEF Return
6	DEF Suction
7	Tank Mounting Strap

DEF Tank

FIGURE 7-12

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DEF Dosing Unit Filter

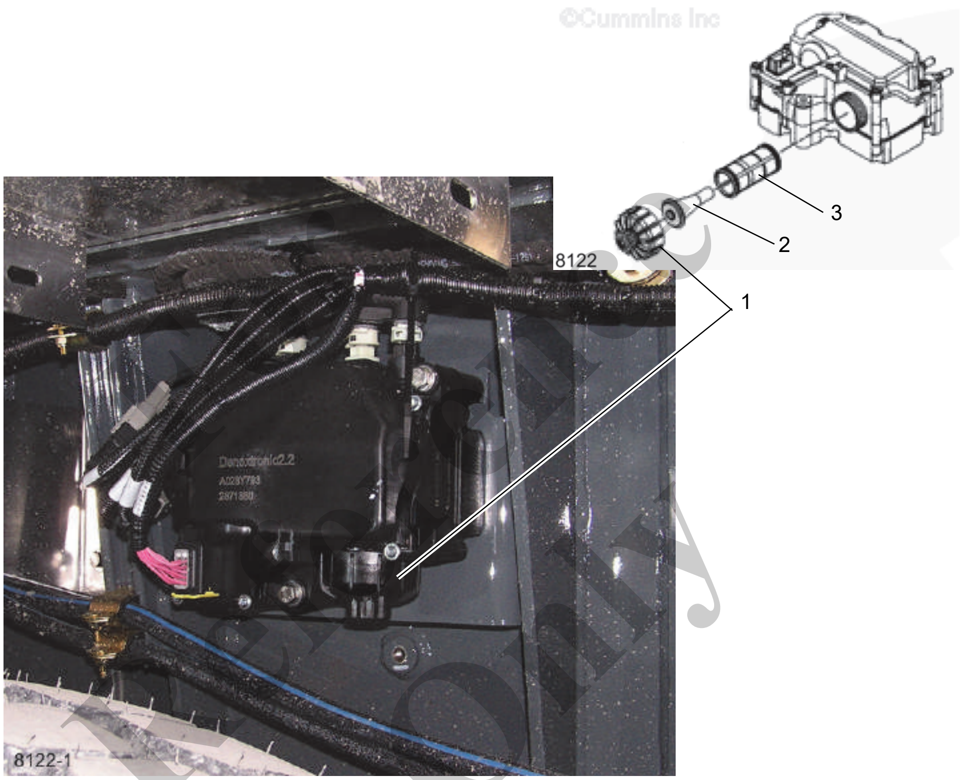
The DEF dosing unit filter is a 10-micron filter designed to prevent foreign objects, that may be suspended in the DEF, from entering the dosing system.

Debris can cause permanent damage and premature failure to either the aftertreatment DEF dosing unit or the aftertreatment DEF dosing valve.

The filter should be replaced every 480,000 km (300,000 miles) or 6750 hours of crane operation.

The aftertreatment DEF dosing unit filter (Figure 7-13) consists of the following components:

- Aftertreatment DEF Dosing Unit Filter Cap
- Aftertreatment DEF Dosing Unit Filter Equalizing Element
- Aftertreatment DEF Dosing Unit Filter Element



Item	Description
1	DEF Filter Cap
2	DEF Filter Equalizing Element
3	DEF Filter Element

DEF Dosing Unit

FIGURE 7-13

Initial Check

Inspect the area around the seal and vent of the aftertreatment DEF dosing unit filter cap for signs of leakage.

DEF leaks leave a white deposit. If deposits are found, see the Clean and Inspect for Reuse section in this procedure.

Preparatory Steps

WARNING

DEF contains urea. Do not get the substance in your eyes. In case of contact, immediately flush eyes with large amounts of water for a minimum of 15 minutes. Do not swallow. In the event the DEF is ingested, contact a physician immediately. Reference the Materials Safety Data Sheet (MSDS) for additional information.

NOTE: Do not disconnect the vehicle batteries until the DEF dosing system has completed the purge cycle. Before beginning to remove and/or disconnect any components, wait at least five minutes after the key switch is turned OFF for the aftertreatment DEF dosing system to purge the DEF from the system. The purge cycle is an automatic process and does not require intervention to occur. The aftertreatment DEF dosing unit will create an audible pumping noise during the purging process.

NOTE: Do not power wash or steam clean this unit. Use compressed air to remove any loose debris.

Turn battery disconnect switch to the OFF position to disconnect the batteries.

Removal

NOTE: There may be residual DEF in the filter housing. A collection container placed below the DEF filter cap is recommended.

1. Unscrew the DEF filter cap (1).
2. Remove the aftertreatment DEF filter equalizing element (2).
3. Remove the old aftertreatment DEF dosing unit filter element (3).

NOTE: If removing the aftertreatment DEF dosing unit filter as part of a maintenance interval, discard the equalizer element and filter.

Clean and Inspect for Reuse

If there is the possibility that contaminated DEF has gone through the DEF dosing system, check the DEF filter prior to discarding the filter.

1. Check the DEF for evidence of contaminated DEF. Use visual and aroma characteristics of the filter to determine if contaminated fluid has passed through the dosing system.
2. Inspect the DEF filter for debris. If debris is evident, also check:
   - DEF tank pick up screen.
   - Aftertreatment DEF dosing unit inlet connector.
3. Discard the filter element and equalizing element.
4. Inspect the aftertreatment DEF dosing unit filter cap for cracks or holes that could create a DEF leak path.
5. Check the condition of the threads on the aftertreatment DEF dosing unit cap. If the threads are damaged, replace the aftertreatment DEF dosing unit filter cap.
6. Inspect the aftertreatment DEF dosing unit threads. This is especially important if the aftertreatment DEF dosing unit cap was damaged. If the aftertreatment DEF dosing unit threads are damaged, replace the entire aftertreatment DEF dosing unit.

NOTE: Never operate the vehicle with the DEF cap removed.

7. Clean the aftertreatment DEF dosing unit cap with warm water and a clean cloth.

Installation

NOTE: Lubrication of the DEF filter O-rings is not required.

1. Slide the DEF filter equalizing element (2) into the DEF filter cartridge (3).
2. Insert the assembly into the aftertreatment DEF dosing unit.
3. Install and tighten the cap (1). Torque Value: 20 Nm (177 lb-in).

Final Steps

CAUTION

DEF is corrosive to certain metals and paint and should be washed off with mild soap and water if spilled.

CAUTION

Do not use the flow test portion of the INSITE™ electronic service tool Diesel Exhaust Fluid Doser Pump Override Test to check the system for leaks. This will spray diesel exhaust fluid into the exhaust system at too low of temperatures to evaporate, resulting in deposit formations in the exhaust system.

NOTE: The aftertreatment DEF dosing system will not prime until the correct SCR temperatures are reached. To verify that there are no DEF leaks, initiate a manual regeneration to get the SCR system up to temperature.

1. Connect the batteries by turning the battery switch to ON.
2. Operate the engine and check for leaks.

WATER COOLING SYSTEM

Description

The cooling system consists of a radiator (Figure 7-15), surge tank, engine cooling circuit, and the connecting hoses and connecting tubes. Cooling system capacity is approximately 43 L (45.4 qt). The radiator is mounted beside the hydraulic oil cooler. The temperature is controlled by a 83°C (181°F) thermostat located between the top of the engine and the top of the radiator. At all times, the antifreeze/coolant should be properly inhibited against corrosion. It is recommended that a mixture of AFC-50/50 blended ethylene-glycol, low silicate, fully formulated, engine antifreeze/coolant concentrate and water which does not require a pre-charge of supplemental coolant additives (SCA) for use in initial fill of heavy duty liquid cooled internal combustion engines be used at all times.

The crane is equipped with a cab hot water heater. Hot water is supplied by the engine coolant system through a strainer and two port water swivel to the cab heater. The strainer is a cleanable type and is located on the left side of the transmission by the rear engine/transmission mount. Refer to *Maintenance and Lubrication*, page 9-1 for service of the strainer.

Maintenance

General

The cooling system includes the Radiator, Surge Tank, Thermostat, the Fan, and Water Pump. Radiator hoses are also included in this group.

The cooling system is often neglected because the effects or damage that result from an improperly maintained system usually occur gradually. The cooling system needs to be maintained with the same attention as other systems.

The circulation of water through the cooling system relies entirely upon the water pump. The water pump draws water from the radiator and forces it through the water jacket and cylinder head. There it accumulates heat and flows to the radiator tank. Then the water flows across through the radiator core and is cooled by air from the fan. This process of removing heat from water as it circulates holds the engine to its efficient operating temperature.

The following paragraphs point out several facts about cooling system components, the effects of cooling system neglect, and procedures to be followed for cooling system maintenance.

Effects of Cooling System Neglect

Whenever an engine does not perform at top efficiency, a neglected cooling system may be at fault even though the part directly responsible is not a part of the cooling system. Most of these problems can be traced to overheating; however, an engine that is running too cold can be just as troublesome.

Overheating

An engine that is overheating may lead to troubles such as the following:

1. Burned valves.
2. Pinging or knocking.
3. Excessive fuel consumption.
4. Poor lubrication - increased engine wear.
5. Sticking valves.
6. Short injector life.
7. Engine hot spots.
8. Need for higher grade fuel.

Overcooling

The following engine troubles result when an engine is overcooled:

1. Excessive fuel consumption.
2. Sludge formation in crankcase.
3. Corrosive acids formed in crankcase.
4. Excessive fuel deposits in the exhaust system.

Antifreeze/Coolant

Heavy duty diesel engines require a balanced mixture of water and antifreeze/coolant. For maximum rust, freeze, and boiling point protection, a 50/50 blended, fully formulated extended life antifreeze/coolant should be maintained at all times. Refer to *Maintenance and Lubrication*, page 9-1. Do not use more than 50 percent antifreeze/coolant in the mixture unless additional freeze protection is required. Never use more than 68 percent antifreeze/coolant under any condition. Antifreeze/coolant at 68 percent provides the maximum freeze protection; antifreeze/coolant protection decreases above 68 percent.

Rust Prevention

To keep engines operating at like new efficiency, all forms of rust formation must be prevented. The formation of rust in the cooling system is a result of the interaction of water, iron, and oxygen, and can only be prevented by maintaining full strength corrosion protection at all times. Supplemental coolant additives (SCA) are recommended for this cooling system. Antifreeze/coolant alone does not provide sufficient protection for heavy-duty diesel engines. Refer to *Section 9* for SCA specification and compatible brands.

Engine Antifreeze/Coolant Fill Procedure (when level is low)

1. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant. Fill to the bottom of the surge tank filler neck. Fill slowly. Flow exceeding 11.2 L/min (3 gpm) can give a false reading.
2. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating step 1.
3. Run the engine for 5 minutes and recheck the antifreeze/coolant level. Refill as necessary repeating step 1. Refer to *Maintenance and Lubrication*, page 9-1.

Antifreeze/Supplemental Coolant Additives Maintenance Summary

Cooling System Level Check Interval

Daily or 10 hours

The cooling system level should be checked every 10 hours of operation or daily, whichever comes first. Refer to *Maintenance and Lubrication*, page 9-1.

SCA Level Check/Coolant Filter Change Interval

6 months or 500 hours

- Check SCA Levels (use only Coolant Test Kit, Grove P/N 9414101675, to check the coolant additive concentration in the cooling system)
- Only add coolant additive if levels are less than 1.2 units/gal (see *Maintenance and Lubrication*, page 9-1 for specification and recommended additives).

NOTE: An inadequate concentration of coolant additive can result in major corrosive damage to the cooling system components. Over concentration can cause formation of a “gel” that can cause restriction or plugging of coolant passages, and overheating.

1 year or 1000 hours

- Test antifreeze/coolant for contamination.

  Condemning limits are:

  - Sulfate level greater than or equal to 1500 ppm.
  - Chloride level greater than or equal to 200 ppm.
  - The pH level is less than 6.5.
  - Oil or fuel contamination can be identified by odor or color.

  If condemned, flush the system using a commercially available flushing agent. Refill system with fully formulated extended life coolant. Refer to *Maintenance and Lubrication*, page 9-1.

NOTE: Remove the radiator cap when draining the system to ensure proper draining.

Cleaning

CAUTION

Burn Hazard!

The cooling system contains very hot pressurized liquid and injury can result when removing the radiator cap at operating temperature. Use proper protection to remove the radiator cap.

1. Coolant shut-off valves to heaters and other accessories should be open to allow complete circulation during cleaning, flushing, and draining. Run the engine with radiator covered if necessary until temperature is up to operating range 71 to 82° C (160 to 180° F). Stop the engine, remove the radiator cap, and drain the system by opening the drain cocks on the radiator and engine block.

NOTE: Use a cleaning compound that is not corrosive to aluminum to prevent damage to the radiator.

2. Allow the engine to cool, close the drain cocks, and pour the cleaning compound into the surge tank according to the directions. Fill the system with water.
3. Place a clean drain pan to catch the overflow, and use it to maintain the level in the radiator. Do not spill the solution on the vehicle paint.
4. Replace the radiator cap and run the engine at moderate speed, covering the radiator if necessary, so the system reaches a temperature of 82° C (180° F) or above, but does not reach the boiling point. Allow the engine to run at least two hours, or according to recommendations of the manufacturer of the cleaning compound, at 82° C (180° F) so the cleaning solution may take effect. Do not drive the vehicle or allow the liquid level in the radiator to drop low enough to reduce circulation.
5. Stop the engine as often as necessary to prevent boiling.
6. With the engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. When there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see *Pressure Flushing*) and repeat the cleaning operation.
8. If problem persists, replace radiator.

Pressure Flushing

1. Disconnect both radiator hoses that connect the radiator to the engine.
2. Clamp a convenient length of hose to the radiator core outlet opening, and attach another suitable length of

hose to the radiator inlet opening to carry away the flushing stream.

3. Connect the flushing gun to compressed air and water pressure, and clamp the gun nozzle to the hose attached to the radiator outlet opening.
4. Fill the core with water. Turn on air pressure in short blasts to prevent core damage.
5. Continue filling the radiator with water and applying air pressure as above until the water comes out clear.
6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill the engine block with water, partly covering the water inlet opening to permit complete filling.
7. Turn on compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. When the vehicle is equipped with a water heater connected to the cooling system, flush the heater, following the same procedure as for the radiator core.
9. After completing the flushing operation, clean out the surge tank overflow pipe; inspect the water pump; clean the thermostat and the radiator cap control valves. Check the thermostat for proper operation before installation.
10. Blow insects and dirt from the radiator core air passages, using water, if necessary, to soften obstructions.

Component Inspection

Radiator/Surge Tank

1. Side Tanks - Look for leaks, particularly where the tank is attached to the core. Vibration and pulsation from pressure can fatigue soldered seams.
2. Filler Neck - The sealing seat must be smooth and clean. Cams on filler neck must not be bent or worn so as to allow a loose fitting cap. Ensure the overflow tube is not plugged.
3. Radiator Cap - This is the pressure-setting type. Its purpose is to hold the cooling system under a slight pressure, increasing the boiling point of the cooling solution and preventing loss of solution due to evaporation and overflow.

The cap has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure falls below the predetermined point.

When removing the pressure type cap, perform the operation in two steps. Loosening the cap to its first notch raises the valve from the gasket and releases the pressure through the overflow pipe. In the first stage position of the cap, it should be possible to depress the cap approximately 3 mm (0.13 in). The prongs on the cap can be bent to adjust this condition. Care must be taken that the cap is not too loose as this would prevent proper sealing.

CAUTION

Burn Hazard!

Loosen cap slowly and pause a moment to avoid possible burning by hot water or steam. Continue to turn the cap to the left until it can be removed.

4. Tubes are very small and can easily become clogged by rust and scale. The general condition of the cooling system and operating temperature are indications as to whether or not tubes are clean. Another good test is to feel the core for cold spots.
5. Fins are thin metal sheets that dissipate heat picked up by the tubes. They should be kept free of bugs, leaves, straw etc., so as to allow the free passage of air. Bent fins should be straightened.

Engine Water Jacket

The water jacket permits coolant to be circulated around the cylinder walls, combustion chamber, and valve assemblies. Some of these coolant passages are small and can easily become clogged, if the cooling system does not receive the proper maintenance.

1. Core Plugs - These are sometimes mistakenly called freeze plugs. They do not provide protection against freezing expansion, but are only present because of engine block casting methods. Remove and replace core plugs that show signs of leaking or rusting through. Use an installation tool for core plug replacement.
2. Drain Plugs - The water jacket of each engine could have one or more drain plugs. These should receive seasonal care and be kept free of rust and scale.
3. Gaskets - All gaskets must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine. Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around the head gasket.

Water Pump

The pump should be checked carefully for leaks and proper lubrication. Replace or rebuild if leaking, cracked, or worn.

Fans and Belts

The fan should be checked for cracked or broken blades.

Refer to *Engine Drive Belts*, page 7-6.

Thermostat

The thermostat is of the nonadjustable type and is incorporated in the cooling system for the purpose of retarding or restricting the circulation of coolant during engine warm up. Engine overheating and loss of coolant is sometimes due to an inoperative thermostat. To check for this condition, remove the thermostat and test by submerging it in hot water and noting the temperature at which the thermostat opens and closes. Use an accurate high temperature thermometer for making this test.

Hoses and Clamps

Hoses and their connections must be checked regularly because they are often the source of hidden trouble. Hoses may often times appear in good condition on the outside while the inside will be partially deteriorated. If there are any doubts about a hose doing its job, replacement should be made. The clamps should be inspected to make sure they are strong enough to hold a tight connection.

Coolant Radiator

Refer to the sub-section *Cooler Assembly*, page 7-34 for procedures to remove and replace the coolant radiator.

Test Equipment

The antifreeze/coolant concentration must be checked using a refractometer. “Floating ball” type density testers or hydrometers are not accurate enough for use with heavy duty diesel cooling systems.

DRIVE TRAIN

The drive train consists of the transmission/torque converter assembly and three drive lines.

The transmission/torque converter is mounted to and driven by the engine. The torque converter assembly provides for mounting and driving the pumps. The transmission is a powershift with six forward speeds and six reverse speeds. The transmission is controlled electrically by a shift lever/knob located on the right side of the steering column and an axle drive mode selector rocker switch located on the left side of the front console.

The transmission/torque converter oil is cooled by passing the oil through an externally mounted transmission cooler (Figure 7-15). The cooler is part of the radiator. An oil filter is located on the left side of the frame bottom rail.

Three drive lines are used. Two drive lines are connected between the transmission and the front axle and the other drive line is connected between the transmission and the rear axle.

Drive Lines

Maintenance

CAUTION

Do not disassemble drive lines when removing them from the crane. Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

Removal

1. Support the drive line being removed so it does not fall when disconnected.
2. Remove the bolts from the bearing cap on each end of the drive line.
3. Remove the drive line.

Installation

1. Position the drive line, install the bearing cap bolts and tighten bolts securely.
2. Torque all bearing cap bolts on the drive line to 95 to 108 N-m (70 to 80 lb-ft).

Lubrication

The drive line slip joints require lubrication. Refer to *Maintenance and Lubrication*, page 9-1.

Transmission/Torque Converter

Description

The transmission/torque converter assembly is mounted to the engine and is connected to the front and rear axles by three drive shafts. The main hydraulic pumps are mounted on the torque converter housing.

Maintenance

General Information

1. Always check the oil level with the engine idling, and the transmission in neutral and at normal operating temperature [82 to 93° C (180 to 200° F)].
2. Change the oil filter element every 500 hours. Drain and refill the system every 1000 hours or 6 months.

Troubleshooting

The following data is presented as an aid to locating the source of difficulty in a malfunctioning unit. It is necessary to consider the torque converter charging pump, transmission, oil cooler, and connecting lines as a complete system when checking for the source of trouble, since the proper operation of any unit therein depends greatly on the condition and operation of the others. By studying the principles of operation together with the data in this section, it may be possible to correct any malfunction which may occur in the system. Troubleshooting procedures basically consist of hydraulic checks.

Hydraulic Checks

Before checking the transmission/torque converter and associated hydraulic system for pressures and rate of oil flow, it is essential that the following preliminary checks be made.

1. Check oil level in transmission. This should be done with oil temperature at 82 to 93° C (180 to 200° F). Do not attempt these checks with cold oil.
2. To bring the oil temperature to this level, it is necessary to either work the machine or stall the converter. When it is impractical to work the machine, stall the converter as follows.
   - **a.** Apply the parking brake.
   - **b.** Set the Drive Axle Selector Switch to the two-wheel drive (high range) position.
   - **c.** Move the Transmission Shift Lever to forward gear (up position) and rotate the Knob to 3rd gear (position III).
   - **d.** Accelerate the engine to between half and three-quarter throttle.

CAUTION

Full throttle stall speeds for an excessive length of time will overheat the torque converter.

e. Hold converter stalled until desired temperature is reached.

NOTE: Always make all troubleshooting checks with the converter outlet temperature at least 82 to 93°C (180 to 200°F).

Troubleshooting Procedures

SYMPTOM	PROBABLE CAUSE	REMEDY
1. Low clutch pressure.	**a.** Low oil level.	**a.** Fill to proper level. Refer to *Maintenance and Lubrication*, page 9-1.
	b. Clutch pressure regulating valve spool stuck open.	**b.** Clean valve spool and housing.
	c. Faulty charging pump.	**c.** Replace pump.
	d. Broken or worn clutch shaft or piston sealing rings.	**d.** Replace clutch shaft or sealing rings, as applicable.
	e. Clutch piston bleed valve stuck open.	**e.** Clean bleed valves thoroughly.
2. Low converter charging pump pressure.	**a.** Low oil level.	**a.** Fill to proper level.
	b. Suction screen plugged.	**b.** Clean suction screen.
	c. Defective oil pump.	**c.** Replace pump.
3. Overheating.	**a.** Worn oil sealing rings.	**a.** Remove, disassemble, and rebuild converter assembly.
	b. Worn oil pump.	**b.** Replace pump.
	c. Low oil level.	**c.** Fill to proper level.
4. Noisy converter.	**a.** Worn oil pump.	**a.** Replace pump.
	b. Worn or damaged bearings.	**b.** A complete disassembly will be necessary to determine what bearing is faulty.
5. Lack of power.	**a.** Low engine RPM at converter stall.	**a.** Tune engine and check governor.
	b. See “Overheating” and make same checks.	**b.** Make corrections as explained in “Overheating.”

Removal

1. Extend and set the outriggers just enough to take up the slack in the outrigger pads. Chock the wheels.
2. Position the boom over the side and stop the engine.
3. Remove the engine and transmission/torque converter from the crane as an assembly. Refer to *Engine Removal*, page 7-2 in this Section.
4. Remove the hydraulic pumps from the transmission/torque converter. Cover all openings. Refer to *Hydraulic Pumps*, page 2-15 for removal of the pump.

NOTE: The transmission/torque converter weighs approximately 374 kg (824.5 lb) dry.

5. Attach an adequate lifting device to the transmission/torque converter and take up any slack.
6. Remove the hardware securing the drive plate assembly to the flywheel.
7. Remove the hardware securing the transmission/torque converter housing to the engine flywheel housing.

Installation

NOTE: The transmission/torque converter assembly weighs approximately 374 kg (824.5 lb) dry.

1. If a new transmission/torque converter is to be installed, remove all fittings and brackets from the old one and install them in the same locations on the new transmission/torque converter.
2. Install the piston and single section hydraulic pumps on the transmission/torque converter. Refer to *Hydraulic Pumps*, page 2-15 for installation of the hydraulic pump.
3. Position the transmission/torque converter to the engine with the lifting device.
4. Remove all burrs from the flywheel mounting face and nose pilot bore. Clean the drive plate surface with solvent Figure 7-14.

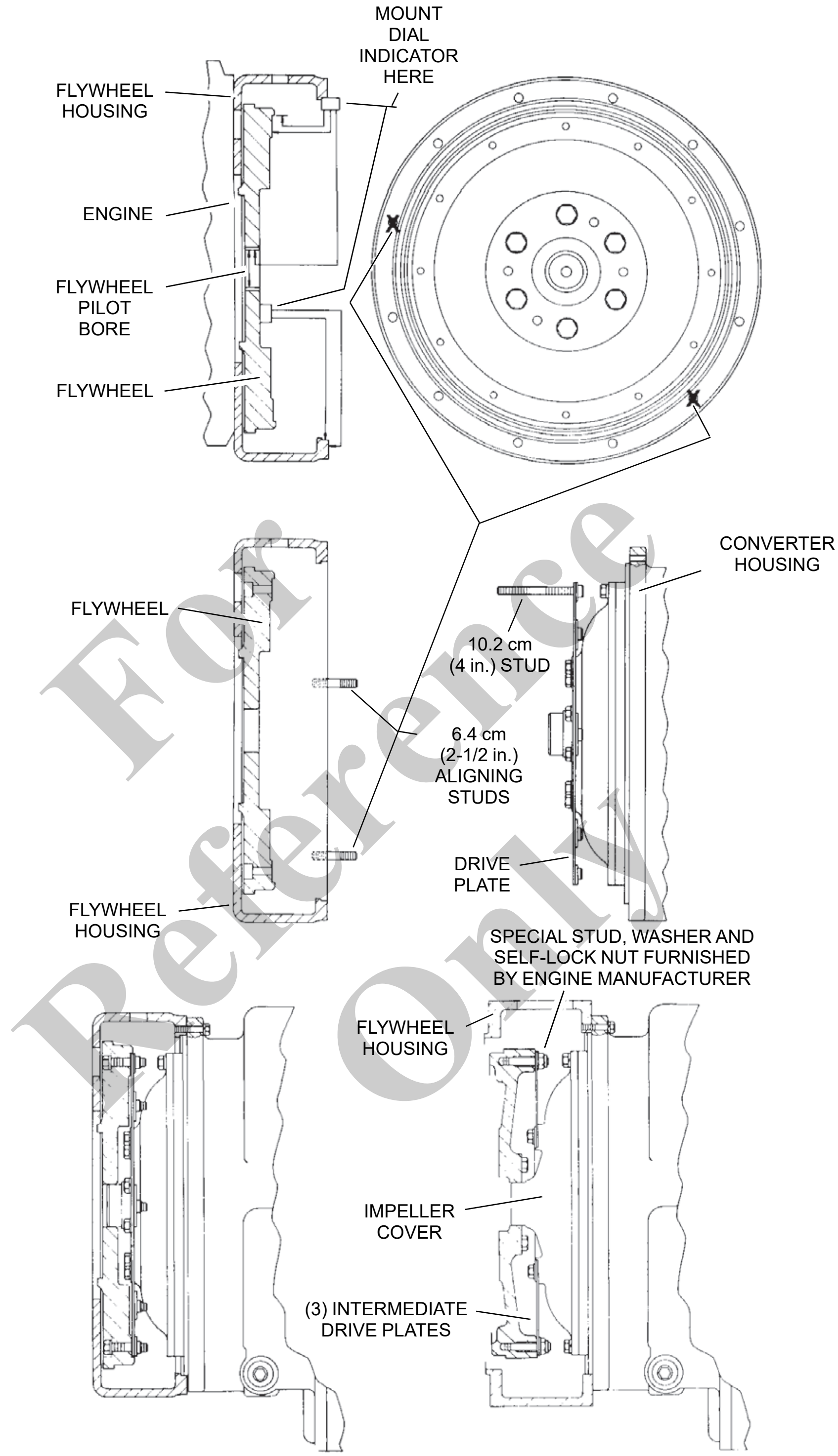

MOUNT DIAL INDICATOR HERE
FLYWHEEL HOUSING
ENGINE
FLYWHEEL PILOT BORE
FLYWHEEL
CONVERTER HOUSING
FLYWHEEL
10.2 cm (4 in.) STUD
6.4 cm (2-1/2 in.) ALIGNING STUDS
DRIVE PLATE
FLYWHEEL HOUSING
SPECIAL STUD, WASHER AND SELF-LOCK NUT FURNISHED BY ENGINE MANUFACTURER
FLYWHEEL HOUSING
IMPELLER COVER
(3) INTERMEDIATE DRIVE PLATES
For Reference Only

FIGURE 7-14

5. Check the engine flywheel and housing for conformance to standard S.A.E. No. 3-S.A.E. J927 tolerance specifications for bore size, pilot bore runout and mounting face flatness. Measure and record engine crankshaft end play.
6. Install two 63.5 mm (2.50 in) long transmission to flywheel housing guide studs in the engine flywheel housing as shown in Figure 7-14. Rotate the engine flywheel to align a drive plate mounting screw hole with the flywheel housing front access hole.
7. Install a 101.6 mm (4.00 in) long drive plate locating stud 0.3750-24 fine thread in a drive plate nut.
8. Rotate the transmission/torque converter to align the locating stud in the drive plate with the flywheel drive plate mounting screw hole positioned in step 6. Locate the transmission on the flywheel housing, aligning the drive plate to the flywheel and the transmission to the flywheel housing guide studs. Install the transmission to flywheel housing nuts and washers. Tighten the bolts to 41 to 43 N-m (30 to 32 lb-ft). Remove the transmission to engine guide studs. Install the two remaining bolts and washers and tighten the bolts to 41 to 43 N-m (30 to 32 lb-ft).
9. Remove the drive plate locating stud. Install one drive plate attaching screw and lockwasher. Snug the screw but ***do not tighten***. **NOTE:** Some engine flywheel housings have a hole located on the flywheel housing circumference in line with the drive plate screw access hole. A screwdriver or pry bar used to hold the drive plate against the flywheel will facilitate installation of the drive plate screws. Rotate the engine flywheel and install the remaining seven flywheel to drive plate attaching screws and lockwashers. Snug the screws but ***do not tighten***. After all eight screws and lockwashers have been installed, torque the screws to 38 to 41 N-m (28 to 30 lb-ft). This will require torquing each screw, then rotating the engine flywheel until all eight screws have been torqued.
10. Measure the engine crankshaft end play after the transmission/torque converter has been completely installed on the engine flywheel. This value must be within 0.025 mm (0.001 in) of the end play recorded in step 5.
11. Install the engine and transmission/torque converter in the crane as an assembly. Refer to *Engine Installation*, page 7-5.
12. Service the crane as required in Servicing the Crane After Transmission/Torque Converter Overhaul (pg 7-32) in this section.
13. Cycle all functions and observe for proper operation.

Servicing the Crane After Transmission/Torque Converter Overhaul

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

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

The following are considered the minimum steps to be taken:

1. Drain the entire system thoroughly.
2. Disconnect and clean all hydraulic lines. Where feasible, hydraulic lines should be removed from the machine for cleaning.
3. Replace oil filter elements, cleaning out the filter cases thoroughly.
4. The oil cooler must be thoroughly cleaned. The cooler should be back flushed with oil and compressed air until all foreign material has been removed. Flushing in the direction of normal oil flow will not adequately clean the cooler. If necessary, the cooler assembly should be removed for cleaning, using oil, compressed air and a steam cleaner for that purpose.

CAUTION

Do not use flushing compounds for cleaning purposes.

5. Remove the drain plug from the transmission/torque converter and inspect the interior of the unit housing, gears, etc. If the presence of considerable foreign material is noted, it will be necessary for the unit to be removed, disassembled, and cleaned thoroughly. It is realized this entails extra labor, however, such labor is a minor cost compared to the cost of difficulties which can result from the presence of such foreign material in the system.
6. Assemble all components and use only the type oil recommended. Fill the transmission through the fill pipe until fluid is at the top of the fill range on the dipstick. Run the engine for two minutes at idle (700 rpm) to prime the torque converter and hydraulic lines. Recheck the level of oil in the transmission with the engine running at idle (950 rpm). Add oil as necessary to bring the level to the LOW mark on the dipstick. After the oil temperature

reaches 82 to 93 °C (180 to 200 °F), add oil to bring the level to the FULL mark on the dipstick.

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

Lubrication

Type Of Oil

Hydraulic Oil (HYDO) or equivalent. Refer to *Maintenance and Lubrication*, page 9-1.

Capacity

System Capacity (includes torque converter, lines, and transmission) - Approximately 24 L (25 qt).

Check Period

Check oil level every 10 hours or DAILY with engine running at 950 RPM and oil at 83 to 93°C (180 to 200°F). Maintain oil level to FULL mark.

Normal Drain Period

NOTE: Normal drain periods and filter change intervals are for average environmental and duty-cycle conditions. Severe or sustained high operating temperatures or very dusty atmospheric conditions will cause accelerated deterioration and contamination. For extreme conditions, judgment must be used to determine the required change intervals.

Every 500 hours, change oil filter element. Every 1000 hours or 6 months, drain and refill system as follows: Drain with oil at 66 to 93°C (150 to 200°F).

NOTE: It is recommended that filter elements be changed after 50 and 100 hours of operation on new and rebuilt or repaired units, then at normal intervals thereafter.

a. Drain transmission and remove pump screen. Clean screen thoroughly and replace, using a new gasket.

b. Remove and discard oil filters. Clean filter housing and install new filters.

c. Refill transmission to LOW mark.

d. Run engine at 700 rpm to prime converter and lines.

e. Recheck level with engine running at 950 RPM and add oil to bring level to LOW mark. When oil temperature is hot (83 to 93°C [180 to 200°F]), make final oil level check. BRING OIL LEVEL TO FULL MARK.

Transmission Oil Cooler

Refer to the sub-section *Cooler Assembly*, page 7-34 for procedures to remove and replace the transmission oil cooler.

COOLER ASSEMBLY

Refer to Figure 7-15 for an exploded view of the cooler assembly.

Removal

NOTE: The three coolers with motors/fans/shrouds are to be removed as an assembly, then separated after being removed from the crane.

NOTE: Complete cooler assembly weighs approximately 145 kg (320 lb) less fluids.

1. Extend and properly set the outriggers.
2. Swing the turntable 90° such that the boom is off to the side of the carrier.
3. Remove the engine cowling from the rear of the carrier.
4. Drain the coolant radiator and the transmission oil cooler.
5. Tag and disconnect all hoses connected to the coolers.
6. Tag and disconnect the electrical connection at the temperature switch at the bottom of the transmission oil cooler and the coolant level switch at the top of the coolant radiator.
7. Tag and disconnect the hydraulic oil hoses to the two fan motors.
8. With lifting lug eyes mounted in the top left and right corners of the cooler assembly, attach an adequate crane and sling to the lifting eyes.
9. Slightly lift the cooler assembly such that the cooler assembly is supported by the crane and sling upon the removal of the cooler support brackets.
10. Remove the cooler support brackets from the left and right sides of the cooler assembly and remove the hardware securing the rear of the cooler to the carrier.
11. Lift the cooler assembly out of the carrier and onto a suitable work area.

Disassembly

1. Separate the two motor/fan/shroud assemblies from the coolers by removing the angle brackets that secure them together.
2. Remove the edge grip moulding from between the two motor/fan/shroud assemblies and the coolers.
3. Separate the three coolers from one another.

Assembly

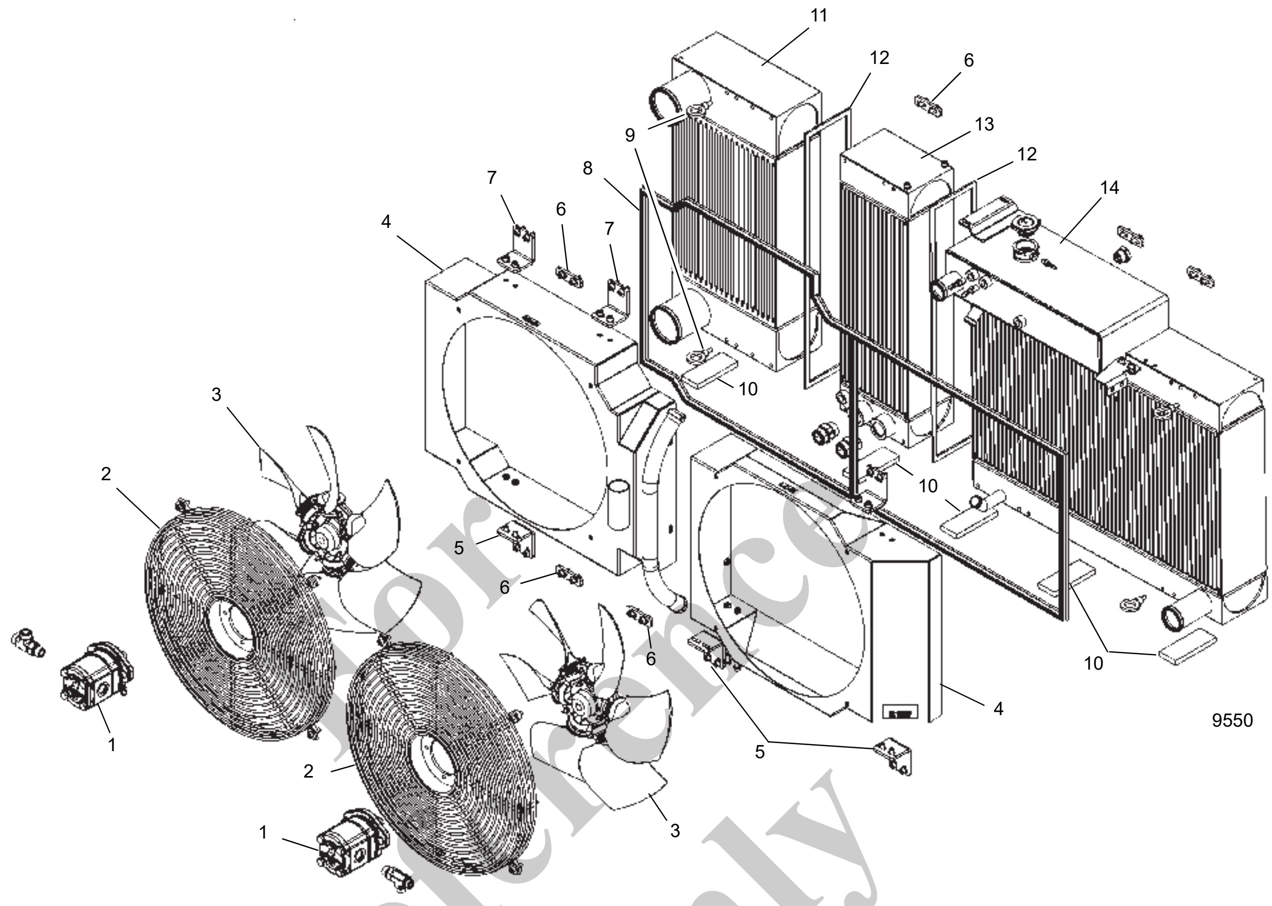
1. Mount the three coolers to one another using tape between them.
2. If coolant radiator was replaced, remove coolant level switch from the original cooler and install it in to the new cooler. Tighten to a torque of 9 N-m (80 in-lb).
3. If transmission oil cooler was replaced, remove temperature switch from the original cooler and install it on to the new cooler.
4. Mount the two motor/fan/shroud assemblies to the cooler assembly ensuring new edge grip moulding is used between them.

Installation

NOTE: The three coolers with motors/fans/shrouds are to be installed as an assembly.

NOTE: Complete cooler assembly weighs approximately 145 kg (320 lb) less fluids.

1. With lifting lug eyes mounted in the top left and right corners of the cooler assembly, attach an adequate crane and sling to the lifting eyes.
2. Lift the cooler assembly on to the carrier.
3. Install the left and right cooler support brackets that secure the cooler assembly to the carrier. Secure the rear of the cooler to the carrier using the bolts and flat washers. Use medium strength thread locking compound. Tighten hardware following specifications found under *Fasteners and Torque Values*, page 1-19.
4. Connect the hydraulic oil hoses to the two fan motors as tagged during disassembly.
5. Connect the electrical connection at the temperature switch at the bottom of the transmission oil cooler and at the coolant level switch at the top of the coolant radiator as tagged during disassembly.
6. Connect all hoses to the coolers as tagged during disassembly. Tighten CAC clamps to a torque of 4.5 ±0.6 N-m (40 ±5 in-lb). Tighten transmission oil cooler clamps to a torque of 10.5 ±0.6 N-m (95 ±5 in-lb)
7. Fill the coolant radiator with antifreeze. Refer to SECTION 9 - Maintenance and Lubrication for the antifreeze specification and filling procedure.
8. Fill the transmission/torque converter with oil. Refer to SECTION 9 - Maintenance and Lubrication for the oil specification and filling procedure.
9. Check all connections for leaks. Repair as needed.
10. Install the engine cowling to the rear of the carrier.



Item	Description
1	Motor Assembly
2	Fan Guard
3	Fan
4	Shroud
5	Bracket
6	Bracket
7	Bracket

Item	Description
8	Edge Grip Moulding
9	Eye Bolt
10	Rubber Pad
11	Charge Air Cooler
12	Tape
13	Transmission Oil Cooler
14	Coolant Radiator

FIGURE 7-15

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SECTION 8
UNDERCARRIAGE

SECTION CONTENTS

AXLES

Description

To provide maximum maneuverability, both the front and rear axles are steerable. The rear axle (Figure 8-1) is mounted on a pivoting cradle (fifth wheel) which allows the axle to oscillate while traversing uneven terrain. The front axle (Figure 8-2) is bolted directly to the frame. All four wheels utilize a hydraulic braking system. The axles are equipped with disc type brakes. A disc-type parking brake is mounted on the front axle input shaft, at the transmission.

Each axle incorporates a single reduction carrier with hypoid gearing mounted in the axle center. The final reduction is of planetary design spur gearing built into the wheel hubs.

The design of these axles permits the hypoid gearing of the differential carrier and the axle shafts to carry only a nominal torsional load while at the same time providing the highest practical numerical gear reduction at the wheels.

The hypoid pinion and differential assembly of the first reduction are supported by tapered roller bearings. The pinion bearing preload is adjusted and maintained by a hardened precision spacer between the inner and outer bearing. The differential tapered bearing preload is adjusted and maintained by the positioning of the threaded adjusting rings in the carrier leg and cap bores.

In the planetary wheel ends, the spur teeth of the sun gear mesh with teeth of the planet spur gears. The planet spur gears rotate on planet pins which are mounted in a spider. The planet spur gear teeth in turn mesh with teeth of the floating ring gear.

Power is transmitted by the hypoid gear set in the differential carrier to the axle shafts and the sun gear of the final reduction, through the revolving planet gears, and into the planetary spider which drives the wheel hub.

As an option, the front axle and rear axle may be provided with a differential lock. When in the locked mode, the axle shafts and the differential are locked together and there is no differential action between the wheels.

Maintenance

NOTE: The axles do not have to be removed from the crane to remove the planetary wheel ends or the drive units.

Removal

1. Using the outriggers, raise the wheels off the ground.
2. Install blocking under the frame at the outboard ends of the four outrigger boxes.

CAUTION

Do not disassemble drive lines when removing them from the crane. Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

3. Disconnect and remove the drive line from the applicable axle. Do not disassemble the drive lines. Refer to *Power Train*, page 7-1.
4. Tag, disconnect, and cap the hydraulic brake line at each wheel.
5. Tag, disconnect, and cap the hydraulic lines to the steer cylinders.
6. On the left side of the rear axle only, tag and disconnect the electrical wires from the rear wheels not centered switch.
7. Axles with driver-controlled differential lock, disconnect the hydraulic lines and cap. Tag and disconnect the electrical connector.

NOTE: Each tire and wheel assembly weighs approximately:

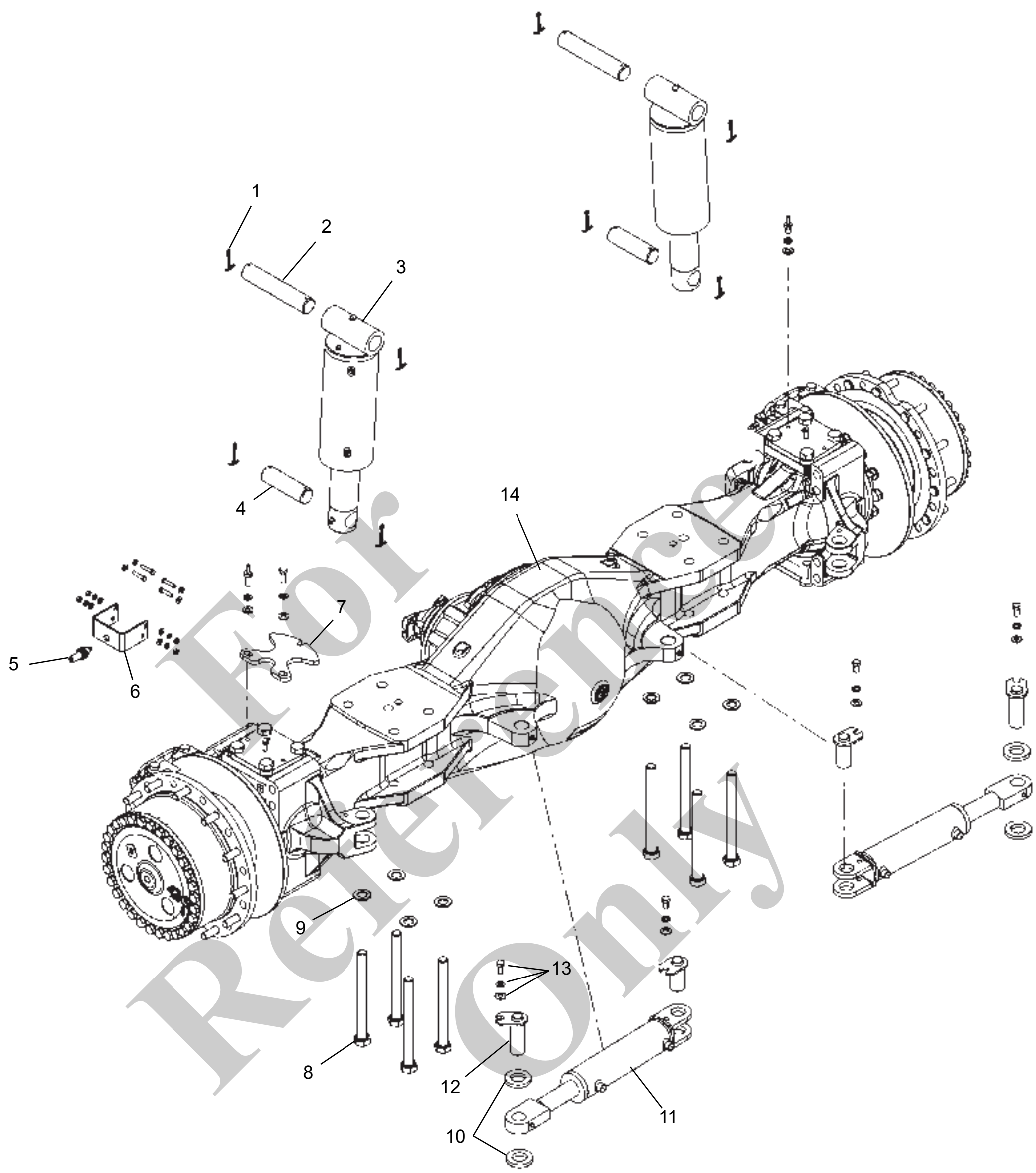
23.5 x 25 - 445 kg (980 lb)

18.0 x 25 - 403 kg (888 lb)

8. Remove the tire and wheel assemblies from the axle.

NOTE: Each axle weighs approximately 1053 kg (2321 lb) with oil.

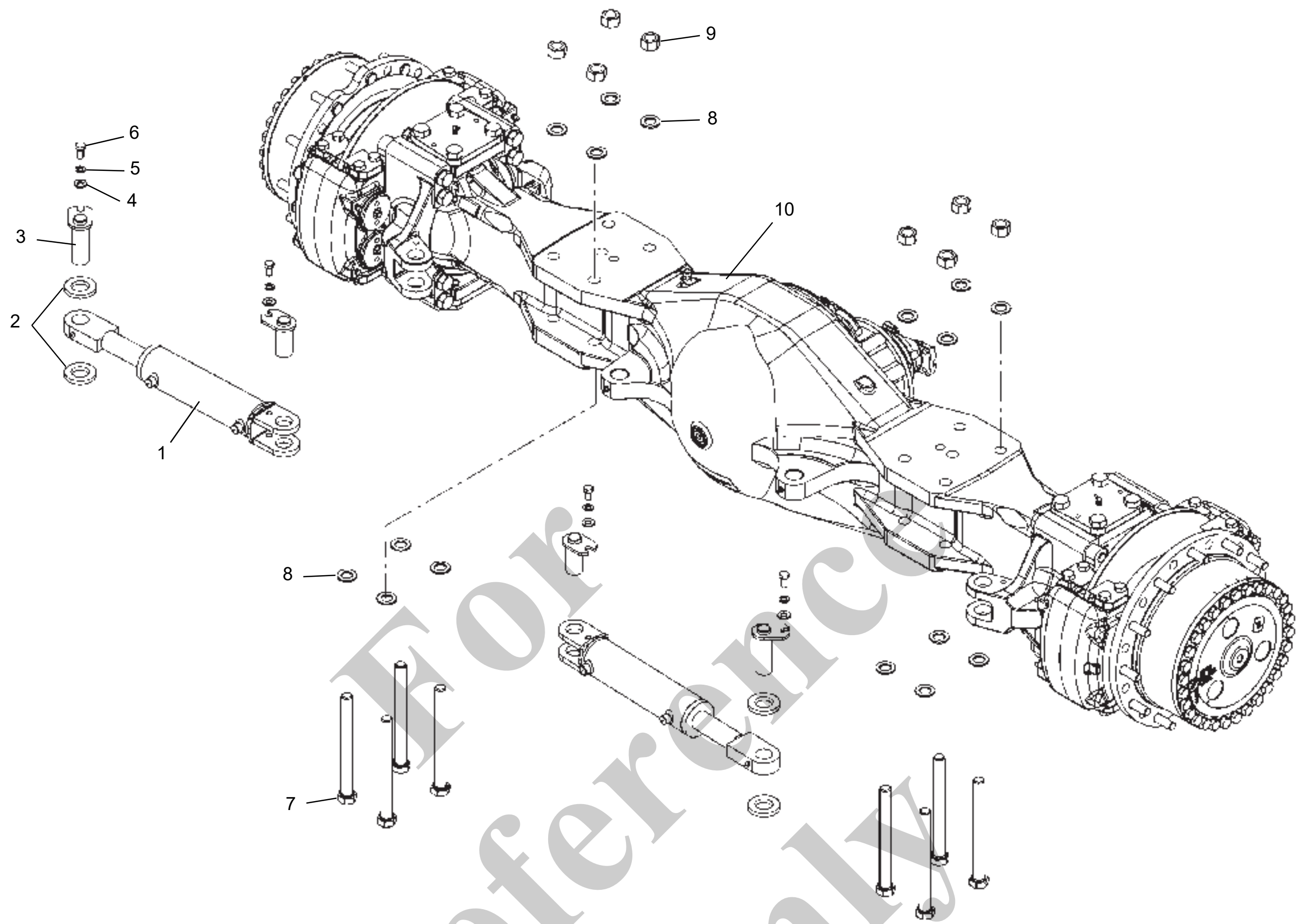
9. Position jacks, which are capable of handling the weight of the axle, under the axle for support.
10. Remove the eight nuts, washers, and capscrews securing the axle to the frame/cradle Figure 8-1 Figure 8-2.
11. Lower the axle to the ground and remove it to a clean working area.
12. If a new axle is to be installed, remove the following from the old axle and install them on the new one.
    a. The steer cylinders. Refer to Steer Cylinders in this section.
    b. The rear wheels not centered switch actuator bracket (rear axle only).



Item	Description
1	Cotter Pin
2	Pin
3	Axle Lock-out Cylinder
4	Pin
5	Rear Steer Sensor
6	Rear Steer Sensor Bracket
7	Rear Steer Sensor Plate

Item	Description
8	Bolt
9	Washer
10	Thrust Washer
11	Steering Cylinder
12	Pin
13	Bolt, Lock Washer, Flat Washer
14	Rear Axle

FIGURE 8-1



Front Axle

Item	Description
1	Steering Cylinder
2	Thrust Washer
3	Pin
4	Flat Washer
5	Lock Washer
6	Bolt
7	Bolt
8	Washer
9	Nut
10	Front Axle

FIGURE 8-2

Cleaning

Completely assembled axles may be steam cleaned on the outside only, to facilitate initial removal and disassembly, providing all openings are closed. Breathers, vented shift units, and all other openings should be tightly covered or closed to prevent the possibility of water entering the assembly.

Installation

1. If a new axle is to be installed, remove the following from the old axle and install them on the new one.
   a. The steer cylinders. Refer to Steer Cylinders in this section.
   b. The rear wheels not centered switch actuator bracket (rear axle only).
2. Position the axle under the crane on jacks which are capable of handling the weight of the axle.
3. Raise the axle into place and secure with the eight attaching capscrews, washers and nuts. Torque the capscrews; see *Fasteners and Torque Values*, page 1-19.
4. Install the wheels onto the axle. Refer to *Wheels and Tires*, page 8-7.
5. Connect the hydraulic lines to the steer cylinder as tagged during removal.
6. Connect the hydraulic brake line to each wheel as marked during removal.
7. On the left side of the rear axle only, connect the electrical wires to the rear wheels not centered switch. Refer to *Rear Steer Indicator Adjustment Procedure*, page 8-5 and adjust the switch.
8. Axles with driver-controlled differential lock, connect the hydraulic lines and connect the electrical connector.
9. Connect the drive line to the applicable axle. Refer to *Drive Lines*, page 7-28.
10. Refer to Brake System in this section and bleed the hydraulic brake system.
11. Remove the blocking under the outrigger beams and retract the outriggers to lower the wheels to the ground.

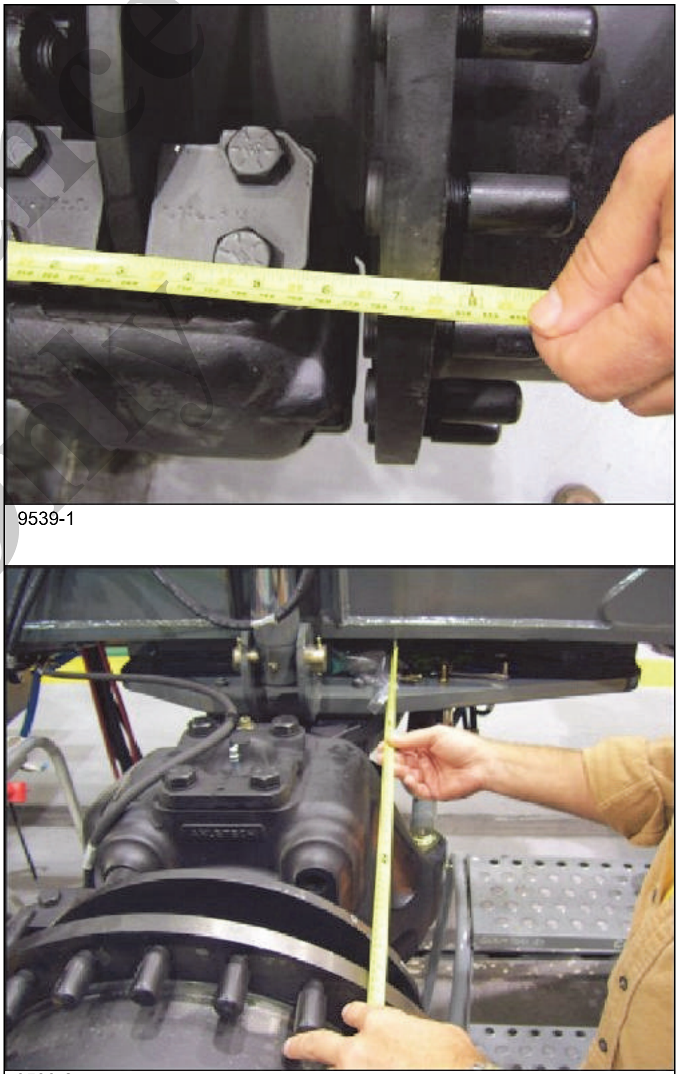
Wheel Alignment Check Procedure

1. Check the axle for wheel alignment. The wheels are to be straight ahead with no toe-in or toe-out. Adjust if necessary by turning the tie rod ends in the direction necessary.
2. Turn the wheels to the extreme left. Check the clearance between the inside of the tire and the nearest object. If the clearance is less than 25 mm (1.0 in) on the rear axle or 25 mm (1.0 in) on the front axle, adjust the axle stop to provide clearance. Do not adjust axle stop if clearance is greater than 25 mm (1.0 in).

   Check the steer cylinders to see that they are not bottomed out. To check the steer cylinders, remove the pin at the rod end and apply pressure to move the cylinder rod. The cylinder rod should travel a minimum of 3.0 mm (0.12 in).
3. Turn the wheels to the extreme right and repeat step 2 for the right side.

Rear Steer Indicator Adjustment Procedure

1. Ensure the rear wheels are straight ahead.
2. Measure the distance from the hub to the frame rail on both sides of the hub. Turn rear wheels until the measurements are equal (see Figure 8-3).



9539-1

9539-2

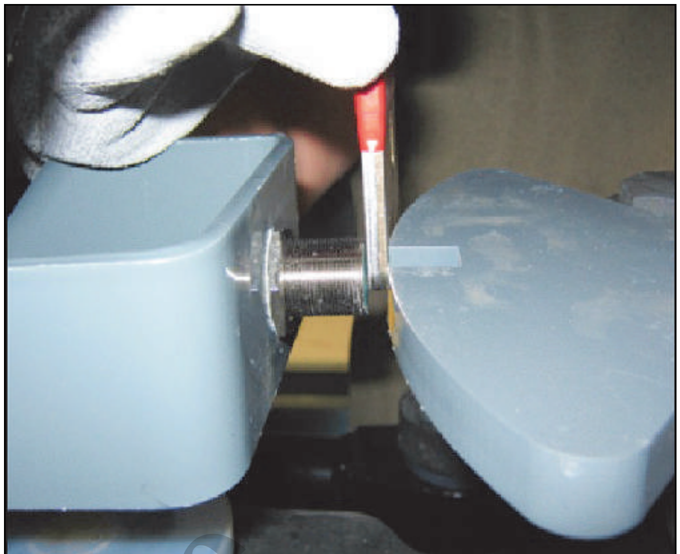
FIGURE 8-3

3. Install proximity sensor into bracket (see Figure 8-4).

9539-3

FIGURE 8-4

4. Set face of proximity sensor such that it face is 4 to 6 mm from opening in rear steer plate (see Figure 8-5).



9539-4

FIGURE 8-5

Wheels and Tires

Description

The standard tire size for this unit is 23.5 x 25 -24 ply. A size 18.00 x 25 -28 ply tire is also available.

WARNING

Possible equipment damage and/or personal injury!

Driving the crane with a tire under inflated at 80% or less of its recommended pressure can cause the wheel and/or tire to fail. Per OSHA Standard 1910.177(f)(2), when a tire has been driven under inflated at 80% or less of its recommended pressure, it must first be completely deflated, removed from the axle, disassembled, and inspected before re-inflation.

CAUTION

Do not mix tires and rims of different manufacturers.

Each wheel assembly (tire and rim) is mounted on the planetary hub with 12 grade 8 lug nuts.

NOTE: The tire diameters, widths, and weights may vary slightly depending on the tire manufacturer.

Off-highway tires are designed to operate with a certain sidewall deflection or bulge. Correct air pressure ensures prior deflection which, in turn, ensures proper traction, flotation, support of load, and prevents excessive flexing of the tire. Over inflation increases rim stresses, which results in lowered rim life.

Refer to and adhere to the inflation pressures in the Load Chart Book in the crane cab.

Maintenance

WARNING

Do not attempt to demount or mount tires without proper training. The high pressures involved can cause tire and rim parts and tools to fly with explosive force, if proper procedures are not used, causing severe injury or death to personnel and damage to the crane and surrounding area.

Mounting Wheel Assemblies

NOTE: Do not lubricate the wheel studs or lug nuts.

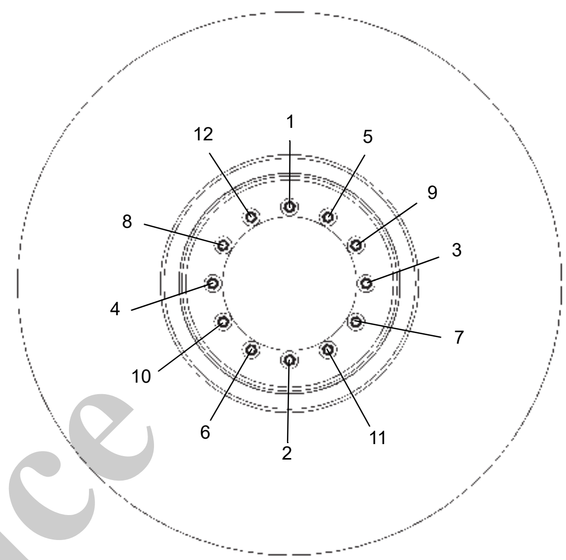


FIGURE 8-6

NOTE: Prior to wheel installation, remove any dirt or grease from wheel mounting surface.

1. Position the wheel assembly on the mounting studs being careful not to damage threads. Install the lug nuts and tighten them to 68 N-m (50 lb-ft) in the sequence shown in Figure 8-6
2. Ensure the wheel assembly is positioned properly on the hub.
3. Torque the lug nuts 407 to 475 N-m (300 to 350 lb-ft) in the sequence shown in Figure 8-6.
4. Retorque lug nuts after approximately one hour of travel.

STEERING SYSTEMS

Description

To maximize maneuverability, the crane can be steered by the front axle, the rear axle, or by the front and rear axles simultaneously. The crane utilizes two separate steering systems, one to control front axle steering and one for rear axle steering.

Front Steering System

NOTE: Pump figures in following text are theoretical.

The front steering system consists of a hydraulic pump, load sense steer priority flow divider valve (part of the swing directional control valve), load sense steering control valve, and two steer cylinders.

The hydraulic pump is driven by the engine and supplies a hydraulic flow of 86.7 L/min (22.9 gpm) to the load sense steering priority flow divider. The load sense steer priority flow divider valve ensures oil is sent to the load sense steering control valve if the steering and swing functions are actuated at the same time.

When the steering wheel is turned, the load sense steering control valve sends a load sense signal to the load sense steer priority flow divider. As the load sense pressure increases, the priority flow divider spool shifts to direct oil from the hydraulic pump to the steering control valve, and to direct oil from the L (left) port and R (right) port of the steering control valve to the steer cylinders.

Rear Steering System

The rear steering system is controlled through a section of the integrated outrigger/rear steer manifold and consists of the control valve and two steer cylinders. Rear steering is activated by the rear steer control switch located on the left armrest in the cab.

A rear steer indicator system is provided to indicate when the rear wheels are not centered. This system consists of an indicator light located on the Operator Display Module (ODM) in the cab and a magnetic switch located on the left side of the rear axle. When the rear wheels are turned to the left or right, the amber indicator light will illuminate.

Secondary Steering System (CE Units)

The secondary steering system is provided to back up the normal front steering system if loss of hydraulic flow occurs due to pump or engine failure. The system consists of one hydraulic accumulator; a pilot-operated, two-position control valve; and a pressure switch. The hydraulic accumulator receives oil through the control valve from the brake dual accumulator charge valve when the engine is running. If the engine or pump fails, the secondary steer valve shifts to send oil from the accumulator to the front steer valve. When this happens, an indicator on the Operator Display Module will come on to indicate that steering pressure is too low.

Maintenance

Front Steering System

Troubleshooting

Table 8-1

Symptom	Probable Cause	Solution
1. Hard to steer left and right.	**a.** Hydraulic oil low.	**a.** Refill hydraulic reservoir. Refer to Section 9 - LUBRICATION
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings. (Refer to your Manitowoc Crane Care Parts Manual)
	c. Defective flow divider valve(s).	**c.** Repair or replace valve(s).
	d. Defective steering control valve.	**d.** Repair or replace valve.
	e. Defective hydraulic pump.	**e.** Repair or replace pump.
2. Hard to steer either left or right.	**a.** Clogged or loose hydraulic lines or fittings.	**a.** Clean or tighten lines or fittings. Refer to Section 9 - LUBRICATION
	b. Defective steer cylinder.	**b.** Repair or replace cylinder.
3. Steering is erratic left and right.	**a.** Hydraulic oil low.	**a.** Refill hydraulic reservoir. Refer to Section 9 - LUBRICATION.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.
4. Noisy hydraulic pump caused by cavitation.	**a.** Hydraulic oil low.	**a.** Refill hydraulic reservoir. Refer to Section 9 - LUBRICATION
	b. Suction line plugged or too small.	**b.** Clean line and check for size.
5. Hydraulic pump shaft seal leakage.	**a.** Worn shaft seal.	**a.** Replace shaft seal.
	NOTE: If replacing the shaft seal does not stop leakage, the pump should be disassembled and checked for the following:	
	b. Broken diaphragm seal or backup gasket.	**b.** Replace seal or gasket.
	c. Bearing out of position.	**c.** Replace bearing.
	d. Excessive internal wear.	**d.** Replace pump.

Functional Check

A normal periodic functional check of the entire steering system will generally be adequate to ensure satisfactory service.

1. Check all fittings for leakage. An accumulation of moist, black dirt is a good indication of leakage.
2. With the engine running at idle and at full throttle, and with the machine standing still and moving, turn the steering wheel through the full range of travel. Note any speed irregularities and sticky sensation. This may indicate dirt in the fluid. If the steering wheel continues to rotate when started and released, a condition known as Motoring exists. This may also indicate dirty fluid in the system.
3. Ensure the system has adequate power. If there is an indication of hard steering, this can be caused by either a reduced oil flow to the control valve or a reduced system relief pressure. Adequate oil flow under all conditions can best be checked by timing the full travel of the cylinder with the steered axle unloaded and loaded. If there is a great difference at low engine speed and slight difference at high engine speeds this may indicate a defective pump. Adequate oil pressure can only be determined by connecting a pressure gauge [24 MPa (3500 psi) full scale recommended] at the accessory manifold with swing directional valve gauge test port (GP5). With the engine running at a medium speed, turn the steering wheel to one end of the travel and hold the cylinders at the travel limit briefly, just long enough to read the pressure gauge. Never hold the system at relief pressure for more than a few seconds at a time. The pressure gauge should indicate 17.3 MPa (2500 psi).

Rear Steering System

Troubleshooting

Table 8-2

Symptom	Probable Cause	Solution
1. Rear steering inoperative.	**a.** Hydraulic oil low.	**a.** Refill hydraulic reservoir. Refer to Section 9 - LUBRICATION.
	b. Clogged, broken, or loose hydraulic lines or fittings.	**b.** Clean, tighten, or replace lines or fittings.
	c. Steer cylinder locked.	**c.** Repair or replace cylinders.
	d. Defective control valve.	**d.** Repair or replace valve.
	e. Defective steer cylinder(s).	**e.** Repair or replace cylinder(s).
	f. Lack of electrical signal	**f.** Check electrical connections/ wiring
2. Hard to steer left and right.	**a.** Hydraulic oil low.	**a.** Refill hydraulic reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.
	e. Clogged or loose hydraulic lines or fittings.	**e.** Clean or tighten lines or fittings.
	f. Defective steer cylinder.	**f.** Repair or replace cylinder.
	g. Damaged relief.	**g.** Replace relief valve.
3. Steering is erratic left and right.	**a.** Hydraulic oil low.	**a.** Refill hydraulic reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.

NOTE:

Steer Cylinders

Description

The steer cylinders are mounted on the axles, two cylinders on each axle. The barrel end of each cylinder is attached to the axle housing and the rod end is attached to the steering lug on the axle end. The front cylinders are controlled hydraulically by the steering control valve. The rear cylinders are controlled by the integrated outrigger/rear steer valve.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines going into the steer cylinder. Cap or plug all openings.
2. Remove the capscrews, flatwashers and spring lockwashers securing each pin weld in the rod end and barrel end of the cylinder.

NOTE: Steer cylinder weighs approximately 13.2 kg (29.1 lb).

3. Remove both pin welds and two thrust washers (rod end only), and remove the cylinder from the axle.

Installation

1. Position the cylinder onto the attachment fittings on the axle and install both pin welds.
2. Secure each pin weld with the capscrew, flatwashers and spring lockwashers. Torque the capscrews see *Fasteners and Torque Values*, page 1-19.
3. Connect the hydraulic lines to the cylinder as tagged during removal.
4. Operate the steering system and check the cylinder for proper operation and any leakage.

REAR AXLE OSCILLATION LOCKOUT SYSTEM

Description

The rear axle oscillation system consists of two lockout cylinders, an axle lockout valve, an axle oscillation relay and an area potentiometer. The lockout cylinders are mounted between a cradle (fifth wheel) and the carrier frame. The axle oscillation lockout valve is located on the left inner center frame rail and hydraulically controls the lockout cylinders.

The area definition potentiometer in the electrical swivel energizes and deenergizes the axle oscillation relay. When the superstructure is more than 6 degrees left or right of directly over the front, the axle oscillation relay is deenergized.

When the axle oscillation relay's contacts are open, the normally closed solenoid valves are deenergized and isolate the lockout cylinders from hydraulic oil supply. This keeps the cylinders from oscillating (moving up and down to damp axle movement) because hydraulic oil cannot leave the cylinders. Instead, the cylinders remain full of hydraulic oil and more rigid.

When the axle oscillation relay's contacts are closed, the solenoid valves are energized and open. This allows hydraulic oil in and out of the cylinders, allowing them to oscillate.

NOTE: For further information on the lockout valve, refer to Section 2 - HYDRAULIC and PRESSURE SETTINGS.

Axle Oscillation Lockout Cylinders

Description

A 12.7 cm (5 inch) diameter bore lockout cylinder is installed on the left and right side of the rear axle. The barrel end of each cylinder is attached to each side of the carrier frame and the rod ends are attached to each side of the cradle (fifth wheel).

The lockout cylinders are connected hydraulically so that hydraulic oil flows from the rod side of the left cylinder to the barrel side of the right cylinder and from the rod side of the right cylinder to the barrel side of the left cylinder.

Maintenance

Removal

1. Raise the crane up on outriggers.
2. Rotate the turntable more than 6 degrees in either direction from directly over the front to lock out the oscillation cylinders.
3. Remove the wheel and tire assembly from the axle.
4. Tag and disconnect both hydraulic hoses from the ports on the cylinder. Cap or plug both hoses and the ports on the cylinder.
5. At the rod end of the cylinder, remove one of the cotter pins securing the retaining pin to the cradle attach fitting.
6. Tap out the retaining pin, freeing the rod end from the cradle.
7. At the barrel end of the cylinder, remove one of the cotter pins securing the retaining pin to the frame attach fitting.
8. Tap out the retaining pin and remove the cylinder. Cylinder weighs approximately 38.8 kg (85.5 lb).

Installation

NOTE: Cylinder weighs approximately 38.8 kg (85.5 lb).

1. Position the barrel end of the cylinder in the frame attach fitting and tap in the retaining pin.
2. Secure the retaining pin with the cotter pin.
3. Align the rod end of the cylinder in the cradle attach fitting and tap in the retaining pin.
4. Secure the retaining pin with the cotter pin.
5. Remove the caps or plugs from the two hydraulic hoses and the cylinder ports and connect the hoses to the appropriate cylinder ports as tagged during removal.
6. Install the wheel and tire assembly on the axle. Tighten the lug nuts in accordance with the procedure in Wheel And Tire Assemblies in this section.
7. Lubricate both ends of the cylinder using the fittings provided.

BRAKE SYSTEM

Description

The brake system includes all the components necessary for the application of the service brakes and the parking brake.

Service Brakes

The service brakes are full power hydraulic disc brakes which are hydraulically controlled and are used to apply the brake assemblies on all four wheels. The system consists of the tandem brake valve with treadle pedal, the dual accumulator charge valve, two hydraulic accumulators, the brake assemblies, and all the associated hoses and tubing. The operator depresses the pedal on the tandem brake valve, located on the cab floor, and the valve modulates the brake line pressure to the brake assemblies at each wheel. The full powered brake system supplies a high brake system pressure with relatively low reactive pedal forces, while controlling the maximum brake line pressure. The service brake dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits. Hydraulic pressure is constantly maintained in the brake circuits by the accumulators and the charging valve.

NOTE: For Description and Maintenance of the tandem brake valve with treadle pedal, the accumulators, and the dual accumulator charge valve, refer to VALVES in Section 2 - HYDRAULIC and PRESSURE SETTINGS.

Parking Brake

The parking brake is a hydraulic release, spring apply, disc-type brake, located on the transmission. The system consists of a two-position switch, a three-way solenoid valve, actuator, one brake assembly, and all the associated hardware and tubing. The selector switch, located on the steering column in the cab, is used to activate the solenoid valve which controls the park brake actuator, which applies and releases the park brake.

Theory of Operation

Service Brakes

Braking begins when the operator depresses the brake pedal in the cab. Mechanical linkage transfers the force created by the lever action of the brake pedal to the hydraulic brake valve which modulates the brake line pressure to the brake assemblies at each wheel.

Hydraulic oil from hydraulic pump number 1 supplies flow to swivel port 5 to the accessory manifold to the dual accumulator charge valve. The dual accumulator charge valve charges the accumulators upon demand to the pre-set high charging limit. When the pressure reaches the high limit, then the accumulators will be fully charged. The dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits. Hydraulic pressure is constantly maintained in the brake circuits by the accumulators and the charging valve. The charged accumulators supply pressurized fluid to the closed tandem brake valve.

After the accumulators are fully charged, the dual accumulator charge valve shifts and flow to the accumulators ceases. As the brakes are being used, the pressure will drop in the accumulators. When this pressure reaches the low charge limit, the dual accumulator charge valve will shift back into it's charging mode, allowing flow to the accumulators and the cycle to repeat.

Once the operator depresses the brake pedal, the tandem brake valve modulates fluid out to the brakes to provide the means of braking. The tandem brake valve will modulate the pressure in the brake system by increasing or decreasing pressure as required in proportion to the input force from the operator via the brake pedal. The hydraulic force acts within the brake assemblies to force the brake pads against the brake discs, acting to slow wheel rotation. Fully powered separate primary (front) and secondary (rear) braking circuits are provided with independent accumulators. A low pressure warning switch is used to sense the accumulator pressures and warn the operator through visual brake warning indicator light on the cab console in the event the pressure in the accumulators drops to an unsafe operating level. In the event of engine failure, the accumulators are pre-charged with dry nitrogen gas and properly sized to provide power-off stopping capacity for secondary braking.

Parking Brake

Hydraulic flow from the transmission charge pump is routed to the parking brake control valve. When the PARK BRAKE switch is in the ON position, the parking brake solenoid valve shifts to route flow from the hydraulic parking brake actuator back to the transmission sump. The actuator spring pulls on the lever on the brake assembly, applying the parking brake.

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Brakes are poor.	**a.** Lining thickness less than 3mm (0.125 in).	**a.** Replace lining.
	b. Brake pedal operation.	**b.** Free mechanical linkage.
	c. Restriction or leaks in lines.	**c.** Check all lines for leaks and restrictions.
	d. Low hydraulic oil flow.	**d.** Check the hydraulic oil level in reservoir and check flow from the tandem brake valve.
	e. Air in brake lines.	**e.** Bleed the brakes.
	f. Brake pads/linings are grease-soaked.	**f.** Replace pads/linings.
	g. Engine not running.	**g.** Start engine. Due to the operation, the engine must be running to provide full brake power.
	h. Brake relief valve stuck open.	**h.** Replace the relief valve.
	i. Dual accumulator charge valve not charging	**i.** Check valve operation and repair or replace valve.
	j. Accumulators not pre-charged.	**j.** Check accumulator pre-charge.
2. Hard brake pedal with engine running.	**a.** Pedal travel being interfered with.	**a.** Check all pedal linkage and ensure it is free and adjusted properly.
3. Brakes lock up.	**a.** Too much hydraulic flow.	**a.** Check the flow from the flow divider. Too much flow will cause the brakes to be applied by the oil trapped in the power boost chamber.
	b. Brake pedal push rod improperly adjusted, causing brakes to be always applied.	**b.** Adjust the push rod linkage so the brake pedal and push rod fully return.
4. Uneven braking or pad wear.	**a.** Lining thickness less than 3 mm (0.125 in).	**a.** Replace the lining.
	b. Grease on the pads/linings.	**b.** Replace the pads/linings.

General

A schedule for the periodic adjustment, cleaning, inspection, and lubrication of brake equipment should be established by the operator on the basis of past experience and severity of operation.

The disc brakes are not adjustable. Brakes should be cleaned, inspected, and linkage lubricated periodically to assure maximum performance.

Bleeding the Brake System

The brake system should be bled whenever air becomes entrapped within the brake system (usually characterized by a spongy feeling during brake pedal application), whenever any brake system line has been opened, or whenever any brake component has been replaced.

Always start at the point in the system that is furthest from the tandem brake valve and work back toward the tandem brake valve. Bleed every bleeder screw on every caliper/

actuator on every wheel. When you complete a bleeder screw, go to the next closest bleeder screw on the same caliper/actuator. When you complete a wheel, go to the furthest bleeder screw on the next closest wheel.

There are two calibers per wheel on the front axle and one caliber per wheel on the rear axle.

Pressure Bleeding the Brake System.

NOTE: Before bleeding the brake system, ensure the hydraulic accumulators are fully charged.

1. Install the bleeding adapter.
2. Using a clean bleeding tank, fill the tank at least half full with hydraulic oil. Position the tank so it will not have to be moved again until all bleeding is finished.
3. Connect a 241 kPa (35 psi) air source to the bleeder tank.
4. Open the bleeder tank valve and bleed all air out of the hose to be connected to the adapter. Connect the bleeder hose to the adapter and open the bleeder valve.
5. Connect the end of the bleeder hose to the bleeder screw on the caliper/actuator. Submerge the other end in a glass jar partially filled with the proper type of clean hydraulic oil.
6. Open the bleeder screw and allow fluid to flow into the jar until it is a solid stream free of air bubbles. Close the bleeder screw and torque to 11.3 to 13.6 N-m (100 to 120 lb-in).
7. Repeat steps 5 and 6 for the remaining wheel calipers/ actuators.
8. Remove the air supply from the bleeder tank.

NOTE: Close the bleeder tank valve and disconnect the hose and the bleeder adapter.

9. Remove the bleeder tank and hose.
10. Remove the bleeder adapter.

Manually Bleeding the Brake System

NOTE: Before bleeding the brake system, ensure the hydraulic accumulators are fully charged.

1. Connect the end of the bleeder hose to the bleed screw on the caliper. Submerge the other end in a jar partially filled with clean hydraulic oil.
2. Open the bleed screw on the caliper/actuator and allow fluid to flow into the jar, while depressing the brake pedal. Depress the brake pedal and close the bleeder screw, then release the brake pedal. Torque the bleeder screw to 11.3 to 13.6 N-m (100 to 120 lb-in).
3. Repeat step 2 until a solid stream free of air bubbles is obtained.
4. Repeat steps 1 thru 3 for the remaining wheel calipers/ actuators.

SERVICE BRAKES

Description

The brakes utilized on the axles are hydraulic disc-type brakes. Two brake assemblies are used at each wheel end on the front axle. One brake assembly is used at the wheel end on the rear axle. The action of the brake pads riding against the brake discs acts to slow the rotation of the wheels.

Maintenance

NOTE: To perform maintenance on the brake caliper, remove the tire and wheel assembly. Refer to AXLES in this section.

Removal

Linings

1. Block the wheels.
2. Remove the bolts securing the end plates to one side of the caliper housing. Remove the end plates.
3. Loosen the bleeder screws to release hydraulic pressure in the caliper.

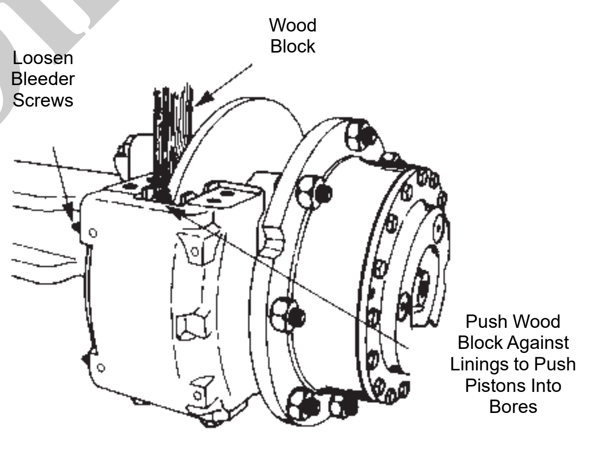


FIGURE 8-7

4. Use a piece of wood against the linings as a pry bar to push the pistons completely into the housing. Tighten the bleeder screws Figure 8-7.
5. Remove the linings from the caliper housing. If necessary, discard the linings.

Caliper

1. Disconnect the hydraulic brake line from the inlet fitting on the caliper. Cap or plug all openings.
2. Remove the linings as described previously.
3. Remove the bolts securing the caliper housing to the mounting bracket. Remove the caliper housing from the mounting bracket. If shims are used mark the position of the shims.

Disassembly

Caliper

1. Remove the inlet fitting and o-ring from the cylinder cap.
2. Drain and discard the brake fluid.
3. Clean the outside of the housing with isopropyl alcohol. Dry the housing with a clean cloth.
4. If installed, remove the bolts that secure the end plates to the housing. Remove the end plates and linings.
5. Remove the pistons from the side of the housing opposite the mounting plate according to the following procedure.
    a. Use a C-clamp to hold a 12.7 mm (0.5 in) block of wood against two pistons on the mounting side of the housing. Ensure the C-clamp is not in the area in front of the piston bore Figure 8-8.

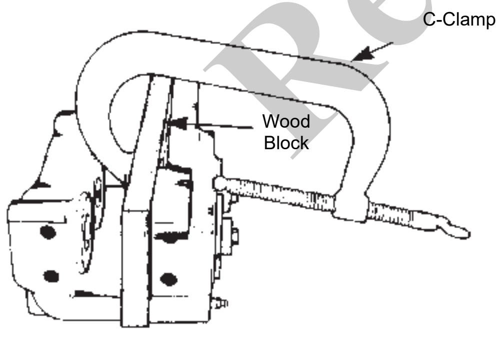


FIGURE 8-8

DANGER

Do not place hand in front of pistons when forcing them out. Serious personal injury may occur.

    b. Apply compressed air to the inlet fitting to force the pistons out of the other housing. If one piston comes out before the other piston, put a piece of wood in front of the piston that comes out first. Apply compressed air to force the other piston out of the housing Figure 8-9.

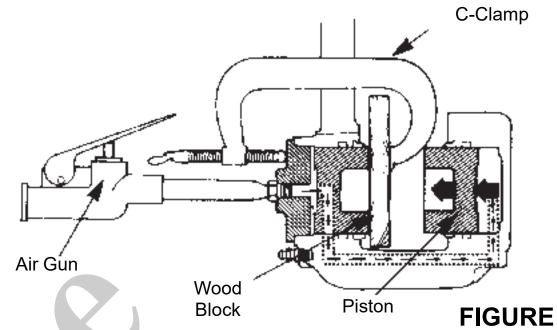


FIGURE 8-9

    c. Remove the wood block and the C-clamp from the housing.
    d. Remove the pistons from the bores that are opposite from the mounting plate.

6. Remove the two bleeder screws from the housing.
7. Remove the cylinder caps from the housing using an open end wrench. Remove and discard the O-rings Figure 8-10.

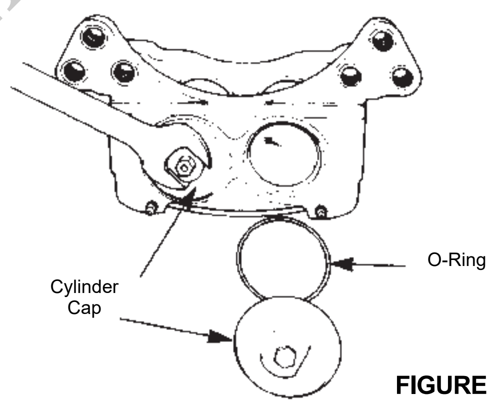


FIGURE 8-10

8. Remove the pistons from the mounting plate side of the housing. Push on the ends of the pistons to force them out of the disc side of the housing Figure 8-11.

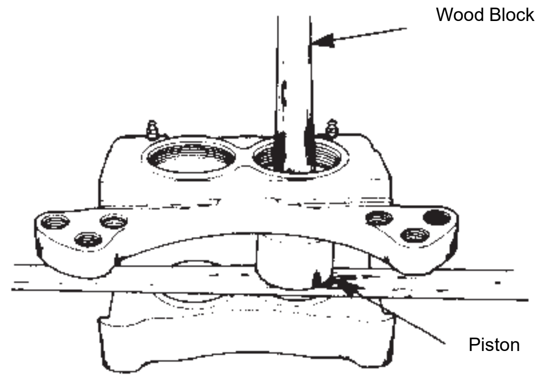


FIGURE 8-11

9. Remove the dust seals from the housing.

10. Remove and discard the O-ring and the backup rings Figure 8-12.

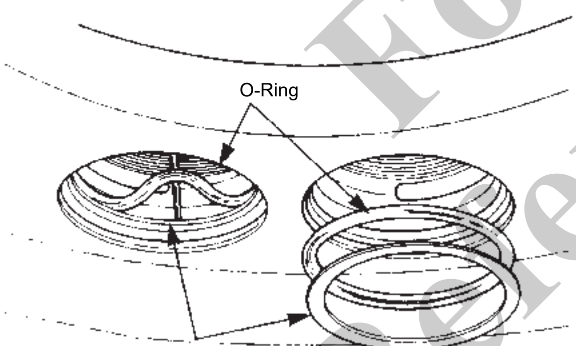


FIGURE 8-12

11. Inspect the ring grooves in the housing for scratches and rust. Remove small scratches and rust with emery cloth. Replace the housing if there are large scratches or large amounts of rust. Refer to Inspection - Caliper Parts.

12. Inspect the pistons and the bores for scratches and rust. Remove small scratches and rust with emery cloth. Replace the components if they are worn or if there are large scratches or large amounts of rust. Refer to Inspection - Caliper Parts.

Inspection

Periodic On-Vehicle

Inspect the caliper, linings, and disc for any damage.

Shoes, Linings, and End Plates

Remove the shoes and linings. To help prevent abnormal lining wear, replace worn, bent, or cracked end plates and distorted backing plates. Inspect end plate bolts for wear. Replace the bolts if worn. Inspect the linings for:

- Lining Wear. Replace the linings when the thickness of the lining is less than 3.2 mm (0.125 in) from the back plate Figure 8-13.
- Lining Wear Not Even. Replace the linings if the thickness of the two linings is significantly different. Check the pistons for correct operation. Replace the piston and/or housing if a piston is cocked in the bore. Check that the disc surface is flat and parallel to the linings Figure 8-13.

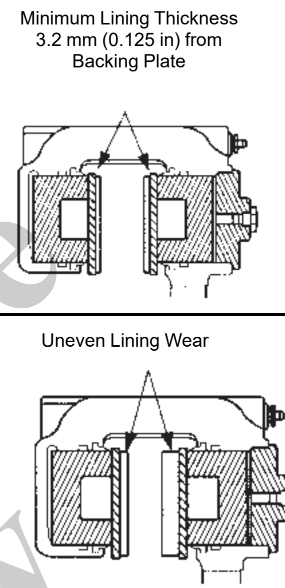


FIGURE 8-13

- Oil or Grease on Linings. Replace the linings.
- Cracks on Linings. Replace linings that have large or deep cracks.

NOTE: Small, tight cracks on the surface of the lining are normal when the caliper is used under high temperature conditions.

Caliper for Leaks

Inspect the following areas for fluid leaks Figure 8-14.

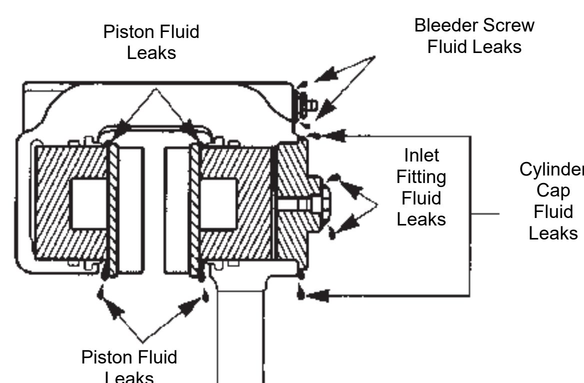


FIGURE 8-14

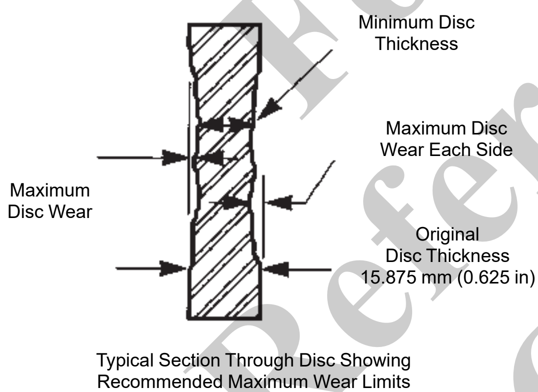
- **Pistons.** If fluid leaks at a piston, disassemble the caliper. Inspect the piston, the bore, the o-rings, and back-up rings. Service as necessary.
- **Cylinder Cap.** If fluid leaks at a cylinder cap, tighten the cylinder cap, the inlet fitting, and the plug. If the leak continues, disassemble the caliper. Inspect the cylinder cap threads, the housing threads, and the o-ring. Service as necessary.
- **Bleeder Screw.** If fluid leaks at the bleeder screw, tighten the bleeder screw. If the leak continues, replace the bleeder screw.
- **Inlet Fitting.** If fluid leaks at the inlet fitting, tighten the fitting. If the leak continues, replace the o-ring.

Dust Seals

Ensure the dust seals are soft and flexible. Disassemble the caliper and replace dust seals that are hard or damaged.

Disc

If the disc is worn beyond the wear limits, replace the disc Figure 8-15.



Lining Backing Plate Thickness	Maximum Disc Wear Each Side	Minimum Disc Thickness
7.1 mm (0.28 in)	1.5 mm (0.06 in)	12.7 mm (0.50 in)
8.6 mm (0.34 in)	2.3 mm (0.09 in)	11.2 mm (0.44 in)

FIGURE 8-15

Caliper Parts

1. Inspect the pistons, housing bores, and o-ring grooves for scratches or corrosion. Remove small scratches or corrosion with fine emery cloth. Replace the components if they are worn beyond wear limits or if there are large scratches or large amount of corrosion.
2. Measure the diameter of the piston. Replace the piston if the outer diameter is worn less than 76.073 mm (2.995 in) Figure 8-16.

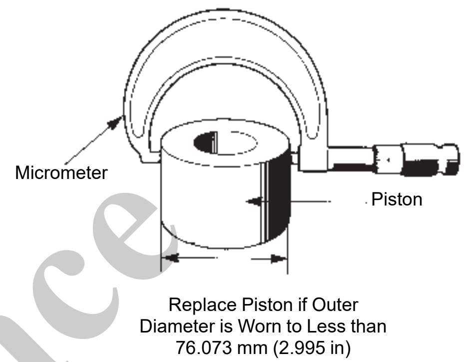


FIGURE 8-16

3. Measure the diameter of the housing bore. Replace the housing if the diameter is worn to more than 76.276 mm (3.003 in) Figure 8-17.

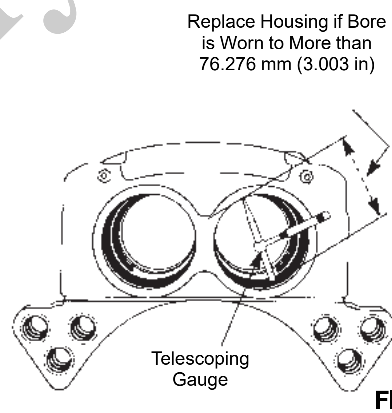


FIGURE 8-17

4. Inspect the linings as described previously.
5. Inspect the threads of the caliper, cylinder caps, and all fittings. Replace any component that has thread damage that cannot be repaired.
6. Discard all back-up rings, o-rings, and dust seals. Use new ones when assembling the caliper.

8

Cleaning

DANGER

Use of cleaning solvents, hot solution tanks, or alkaline solutions incorrectly, can cause serious personal injury. To prevent serious personal injury, follow the instructions supplied by the manufacturer of these products. Do not use gasoline to clean parts. Gasoline can explode and cause serious personal injury.

CAUTION

Use only solvent cleaners to clean ground or polished metal parts. Hot solution tanks or water and alkaline solutions will damage these Parts. Isopropyl alcohol, kerosene, or diesel fuel can be used for this purpose.

- Use solvent cleaners to clean all metal parts that have ground or polished surfaces. Examples of ground or polished parts are the piston and the piston bore in the caliper.
- Metal parts with rough surfaces can be cleaned with solvent cleaners or with alkaline solutions.
- Use a wire brush to clean the threads of fasteners and fittings.
- Use soap and water to clean parts that are not made of metal.
- Scrape away build-ups of mud and dirt on the linings. Replace all linings contaminated with oil or grease.
- Immediately after cleaning, dry all parts with clean paper or rags.

Corrosion Protection

Apply brake system fluid to the cleaned and dried parts that are not damaged and are to be immediately assembled. **Do Not** apply fluid to the brake linings or the disc.

If parts are to be stored, apply a special material that prevents corrosion to all surfaces. **Do Not** apply the material to the brake linings or the disc. Store the parts inside special paper or other material that prevents corrosion.

Assembly

Caliper

CAUTION

Use only specified components when assembling the calipers. Do not mix components from other calipers. Installing the wrong components may cause the caliper not to operate correctly and may cause damage to equipment. Use of non manufacturer's parts can cause damage, loss of braking, and serious personal injury.

NOTE: The o-rings, back-up rings, pistons, and bores must be lubricated before installing the pistons.

1. Lubricate all pistons, bores, o-rings, and back-up rings with silicone grease. If silicone grease is not available, use the same type of fluid that is used in the brake system.
2. Install new o-ring and a new back-up ring in the groove in the middle of the bore. The o-ring is installed toward the outboard end of the bore. The back-up ring is installed toward the lining side of the bore (Figure 8-16).

CAUTION

Do not use silicone grease on the dust seal.

3. Install a new dust seal in the top groove of the bore Figure 8-18.

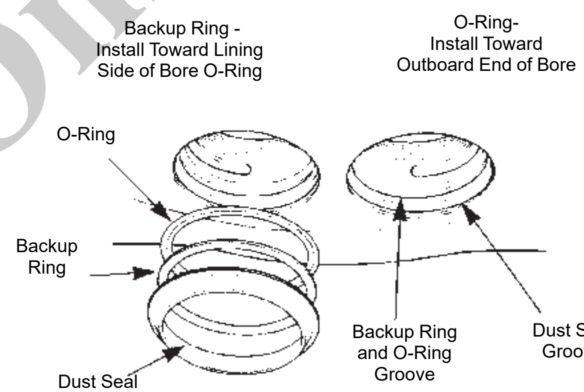


FIGURE 8-18

4. Install the pistons in the housing. Push the pistons in from the lining side of the housing. Ensure the pistons are straight in the bores. Push each piston into the bore until the top of the piston is even with the top of the dust seal Figure 8-19.

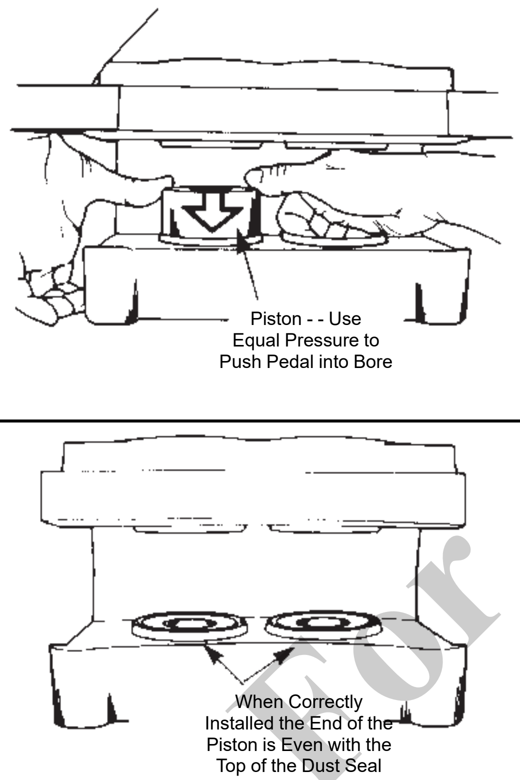


FIGURE 8-19

5. Install a new o-ring in the groove of the cylinder cap. Ensure the o-ring is not cut by the threads on the cylinder cap.

NOTE: Apply extra grease on o-ring before installing cylinder caps. this will keep o-ring from catching on threads as cylinder cap is threaded into housing.

6. Install the cylinder caps in the caliper housing. Tighten the cylinder caps to 102 N-m (75 lb-ft) minimum as shown in Figure 8-20.

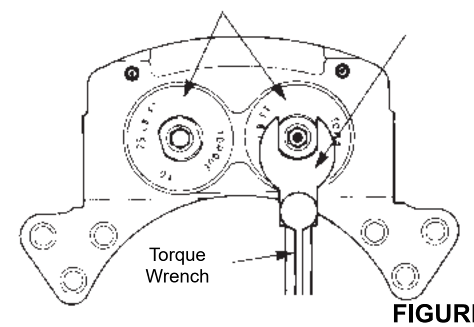


FIGURE 8-20

7. Install the bleeder screws in the housing. Tighten to 11.3 to 13.6 N-m (100 to 120 lb-in).

8. Install the o-ring and the inlet fitting in the cylinder cap.

Installation

Linings

CAUTION

Always replace both linings. If only one lining is replaced, possible disc damage can occur.

1. Install the linings in the caliper housing.

2. Position the end plates on the housing and secure with bolts. Apply Loctite 271 or equivalent to the bolt threads. Tighten the bolts to 224 to 285 N-m (165 to 210 lb-ft).

3. Ensure the linings move freely in the housing.

4. Bleed the brake system.

5. Apply and release the brakes three times to ensure the caliper operates correctly. Check for fluid leaks. Ensure the linings move freely.

Caliper

1. Position the caliper housing on the mounting bracket. If shims where used, place them as marker during removal.
2. Secure the caliper housing with the bolts and tighten them to 678 to 813 N-m (500 to 600 lb-ft).
3. Install the linings. Refer to INSTALLATION - Linings.
4. Ensure the housing is installed correctly on the mounting bracket. The disc must be within ±1.5 mm (±0.06 in) of being centered between the lining end plates.
   a. To increase outboard clearance and decrease inboard clearance, install a shim either between the housing and mounting bracket or between the hub and disc.
   b. The shims must be steel, ground flat, and parallel and must cover the entire mounting surface of the hub or housing. The linings must move freely in the housing and between the end plates Figure 8-21.

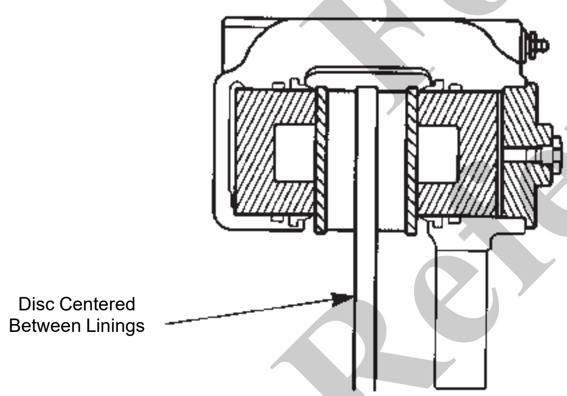


FIGURE 8-21

5. Connect the hydraulic brake line to the inlet fitting.
6. Bleed the brake system.
7. Apply and release the brakes three times to ensure the caliper operates correctly. Check for fluid leaks. Ensure the linings move freely.

PARKING BRAKE ACTUATOR

Description

The spring-applied, hydraulically-released parking brake actuator is located on the transmission and is used to apply and release the parking brake.

Maintenance

Removal

1. Chock the wheels to prevent crane movement.
2. Release the parking brake by performing the procedures under *Procedure for Manually Releasing the Parking Brake*, page 8-24.
3. Remove the capscrews securing actuator to the brake caliper. Slide the actuator off the actuator rod.
4. Position the Park Brake switch to On (press top of switch) and shut down the engine.
5. Disconnect the hydraulic line from the brake actuator, then cap or plug all openings.

Installation

NOTE: Mount brake so that the linings are parallel with the disc within 0.381 mm (0.015 in). Disc is to be located the proper distance from the mounting surface per assembly drawing.

1. Slide brake over disc and into mounting position.
2. Start hex mounting bolts into mounting surface far enough to just support the brake.
3. Remove plug, loosen the coupling nut and then tighten socket setscrew until linings are clamped to the disc. This locates and holds the brake in the proper position to set the hex mounting bolts and hex nuts.
4. Tighten hex mounting bolts until they make contact with the urethane springs, then tighten 4 flats approximately 1.8 mm (0.07 in) more. This puts the proper amount of pre-load on the urethane springs.
5. Tighten jam nut/sleeves against mounting surface and torque 271 N-m (200 lb-ft).

CAUTION

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

6. Attach brake line to inlet port located on top of the hydraulic cylinder.
7. Apply hydraulic pressure to the brake.
8. With plug removed, loosen coupling nut and set running clearance to 0.5 to 0.7 mm (0.020 to 0.030 in) total by adjusting the socket setscrew. Torque the coupling nut while holding the socket setscrew in position. Torque nut 68 to 75 N-m (50 to 55 lb-ft).
9. Replace plug. Torque plug 61 to 68 N-m (45 to 50 lb-ft).
10. Even up running clearance to 0.25 to 0.3 mm (0.010 to 0.015 in) each side by adjusting the socket head capscrew.

NOTE: Re-adjust the brake when running clearance reaches a total of 2.54 mm (0.100 in).

11. Position the Park Brake switch to On (press top of switch) and shut down the engine.

Adjustment

1. Chock the wheels to prevent crane movement.

CAUTION

Do not exceed 1861.5 kPa/18.6 bar (270 psi) hydraulic pressure to avoid damage to the brake. 1172.1kPa/11 bar (170 psi) is required to fully release the brake.

2. Start the engine, ensure the transmission is in neutral, and position the Park Brake switch to Off (press bottom of switch). This will pressurize the brake actuator to release the tension on the brake linkage. A porta-power type device may be used to pressurize the actuator 1862 kPa (270 psi). Screw the caging nut up under the actuator chamber.
3. Install the rod ball joint until the ball joint will just connect to the brake linkage with the brake lever in a horizontal position.
4. Lock the rod ball joint with the jam nut and back off the caging nut.
5. Position the Park Brake switch to On (press top of switch) and shut down the engine.

8

Procedure for Manually Releasing the Parking Brake

NOTE: Refer to Figure 8-22 and Figure 8-23 during parking brake adjustment procedure.

1. Block wheels to prevent crane from moving.
2. Remove the screw-in plug (1).
3. Loosen coupling nut (3).
4. Back out socket setscrew (2) until brake is released.
5. While holding the socket setscrew (2), tighten the coupling nut (3).
6. Reinstall the screw-in plug (1).

PARK BRAKE VALVE

Refer to SECTION 2 - HYDRAULIC SYSTEM for information regarding the Park Brake Valve.

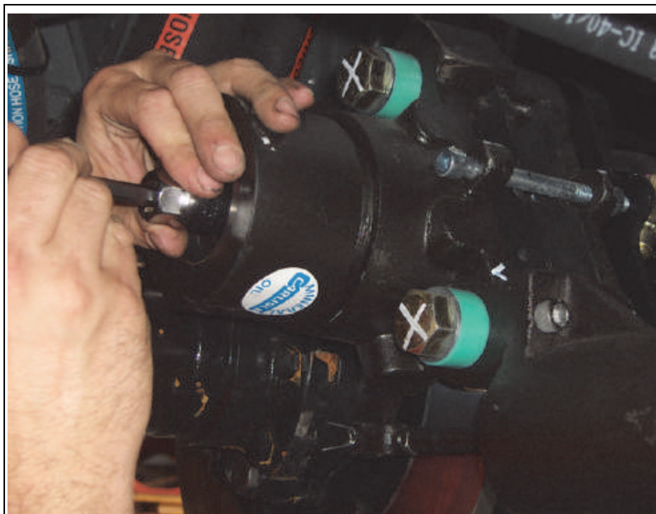


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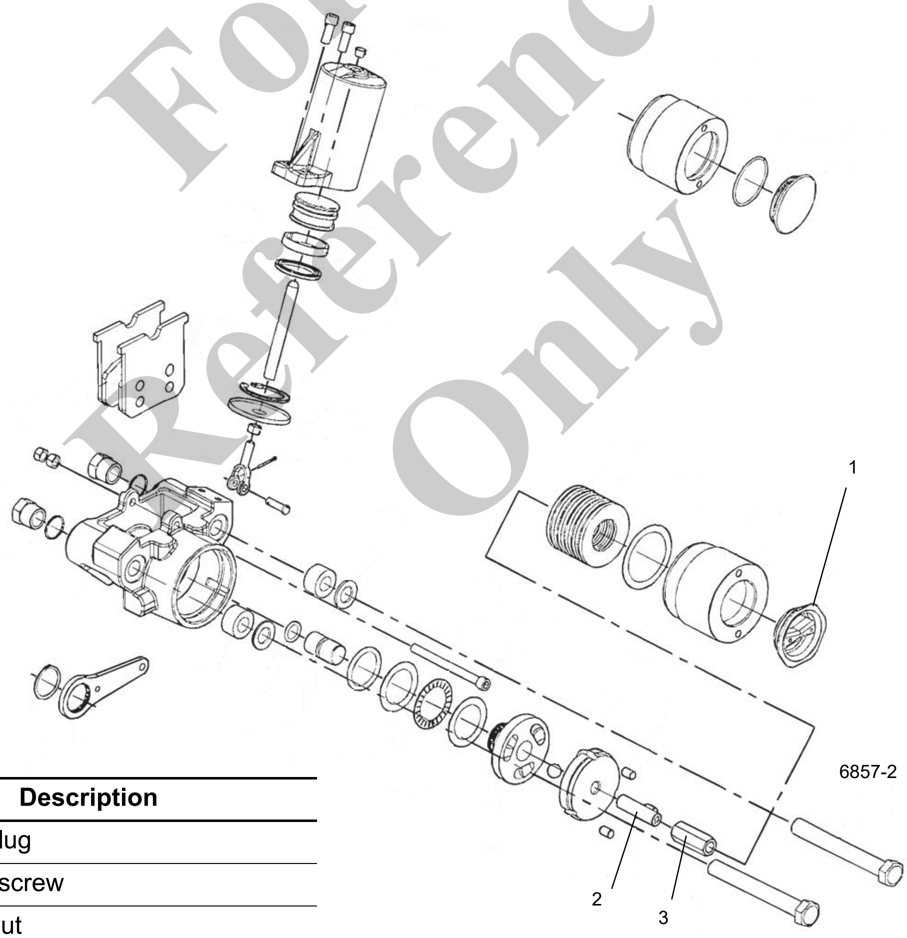
FIGURE 8-22



Item	Description
1	Screw-in Plug
2	Socket Setscrew
3	Coupling Nut

FIGURE 8-23

Published 3-26-2021, Control # 676-02

OUTRIGGERS

Outrigger Circuit

The outrigger circuit consists of four extension cylinders with integral encoders, four jack cylinders with pilot operated check valves, an integrated outrigger/rear steer valve, and front and rear outrigger control manifolds. The front two extension cylinders are mounted in the front outrigger beams and the rear two extension cylinders are mounted in the rear outrigger beams. The front and rear outrigger beams are mounted in their respective outrigger boxes; in turn a jack cylinder is mounted on the end of each outrigger beam. The integrated outrigger/rear steer valve is mounted on the front face of the carrier frame front cross member (Figure 2-13). The front and rear outrigger control manifolds are mounted on the inside center of their respective outrigger box. The encoder integral to each extension cylinder is part of the Outrigger Monitoring System (OMS). The OMS indicates the horizontal beam position to the Rated Capacity Limiter (RCL), which aids the operator in accurately programming the RCL.

The outrigger selector controls are located in the cab on the CCS display or jog dial. Both the integrated outrigger valve and the manifold solenoid valves are electrically actuated from these controls. The solenoid switches must be depressed and held to actuate the solenoid valves. The integrated outrigger valve switch is spring loaded to the off position.

A bubble level is mounted on the right side of the cab. The bubble level provides the operator with a visual indication of crane level attitude.

Theory of Operation

Refer to Section 3 - OPERATING CONTROLS and PROCEDURES in the Operator Manual for operation of the outrigger switches.

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Slow or erratic operation of outrigger extension cylinders.	**a.** Damaged relief valve.	**a.** Remove relief valve; clean or replace.
	b. Low hydraulic oil.	**b.** Replenish oil to proper level. Refer to Maintenance and Lubrication, page 9-1
	c. Sticking solenoid valve spool.	**c.** Repair or replace valve spool.
	d. Improper ground to base of solenoid.	**d.** Ground properly.
	e. Damaged O-rings and swivel	**e.** Remove swivel and replace O-rings.
	f. Directional selector switch sticking.	**f.** Clean or replace switch.
	g. Collector ring dirty or glazed.	**g.** Clean and deglaze collector ring.
	h. Damaged wiring to solenoid.	**h.** Replace wiring.
	i. Weak brush springs on collector ring.	**i.** Replace brush springs.
	j. Damaged extension cylinder (internal parts).	**j.** Remove extension cylinder and repair as necessary.
	k. Bent cylinder rods.	**k.** Replace piston rods and seals.
	l. Excessive material on outrigger beams.	**l.** Clean outrigger beams.
	m. Binding outrigger beam.	**m.** Repair or replace outrigger beam.
	n. Damaged outrigger valve.	**n.** Repair or replace valve.
	o. Damaged valve coil.	**o.** Replace coil.
	p. Main hydraulic pump cavitation.	**p.** Replace or tighten hose or fitting.

Symptom	Probable Cause	Solution
Slow or erratic operation of outrigger extension cylinders. (continued)	**q.** Partially shifted hydraulic spool in selector valve or manifolds.	**q.** Disassemble, clean, and polish spool and valve housing with very fine emery cloth (water paper).
	r. Insufficient voltage for operation of solenoid valve.	**r.** Solenoids require a minimum of 9.5 volts to energize. Check outrigger wiring and electrical coupling collector rings.
	s. Damaged piston seals.	**s.** Replace all cylinder seals.
	t. Worn or damaged hydraulic pump section.	**t.** Repair or replace pump section.
	u. Scored cylinder barrel.	**u.** Repair or replace extension cylinder.
	v. Cracked or damaged piston.	**v.** Replace rod weld and all cylinder seals.
	w. Piston loose on piston rod.	**w.** Replace all cylinder seals and torque piston locknut.
2. Sticking spool.	**a.** Dirt in the system.	**a.** Change oil and flush system.
	b. Distortion caused by tie bolts being overtorqued.	**b.** Retorque tie bolts.
	c. Flow in excess of valve rating.	**c.** Limit flow through valve to that recommended. Check pump output and cylinder ratio.
	d. Pressure in excess of valve rating.	**d.** Check relief valve setting or pump compensation with that recommended.
	e. Electrical failure.	**e.** Check wiring and solenoids.
3. External leakage.	**a.** Damaged O-ring or quad rings.	**a.** Check for chipped packings and replace.
	b. Loose tie bolts.	**b.** Retorque tie bolts.
	c. Damaged solenoid.	**c.** Replace damaged parts.
4. Solenoid failure.	**a.** No current.	**a.** Check power source of at least 85% of coil rating.
	b. Damaged solenoid assembly.	**b.** Replace solenoid.
	c. Short in solenoid.	**c.** Replace coil.
	d. Loss of solenoid force.	**d.** Decrease time of solenoid energization, decrease cycle rate.

Symptom	Probable Cause	Solution
5. Outrigger jack cylinder slow or erratic.	**a.** Low in hydraulic oil.	**a.** Replenish oil to proper level.
	b. Damaged main relief valve.	**b.** Repair or replace valve.
	c. Damaged holding valve seals.	**c.** Replace holding valve seals.
	d. Bent cylinder rod.	**d.** Replace cylinder rod and seals.
	e. Bent outrigger housing.	**e.** Repair or replace outrigger housing.
	f. Excessive material on beams.	**f.** Clean outrigger beams.
	g. Sticking solenoid valve spool.	**g.** Repair or replace valve spool.
	h. Damaged wiring to solenoid.	**h.** Repair or replace wiring.
	i. Weak brush springs on collector rings.	**i.** Replace brush springs.
	j. Collector ring dirty or glazed.	**j.** Clean or deglaze collector ring.
	k. Directional selector switch sticking.	**k.** Clean or replace switch.
	l. Main hydraulic pump cavitation.	**l.** Replace or tighten hose and fittings.
	m. Worn or damaged hydraulic pump section.	**m.** Repair or replace pump section.
6. Outrigger jack cylinder retracts under load.	**a.** Damaged piston seals.	**a.** Replace all cylinder seals.
	b. Damaged holding valve seals.	**b.** Replace seals.
	c. Damaged holding valve.	**c.** Replace valve assembly.
	d. Scored cylinder barrel.	**d.** Repair or replace cylinder.
	e. Cracked or damaged piston.	**e.** Replace piston and all cylinder seals.
7. Outrigger jack cylinder extends while machine is traveling.	**a.** Damaged piston seals.	**a.** Replace all cylinder seals.
	b. Scored cylinder barrel.	**b.** Replace jack cylinder.
	c. Cracked or damaged piston.	**c.** Replace piston and seals.
	d. Piston loose on cylinder rod.	**d.** Replace seal and retorque.
8. Outrigger system will not activate (from stowed or extended and down position).	**a.** Hydraulic oil low.	**a.** Replenish system.
	b. Loose or broken wire on switch.	**b.** Repair or replace wiring.
	c. Clogged, broken, or loose lines or fittings.	**c.** Clean, tighten, or replace lines or fittings.
	d. Damaged relief valve or damaged control valve.	**d.** Repair or replace valve.

Symptom	Probable Cause	Solution
9. Outrigger system activates, but selected outrigger will not stow or extend and lower as desired.	**a.** Clogged, broken, or loose hydraulic lines or fittings.	**a.** Clean, tighten, or replace lines or fittings.
	b. Loose or broken wire on control switch or solenoid valve.	**b.** Repair or replace wiring.
	c. Damaged solenoid valve.	**c.** Repair or replace valve.
	d. Damaged control switch.	**d.** Replace switch.
	e. Damaged hydraulic cylinder.	**e.** Repair or replace cylinder.
10. Outriggers will not set.	**a.** Improper sequence of activation.	**a.** Activate individual control switch; then activate system control switch.
11. Two outriggers activate from single control switch.	**a.** Damaged solenoid valves.	**a.** Repair or replace.
12. The two outriggers will not stow.	**a.** Hydraulic lock.	**a.** Recycle individual outrigger(s).
13. Individual outrigger will not set or stow.	**a.** Damaged piston seals.	**a.** Replace seals.
	b. Damaged check valve.	**b.** Repair or replace valve.
	c. Loosen or broken wire on control switch or solenoid valve.	**c.** Repair or replace wiring.
	d. Damaged solenoid valve.	**d.** Repair or replace valve.

Outrigger Beam

Description

The outrigger beam assembly (Figure 8-24) consists of an outrigger beam, a jack cylinder, a extension cylinder, and the required hoses and mounting hardware.

Theory of Operation

When the outrigger extension is activated, it extends or retracts the outrigger beam within the outrigger box. The outrigger beam can be extended to the mid-extend position by allowing the lock pin to ride on the top of the beam while it's extending. The lock pin will automatically drop into the hole when the beam reaches the mid-extend position.

The jack cylinder is mounted to the end of the beam and applies force to the outrigger beam vertically. This sequence of events provides for lifting and stabilizing the crane for operation.

NOTE: Cranes equipped with the Outrigger Monitoring System (OMS) have beam cylinders with integral encoders, which indicate their horizontal position to the Rated Capacity Limiter (RCL). The encoders in the beam cylinders are identified in the crane control system as being at the front-right, front-left, right-rear, and left-rear positions. Therefore, beam cylinders cannot be relocated to a different position on the crane without re-identifying the beam cylinder encoders in their new positions using the crane service tool.

Maintenance

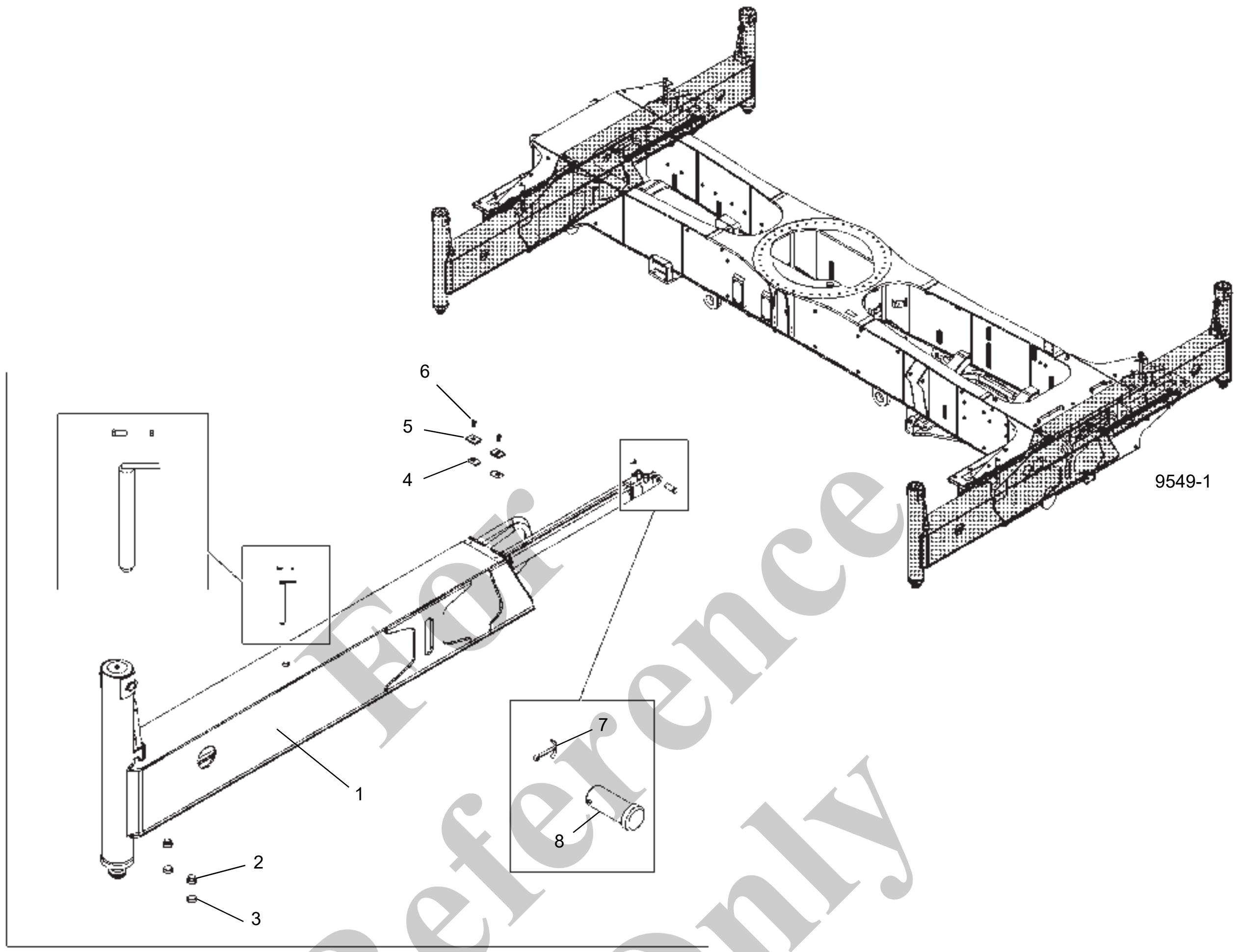
Removal

1. Remove the setscrews from the bottom adjustable wear pads and back off the wear pads.
2. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.

DANGER

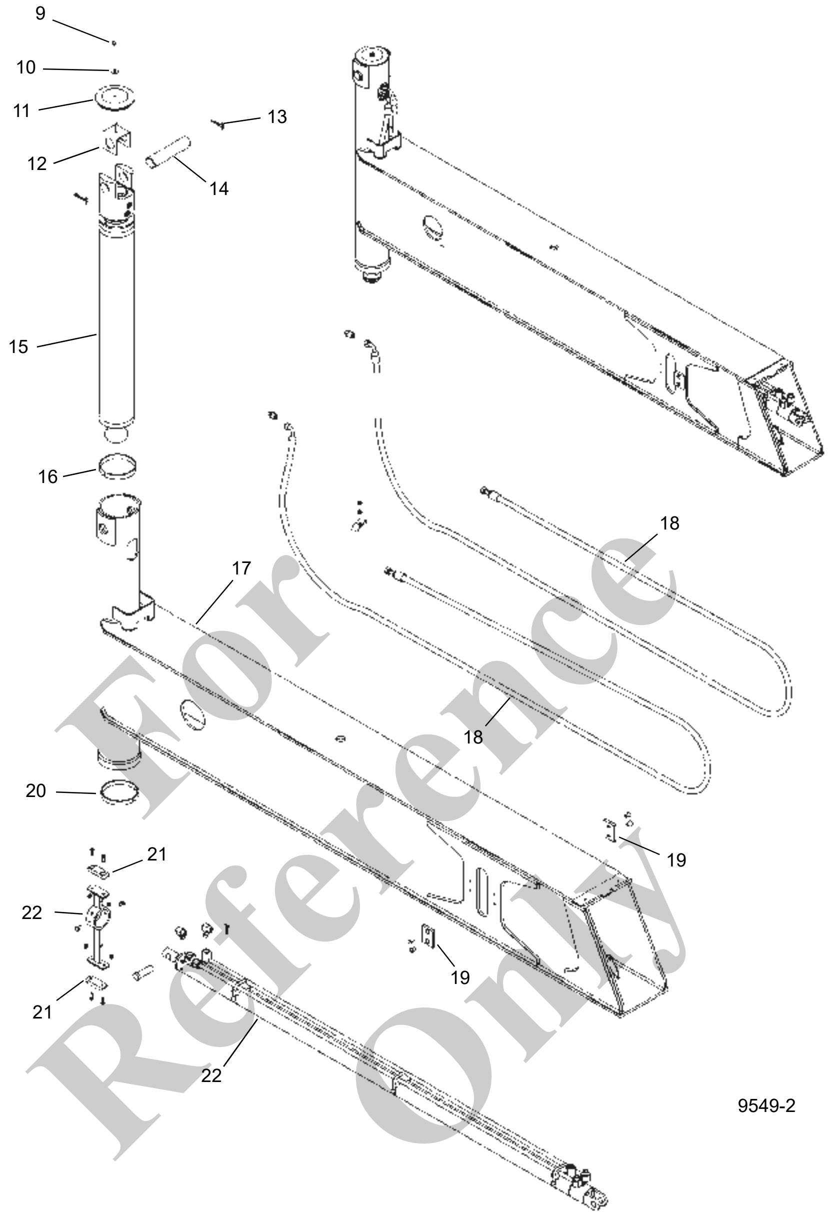
Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide. Failure to do so could result in death or injury to personnel.

3. Place blocking material under the outrigger beam.



Item	Description
1	Outrigger Beam
2	Wear Pad Assembly
3	Set Screw
4	Plate
5	Wear Pad
6	Bolt
7	Cotter Pin
8	Clevis Pin

FIGURE 8-24



Item	Description
9	Acorn Nut
10	Nylon Washer
11	Tube Cap
12	Cap Bracket
13	Cotter Pin
14	Pin
15	Jack Cylinder
16	Outrigger Beam Weldment
17	Hose Assembly
18	Wear Pad
19	Bearing
20	Wear Pad
21	Foot Weldment
22	Extend Cylinder

FIGURE 8-24 continued

NOTE: Outrigger removal and installation similar for both front and rear outriggers.

NOTE: Lifting belts or straps should be used for lifting purposes so as to avoid nicking or scratching the bottom edges of the outrigger beam.

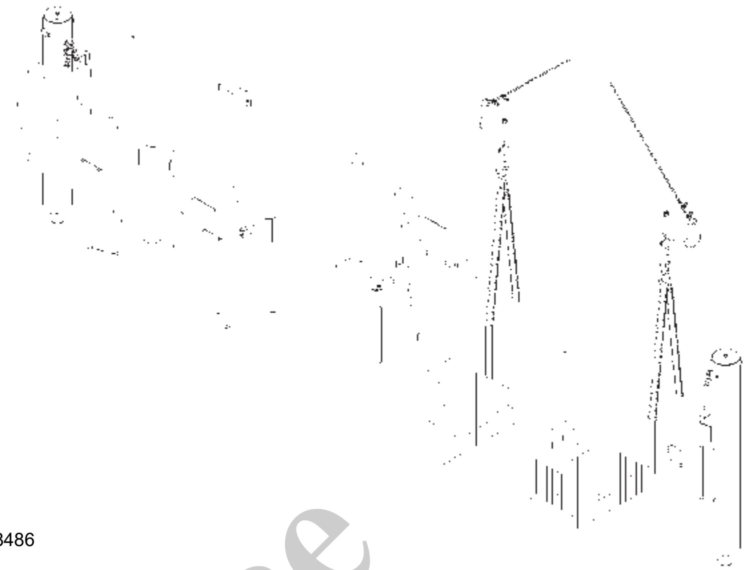


FIGURE 8-25

4. Tag and disconnect the hydraulic lines at the cylinder barrel end of the extension cylinder. Cap all lines and fittings.

NOTE: Do not allow the end of the outrigger extension cylinder to fall when the cylinder mounting shaft is removed. Use blocking to limit the drop or an adequate soft support to cushion any distance the rod will drop.

5. If crane is equipped with the Outrigger Monitoring System (OMS), disconnect the electrical connection from the cylinder.

6. Remove the cotter pin and clevis pin securing the cylinder barrel end of the extension cylinder to the outrigger housing. Carefully extend the outrigger beam until the extension cylinder is free of the housing and carefully lay the end of the cylinder on the bottom of the outrigger beam or leave on blocking.

7. After attaching a suitable lifting device of straps or belts (Figure 8-25) instead of chains to prevent nicking the bottom edges of the outrigger beam, pull the outrigger beam out of the outrigger box, re-adjusting the lifting attachment to prevent the extension cylinder from sliding out of the outrigger beam when the beam clears the outrigger box.

DANGER

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide. Failure to do so could result in death or injury to personnel.

NOTE: The outrigger beam assembly weighs approximately 530 kg (1170 lb).

8. Position the outrigger beam on the blocking material.

Inspection

Inspect the outrigger beams for bends, evidence of cracks, or other damage. Check the outrigger beam internally for hydraulic fluid, which may indicate a leaking cylinder, loose connection, or damaged hydraulic line.

Installation

NOTE: The outrigger beam assembly weighs approximately 530 kg (1170 lb).

NOTE: Apply anti-seize compound on clevis pins and setscrews during installation.

NOTE: At installation, be sure that the outrigger jack cylinder hydraulic hoses are not trapped against the outrigger box when the beam is fully retracted.

NOTE: If installing a new outrigger beam, ensure there is no less than 2 mm (0.08 in) gap at the tightest point between the side of the outrigger beam and the inside of the outrigger box.

1. Apply grease (EPMPG) to the bottom of the outrigger beam.
2. Install the bottom wear pads with approximately 5 mm (0.2 in) protruding. This will prevent the bottom side of the beam from riding on the bottom plate of the outrigger box.
3. Attach a suitable lifting device of straps or belts instead of chains to prevent nicking the bottom edges of the outrigger beam.
4. Slide the beam into the outrigger housing and align the cylinder bushing with the mounting hole.
5. Apply anti-seize compound to the clevis pin. Secure the cylinder barrel to the housing with the clevis pin and cotter pin.

CAUTION

Be sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.

CAUTION

During initial start-up and checking of the outrigger operation, each control switch must be operated before operating the selector valve. If hydraulic lines are reversed to one or more cylinders, this will prevent damage to the cylinders.

6. If crane is equipped with the Outrigger Monitoring System (OMS), connect the electrical connection to the cylinder.
7. Connect the hydraulic lines as tagged prior to removal.

NOTE: If extension cylinder was replaced, the cylinder must be recalibrated in the Crane Control System (CCS).

8. Install the end cover.
9. Actuate the outrigger functions and ensure they work correctly and that there are no leaks. Verify that the OMS functions properly.

Extension Cylinder

Description

Two outrigger extension cylinders are utilized within each outrigger box assembly. The extension cylinders provide the force for the outrigger beam’s horizontal movement. The cylinder weighs approximately 40 kg (88 lb).

Maintenance

Removal

1. Remove the outrigger beam. Refer to OUTRIGGER BEAM - REMOVAL in this section.
2. Remove the cotter pin and clevis pin securing the rod end of the extension cylinder to the outrigger beam.
3. Pull the extension cylinder from the outrigger beam until the hydraulic hoses on the rod end of the cylinder can be accessed. Tag and disconnect the hoses from the rod end of the cylinder. Cap or plug all openings.
4. Remove the cylinder.

Installation

1. Place the cylinder in the beam.

NOTE: Keep hydraulic fittings and hoses close to angles shown Figure 8-26 and as low as possible to prevent rubbing with the beam top plate and side plate, and for proper tracking during beam extension and retraction.

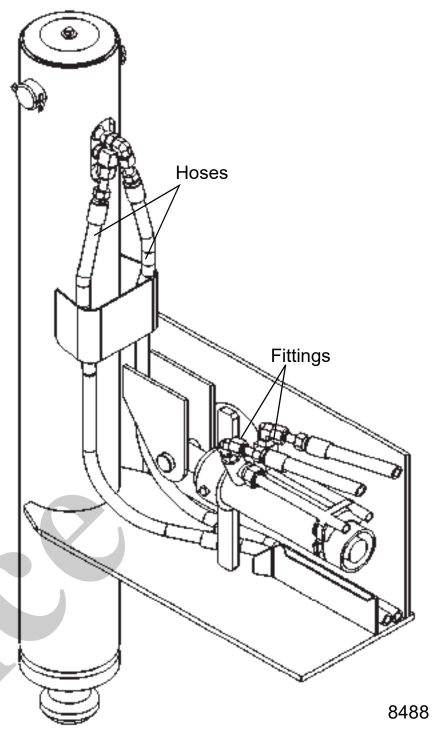


FIGURE 8-26

2. Position the extension cylinder so the hydraulic ports on the rod end of the cylinder can be accessed. Connect the hydraulic hoses to the ports as tagged during removal.
3. Push the cylinder into the outrigger beam. Align the cylinder rod with the clevis in the beam. Apply anti-seize to the clevis pin and secure in place with the clevis pin and cotter pin.
4. Install the outrigger beam. Refer to OUTRIGGER BEAM - INSTALLATION in this section.
5. If a new extension cylinder with OMS (Outrigger Monitoring System) was installed, the cylinder must be identified within the crane control system using the Grove Service Tool. The OMS will not function properly if the new cylinder is not identified to the cane control system.

NOTE: To identify the new extension cylinder within the crane control system, a CAN-link service software (80112606), and a connection cable (80078354) are required. The CAN-Link service software and connection cable are available through Manitowoc Crane Care to those service technicians who have attended the Grove New Technology training course.

Functional Check

1. Activate the hydraulic system; extend and retract the outrigger.
2. Observe the operation of the outrigger beam.
3. Check the hydraulic connections for any evidence of leakage.
4. If equipped, ensure Outrigger Monitoring System (OMS) functions properly.

Jack Cylinder

Description

Four jack cylinders are used on the crane, one at the end of each outrigger beam. The jack cylinders provide the force for the outrigger beam's vertical movement. The cylinder weighs approximately 86 kg (190 lb).

Maintenance

Removal

1. Extend the outrigger beam slightly for improved access to the jack cylinder; shut down the engine.
2. Tag and disconnect the hydraulic hoses from the jack cylinder. Remove the fittings from the ports. Cap or plug all openings.
3. Remove the nut and washer and remove the cylinder cap.
4. Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.
5. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap retaining bracket.
6. Raise the jack cylinder just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure the pin in place with the cotter pins.

CAUTION

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

7. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube on the beam assembly.

Installation

1. Apply grease (EPMPG) to the ID of the jack cylinder support tube.
2. If removed, install wear ring in groove in bottom of support tube and in groove at top on jack cylinder.
3. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under REMOVAL, lower the jack cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
4. Remove the retaining pin and cotter pins from the cylinder.
5. Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam.
6. Apply anti-seize compound to the retaining pin. Secure the cylinder and cylinder cap retaining bracket to the support tube with the retaining pin and cotter pins.
7. Install the cylinder cap.
8. Install the fittings in the cylinder ports and connect the hoses as tagged during removal.

Functional Check

1. Activate the hydraulic system.
2. Extend and retract the jack cylinder.
3. Check for smooth operation of the cylinder.
4. Check all hydraulic connections and hoses for evidence of leakage.

Outrigger Jack Cylinder Internal Leak Test

Use the following procedure to troubleshoot and diagnose an internal leak, a leaking pilot operated check valve or a thermal contraction on an outrigger jack cylinder.

DANGER

Perform the following procedures with the crane positioned on a firm level surface with outriggers fully extended and set, and the crane in the travel position

Remove hoses from one cylinder at a time.

Checking Cylinder For Internal Piston Seal Leak

1. Fully extend and set the outriggers.

CAUTION

When performing step number 2, remove hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

2. Remove the rod side cylinder hose from the suspected leaking jack cylinder Figure 8-27. Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the rod side port.

   Check for the following conditions:

   a. If oil stops flowing, the cylinder's internal piston seal is sealing properly.

   b. If oil continues to flow out the rod port, the cylinder's internal piston seal is leaking.

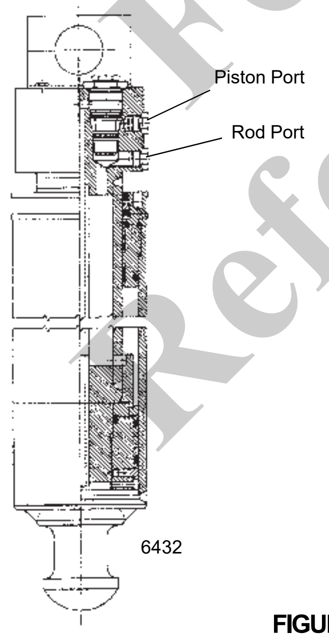


FIGURE 8-27

3. After determining the condition of the cylinders internal piston seal, let the rod side hose disconnected and continue to test the pilot operated check valve.

Testing Pilot Operated Check Valve For Leakage

1. Fully extend and set the outriggers.

CAUTION

When performing step number 2, remove hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

2. Remove the piston side cylinder hose from the suspected leaking jack cylinder, see Figure 8-27. Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the piston side port.

   a. If oil stops flowing, the cylinder's pilot operated check valve is sealing properly.

   b. If oil continues to flow out the piston port, the cylinder's pilot operated check valve is leaking.

If oil flow is not noticed from either port, the cylinder and pilot operated check valve are functioning properly, and any cylinder contraction during normal operation can be attributed to thermal contraction of the oil.

Outrigger Control Valves

Refer to SECTION 2 - HYDRAULIC SYSTEM for information regarding the Outrigger Control Valves.

SECTION 9
MAINTENANCE AND LUBRICATION

SECTION CONTENTS

GENERAL

Following designated lubrication procedures are important in ensuring maximum crane lifetime and utilization. Procedures and lubrication charts in this section include information on types of lubricants used, location of the lubrication points, frequency of lubrication, and other information.

ENVIRONMENTAL PROTECTION

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

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

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

When filling and draining crane components:

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

LUBRICANTS AND LUBRICATION INTERVALS

The service intervals specified are for normal operation where moderate temperature, humidity, and atmospheric conditions prevail. In areas of extreme conditions, the service periods and lubrication specifications should be altered to meet existing conditions.

For information on extreme condition lubrication, contact your local Grove Cranes distributor or Manitowoc Crane Care.

NOTE: All fluids and lubricants may be purchased by contacting an authorized Grove distributor or Manitowoc Crane Care Parts Department.

CAUTION

Possible Equipment Damage!

Chassis grease lubricants must not be applied with air pressure devices as this lubricant is used on sealed fittings.

The multipurpose grease applied during manufacturing is of a lithium base. Use of a non-compatible grease could result in damage to equipment.

Standard Lubricants

Standard lubricants are used on all Grove cranes unless the crane is ordered with a cold weather package. These standard lubricants are effective in temperatures down to -9°C (15°F). Refer to Table 9-1 for a list of the recommended standard lubricants.

Table 9-1: Standard Lubricants [Down to -9°C (15°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant Type	Grade	Classification
Axle Gear Oil	6829014058	Century Unigear Semi-synthetic Texaco Multigear SS Chevron DELO Gear Lubricant	80W-90	
Engine Oil - Tier 3	6829003483	Exxon XD-3 Conoco Fleet Supreme	15W-40	CI-4
Engine Oil - Tier 4	6829104182	Conoco Fleet Supreme EC Mobil Delvac 1300 Super	15W-40	CJ-4
Hydraulic/Transmission Oil	6829006444	Phillip 66 PowerTran XP Exxon Mobil 424	ISO 46/68	Must meet John Deere Std. JDM J20c
Hoist Gear Oil Swing Drive Oil	6829100213	Mobil: Mobilegear 600XP 150 Texaco: Meropa 150 Phillips 66 Extra Duty Gear Oil, 150		AGMA No. 4 EP
Grease, Multipurpose	6829003477	Citgo Lithoplex MP# 2 Texaco Starplex Moly # 2 Phillips 66 Philube M Mobil Mobilgrese XHP 222 Special Chemtool Inc, Lube-A-Boom	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Compleat EG	Mix 50/50	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		

Table 9-1: Standard Lubricants [Down to -9°C (15°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		
Extreme Pressure 3% Moly Grease	6829015304	Citgo Lithoplex CM2 Mobil Mobilgrease CM-P Ipiranga IPIFLEX LI-COMP MOLY 2	NLGI 2	

Arctic Lubricants and Conditions

Temperatures Below -9°C (15°F)

Regions with ambient temperatures below -9°C (15°F) are considered arctic. In general, petroleum based fluids developed especially for low temperature service may be used with satisfactory results in these temperatures. However, certain fluids, such as halogenated hydrocarbons, nitro hydrocarbons, and phosphate ester hydraulic fluids, may not be compatible with hydraulic system seals and wear bands. Therefore, always check with an authorized Grove distributor or Manitowoc Crane Care if in doubt of the suitability of a specific fluid or lubricant.

NOTE: Additional information regarding cold weather operation is available through your Cummins dealer/service center under Service Bulletin 3379009.

When operating in cold weather and regardless of the oil viscosity of the crane's lubricants, always follow the cold weather start-up and operating procedures described in *Section 4 - Operating Procedures* of the *Operator Manual* to ensure adequate lubrication during system warm-up and proper operation of all crane functions.

Cold Weather Package and Lubricants

Grove recommends the following cold weather lubricants for use with ambient temperatures down to -29°C (-20°F) (Table 9-2) and -40°C (-40°F) (Table 9-3). These cold weather lubricants alone are not sufficient to operate the crane in extreme low temperatures. Therefore, it is also recommended that the crane be equipped with the cold weather accessories given under the section titled *Cold Weather Operation* in the *Operator Manual*.

Table 9-2: Cold Weather Lubricants [Down to -29°C (-20°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Axle Gear Oil	6829014058	Petro-Canada Traxon E Synthetic CITGO, Syntetic Gear Lube Eaton, Roadranger EP Mobil, Mobilube SCH Shell, Spirax S Sunoco Duragear EP	75W-90	
Engine Oil - Tier 3	6829101560	Mobil Delvac 1	5W-40	CI-4
Engine Oil - Tier 4	80056036	Shell Rotella® T6 Mobil Delvac 1 ESP Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4
Hydraulic/Transmission Oil	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20c & J20d
Hoist Gear Oil Swing Drive Oil	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629 Phillips 66 Syncon EP Plus	ISO 150	AGMA No. 4 EP
Grease, Multipurpose	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Compleat EG	Mix 50/50	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Hydraulic Oil	6829006993	Exxon Mobil Univis HVI	26	
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		
Windshield Washer fluid	90037773	Splash De-icer		

Table 9-2: Cold Weather Lubricants [Down to -29°C (-20°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant Type	Grade	Classification
Diesel Fuel	80069407	NOCO Kerosene, 3, UN1223, III Product #1	#1	NLOCK08
Extreme Pressure 3% Moly Grease	6829104275	Mobil Mobilith SHC 220 Petro-Canada Precision Synthetic EP1	NLGI 2	

Table 9-3: Cold Weather Lubricants [Down to -40°C (-40°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant Type	Grade	Classification
Axle Gear Oil Hoist Gear Oil	6829014058	Petro-Canada Traxon E Synthetic CITGO, Syntetic Gear Lube Eaton, Roadranger EP Mobil, Mobilube SCH Shell, Spirax S Sunoco Duragear EP	75W-90	
Tier 3/Tier 4 Engine Oil	80056036	Shell Rotella® T6 Mobil Delvac 1 ESP Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4
Transmission Oil	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20c & J20d
Swing Drive Oil	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP
Grease, Multipurpose	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829104212	Old World Industries, Inc. Fleet Charge SCA Pre-charged Fleetguard Compleat EG Petro-Canada	Mix 60/40	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Hydraulic Oil	6829006993	Exxon Mobil Univis HVI	26	

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Table 9-3: Cold Weather Lubricants [Down to -40°C (-40°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		
Windshield Washer fluid	90037773	Splash De-icer		
Diesel Fuel	80069407	NOCO Kerosene, 3, UN1223, III	#1	NLOCK08
Extreme Pressure 3% Moly Grease	6829104275	Mobil Mobilith SHC 220 Petro-Canada Precision Synthetic EP1	NLGI 2	

CYLINDER ROD SURFACE PROTECTION

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

It is recommended that all exposed cylinder rods be protected using Boeshield® T-9 Premium Metal Protectant. Manitowoc Crane Care has Boeshield® T-9 Premium Metal Protectant available in 12 oz. aerosol cans by ordering part number 9999101803 through the Parts Department.

Cylinder operation and inclement weather will remove the Boeshield® protectant; therefore, inspect machines once a week and reapply Boeshield® to unprotected rods.

WIRE ROPE LUBRICATION

Wire rope is lubricated during manufacturing so that the strands, and individual wires in strands, may move as the rope moves and bends. A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added periodically throughout the life of a rope to replace factory lubricant which is used or lost. For more detailed information concerning the lubrication and inspection of wire rope, refer to *Wire Rope* in *Section 1 - Introduction* of the *Service Manual*.

LUBRICATION POINTS

A regular frequency of lubrication must be established for all lubrication points. Normally, this is based on component operating time. The most efficient method of keeping track of lube requirements is to maintain a job log indicating crane usage. The log must use the engine hourmeter to ensure coverage of lube points that will receive attention based on their readings. Other lubrication requirements must be made on a time basis, i.e. weekly, monthly, etc.

Check all oil levels with crane parked on a level surface in transport position, while oil is cold, unless otherwise specified.

On plug type check points, oil levels are to be at the bottom edge of the check port.

On all hoists with a check plug in the drum, the fill plug shall be directly on top of the hoist, and check plug level.

All grease fittings are SAE STANDARD unless otherwise indicated. Grease non-sealed fittings until grease is seen extruding from the fitting. One ounce (28 grams) of EP-MPG equals one pump on a standard 1 lb (0.45 kg) grease gun.

Overlubrication on non-sealed fittings will not harm fittings or components, but underlubrication will definitely lead to a shorter lifetime.

Unless otherwise indicated, items not equipped with grease fittings, such as linkages, pins, levers, etc., should be lubricated with oil once a week. Motor oil, applied sparingly, will provide the necessary lubrication and help prevent the formation of rust. An Anti-Seize compound may be used if rust has not formed, otherwise the component must be cleaned first.

Grease fittings that are worn and will not hold the grease gun, or those that have a stuck check ball, must be replaced.

Where wear pads are used, cycle the components and relubricate to ensure complete lubrication of the entire wear area.

CraneLUBE

Grove highly recommends use of CraneLUBE lubricants to increase your crane's reliability and performance. Contact your Grove distributor for information about the Grove's CraneLUBE lubrication program.

Cummins Oil Registration List

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

Safety

To lubricate many locations, the engine must be started. After positioning areas of the unit for lubrication, the engine must be turned off and moved areas stable before approaching.

WARNING

Crushing Hazard!

Movement of the superstructure and the boom may create a crushing and/or pinching hazard. Failure to observe this warning could result in death or serious injury if the message is ignored.

Table 9-4: Approved Lubricant Reference Table

Ref.	Approved Lubricant	Lube Specification Down To -9˚C (15˚F)	Lube Specification Down To TO -29˚C (-20˚F)	Lube Specification Down To -40˚C (-40˚F)
A	Extreme Pressure Multipurpose Grease	6829003477	6829104275	6829104275
B	Gear Lube (GL-5)	6829014058	6829014058	6829014058
C	Fully Formulated Anti-Freeze Coolant	6829101130	6829101130	6829104212
D	Liquid Coolant Conditioner	6829012858	6829012858	6829012858
E	Tractor Hydraulic Fluid	6829006444	6829101559	6829101559
F	Engine Oil SAE (Tier 3)	6829003483	6829101560	80056036
	Engine Oil SAE (Tier 4)	6829104182	80056036	80056036
G	Open Gear Lube	6829102971	6829102971	6829102971
H	Extreme Pressure Gear Lube	6829100213	6829103636	6829103636
J	Hydraulic Oil	6829006444	6829006993	6829006993
K	Diesel Exhaust Fluid (DEF)	80019225	80019225	80019225
L	Extreme Pressure Multipurpose Grease	6829015304	6829104275	6829104275

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Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Drive Train						
1	Air Filter - Tier 4	Figure 9-1	---	---	Replace filter element when fault code 5576 or 3341 appears.	
	Air Filter - Tier 3	Figure 9-1	---	---	Replace filter element when air restriction indicator is in the red zone.	
2	Fuel Filter	Figure 9-2	---	---	Change filter every 500 hours or 6 months.	Fuel filter is located on inside right-hand side frame rail behind the engine.
3	Tier 4 Engine Crankcase	Figure 9-1	F	18 L (19 qt)	• Check level every 10 hours or daily. • Drain, fill and replace filter every 500 hours.	• Through fill cap to FULL mark on dipstick. • Refer to Item 6.
	Tier 3 Engine Crankcase	Figure 9-1	F	18 L (19 qt)	• Check level every 10 hours or daily. • Drain, fill and replace filter every: 500 hours (0-500 ppm sulfur fuel); 400 hours (500-5000 ppm sulfur fuel); 250 hours (>5000 ppm sulfur fuel).	• Through fill cap to FULL mark on dipstick. • Refer to Item 6.
4	Engine Cooling System and SCA Levels	Figure 9-1	C, D	43 L 45.4 qt	• Check coolant level every 10 hours or daily. • Check SCA levels every 500 hours. • Check coolant for contamination every 1000 hours.	Fill top tank to bottom of filler neck. Run engine through two (2) thermal cycles. Check level and refill as required.
NOTE: Refer to Service Manual for information regarding SCA levels and contamination limits.						

<table>
<tr><th>Item</th><th>Lube Point Description</th><th>Figure No.</th><th>Approved Lubricant</th><th>Lube Capacity</th><th>Lube Interval</th><th>Application</th></tr>
<tr><td colspan="7">Drive Train (Continued)</td></tr>
<tr><td>5</td><td>Transmission, Torque Converter</td><td>Figure 9-1</td><td>E</td><td>29.3 L
(31 qt)</td><td>• Check level every 10 hours or daily.
• Drain, fill, and replace filter after first 50 and 100 hours of service, then every 1000 hours or 6 months thereafter.</td><td>• Through fill pipe to FULL mark on dipstick.
• Refer to Item 7.</td></tr>
<tr><td colspan="7">NOTE:
• Check transmission fluid level with engine running at 850 rpm idle and converter oil at 65°C to 93°C (150°F to 200°F). Do not attempt an oil level check with cold oil. To bring oil temperature to this range, it is necessary to work the crane or stall the converter. Converter stall should be accomplis hed by engaging shift lever in forward high range with brakes applied and then accelerating engine to half or three-quarter throttle. Hold stall until required converter temperature is reached and stabilized.
NOTICE
Do not operate converter at stall condition for longer than 30 seconds at one time. Shift to neutral for 15 seconds and repeat procedure until desired temperature is reached. Excessive temperature [120°C (250°F) maximum] will damage transmission clutches, fluid, converter and seals.
• Drain oil at 65°C to 93°C (150°F to 200°F).
• Transmission filter is located on the outside left hand frame in the area of the fuel tank.
• To add fluid:
a. Fill to FULL mark on dipstick.
b. Run engine at 850 rpm to prime torque converter and lines.
c. Check oil level with engine running at 850 rpm and converter oil at 65°C to 93°C (150°F to 200°F). Add oil to bring oil level to FULL mark on dipstick.</td></tr>
<tr><td>6</td><td>Engine Oil Filter</td><td>Figure 9-2</td><td>---</td><td>---</td><td>Tier 4 engine, replace oil filter every 500 hours.

Tier 3 engine, replace oil filter every:
• 500 hours (0-500 ppm sulfur fuel)
• 400 hours (500-5000 ppm sulfur fuel)
• 250 hours (>5000 ppm sulfur fuel)</td><td>Refer to Item 3.</td></tr>
</table>

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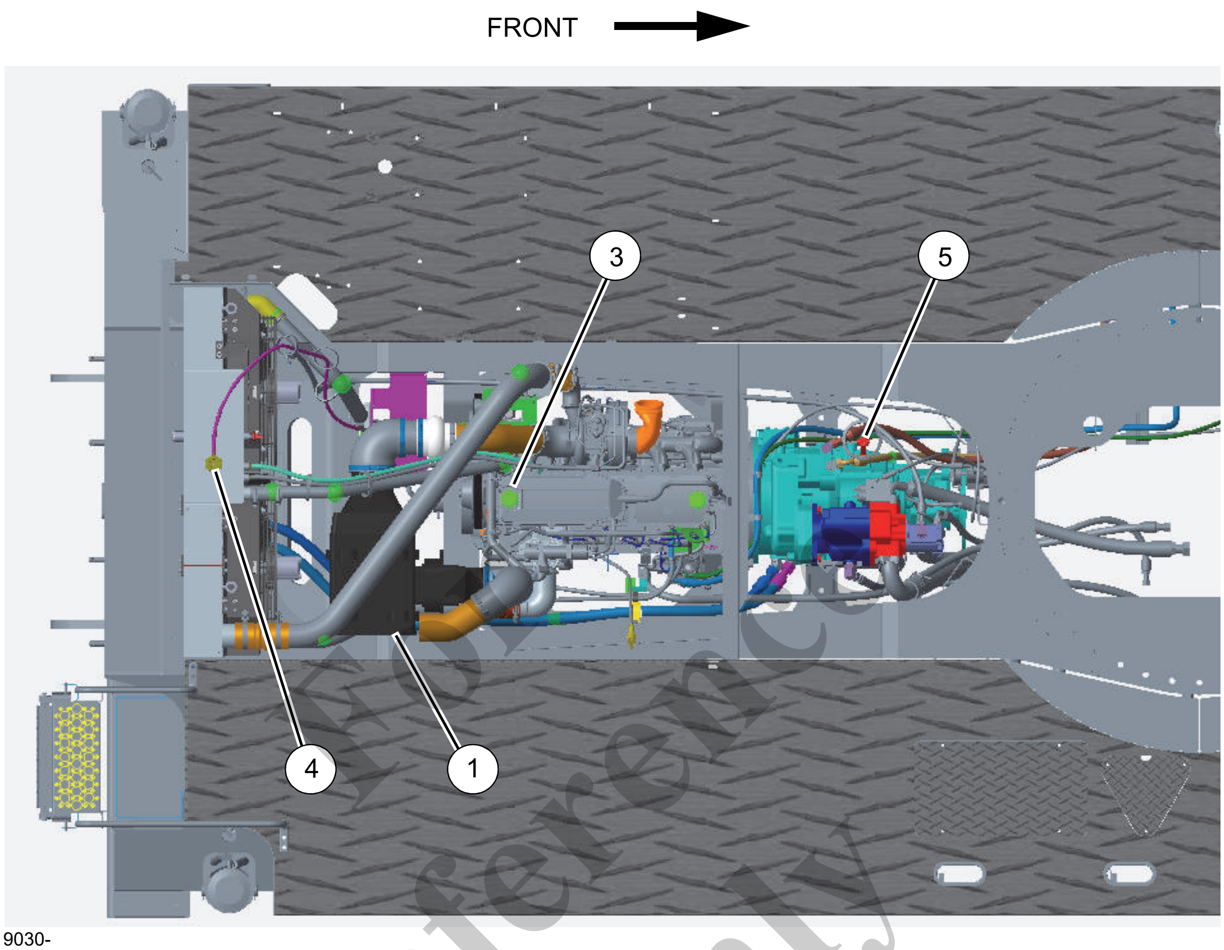
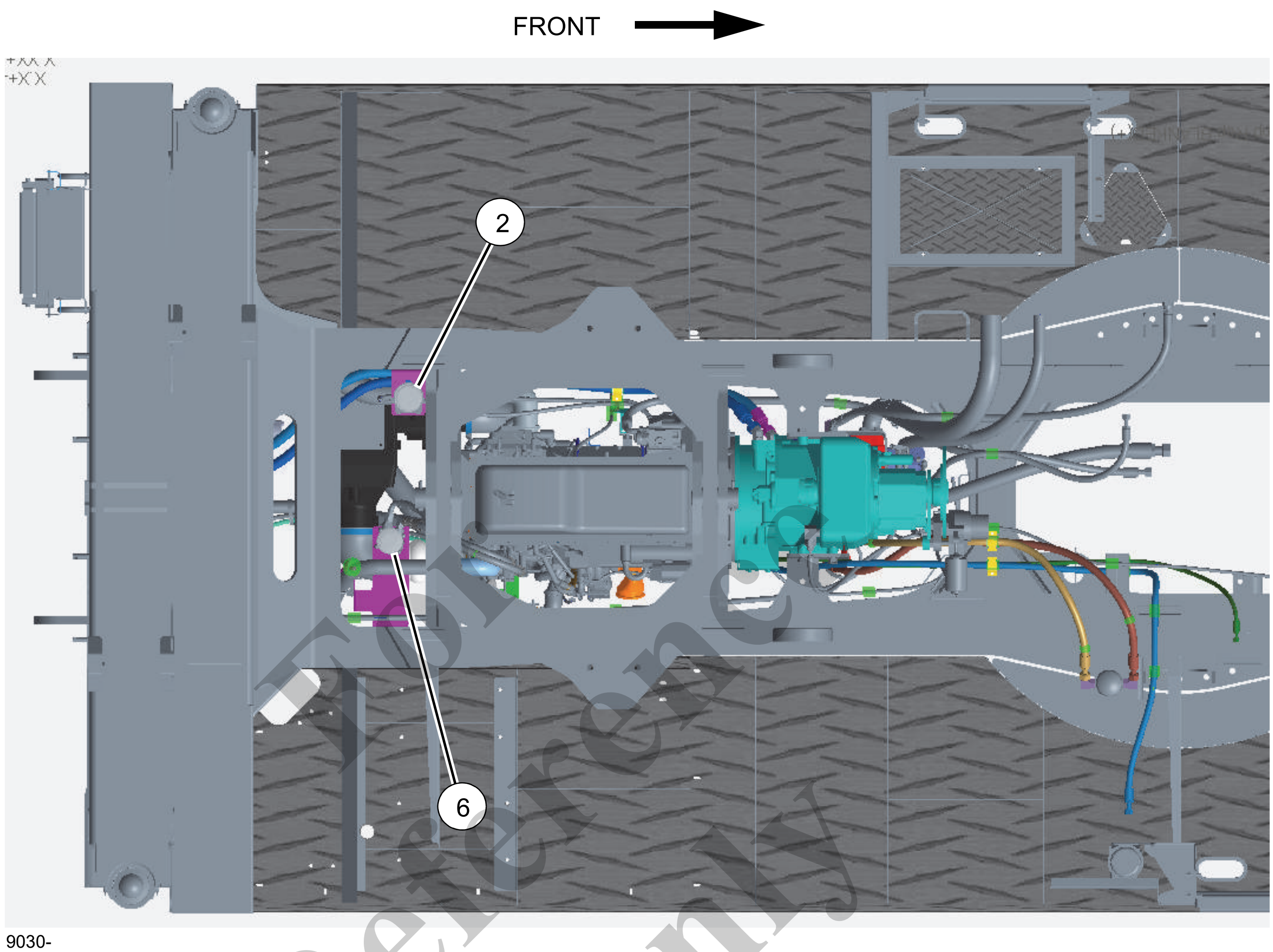


TOP VIEW OF CARRIER

FIGURE 9-1



BOTTOM VIEW OF CARRIER

FIGURE 9-2

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Drive Train (Continued)						
7	Transmission Filter	Figure 9-3	---	---	Change transmission filter after first 50 and 100 hours of service, then every 500 hours thereafter.	• Refer to Item 5. • Filter is located on the outside left hand frame in the area of the fuel tank.
8	Coolant Strainer (Cab Heater)	Figure 9-3	---	---	Clean strainer screen after first 100 hours and every 2000 hours or 12 months intervals thereafter.	Close shutoff valves. Unscrew hex plug to clean filter.
9	Fuel/Water Separator	Figure 9-3	---	---	Drain water trap every 10 hours or daily.	
NOTE: During replacement of the water separator, note direction of the arrow. Arrow must point toward fuel filter						
10	Driveline - Slip Joints	Figure 9-3	A	Until grease extrudes	500 hours or 3 months	2 grease fittings

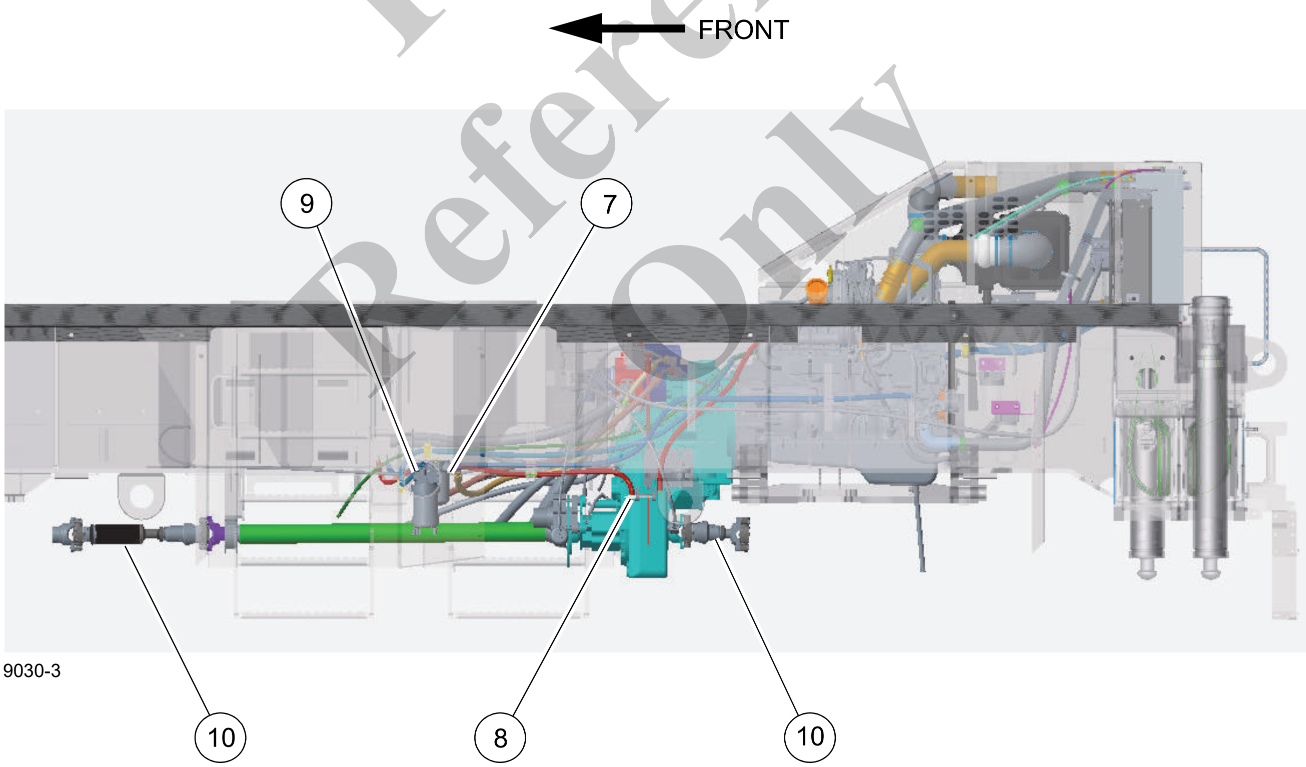


FIGURE 9-3

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Drive Train (Continued)						
11	DEF Supply Module Filter (Tier 4)	Figure 9-4	---	---	Check filter every 4500 hours or 3 years	
12	DEF Tank (Tier 4)	Figure 9-4	K	18.9 L (20 qt)	Check and fill every 10 hours or daily	Indicator in cab comes on when fluid level is low.
13	DEF Tank Filter (Tier 4)	Figure 9-4	---	---	Check every 2000 hours or 1 year	

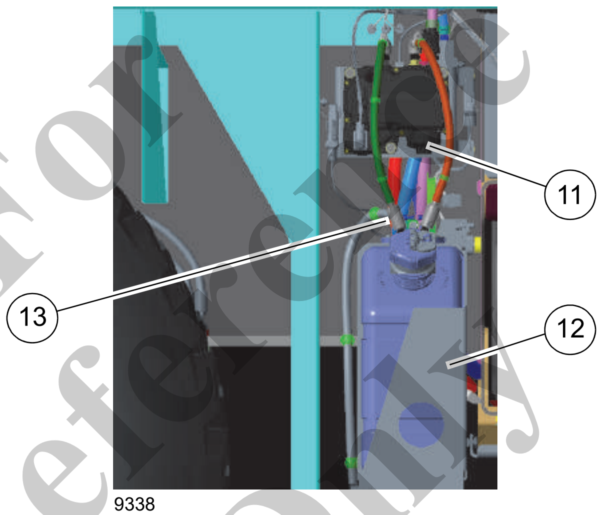


FIGURE 9-4

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Steering and Suspension						
20	Steer Cylinder Pivot Pins	Figure 9-5	A	Until grease extrudes	500 hours or 3 months	8 grease fittings
21	Upper and Lower King Pins	Figure 9-5	A	Until grease extrudes	500 hours or 3 months	8 grease fittings
22	Tie Rod Pivot Pins	Figure 9-5	A	Until grease extrudes	500 hours or 3 months	4 grease fittings
23	Lockout Cylinder Pivot Pins	Figure 9-5	A	Until grease extrudes	500 hours or 3 months	4 grease fittings

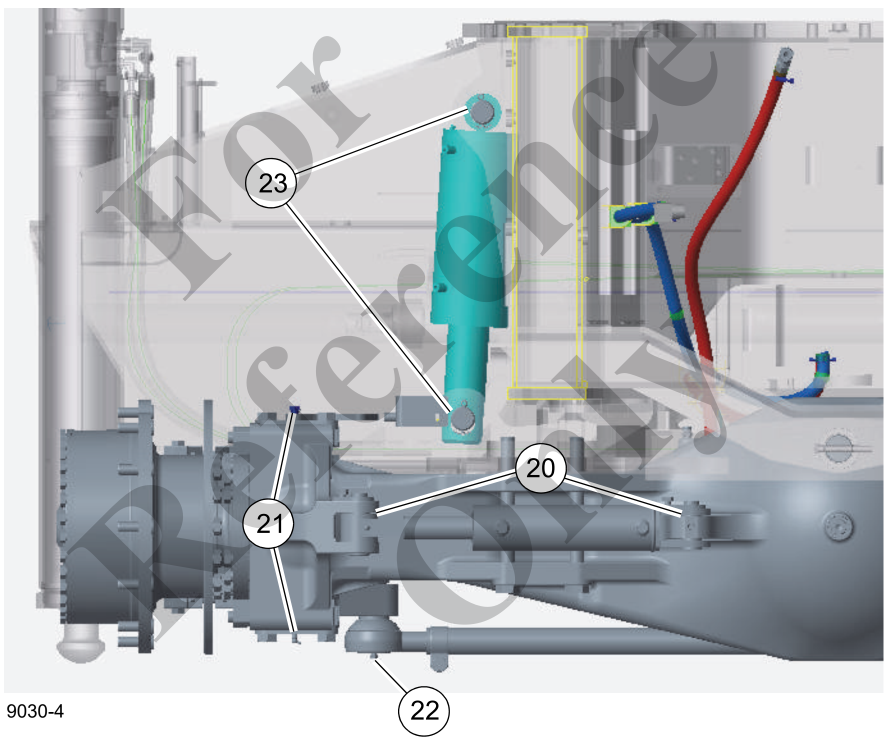


FIGURE 9-5

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Steering and Suspension (Continued)						
24	Fifth Wheel Pivots	Figure 9-6	A	Until grease extrudes	500 hours or 3 months	2 grease fittings

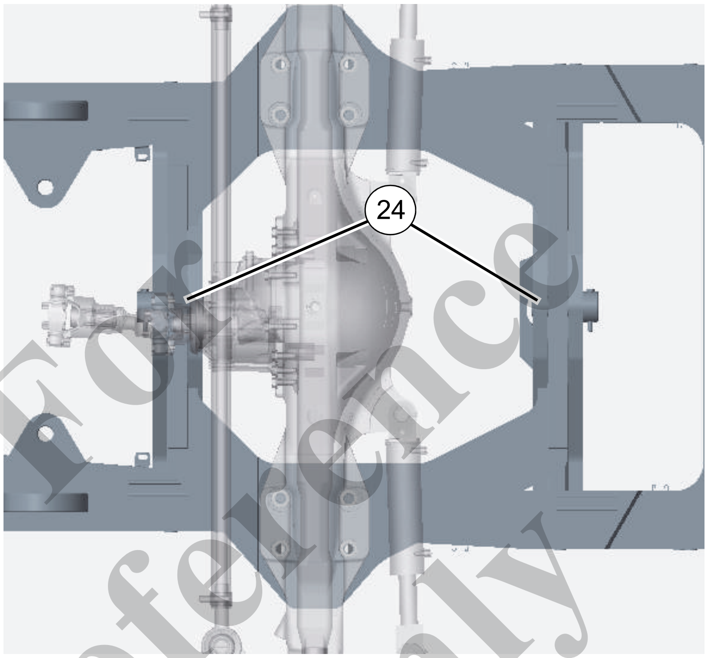


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FIGURE 9-6

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Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Axles						
30	Differentials	Figure 9-7	B	28.4 L (30 qt)	• Check level every 500 hours or 3 months. • Drain and fill every 4000 hours or 2 years.	
NOTE: Lube level close enough to the hole to be seen or touched is not sufficient. It must be level with the hole. When checking lube level, also check and clean housing breathers. **CAUTION:** Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals. **CAUTION:** If the makeup amount is substantially more than 0.23 L (0.5 pt), check for leaks.						
31	Planetary Hubs and Wheel Bearings	Figure 9-7	B	2.5 L (5.3 pt)	• Check level every 500 hours or 3 months. • Drain and fill every 4000 hours or 2 years.	Fill to oil level indicated on axle hub.
CAUTION: Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals.						

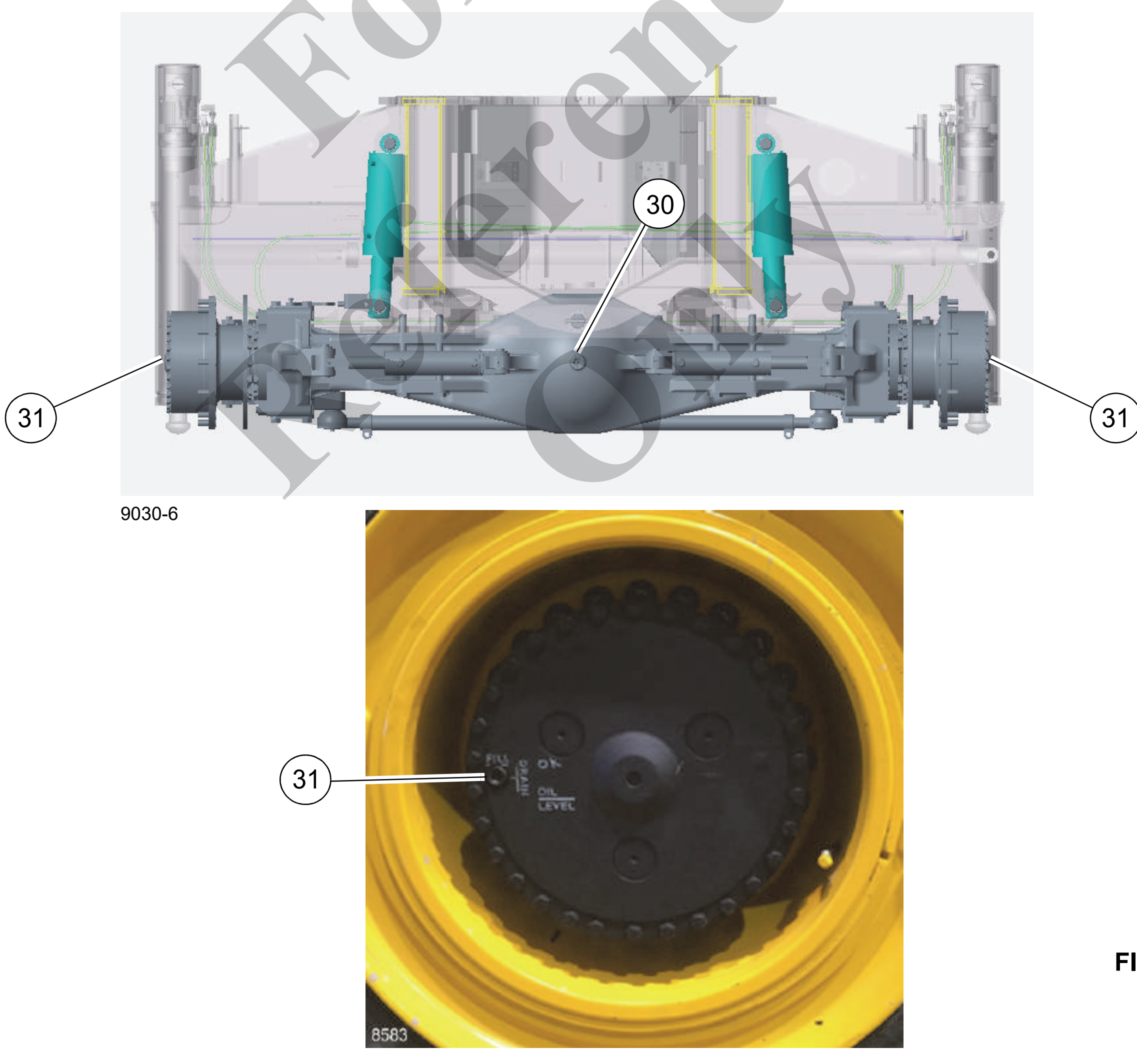

FIGURE 9-7

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Turntable						
40	Turntable Gearbox	Figure 9-8	H	5.0 L (5.3 qt)	• Check and fill every 50 hours • Drain and fill after first 250 hours and every 500 hours or 12 months thereafter.	Fill gearbox to markings on dipstick.
41	Turntable Gear and Drive Pinion	Figure 9-8	G	Coat all teeth	500 hours or 6 months	Spray on
42	Turntable Bearing	Figure 9-8	A	Until grease extrudes from entire bearing circumference	500 hours or 6 months	2 grease fittings at front of turntable.
NOTE: Rotate turntable 90° and apply grease to fittings. Continue rotating in 90° increments and grease fittings until entire bearing is greased.						

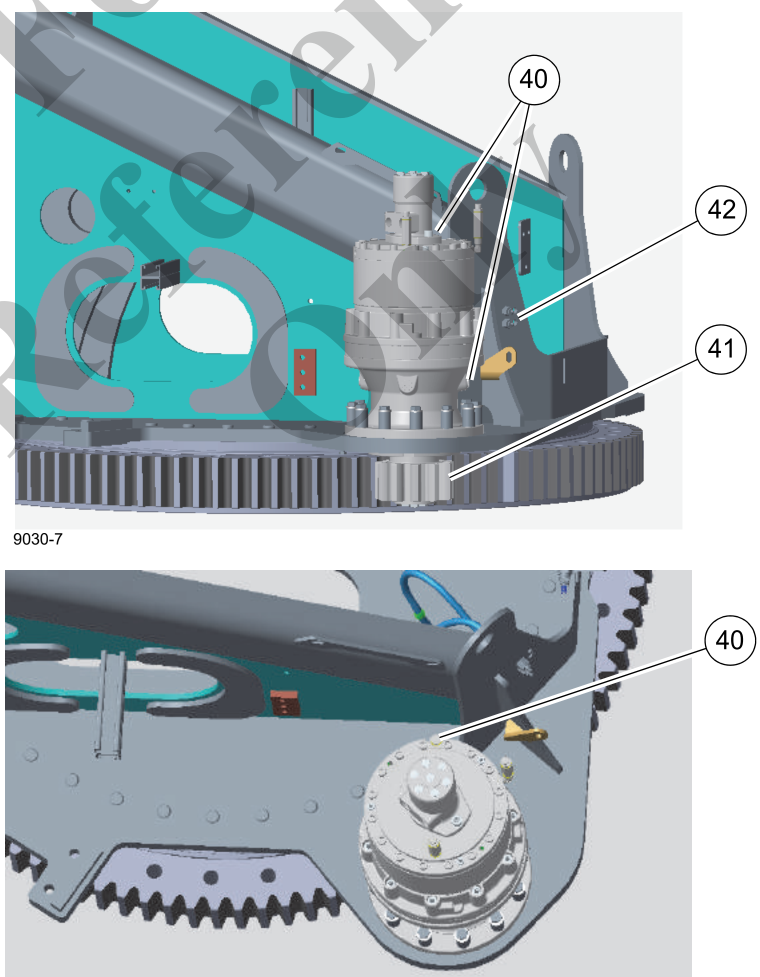

FIGURE 9-8

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Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Turntable (Continued)						
43	Turntable Lock Pin	Figure 9-9	G	Coat pin	500 hours or 6 months	Spray on
Cab Tilt						
50	Tilt Cylinder Pivot Pins	Figure 9-9	A	Until grease extrudes from entire bearing circumference	500 hours or 3 months	2 grease fittings
51	Pillow Block	Figure 9-9	A	Until grease extrudes from entire bearing circumference	500 hours or 3 months	4 grease fittings
HVAC System						
55	HVAC Filter	---	---	---	Replace HVAC filter yearly. If used in dirty conditions, check filter monthly or as needed and replace if necessary.	HVAC filter is located behind access panel on bottom side of cab.

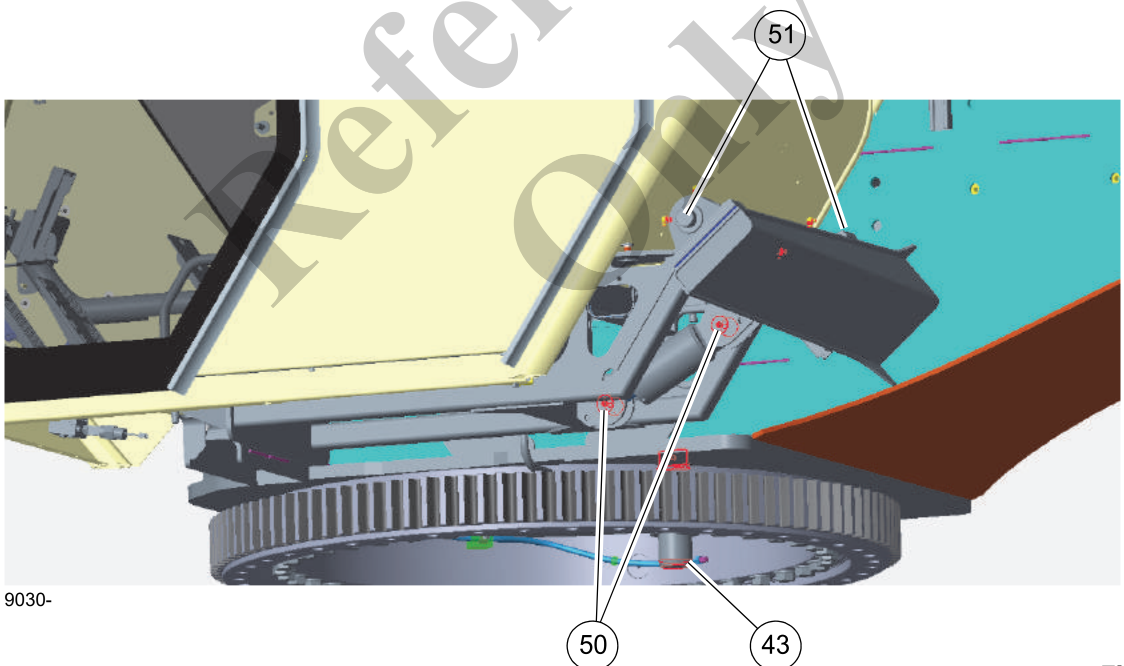

FIGURE 9-9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Outriggers						
60	Wear Pads	Figure 9-10	L	---	50 hours or 1 week	• Brush on • 16 places
61	Outrigger Beams	Figure 9-10	L	---	50 hours or 1 week	Brush on outrigger beam contact points
62	Jack Cylinder Support Tubes	Figure 9-10	L	---	Apply grease at tear-down.	4 places
NOTE: Brush lubricant on inside diameter of jack cylinder support tubes and wear bands before installing jack cylinders.						

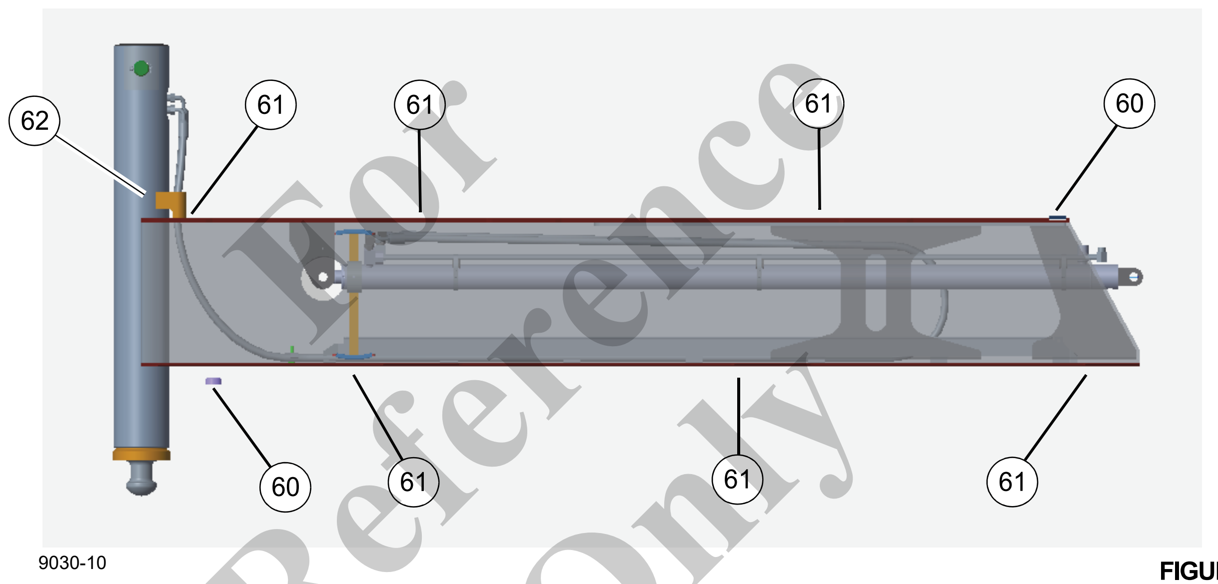

FIGURE 9-10

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Boom						
NOTE: Crane Setup: Machine shall be set up on firm level surface with fully extended outriggers and a 5579 kg (12,300 lb) counterweight installed. Ensure crane is level. • Boom must be directly over the front with house lock engaged. • Fully retract the boom and set boom angle to 0°. Remove the quick reeve pin on the boom nose, remove any reeved wire rope laying it off to the to the right side of the boom and place the rigging down on the ground in front of the crane. The boom should have no load on it. • At 0° boom angle, extend the boom to enable accessibility to the boom grease zerks. Do not exceed a boom length of 32.2 m (105.5 ft) for the GRT655 or a boom length of 29.5 m (96.8 ft) for the GRT655L. If stated boom length is exceeded, the RCL lockout function will activate. • After greasing is completed, fully retract the boom and then reinstall/reeve the rigging and wire rope that was temporarily removed.						
80	Hook Block Swivel Bearing	Figure 9-11	A	Until grease extrudes	250 hours or 3 months	3 grease fittings
82	Overhaul Ball	Figure 9-11	A	Until grease extrudes	250 hours or 3 months	1 grease fitting

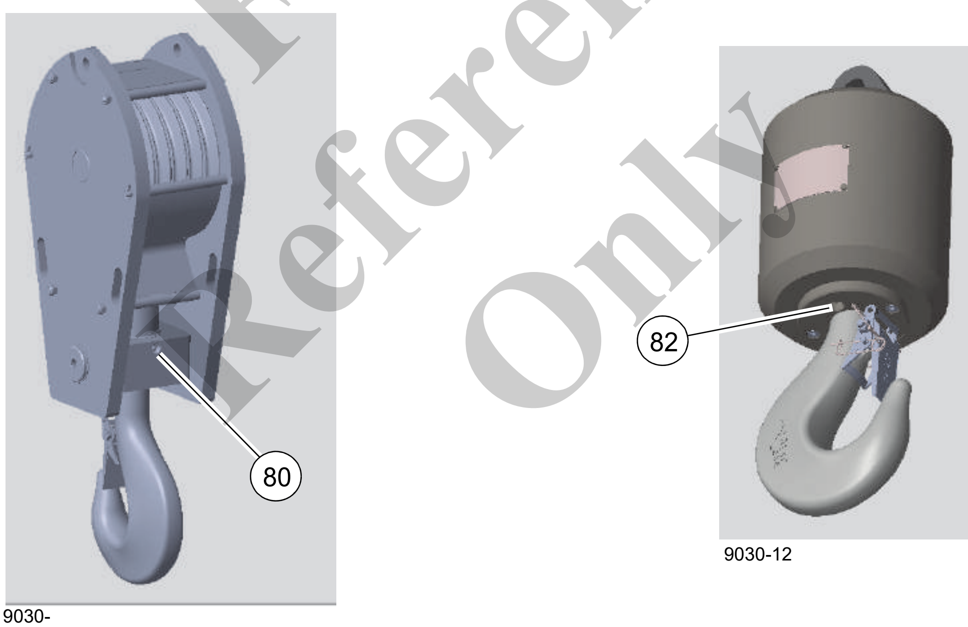

FIGURE 9-11

<table>
<tr><th>Item</th><th>Lube Point Description</th><th>Figure No.</th><th>Approved Lubricant</th><th>Lube Capacity</th><th>Lube Interval</th><th>Application</th></tr>
<tr><td colspan="7">Boom (Continued)</td></tr>
<tr><td colspan="7">NOTE: Crane Setup: Machine shall be set up on firm level surface with fully extended outriggers and a 5579 kg (12,300 lb) counterweight installed. Ensure crane is level.
• Boom must be directly over the front with house lock engaged.
• Fully retract the boom and set boom angle to 0°. Remove the quick reeve pin on the boom nose, remove any reeved wire rope laying it off to the to the right side of the boom and place the rigging down on the ground in front of the crane. The boom should have no load on it.
• At 0° boom angle, fully extend the boom to enable accessibility to the boom grease zerks. During boom extending, function the RCL bypass switch in order to enable the boom to proceed beyond the RCL limit to fully extended.
• After greasing is completed, fully retract the boom and then reinstall/reeve the rigging and wire rope that was temporarily removed.</td></tr>
<tr><td>83</td><td>Telescope Cylinder Wear Pads</td><td>Figure 9-12</td><td>L</td><td>Thoroughly coat</td><td>Apply grease at tear-down.</td><td>• 1 place on 4-section boom
• 2 places on 5-section boom</td></tr>
<tr><td>84</td><td>Internal Side and Bottom Wear Pads - Inner Sections</td><td>Figure 9-12</td><td>L</td><td>Thoroughly coat</td><td>Apply grease at tear-down.</td><td>• Brush on
• 12 places on 4-section boom
• 16 places on 5-section boom</td></tr>
<tr><td>85</td><td>Boom Section Rear Upper Wear Pads</td><td>Figure 9-12</td><td>L</td><td>---</td><td>50 hours or 1 week</td><td>• 12 grease fittings on 4-section boom
• 16 grease fittings on 5-section boom
• See note below</td></tr>
<tr><td>86</td><td>Boom Section Lower and Upper Wear Pads</td><td>Figure 9-12</td><td>L</td><td>Thoroughly coat all areas the wear pads move on</td><td>50 hours or 1 week</td><td>• Brush on bottom, top, and side surfaces that wear pads move on
• 12 places on 4-section boom
• 9 places on 5-section boom</td></tr>
<tr><td colspan="7">NOTE: Lubricate items more frequently than interval in table if environmental conditions and/or operating conditions require.
CAUTION: Do not apply excessive pressure or force when greasing wear pads. This can cause grease fitting to separate from wear pad. Only apply grease until resistance is felt.</td></tr>
</table>

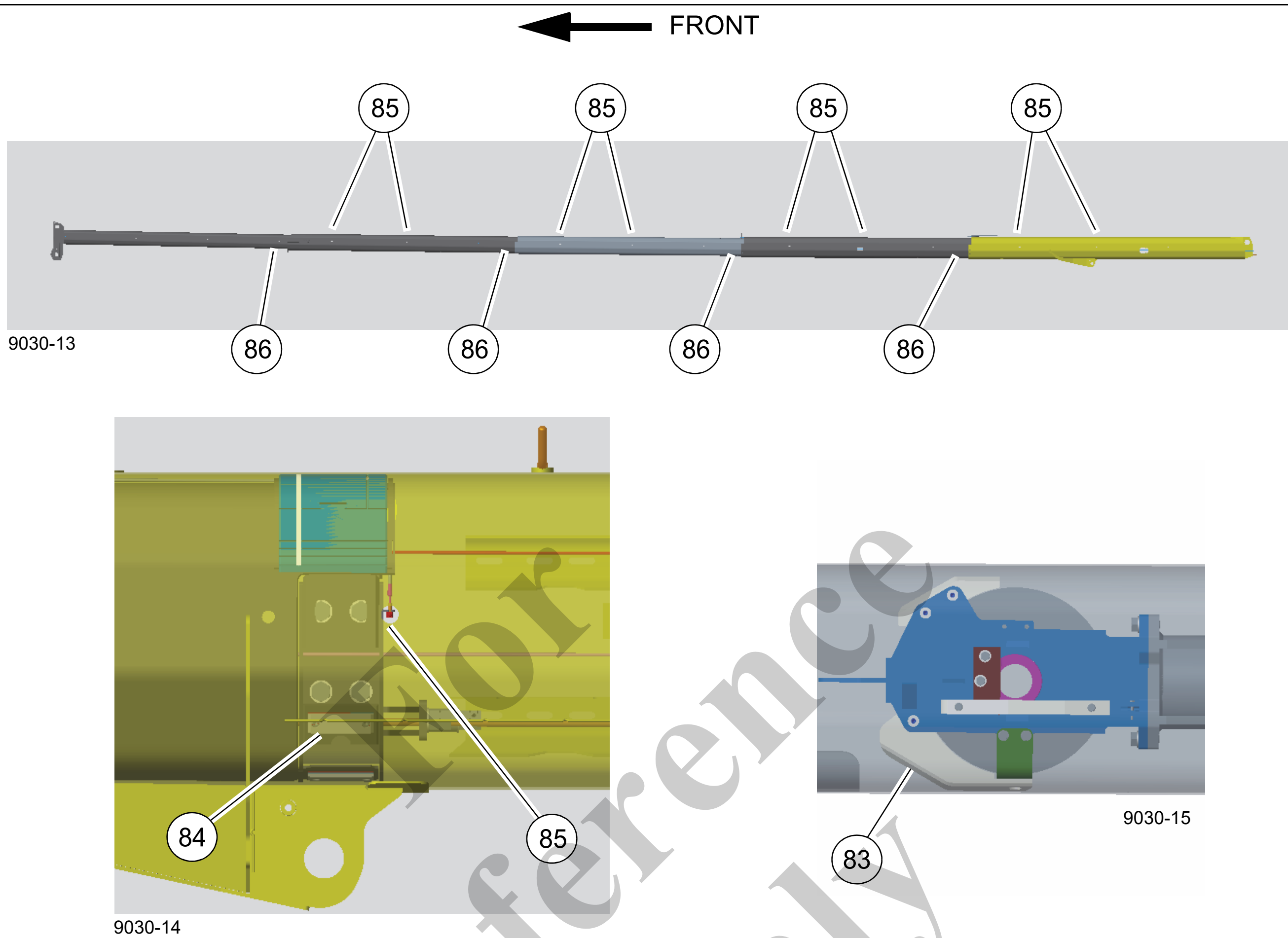

FIGURE 9-12

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Boom (Continued)						
NOTE: Crane Setup: Machine shall be set up on firm level surface with fully extended outriggers and 5579 kg (12,300 lb) counterweight installed. Ensure crane is level. • Boom must be directly over the front with house lock engaged. • Fully retract the boom and set boom angle to 0°. Remove the quick reeve pin on the boom nose, remove any reeved wire rope laying it off to the to the right side of the boom and place the rigging down on the ground in front of the crane. The boom should have no load on it. • At 0° boom angle, fully extend the boom to enable accessibility to the boom grease zerks. During boom extending, function the RCL bypass switch in order to enable the boom to proceed beyond the RCL limit to fully extended. • After greasing is completed, fully retract the boom and then reinstall/reeve the rigging and wire rope that was temporarily removed.						
87	Boom Pivot Shaft	Figure 9-13	L	---	• 250 hours or 3 months • Apply grease at tear down	2 grease fittings
88	Upper Boom Nose Sheave	Figure 9-13	A	Coat shaft and bushings	Apply grease at tear down.	
89	Lower Boom Nose Sheave	Figure 9-13	A	Coat shaft and bushings	Apply grease at tear down.	
90	Auxiliary Boom Nose Sheave	Figure 9-13	A	Until grease extrudes	• 250 hours or 3 months • Apply grease at tear down	1 grease fitting
91	Mast Sheave	Figure 9-13	A	Until grease extrudes	• 500 hours or 12 months • Apply grease at tear down	1 grease fitting
92	Boom Extension Sheaves	Figure 9-13	A	Until grease extrudes	• 250 hours or 3 months • Apply grease at tear down	1 grease fitting
93	Boom Extension Rollers	Figure 9-13	A	Until grease extrudes	• 250 hours or 3 months • Apply grease at tear down	4 grease fittings
NOTE: Lubricate items more frequently than interval in table if environmental conditions and/or operating conditions require.						

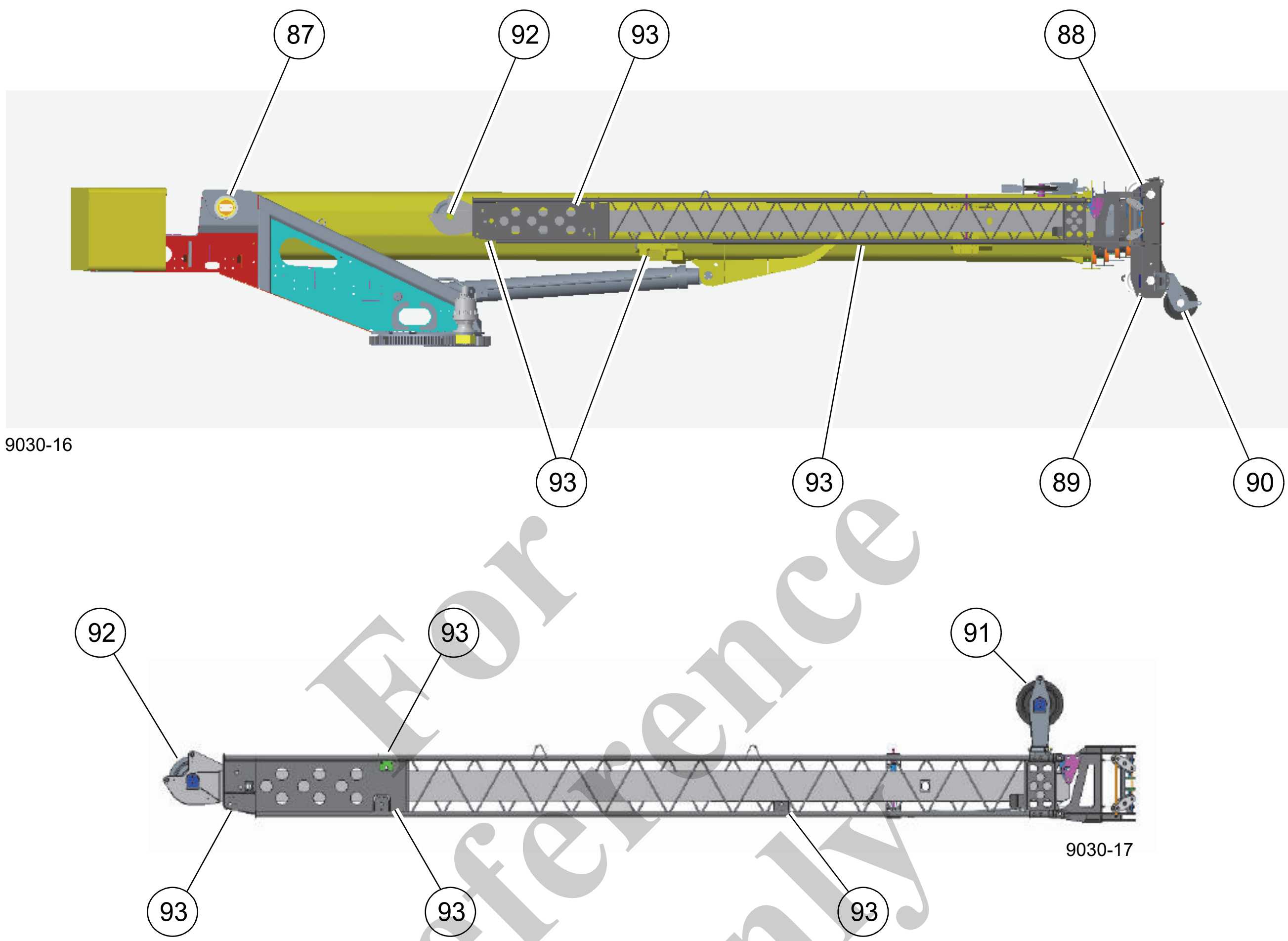

FIGURE 9-13

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Hoist						
100	Main Hoist	Figure 9-14	H	8.5 L (9.0 qt)	• Check and fill every 50 hours or weekly • Drain and fill after first 300 hours, then every 1000 hours or 12 months thereafter • Check and clean breather needed	Oil level must be visible in the sight glass.
101	Auxiliary Hoist	Figure 9-14	H	8.5 L (9.0 qt)	• Check and fill every 50 hours or weekly • Drain and fill after first 300 hours, then every 1000 hours or 12 months thereafter • Check and clean breather as needed	Oil level must be visible in the sight glass.
NOTE: Line up the Fill/Drain Plug with the top cutout hole (A). Verify hoist is level side to side. Place a level along the tie rod and confirm the bubble is centered. Let hoist sit idle for 20 minutes for an accurate reading. Oil should be visible in sight glass. Level of oil is acceptable if it is at least 1.6 mm (1/16 in) down from top or up 1.6 mm (1/16 in) from the bottom of the sight glass. Hoist and oil temperature should be in the 21°C ± 7°C (70°F ± 20°F) range. If oil temperature is outside this range, allow for a higher oil level reading if hotter or a lower oil level reading if colder. Oil escaping from vent plug is an indication the hoist may be overfilled. If hoist is over filled move the Fill/Drain Plug to the lower cutout hole (B) and drain until oil level falls within the sight glass.						
102	Rope Follower (Arm)	Figure 9-14	G	Thoroughly coat	250 hours or 3 months	• Spray on • 4 places per hoist
103	Hoist Lower Limit Switch (Optional)	Figure 9-14	G	Thoroughly coat	250 hours or 3 months	• Spray on • 1 place per hoist
NOTE: Lubricate more frequently than interval indicated if environmental and/or operating conditions required.						

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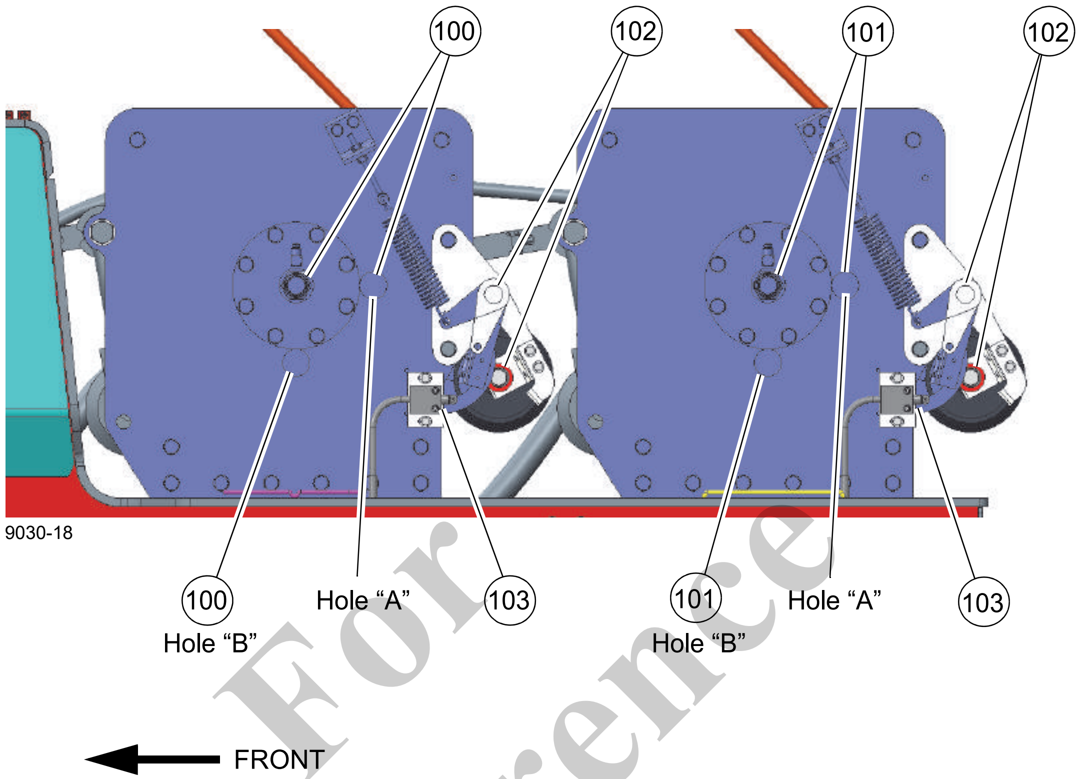
100
102
101
102
9030-18
100
Hole "B"
Hole "A"
103
101
Hole "B"
Hole "A"
103
FRONT

FIGURE 9-14

<table>
<tr><th>Item</th><th>Lube Point Description</th><th>Figure No.</th><th>Approved Lubricant</th><th>Lube Capacity</th><th>Lube Interval</th><th>Application</th></tr>
<tr><td colspan="7">Hydraulic</td></tr>
<tr><td>110</td><td>Hydraulic Tank (Tank Only)</td><td>Figure 9-15</td><td>J</td><td>469.7 L (124.1 gal)</td><td>Check fluid level every 10 hours or daily.</td><td>• Use sight gauge on side of tank, with boom fully lowered and all outrigger cylinders retracted.
• Drain and refill as necessary</td></tr>
<tr><td colspan="7">NOTE:
• Environmental and other conditions can dramatically affect the condition of hydraulic oil and filters. Therefore, specific intervals for servicing/changing hydraulic oil, filters and hydraulic tank breathers cannot be set. However, it is imperative for the continued satisfactory performance of Grove cranes that inspections be performed on the basis of how and where each crane is used. Airborne and ingested contaminants can significantly reduce the life of oil and condition of hydraulic oil filters and tank breathers.
• Under normal operating conditions, it is recommended that hydraulic oil, filters and breathers be inspected and oils sampled at least every 3 to 6 months and more frequently for severe operating conditions. Inspections should be for airborne and/or ingested particles and water that deteriorate and contaminate the oil (e.g., oil appears “milky” or no longer has a transparent clear to amber color). The return filter by-pass indicator should be observed daily to determine if the contaminants content may be high. If indicator reaches red zone or indicates a by-pass condition, hydraulic oil must be sampled. The hydraulic tank breather should also be inspected to ensure it does not restrict air flow in and out of the reservoir.
• To inspect hydraulic oil, fill a small glass container with a sample of reservoir oil and another glass container with fresh oil. Let samples stand undisturbed for one to two hours, then compare the samples. If reservoir oil is heavily contaminated with water, the sample will appear “milky” with only a small layer of transparent oil on top. If the “milky” appearance was due to air foaming, it will dissipate and the oil should closely match the fresh oil. Should you have any questions, please contact your local authorized Grove distributor.
• Hydraulic oil shall meet or exceed ISO 4406 class 17/14 cleanliness level.</td></tr>
<tr><td>111</td><td>Hydraulic Filter</td><td>Figure 9-15</td><td>---</td><td>---</td><td>Change filter element when indicator is red. Replace breather when filter is replaced.</td><td>Oil must be at operating temperature.</td></tr>
</table>

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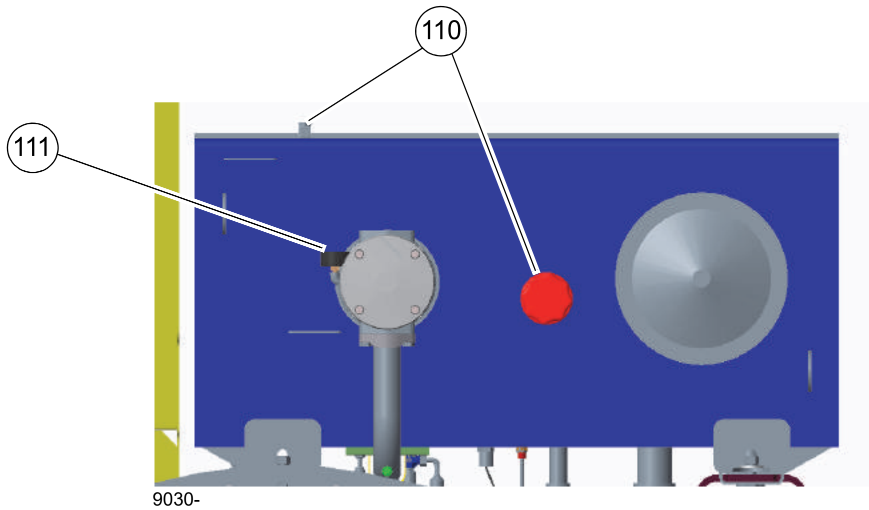

FIGURE 9-15

RUST PROTECTION

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

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, and water-repelling/water-displacing agents.

Special equipment is used to spray a light film on the entire undercarriage and various other areas of each new crane before shipment. When applied, the product has a red tint to allow applicators to view coverage. This red tint turns clear 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 be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it must be removed using standard steam-cleaning techniques.

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

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

The most common causes of corrosion include the following:

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

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

Exercise special care and increase frequency of cleaning if 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 cleaning 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 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 near electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

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

NOTE: Polishing and waxing (using automotive-type wax) is recommended to maintain 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.
- Any area scratched through to bare 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 a qualified body repair technician 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:

1. Sand to remove scratch. Feather outward from the mark to blend repair into the original surface. Apply body putty as necessary to hide the defect; then sand smooth.
2. Cover all bare metal with a primer compatible with the original paint finish and allow to dry thoroughly.
3. Prepare surface before applying finish coat of paint.
4. Apply a finish coat using accepted blending techniques. Use of original paint colors is recommended to ensure 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 effects of corrosion and enable you to do the repair later 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 on the environment in which a crane is used and/or stored, initial factory application of Carwell® T32 (CP-90) should help inhibit corrosion approximately 12 months.

It is recommended 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, product needs to be fogged on the unit.
- Use of pressure pots to apply treatment is recommended.
- Carwell® treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After treatment application is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Contact Manitowoc Crane Care should you have any questions.

Areas of Application

Refer to (Figure 9-16) and (Figure 9-17).

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

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Picture may not be same model as your machine, it is for reference only.

FIGURE 9-16

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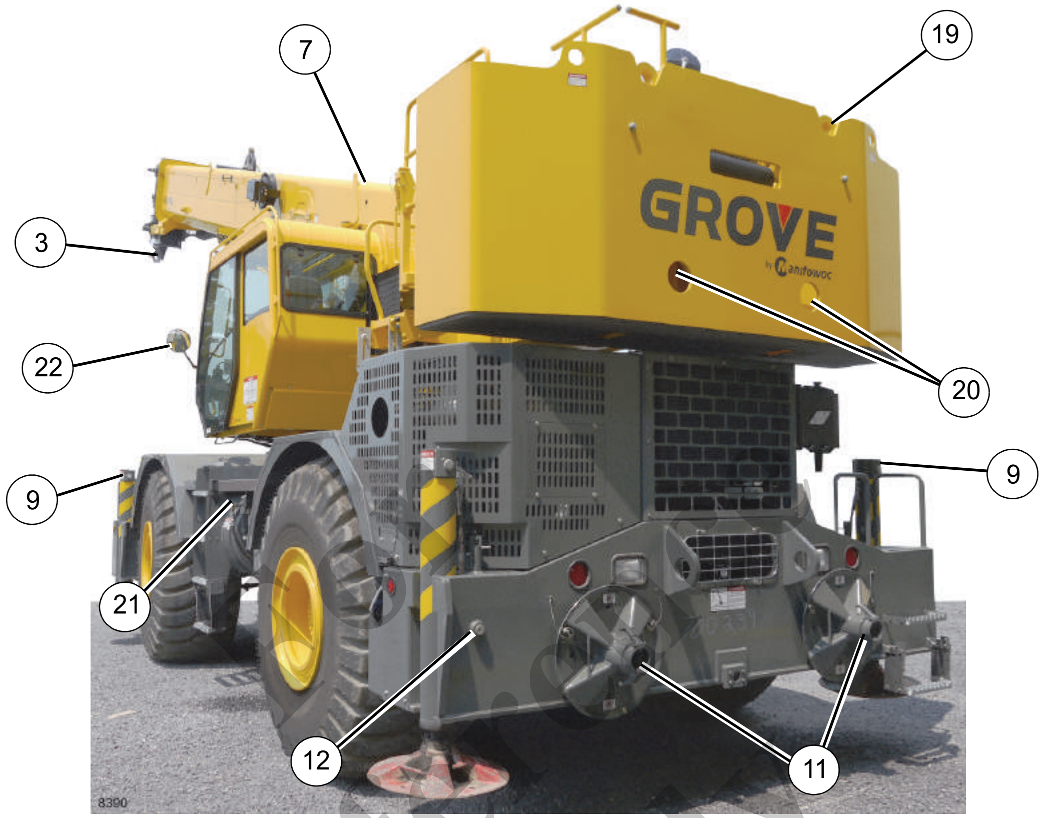

Picture may not be same model as your machine, it is for reference only.

FIGURE 9-17

TABLE 9-1. Rust Inhibitor Application Locations

1	Pivot Shaft	12	O/R Beam Wear Pad Adjustment Hardware
2	Boom Extension Pins, Clips	13	Entire underside of unit
3	Boom Nose Pins, Clips	14	Powertrain Hardware Inside Compartment
4	Hook Block/Overhaul Ball	15	Valve Bank
5	Boom Extension Hanger Hardware	16	Hoist Hose Connections
6	Hose Connections inside turntable	17	Tension Spring
7	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips	18	Wire Rope
8	Turntable Bearing Fasteners	19	Counterweight Mounting Hardware
9	O/R Hose Connections	20	Counterweight Pins
10	Hook Block Tiedown Cable	21	Hose Connections
11	O/R Pins, Clips	22	Mirror Mounting Hardware