



An Oshkosh Corporation Company

Service and Maintenance Manual

Model

E600

E600J

E600JP

M600

M600J

M600JP

P/N - 3121117

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ANSI



An Oshkosh Corporation Company

SECTION A. INTRODUCTION - MAINTENANCE SAFETY PRECAUTIONS

A GENERAL

This section contains the general safety precautions which must be observed during maintenance of the aerial platform. It is of utmost importance that maintenance personnel pay strict attention to these warnings and precautions to avoid possible injury to themselves or others, or damage to the equipment. A maintenance program must be followed to ensure that the machine is safe to operate.

WARNING

MODIFICATION OR ALTERATION OF AN AERIAL WORK PLATFORM SHALL BE MADE ONLY WITH WRITTEN PERMISSION FROM THE MANUFACTURER.

The specific precautions to be observed during maintenance are inserted at the appropriate point in the manual. These precautions are, for the most part, those that apply when servicing hydraulic and larger machine component parts.

Your safety, and that of others, is the first consideration when engaging in the maintenance of equipment. Always be conscious of weight. Never attempt to move heavy parts without the aid of a mechanical device. Do not allow heavy objects to rest in an unstable position. When raising a portion of the equipment, ensure that adequate support is provided.

WARNING

SINCE THE MACHINE MANUFACTURER HAS NO DIRECT CONTROL OVER THE FIELD INSPECTION AND MAINTENANCE, SAFETY IN THIS AREA RESPONSIBILITY OF THE OWNER/OPERATOR.

B HYDRAULIC SYSTEM SAFETY

It should be noted that the machines hydraulic systems operate at extremely high potentially dangerous pressures. Every effort should be made to relieve any system pressure prior to disconnecting or removing any portion of the system.

Relieve system pressure by cycling the applicable control several times with the engine stopped and ignition on, to direct any line pressure back into the reservoir. Pressure feed lines to system components can then be disconnected with minimal fluid loss.

C MAINTENANCE

WARNING

FAILURE TO COMPLY WITH SAFETY PRECAUTIONS LISTED IN THIS SECTION COULD RESULT IN MACHINE DAMAGE, PERSONNEL INJURY OR DEATH AND IS A SAFETY VIOLATION.

- ENSURE REPLACEMENT PARTS OR COMPONENTS ARE IDENTICAL OR EQUIVALENT TO ORIGINAL PARTS OR COMPONENTS.
- NO SMOKING IS MANDATORY. NEVER REFUEL DURING ELECTRICAL STORMS. ENSURE THAT FUEL CAP IS CLOSED AND SECURE AT ALL OTHER TIMES.
- REMOVE ALL RINGS, WATCHES AND JEWELRY WHEN PERFORMING ANY MAINTENANCE.
- DO NOT WEAR LONG HAIR UNRESTRAINED, OR LOOSE-FITTING CLOTHING AND NECKTIES WHICH ARE APT TO BECOME CAUGHT ON OR ENTANGLED IN EQUIPMENT.
- OBSERVE AND OBEY ALL WARNINGS AND CAUTIONS ON MACHINE AND IN SERVICEMANUAL.
- KEEP OIL, GREASE, WATER, ETC. WIPED FROM STANDING SURFACES AND HAND HOLDS.
- USE CAUTION WHEN CHECKING A HOT, PRESSURIZED COOLANT SYSTEM.
- NEVER WORK UNDER AN ELEVATED BOOM UNTIL BOOM HAS BEEN SAFELY RESTRAINED FROM ANY MOVEMENT BY BLOCKING OR OVERHEAD SLING, OR BOOM SAFETY PROP HAS BEEN ENGAGED.
- BEFORE MAKING ADJUSTMENTS, LUBRICATING OR PERFORMING ANY OTHER MAINTENANCE, SHUT OFF ALL POWER CONTROLS.
- BATTERY SHOULD ALWAYS BE DISCONNECTED DURING REPLACEMENT OF ELECTRICAL COMPONENTS.
- KEEP ALL SUPPORT EQUIPMENT AND ATTACHMENTS STOWED IN THEIR PROPER PLACE.
- USE ONLY APPROVED, NONFLAMMABLE CLEANING SOLVENTS.

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SECTION 1. SPECIFICATIONS

1.1 CAPACITIES

Table 1-1. Capacities

Generator Fuel Tank (M Models Only)	13 gallons (49.2 liters)
Hydraulic Tank	
Prior to S/N 51941	15 gallons (57 liters)
S/N 51941 to Present	15.9 gal. (60.2 L)
	12.4 gal. (46.9 L) to full mark
Drive Hub	0.4 gal. (1.5 liters)

1.2 OPERATING SPECIFICATIONS

Table 1-2. Operating Specifications

Maximum Work Load (Capacity) Unrestricted:	500 lb (230 kg)
Maximum Travel Grade (Gradeability) with Boom retracted and approximately horizontal. Tower Boom fully lowered.	30%
Maximum Travel Grade (Side Slope) with Boom retracted and approximately hori- zontal. Tower Boom fully lowered.	5°
Tilt Alarm Setting (See Section 3)	
ANSI, CSA	5°
CE E/M600 & E/M600J	4°
CE E/M 600JP	3°
Maximum Vertical Platform Height:	60 ft. (18.29 m)
Maximum Horizontal Platform Reach	
E600	43 ft. (13.11 m)
E600J	42 ft. 9 in. (13.11 m)
Machine Width	
2WD	7 ft. 11 7/16 in. (2.42 m)
4WD	7 ft. 11 3/8 in. (2.42 m)
Machine Length	
E/M600	30 ft. 11 5/16 in. (9.43 m)
E/M600J	30 ft. 8 15/16 in. (9.37 m)
E/M600JP	33 ft. 3 3/4 in. (10.15 m)
Turning Radius (outside)	15 ft. 3 in. (4.65 m)
Turning Radius (inside)	4 ft. (1.23 m)
Maximum Tire Load:	7700 lbs. (3500 kg)
Maximum Ground Bearing Pressure	
E600J/M600J	52 psi (3.7 kg/cm ²)
E600JP/M600JP	51 psi (3.6 kg/cm ²)
Maximum Drive Speed:	3.0 mph (1.3 m/s)
Electrical System Voltage	48 volts
Maximum Hydraulic System Pressure	3200 psi (221 Bar)
Maximum Wind Speed	28 mph (12.5 m/s)

Table 1-2. Operating Specifications

Maximum Manual Force	400N
Gross Machine Weight (Platform Empty)	
E600J/M600J	16,300 lb. (7,393 kg)
E600JP/M600JP	16,800 lb. (7,620 kg)

1.3 GENERATOR

Table 1-3. Generator

Alternator Output	58 volts @ 45 Amps
RPM's under max. load	3100
Start Battery	12 volts
Engine Oil	10W30 (Refer to Engine Manual)
Dynamo	12 volt, 15 amp DC
Dynamo Output Fuse	20 amps DC
Control Fuse	15 amps DC

1.4 BATTERY CHARGER

Table 1-4. Battery Charger

AC Input	120V - 240V Auto Seeking
AC Draw	17 amps at start of charging
DC Output	48 volts, 23 amps

1.5 DRIVE/STEER SYSTEM

Table 1-5. Drive System

Drive Motor	48 VDC, 12.5 H.P. @ 3200 rpm. con- tinuous, rotation - reversible
Drive Brake	spring-applied, hydraulically released

1.6 TIRES

Table 1-6. Tires

Size	Type	Pressure
36/14 LL-22.5	pneumatic	55 psi (4.0 Bar)
36/14 LL-22.5	foam filled	N/A

1.7 FUNCTION SPEEDS

Table 1-7. Function Speeds

Lift Up	55-61
Lift Down	55-61
Swing Right & Left	72-84
Telescope Out	46-50
Telescope In	46-50
Platform Rotate Left & Right	24-26
Jib Up	25-27
Jib Down	21-23
Jib Swing	30-40
High Drive (200 ft.)	42-46 (3.0 mph)
Drive above Horizontal (50 ft.)	65-71 (0.5 mph)

4150273-N

Machine Orientation When Doing Speed Tests

Lift: Boom Retracted. Telescope Retracted. Lift Up, Record Time, Lift Down, Record Time.

Swing: Boom at Full Elevation. Telescope Retracted. Swing the Turntable to the end stop. Swing the Opposite Direction, Record Time.

Telescope: Boom at Full Elevation; Telescope Retracted; Telescope Out, Record Time. Telescope In, Record Time.

Drive: Test to be done on a smooth level surface. Start approximately 25 ft. (7.62 m) from starting point so that the unit is at maximum speed when starting the test. Results should be recorded for a 200 ft. (60.96 m) course. Drive Forward, record time. Drive Reverse, Record Time.

Drive (Above Horizontal): Test should be done on a smooth level surface. The Platform Speed Knob should be selected out of the creep speed. This verifies that the switches are working when the boom is above horizontal. Results should be recorded for a 50 ft. course. Drive Forward, Record Time. Drive Reverse, Record Time.

Platform Rotate: Platform level and completely rotated one direction. Rotate the opposite direction, Record Time. Rotate the other direction, Record Time.

Articulating Jib: Platform level and centered with the boom. Start with the Jib down. Jib Up, Record Time. Jib Down, Record Time.

Test Notes

1. Stop watch should be started with the function, not with the controller or switch.
2. Drive test results reflect 36/14LL-22.5 tires.
3. All speed tests are run from the platform. These speeds do not reflect the ground control operation.
4. The platform speed knob control must be at full speed (turned clockwise completely).
5. Function speeds may vary due to cold, thick hydraulic oil. Test should be run with the oil temperature above 100° F (38° C).
6. Some flow control functions may not work with the speed knob clicked into the creep position.

1.8 PRESSURE SETTINGS

Table 1-8. Pressure Settings

SETTING	PSI	BAR
Proportional Main Relief	3200	220
Bang Bang Main Relief	3000	207
Lift Up	2500	172
Lift Down	1100	76
Swing	2500	172
Swing Brake	320	22
Steer	1800	124
Platform Level Up	2500	172
Platform Level Down	1500	103
Jib Up	2300	158.5
Jib Down	2300	158.5

1.9 TORQUE REQUIREMENTS

Table 1-9. Torque Requirements

Description	Torque Value (Dry)	Interval Hours
Wheel Lugs	170 ft. lbs. (238 Nm)	150
T/T Counterweight Bolts	400 ft. lbs. (560 Nm)	A/R
Swing Bearing Bolts	190 ft. lbs. (260 Nm)	50/600*
*Check swing bearing bolts for security after first 50 hours of operation and every 600 hours thereafter. (See Swing Bearing in Section 3.)		
NOTE: When maintenance becomes necessary or a fastener has loosened, refer to the Torque Chart to determine proper torque value.		

1.10 MAJOR COMPONENT WEIGHTS

Table 1-10. Component Weights

Component	Pounds	Kilograms
Frame (bare)	1381	626
T/T (bare)	2093	950
Boom Assembly (E/M 600)	4464	2025
Boom Assembly (E/M 600J)	4464	2025
Tire & Wheel	226	102.5
Swing Drive	70	32
Swing Bearing	100	45.4
Platform Console	25	11
Side Entry Platform - 30x72 (bare)	175	80
Side Entry Platform - 30x48 (bare)	144	66
Counterweight	2560	1161
Foam Fill (Filled Tires)	441	200

1.11 SERIAL NUMBER LOCATION

A serial number plate is affixed to the right side of the frame. If the serial number plate is damaged or missing, the machine serial number is stamped on the left side of the frame at the top.

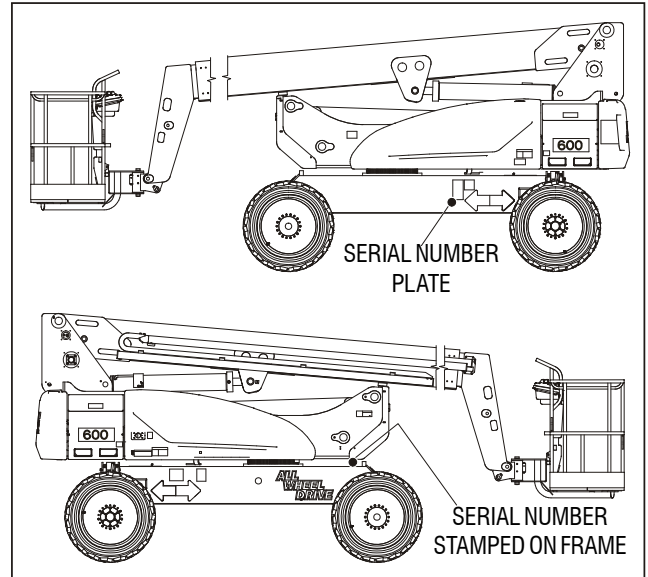


Figure 1-1. Serial Number Location

1.12 HYDRAULIC OIL

Table 1-11. Hydraulic Oil

Hydraulic System Operating Temperature Range	S.A.E. Viscosity Grade
+0° to +180° F (-18° to +83° C)	10W
+0° to +210° F (-18° to +99° C)	10W-20, 10W30
+50° to +210° F (+10° to +99° C)	20W-20

NOTE: Hydraulic oils must have anti-wear qualities at least to API Service Classification GL-3, and sufficient chemical stability for mobile hydraulic system service.

Aside from JLG recommendations, it is not advisable to mix oils of different brands or types, as they may not contain the same required additives or be of comparable viscosities. If use of hydraulic oil other than Mobil DTE 11M is desired, contact JLG Industries for proper recommendations.

Table 1-12. Mobil DTE 11M Specs

ISO Viscosity Grade	#15
Gravity API	31.9
Pour Point, Max	-40°F (-40°C)
Flash Point, Min.	330°F (166°C)
Viscosity	
at 40° C	15 cSt
at 100° C	4.1 cSt
at 100° F	80 SUS
at 210° F	43 SUS
cp at -30° F	3.200
Viscosity Index	140

Table 1-13. Mobil DTE 13M Specs

ISO Viscosity Grade	#32
Specific Gravity	0.877
Pour Point, Max	-40°F (-40°C)
Flash Point, Min.	330°F (166°C)
Viscosity	
at 40° C	33cSt
at 100° C	6.6 cSt
at 100° F	169 SUS
at 210° F	48 SUS
cp at -20° F	6,200
Viscosity Index	140

Table 1-14. Mobil EAL H 46 Specs

Type	Synthetic Biodegradable
ISO Viscosity Grade	46
Specific Gravity	.910
Pour Point	-44°F (-42°C)
Flash Point	500°F (260°C)
Operating Temp.	0 to 180°F (-17 to 162°C)
Weight	7.64 lb. per gal. (0.9 kg per liter)
Viscosity	
at 40° C	45 cSt
at 100° C	8.0 cSt
Viscosity Index	153

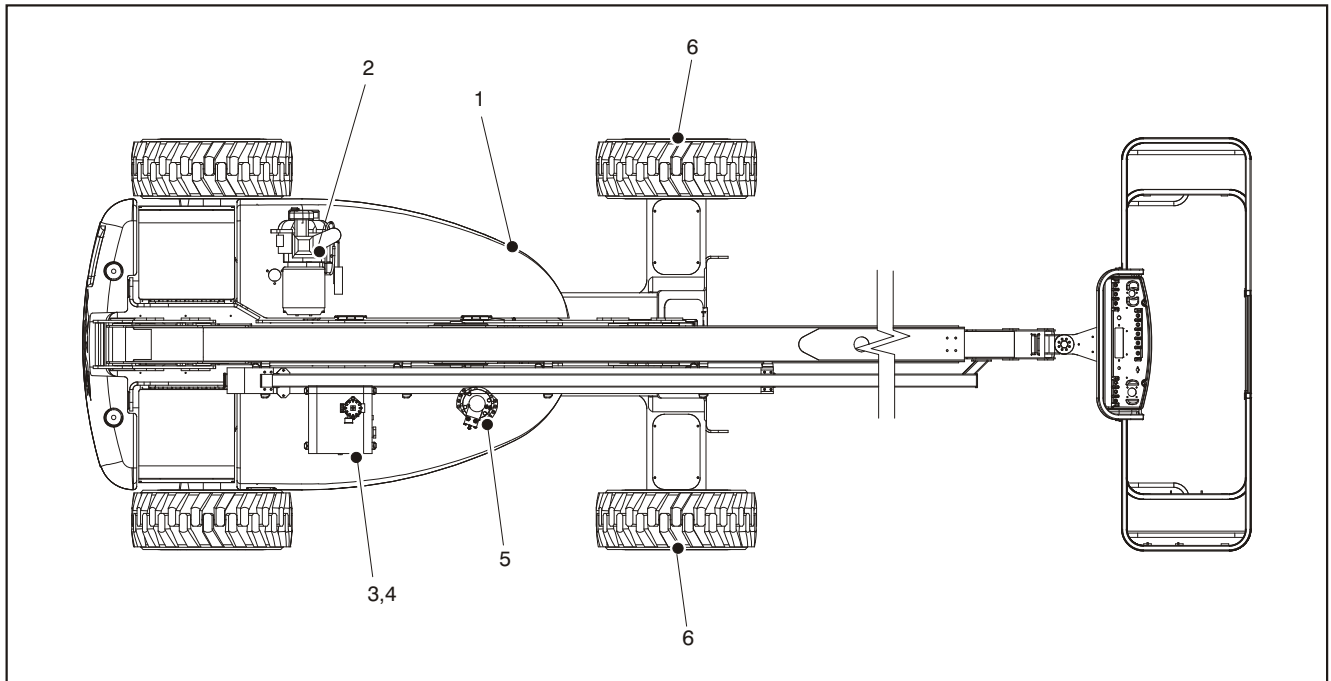


Figure 1-2. Operator Maintenance and Lubrication Diagram

1.13 OPERATOR MAINTENANCE

NOTE: The following numbers correspond to those in Figure 1-2., Operator Maintenance and Lubrication Diagram.

Table 1-15. Lubrication Specifications.

KEY	SPECIFICATIONS
MPG	Multipurpose Grease having a minimum dripping point of 350 degrees F. Excellent water resistance and adhesive qualities; and being of extreme pressure type (Timken OK 40 pounds minimum).
EPGL	Extreme Pressure Gear Lube (oil) meeting API Service Classification GL-5 or Mil-Spec Mil-L-2105.
HO	Hydraulic Oil. Mobil DTE-11M
OG*	Open Gear Lube - Tribol Molub-Alloy 936 Open Gear Compound. (JLG Part No. 3020027)
BG*	Bearing Grease (JLG Part No. 3020029) Mobilith SHA 460.
LL	Synthetic Lithium Lubricant, Gredag 741 Grease. (JLG Part No. 3020022)
EO	Engine (crankcase) Oil. Gas - API SF/SG class, MIL-L-2104. Diesel - API CC/CD class, MIL-L-2104B/MIL-L-2104C.

*MPG may be substituted for these lubricants, if necessary, but service intervals will be reduced.

NOTICE

LUBRICATION INTERVALS ARE BASED ON MACHINE OPERATION UNDER NORMAL CONDITIONS. FOR MACHINES USED IN MULTI-SHIFT OPERATIONS AND/OR EXPOSED TO HOSTILE ENVIRONMENTS OR CONDITIONS, LUBRICATION FREQUENCIES MUST BE INCREASED ACCORDINGLY.

NOTE: It is recommended as a good practice to replace all filters at the same time.

1. Swing Bearing - Internal Ball Bearing



Lube Point(s) - 1 Grease Fittings

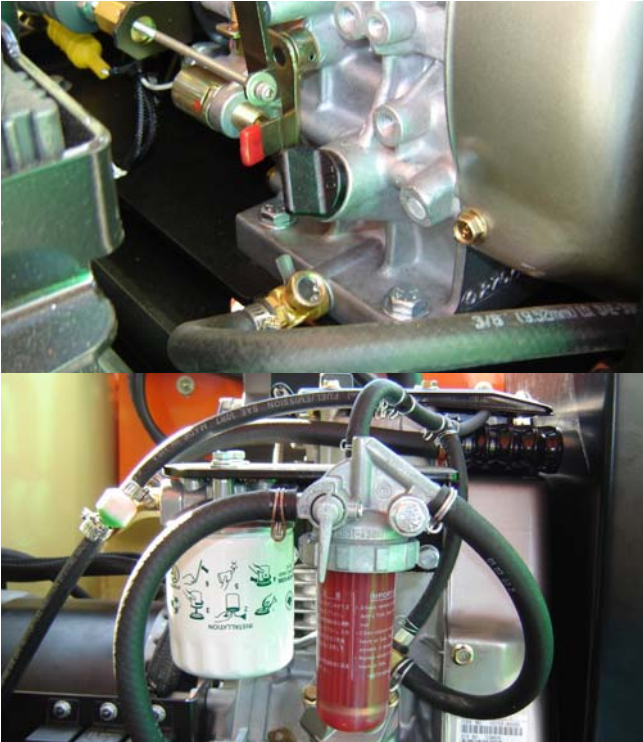
Capacity - A/R

Lube - MPG

Interval - Every 3 months or 150 hrs of operation

SECTION 1 - SPECIFICATIONS

2. Generator Engine (If Equipped)



Lube Point(s) - Fill Cap

Capacity - Refer to Engine Manual

Lube - EO

Interval - 3 Months or 150 hours of operation

Comments - Check level daily/Change in accordance with engine manual.

3. Hydraulic Tank



Lube Point(s) - Fill Cap

Capacity -

Prior to S/N 51941 - 15 gal. tank (56.7 L)

S/N 51941 to present - 15.9 gal. system (56.7L)

12.4 gal. (46.9 L) to Full Mark

Lube - HO

Interval - Check Level daily; Change every 2 years or 1200 hours of operation.

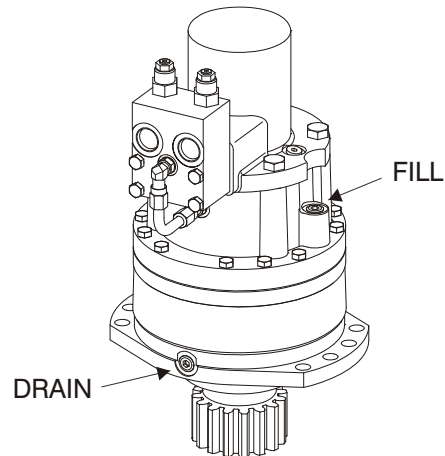
4. Hydraulic Filter



Interval - Change after first 50 hrs. and every 6 months or 300 hrs. thereafter or as indicated by Condition Indicator.

Comments - Under certain conditions, it may be necessary to replace the filter on a more frequent basis.

5. Swing Drive Hub (S/N 58845 to Present)



Lube Point(s) - Level/Fill Plug

Capacity - 24 oz. (0.7 L)

Lube - EPGL

Interval - Check level every 3 months or 150 hrs of operation; change every 2 years or 1200 hours of operation

6. Wheel Drive Hub



Lube Point(s) - Level/Fill Plug

Capacity - 0.4 gal. (1.5 L)

Lube - EPGL

Interval - Check level every 3 months or 150 hrs of operation; change every 2 years or 1200 hours of operation

SECTION 1 - SPECIFICATIONS

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)												
SAE GRADE 5 BOLTS & GRADE 2 NUTS												
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry)		Torque Lubricated		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140)		Torque (Loctite® 262™ or Vibra-TITE™ 131)	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604	380	8	0.9	6	0.7				
	48	0.1120	0.00661	420	9	1.0	7	0.8				
6	32	0.1380	0.00909	580	16	1.8	12	1.4				
	40	0.1380	0.01015	610	18	2.0	13	1.5				
8	32	0.1640	0.01400	900	30	3.4	22	2.5				
	36	0.1640	0.01474	940	31	3.5	23	2.6				
10	24	0.1900	0.01750	1120	43	4.8	32	3.5				
	32	0.1900	0.02000	1285	49	5.5	36	4				
1/4	20	0.2500	0.0318	2020	96	10.8	75	9	105	12		
	28	0.2500	0.0364	2320	120	13.5	86	10	135	15		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	3340	17	23	13	18	19	26	16	22
	24	0.3125	0.0580	3700	19	26	14	19	21	29	17	23
3/8	16	0.3750	0.0775	4940	30	41	23	31	35	48	28	38
	24	0.3750	0.0878	5600	35	47	25	34	40	54	32	43
7/16	14	0.4375	0.1063	6800	50	68	35	47	55	75	45	61
	20	0.4375	0.1187	7550	55	75	40	54	60	82	50	68
1/2	13	0.5000	0.1419	9050	75	102	55	75	85	116	68	92
	20	0.5000	0.1599	10700	90	122	65	88	100	136	80	108
9/16	12	0.5625	0.1820	11600	110	149	80	108	120	163	98	133
	18	0.5625	0.2030	12950	120	163	90	122	135	184	109	148
5/8	11	0.6250	0.2260	14400	150	203	110	149	165	224	135	183
	18	0.6250	0.2560	16300	170	230	130	176	190	258	153	207
3/4	10	0.7500	0.3340	21300	260	353	200	271	285	388	240	325
	16	0.7500	0.3730	23800	300	407	220	298	330	449	268	363
7/8	9	0.8750	0.4620	29400	430	583	320	434	475	646	386	523
	14	0.8750	0.5090	32400	470	637	350	475	520	707	425	576
1	8	1.0000	0.6060	38600	640	868	480	651	675	918	579	785
	12	1.0000	0.6630	42200	700	949	530	719	735	1000	633	858
1 1/8	7	1.1250	0.7630	42300	800	1085	600	813	840	1142	714	968
	12	1.1250	0.8560	47500	880	1193	660	895	925	1258	802	1087
1 1/4	7	1.2500	0.9690	53800	1120	1518	840	1139	1175	1598	1009	1368
	12	1.2500	1.0730	59600	1240	1681	920	1247	1300	1768	1118	1516
1 3/8	6	1.3750	1.1550	64100	1460	1979	1100	1491	1525	2074	1322	1792
	12	1.3750	1.3150	73000	1680	2278	1260	1708	1750	2380	1506	2042
1 1/2	6	1.5000	1.4050	78000	1940	2630	1460	1979	2025	2754	1755	2379
	12	1.5000	1.5800	87700	2200	2983	1640	2224	2300	3128	1974	2676

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- NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
 2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
 3. * ASSEMBLY USES HARDENED WASHER

REFERENCE JLG ANEROBIC THREAD LOCKING COMPOUND				
JLG P/N	Loctite® P/N		ND Industries P/N	Description
0100011	242™		Vibra-TITE™ 121	Medium Strength (Blue)
0100019	271™		Vibra-TITE™ 140	High Strength (Red)
0100071	262™		Vibra-TITE™ 131	Medium - High Strength (Red)

Figure 1-3. Torque Chart (SAE Fasteners - Sheet 1 of 7)

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)										
SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263) K= 0.20		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K=.18		Torque (Loctite® 262™ or Vibra- TITE™ 131) K=0.15	
					IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604							
	48	0.1120	0.00661							
6	32	0.1380	0.00909							
	40	0.1380	0.01015							
8	32	0.1640	0.01400							
	36	0.1640	0.01474	1320	43	5				
10	24	0.1900	0.01750	1580	60	7				
	32	0.1900	0.02000	1800	68	8				
1/4	20	0.2500	0.0318	2860	143	16	129	15		
	28	0.2500	0.0364	3280	164	19	148	17		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	25	35	20	25	20	25
	24	0.3125	0.0580	5220	25	35	25	35	20	25
3/8	16	0.3750	0.0775	7000	45	60	40	55	35	50
	24	0.3750	0.0878	7900	50	70	45	60	35	50
7/16	14	0.4375	0.1063	9550	70	95	65	90	50	70
	20	0.4375	0.1187	10700	80	110	70	95	60	80
1/2	13	0.5000	0.1419	12750	105	145	95	130	80	110
	20	0.5000	0.1599	14400	120	165	110	150	90	120
9/16	12	0.5625	0.1820	16400	155	210	140	190	115	155
	18	0.5625	0.2030	18250	170	230	155	210	130	175
5/8	11	0.6250	0.2260	20350	210	285	190	260	160	220
	18	0.6250	0.2560	23000	240	325	215	290	180	245
3/4	10	0.7500	0.3340	30100	375	510	340	460	280	380
	16	0.7500	0.3730	33600	420	570	380	515	315	430
7/8	9	0.8750	0.4620	41600	605	825	545	740	455	620
	14	0.8750	0.5090	45800	670	910	600	815	500	680
1	8	1.0000	0.6060	51500	860	1170	770	1045	645	875
	12	1.0000	0.6630	59700	995	1355	895	1215	745	1015
1 1/8	7	1.1250	0.7630	68700	1290	1755	1160	1580	965	1310
	12	1.1250	0.8560	77000	1445	1965	1300	1770	1085	1475
1 1/4	7	1.2500	0.9690	87200	1815	2470	1635	2225	1365	1855
	12	1.2500	1.0730	96600	2015	2740	1810	2460	1510	2055
1 3/8	6	1.3750	1.1550	104000	2385	3245	2145	2915	1785	2430
	12	1.3750	1.3150	118100	2705	3680	2435	3310	2030	2760
1 1/2	6	1.5000	1.4050	126500	3165	4305	2845	3870	2370	3225
	12	1.5000	1.5800	142200	3555	4835	3200	4350	2665	3625

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. * ASSEMBLY USES HARDENED WASHER

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Figure 1-4. Torque Chart (SAE Fasteners - Sheet 2 of 7)

SECTION 1 - SPECIFICATIONS

SOCKET HEAD CAP SCREWS										
Magni Coating (Ref 4150701)*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See Note 4	Torque (Dry) K = .17		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140 OR Precoat 85® K=0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
					IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604							
	48	0.1120	0.00661							
6	32	0.1380	0.00909							
	40	0.1380	0.01015							
8	32	0.1640	0.01400							
	36	0.1640	0.01474							
10	24	0.1900	0.01750							
	32	0.1900	0.02000							
1/4	20	0.2500	0.0318	2860	122	14	114	13		
	28	0.2500	0.0364	3280	139	16	131	15		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	20	25	20	25	20	25
	24	0.3125	0.0580	5220	25	35	20	25	20	25
3/8	16	0.3750	0.0775	7000	35	50	35	50	35	50
	24	0.3750	0.0878	7900	40	55	40	55	35	50
7/16	14	0.4375	0.1063	9550	60	80	55	75	50	70
	20	0.4375	0.1187	10700	65	90	60	80	60	80
1/2	13	0.5000	0.1419	12750	90	120	85	115	80	110
	20	0.5000	0.1599	14400	100	135	95	130	90	120
9/16	12	0.5625	0.1820	16400	130	175	125	170	115	155
	18	0.5625	0.2030	18250	145	195	135	185	130	175
5/8	11	0.6250	0.2260	20350	180	245	170	230	160	220
	18	0.6250	0.2560	23000	205	280	190	260	180	245
3/4	10	0.7500	0.3340	30100	320	435	300	410	280	380
	16	0.7500	0.3730	33600	355	485	335	455	315	430
7/8	9	0.8750	0.4620	41600	515	700	485	660	455	620
	14	0.8750	0.5090	45800	570	775	535	730	500	680
1	8	1.0000	0.6060	51500	730	995	685	930	645	875
	12	1.0000	0.6630	59700	845	1150	795	1080	745	1015
1 1/8	7	1.1250	0.7630	68700	1095	1490	1030	1400	965	1310
	12	1.1250	0.8560	77000	1225	1665	1155	1570	1085	1475
1 1/4	7	1.2500	0.9690	87200	1545	2100	1455	1980	1365	1855
	12	1.2500	1.0730	96600	1710	2325	1610	2190	1510	2055
1 3/8	6	1.3750	1.1550	104000	2025	2755	1905	2590	1785	2430
	12	1.3750	1.3150	118100	2300	3130	2165	2945	2030	2760
1 1/2	6	1.5000	1.4050	126500	2690	3660	2530	3440	2370	3225
	12	1.5000	1.5800	142200	3020	4105	2845	3870	2665	3625

NO. 5000059 REV. J

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS

2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%

*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM

4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-5. Torque Chart (SAE Fasteners - Sheet 3 of 7)

SOCKET HEAD CAP SCREWS										
Zinc Yellow Chromate Fasteners (Ref 4150707)*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See Note 4	Torque (Dry) K = .20		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140 OR Precoat 85® K=0.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604							
	48	0.1120	0.00661							
6	32	0.1380	0.00909							
	40	0.1380	0.01015							
8	32	0.1640	0.01400							
	36	0.1640	0.01474							
10	24	0.1900	0.01750							
	32	0.1900	0.02000							
1/4	20	0.2500	0.0318	2860	143	16	129	15		
	28	0.2500	0.0364	3280	164	19	148	17		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	25	35	20	25	20	25
	24	0.3125	0.0580	5220	25	35	25	35	20	25
3/8	16	0.3750	0.0775	7000	45	60	40	55	35	50
	24	0.3750	0.0878	7900	50	70	45	60	35	50
7/16	14	0.4375	0.1063	9550	70	95	65	90	50	70
	20	0.4375	0.1187	10700	80	110	70	95	60	80
1/2	13	0.5000	0.1419	12750	105	145	95	130	80	110
	20	0.5000	0.1599	14400	120	165	110	150	90	120
9/16	12	0.5625	0.1820	16400	155	210	140	190	115	155
	18	0.5625	0.2030	18250	170	230	155	210	130	175
5/8	11	0.6250	0.2260	20350	210	285	190	260	160	220
	18	0.6250	0.2560	23000	240	325	215	290	180	245
3/4	10	0.7500	0.3340	30100	375	510	340	460	280	380
	16	0.7500	0.3730	33600	420	570	380	515	315	430
7/8	9	0.8750	0.4620	41600	605	825	545	740	455	620
	14	0.8750	0.5090	45800	670	910	600	815	500	680
1	8	1.0000	0.6060	51500	860	1170	775	1055	645	875
	12	1.0000	0.6630	59700	995	1355	895	1215	745	1015
1 1/8	7	1.1250	0.7630	68700	1290	1755	1160	1580	965	1310
	12	1.1250	0.8560	77000	1445	1965	1300	1770	1085	1475
1 1/4	7	1.2500	0.9690	87200	1815	2470	1635	2225	1365	1855
	12	1.2500	1.0730	96600	2015	2740	1810	2460	1510	2055
1 3/8	6	1.3750	1.1550	104000	2385	3245	2145	2915	1785	2430
	12	1.3750	1.3150	118100	2705	3680	2435	3310	2030	2760
1 1/2	6	1.5000	1.4050	126500	3165	4305	2845	3870	2370	3225
	12	1.5000	1.5800	142200	3555	4835	3200	4350	2665	3625

NO. 5000059 REV. J

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS

2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%

*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM

4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-6. Torque Chart (SAE Fasteners - Sheet 4 of 7)

SECTION 1 - SPECIFICATIONS

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)							
CLASS 8.8 METRIC BOLTS CLASS 8 METRIC NUTS							
Size	PITCH	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263™)	Torque (Lub)	Torque (Loctite® 262™ OR Vibra-TITE™ 131)	Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140)
		Sq mm	KN	[N.m]	[N.m]	[N.m]	[N.m]
3	0.5	5.03	2.19	1.3	1.0	1.2	1.4
3.5	0.6	6.78	2.95	2.1	1.6	1.9	2.3
4	0.7	8.78	3.82	3.1	2.3	2.8	3.4
5	0.8	14.20	6.18	6.2	4.6	5.6	6.8
6	1	20.10	8.74	11	7.9	9.4	12
7	1	28.90	12.6	18	13	16	19
8	1.25	36.60	15.9	26	19	23	28
10	1.5	58.00	25.2	50	38	45	55
12	1.75	84.30	36.7	88	66	79	97
14	2	115	50.0	140	105	126	154
16	2	157	68.3	219	164	197	241
18	2.5	192	83.5	301	226	271	331
20	2.5	245	106.5	426	320	383	469
22	2.5	303	132.0	581	436	523	639
24	3	353	153.5	737	553	663	811
27	3	459	199.5	1080	810	970	1130
30	3.5	561	244.0	1460	1100	1320	1530
33	3.5	694	302.0	1990	1490	1790	2090
36	4	817	355.5	2560	1920	2300	2690
42	4.5	1120	487.0	4090	3070	3680	4290

NO. 5000059 REV. J

- NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
 2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
 *3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
 4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-7. Torque Chart (METRIC Fasteners - Sheet 5 of 7)

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)						
CLASS 10.9 METRIC BOLTS CLASS 10 METRIC NUTS CLASS 12.9 SOCKET HEAD CAP SCREWS M3 - M5*						
Size	PITCH	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263™) K = 0.20	Torque (Lub OR Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K= 0.18	Torque (Loctite® 262™ OR Vibra-TITE™ 131) K=0.15
		Sq mm	KN	[N.m]	[N.m]	[N.m]
3	0.5	5.03	3.13			
3.5	0.6	6.78	4.22			
4	0.7	8.78	5.47			
5	0.8	14.20	8.85			
6	1	20.10	12.5			
7	1	28.90	18.0	25.2	22.7	18.9
8	1.25	36.60	22.8	36.5	32.8	27.4
10	1.5	58.00	36.1	70	65	55
12	1.75	84.30	52.5	125	115	95
14	2	115	71.6	200	180	150
16	2	157	97.8	315	280	235
18	2.5	192	119.5	430	385	325
20	2.5	245	152.5	610	550	460
22	2.5	303	189.0	830	750	625
24	3	353	222.0	1065	960	800
27	3	459	286.0	1545	1390	1160
30	3.5	561	349.5	2095	1885	1575
33	3.5	694	432.5	2855	2570	2140
36	4	817	509.0	3665	3300	2750
42	4.5	1120	698.0	5865	5275	4395

NO. 5000059 REV. J

- NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
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 *3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
 4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-8. Torque Chart (METRIC Fasteners - Sheet 6 of 7)

SECTION 1 - SPECIFICATIONS

Magni Coating (Ref 4150701)*						
CLASS 12.9 SOCKET HEAD CAP SCREWS M6 AND ABOVE*						
Size	PITCH	Tensile Stress Area	Clamp Load See Note 4	Torque (Dry or Loctite® 263™) K = .17	Torque (Lub OR Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K = .16	Torque (Loctite® 262™ OR Vibra-TITE™ 131) K = .15
		Sq mm	kN	[N.m]	[N.m]	[N.m]
3	0.5	5.03				
3.5	0.6	6.78				
4	0.7	8.78				
5	0.8	14.20				
6	1	20.10	12.5	13	12	11
7	1	28.90	18.0	21	20	19
8	1.25	36.60	22.8	31	29	27
10	1.5	58.00	36.1	61	58	54
12	1.75	84.30	52.5	105	100	95
14	2	115	71.6	170	160	150
16	2	157	97.8	265	250	235
18	2.5	192	119.5	365	345	325
20	2.5	245	152.5	520	490	460
22	2.5	303	189.0	705	665	625
24	3	353	220.0	900	845	790
27	3	459	286.0	1315	1235	1160
30	3.5	561	349.5	1780	1680	1575
33	3.5	694	432.5	2425	2285	2140
36	4	817	509.0	3115	2930	2750
42	4.5	1120	698.0	4985	4690	4395

NO. 5000059 REV. J

- NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
 2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
 *3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
 4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-9. Torque Chart (METRIC Fasteners - Sheet 7 of 7)

SECTION 2. GENERAL

2.1 MACHINE PREPARATION, INSPECTION, AND MAINTENANCE

General

This section provides the necessary information needed by those personnel that are responsible to place the machine in operation readiness and maintain its safe operating condition. For maximum service life and safe operation, ensure that all the necessary inspections and maintenance have been completed before placing the machine into service.

Preparation, Inspection, and Maintenance

It is important to establish and conform to a comprehensive inspection and preventive maintenance program. The following table outlines the periodic machine inspections and maintenance recommended by JLG Industries, Inc. Consult your national, regional, or local regulations for further requirements for aerial work platforms. The frequency of inspections and maintenance must be increased as environment, severity and frequency of usage requires.

Pre-Start Inspection

It is the User's or Operator's primary responsibility to perform a Pre-Start Inspection of the machine prior to use daily or at each change of operator. Reference the Operator's and Safety Manual for completion procedures for the Pre-Start Inspection. The Operator and Safety Manual must be read in its entirety and understood prior to performing the Pre-Start Inspection.

Pre-Delivery Inspection and Frequent Inspection

The Pre-Delivery Inspection and Frequent Inspection shall be performed by a qualified JLG equipment mechanic. JLG Industries, Inc. recognizes a qualified JLG equipment mechanic as a person who, by possession of a recognized degree, certificate, extensive knowledge, training, or experience, has successfully demonstrated the ability and proficiency to service, repair, and maintain the subject JLG product model.

The Pre-Delivery Inspection and Frequent Inspection procedures are performed in the same manner, but at different times. The Pre-Delivery Inspection shall be performed prior to each sale, lease, or rental delivery. The Frequent Inspection shall be accomplished for each machine in service for 3 months or 150 hours (whichever comes first); out of service for a period of more than 3 months; or when purchased used. The frequency of this inspection must be increased as environment, severity and frequency of usage requires.

Reference the JLG Pre-Delivery and Frequent Inspection Form and the Inspection and Preventative Maintenance Schedule for items requiring inspection during the performance of these inspections. Reference the appropriate areas of this manual for servicing and maintenance procedures.

Annual Machine Inspection

The Annual Machine Inspection must be performed by a Factory-Certified Service Technician on an annual basis, no later than thirteen (13) months from the date of the prior Annual Machine Inspection. JLG Industries, Inc. recognizes a Factory-Certified Service Technician as a person who has successfully completed the JLG Service Training School for the subject JLG product model. Reference the machine Service and Maintenance Manual and appropriate JLG inspection form for performance of this inspection.

Reference the JLG Annual Machine Inspection Form and the Inspection and Preventative Maintenance Schedule for items requiring inspection during the performance of this inspection. Reference the appropriate areas of this manual for servicing and maintenance procedures.

For the purpose of receiving safety-related bulletins, it is important that JLG Industries, Inc. has updated ownership information for each machine. When performing each Annual Machine Inspection, notify JLG Industries, Inc. of the current machine ownership.

Preventative Maintenance

In conjunction with the specified inspections, maintenance shall be performed by a qualified JLG equipment mechanic. JLG Industries, Inc. recognizes a qualified JLG equipment mechanic as a person who, by possession of a recognized degree, certificate, extensive knowledge, training, or experience, has successfully demonstrated the ability and proficiency to service, repair, and maintain the subject JLG product model.

Reference the Preventative Maintenance Schedule and the appropriate areas of this manual for servicing and maintenance procedures. The frequency of service and maintenance must be increased as environment, severity and frequency of usage requires.

Table 2-1. Inspection and Maintenance

Type	Frequency	Primary Responsibility	Service Qualification	Reference
Pre-Start Inspection	Prior to use each day; or At each Operator change.	User or Operator	User or Operator	Operator and Safety Manual
Pre-Delivery Inspection	Prior to each sale, lease, or rental delivery.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual and applicable JLG inspection form.
Frequent Inspection	In service for 3 months or 150 hours, which- ever comes first; or Out of service for a period of more than 3 months; or Purchased used.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual and applicable JLG inspection form.
Annual Machine Inspection	Annually, no later than 13 months from the date of the prior inspection.	Owner, Dealer, or User	Factory-Certified Service Technician	Service and Maintenance Manual and applicable JLG inspection form.
Preventative Maintenance	At intervals as specified in the Service and Maintenance Manual.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual

2.2 SERVICE AND GUIDELINES

General

The following information is provided to assist you in the use and application of servicing and maintenance procedures contained in this book.

Safety and Workmanship

Your safety, and that of others, is the first consideration when engaging in the maintenance of equipment. Always be conscious of weight. Never attempt to move heavy parts without the aid of a mechanical device. Do not allow heavy objects to rest in an unstable position. When raising a portion of the equipment, ensure that adequate support is provided.

Cleanliness

1. The most important single item in preserving the long service life of a machine is to keep dirt and foreign materials out of the vital components. Precautions have been taken to safeguard against this. Shields, covers, seals, and filters are provided to keep air, fuel, and oil supplies clean; however, these items must be maintained on a scheduled basis in order to function properly.

2. At any time when air, fuel, or oil lines are disconnected, clear adjacent areas as well as the openings and fittings themselves. As soon as a line or component is disconnected, cap or cover all openings to prevent entry of foreign matter.
3. Clean and inspect all parts during servicing or maintenance, and assure that all passages and openings are unobstructed. Cover all parts to keep them clean. Be sure all parts are clean before they are installed. New parts should remain in their containers until they are ready to be used.

Components Removal and Installation

1. Use adjustable lifting devices, whenever possible, if mechanical assistance is required. All slings (chains, cables, etc.) should be parallel to each other and as near perpendicular as possible to top of part being lifted.
2. Should it be necessary to remove a component on an angle, keep in mind that the capacity of an eye-bolt or similar bracket lessens, as the angle between the supporting structure and the component becomes less than 90 degrees.
3. If a part resists removal, check to see whether all nuts, bolts, cables, brackets, wiring, etc., have been removed and that no adjacent parts are interfering.

Component Disassembly and Reassembly

When disassembling or reassembling a component, complete the procedural steps in sequence. Do not partially disassemble or assemble one part, then start on another. Always recheck your work to assure that nothing has been overlooked. Do not make any adjustments, other than those recommended, without obtaining proper approval.

Pressure-Fit Parts

When assembling pressure-fit parts, use an anti-seize or molybdenum disulfide base compound to lubricate the mating surface.

Bearings

1. When a bearing is removed, cover it to keep out dirt and abrasives. Clean bearings in nonflammable cleaning solvent and allow to drip dry. Compressed air can be used but do not spin the bearing.
2. Discard bearings if the races and balls (or rollers) are pitted, scored, or burned.
3. If bearing is found to be serviceable, apply a light coat of oil and wrap it in clean (waxed) paper. Do not unwrap reusable or new bearings until they are ready to install.
4. Lubricate new or used serviceable bearings before installation. When pressing a bearing into a retainer or bore, apply pressure to the outer race. If the bearing is to be installed on a shaft, apply pressure to the inner race.

Gaskets

Check that holes in gaskets align with openings in the mating parts. If it becomes necessary to hand-fabricate a gasket, use gasket material or stock of equivalent material and thickness. Be sure to cut holes in the right location, as blank gaskets can cause serious system damage.

Bolt Usage and Torque Application

1. Use bolts of proper length. A bolt which is too long will bottom before the head is tight against its related part. If a bolt is too short, there will not be enough thread area to engage and hold the part properly. When replacing bolts, use only those having the same specifications of the original, or one which is equivalent.

2. Unless specific torque requirements are given within the text, standard torque values should be used on heat-treated bolts, studs, and steel nuts, in accordance with recommended shop practices. (See Torque Chart Section 1.)

Hydraulic Lines and Electrical Wiring

Clearly mark or tag hydraulic lines and electrical wiring, as well as their receptacles, when disconnecting or removing them from the unit. This will assure that they are correctly reinstalled.

Hydraulic System

1. Keep the system clean. If evidence of metal or rubber particles are found in the hydraulic system, drain and flush the entire system.
2. Disassemble and reassemble parts on clean work surface. Clean all metal parts with non-flammable cleaning solvent. Lubricate components, as required, to aid assembly.

Lubrication

Service applicable components with the amount, type, and grade of lubricant recommended in this manual, at the specified intervals. When recommended lubricants are not available, consult your local supplier for an equivalent that meets or exceeds the specifications listed.

Battery

Clean battery, using a non-metallic brush and a solution of baking soda and water. Rinse with clean water. After cleaning, thoroughly dry battery and coat terminals with an anti corrosion compound.

Lubrication and Servicing

Components and assemblies requiring lubrication and servicing are shown in the Lubrication Chart in Section 1.

2.3 LUBRICATION AND INFORMATION

Hydraulic System

1. The primary enemy of a hydraulic system is contamination. Contaminants enter the system by various means, e.g., using inadequate hydraulic oil, allowing moisture, grease, filings, sealing components, sand, etc., to enter when performing maintenance, or by permitting the pump to cavitate due to insufficient system warm-up or leaks in the pump supply (suction) lines.
2. The design and manufacturing tolerances of the component working parts are very close, therefore, even the smallest amount of dirt or foreign matter entering a system can cause wear or damage to the components and generally results in faulty operation. Every precaution must be taken to keep hydraulic oil clean, including reserve oil in storage. Hydraulic system filters should be checked, cleaned, and/or replaced as necessary, at the specified intervals required in the Lubrication Chart in Section 1. Always examine filters for evidence of metal particles.
3. Cloudy oils indicate a high moisture content which permits organic growth, resulting in oxidation or corrosion. If this condition occurs, the system must be drained, flushed, and refilled with clean oil.
4. It is not advisable to mix oils of different brands or types, as they may not contain the same required additives or be of comparable viscosities. Good grade mineral oils, with viscosities suited to the ambient temperatures in which the machine is operating, are recommended for use.

NOTE: Metal particles may appear in the oil or filters of new machines due to the wear-in of meshing components.

Hydraulic Oil

1. Refer to Section 1 for recommendations for viscosity ranges.
2. JLG recommends Mobil DTE-11M hydraulic oil for this machine.

NOTE: Start-up of hydraulic system with oil temperatures below -15 degrees F (-26 degrees C) is not recommended. If it is necessary to start the system in a sub-zero environment, it will be necessary to heat the oil with a low density, 100VAC heater to a minimum temperature of -15 degrees F (-26 degrees C).

Changing Hydraulic Oil

1. Use of any of the recommended crankcase or hydraulic oils eliminates the need for changing the oil on a regular basis. However, filter elements must be changed after the first 50 hours of operation and every 300 hours thereafter. If it is necessary to change the oil, use only those oils meeting or exceeding the specifications appearing in this manual. If unable to obtain the same type of oil supplied with the machine, consult local supplier for assistance in selecting the proper equivalent. Avoid mixing petroleum and synthetic base oils. JLG Industries recommends changing the hydraulic oil annually.
2. Use every precaution to keep the hydraulic oil clean. If the oil must be poured from the original container into another, be sure to clean all possible contaminants from the service container. Always clean the mesh element of the filter and replace the cartridge any time the system oil is changed.
3. While the unit is shut down, a good preventive maintenance measure is to make a thorough inspection of all hydraulic components, lines, fittings, etc., as well as a functional check of each system, before placing the machine back in service.

Lubrication Specifications

Specified lubricants, as recommended by the component manufacturers, are always the best choice, however, multi-purpose greases usually have the qualities which meet a variety of single purpose grease requirements. Should any question arise, regarding the use of greases in maintenance stock, consult your local supplier for evaluation. Refer to Section 1 for an explanation of the lubricant key designations appearing in the Lubrication Chart.

2.4 CYLINDER DRIFT TEST

Maximum acceptable cylinder drift is to be measured using the following methods.

Platform Drift

Measure the drift of the platform to the ground. Lower booms (if equipped) slightly elevated, upper boom fully extended with the rated load in the platform and power off. Maximum allowable drift is 2 inches (5 cm) in 10 minutes. If the machine does not pass this test, proceed with the following.

Cylinder Drift

Table 2-2. Cylinder Drift

Cylinder Bore Diameter		Max. Acceptable Drift in 10 Minutes	
inches	mm	inches	mm
3	76.2	0.026	0.66
3.5	89	0.019	0.48
4	101.6	0.015	0.38
5	127	0.009	0.22
6	152.4	0.006	0.15
7	177.8	0.005	0.13
8	203.2	0.0038	0.10
9	228.6	0.0030	0.08

Drift is to be measured at the cylinder rod with a calibrated dial indicator. The cylinder oil must be at ambient temperature and temperature stabilized.

The cylinder must have the normal load, which is the normal platform load applied.

If the cylinder passes this test, it is acceptable.

NOTE: This information is based on 6 drops per minute cylinder leakage.

2.5 PINS AND COMPOSITE BEARING REPAIR GUIDELINES

Filament wound bearings.

- Pinned joints should be disassembled and inspected if the following occurs:
 - Excessive sloppiness in joints.
 - Noise originating from the joint during operation.
- Filament wound bearings should be replaced if any of the following is observed:
 - Frayed or separated fibers on the liner surface.
 - Cracked or damaged liner backing.
 - Bearings that have moved or spun in their housing.
 - Debris embedded in liner surface.
- Pins should be replaced if any of the following is observed (pin should be properly cleaned prior to inspection):
 - Detectable wear in the bearing area.
 - Flaking, peeling, scoring, or scratches on the pin surface.
 - Rusting of the pin in the bearing area.
- Re-assembly of pinned joints using filament wound bearings.
 - Housing should be blown out to remove all dirt and debris...bearings and bearing housings must be free of all contamination.
 - Bearing / pins should be cleaned with a solvent to remove all grease and oil...filament wound bearing are a dry joint and should not be lubricated.
 - Pins should be inspected to ensure it is free of burrs, nicks, and scratches which would damage the bearing during installation and operation.

2.6 WELDING ON JLG EQUIPMENT

NOTE: This instruction applies to repairs, or modifications to the machine and to welding performed from the machine on an external structure, or component,

Do the Following When Welding on JLG Equipment

- Disconnect the battery.
- Disconnect the moment pin connection (where fitted)
- Ground only to structure being welded.

Do NOT Do the Following When Welding on JLG Equipment

- Ground on frame and weld on any other area than the chassis.
- Ground on turntable and weld on any other area than the turntable.
- Ground on the platform/support and weld on any other area than the platform/support.
- Ground on a specific boom section and weld on any other area than that specific boom section.
- Allow pins, wear pads, wire ropes, bearings, gearing, seals, valves, electrical wiring, or hoses to be between the grounding position and the welded area.

CAUTION

FAILURE TO COMPLY WITH THE ABOVE REQUIREMENTS MAY RESULT IN COMPONENT DAMAGE (I.E. ELECTRONIC MODULES, SWING BEARING, COLLECTOR RING, BOOM WIRE ROPES ETC.)

2.7 APPLYING SILICONE DIELECTRIC COMPOUND TO ELECTRICAL CONNECTIONS

Silicone Dielectric Compound must be used on all electrical connections for the following reasons:

- To prevent oxidation at the mechanical joint between male and female pins.
- To prevent electrical malfunction caused by low level conductivity between pins when wet.

Use the following procedure to apply Silicone Dielectric Compound to the electrical connectors. This procedure applies to all plug connections not enclosed in a box. Silicone grease should not be applied to connectors with external seals.

1. To prevent oxidation, silicone grease must be packed completely around male and female pins on the inside of the connector prior to assembly. This is most easily achieved by using a syringe.

NOTE: Over a period of time, oxidation increases electrical resistance at the connection, eventually causing circuit failure.

2. To prevent shorting, silicone grease must be packed around each wire where they enter the outside of the connector housing. Also, silicone grease must be applied at the joint where the male and female connectors come together. Any other joints (around strain reliefs, etc.) where water could enter the connector should also be sealed.

NOTE: This condition is especially common when machines are pressure washed since the washing solution is much more conductive than water.

3. Anderson connectors for the battery boxes and battery chargers should have silicone grease applied to the contacts only.

NOTE: Curing-type sealants might also be used to prevent shorting and would be less messy, but would make future pin removal more difficult.

Table 2-3. Inspection and Preventive Maintenance Schedule

AREA	INTERVAL					
	Pre-Start ¹ Inspection	Weekly Preventive Maintenance	Monthly Preventive Maintenance	Pre-Delivery ² or Frequent ³ Inspection	Annual ⁴ (Yearly) Inspection	Every 2 Years
Boom Assembly	9					
Boom Weldments				1,2,4	1,2,4	
Hose/Cable Carrier Installations				1,2,9,12	1,2,9,12	
Pivot Pins and Pin Retainers				1,2	1,2	
Sheaves, Sheave Pins				1,2	1,2	
Bearings				1,2	1,2	
Wear Pads				1,2	1,2	
Covers or Shields				1,2	1,2	
Extend/Retract Chain or Cable Systems				1,2,3	1,2,3	
Platform Assembly	9					
Platform	1,2				1,2	
Railing	1,2			1	1,2	
Gate			5	1	1,5	
Floor	1,2			1	1,2	
Rotator		9,5		15		
Lanyard Anchorage Point	2			1,2,10	1,2,10	
Turntable Assembly	9					
Swing Bearing				1,2,14	1,2,3,13,14	
Swing Drive System				11	11	
Turntable Lock				1,2,5	1,2,5	
Hood, Hood Props, Hood Latches				5	1,2,5	
Chassis Assembly	9					
Tires	1	16,17		16,17,18	16,17,18	
Wheel Nuts/Bolts	1	15		15	15	
Wheel Bearings						14,24
Oscillating Axle/Lockout Cylinder Systems					5,8	
Steer Components						
Drive Motors						
Drive Hubs				11	11	
Functions/Controls	9					
Platform Controls	5	5		6	6	
Ground Controls	5	5		6	6	
Function Control Locks, Guards, or Detents	1,5	1,5		5	5	
Footswitch	1,5			5	5	

SECTION 2 - GENERAL

Table 2-3. Inspection and Preventive Maintenance Schedule

AREA	INTERVAL					
	Pre-Start ¹ Inspection	Weekly Preventive Maintenance	Monthly Preventive Maintenance	Pre-Delivery ² or Frequent ³ Inspection	Annual ⁴ (Yearly) Inspection	Every 2 Years
Emergency Stop Switches (Ground & Platform)	5			5	5	
Function Limit or Cutout Switch Systems	5			5	5	
Capacity Indicator					5	
Drive Brakes				5		
Swing Brakes				5		
Boom Synchronization/Sequencing Systems					5	
Manual Descent or Auxiliary Power				5	5	
Power System	9					
Engine Idle, Throttle, and RPM				3	3	
Engine Fluids (Oil, Coolant, Fuel)	11	9,11		11	11	
Air/Fuel Filter		1,7		7	7	
Exhaust System			1,9	9	9	
Batteries	5	1,9			19	
Battery Fluid		11		11	11	
Battery Charger		5			5	
Fuel Reservoir, Cap, and Breather	11,9		2	1,5	1,5	
Hydraulic/Electric System	9					
Hydraulic Pumps		1,9		1,2,9		
Hydraulic Cylinders		1,9,7	2	1,2,9	1,2,9	
Cylinder Attachment Pins and Pin Retainers		1,9		1,2	1,2	
Hydraulic Hoses, Lines, and Fittings		1,9	12	1,2,9,12	1,2,9,12	
Hydraulic Reservoir, Cap, and Breather	11	1,9	2	1,5	1,5	24
Hydraulic Filter		1,9		7	7	
Hydraulic Fluid	11			7,11	7,11	
Electrical Connections		1		20	20	
Instruments, Gauges, Switches, Lights, Horn		1			5,23	
General						
Operators and Safety Manuals in Storage Box	21			21	21	
ANSI and EMI Manuals/Handbooks Installed					21	
Capacity Decals Installed, Secure, Legible	21			21	21	
All Decals/Placards Installed, Secure, Legible	21			21	21	
Walk-Around Inspection Performed	21					
Annual Machine Inspection Due				21		
No Unauthorized Modifications or Additions				21	21	

Table 2-3. Inspection and Preventive Maintenance Schedule

AREA	INTERVAL					
	Pre-Start ¹ Inspection	Weekly Preventive Maintenance	Monthly Preventive Maintenance	Pre-Delivery ² or Frequent ³ Inspection	Annual ⁴ (Yearly) Inspection	Every 2 Years
All Relevant Safety Publications Incorporated				21	21	
General Structural Condition and Welds				2,4	2,4	
All Fasteners, Pins, Shields, and Covers				1,2	1,2	
Grease and Lubricate to Specifications				22	22	
Function Test of All Systems	21			21	21, 22	
Paint and Appearance				7	7	
Stamp Inspection Date on Frame					22	
Notify JLG of Machine Ownership					22	
Footnotes: ¹ Prior to use each day; or at each Operator change ² Prior to each sale, lease, or delivery ³ In service for 3 months or 150 Hours; or Out of service for 3 months or more; or Purchased used ⁴ Annually, no later than 13 months from the date of the prior inspection						
Performance Codes: 1 - Check for proper and secure installation 2 - Visual inspection for damage, cracks, distortion or excessive wear 3 - Check for proper adjustment 4 - Check for cracked or broken welds 5 - Operates Properly 6 - Returns to neutral or "off" position when released 7 - Clean and free of debris 8 - Interlocks function properly 9 - Check for signs of leakage 10 - Decals installed and legible 11 - Check for proper fluid level 12 - Check for chafing and proper routing 13 - Check for proper tolerances 14 - Properly lubricated 15 - Torqued to proper specification 16 - No gouges, excessive wear, or cords showing 17 - Properly inflated and seated around rim 18 - Proper and authorized components 19 - Fully charged 20 - No loose connections, corrosion, or abrasions 21 - Verify 22 - Perform 23 - Sealed Properly 24 - Drain, Clean, Refill						

SECTION 2 - GENERAL

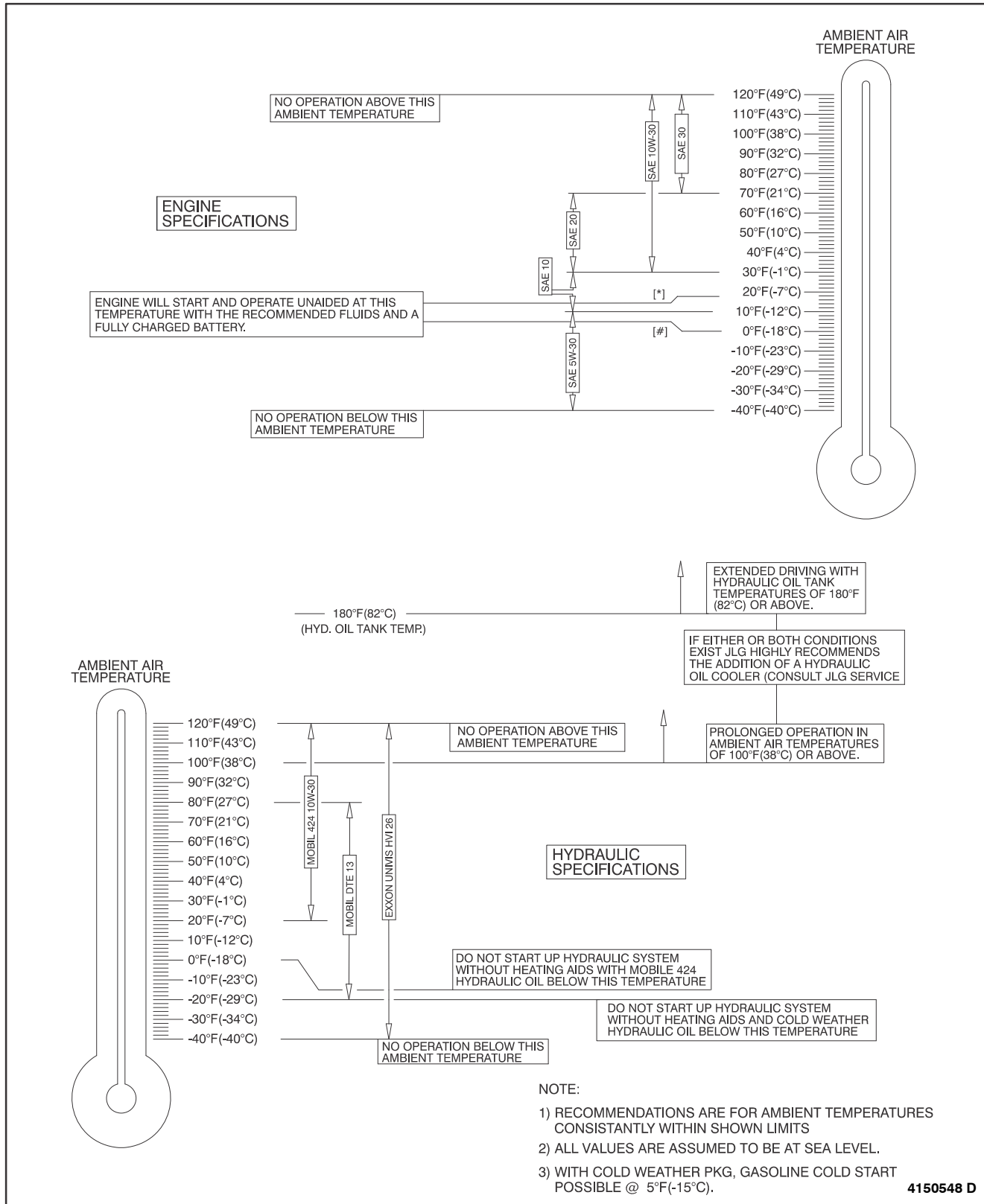


Figure 2-1. Operating Temperature Specifications - Kubota

SECTION 3. CHASSIS & TURNTABLE

3.1 TIRES & WHEELS

Tire Inflation

The air pressure for pneumatic tires must be equal to the air pressure that is stenciled on the side of the JLG product or rim decal for safe and proper operational characteristics.

Tire Damage

For pneumatic tires, JLG Industries, Inc. recommends that when any cut, rip, or tear is discovered that exposes sidewall or tread area cords in the tire, measures must be taken to remove the JLG product from service immediately. Arrangements must be made for replacement of the tire or tire assembly.

For polyurethane foam filled tires, JLG Industries, Inc. recommends that when any of the following are discovered, measures must be taken to remove the JLG product from service immediately and arrangements must be made for replacement of the tire or tire assembly.

- a smooth, even cut through the cord plies which exceeds 3 inches (7.5 cm) in total length
- any tears or rips (ragged edges) in the cord plies which exceeds 1 inch (2.5 cm) in any direction
- any punctures which exceed 1 inch in diameter
- any damage to the bead area cords of the tire

If a tire is damaged but is within the above noted criteria, the tire must be inspected on a daily basis to insure the damage has not propagated beyond the allowable criteria.

Tire Replacement

JLG recommends a replacement tire be the same size, ply and brand as originally installed on the machine. Please refer to the JLG Parts Manual for the part number of the approved tires for a particular machine model. If not using a JLG approved replacement tire, we recommend that replacement tires have the following characteristics:

- Equal or greater ply/load rating and size of original
- Tire tread contact width equal or greater than original
- Wheel diameter, width, and offset dimensions equal to the original
- Approved for the application by the tire manufacturer (including inflation pressure and maximum tire load)

Unless specifically approved by JLG Industries Inc. do not replace a foam filled or ballast filled tire assembly with a

pneumatic tire. When selecting and installing a replacement tire, ensure that all tires are inflated to the pressure recommended by JLG. Due to size variations between tire brands, both tires on the same axle should be the same.

Wheel Replacement

The rims installed on each product model have been designed for stability requirements which consist of track width, tire pressure, and load capacity. Size changes such as rim width, center piece location, larger or smaller diameter, etc., without written factory recommendations, may result in an unsafe condition regarding stability.

Wheel Installation

It is extremely important to apply and maintain proper wheel mounting torque.

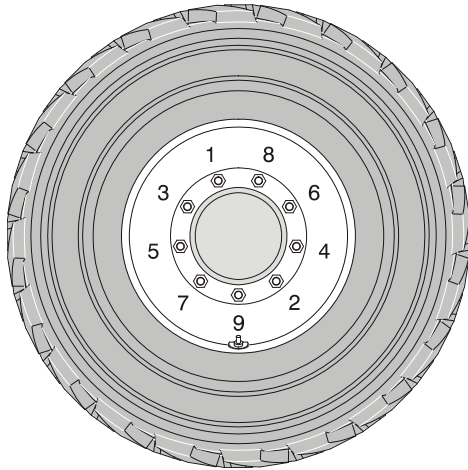
WARNING

WHEEL NUTS MUST BE INSTALLED AND MAINTAINED AT THE PROPER TORQUE TO PREVENT LOOSE WHEELS, BROKEN STUDS, AND POSSIBLE DANGEROUS SEPARATION OF WHEEL FROM THE AXLE. BE SURE TO USE ONLY THE NUTS MATCHED TO THE CONE ANGLE OF THE WHEEL.

Tighten the lug nuts to the proper torque to prevent wheels from coming loose. Use a torque wrench to tighten the fasteners. If you do not have a torque wrench, tighten the fasteners with a lug wrench, then immediately have a service garage or dealer tighten the lug nuts to the proper torque. Over-tightening will result in breaking the studs or permanently deforming the mounting stud holes in the wheels. The proper procedure for attaching wheels is as follows:

1. Start all nuts by hand to prevent cross threading. DO NOT use a lubricant on threads or nuts.

2. Tighten nuts in the following sequence:



3. The tightening of the nuts should be done in stages. Following the recommended sequence, tighten nuts per wheel torque chart.

Table 3-1. Wheel Torque Chart

TORQUE SEQUENCE		
1st Stage	2nd Stage	3rd Stage
40 ft. lbs. (55 Nm)	100 ft. lbs. (130 Nm)	170 ft. lbs. (255 Nm)

4. Wheel nuts should be torqued after first 50 hours of operation and after each wheel removal. Check torque every 3 months or 150 hours of operation.

3.2 DRIVE HUB -REAR (PRIOR TO S/N 0300112585)

The final drive consists of two planetary stages with an integrated disconnect mechanism. Each stage incorporates a set of matched planetary gears, which provide an equal load distribution. All torque transmitting components are made of forged quenched and tempered high-alloy steels. External gears are carburized. Precision roller bearings support the sprocket or wheel loads. A shaft seal protects the unit against contamination.

Disengaging for Towing

NOTICE

PRIOR TO OPERATING THE DISCONNECT THE MACHINE HAS TO BE ON LEVEL GROUND AND COMPLETELY SECURED FROM ANY MOVEMENT, I.E. VIA TOW BAR TO PULLING VEHICLE. THE MACHINE SHOULD NOT BE MOVED UNLESS IT IS SECURED TO THE TOWING VEHICLE TO PREVENT RUNAWAY.

NOTICE

ENSURE THE DISCONNECT MECHANISM IS ONLY OPERATED WITH THE MACHINE AT A STANDSTILL.

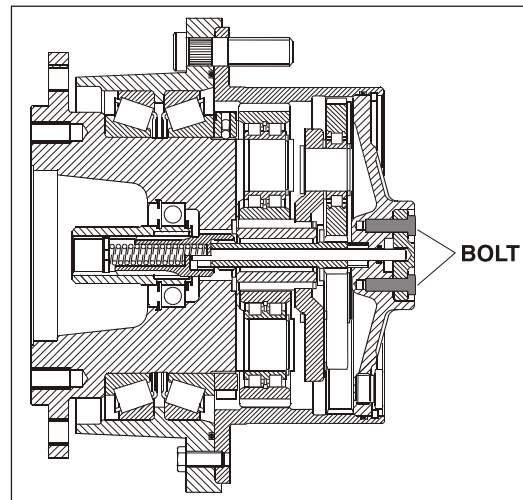
CAUTION

THE GEAR DRIVE TEMPERATURE SHOULD BE CHECKED PRIOR TO ANY WORK BEING DONE. THIS IS IMPORTANT IF THE GEAR DRIVE HAS RECENTLY BEEN OPERATED SINCE IT MAY BE HOT AND CAUSE INJURY.

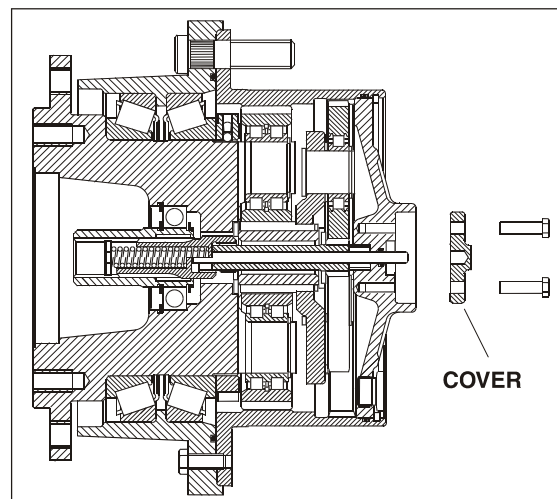
NOTICE

ENSURE THE AREA SURROUNDING THE DISCONNECT IS CLEANED PRIOR TO OPERATION. ENSURE THAT DIRT OR OTHER CONTAMINANTS DO NOT ENTER THE GEAR DRIVE.

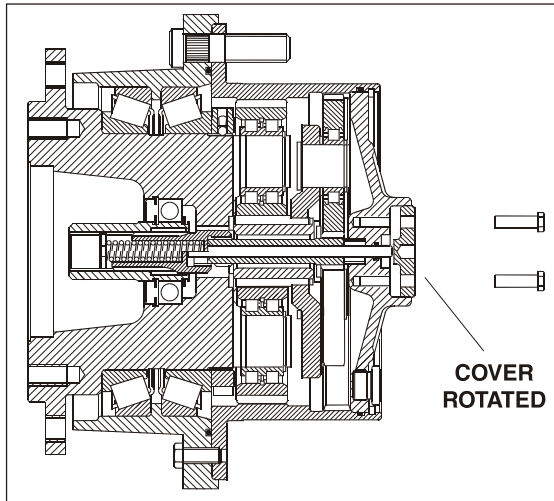
1. Remove the two hex head bolts from the cover.



2. Remove the cover.



3. Rotate the cover to show the inside diameter



4. Press the cover sufficiently against the shift rod to insert the bolts at least 2 to 3 threads into the cover. This will subject the shift rod to spring force.
5. Install the bolts and torque 6.3 ft. lbs. (8.8 Nm) until they are flush with the cover.
6. The sun gear shaft and input shaft are now disconnected and the machine is ready to be towed.

⚠ WARNING

BEFORE THE MACHINE IS SEPARATED FROM THE TOWING VEHICLE, EITHER THE GEAR DRIVE HAS TO BE REENGAGED OR SUITABLE MEASURES MUST BE TAKEN TO SECURE THE MACHINE FROM MOVEMENT.

Engaging after Towing is Complete

NOTICE

PRIOR TO OPERATING THE DISCONNECT THE MACHINE HAS TO BE ON LEVEL GROUND AND COMPLETELY SECURED FROM ANY MOVEMENT, I.E. VIA TOW BAR TO PULLING VEHICLE. THE MACHINE SHOULD NOT BE MOVED UNLESS IT IS SECURED TO THE TOWING VEHICLE TO PREVENT RUNAWAY.

⚠ CAUTION

ENSURE THE DISCONNECT MECHANISM IS ONLY OPERATED WITH THE MACHINE AT A STANDSTILL.

⚠ WARNING

THE GEAR DRIVE TEMPERATURE SHOULD BE CHECKED PRIOR TO ANY WORK BEING DONE. THIS IS IMPORTANT IF THE GEAR DRIVE HAS RECENTLY BEEN OPERATED SINCE IT MAY BE HOT AND CAUSE INJURY.

⚠ CAUTION

ENSURE THE AREA SURROUNDING THE DISCONNECT IS CLEANED PRIOR TO OPERATION. ENSURE THAT DIRT OR OTHER CONTAMINANTS DO NOT ENTER THE GEAR DRIVE.

⚠ WARNING

THE COVER IS UNDER SPRING FORCE

1. Remove the 2 hex head bolts securing the cover evenly and remove the cover.
2. Rotate the cover 180 degrees and secure with the two hex head bolts.
3. Torque the hex head bolts 6.3 ft.lbs. (8.8 Nm).

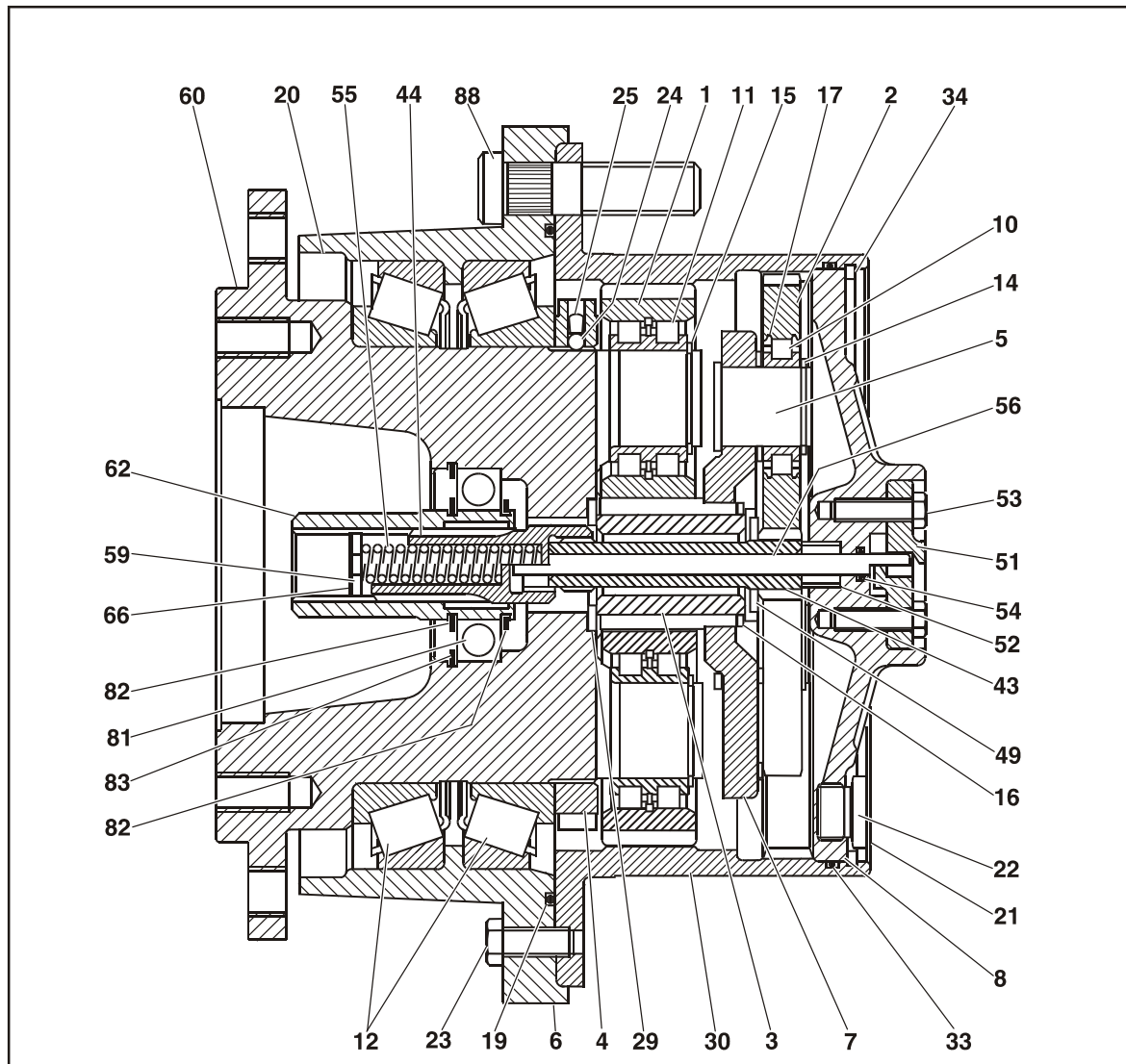
NOTICE

PULL VERY SLOWLY WITH THE TOWING VEHICLE CONNECTED TO THE MACHINE TO ALLOW THE SPLINE OF THE SUN GEAR SHAFT TO ENGAGE WITH THE SPLINE OF THE INPUT SHAFT.

⚠ CAUTION

DO NOT OPERATE THE MOTOR TO MAKE THE SUN GEAR SHAFT TO ENGAGE WITH THE SPLINE OF THE INPUT SHAFT.

4. Check to ensure all bolts are tight and all components are returned to their original positions.
5. The gear drive should now be reengaged and the machine can be disconnected from the towing vehicle.



- | | | | | |
|--------------------|--------------------|---------------------|---------------------|--------------------|
| 1. Planet Gear | 13. Not Used | 24. Ball | 45 to 48. Not Used | 60. Spindle |
| 2. Planet Gear | 14. Retaining Ring | 25. Expander | 49. Thrust Washer | 61. Not Used |
| 3. Sun Gear | 15. Retaining Ring | 26. to 28. Not Used | 50. Not Used | 62. Coupler |
| 4. Shaft Nut | 16. Retaining Ring | 29. Housing Washer | 51. Cover | 63 to 65. Not Used |
| 5. Planet Bolt | 17. Support Disk | 29. Ring Gear | 52. Disk | 66. Snap Ring |
| 6. Support Ring | 18. Not Used | 31. & 32. Not Used | 53. Bolt | 67 to 80. Not Used |
| 7. Planet Carrier | 19. O-ring | 33. O-ring | 54. O-ring | 81. Ball Bearing |
| 8. Cover | 20. Ring Seal | 34. Retaining Ring | 55. Pressure Spring | 82. Snap Ring |
| 9. Not Used | 21. Plug | 35 to 42. Not Used | 56. Shaft Rod | 83. Snap Ring |
| 10. Roller Bearing | 22. Ring Seal | 44. Input Shaft | 57 & 58. Not Used | 84 to 87. Not Used |
| 11. Roller Bearing | 23. Bolt | | 59. Disk Rotor | 88. Wheel Stud |
| 12. Roller Bearing | | | | |

Figure 3-1. Torque Hub

Disassembly

1. Position drive so that one of the fill holes is at the bottom of the end cover and drain the oil.
2. Remove all bolts holding the motor and Remove motor from drive.
3. Compress the disc (59) using a simple fixture or other suitable device.
4. Remove snap ring (66) and release pressure on disc until loose. Remove tool and disc.
5. Remove the spring (55) from the input shaft (44).
6. Turn unit so that cover (8) is in the up position.
7. Remove the screw plugs (22) and seal rings (21).
8. Remove snap rings (34), and remove the cover unit (8) from drive.
9. Remove "o" ring (33).
10. Remove the first stage planetary assembly (7).
11. Remove hex bolts (23).
12. Remove ring gear (30) and "o" ring (19).
13. Remove snap rings (15).
14. Pull off planet gears (1) together with cylindrical roller bearings (11) from spindle (60).

NOTE: Further disassembly of the hub is discouraged. reinstallation of the shaft nut (4) requires a special tool and a torque of 626 ft./ lbs. (876 Nm) for proper reassembly. These components Will Fail if not properly reassembled.

15. Inspect the planetary stage assemblies as complete units. Thoroughly clean and check both the gearing and the bearings for damage and apply new oil. If the gears or bearings need replacing, they must be replaced as complete sets.
16. The first stage planetary gears (2) **must be changed in sets of three pieces.**
17. The first stage planetary gears (2) **must** be changed as a complete set of three and JLG recommends changing the sun gear shaft (43) along with this set of planets.
18. The second stage planetary bearings (11) **must** be replaced in sets of four pieces.
19. The second stage planetary gears (1) **must** be changed as a complete set of four and JLG recommends changing the sun gear (3) along with this set of planets.

Disassembly of Cover

1. Loosen and remove hex head bolts (53) to remove cover (51).
2. Remove shaft rod (56) and "o" ring (54).
3. Remove sleeve (52).

Disassembly of the first stage planetary assembly (7)

1. Push sun gear shaft (43) out of the first stage.
2. Remove snap rings (14).
3. Press planet pins (5) out of the planet gears (2).
4. Pull cylindrical roller bearing (10) out of the planet gears (2).
5. Remove snap ring (16) from sun gear (3) and Remove planet carrier (7) from sun gear (3).
6. Remove thrust washer (49).

Disassembly of second stage planet gears (1)

Press cylindrical roller bearings out of planet gears (1).

Assembly of first stage planetary assembly (7)

1. Pre-freeze planet pins (5) and install into planet carrier (7).
2. Install planet carrier (7) together with planet pins (5) on sun gear (3), and install snap ring (16).
3. Pre-heat thrust washer (49) and Install onto sun gear shaft (43).
4. Put sun gear shaft (43) into sun gear (3).
5. Pre-heat stay rings (17) and install onto planet pins (5).
6. Pre-heat cylindrical roller bearings (10) and install onto planet pins (5) and fix bearings with snap rings (14).

Assembly of end cover unit (8)

1. Press sleeve (52) into cover (8).
2. Install "o" ring (54) into groove of cover (8).
3. Install shift rod (56) into cover (8).
4. Install the cover (51) into cover (8) and fix cover (51) with hex bolts (53). Tighten bolts with torque wrench to 6.3 ft. lbs. (8.5 Nm).

Final Assembly

1. Install thrust washer (29) in spindle (60).
2. Install "o" ring (19) into groove of support ring (6).
3. Install planet gears (1) onto planet pins which are part of spindle (60).
4. Install snap rings (15) on planet pins of spindle (60) in order to fix the planet gears (1).
5. Put ring gear (30) onto support ring (6) and fix ring gear (30) with hex head bolts (23). Tighten bolts with torque wrench to 15.5 ft. lbs. (21.1 Nm).
6. Insert the first stage planetary assembly (7) into drive.
7. Install "o" ring (33) in groove of ring gear (30).
8. Install end the cover unit (8) on shoulder ring gear (30) and fix with snap ring (34).
9. Install seal rings (21) and screw plugs (22).
10. Before installation of motor, CHECK THAT THERE IS 1-2mm OF CLEARANCE BETWEEN THE MOTOR SPLINE SHAFT SHOULDER AND THE COUPLER (62).
11. Install the motor and reconnect hydraulic lines.
12. Roll motor so that one fill plug is at 12 o'clock position, and the other is at 3 o'clock. Fill to bottom of 3 o'clock plug with gear oil. reinstall plugs

Initial Start-Up and After Repairs

Before operating the machine, make sure that the drive is filled with clean oil, approximately 0.2 us gallons (0.8 L). An accurate oil level is determined by the oil level plug, which should be removed before oil fill.

With the gear case filled to their proper levels, start the machine and allow sufficient time for run-in at moderate pressure and speed before running at full speed. After 4 hours of operation, recheck oil level.

Daily: - Check for oil leakage

Weekly: - Check oil level

Monthly: - Check mounting bolt torque

Oil Change Interval-Gear Drive

1. Perform the first oil change after approximately 150 hours.
2. Subsequent changes, every 1500 hours or annually, whichever occurs first.

NOTE: Flush the drive before filling with new oil.

3.3 DRIVE HUB (S/N 115723 TO PRESENT)

Roll and Leak Testing

Torque-Hub units should always be roll and leak tested before disassembly and after assembly to make sure that the unit's gears, bearings and seals are working properly. The following information briefly outlines what to look for when performing these tests.

THE ROLL TEST

The purpose of the roll test is to determine if the unit's gears are rotating freely and properly. You should be able to rotate the gears in your unit by applying constant force to the roll checker. If you feel more drag in the gears only at certain points, then the gears are not rolling freely and should be examined for improper installation or defects. Some gear packages roll with more difficulty than others. Do not be concerned if the gears in your unit seem to roll hard as long as they roll with consistency.

THE LEAK TEST (MAIN UNIT)

The purpose of a leak test is to make sure the unit is air tight. You can tell if your unit has a leak if the pressure gauge reading on your leak checking fitting starts to fall after the unit has been pressurized and allowed to equalize. Leaks will most likely occur at the pipe plugs, the main seal or wherever o-rings or gaskets are located. The exact location of a leak can usually be detected by brushing a soap and water solution around the main seal and where the o-rings or gaskets

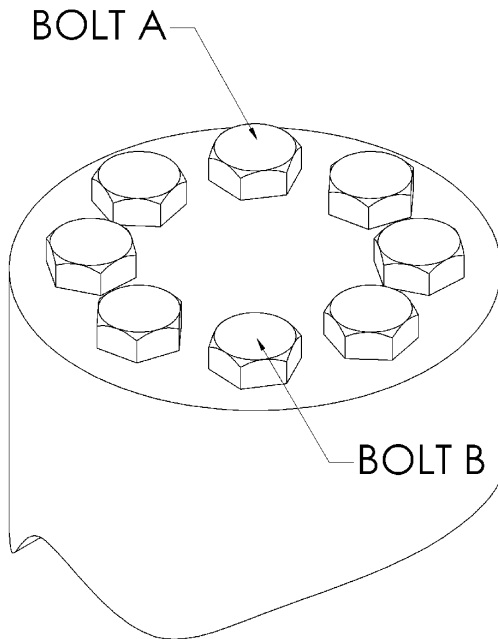
meet on the exterior of the unit, then checking for air bubbles. If a leak is detected in a seal, o-ring or gasket, the part must be replaced, and the unit rechecked. Leak test at 10 psi for 20 minutes.

Tightening and Torquing Bolts

If an air impact wrench is used to tighten bolts, extreme care should be taken to ensure that the bolts are not tightened beyond their specified torque.

The following steps describe how to tighten and torque bolts or socket head cap screws in a bolt circle.

1. Tighten (but do not torque) bolt "A" until snug.
2. Go to the opposite side of the bolt circle and tighten bolt "B" until equally snug.
3. Crisscross around the bolt circle and tighten remaining bolts.
4. Now use a torque wrench to apply the specified torque to bolt "A".
5. Using the same sequence, crisscross around the bolt circle and apply an equal torque to the remaining bolts.



Main Disassembly

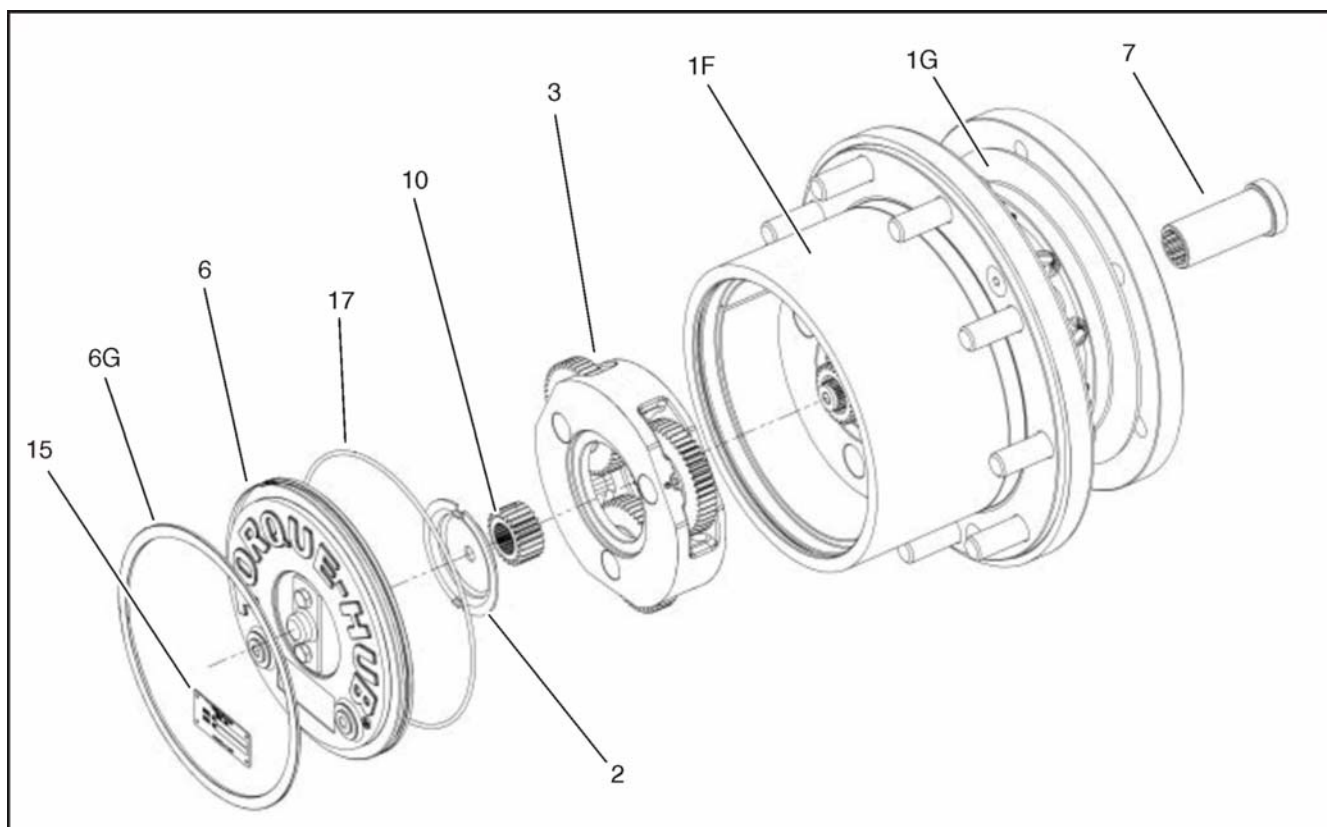
1. Perform Roll Check and Leak Check if applicable prior to disassembling the unit.
2. Drain oil from unit. Note the condition and volume of the oil.
3. Remove Coupling (7) from Spindle End first.
4. Remove Retaining Ring (6G) by prying the open end of Retaining Ring out of the groove in the Ring Gear (1F) with a screwdriver, then grasp the loose end with pliers and pull the Retaining Ring completely out of the groove.
5. Remove the Cover Subassembly (6) from the unit. The unit can be carefully pressurized with air to pop the cover out of the unit. Washer (2) may have to be removed separately because of the loose attachment.
6. Remove the First Stage Sun Gear (10) if applicable.

NOTE: On units with ratios greater than 36:1 numerically, there will not be a separate First Stage Sun Gear (10), as the gear teeth will be integral to the Input Shaft (9).

7. Remove the Input Carrier Sub-assembly (3). Continued on next page.
8. Remove the Second Stage Sun Gear (11).
9. Remove the Input Shaft (9).

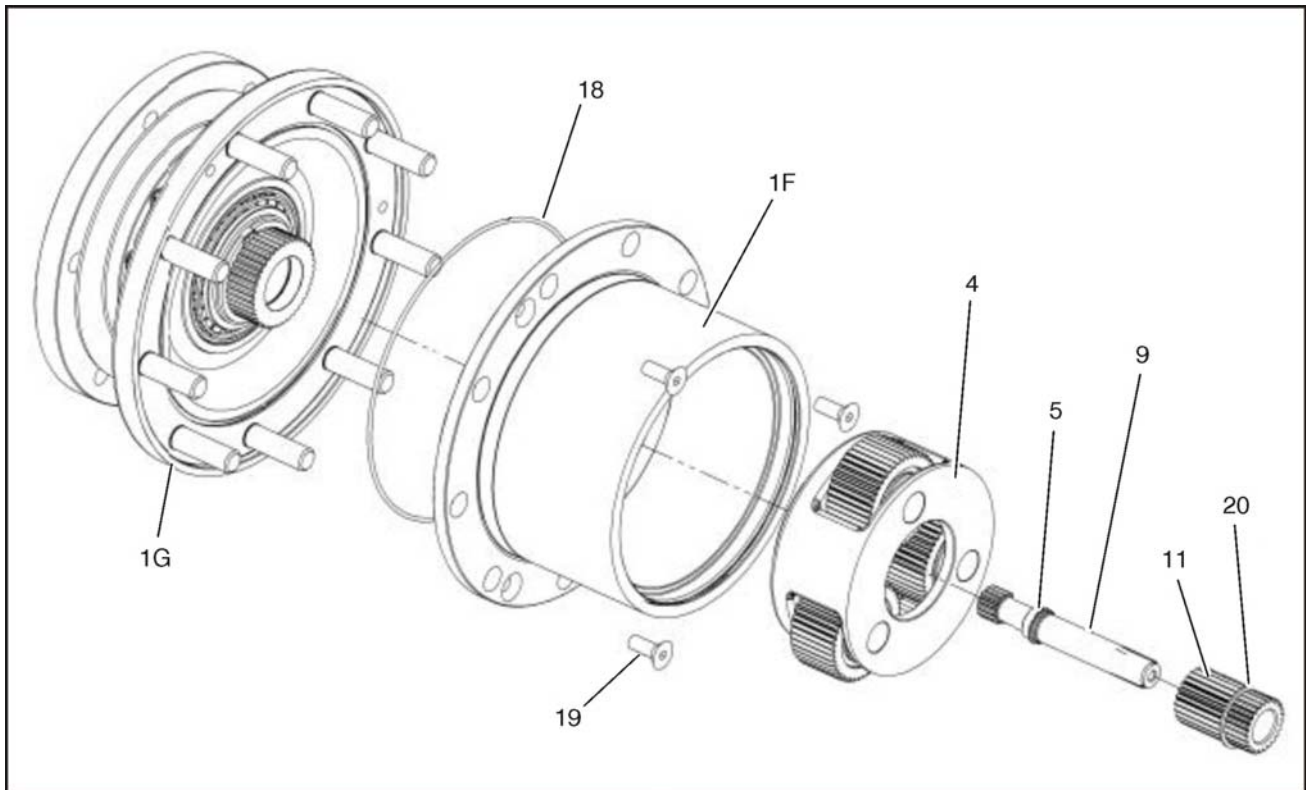
NOTE: On units with a ratio 48:1, the Sun Gear (11) and the Input Shaft (9) will need to be removed together.

10. Remove the Output Stage Carrier Sub-assembly (4)
11. Loosen and remove the three Flat Head Bolts (19) that retain the Ring Gear (1F) to the Housing (1G).
12. Lift the Ring Gear (1F) off of the Housing (1G).
13. Remove the O-ring (18) from between the Housing (1G) and the Ring Gear (1F).



- | | |
|-------------------------------|---------------------------|
| 1F. Ring Gear | 7. Coupling |
| 1G. Housing | 9. Input Shaft |
| 2. Washer | 10. First Stage Sun Gear |
| 3. Input Carrier Subassembly | 11. Second Stage Sun Gear |
| 4. Output Carrier Subassembly | 15. I.D. Plate |
| 6. Cover Assembly | 18. O-ring |
| 6G. Retaining Ring | 19. Flat Head Bolts |

Figure 3-2. Main Disassembly Drawing 1

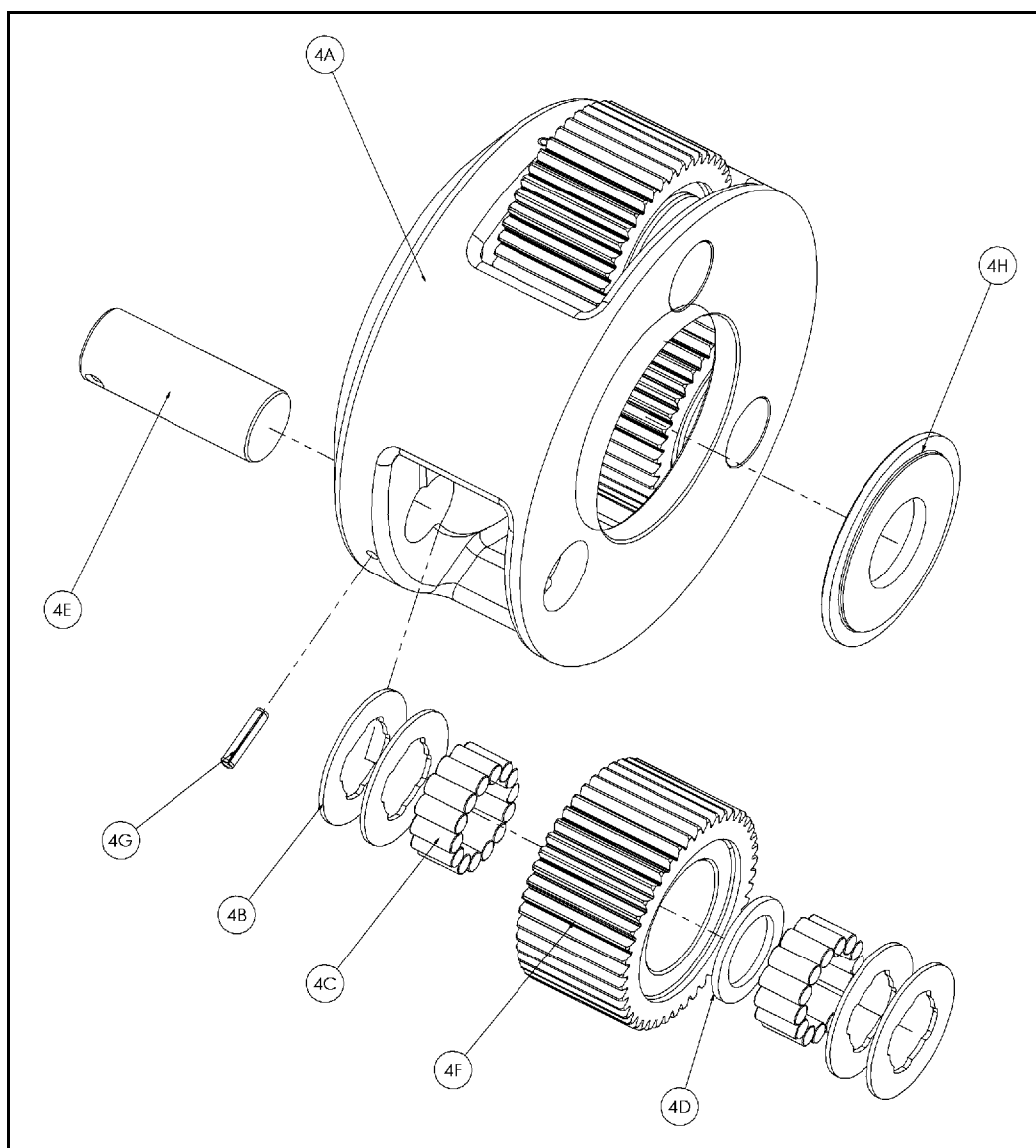


- | | |
|-------------------------------|---------------------------|
| 1F. Ring Gear | 9. Input Shaft |
| 1G. Housing | 10. First Stage Sun Gear |
| 4. Output Carrier Subassembly | 11. Second Stage Sun Gear |
| 5. Retaining Ring | 18. O-ring |
| 6. Cover Assembly | 19. Flat Head Bolts |
| 6G. Retaining Ring | 20. Retaining Ring |

Figure 3-3. Main Disassembly Drawing 2

Output Carrier Disassembly

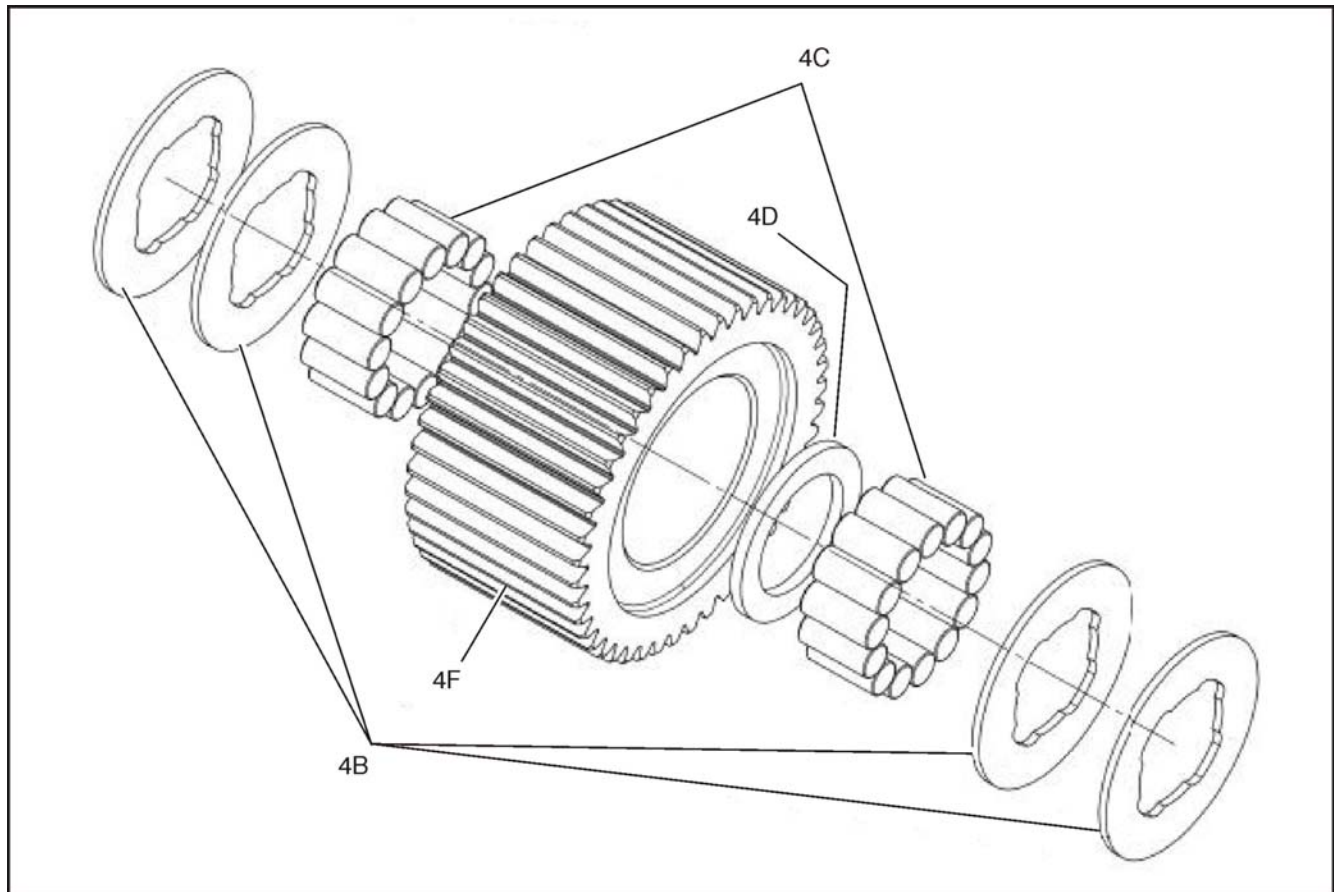
1. Using a 1/8" diameter punch, drive the Roll Pin (4G) into the Planet Shaft (4E) until it bottoms against the Carrier (3A).
2. Using a soft face hammer, tap the Planet Shaft (4E) out of the Carrier (4A).
3. Using a 1/8" diameter punch, drive the Roll Pin (4G) out of the Planet Shaft (4E). NOTE: The Roll Pins (4G) should not be reused when reassembling the unit.
4. Slide the Planet Gear Sub-assembly (4) out of the Output Carrier (4A) being careful to not drop the Needle Bearings (4C) in the process.



- | | |
|-------------------|------------------|
| 4A Output Carrier | 4E Planet Shaft |
| 4B Thrust Washer | 4F Planet Gear |
| 4C Needle Bearing | 4G Roll Pin |
| 4D Thrust Spacer | 4H Thrust Washer |

Figure 3-4. Output Carrier

5. Remove 4 Thrust Washers (4B), 28 Needle Rollers (4C) and the Thrust Spacer (4D) from the Second Stage Planet Gear (4F).
6. Repeat Steps 1 through 5 for the remaining two Planet Gears (4F).
7. Remove the Thrust Washer (4H) from the counter-bore in the Output Carrier (4A).



- 1F Output Carrier
- 4B Thrust Washer
- 4C Needle Bearing
- 4D Thrust Spacer
- 4F Planet Gear

Figure 3-5. Planet Gear

Input Carrier Disassembly

1. Using a 1/8" diameter punch, drive the Roll Pin (4G) into the Planet Shaft (3E) until it bottoms against the Carrier (3A).
2. Using a soft face hammer, tap the Planet Shaft (3E) out of the Carrier (3A).
3. Using a 1/8" diameter punch, drive the Roll Pin (4G) out of the Planet Shaft (3E). NOTE: The Roll Pins (4G) should not be reused when reassembling the unit.
4. Slide the Planet Gear (3F) and the two Thrust Washers (3B) out of the Carrier (3A).
5. Remove the 14 needle Bearings (3C) from the bore of the Planet Gear (3F).
6. Repeat steps 1 through 5 for each of the two remaining planet gears.

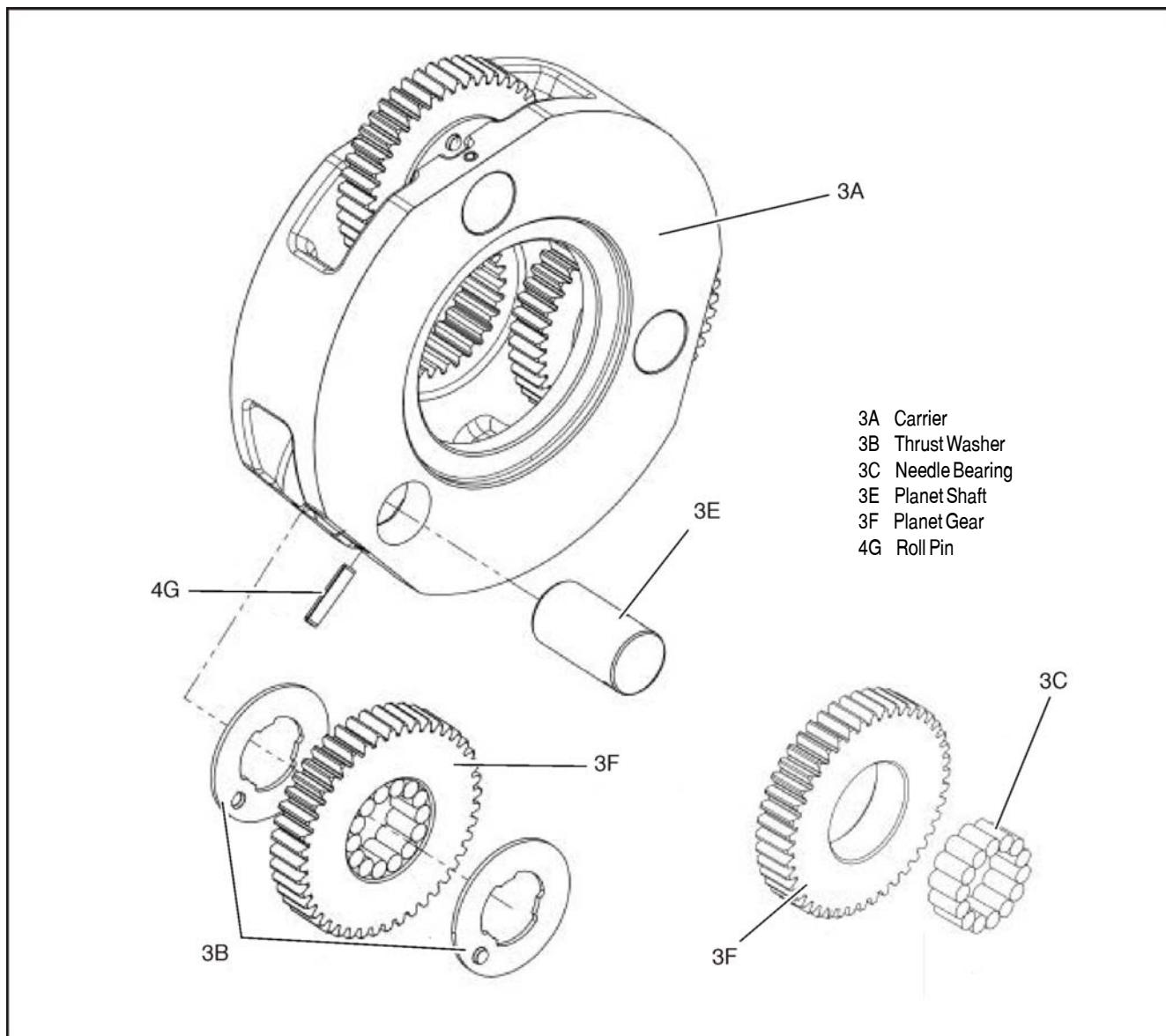


Figure 3-6. Input Carrier

Hub-Spindle Disassembly

1. Place unit on bench with Spindle (1A) end down.
2. Remove Retaining Ring (1J) with appropriate tool.
3. Remove Spacer (1N).
4. Remove "A" position Bearing Cone (1E) from Bearing Cup (1D) in Hub (1G).
5. Lift Hub (1G) off of Spindle (1A). Remove Boot Seal (1Q) from Hub (1G) if applicable.

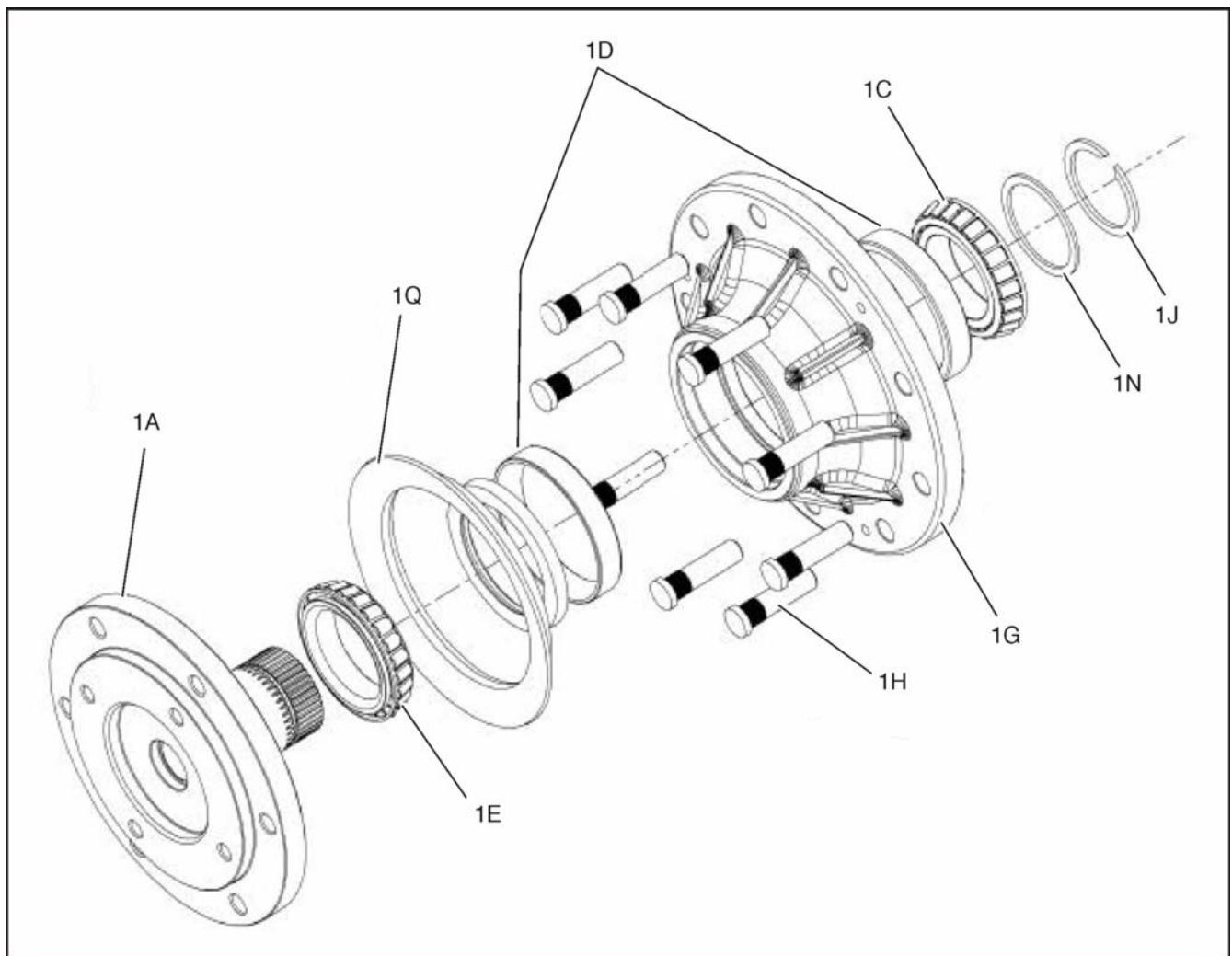
6. If necessary, press 9 Studs (1H) out of Hub (1G). Locate Hub (1G) on Seal (1B) end.

7. Remove Seal (1B) from Hub (1G).

NOTE: The Seal (1B) should NOT be reused when reassembling the unit.

8. Remove "B" position Bearing Cone (1E) from Hub (1G).

9. Using a soft steel rod, knock both Bearing Cups (1D) out of Hub (1G).

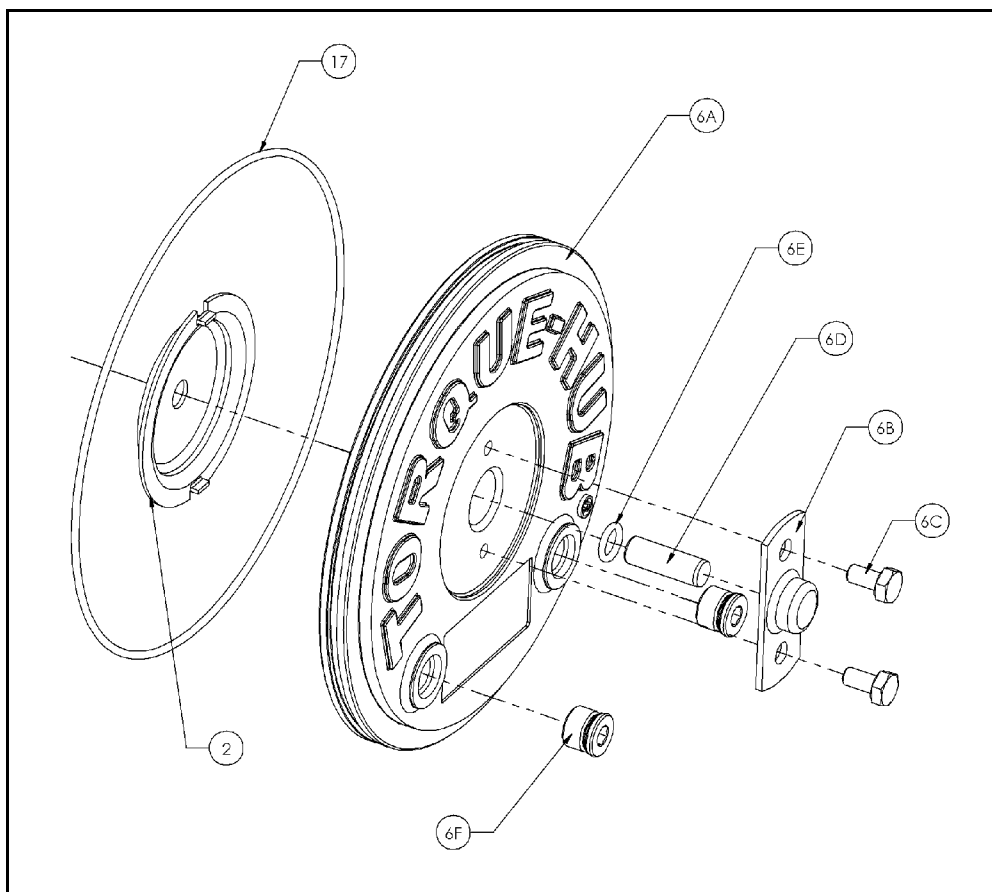


- | | |
|-------------------------|------------------------|
| 1A Spindle | 1H Stud |
| 1D Tapered Bearing Cup | 1J Retaining Ring Ext. |
| 1E Tapered Bearing Cone | 1N Spacer |
| 1G Hub (Housing) | 1Q Seal Boot |

Figure 3-7. Hub Spindle

Cover Disassembly

1. Remove O-Ring (17) from groove in Cover (6A).
2. Remove Thrust Washer (2) from Cover (6A) pockets.
3. Unscrew two Hex Head Bolts (6C) and remove Disengage Cap (6B) from Cover (6A).
4. Pull Disengage Rod (6D) out from Cover (6A).
5. Use appropriate tool to remove O-ring (6E) from internal groove in Cover (6A).
6. Remove two O-Ring Pipe Plugs (6F) from Cover (6A).



- 2 Thrust Spacer
- 3A Input Carrier
- 6A Cover
- 6B Disengage Cap
- 6C Bolt, Hex
- 6D Dowel Pin
- 6E O-ring
- 6F Pipe Plug
- 17 O-ring

Figure 3-8. Cover Assembly

Input Carrier Assembly

(Refer to Figure 3-6., Input Carrier)

1. Apply a liberal coat of grease to the bore of one Input Planet Gear (3F).
2. Line the inside of the Planet Gear (3F) with 14 Needle Rollers (3C).

NOTE: *The last roller installed must be installed end wise. That is, the end of the last roller must be placed in between the ends of the two rollers which form the space, and then slid, parallel to the other rollers, into place.*

3. Set Carrier (3A) in an upright position.
4. Insert a Planet Shaft (3E) into the planet shaft hole in the end of the Carrier (3A) opposite the splined end. The end of the planet shaft that does NOT have the roll pin hole should be inserted into the carrier FIRST.
5. Place one Thrust Washer (3B) onto the end of Planet Shaft (3E). Make sure the flat faces towards the inside of the carrier and make sure the button fits in the pocket on the inside of the Carrier (3A) towards the OD.
6. Following the thrust washer, place Planet Gear (3F) with needle rollers, onto Planet Shaft (3E).
7. Following the planet gear, place one more Thrust Washer (3B) onto Planet Shaft (3E). Align the Thrust Washer (3B) in the same manner described in Step 5.
8. Now insert Planet Shaft (3E) through the opposite planet shaft hole on Carrier (3A). Use an alignment punch or similar tool to align the roll pin holes on Carrier (3A) and Planet Shaft (3E).

NOTE: *Be sure not to hit the Planet Gears (3F) when driving in the Roll Pins (4G).*

9. Drive Roll Pin (4G) down into the aligned roll pin holes. Pin should be flush with the flat of carrier.
10. Repeat Steps 1-9 for the installation of the two remaining Planet Gears (3F).

NOTE: *Some grease may need to be applied to the Thrust Washers (3B) to hold them in place while installing the planet gears.*

Output Planet Gear Assembly

(Refer to Figure 3-5., Planet Gear)

1. Apply a liberal coat of grease to the bore of one Output Planet Gear (4F).
2. Line the inside of the Planet Gear (4F) with 14 Needle Rollers (4C).

NOTE: *The last roller installed must be installed end wise. That is, the end of the last roller must be placed in between the ends of the two rollers which form the space, and then slid, parallel to the other rollers, into place.*

3. Place Spacer (4D) into the bore of the Output Planet (4F).
4. Repeat Step 2 to put in second roll of Needle Rollers (4C).
5. Apply grease to hold two Thrust Washers (4B) together and onto Output Planet Gear (4F) counter-bore. Do the same to the other side.
6. Repeat Steps 1 -5 to finish the assembly of the two remaining Output Planet Gears (4F).

Output Carrier Assembly

(Refer to Figure 3-4., Output Carrier)

1. Place Thrust Washer (4H) into counterbore of Carrier (4A). BE SURE the small diameter side of Washer (4H) facing planet gear side.
2. Place Planet Gear Sub-assembly (4) into Carrier (4A). Visually align the planet gear bore with one of the planet shaft holes on the Carrier (4A).
3. Insert a Planet Shaft (4E) into the planet shaft hole described in Step 2 on Carrier (4A). The end of the planet shaft that does NOT have the roll pin hole should be inserted into the Carrier (4A) FIRST.
4. Now insert Planet Shaft (4E) through the first set of Thrust Washers (4B), Planet gear, then the second set of Thrust Washers (4B). Use an alignment punch or similar tool to align roll pin holes on Carrier (4A) and Planet Shaft (4E).

NOTE: Be sure not to hit the Planet Gears (4F) when driving in Roll Pins (4G).

5. Drive Roll Pin (4G) down into the aligned roll pin holes. Pin should be flush with OD of Carrier (4A).
6. Repeat Steps 1-5 for the installation of the two remaining Planet Gears (4F).

Hub-Spindle Assembly

(Refer to Figure 3-7., Hub Spindle)

NOTE: Spray a light film of oil on all component parts during assembly.

1. Place Hub (1G) into pressing base. Press nine Studs (1H) into Hub.

NOTE: Use enough pressure to press in studs. Don't use excessively high pressure to press in studs or hub may crack.

NOTE: Spray a generous amount of oil on bearings during installation.

2. Press Bearing Cup (1D), position "A", into Hub (1G) using appropriate pressing tool.
3. Turn hub over and press Bearing Cup (1D), position "B", into hub using appropriate pressing tool.
4. Place Bearing Cone (1E), into Bearing Cup (1D), position "B".
5. Grease Seal (1B) lip and press seal into Hub (1G) using appropriate tool until seal is flush with end of hub.
6. Press Seal Boot (1Q) onto Hub (1G) if required. Turn Hub (1G) over and lower onto Spindle (1A).
7. Install Bearing Cone (1C) into Bearing Cup (1D), position "A".
8. Place Bearing Spacer (1N) on top of Bearing Cone (1C).
9. Using appropriate tool, install Retaining Ring (1J) into Spindle (1A) groove. Make sure ring is completely seated in groove.

NOTE: Extra bearing pre-load caused by using tool in Step #9 must be removed. This should be done by placing a tool (NOT THE SAME TOOL USED IN STEP #9) on the end of the spindle, and then striking the tool with a piece of barstock. This should be adequate to remove any additional bearing pre-load.

Cover Subassembly

(Refer to Figure 3-8., Cover Assembly)

1. Grease O-Ring (6E) and insert into internal groove in Cover (6A).
2. Assemble Disengage Cap (6B) onto Cover (6A) using two Hex Head Bolts (6C). Torque bolts to 70-80 in-lbs.
3. Insert Disengage Rod (6D) into hole in Cover (6A) until it touches the inside of the Disengage Cap (6B).

NOTE: *The Disengage Rod can be inserted either end first.*

4. Grease Face of Thrust Washer (2) and place in Cover (6A) making sure that tangs on washer seat into pockets in cover.
5. Install O-Ring Pipe Plugs (6F) into Cover (6A). The plugs should be hand tight according to SAE standard.

Main Assembly

(Refer to Figure 3-2., Main Disassembly Drawing 1 and Figure 3-3., Main Disassembly Drawing 2)

NOTE: *All components should receive a generous amount of lubricant oil as they are being assembled.*

1. Place Hub-Spindle Sub-Assembly on the bench.
2. Grease O-Ring (18) and place it into groove of Hub (1G).
3. Place Ring Gear (1F) onto Hub (1G). Align the three shipping Cap Screw Holes on Hub (1G) and Ring Gear (1F).
4. Install three shipping Cap Screws (19) into ring gear and hub. Torque them to 15-20 ft-lbs.
5. Place Output Carrier Sub-Assembly (4) into mesh with Spindle (1A) splines.
6. Place External Retaining Ring (5) over 13T spline to the retaining groove on Input Shaft (9).

NOTE: *For ratio 48:1, assemble Output Sun Gear (11) over Input Shaft (9) first, then install External Retaining Ring (5).*

7. Using appropriate tool to install Retaining Ring (20) into groove on Output Sun (11)
8. Place Input Shaft (9) spline end into mesh with Internal Coupling (7) splines.
9. With the modified spline end facing up, place the Output Sun Gear (11) into mesh with the output planet gears.
10. Place Input Carrier Sub-Assembly (3) onto Output Sun Gear (11) splines. Drop Input Sun (10) into mesh with planet gears for specific ratios, if required. (No timing required)
11. Grease O-Ring (17) and insert into groove in Cover Sub-Assembly (6).
12. Install Cover Sub-Assembly (6) into Ring Gear (1F) counterbore and install Retaining Ring (6G) into groove in Ring Gear (1F).
13. Attach ID Tag (15) onto unit using Drive Screws (16).
14. Check disconnect, roll and air check unit, leak check brake, and record release pressure. 14. Insert Plastic Plug (12) into place if applicable.

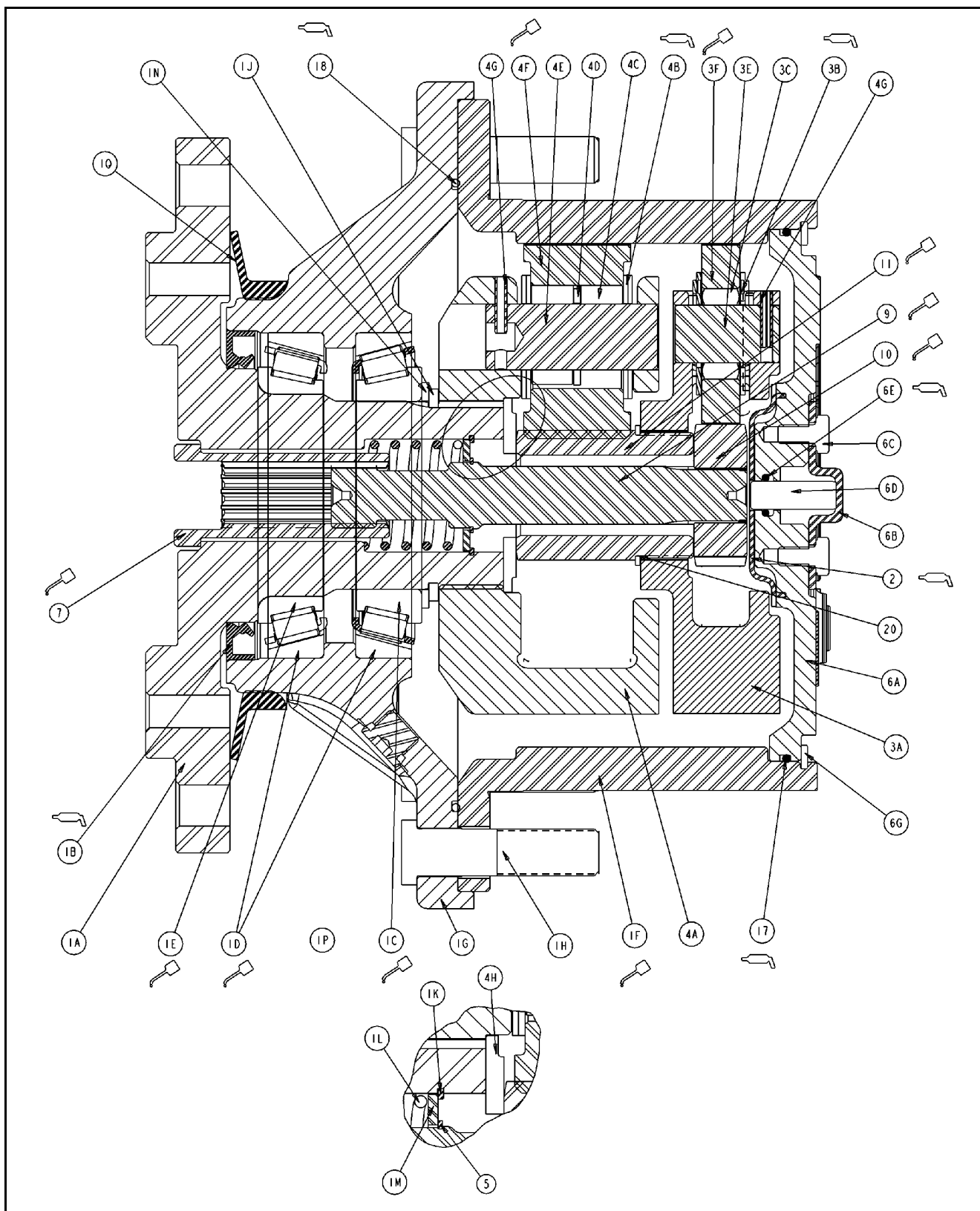


Figure 3-9. Hub Assembly - Sheet 1 of 2

1A Spindle	3B Thrust Washer	6C Bolt, Hex (.250-20 Unc, .500 Gr5)
1B Lip Seal	3C Needle Bearing	6D Dowel Pin
1C Tapered Bearing Cone	3E Planet Shaft	6E O-ring
1D Tapered Bearing Cup	3F Planet Gear	6F Pipe Plug
1E Tapered Bearing Cone	4A Output Carrier	6G Retaining Ring - Int 7.086
1F Ring Gear	4B Thrust Washer	7 Coupling
1G Hub (Housing)	4C Needle Bearing	9 Input Shaft
1H Stud	4D Thrust Spacer	10 Input Sun Gear
1J Retaining Ring Ext.	4E Planet Shaft	11 Output Sun Gear
1K Retaining Ring Int.	4F Planet Gear	15 ID Plate
1L Spring (1.460, 1.500)	4G Roll Pin	16 Drive Screw
1M Thrust Washer	4H Thrust Washer	17 O-ring
1Q Seal Boot	5 Retaining Ring - Ext	18 O-ring
2 Thrust Spacer	6A Cover	19 Bolt, Flat Head - Hex Skt (.375-16)
3A Input Carrier	6B Disengage Cap	20 Retaining Ring - Ext.

Figure 3-10. Hub Assembly - Sheet 1 of 2

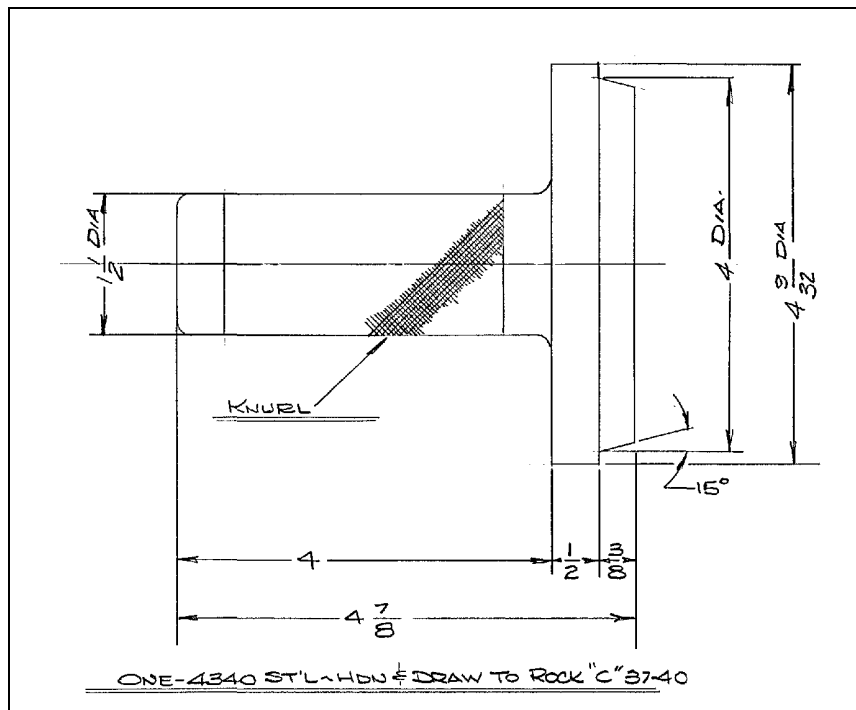


Figure 3-11. Cup Pressing Tool

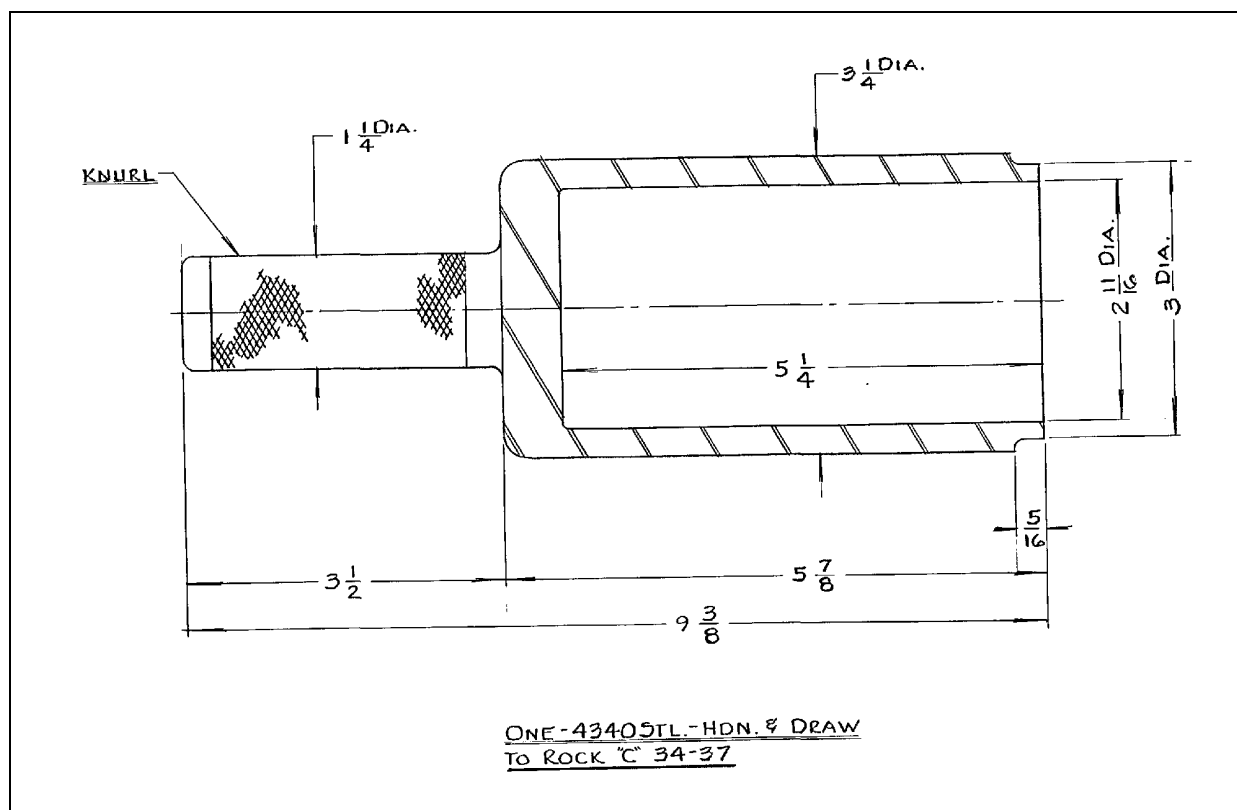


Figure 3-12. Cup Pressing Tool

3.4 DRIVE BRAKE - MICO

Disassembly

1. Remove pressure plate (3) from cover (21) by removing the capscrews (1) and washers (2).

CAUTION

PRESSURE PLATE IS UNDER SPRING TENSION OF APPROXIMATELY 1500 LBS (680 KGF). THE FOUR CAP SCREWS SHOULD BE LOOSENED EVENLY TO RELIEVE THIS FORCE. IF A HYDRAULIC PRESS IS AVAILABLE, 3000 LBS (1361 KGF) MINIMUM, THE PRESSURE PLATE CAN BE HELD IN POSITION WHILE REMOVING THE CAP SCREWS AND WASHERS

2. Remove case seal (4) from cover (21).
3. Remove piston (7) from pressure plate (3).
4. Remove o-ring (5), back-up ring (6), o-ring (8) and back-up ring (9) from piston (7).

NOTICE

IF THE SENSOR RING (12) IS DAMAGED OR NEEDS REPLACED, THE ENTIRE BRAKE MUST BE REPLACED AS A UNIT. THE SENSOR RING IS NOT AVAILABLE AS A SERVICE PART.

5. Remove stack assembly, consisting of stator disc (11), sensor ring (12), rotor disc (13), and plate (14) from cover (21).
6. Remove dowel pins (20), springs (15) and spring retainer (16) from cover (21).

NOTE: Note number and pattern of springs for reassembly purposes.

7. Remove retaining ring (17) from cover (21).
8. Remove shaft (10) by pressing or using a soft mallet on male end of the shaft.
9. Remove retaining ring (19) and bearing (18) from shaft (10).
10. Press rotary oil seal (20) from cover (18).

Assembly

NOTE: Lubricate all rubber components from the repair kit with clean type fluid used in the system.

1. Clean all parts thoroughly before assembly.
2. Press new rotary seal (22) into cover (21). **Note direction of seal**
3. Install new bearing (18) and retaining ring (19) on shaft (10).

4. Install shaft assembly and retaining ring (17) in cover (21).

NOTE: Be sure to use the same number of springs and spring pattern as recorded during disassembly.

5. Install dowel pins (20), spring retainer (16) and springs (5) in cover plate (21).
6. Position plate (14) on springs (15). **NOTE: Disc (13 & 11) and plate (14) must remain dry during installation. No oil residue must be allowed to contaminate disc surfaces.**
7. Press the speed sensor ring (12) onto the rotor disc (13).
8. Place a new rotor disc (13) on the shaft (10) until it contacts the plate (14). Install stator disc (11).
9. Install new o-ring (5), new back-up ring (6), new o-ring (8) and new back-up ring (9) on piston (7). Note order of o-rings and backup rings. Insert piston (7) into pressure plate (3). Be careful not to shear o-rings or back-up rings.
10. Install new case seal (4) in cover (21).
11. Position pressure plate (3) on cover (21) aligning dowel pins (20) with holes in pressure plate.

NOTE: A hydraulic press will simplify installation of pressure plate on cover. Clamp pressure plate in position while tightening the cap screws.

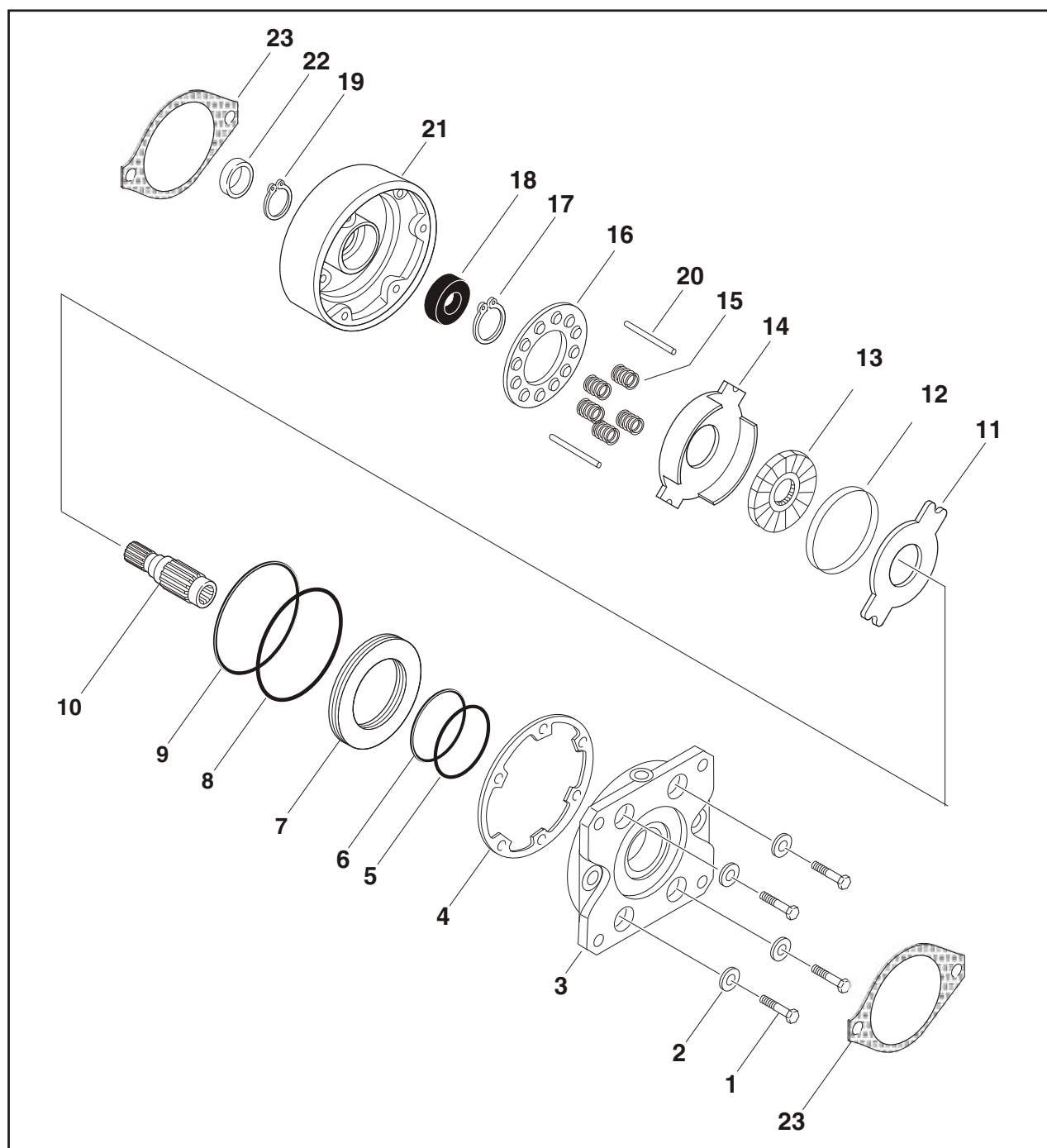
12. Install capscrews (1) and washers (2) and tighten evenly to draw pressure plate (3) to cover (21). Torque capscrews to 55 ft.lbs. (74.6 Nm).

CAUTION

IF HYDROSTATIC BENCH TESTING IS PERFORMED ON THE BRAKE ASSEMBLY, RELEASE PRESSURE SHOULD NOT EXCEED 2000 PSI (137.9 BAR) UNLESS TWO ADDITIONAL BOLTS ARE USED FOR SUPPLEMENTAL CLAMPING.

Bleeding

1. Install brake in system and connect pressure lines.
2. Bleed pressure release section of brake by pressurizing side inlet port and allowing air to escape from top port. Pressure should not exceed 100 psi (6.9 bar) during bleeding.
3. Apply sufficient pressure to release brake and check for proper operation in system.



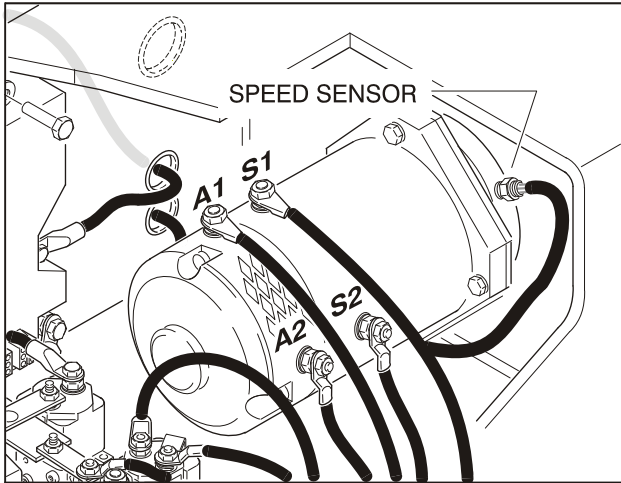
- | | | | |
|-------------------|-----------------|---------------------|---------------------|
| 1. Capscrew | 7. Piston | 13. Rotor Disc | 19. Retaining Ring |
| 2. Washer | 8. O-ring | 14. Plate | 20. Dowel Pin |
| 3. Pressure Plate | 9. Backup Ring | 15. Spring | 21. Cover |
| 4. Case Seal | 10. Shaft | 16. Spring Retainer | 22. Rotary Oil Seal |
| 5. O-ring | 11. Stator Disc | 17. Retaining Ring | 23. Gasket |
| 6. Backup Ring | 12. Sensor Ring | 18. Bearing | |

Figure 3-13. Drive Brake

Table 3-2. Drive Brake Diagnosis

Problem	Cause	Explanation	Corrective Action
Brake slips	Excessive pressure In hydraulic system	If there is back pressure in the actuation line of the brake, holding torque will be reduced.	Check filters, hose size, restrictions in other hydraulic components.
	Oil In brake if designed for dry use	Wet linings generate 67% of the dry torque rating. If the brake has oil In it, check the type of oil hydraulic or gearbox. 1. Gearbox oil 2. Hydraulic oil	Replace oil seal in brake. Check motor seal. Check piston seals. Note: Internal components will need to be inspected, cleaned, and replaced as required.
	Disc plates worn	The thickness of the disc stack sets the torque level. A thin stack reduces torque.	Check disc thickness.
	Springs broken or have taken a permanent set	Broken or set springs can cause reduced torque - rare occurrence.	Check release pressure. (See spring replacement)
Brake drags or runs hot	Low actuation pressure	The brake should be pressurized to minimum of 1.38 bar (20 psi) over the full release pressure under normal operating conditions. Lower pressures will cause the brake to drag thus generating heat.	Place pressure gauge in bleed port & check pressure with system on.
	Bearing failure	If the bearing should fail, a large amount of drag can be generated.	Replace bearing.
Brake will not release	Stuck or clogged valve	Brakes are designed to come on when system pressure drops below stated release pressure. If pressure cannot get to brake, the brake will not release.	Place pressure gauge in bleed port - check for adequate pressure. Replace defective line or component.
	Bad O-rings	f release piston will not hold pressure, brake will not release.	Replace o-rings.
	Discs frozen	These brakes are designed for only limited dynamic braking. A severe emergency stop or prolonged reduced release pressure operation may result in this type of damage.	Replace disc stack.

3.5 SPEED SENSOR ADJUSTMENT



For proper drive operation, the speed sensors must be properly installed and adjusted. The sensor operates on a leading pulse to show direction. If installed wrong, the sensor will not be able to sense the proper direction.

⚠ WARNING

IF BOTH SPEED SENSORS ARE INSTALLED WRONG, THE CONTROLLER WILL THINK THE MACHINE IS ON A HILL AND WILL GO INTO FULL SPEED MODE IMMEDIATELY WHEN DRIVE IS SELECTED. THE MACHINE WILL NOT STOP UNLESS THE FOOT-SWITCH IS RELEASED OR THE EMS IS PUSHED IN.

IF ONLY ONE SENSOR IS INSTALLED WRONG, THE CONTROLLER SENSES A PROBLEM AND THE MACHINE WILL ONLY DRIVE AT CREEP SPEED. IF BOTH SENSORS ARE ADJUSTED TOO FAR OUT, THE CONTROL SYSTEM CONTROLLER WILL NOT DRIVE THE MACHINE.

Adjustment Procedure

1. Back off the locking nut and o-ring.
2. Thread the sensor in until it bottoms out (don't use excessive force).
3. Back-off 1-2 turns and align the notch with the axis of the brake. Refer to Figure 3-14., Speed Sensor Orientation.
4. Use a 1/2" wrench to hold the sensor and a 11/16" wrench to snug the lock nut to the brake.

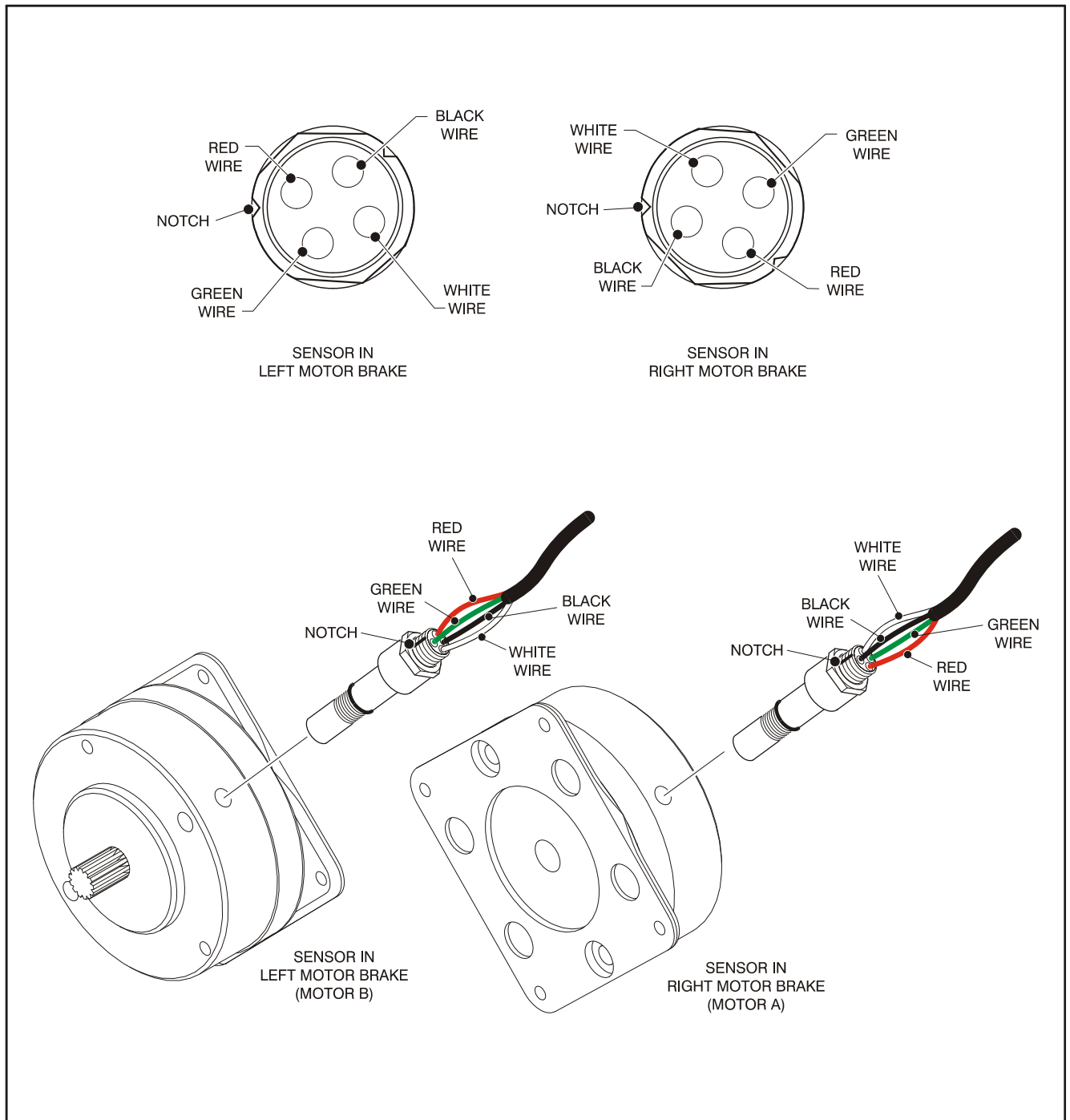


Figure 3-14. Speed Sensor Orientation

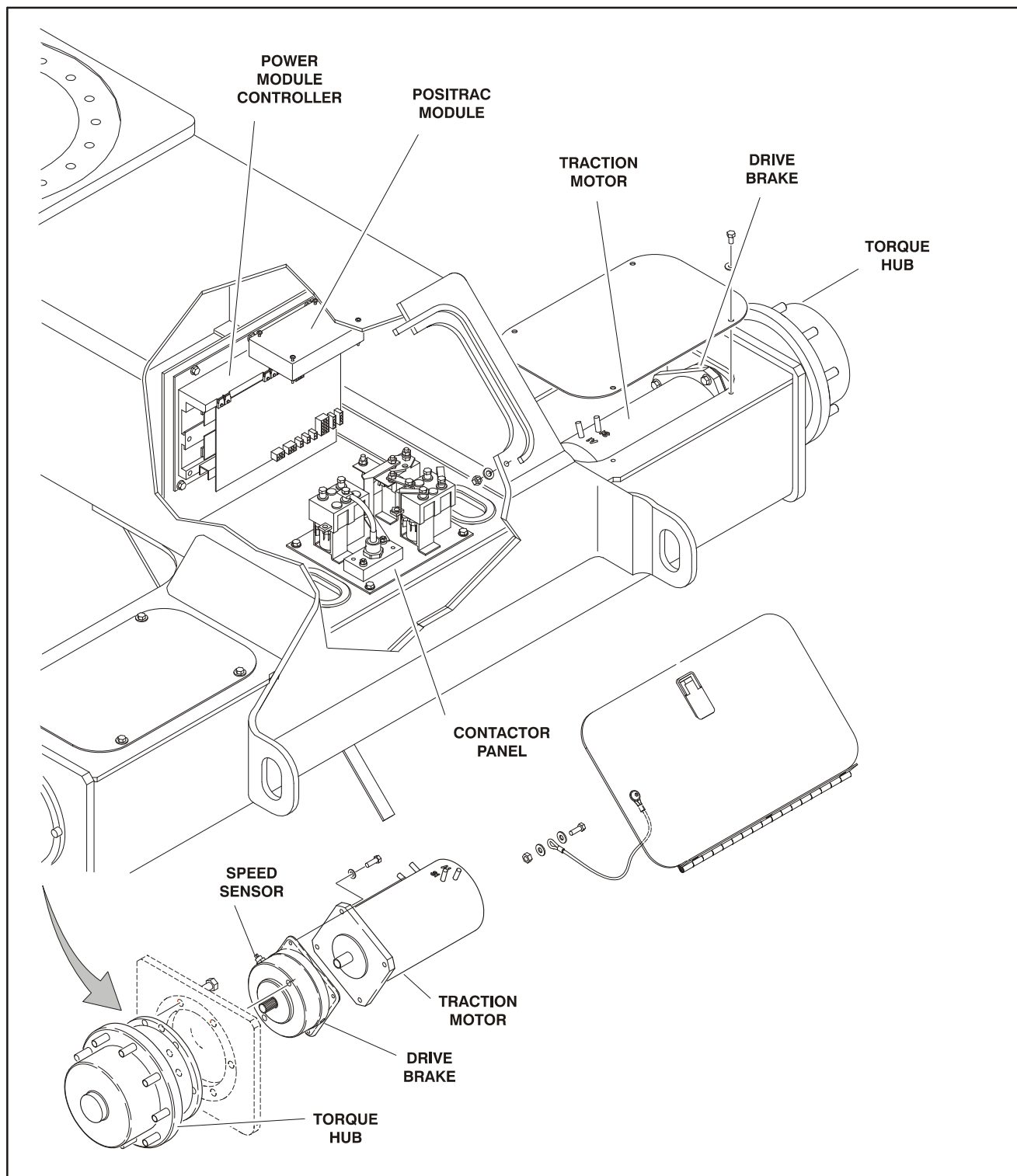


Figure 3-15. Drive Components

Speed Sensor Installation Verification

The motor controller averages the readings from the right and left speed sensors and therefore, it can be difficult to detect if the speed sensors are adjusted properly. When the positrac keeps coming in and out while on level surfaces, this is a sure indication that one of the speed sensors is not adjusted properly.

The worse case condition of speed sensor misadjustment occurs when both sensors are installed in a manner that allows them to indicate the exact opposite direction that the machine is traveling. This situation causes the controller to believe that the machine is rolling in opposite direction than that selected by the operator. The controllers reaction to this situation is to put more power into the drive motors to attempt to overcome the fact that it believes the machine is rolling backwards. This presents itself as uncontrolled movement in the direction selected by the operator until the controller recognizes that it is placing maximum power in the motors and the controller and the speed sensors are still reporting movement in the opposite direction. The controller responds by shutting down drive and reporting flash code 5/5- Vehicle Runaway Check Speed Encoders.

If either speed sensor is disconnected or faulty, the controller will recognize this condition and immediately report flash code 5/5 - Left or Right speed Encoder Faulty.

Verification w/ Analyzer Procedure

Below is a procedure using the Analyzer that will verify that the speed sensors are installed correctly.

NOTICE

THIS PROCEDURE REQUIRES A LARGE SPACE CLEAR OF OBSTRUCTIONS. THE OPERATOR SHOULD BE FAMILIAR WITH JLG EQUIPMENT AND BE PREPARED TO USE THE FOOTSWITCH TO STOP THE MACHINE. READ AND UNDERSTAND THIS ENTIRE PROCEDURE PRIOR TO BEGINNING.

1. Before beginning this procedure, insure that there is at least 10 ft (3m) in front and back of machine. Be sure that all other personnel stand clear of the machine during this procedure.
2. Unplug the left speed sensor from the posi-trac tilt module.
3. Power up the machine in platform mode and plug in the Analyzer in the platform.
4. Use the right and left cursor keys on the analyzer to highlight "DIAGNOSTICS" and press enter.
5. Use the right and left cursor keys on the analyzer to highlight "DRIVE" and press enter.

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6. Use the right and left cursor keys to display 'SPEED 0%' on the analyzer.
7. While watching the analyzer display, select drive forward. Be ready to remove your foot from the foot-switch if the machine lunges forward.
8. The analyzer display should read the following if the RIGHT speed sensor is adjusted properly: "SPEED 20% FWD".
9. If the speed sensor is adjusted improperly, the analyzer will display "SPEED 20%REV" and the machine will lunge forward.
10. Adjust the right speed sensor using the preceding **Adjustment Procedure** until the analyzer displays "SPEED 20% FWD" when forward is selected at the platform. The percentage displayed is not critical, just the direction.
11. After obtaining the display in step 10, operate the machine in both forward and reverse directions. The machine should be controllable in both directions and will only drive at a maximum of creep speed. The display on the analyzer should match the direction selected.
12. After completing adjustment of the right sensor, plug the left sensor into the posi-tilt module.
13. Unplug the right sensor from the power module.
14. Power up the machine in platform mode and plug in the analyzer in the platform.
15. Use the right left cursor keys on the analyzer to highlight diagnostics and press enter.
16. Use the right and left cursor keys on the analyzer to highlight drive and press enter.
17. Use the right and left cursor keys to display "speed 0%" ON THE ANALYZER.
18. while watching the analyzer display, select drive forward. Be ready to remove your foot from the foot-switch if the machine lunges forward.
19. The analyzer display should read the following if the left speed sensor is adjusted properly: "SPEED 20% FWD".
20. If the left speed sensor is adjusted improperly, the analyzer will display "SPEED 20% REV", and the machine will lunge forward.
21. Adjust the left speed sensor using the preceding **Adjustment Procedure** until the analyzer displays "SPEED 20% FWD" when forward is selected in the platform. The percentage displayed is not critical, just the direction.
22. After obtaining the display in step 10, operate the machine in both the forward and reverse directions. The machine should be controllable in both directions and will only drive at a maximum of creep speed. The display on the analyzer should match the direction selected.
23. Plug in the right sensor to the power module.
24. Test the machine. The machine should now have maximum drive speed available in both directions and should be controllable in both directions. The analyzer display should match the direction selected.

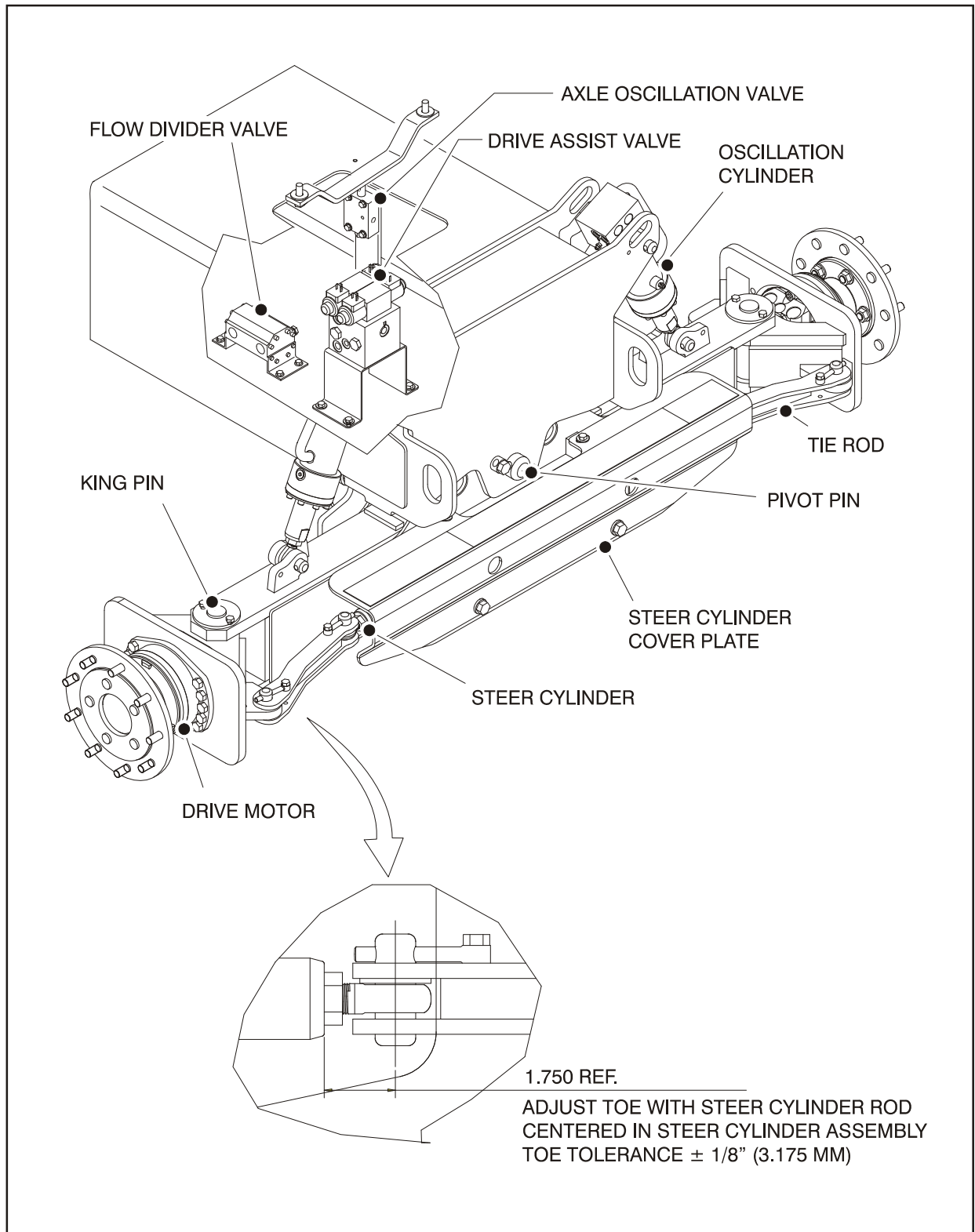


Figure 3-16. Oscillating Axle

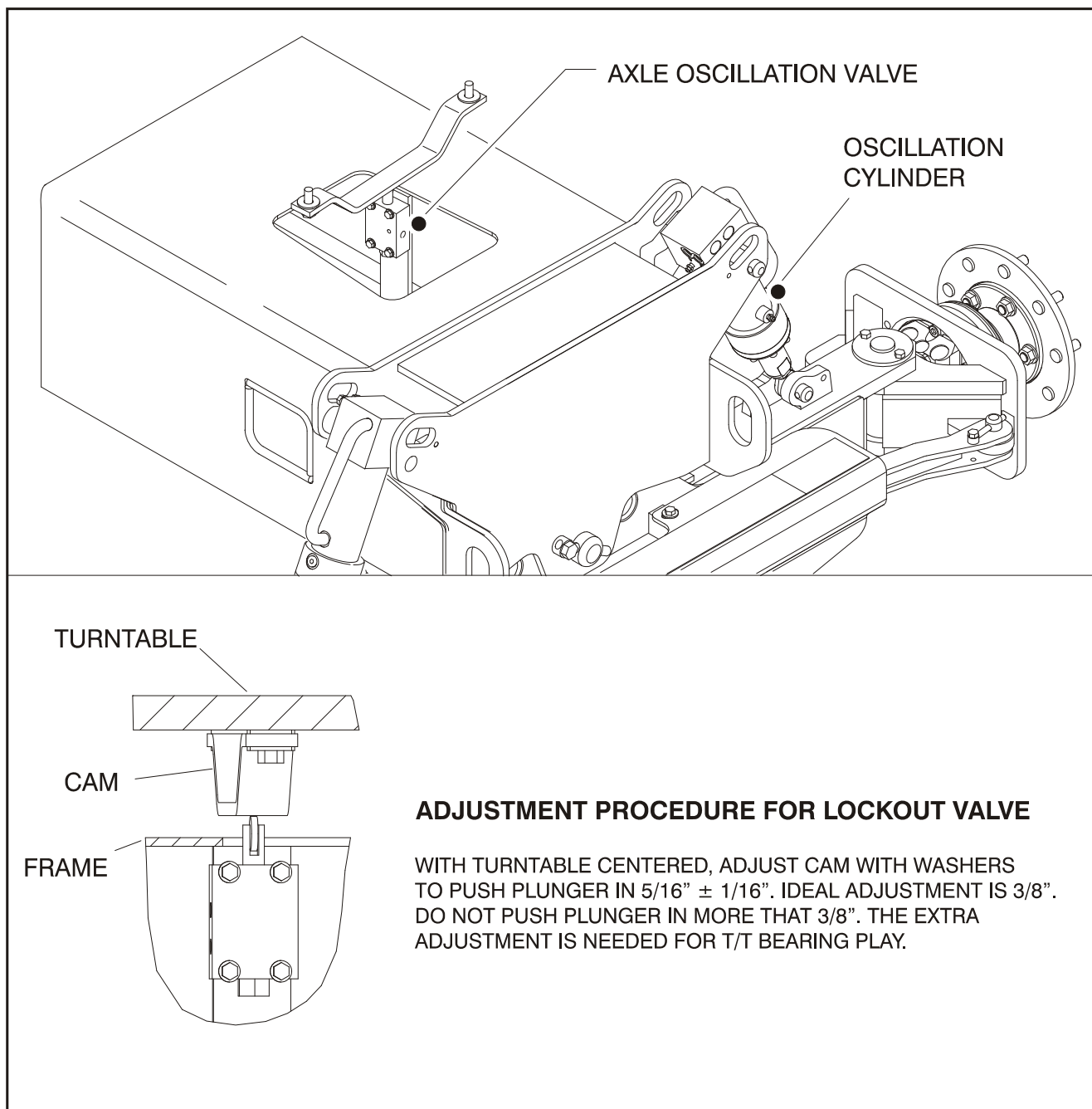


Figure 3-17. Axle Oscillation Lockout Valve

3.6 OSCILLATING AXLE LOCKOUT TEST (IF EQUIPPED)

NOTICE

LOCKOUT SYSTEM TEST MUST BE PERFORMED QUARTERLY, ANY TIME A SYSTEM COMPONENT IS REPLACED, OR WHEN IMPROPER SYSTEM OPERATION IS SUSPECTED.

NOTE: *Ensure boom is fully retracted, lowered, and centered between drive wheels prior to beginning lockout cylinder test.*

1. Place a 6 inches (15.2 cm) high block with ascension ramp in front of left front wheel.
2. From platform control station, start engine
3. Place the Drive control lever to the forward position and carefully drive machine up ascension ramp until left front wheel is on top of block.
4. Carefully activate Swing control lever and position boom over right side of machine.
5. With boom over right side of machine, place Drive control lever to Reverse and drive machine off of block and ramp.
6. Have an assistant check to see that left front or right rear wheel remains elevated in position off of ground.
7. Carefully activate Swing control lever and return boom to stowed position (centered between drive wheels). When boom reaches center, stowed position, lockout cylinders should release and allow wheel to rest on ground, it may be necessary to activate Drive to release cylinders.
8. Place the 6 inches (15.2 cm) high block with ascension ramp in front of right front wheel.
9. Place Drive control lever to Forward and carefully drive machine up ascension ramp until right front wheel is on top of block.
10. With boom over left side of machine, place Drive control lever to Reverse and drive machine off of block and ramp.
11. Have an assistant check to see that right front or left rear wheel remains elevated in position off of ground.
12. Carefully activate Swing control lever and return boom to stowed position (centered between drive wheels). When boom reaches center, stowed position, lockout cylinders should release and allow wheel to rest on ground, it may be necessary activate Drive to release cylinders.

13. If lockout cylinders do not function properly, have qualified personnel correct the malfunction prior to any further operation.

3.7 OSCILLATION CYLINDER BLEEDING

NOTE: *The oscillating axle must be checked daily for proper operation.*

Bleeding Procedure

1. Run one side wheel onto a ramp or block of wood. On the other side, the lockout cylinder should be extended.
2. Block the rear wheels and disconnect the drive hubs.

NOTE: *Step three is only for models with all wheel drive.*

3. Next, unplug the 4 wheel assist valve under the frame.
4. Have an assistant activate drive forward and telescope in from the platform. Open up the bleeder screws on the extended side lockout cylinder. Let the hydraulic oil run out until all the air bubbles are out of the cylinder. Then close the bleeder screws.

Checking Oscillation Cylinders

After bleeding the lockout cylinders, check to see that they are holding their position when oscillated.

1. Reconnect the drive hubs and 4-wheel assist valve.
2. Run one wheel onto a ramp or a block of wood, mark the retracted cylinder with a marker, swing the turntable off of the cam valve.
3. Back the unit off of the ramp, check the retracted cylinder for drive no more than 1/2" (12.7 mm).
4. Repeat this procedure for the other side. If the lockout cylinders do not hold, repeat the bleeding procedure or check for the following:
 - a. Air in lockout system.
 - b. Bad cylinder seals.
 - c. Bad holding valves.

3.8 SWING DRIVE

Roll, Leak and Brake Testing

Torque-Hub units should always be roll and leak tested before disassembly and after assembly to make sure that the unit's gears, bearings and seals are working properly. The following information briefly outlines what to look for when performing these tests.

NOTE: The brake must be released and hydraulic lines to motor removed before performing the roll test.

ROLL TEST

The purpose of the roll test is to determine if the unit's gears are rotating freely and properly. You should be able to rotate the gears in your unit by applying constant force to the roll checker. If you feel more drag in the gears only at certain points, then the gears are not rolling freely and should be examined for improper installation or defects. Some gear packages roll with more difficulty than others. Do not be concerned if the gears in your unit seem to roll hard as long as they roll with consistency.

LEAK TEST (MAIN UNIT)

The purpose of a leak test is to make sure the unit is air tight. You can tell if your unit has a leak if the pressure gauge reading on your air checker starts to fall after the unit has been pressurized and allowed to equalize. Leaks will most likely occur at the pipe plugs, the main seal or wherever o-rings or gaskets are located. The exact location of a leak can usually be detected by brushing a soap and water solution around the main seal and where the o-rings or gaskets meet on the exterior of the unit, then checking for air bubbles. If a leak is detected in a seal, o-ring or gasket, the part must be replaced, and the unit rechecked. Leak test at 10 psi for 20 minutes.

BRAKE TEST

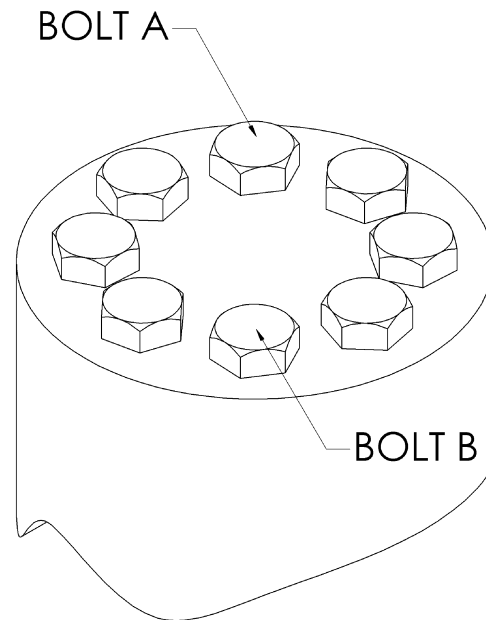
The brake test should be performed prior to disassembly and after reassembly to ensure that the brake functions properly and does not leak. The brake test procedure can be found in the Motor-Brake Subassembly section of this manual.

NOTE: Failure to perform this test may result in damaged or ineffective brake parts.

Tightening and Torquing Bolts

If an air impact wrench is used to tighten bolts, extreme care should be taken to ensure that the bolts are not tightened beyond their specified torque.

The following steps describe how to tighten and torque bolts or socket head cap screws in a bolt circle.



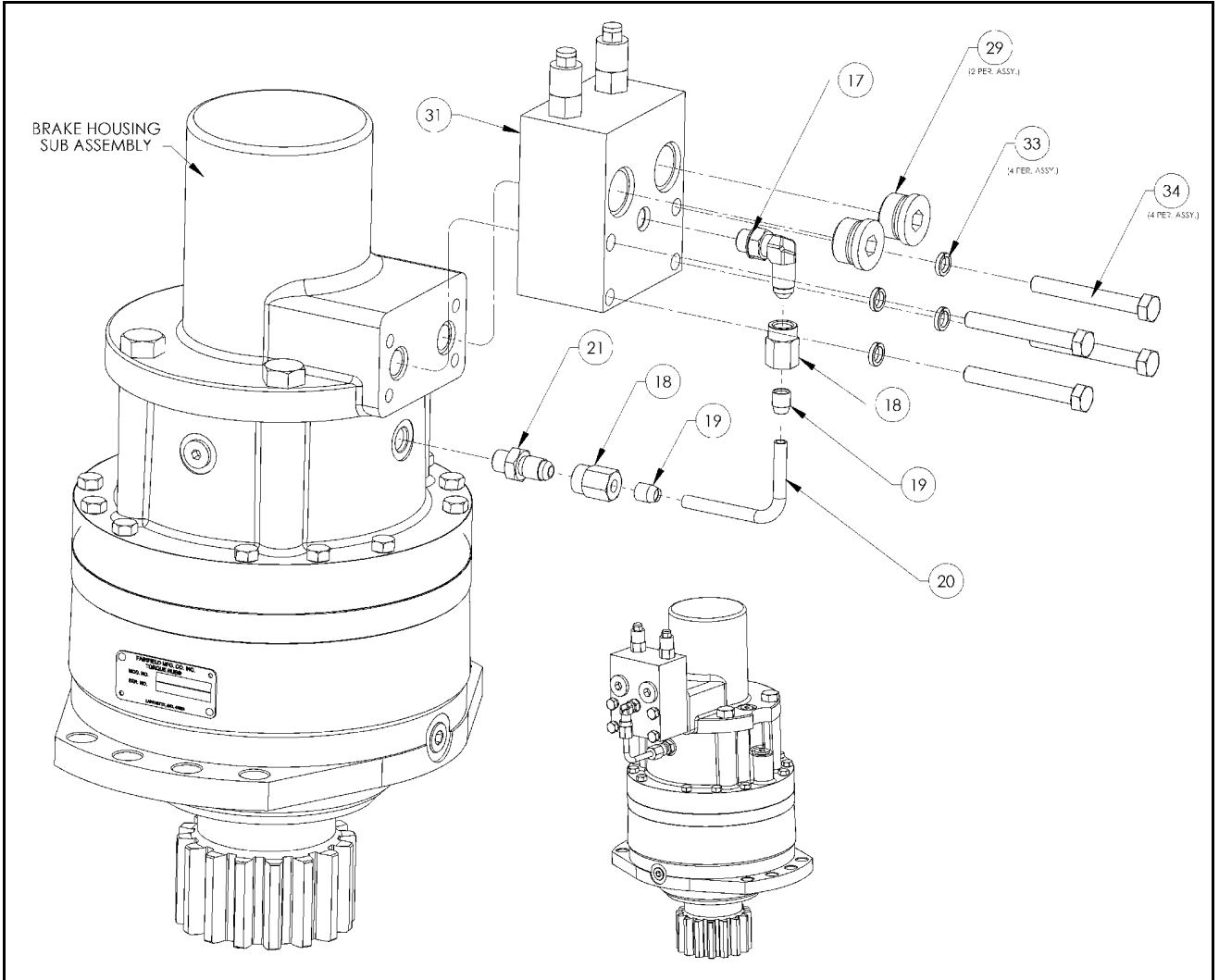
1. Tighten (but do not torque) bolt "A" until snug.
2. Go to the opposite side of the bolt circle and tighten bolt "B" until equally snug.
3. Crisscross around the bolt circle and tighten remaining bolts.
4. Now use a torque wrench to apply the specified torque to bolt "A".
5. Using the same sequence, crisscross around the bolt circle and apply an equal torque to the remaining bolts.

Motor Control Valve Disassembly

1. Place unit on bench with the motor end up.
2. Remove Hydraulic Tubing Assembly (20) by loosening Fittings (18) on both ends of tube with a wrench.

NOTE: Items (18) & (19) are included on Item (20) when ordering a replacement Tubing Assembly.

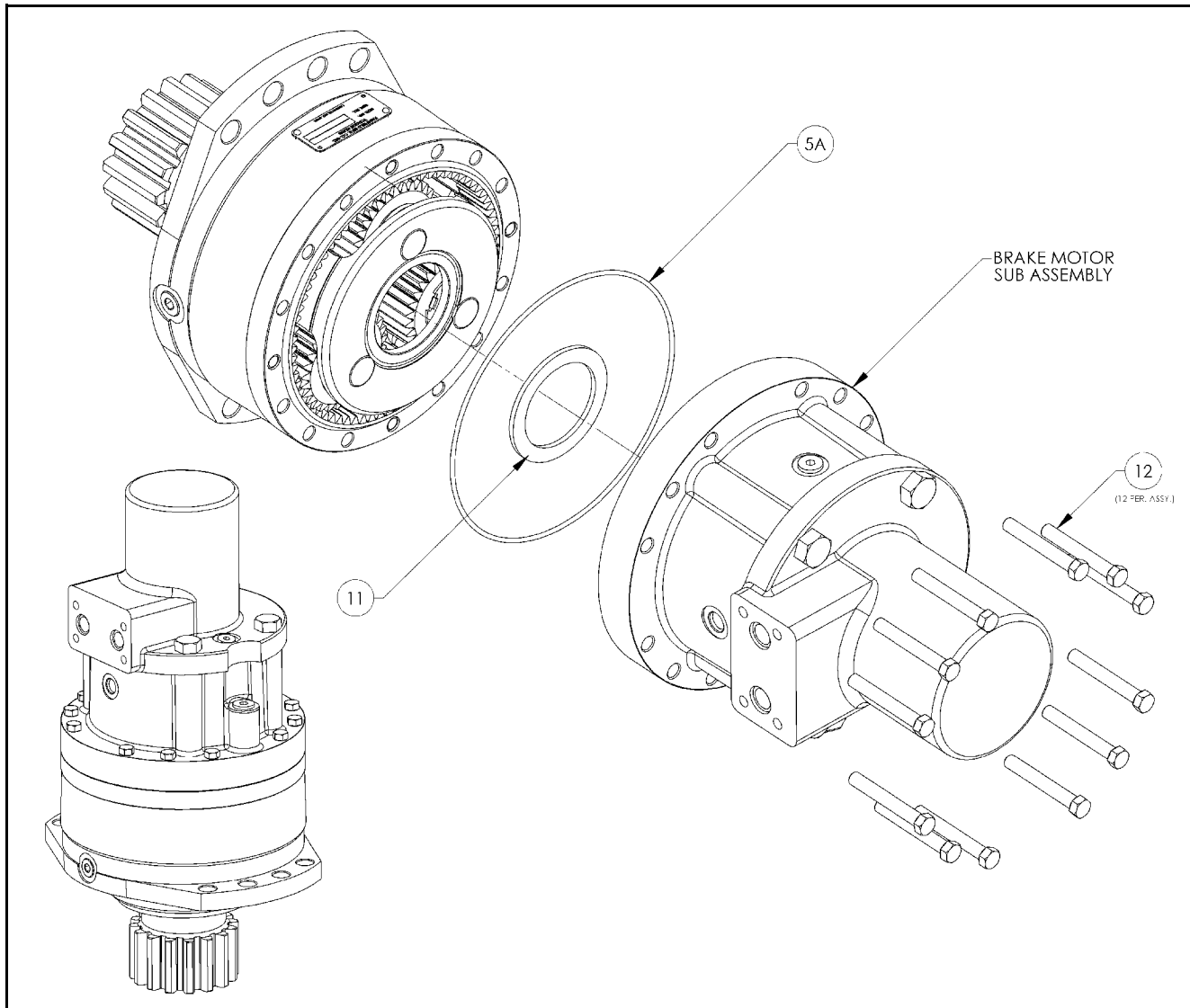
3. Using a wrench, loosen jam nut on Elbow Fitting (17) and remove fitting from Motor Control Valve (31).
4. Using a wrench, remove Fitting (21) from Brake Housing.
5. Remove Motor Control Valve (31) from Motor (10) by removing the four Bolts (34) and washers (33).



- | | |
|---------------------|-------------------------|
| 17. Elbow Fitting | 29. Plug |
| 18. Fittings | 31. Motor Control Valve |
| 19. Ferrule | 33. Washers |
| 20. Tubing Assembly | 34. Bolts |
| 21. Fitting | |

Figure 3-18. Motor Control Valve Disassembly

Motor and Brake Disassembly



- 5A. O-ring
- 11. Thrust Washer
- 12. Hex Bolts

Figure 3-19. Motor and Brake Disassembly

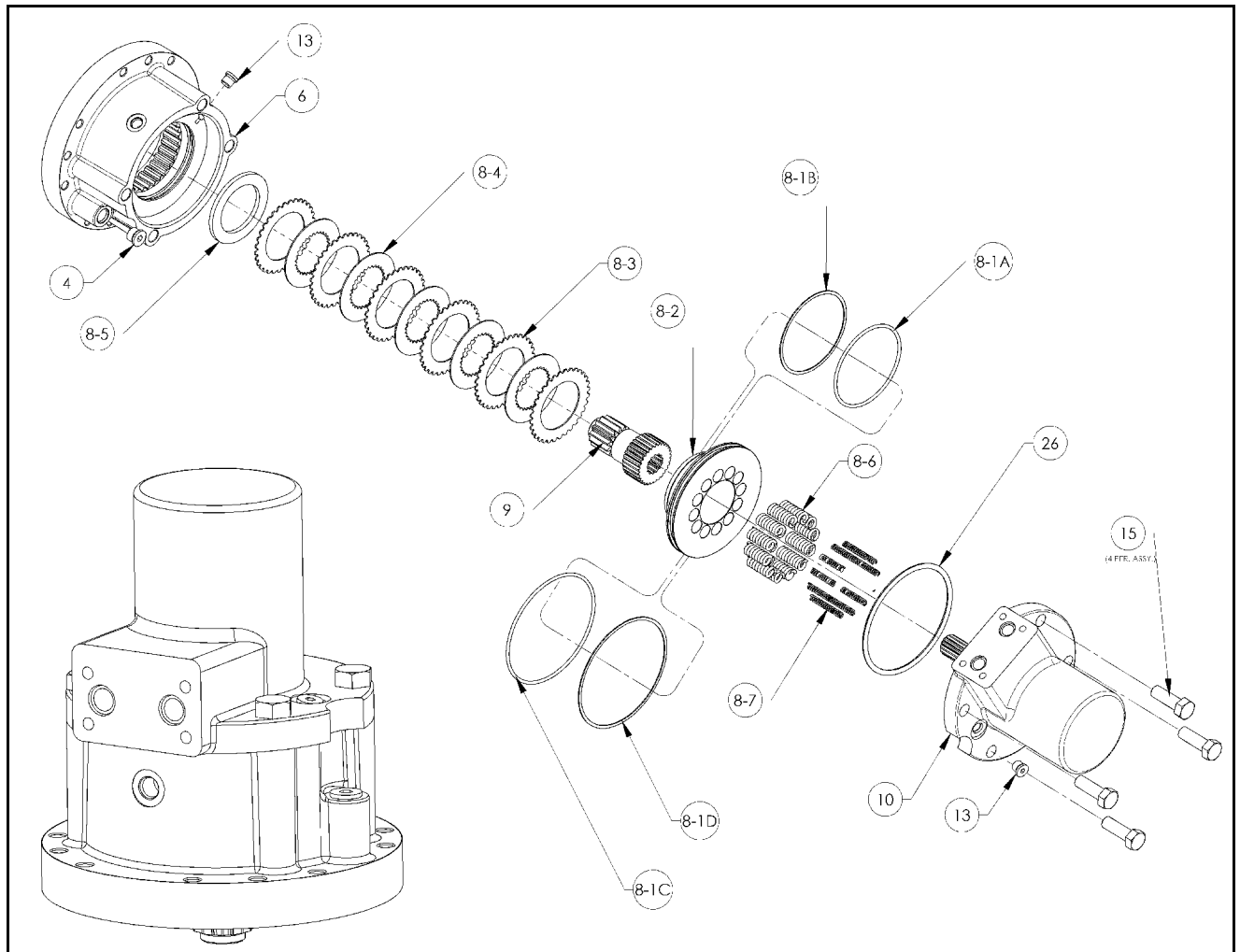
1. With unit resting on bench with Motor (10) end up, loosen Hex Bolts (12) and remove Brake/Motor Sub-assembly from the Housing (1G) (See assembly drawing).
2. Remove O-Ring (5A) from between Brake/Motor Subassembly and Housing (1G) (See assembly drawing).
3. Remove Thrust Washer (11) from between Brake/Motor Subassembly and Carrier.
4. Remove one O-Ring Plug (13) from Motor (10) and one O-Ring Plug (13) from Brake Housing (6).
5. Remove O-Ring Plug (4) from Brake Housing (6).

6. Remove Motor (10) from Brake Housing (6) by removing four Bolts (15) incrementally until spring pressure is relieved.
7. Remove O-Ring (26) from between Motor (10) and Brake Housing (6).
8. Remove Springs (8-6) & (8-7) from Brake Piston (8-2).

⚠ CAUTION

WEAR EYE PROTECTION DURING THE NEXT STEP OF THIS PROCEDURE.

9. Remove Brake Piston (8-2) from Brake Housing (6) by slowly pressurizing brake port in Brake Housing (6) with air.
10. Remove O-Rings (8-1A) & (8-1C) and Backup Rings (8-1B) & (8-1D) from Brake Piston (8-2).
11. Remove Sun Gear (9).
12. Remove Outer Plates (8-3) and Inner Plates (8-4) from the Brake Housing (6).
13. Remove the Thrust Spacer (8-5).

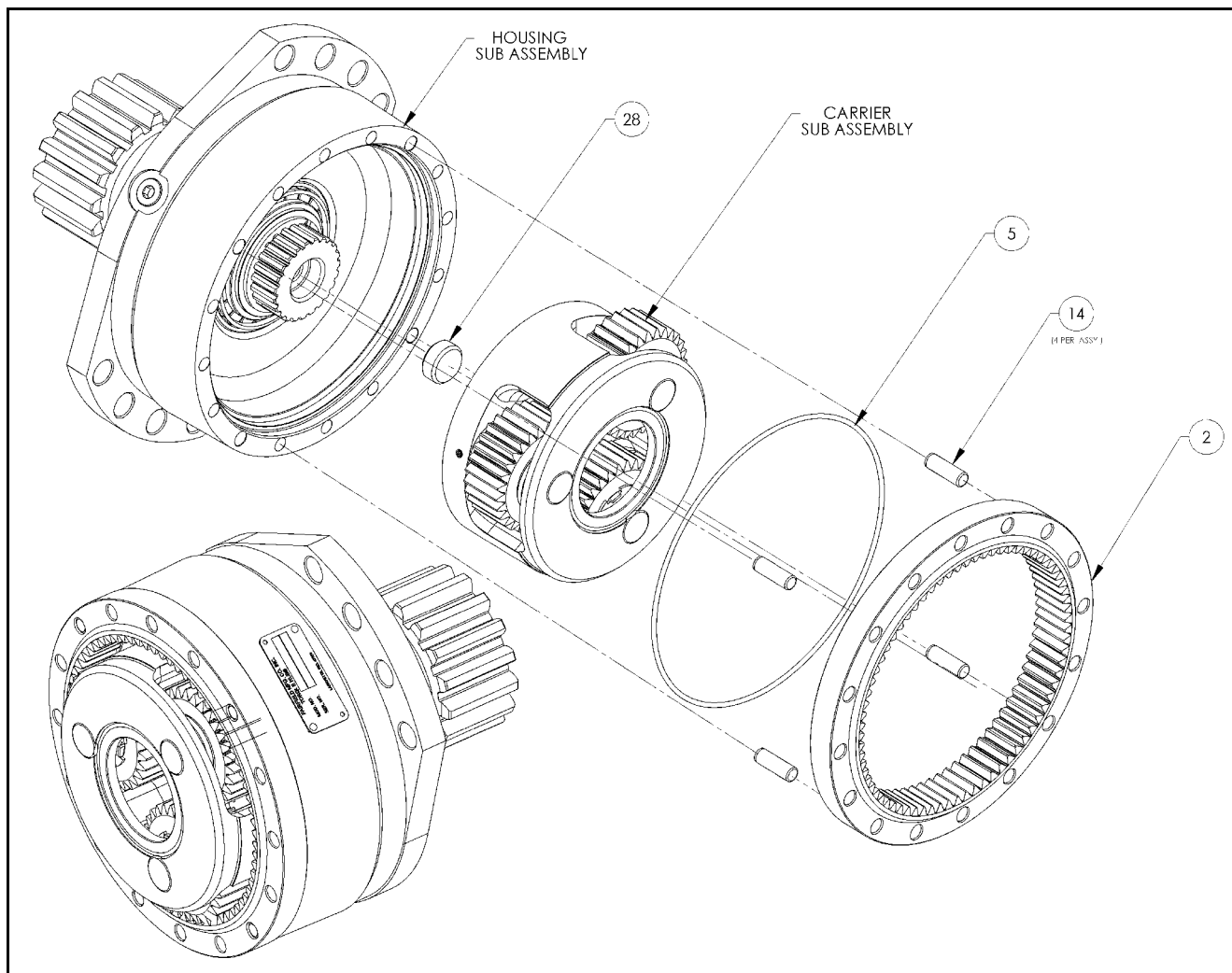


- | | | |
|-------------------|--------------------|-----------------|
| 4. O-ring Plug | 8-2. Brake Piston | 9. Sun Gear |
| 6. Brake Housing | 8-3. Outer Plates | 10. Motor |
| 8-1A. O-ring | 8-4. Inner Plates | 13. O-ring Plug |
| 8-1B. Backup Ring | 8-5. Thrust Spacer | 15. Bolts |
| 8-1C. O-ring | 8-6. Spring | 26. O-ring |
| 8-1D. Backup Ring | 8-7. Spring | |

Figure 3-20. Brake Disassembly

Main Disassembly

1. With the unit resting on the Output Shaft (Pinion) (1A), remove the Carrier Subassembly.
2. Remove Ring Gear (2) from Housing Subassembly.
3. Remove O-ring (5) from between Ring Gear (2) and Housing Subassembly.
4. Remove four Dowel Pins (14) from Housing Subassembly.



- 2. Ring Gear
- 5. O-Ring
- 14. Dowel Pins
- 28. Input Spacer

Figure 3-21. Main Disassembly

Hub-shaft Disassembly

1. Using retaining ring pliers, remove Retaining Ring (1I) from groove in Output Shaft (1A) and discard.

CAUTION

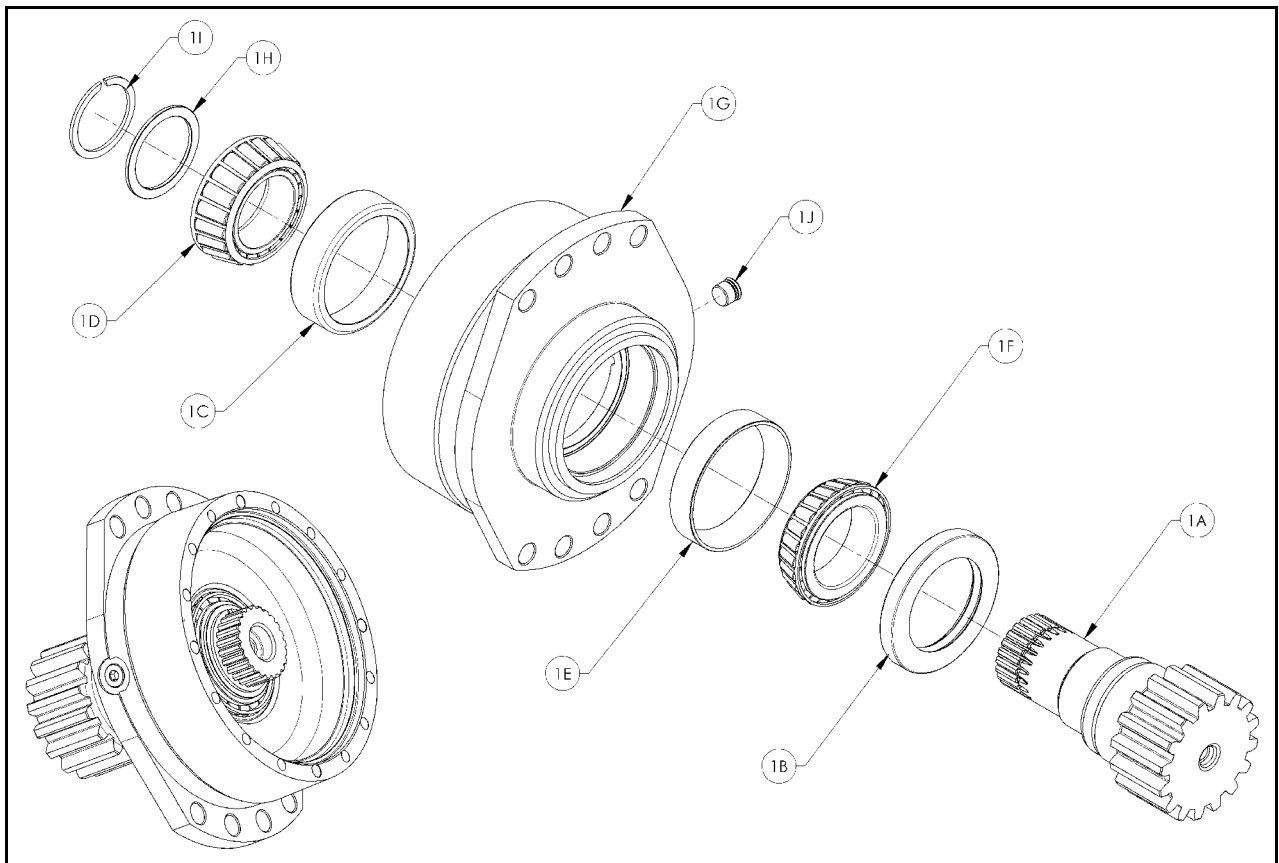
EYE PROTECTION SHOULD BE WORN DURING THIS PROCEDURE.

2. Remove Thrust Washer (1H).
3. While supporting the Housing (1G) on the Output Shaft (1A) end, press the Output Shaft (1A) out of the Housing (1G).

NOTE: The Lip Seal (1B) may or may not be pressed out of the Housing (1G) by the Bearing Cone (1D) during this step.

4. Remove the Bearing Cone (1D) from the Housing (1G).
5. Invert the Housing (1G) and remove the Lip Seal (1B) if not already removed when Output Shaft (1A) was pressed out of Housing (1G).
6. Using a bearing puller, remove the Bearing Cone (1F) from the Output Shaft (1A).
7. Bearing Cups (1C & 1E) will remain in Housing (1G).

NOTE: If bearing replacement is necessary, the Bearing Cups (1C & 1E) can be removed with a slide hammer puller or driven out with a punch.



- | | |
|------------------|--------------------|
| 1A. Output Shaft | 1F. Bearing Cone |
| 1B. Lip Seal | 1G. Housing |
| 1C. Bearing Cup | 1H. Thrust Washer |
| 1D. Bearing Cone | 1I. Retaining Ring |
| 1E. Bearing Cup | |

Figure 3-22. Hub Shaft Disassembly

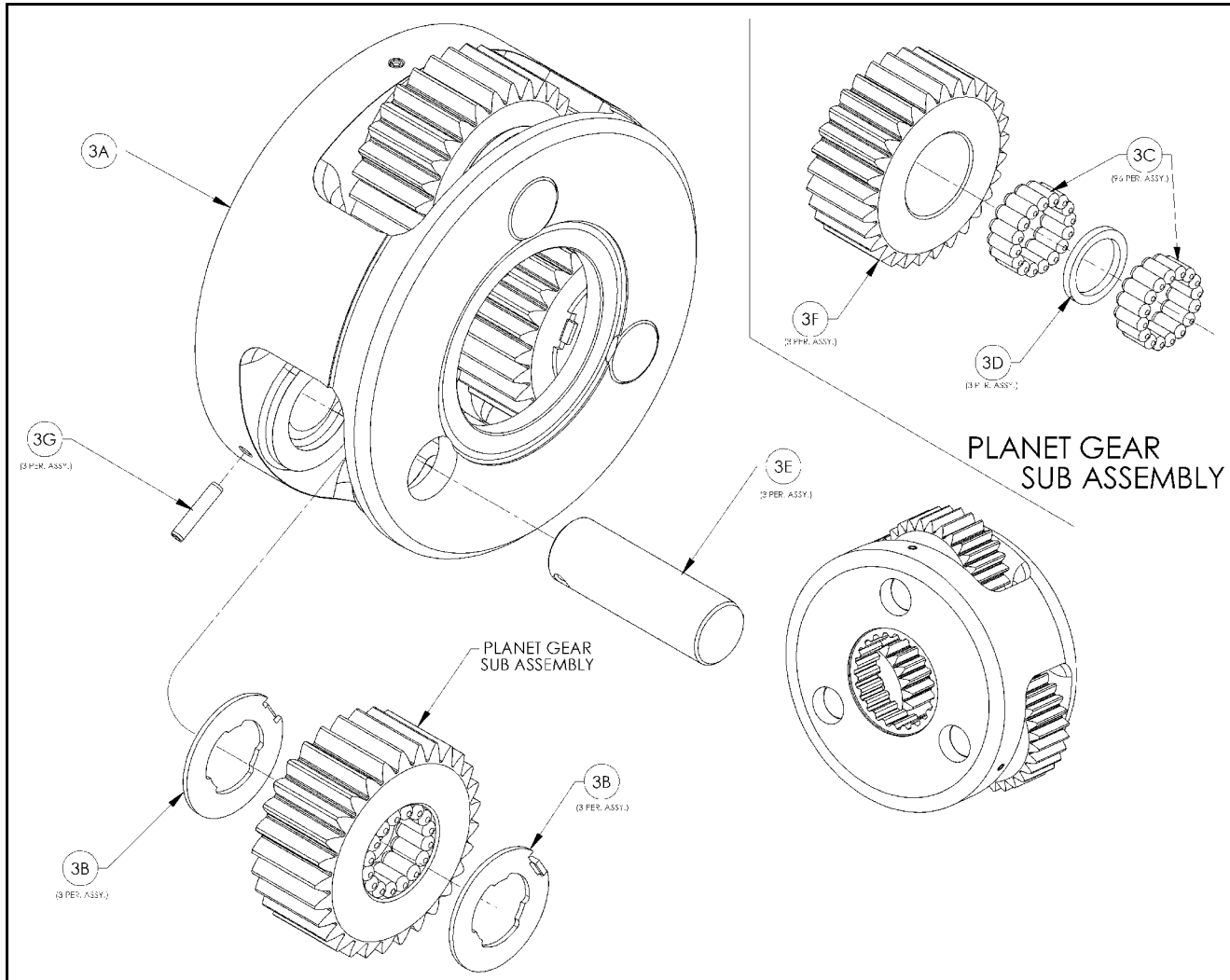
Carrier Disassembly

1. Using a 1/4" punch, drive the Roll Pin (3G) which holds the Planet Shaft (3E) in the Carrier (3A) down into the Planet Shaft (3E) until it bottoms.

NOTE: Make sure that the Roll Pin has bottomed. Otherwise, damage to the carrier could occur when the Planet Shaft is removed.

2. Remove the Planet Shaft (3E) from the Carrier (3A).

3. Slide the Planet Gear (3F) and the two Thrust Washers (3B) out of the Carrier (3A).
4. Remove both rows of Needle Bearings (3C) and the Spacer (3D) from the bore of the Planet Gear (3F).
5. Using a 1/4" punch, drive the Roll Pin (3G) out of the Planet Shaft (3E).
6. Repeat Steps 1 through 5 for the remaining two Planet Gears (3F).



- | | |
|---------------------|------------------|
| 3A. Carrier | 3E. Planet Shaft |
| 3B. Thrust Washers | 3F. Planet Gear |
| 3C. Needle Bearings | 3G. Roll Pin |
| 3D. Spacer | |

Figure 3-23. Carrier Disassembly

Hub-Shaft Sub-Assembly

(See Figure 3-22., Hub Shaft Disassembly)

1. Press Bearing Cup (1E) into Motor end of Housing (1G) using an appropriate pressing tool.
2. Invert Housing (1G) and press Bearing Cup (1C) into Housing (1G) using an appropriate pressing tool. Set Bearing Cone (1F) onto Bearing Cup (1E).
3. Using an appropriate pressing tool, press Seal (1B) into Housing (1G) until it is flush with the end of the Housing (1G).
4. Apply liberal amount of grease to lip of Seal (1B).
5. Invert Housing (1G) and lower onto Output Shaft (1A).

NOTE: Be careful not to damage seal while lowering Housing onto Output Shaft.

6. Press Bearing Cone (1D) onto Output Shaft (1A) until it seats against the bearing shoulder.
7. Place Thrust Washer (1H) onto Bearing Cone (1D).

CAUTION

EYE PROTECTION SHOULD BE WORN DURING THE NEXT STEP OF THIS PROCEDURE.

NOTE: Retaining Ring (1I) should never be reused in a repair or rebuild.

8. Using retaining ring pliers, install Retaining Ring (1I) into groove in Output Shaft (1A). If Retaining Ring (1I) will not seat completely into groove, use an appropriate pressing tool to press down on Bearing Cone (1D) while rotating Housing (1G). Reinstall Thrust Washer (1H) and Retaining Ring according to preceding procedures. Tap the Retaining Ring (1I) with a soft metal punch to ensure that the Retaining Ring (1I) is completely seated in the groove of the Output Shaft (1A).
9. Using a soft face hammer, hit the end of the Shaft (1A) to remove the bearing preload.
10. Install O-ring Plug (1J) and torque to 23 to 24 ft-lbs.

Carrier Sub-Assembly

(See Figure 3-23., Carrier Disassembly)

1. Apply a liberal coat of grease to the bore of Planet Gear (3F). This will enable the Needle Rollers (3C) to be held in place during assembly.
2. Install the first row of 16 Needle Rollers (3C) into the bore of Planet Gear (3F).
3. Insert Spacer (3D) into bore of Planet Gear (3F) on top of the Needle Rollers (3C).
4. Place second row of Needle Rollers (3C) into bore of Planet Gear (3F) against Spacer (3D) and remove Planet Shaft (3E).
5. Place Carrier (3A) on bench so that one of the Roll Pin (3G) holes is straight up.
6. Paying attention to the location of the Roll Pin (3G) hole in the Planet Shaft (3E), start Planet Shaft (3E) through the hole in Carrier (3A). Using ample grease to hold it in position, slide one Thrust Washer (3B) over the Planet Shaft (3E) with the tang resting in the cast slot of the Carrier (3A).
7. Place the Planet Gear (3F) into position in Carrier (3A) and push Planet Shaft (3E) through the Planet Gear (3F) without going all the way through.
8. Slide the second Thrust Washer (3B) between the Planet Gear (3F) and the Carrier (3A) with the tang of the washer located in the cast slot of the Carrier (3A). Finish sliding the Planet Shaft (3E) through the Thrust Washer (3B) and into the Carrier (3A).
9. Position the non-chamfered side on the Planet Shaft (3E) roll pin hole so that it is in line with the hole in the Carrier (3A) using a 1/8 inch diameter punch.

NOTE: If Planet Shaft (3E) has a flat on the end, position the flat toward the center of the Carrier (3A).

10. After using a 1/4" punch to align the Roll Pin (3G) holes in the Carrier (3A) and the Planet Shaft (3E), drive the Roll Pin (3G) through Carrier (3A) and into the Planet Shaft (3E) until the Roll Pin (3G) is flush with the bottom of the cast tang slot in the Carrier (3A). Use a 1/4" pin punch to make sure the Roll Pin (3G) is flush in the slot.

NOTE: On 6:1 Ratios of S1C"s, the pin must be 0.125" below the surface of the outside diameter.

11. Repeat Steps 1 through 10 for the remaining two Planet Gears (3F).

Main Assembly

(See Figure 3-21., Main Disassembly)

1. With the Housing-Shaft Subassembly resting on the Shaft (1A) install one Dowel Pin (14) into each of the four counter-bored holes in the Housing (1G) (See assembly drawing) until they bottom out. Also at this time, mark the four Dowel Pin (14) holes on the O.D. of the Housing (1G) (See assembly drawing). This is for identification later in the assembly.
2. Install Thrust Spacer (28) into counter-bore in splined end of the Output Shaft (1A).
3. Place O-Ring (5) into Housing (1G) counter-bore. Use grease to hold O-ring in place.



BEWARE OF SHARP EDGES OF THE COUNTER BORE WHILE SEATING THIS O-RING.

4. Install Carrier Subassembly with splined end down so that the spline of the Carrier Subassembly is in mesh with the spline of the Housing-Shaft Subassembly. Rotate carrier in assembly to check for freedom of rotation.
5. With large shoulder side of Ring Gear (2) facing down, place Ring Gear (2) onto Housing-Shaft Subassembly with gear teeth in mesh with the Planet Gears (3f) in the Carrier (3A). The side of the Ring Gear (4) with an "X" or punch mark stamped on it should be up and the marked hole should be at a Dowel Pin (14) location.

Motor-Brake Subassembly

(See Figure 3-19., Motor and Brake Disassembly)

1. Place Brake Housing (6) on bench with flange end down. Either block Brake Housing (6) up or place over hole in bench large enough for the shoulder of the Sun Gear (9) to rest on the bottom of the Brake Housing (6). Then install Sun Gear (9) with gear end down into Brake Housing (6).
2. Place Spacer (8-5) into Brake Housing (6) in bottom of small counter bore below splines.
3. Install brake disks, starting with an Outer Plate (8-3), then alternating Inner Plates (8-4) and Outer Plates (8-3) into splined bore.
4. Grease the O Rings (8-1A) & (8-1C) and Backup Rings (8-1B) & (8-1D), and place them in their respective grooves in the Piston (8-2). Make sure the backup-rings are correctly positioned as per the assembly print.

NOTE: Be sure that Backup Rings (8-1B) & (8-1D) are located as tightly into the grooves in the Piston (8-2) as possible to prevent them from being "shaved" when Piston (8-2) is installed into Brake Housing (6).

5. Apply grease sparingly to Piston (8-2) O.D. and the cylinder bore of Brake Housing (6). Insert Piston (8-2) into cylinder of Brake Housing (6), be sure not to cut the O Rings (8-1A) & (8-1C) or Backup Rings (8-1B) & (8-1D).
6. Install Compression Springs (8-6) into spring pockets in Piston (8-2).
7. Install Compression Springs (8-7) into Compression Springs (8-6) in spring pockets in Piston (8-2).
8. Grease O-Ring (26) and install into counter-bore in Brake Housing (6).
9. Assemble Test Cover (See Tools at back of manual for drawing) to Brake Housing (6) using four Bolts (15) evenly tightening Bolts (15) to 80-100 ft-lbs.
10. Check the brake for release. Apply pressure to brake port in side of Brake Housing (6) while trying to rotate Sun Gear (9) by hand. The brake should release between 200-255psi. Remove Test Cover.
11. Assuming that Brake passed the Brake Test, place Motor (10) into Brake Housing (6) with splines of Motor (10) meshing with splines of Sun Gear (9).
12. Attach Motor (10) to Brake Housing (6) with four Bolts (15) and torque to Bolts (15) to 80-100 ft-lbs.
13. 13. Install O-Ring Plug (13) and torque to 13-15 ft-lbs.

Motor-Brake Assembly

(See Figure 3-19., Motor and Brake Disassembly)

1. Grease Thrust Washer (11) and install into counter-bore of Carrier Subassembly, which should already be installed into the Main Subassembly.
2. Grease O-Ring (5A) and install into counter-bore of the Brake Housing (6) in the Motor-Brake Subassembly.
3. Install Motor-Brake Subassembly onto Main Assembly using twelve Bolts (12). Torque bolts to 23 – 27 ft-lbs.

Motor Control Valve Assembly

(See Figure 3-18., Motor Control Valve Disassembly)

1. Lay assembly down with motor ports facing up. Remove the two plastic plugs in the motor ports on new motors, being careful not to loose the O ring in each port. Assemble the Motor control Valve (31) onto the Motor (10) with Bolts (34) and Washers (33). Torque Bolts (34) to 23-27 ft-lbs.

NOTE: Be sure to align the holes in the control valve with the motor ports and make sure o-ring is in hole.

2. Install Straight Fitting (21) into Brake Housing (6) and torque to 13-15 ft-lbs.
3. Install Elbow Fitting (17) into Motor Control Valve (31) with chamfered end of fitting pointing towards straight Fitting (21). Thread fitting all the way in until in the correct position, then torque jam nut to 13-15 ft-lbs.
4. Assemble Tubing (20) Nuts (18) and Ferrules (19) per the procedures below.

Tube Fitting Assembly Procedures

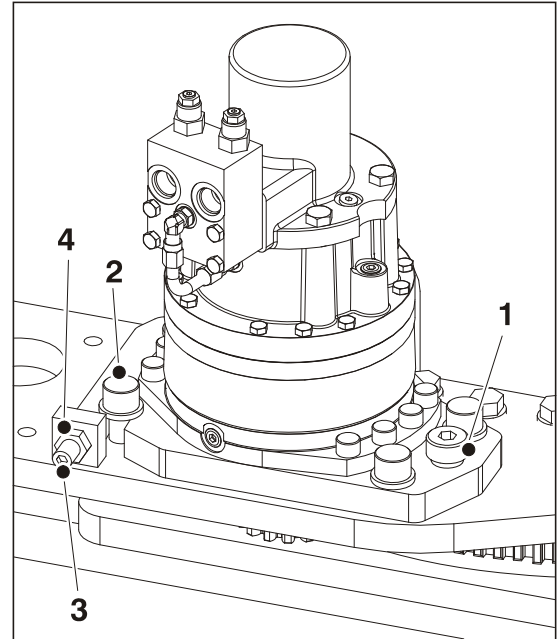
NOTE: Be sure the tube is inline with the fitting. If required, gently modify the tube bends to be inline.

1. Assemble nut onto tubing with threaded end toward the assembled end of the tube.
2. Assemble ferrule onto tube with the large tapered end into the nut.
3. Place tube tight against the flared fitting in the assembly.
4. Lubricate threads and fitting end with hydraulic oil.
5. Slide ferrule and nut against fitting and **hand** tighten nut to the fitting.
6. Mark nut in relation to the fitting.
7. Hold tube tight against fitting and tighten nut 1-1/4 turns of the nut past the marked location.

NOTE: Be sure to align the holes in the control valve with the motor ports.

8. Pressure test brake, tube and control valve connections by applying 3000psi pressure to the brake bleed port and holding for 1 minute. Check for leaks at the control-valve-motor interface and the tube connections. Release pressure.

Procedure for Setting Gear Backlash

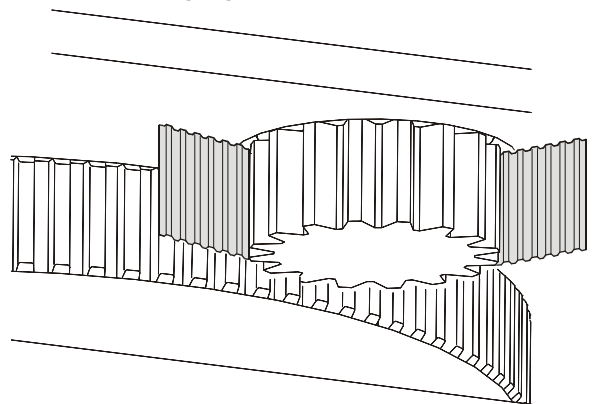


1. Shoulder Screw
2. Capscrew
3. Setscrew
4. Jam Nut

Figure 3-24. Setting Gear Backlash

NOTE: The bearing high spot will be marked with yellow paint.

1. Place a shim, JLG P/N 4071009, between the pinion and bearing high spot.



2. Torque the shoulder screw (1) to 420 ft-lbs. (588 Nm) with Loctite #271.
3. Remove the turntable lock pin.
4. Pre-torque the 3/4 inch cap screws (2) to 120 ft-lbs. (168 Nm) with Loctite #271.

5. Tighten the setscrew (3) until the pinion is completely snug against the shim and bearing and then back off the setscrew.
6. Torque the setscrew to 50 ft.lbs. (70 Nm).
7. Tighten the jam nut (4).
8. Torque the four 3/4 inch capscrews (2) to 420 ft.lbs. (588 Nm).
9. Remove and discard the shim.

3.9 SWING BEARING

Turntable Bearing Mounting Bolt Condition Check

NOTE: This check is designed to replace the existing bearing bolt torque checks on JLG Lifts in service. This check must be performed after the first 50 hours of machine operation and every 600 hours of machine operation thereafter. If during this check any bolts are found to be missing or loose, replace missing or loose bolts with new bolts and torque to the value specified in the torque chart, after lubricating the bolt threads with loctite #271. After replacing and retorquing bolt or bolts recheck all existing bolts for looseness.

Check the frame to bearing. Attach bolts as follows:

1. Elevate the fully retracted boom to full elevation and rotate platform 90°.
2. Swing turntable over the side.
3. On the frame, at the rear of the turntable, try to insert the 0.0015" feeler gauge between the bolt head and hardened washer at the indicated position. (Figure 3-25., Swing Bearing Feeler Gauge Check)
4. Assure that the 0.0015" feeler gauge will not penetrate under the bolt head to the bolt shank.
5. Swing the turntable 90 degrees, and check some selected bolts at the new position.
6. Continue rotating the turntable at 90 degrees intervals until a sampling of bolts have been checked in all quadrants.
7. Lower the boom to horizontal and fully extend the boom.
8. Swing the turntable over the side.
9. On the frame, at the front of the turntable, try to insert the 0.0015" feeler gauge between the bolt head and hardened washer at the indicated position.
10. Assure that the 0.0015" feeler gauge will not penetrate under the bolt head to the bolt shank.
11. Swing the turntable 90 degrees, and check some selected bolts at the new position.
12. Continue rotating the turntable at 90 degrees intervals until a sampling of bolts have been checked in all quadrants.

Check the turntable to bearing. Attach bolts as follows:

1. Elevate the fully retracted boom to full elevation and rotate the platform 90°.
2. Swing the turntable over the side.
3. At turntable rear, try and insert the 0.0015" feeler gauge between the bolt head and hardened washer at the arrow indicated position.

4. Assure that the 0.0015" feeler gauge will not penetrate under the bolt head to the bolt shank.
5. Swing the turntable 90 degrees, and check some selected bolts at the new position.
6. Continue rotating the turntable at 90 degrees intervals until a sampling of bolts have been checked in all quadrants.

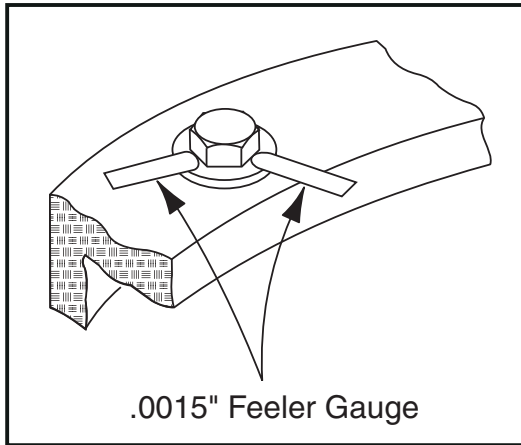


Figure 3-25. Swing Bearing Feeler Gauge Check

7. Lower the boom to horizontal and fully extend the boom.
8. At turntable front, try and insert the 0.0015" feeler gauge between the bolt head and hardened washer at the arrow indicated position.
9. Assure that the 0.0015" feeler gauge will not penetrate under the bolt head to the bolt shank.
10. Swing the turntable 90 degrees, and check some selected bolts at the new position.
11. Continue rotating the turntable at 90 degrees intervals until a sampling of bolts have been checked in all quadrants.

Wear Tolerance

1. With the boom positioned over the side of the machine, the Boom horizontal with telescope fully extended, using a magnetic base dial indicator, measure and record the distance between the swing bearing and turntable front.
2. With the boom positioned over the side of the machine, the Boom fully elevated, retracted, and platform rotated 90°, using a magnetic base dial indicator, measure and record the distance between the swing bearing and turntable rear.

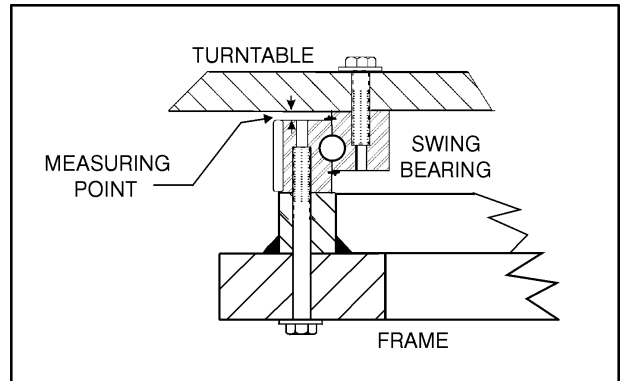


Figure 3-26. Swing Bearing Tolerance Measuring Point

3. If a difference greater than 0.057 in. (1.40 mm) is determined, the swing bearing should be replaced.
4. If a difference less than 0.057 in. (1.40 mm) is determined, and any of the following conditions exist, the bearing should be removed.
 - a. Metal particles in the grease.
 - b. Increased drive power.
 - c. Noise.
 - d. Rough rotation.
5. If bearing inspection shows no defects, reassemble bearing and return to service.

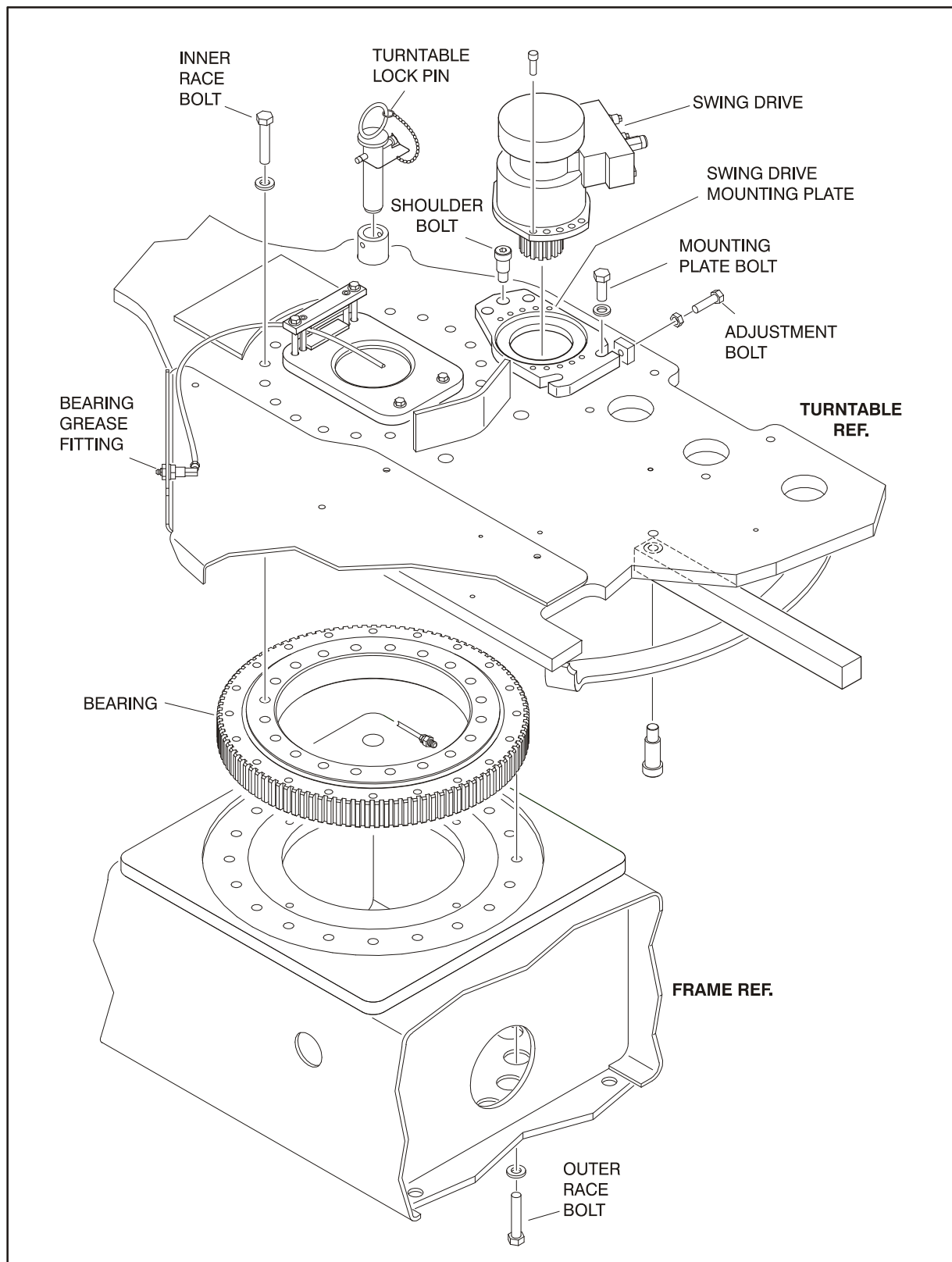


Figure 3-27. Swing Drive and Bearing Installation

Replacement of Swing Bearing

Removal of the swing bearing is as follows:

1. Attach an adequate support sling to the boom and draw all slack from sling. Prop or block the boom if feasible.
2. Tag and disconnect hydraulic lines running through center of turntable and frame. Use a suitable container to retain any residual hydraulic fluid. Cap lines and ports.
3. Attach suitable overhead lifting equipment to the base of turntable weldment.
4. Use a suitable tool to scribe a line on the inner race of the swing bearing and on the underside of the turntable. This will aid in aligning the bearing upon installation. Remove bolts, nuts and washers which attach the turntable to the bearing inner race. Discard nuts and bolts.
5. Use the lifting equipment to carefully lift the complete turntable assembly from the bearing. Ensure that no damage occurs to the turntable, bearing or frame mounted components.
6. Carefully place the turntable on a suitably supported trestle.

NOTE: The bearing weighs approximately 100 lbs. (45 kg.).

7. Use a suitable tool to scribe a line on the outer race of the swing bearing and the frame. This line will aid in aligning the bearing upon installation. Remove the bolts and washers which attach the outer race of the bearing to the frame. Discard the bolts. Use suitable lifting equipment to remove the bearing from the frame; move to a clean, suitably supported work area.

Installation of the swing bearing is as follows:

1. Install bearing to turntable with two capscrews, so the grease hose is on the forward side of the frame as close to the centerline of the turntable as the bolt pattern will allow. Do not tighten capscrews.
2. Line up high spot (marked with yellow paint) of bearing with center tooth of bull gear. Set backlash to 0.008 - 0.012 inch (0.20 - 0.30 mm). Refer to Swing Drive Installation. Tighten capscrews as shown in Figure 3-28., Swing Bearing Torque Sequence
3. Grease bearing with Mobilith SHC Bearing Grease. Grease fitting is on inside wall of inner race of bearing.

NOTE: If Mobilnac 375NC is not available, Tribol Molub-Alloy 936 Open Gear Compound or Mobilith SHC Bearing Grease or Multi-Purpose Grease (MPG) can be substituted, however the service interval will be shorter.

4. Using suitable lifting equipment, install bearing/assembly to frame with soft spot (red) 90 degree relative to load axis. If reusing old bearing, ensure that scribed line of outer race of the bearing aligns with the scribed mark on the frame.

CAUTION

JLG INDUSTRIES RECOMMENDS THAT ALL REMOVED GRADE 8 BEARING NUTS AND BOLTS BE DISCARDED AND REPLACED WITH NEW GRADE 8 NUTS AND BOLTS. SINCE THE SWING BEARING IS THE ONLY STRUCTURAL LINK BETWEEN THE FRAME AND TURNTABLE, IT IS IMPERATIVE THAT SUCH REPLACEMENT HARDWARE MEETS JLG SPECIFICATIONS. USE OF GENUINE JLG HARDWARE IS HIGHLY RECOMMENDED.

5. Apply a light coating of Loctite 271 to the new bearing bolts and loosely install the bolts and washers through the frame and outer race of bearing.

CAUTION

IF COMPRESSED AIR OR ELECTRICALLY OPERATED IMPACT WRENCH IS USED FOR TIGHTENING THE BEARING ATTACHMENT BOLTS, THE TORQUE SETTING ACCURACY OF THE TOOL SHOULD BE CHECKED PRIOR TO USE.

6. Following the torque sequence diagram shown in Figure 3-28., Swing Bearing Torque Sequence, tighten the bolts to an initial torque of 130 ft. lbs. (175 Nm). Then following the same sequence, tighten to a final torque of 190 ft. lbs. (260 Nm).
7. Remove lifting equipment from bearing.
8. Use suitable lifting equipment to carefully position the turntable assembly above the machine frame.
9. Carefully lower the turntable onto the swing bearing. Ensure that the scribed line of the inner race of the bearing aligns with the scribed mark on the turntable. If a new swing bearing is used, ensure that the filler plug fitting is at 90 degrees from the fore and aft centerline of the turntable.
10. Apply a light coating of Loctite 271 to the new bearing bolts and install through the turntable and inner race of bearing.

11. Following the torque sequence shown in Figure 3-28., Swing Bearing Torque Sequence tighten the bolts to an initial torque of 130 ft. lbs. (175 Nm). Then following the same sequence, tighten the bolts to 190 ft. lbs (260 Nm).
12. Remove the lifting equipment.
13. Route hydraulic lines through center of turntable and frame and connect as tagged prior to removal.
14. Using all applicable safety precautions, activate the hydraulic system and functionally check swing system for proper and safe operation

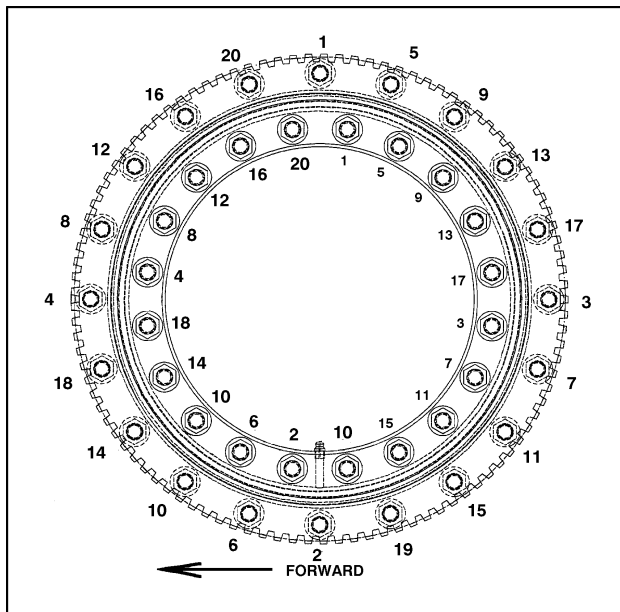


Figure 3-28. Swing Bearing Torque Sequence

Swing Bearing Torque Value

Install with Loctite - 190 ft. lbs. (260 Nm).

Swing Drive Installation

1. Coat the threads of the socket head bolts securing the swing drive to the mounting plate with Loctite #271 and torque to 120 ft.lbs. (168 Nm).
2. Position swing drive to location of bearing gear max eccentric tooth. High spot is marked with yellow paint in tooth.
3. With the mounting plate pivoting about the shoulder bolt, adjust backlash between the pinion and bearing gear teeth to 0.008 to 0.012 inch backlash (0.20mm to 0.30mm).
4. Tighten the adjusting bolt, jam nut, and shoulder bolt to prevent the swing drive from moving. Coat the threads of the shoulder bolt with Loctite #271 and torque to 420 ft.lbs. (588 Nm).
5. Coat the threads of the mounting plate bolts with Loctite #271 and torque to 420 ft.lbs. (588 Nm).

Setting Backlash

1. Place a shim (JLG P/N 4071009) between pinion and bearing on high spot of bearing.
2. After applying Loctite #271 to the shoulder bolt, torque to 420 foot-pounds (588 Nm).
3. Remove the lock pin on the turntable.
4. After applying Loctite #271, torque the four 3/4" socket head bolts to 120 foot-pounds (168 Nm).
5. Tighten the setscrew until the pinion is snug against the shim and bearing.
6. Torque the setscrew to 50 foot-pounds (70 Nm).
7. Tighten the jam nut.
8. Torque the four 3/4" socket head bolts to 420 foot-pounds (588 Nm).
9. Recover the shim and throw it away.

3.10 BATTERY MAINTENANCE AND CHARGING

WARNING

IF REPLACING A BATTERY, EACH NEW BATTERY MUST WEIGH AT LEAST 115 POUNDS (52 KG). FAILURE TO REPLACE THE BATTERY WITH ONE OF THE CORRECT WEIGHT WILL RESULT IN A TIPOVER HAZARD WHICH COULD RESULT IN SERIOUS INJURY OR DEATH.

Battery Maintenance, Quarterly

1. Open battery compartment cover to allow access to battery terminals and vent caps.

CAUTION

WHEN ADDING WATER TO BATTERIES, ADD WATER UNTIL ELECTROLYTE COVERS PLATES. DO NOT CHARGE BATTERIES UNLESS ELECTROLYTE COVERS THE PLATES.

NOTE: When adding distilled water to batteries, non-metallic containers and/or funnels must be used.

To avoid electrolyte overflow, add distilled water to batteries after charging.

When adding water to the battery, fill only to level indicated or 3/8" above separators.

2. Remove all vent caps and inspect electrolyte level of each cell. Electrolyte level should be to the ring approximately one inch from top of battery. Fill batteries with distilled water only. Replace and secure all vent caps.
3. Remove battery cables from each battery post one at a time, negative first. Clean cables with acid neutralizing solution (e.g. baking soda and water or ammonia) and wire brush. Replace cables and/or cable clamp bolts as required.
4. Clean battery post with wire brush then re-connect cable to post. Coat non-contact surfaces with mineral grease or petroleum jelly.
5. When all cables and terminal posts have been cleaned, ensure all cables are properly positioned and do not get pinched. Close battery compartment cover.
6. Start hydraulic system and ensure that it functions properly.

Optional On Board Generator

WARNING

EXHAUST GAS HAZARD. RUN THE GENERATOR IN A WELL VENTILATED AREA ONLY.

NOTICE

WHEN THE GENERATOR ENABLE CONTROL LOCATED IN THE PLATFORM CONTROL BOX IS IN THE ON POSITION AND THE GROUND EMERGENCY STOP SWITCH IN ON (PULLED OUT), THE GENERATOR WILL START AUTOMATICALLY WHEN THE BATTERIES REACH A LOW-CHARGE STATE AUTOMATICALLY CHARGING THE BATTERIES.

NOTE: The engine will automatically shut down under the following conditions:

*Charged Batteries
High Engine Oil Temperature
Low Engine Oil Pressure
Engine Overspeed
Generator Overvoltage*

WARNING

TO AVOID INJURY FROM AN EXPLOSION, DO NOT SMOKE OR ALLOW SPARKS OR A FLAME NEAR BATTERY DURING SERVICING. ALWAYS WEAR EYE AND HAND PROTECTION WHEN SERVICING BATTERIES.

Battery Charging (On Board Charger)

1. For maximum battery life:
 - a. Avoid completely discharging the batteries.
 - b. Fully charge the batteries each day the machine is used.
 - c. Charge the batteries at available times between charging.
 - d. Be sure the battery fluid covers the battery plates before charging, but to avoid overflow, do not top off the fluid level until charging.
2. To charge the batteries, connect the charger to a 115 volt source with a 15 amp minimum capacity.
3. The charge cycle is complete when the 100% LED is lit. Any other reading indicates the charge cycle is not complete.
4. The Charger will shut off automatically when the batteries are fully charged.

Depleted batteries will take approximately 23 hours to charge.

Removing the Battery Box

To remove the battery box, perform the following steps.

1. Pull the pull ring to disconnect the batteries at the battery disconnect beside the box.
2. Remove the two attachment bolts that secure the battery box to the turntable.

NOTE: The battery box and batteries complete weigh approximately 668 pounds (303 kg).

3. Using a forklift, lift the battery box up enough to clear the notch on the battery box rails and remove the battery box from the machine.

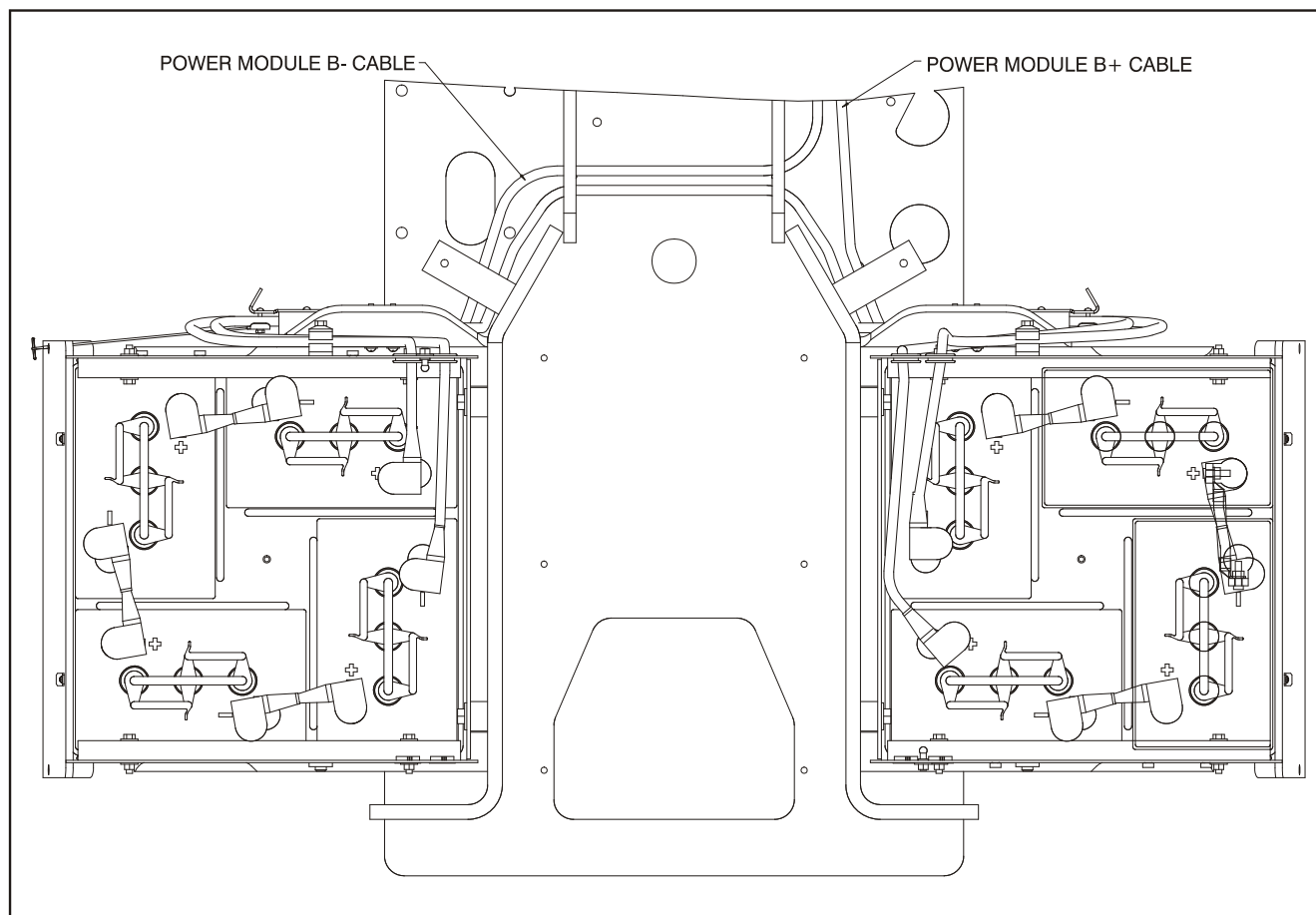


Figure 3-29. Battery Cable Routing

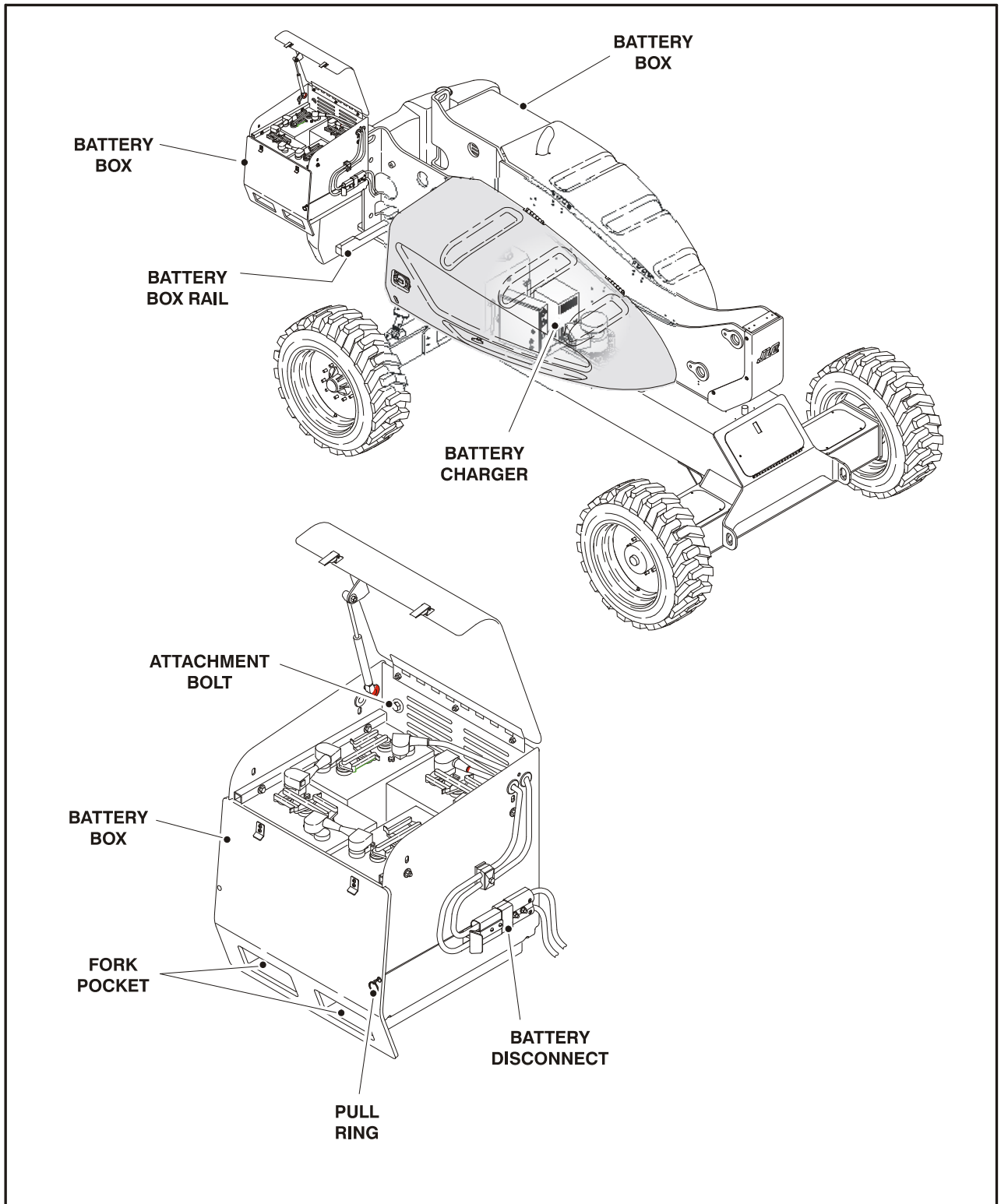
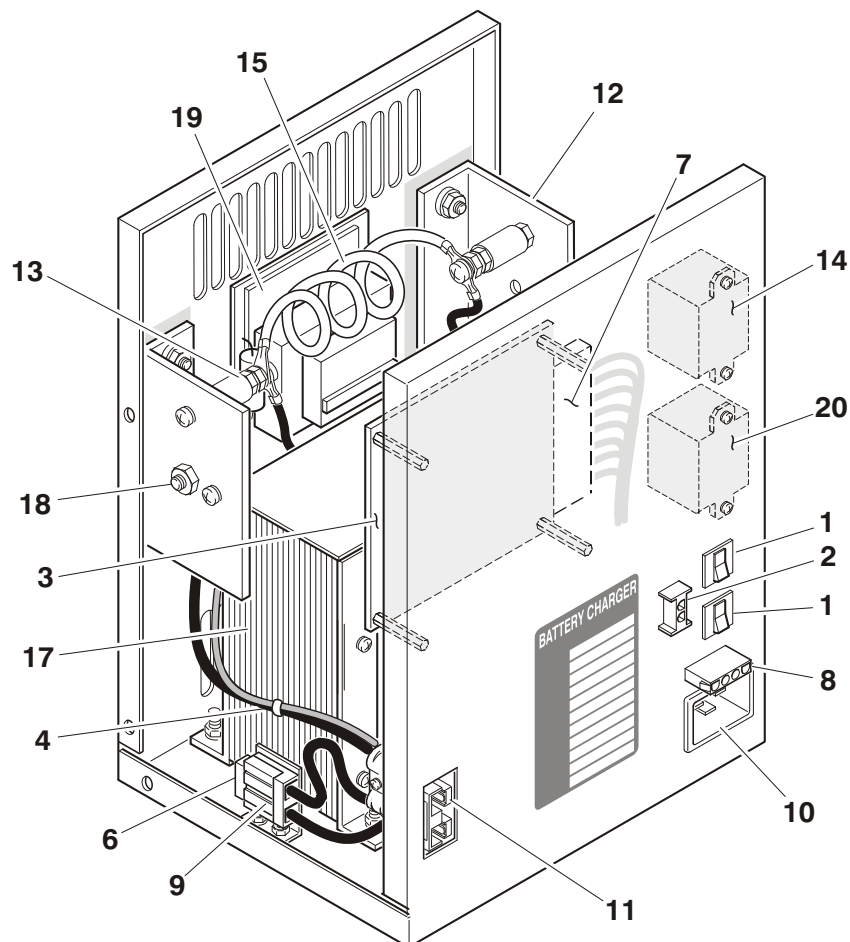


Figure 3-30. Batteries and Battery Charger



NOTE: Charger Cover removed for clarity.
Item #5 Not Shown.

- | | | |
|---------------------------|-------------------|--------------------|
| 1. 20 Amp Circuit Breaker | 7. Harness | 13. SCR |
| 2. Connector | 8. Harness | 14. Relay |
| 3. PC Board | 9. Fuse Holder | 15. Shunt Assembly |
| 4. DC Cord | 10. AC Inlet Plug | 16. Strain Relief |
| 5. Fuse Holder | 11. DC Plug | 17. Transformer |
| 6. 80 Amp DC Fuse | 12. Rectifier | 18. Varistor |

Figure 3-31. Battery Charger

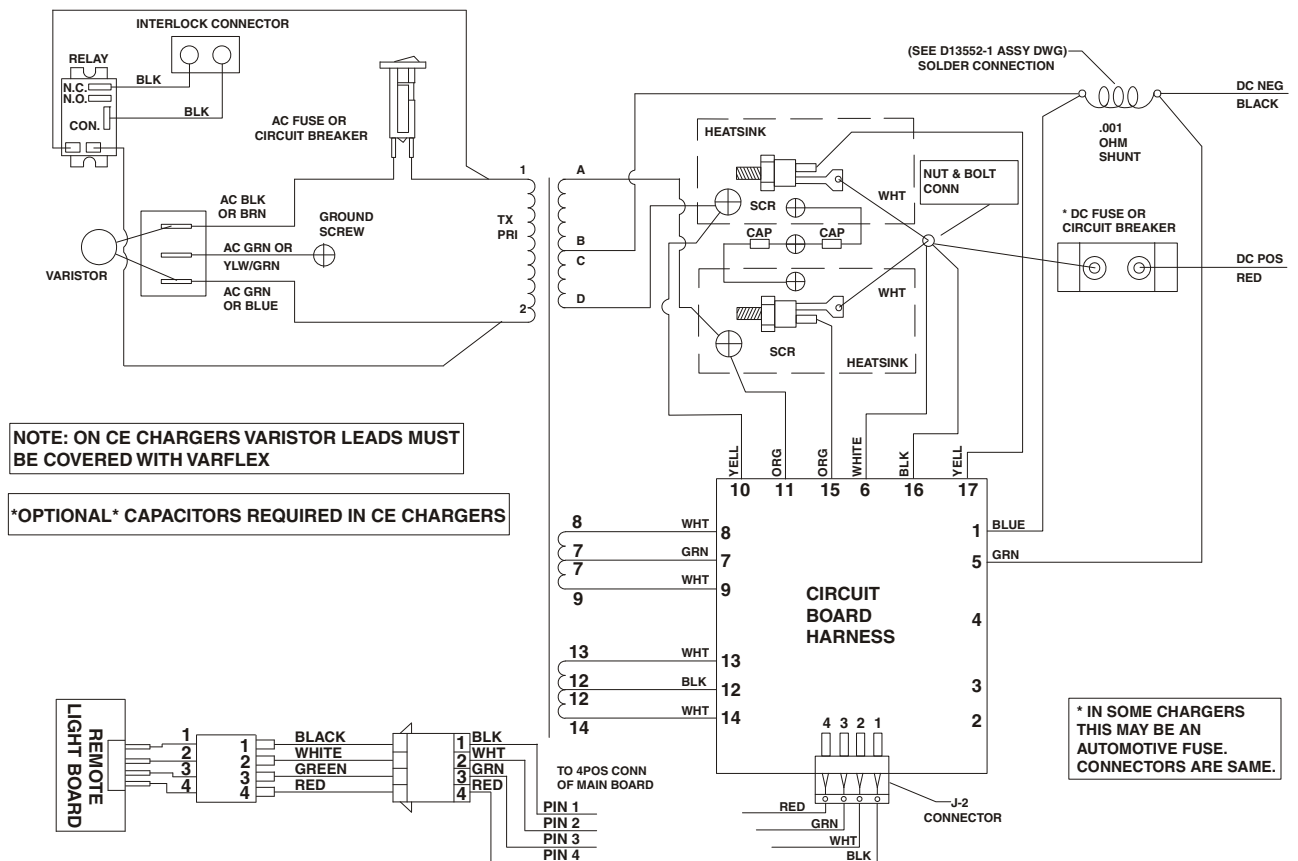


Figure 3-32. Battery Charger Schematic

3.11 GENERATOR (PRIOR TO S/N 88375)

NOTE: Throughout the Generator section, the abbreviations *RBS* and *CTS* are used. *RBS* stands for Rotary Battery System, which is the generator system. *CTS* stands for Call To Start, which is the electronic inputs which signal the generator to start and charge the batteries.

The generator consists of a drive engine, controller, and related components.

- **Alternator**

The alternator is a brushless, DC output alternator. The 3 phase output of the alternator is full wave rectified and directed to the output terminator.

The output rating is 58 volts DC at 45 amps. Voltage regulation and current limiting is provided by the Engine/Generator Controller.

The rectifier diodes and output current sensor are located in the alternator end.

- **Dynamo and Dynamo Voltage Regulator**

The engine is equipped with a 12 Volt, 15 Amp DC output dynamo.

- **Dynamo Output Fuse**

The dynamo output fuse is used to protect the output of the dynamo. This fuse is rated at 20 Amps DC, slow blow and is located on the left side of the engine.

- **Control Fuse**

This fuse provides power to the engine/generator and the relays for start control, fuel control, and pre-heater. This fuse is rated at 15 Amps DC and is located on the right side of the engine.

- **Start Battery**

A 12 volt lead-acid battery is utilized to provide starting power for the generator and power for the generator controls. This battery is charged by the engine dynamo and dynamo regulator when the engine is running.

- **Engine Starter**

The engine is equipped with a 12 Volt DC starter. This starter provides mechanical power to crank the engine. Electrical power for the starter is provided by the start battery. The starter is energized by the start control relay.

- **Start Control Relay**

The start control relay energizes the solenoid of the engine starter and the pull coil of the engine fuel solenoid. The start control relay is located on the fuel solenoid bracket on the right side of the engine. The start control relay is energized by the engine/generator controller.

- **Fuel Control Relay**

The fuel control relay energizes the hold coil of the fuel solenoid. The fuel control relay is energized by the engine/generator controller.

- **Fuel Solenoid**

The fuel solenoid actuates the run/stop lever of the engine. This solenoid has a pull and hold coil. The pull coil is energized by the start control relay and the hold coil is energized by the fuel control relay.

- **Engine Oil Temperature Sensor**

The engine oil temperature sensor is used to sense the temperature of the oil in the sump of the engine. This sensor provides a signal to the engine/generator controller for high engine temperature shutdown.

- **Alternator Output Current Sensor**

The alternator output current sensor provides a signal proportional to the output current of the alternator to the engine/generator controller. This signal is used by the controller to regulate the current output of the alternator. The output current is regulated at 55 Amps DC. The alternator output current sensor is located inside the rear cover of the alternator.

- **Engine Speed Sensor**

The engine speed sensor provides a signal proportional to the rotational speed of the engine to the engine/generator controller. This signal is used by the controller to determine starter cut-out, overspeed fault, and underspeed fault. This signal has failsafe protection, if it is not present at the controller, the unit will fault with a loss of speed signal indication. The engine speed sensor is located inside the recoil starter cover at the front of the engine.

- **Engine Low Oil Pressure Switch**

The engine is equipped with a low oil pressure switch. The switch is closed when the oil pressure is below 14.2 psi (1 Bar).

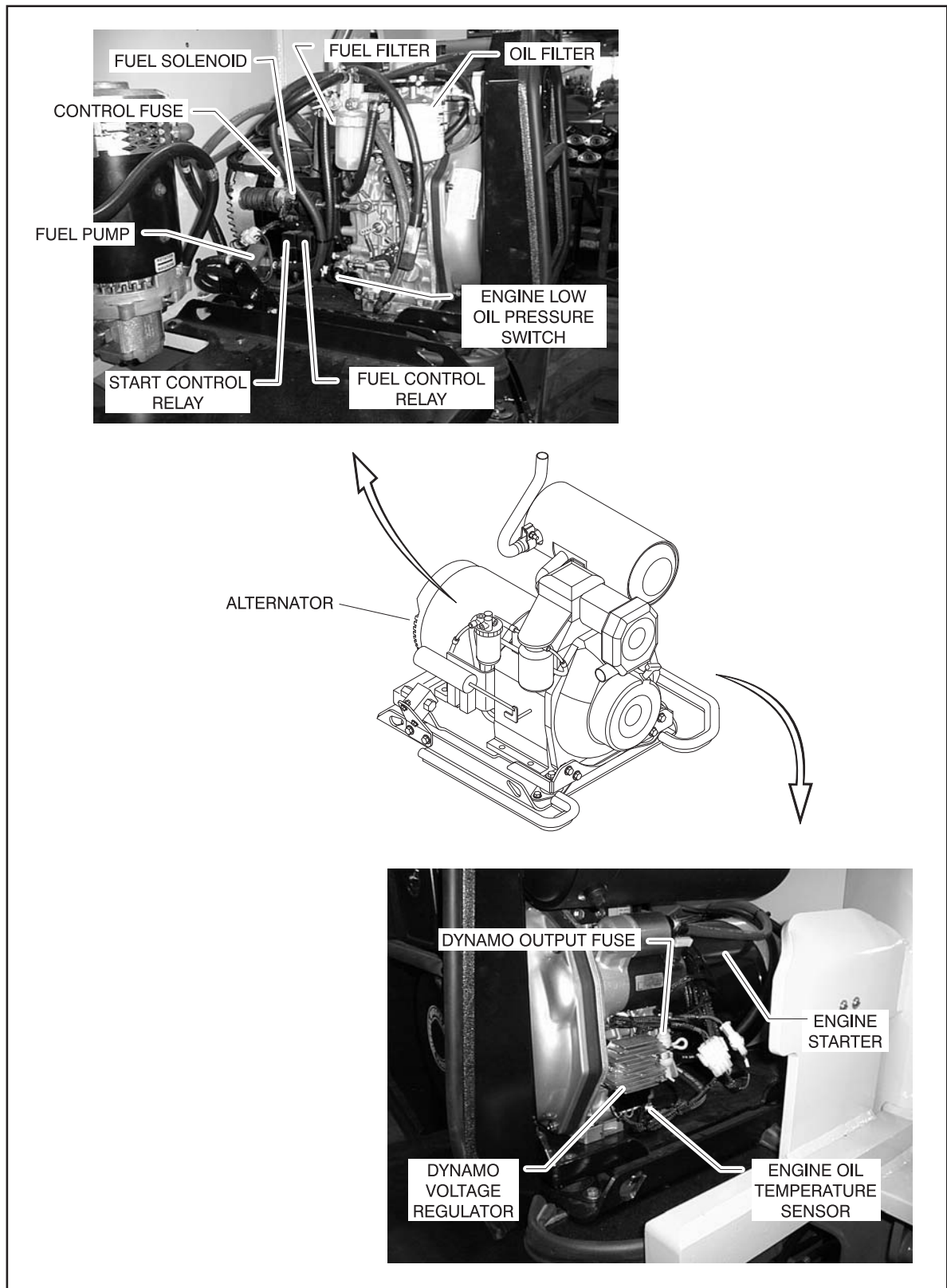


Figure 3-33. Generator Components

Timing Sequences

• RBS Prestart Sequence

1. Time Delay Engine Start (TDES)

TDES is the period which the RBS waits to verify that the CTS is valid rather than a transient condition.

2. Time Delay Pre-Heat (TDPH)

TDPH, if enabled, occurs after TDES has elapsed and the engine temperature is below the factory set engine preheat temperature setting. The engine preheater will be energized for the factory set preheat delay period.

Table 3-3. RBS Prestart Sequence

CTS (Call to Start)
TDES (Engine Start)
Preheat Delay
RBS Startup Sequence

• RBS Startup Sequence

3. Crank Time

The RBS will crank for a period up to the crank time or until the engine starts.

4. Rest Time

If the engine does not successfully start, the RBS will wait for the rest time before attempting to crank the engine again.

5. Crank Cycles

The RBS will attempt to start the engine up until the number of crank cycles is reached. If the RBS does not start, an Overcrank fault is indicated.

6. Time Delay Bypass (TDBP)

Once the engine starts, TDBP must elapse before low oil pressure and underspeed shutdowns are activated. This allows the engine to come up to normal operating conditions before enabling these shutdowns are monitored.

Table 3-4. RBS Startup Sequence

Crank Time -> Rest Time (Until Engine Start or # of Crank Cycles)
TDBP Bypass
Normal Running Operation

• RBS Shutdown Sequence

Once all CTS conditions have been removed, the RBS will begin the shutdown sequence. If a CTS condition is initiated during the shutdown sequence, the RBS will return to normal running operation until the CTS is removed.

1. Time Delay Engine Run (TDER)

Once the CTS condition is removed, the TDER period begins. This period ensures that no further CTS conditions occur prior to the cooldown period.

2. Time Delay Cooldown (TDC)

Once the TDER period ends, the alternator output is reduced to a minimal level in order to allow the engine to cool down for the TDC period. If a CTS is received during the TDC period, the CTS must last for at least the TDES period for the RBS to return to normal running operation.

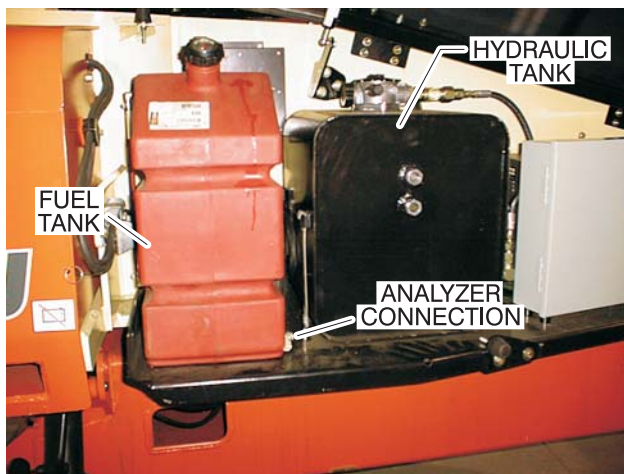
Table 3-5. RBS Shutdown Sequence

Remove CTS
TDER Engine Run
TDC Cooldown
Engine Stop

To Connect the JLG Control System Analyzer to the Generator

The JLG Control System Analyzer can be used to monitor generator settings and conditions. Connect the analyzer as follows:

1. Connect the four pin end of the cable supplied with the analyzer, to the connector behind the ground control module located on the left side of the machine next to the ground control station and connect the remaining end of the cable to the analyzer. The ground control module contains the settings for the generator.



NOTE: The cable has a four pin connector at each end of the cable; the cable cannot be connected backwards.

2. Power up the Analyzer by pulling out the ground station EMS and positioning the Generator Enable switch on the platform control box to the "on" position. Refer to Figure 3-34., Generator System Analyzer Flow Chart

Alarms and Fault Flash Codes

In the event of an RBS alarm, a flash code will be issued and an alarm indicated on the analyzer.

NOTE: Alarms must be reset once the fault has been corrected.

Table 3-6. Generator System Flash Codes

Code	Alarm	Description
1-1	Low Oil Pressure	Shutdown due to low engine oil pressure
1-2	High Engine Temperature	Shutdown due to high engine oil temperature
1-3	Engine Overspeed	Shutdown due to high engine speed
1-4	Engine Under-speed/Overcrank	Shutdown due to engine overcrank or underspeed
1-5	No Speed Signal	Shutdown due to loss of speed signal
2-1	Overvoltage	Shutdown due to high output voltage
2-2	Engine Starting System fault	Alarm not a shutdown; Indicates problem with the engine starting system
2-3	Not Used	Not Used
2-4	Loss of Voltage Sense	Shutdown due to loss of voltage sensing
Continuous	Unit Disabled	No Faults. RBS enabled and can respond to any CTS
Off	Unit Disabled	RBS off or disabled; Will not respond to any CTS

• Low Oil Pressure

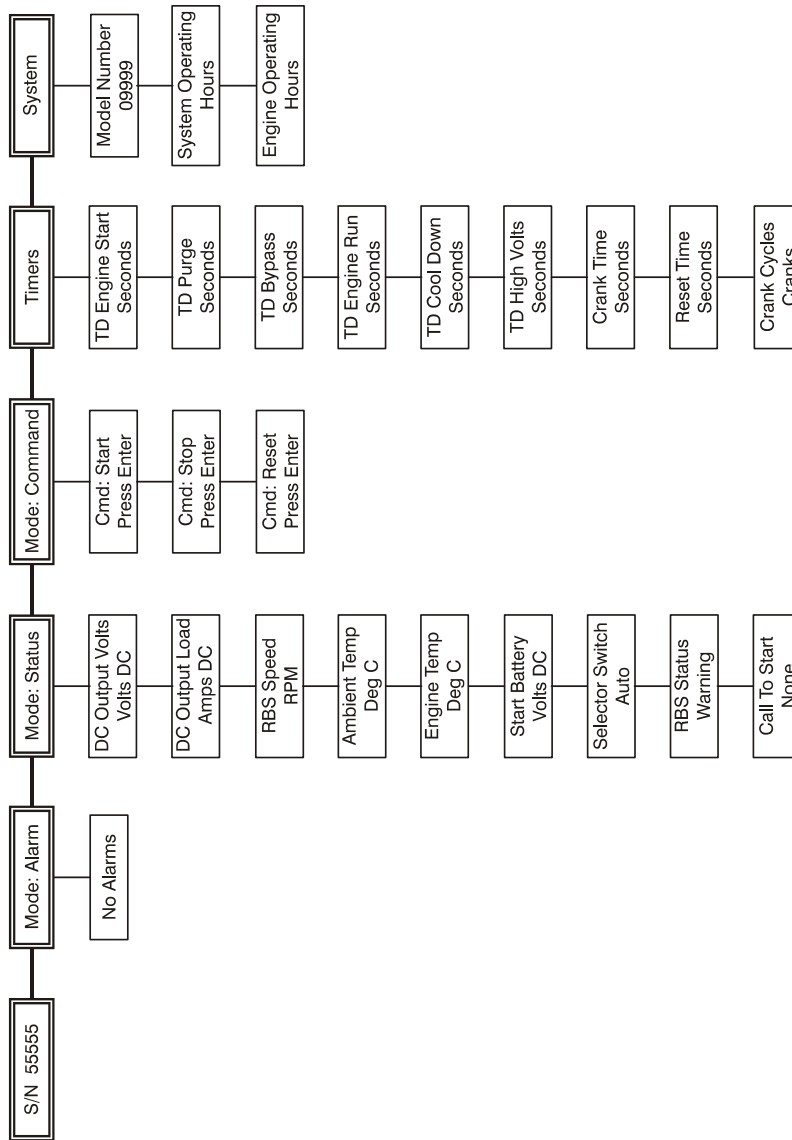
Enabled once TDBP (time delay bypass) period has elapsed after engine startup. If the low engine oil pressure switch closes, the engine will stop immediately and a low oil pressure alarm will be indicated.

• High Engine Temperature

If the engine oil temperature exceeds the high engine temperature setting, the engine will stop immediately and a low oil pressure alarm will be indicated.

• Overspeed

If the engine speed exceeds the overspeed limit, the engine will stop immediately and an overspeed alarm will be indicated.



NOTE: The Ground Station EMS must be pulled out and the Generator Enable Switch must be "on" in order for the Analyzer to test the generator circuit.

Figure 3-34. Generator System Analyzer Flow Chart

- **Underspeed**

Enabled once TDBP (time delay bypass) period has elapsed after engine startup. If the engine speed drops below the underspeed limit, the engine will stop immediately and an engine underspeed alarm will be indicated.

- **Overcrank**

If the engine fails to start after a set number of start attempts, the RBS will cease attempts to restart and an engine overcrank alarm will be indicated.

- **No Speed Signal**

In the event of a loss of speed signal, the RBS will shut-down and an engine no speed signal alarm will be indicated. This shutdown is delayed by a factory set period to ensure the fault was not momentary.

- **Overvoltage**

If the voltage measured at the alternator output exceeds the high voltage setting, the RBS will stop immediately and an RBS high output alarm will be indicated. This shutdown is delayed by a factory set period to ensure the fault was not caused by a transient condition. This feature protects the batteries and load from high DC voltages.

- **Engine Starting System Fault**

Indicates a problem with either the engine start battery, engine magneto, or magneto voltage regulator.

- **Loss Of Voltage Sense**

If the voltage measured at the alternator output is less than half of the system nominal voltage, the RBS will stop immediately and an RBS loss of voltage sense alarm will be indicated. This feature protects the batteries and load from high DC voltages due to a loss of output control.

- **Run Inhibited**

The RBS unit is disabled by the run inhibited input.

Output Current and Voltage Settings

- **Normal/Extended Output Voltage**

The normal/extended output voltage setting is the voltage at which the alternator changes under normal operating conditions.

- **Current Limit**

The current limit setting determines the maximum alternator output current.

- **High Voltage Shutdown Level**

This setting determines the alternator output voltage at which the high voltage shutdown occurs. This protects the load from abnormally high voltages.

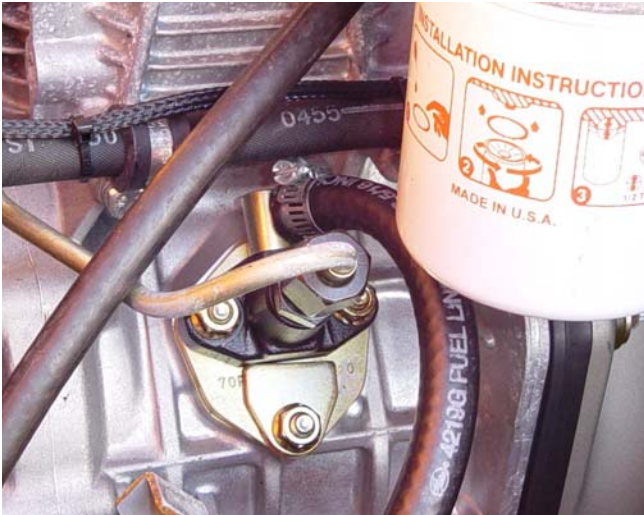
- **Finish Charging Current**

The finish charging current determines the level of the current alternator output must drop below for a low battery voltage CTS to be removed. This ensures that the batteries have accepted sufficient charge prior to shutting down the RBS. This level is used along with the low battery voltage remove CTS level to determine when the RBS removes the CTS after a low battery voltage CTS. If the charging current falls below the finish charging current while another CTS is active, the RBS will continue to operate at the normal/extended output voltage until all CTS's are removed.

Priming the Fuel Line

The following procedure is for re-priming the fuel line on the generator engine in the event fuel system components have been replaced or the unit has been run dry of fuel.

1. Make sure the fuel line isn't blocked or kinked.
2. Make sure fuel tank has fuel.
3. Disconnect the rubber fuel line at the fuel injector pump.



4. When fuel starts to flow out of the rubber line, re-connect the fuel line to the fuel injector pump.

5. Clean up any spilled fuel and try to start the generator engine.
6. If the engine still doesn't start, remove the steel line from the fuel injector pump.
7. Once fuel starts to flow, re-connect the fuel line to the fuel injector pump.
8. Clean up any spilled fuel and try to start the generator engine.
9. If no fuel flows there are some possibilities:
 - a. There is no fuel getting to the injector pump. No fuel in tank, or obstruction in fuel line, or clogged inline fuel filter.
 - b. The engine/camshaft rotation is not opening the injection fuel pump. Using the recoil starter, rotate the engine 1/3 of a turn and fuel should spill from the fuel injector pump.
10. Engine might run rough for 20 seconds or so, but it will clean out.

3.12 GENERATOR (S/N 88375 TO PRESENT)

NOTE: Throughout the Generator section, the abbreviation *RBS* is used. *RBS* stands for Rotary Battery System, which is the generator system.

The engine-driven generator is designed to produce a DC output directly without the need of a separate rectifier. Included in the RBS unit is the engine, generator, engine/generator controller, harness and related components.

Engine

Peak rating:

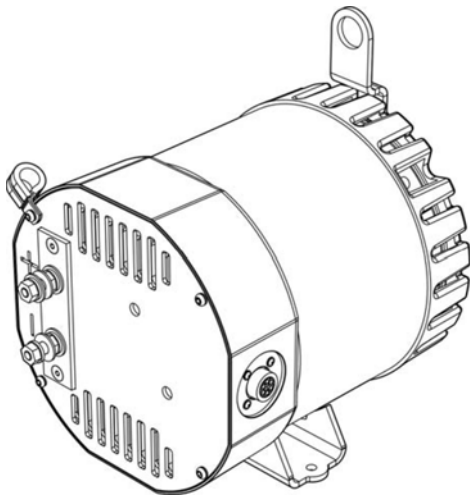
Continuous rating:

6.2 HP

0.6 HP at 3600 RPM

Refer to the Engine Manual for a complete description of the engine.

Alternator



The RBS is equipped with a brushless DC output alternator.

The 3-phase AC output of the alternator is full wave rectified and presented to the output terminals.

Output rating: 58.0V at 45A

Voltage regulation and current limiting is provided by the RBS Engine/Generator Controller.

The rectifier diodes and output current sensor are located in the alternator endbell.

Dynamo and Dynamo Voltage Regulator

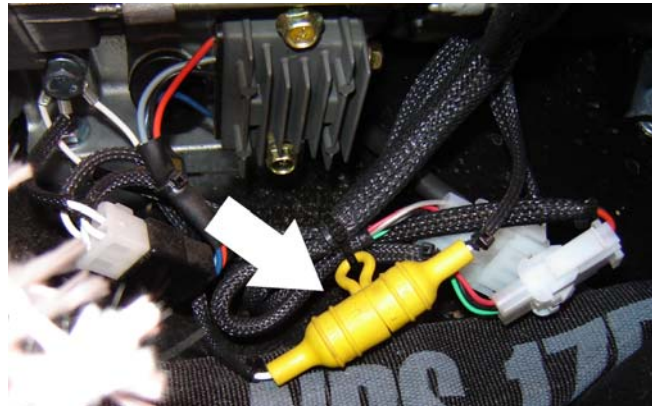


The engine is equipped with a dynamo and dynamo voltage regulator.

Dynamo output: 12V
7A DC

Refer to the Engine Manual for a complete description of the dynamo and dynamo voltage regulator.

Dynamo Output Fuse



This fuse protects the dynamo output; it is located on the left side of the engine.

Rating: 20ADC

Control Fuse

The control fuse provides power to the engine/generator controller and the relays for start control, fuel control and glow plug.

Rating: 15ADC

This fuse is located on the right side of the engine.

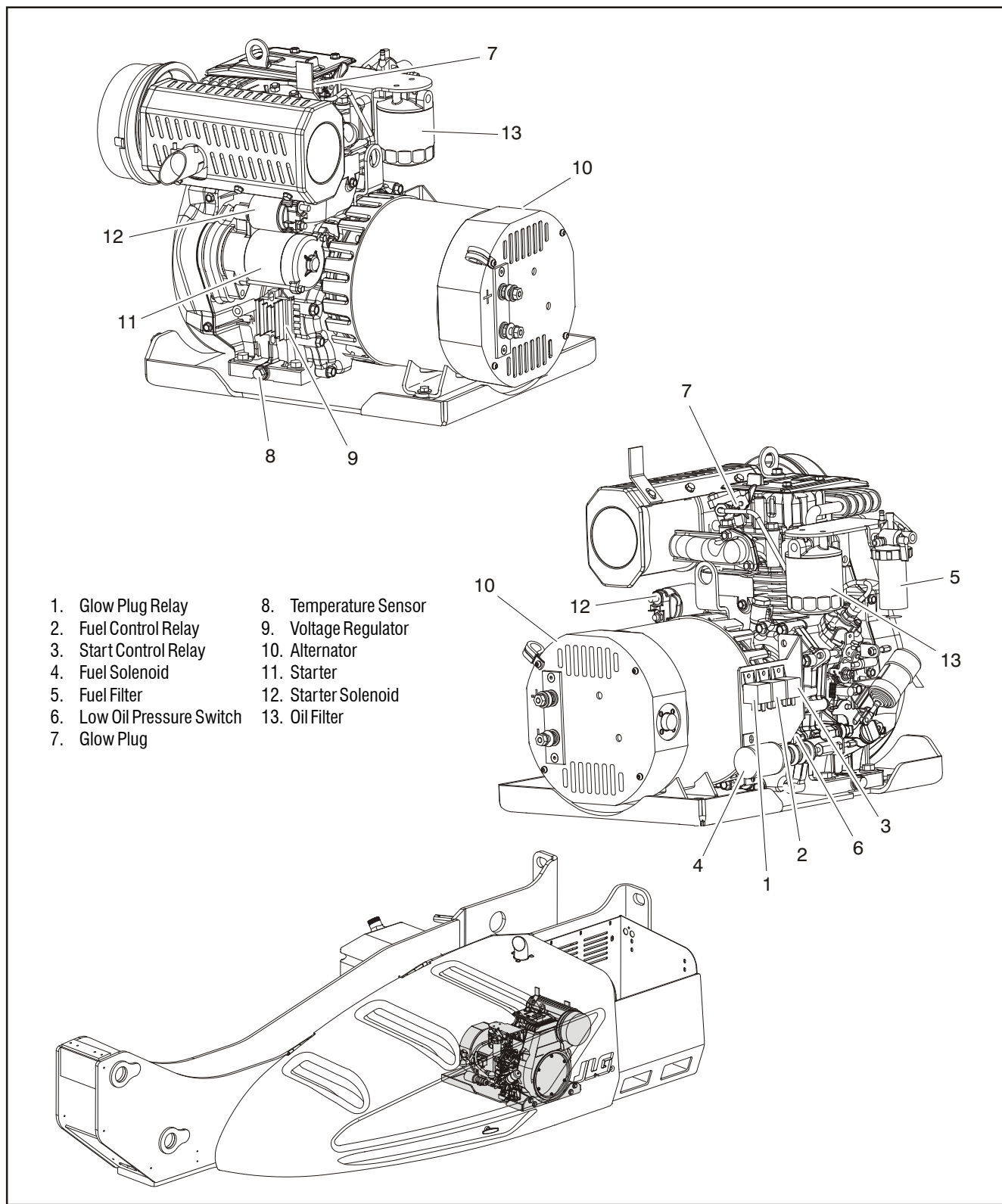


Figure 3-35. Generator

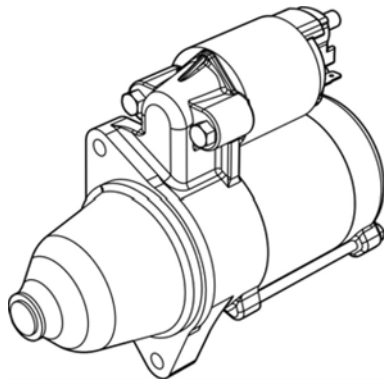
Start Battery



The RBS requires a 12V lead-acid start battery (not supplied with the system), which provides starting power and power for the RBS controls.

This battery is charged by the engine dynamo and dynamo regulator when the engine is running.

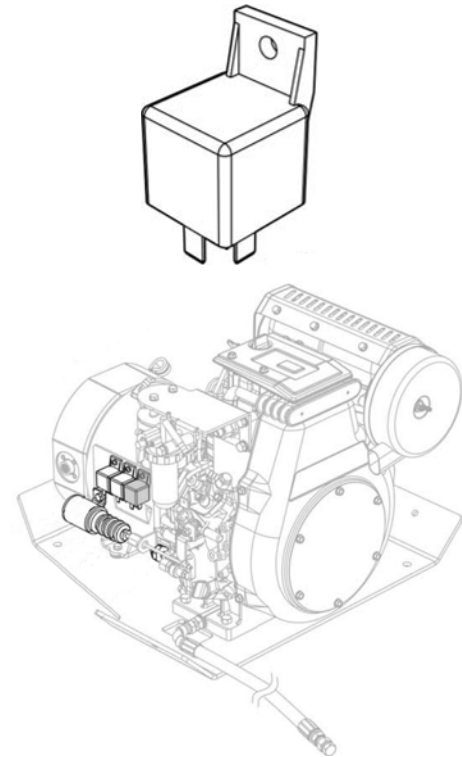
Engine Starter



The engine is equipped with a 12VDC starter, which provides the mechanical power to crank the engine. Electrical power for the starter is provided by the start battery.

The starter is energized by the start control relay.

Start Control Relay

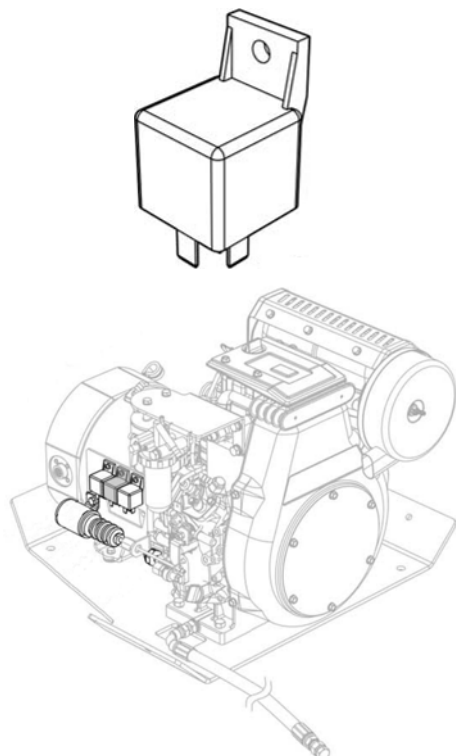


The start control relay energizes the solenoid of the engine starter and the pull coil of the engine fuel solenoid.

The start control relay is energized by the engine/generator controller from pin J2-4.

The start control relay is located on the fuel solenoid bracket on the right side of the engine.

Fuel Control Relay

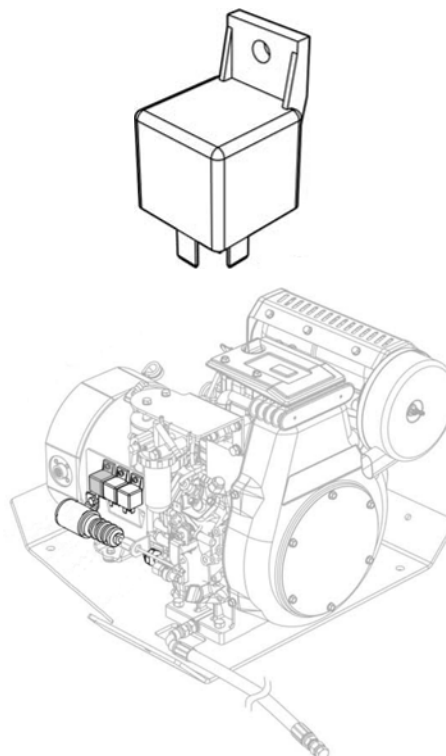


The fuel control relay energizes the hold coil of the fuel solenoid.

The fuel control relay is energized by the engine/generator controller from pin J2-3.

The fuel control relay is located on the fuel solenoid bracket on the right side of the engine.

Glow Plug Control Relay



The glow plug control relay energizes the glow plug. It is energized by the engine/generator controller, pin J2-27.

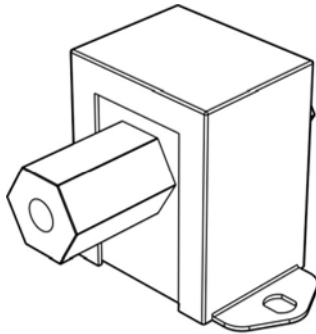
The glow plug control relay is located on the fuel solenoid bracket on the right side of the engine.

Glow Plug

The glow plug is a resistive heating element located in the combustion chamber. It is used during starting at temperatures below 32°F (0°C).

The heater is energized by the glow plug control relay.

Fuel Pump

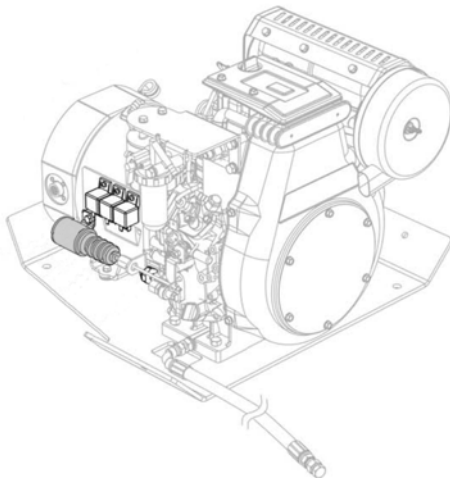
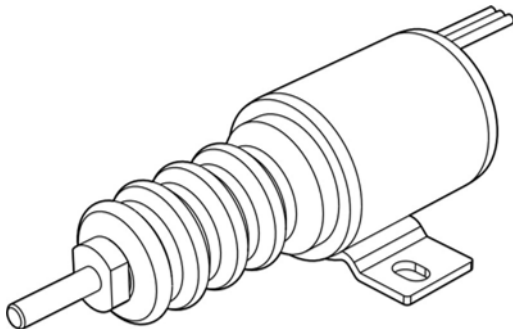


The fuel pump runs in parallel with the fuel solenoid hold coil which is run by the fuel control relay.

The pump runs whenever the engine runs, and keeps the fuel filter filled. Excess fuel flows through the return line back to the fuel tank.

The fuel pump is located on the right side of the engine.

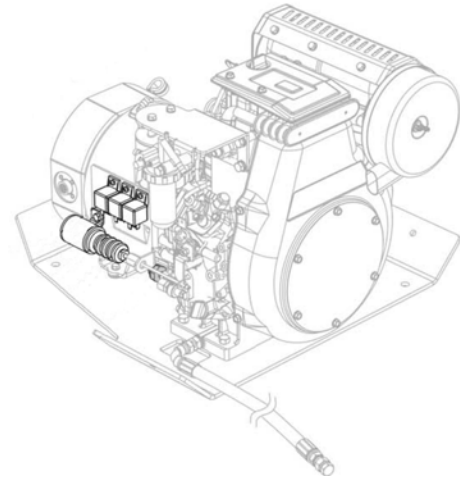
Fuel Solenoid



The fuel solenoid actuates the run/stop lever of the engine. This solenoid has a pull coil energized by the start control relay and a hold coil energized by the fuel control relay.

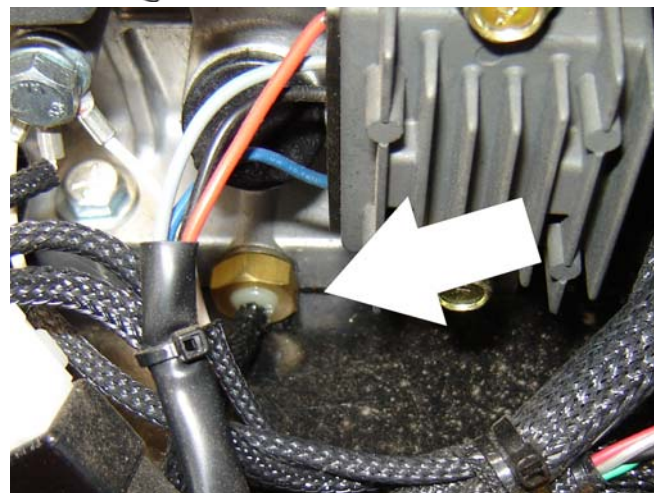
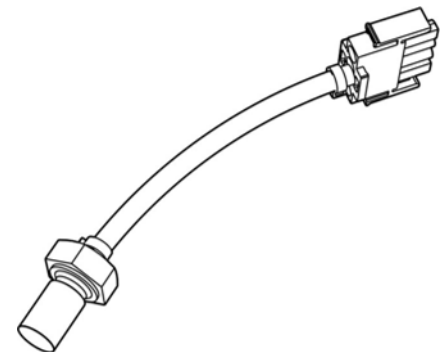
The fuel solenoid is located on the right side of the engine.

Engine Low Oil Pressure Switch



The engine is equipped with a low oil pressure switch. This switch is closed when the oil pressure is below 7psi. It is mounted on the side cover.

Engine Oil Temperature Sensor



The engine oil temperature sensor is used to sense the temperature of the oil in the sump of the engine.

This sensor provides an analog signal to the engine/generator controller. The primary use of this signal is for high engine temperature shutdown 248°F (120°C) for the

engine. The signal is also used in determining if the air glow plug should be energized.

The engine oil temperature sensor is connected to the engine/generator controller at pins J2-8 and J2-19.

The engine oil temperature sensor is located on the left side of the engine.

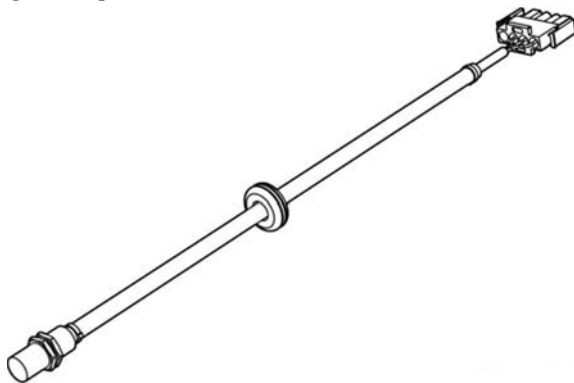
Alternator Output Current Sensor

The alternator output current sensor provides a signal proportional to the output current of the alternator to the engine/generator controller. The output current is regulated at 45ADC.

The alternator output current sensor is connected to the engine/generator controller at pins J2-21, J2-31 and J2-32.

The alternator output current sensor is located inside the rear cover of the alternator.

Engine Speed Sensor



The engine speed sensor provides a signal proportional to the rotational speed of the engine to the engine/generator controller. This signal is used by the engine/generator controller to determine starter cut-out, overspeed fault and underspeed fault. If the signal is not present at the engine/generator controller, the unit will fault with a loss of speed signal indication.

The engine speed sensor is connected to the engine/generator controller at pins J2-9, J2-15 and J2-20.

The engine speed sensor is located inside the recoil starter cover at the front of the engine.

RBS Engine/Generator Controller

The control system enclosure houses the RBS engine/generator controller, which performs all control tasks associated with the RBS.

The engine/generator controller interface is via a J2 35-pin connector.

Table 3-7. Controller Interface Pin Assignments

PIN	FUNCTION
1	System 48VDC
2	System 0V DC
3	Fuel solenoid
4	Starter Solenoid
5	Manual call to start
6	Low oil pressure
7	Not used
8	Engine oil temperature
9	Speed sensing input
10	RS-232 +12V
11	RXD
12	TXD
13	LED Driver GND
14	LED Driver +48V
15	Speed sensor GND
16	Not used
17	Not used
18	- Output voltage
19	Engine oil temperature/ambient temp. + 8V
20	Speed Sensing + 8V
21	Output current sensor (GND)
22	Not used
23	RS-232 GND
24	- Field drive
25	+ Start battery
26	- Start battery
27	Pre-heat
28	Inhibit run
29	Engine temp. switch
30	+ Output voltage
31	Speed sensing + 5V
32	Output current sense
33	Not used
34	Not used
35	Field Drive

Warnings and Safety Precautions

WARNING

THE RBS MAY START WITHOUT WARNING.

WARNING

MORE THAN ONE LIVE CIRCUIT IS USED INSIDE THE RBS CONTROL PANEL. EXERCISE CAUTION WHEN THE CONTROL PANEL IS OPEN, EVEN WHEN THE RBS IS NOT RUNNING.

System Controls

INHIBIT RUN INPUT

The inhibit run input prevents the RBS from starting, clears any existing calls to start and stops the engine immediately. To return to normal operating mode, the inhibit run input must be removed.

MANUAL CALL TO START

The manual call to start input initiates an automatic run of the RBS unit.

RS232 PORT

The RS232 allows the RBS to be monitored and controlled using an analyzer.

System Status and Performance Monitoring

System status and performance can be monitored by the analyzer.

System Settings

CALL TO START SETTINGS

Low battery voltage call to start level	48.0 VDC
Low battery voltage remove call to start level	54.0 VDC
Low temperature call to start level	5°C
Low temperature remove call to start level	8°C
Low start battery voltage call to start level	12.2 V
Low start battery voltage remove call to start level	12.9 V

CURRENT AND VOLTAGE SETTINGS

Normal output voltage level	58.0 VDC
Extend output voltage level	58.0 VDC
Current limit level	45 ADC
High voltage shutdown level	63 ADC
Finish charging current level	30 ADC

TIME DELAY SETTINGS

TD engine start	30s
TD purge	0s
TD bypass	10s
TD engine run	1800s
TD cool-down	30s
TD high volts	2s

CRANK SETTINGS

Crank time	15s
Reset time	15s
Crank cycles	3

SPEED TIME AND GLOW PLUG SETTINGS

TD no speed signal	5s
TD DC sensing fault	10s
Starter disconnect	1000 Hz
Overspeed shutdown	3800 RPM
Underspeed shutdown	2000 RPM
Glow plug on temperature	5°C
Glow plug on time	15s

RBS Start

Call to start	Manual	48V DC applied to the input
	Automatic	1 Low battery voltage (below 48VDC)
		2 Low engine temperature (below 5°C)
		3 Low start battery voltage (below 12.2V)
Engine start time delay		RBS waits to verify that call to start is valid (not a transient condition).
Preheat delay		- if engine temperature is below 32°F (0°C)
Crank time (Rest time)		RBS will crank and rest until engine starts, or Overcrank fault is indicated after 3 failed crank cycles.
Time delay bypass		RBS waits until normal engine operating conditions are reached before Low oil pressure and Underspeed faults are monitored.

RBS shutdown

Call to start removed	Manually	Inhibit run input applied
	Automatically:	1 Battery voltage above 54VDC and finish charging current below 30ADC
		2 Engine temperature above 8°C
		3 Start battery voltage above 12.9V and finish charging current below 30ADC
Engine run time delay		This period ensures that no further call to start conditions occur prior to cool-down period.
Cool-down period		Alternator output is reduced to a minimal level to allow the engine to cool down.

RBS Alarms and Flash Codes

In the event of an RBS alarm, a flash code will be issued and an alarm indicated on the analyzer.

Table 3-8. RBS Alarms and Flash Codes

Flash Code	Problem		RBS Condition
1-1	Low Oil Pressure ¹	Below 7psi	Shutdown
1-2	High Engine Temp.	Over 248°F (120°C)	Shutdown
1-3	Overspeed	Over 3800 RPM	Shutdown
1-4	Underspeed 1	Below 2000 RPM	Shutdown
	Overcrank	3 failed crank cycles Call to start removed	Call to start removed
1-5	No Speed Signal ²		Shutdown
2-1	Overvoltage ³	Over 63VDC	Shutdown
2-2	Engine Starting System fault 4		Alarm
2-4	Loss Of Voltage Sense	Alternator output less than 1/2 of the system nominal voltage (58VDC)	Shutdown
steady	Unit Enabled, no faults		Unit can respond to any call to start
-	Unit Off / Disabled		Unit will not respond to any call to start
Notes:			
1 Enabled once time delay bypass period has elapsed after engine startup.			
2 Delayed to ensure the fault was not momentary.			
3 Measured at the alternator output, shutdown is delayed by a factory set period to ensure the fault was not caused by a transient condition.			
4 Indicates a problem with the engine start battery, engine magneto or magneto-voltage regulator.			

Alarms must be reset once the fault has been corrected (see below).

Resetting the RBS Controller

The RBS can be reset using the analyzer or by disabling and re-enabling the RBS controller. This will clear any current fault condition with the controller.

Maintenance Schedule

Check oil level every 24 hours

Change engine oil and filter every 150 hours

Troubleshooting

Table 3-9. Troubleshooting

Flash Code	Problem	Solution
-	Unit Off / Disabled (engine will not crank)	Check position of selector switch. Verify that the inhibit run is released. Check the warning LED. Remedy fault if present and restart the RBS. Check the start battery voltage. Check control fuse. Check for loose wiring or connection.
1-1	Low Oil Pressure	Check oil level. Check oil supply lines. Refer to Kubota Workshop manual WSM OC60/80/95. Verify correct operation of oil pressure switch with a test gauge.
1-2	High Engine Temp.	Check for obstructions in the cooling airflow to the engine. Check that the ambient temperature is within the design limits of the engine. Verify correct operation of engine temperature sensor.
1-3	Overspeed	Verify setting of governor lever. Readjust, if required. Refer to Kubota Workshop manual WSM OC60/80/95.
1-4	Underspeed	Ensure there is an adequate supply of fuel to the engine. Ensure there is an adequate supply of combustion air to the engine. Check air cleaner. Verify setting of governor lever. Readjust if required. Refer to Kubota OC60 Engine Manual.
	Overcrank	Check fuel level. Check fuel connections. Verify operation of fuel solenoid and fuel pump. Check the start battery voltage. If the engine exhaust contains white smoke then fuel is entering the engine but the engine is not firing. Refer to the Kubota OC60 Engine Manual for further checks. If the ambient temperature is low, verify that the heater and/or glow plug are operating.
1-5	No Speed Signal	Check wiring connections.
2-1	Overvoltage	Check alternator output voltage.

Table 3-9. Troubleshooting

Flash Code	Problem	Solution
2-2	Engine Starting System fault	Check engine start battery charging system for current output. Check for failed engine start battery.
2-4	Loss Of Voltage Sense	

APU Engine Start Battery Boosting

Always connect the POSITIVE (+) of the booster battery to the POSITIVE (+) of the APU start battery, and the NEGATIVE (-) of the booster battery to the ground of the engine block.

WARNINGS:

WARNING

ALWAYS SHIELD YOUR EYES AND AVOID LEANING OVER THE BATTERY WHENEVER POSSIBLE.

WARNING

DO NOT ALLOW BATTERY ACID TO CONTACT EYES OR SKIN. FLUSH ANY CONTACTED AREA WITH WATER IMMEDIATELY. SEEK MEDICAL ATTENTION IF IRRITATION PERSISTS.

WARNING

STARTING BATTERIES GENERATE EXPLOSIVE GASES. KEEP SPARKS, FLAME AND LIGHTED CIGARETTES AWAY FROM BATTERIES.

WARNING

IMPROPER USE OF A BOOSTER BATTERY TO START AN APU MAY CAUSE AN EXPLOSION.

WARNING

DO NOT ATTEMPT TO JUMP START AN APU WITH A LOW ACID LEVEL IN THE BATTERY.

WARNING

THE VOLTAGE OF THE BOOSTER BATTERY MUST BE RATED AT 12V. THE AMP-HOUR CAPACITY OF THE BOOSTER BATTERY MUST NOT BE LOWER OR SUBSTANTIALLY HIGHER THAN THAT OF THE DISCHARGED BATTERY. USE OF BATTERIES OF DIFFERENT VOLTAGE OR SUBSTANTIALLY DIFFERENT AMP-HOUR RATING MAY CAUSE AN EXPLOSION OR PERSONAL INJURY. APPLYING A HIGHER VOLTAGE WHILE BOOSTING WILL ALSO CAUSE DAMAGE TO SENSITIVE ELECTRONIC COMPONENTS.

WARNING

A CHARGING SYSTEM (BATTERY CHARGER OR BATTERY CHARGING ALTERNATOR) MUST NEVER BE ENERGIZED WHILE BOOSTING. DAMAGE TO SENSITIVE ELECTRONIC COMPONENTS WILL RESULT.

NOTICE

THE MAIN BATTERY OF THE LIFT MUST NEVER BE USED TO BOOST THE APU. DAMAGE TO SENSITIVE ELECTRONIC COMPONENTS WILL RESULT.

3.13 SUPPLEMENTARY FUSE FOR ENGINE GENERATOR CONTROLLER

The purpose of this section is to describe the procedure to add a supplementary fuse for the Engine Generator Controller for the APU.

Tools And Material

- - Weather proof fuse holder - JLG P/N 2400081
- - AGC1, 1 Amp fuse - JLG P/N 2400080
- - 45 cm of #16 AWG wire - JLG P/N 4920019
- - 2 X insulated butt splice connectors - JLG P/N 4460035
- - 6 X medium length wire ties - JLG P/N 4240033
- - Wire/Side cutters
- - 5/32" Allen Key
- - Crimping tool

Procedure

⚠ WARNING

BEFORE BEGINNING THIS PROCEDURE, ENSURE THAT ALL SOURCES OF POWER ARE DISCONNECTED FROM THE APU!

This procedure is common for all applications of the APU. The photos contained in this document illustrate the modification performed to an APU supplied in a JLG M450 lift.

1. Locate the harness at the rear of the APU.



that the cable sleeve can be moved, exposing the

2. Find where the harness attaches to the rear cover of the generator and the connection point for the new inline fuse.



3. Remove the socket head drive screw with a 5/32" Allen key. Next remove the cable clamp from the harness.



4. Cut and remove the Wire Ties holding the Harness label to the harness. Next, remove the Wire Ties so

conductors of the harness.



5. Cut wire 106 going to the Engine/Generator Controller after the existing connection point and install the conductors that lead to the new inline fuse holder. Use insulated butt splice connectors for these conductors.



6. Re-install the harness with the new fuse in place.



7. Reconnect the lift and APU start battery. The APU is now ready for use.

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SECTION 4. BOOM & PLATFORM

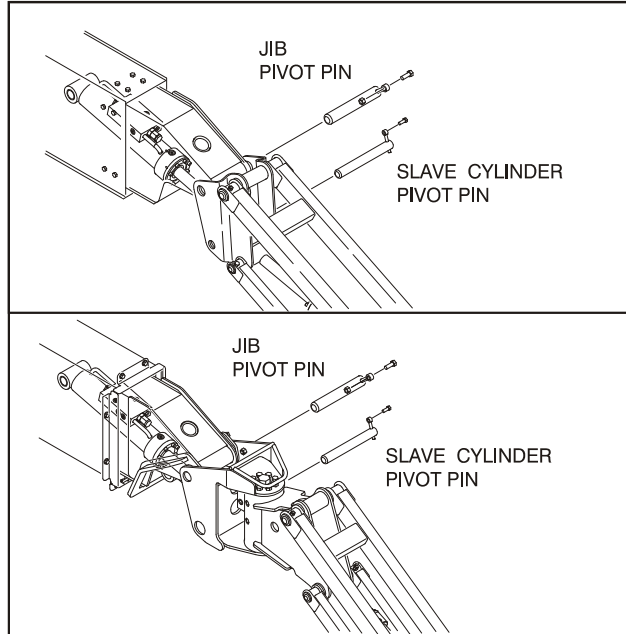
4.1 BOOM

Removal

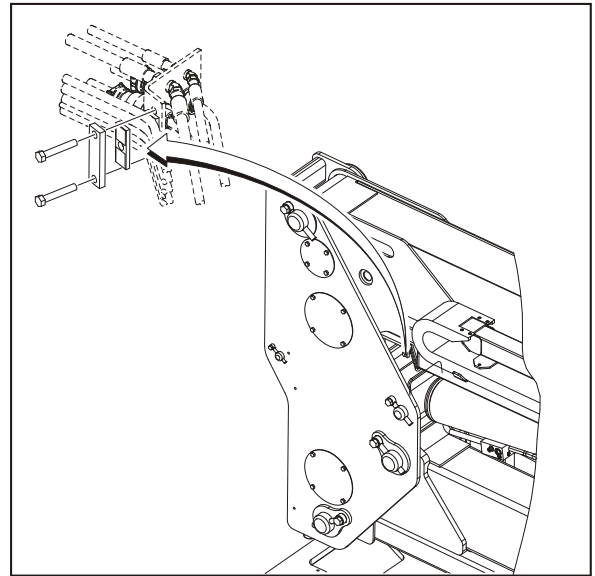
1. Raise the boom to horizontal and make sure that it is adequately supported with a lifting device or blocking.
2. Tag and disconnect the electrical leads at the platform and the platform valve.
3. Tag and disconnect all hydraulic lines on the platform valve and rotator. Cap or plug all openings.
4. Remove the hardware attaching the platform and platform support and remove the platform.

NOTE: Steps 5 and 6 are only applicable if the machine is equipped with a jib.

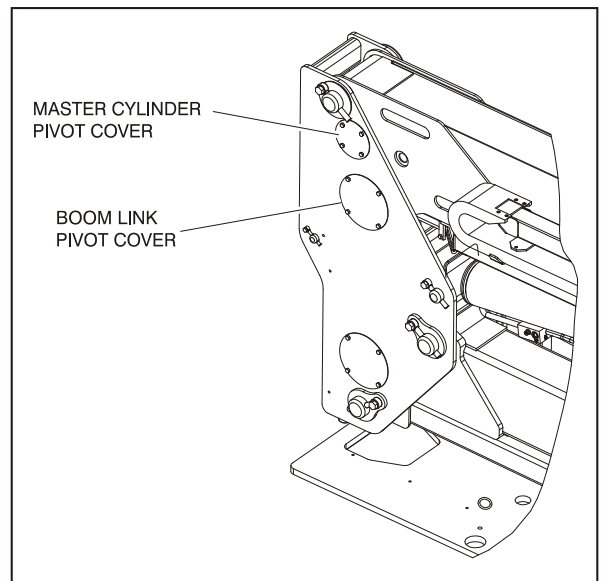
5. If equipped with a jib, place the jib in a horizontal position and support it with blocking. Tag and disconnect the hydraulic lines running to the jib cylinder. If equipped with a side swing jib, also tag and disconnect the hydraulic lines running to the jib rotator.



6. Remove the jib pivot pin and the slave cylinder pivot pin and remove the jib.



7. Disconnect the hydraulic and electrical lines from the bulkhead fittings at the rear of the boom.
8. Remove the cover at the rear of the upright.



9. Remove the covers on the side of the upright for the pivot pins.
10. Tag and disconnect the hydraulic lines running to the telescope cylinder.
11. Tag and disconnect the hydraulic lines running to the master cylinder.
12. Remove the upper lift cylinder pivot pin.

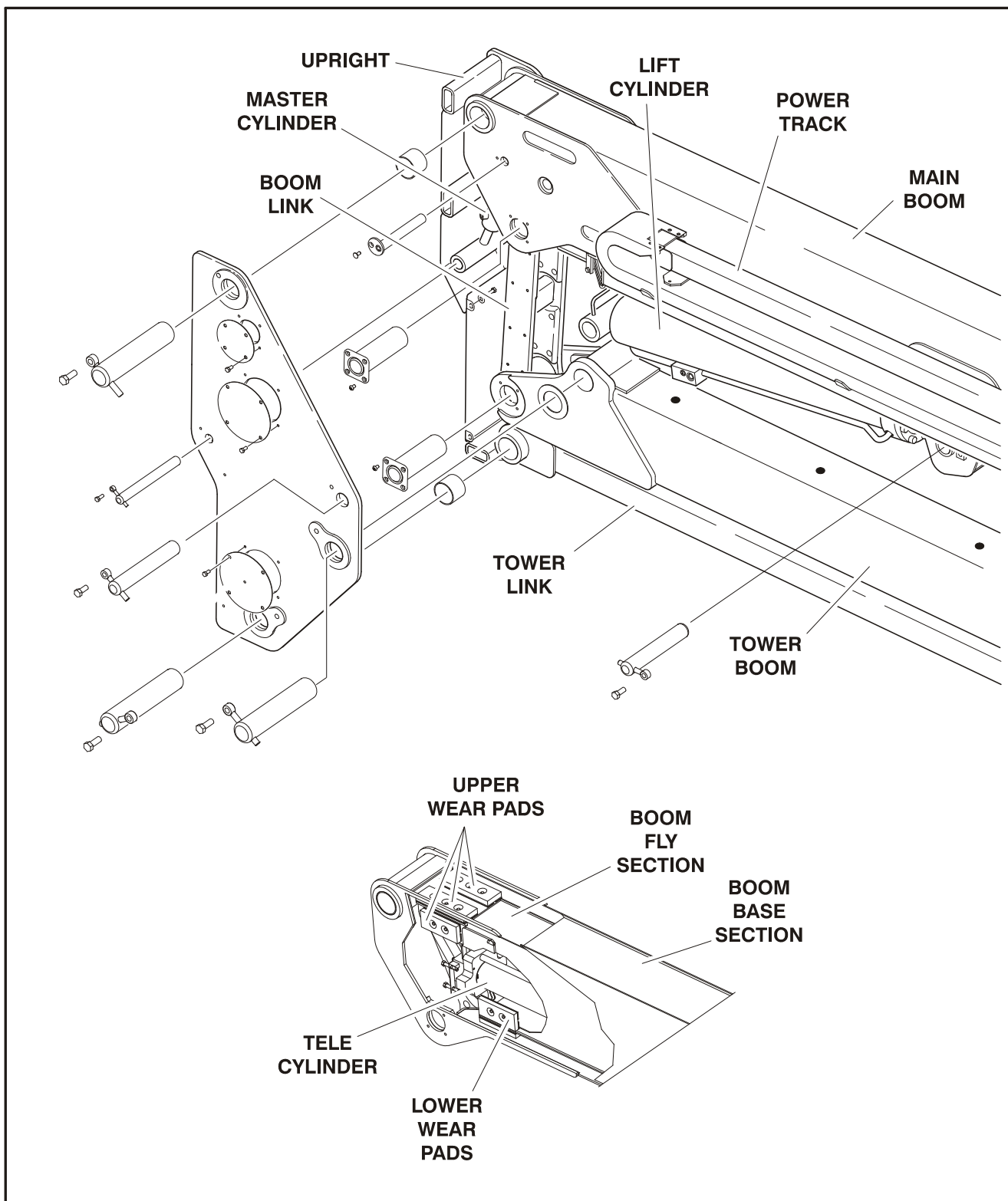


Figure 4-1. Boom Assembly - Sheet 1 of 3

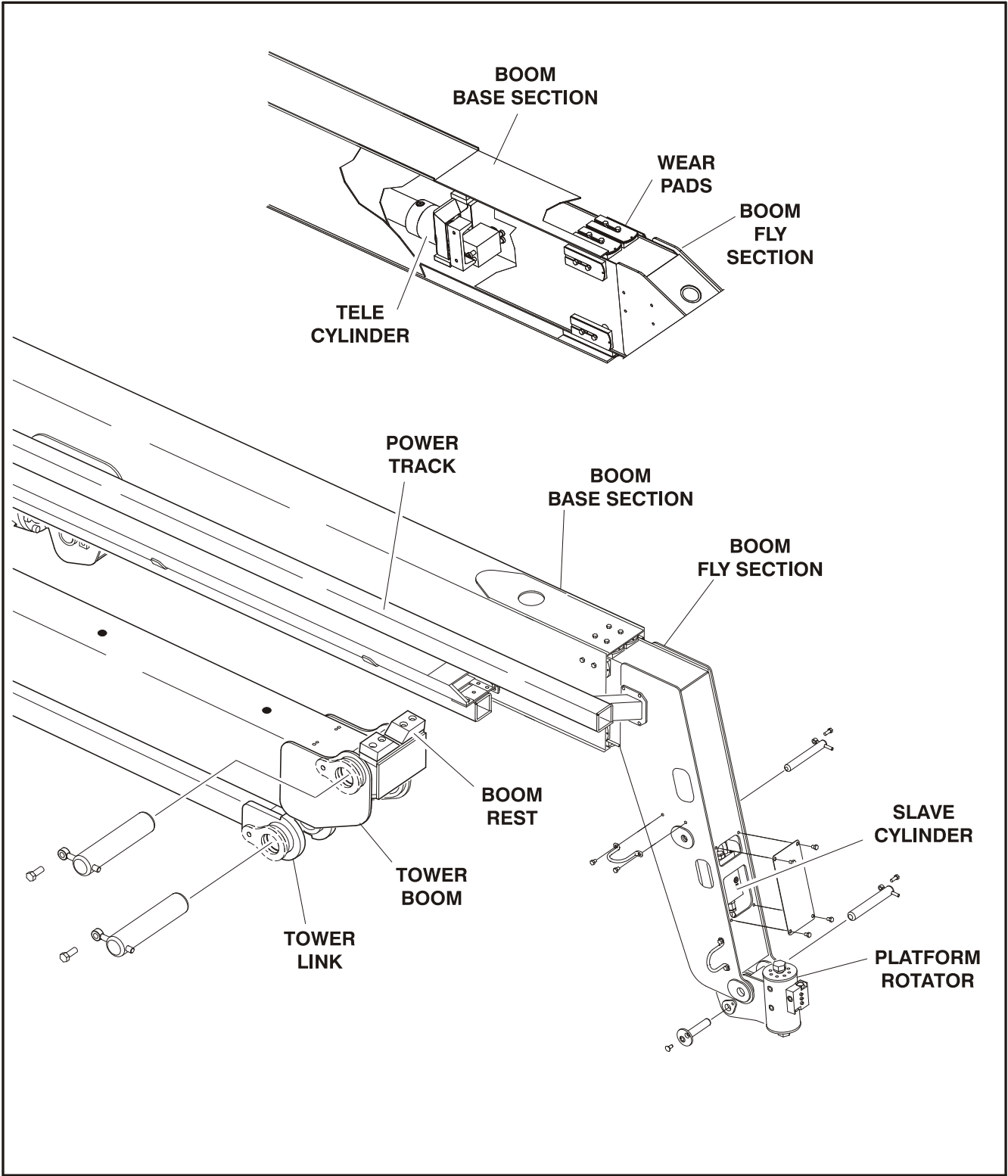


Figure 4-2. Boom Assembly - Sheet 2 of 3

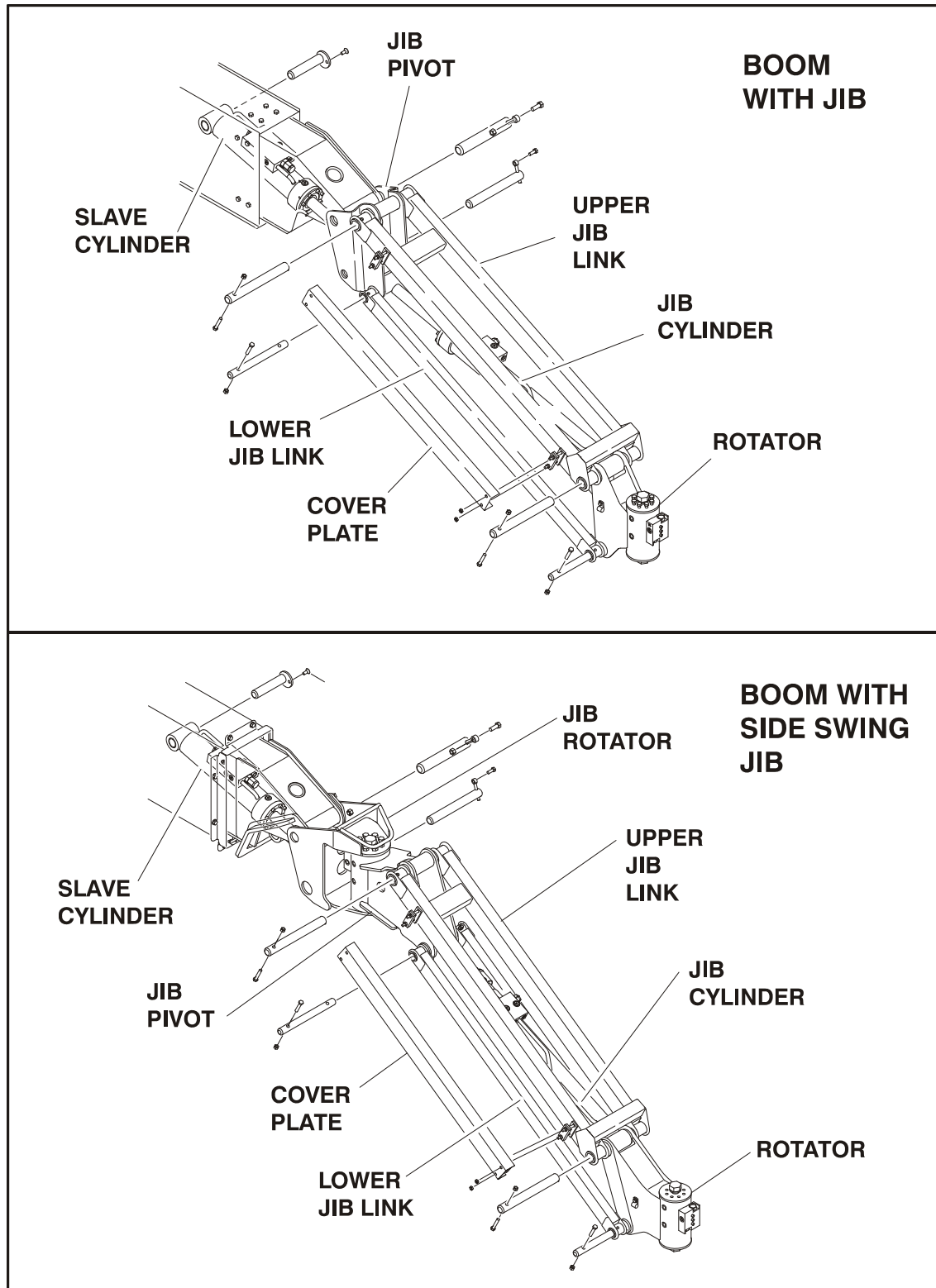
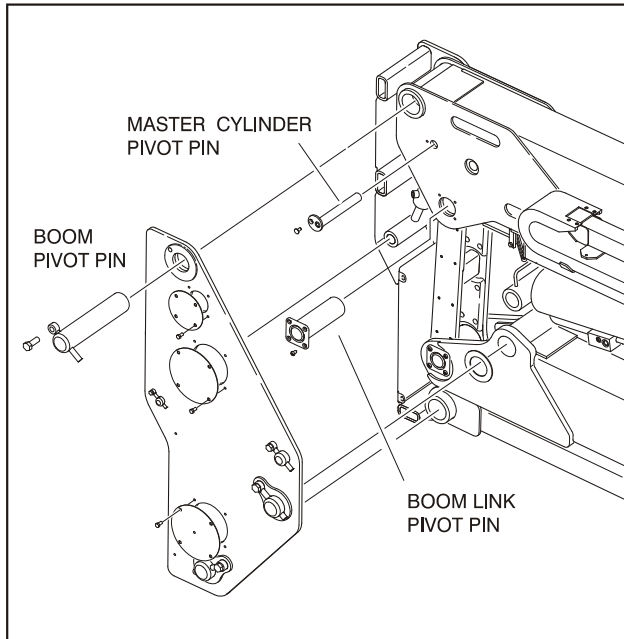


Figure 4-3. Boom Assembly - Sheet 3 of 3



13. Remove the upper master cylinder pivot pin.
14. Remove the boom pivot pin.
15. Remove the boom link pivot pin.

NOTE: The standard boom assembly weighs approximately 1993 lbs. (904 kg).

16. Using an adequate lifting device, remove the boom from the machine.

Installation

1. Using an adequate lifting/supporting device, position the boom into the proper position on the upright.
2. Install the boom link pivot pin.
3. Install the boom pivot pin.
4. Install the upper master cylinder pivot pin.
5. Install the upper lift cylinder pivot pin.

6. Connect the hydraulic lines running to the master cylinder as tagged during removal.
7. Connect the hydraulic lines running to the telescope cylinder as tagged during removal.
8. Install the covers on the side of the upright to conceal the pivot pins.
9. Install the rear cover on to the upright.
10. Connect all the hydraulic and electrical lines at the bulkhead fitting at the rear of the boom.

NOTE: Steps 10 and 11 are only applicable if the machine is equipped with a jib.

11. Position the jib to the pivot points and install the jib pivot pin and the slave cylinder pivot pin.
12. Connect the hydraulic lines running to the jib cylinder as tagged during removal. If equipped with a side swing jib, connect the hydraulic lines running to the jib rotator.
13. Install the platform support and platform.
14. Install the hydraulic lines to the platform valve and rotator as tagged during removal.
15. Reconnect the electrical leads at the platform and platform valve as tagged during disassembly.
16. Cycle test the boom from the ground station to ensure all functions operate properly.
17. After verifying that all functions operate properly from the ground station, cycle test the boom from the platform station to ensure all functions operate properly from the platform station as well.

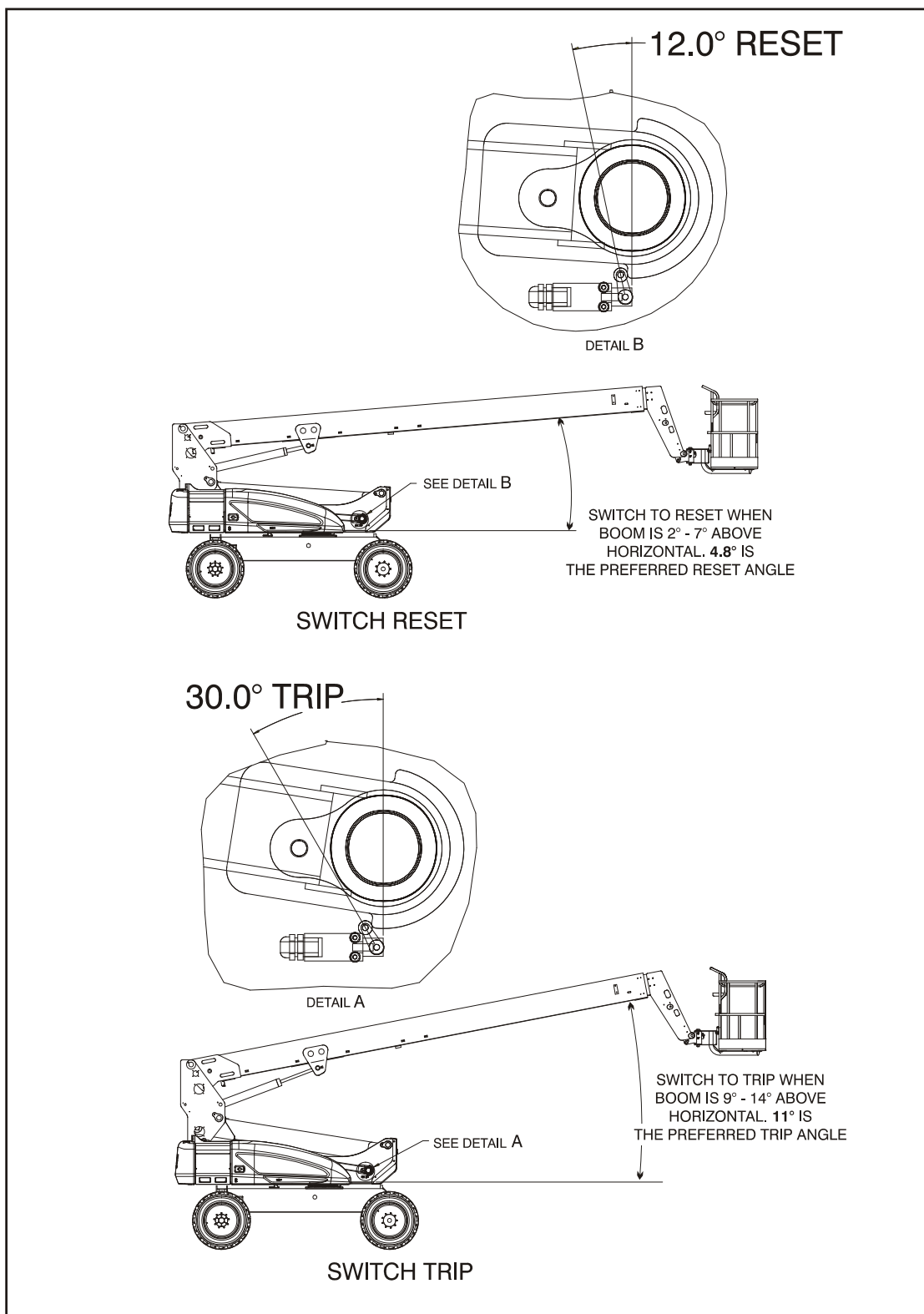


Figure 4-4. Boom Limit Switch Adjustment

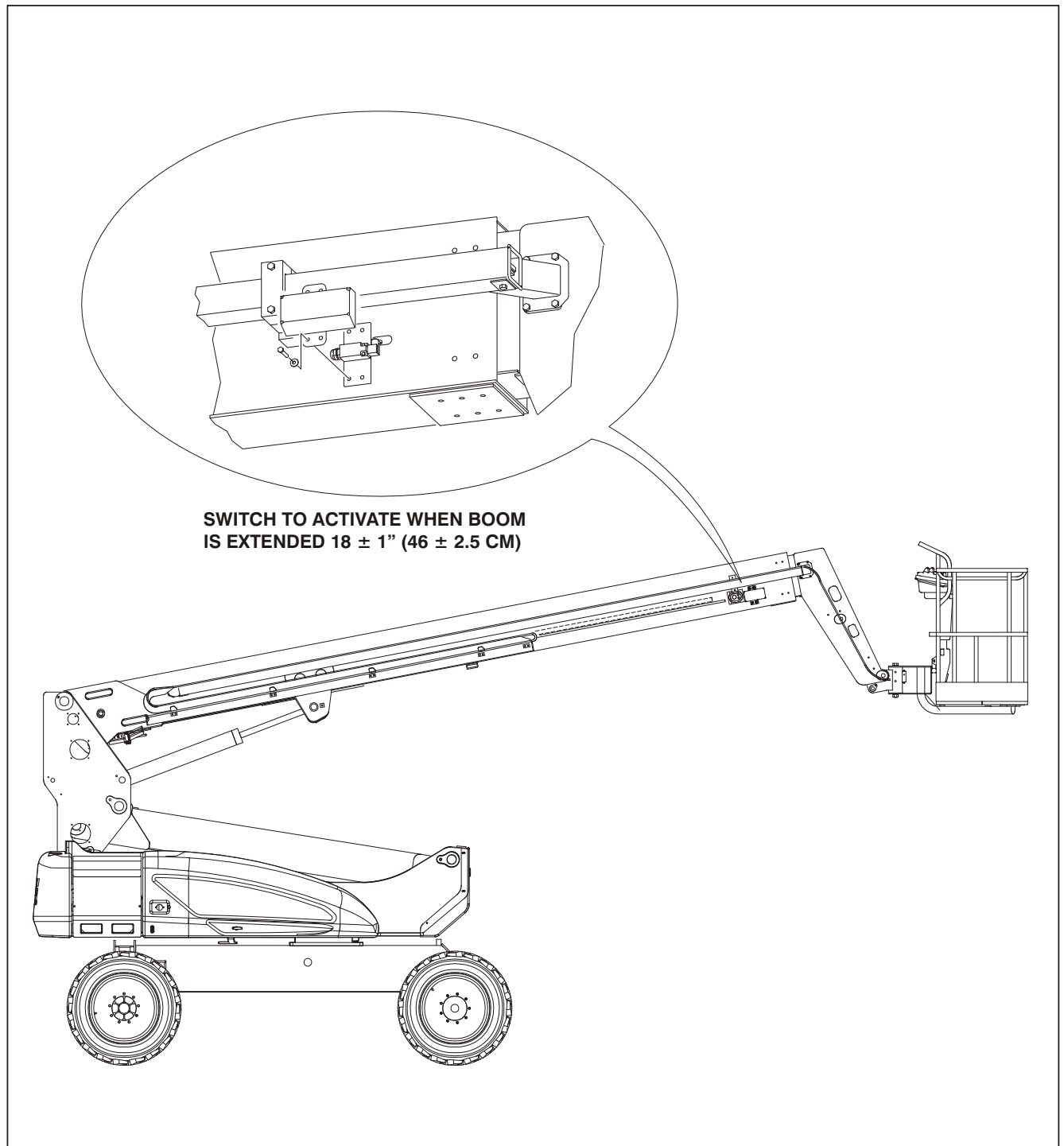
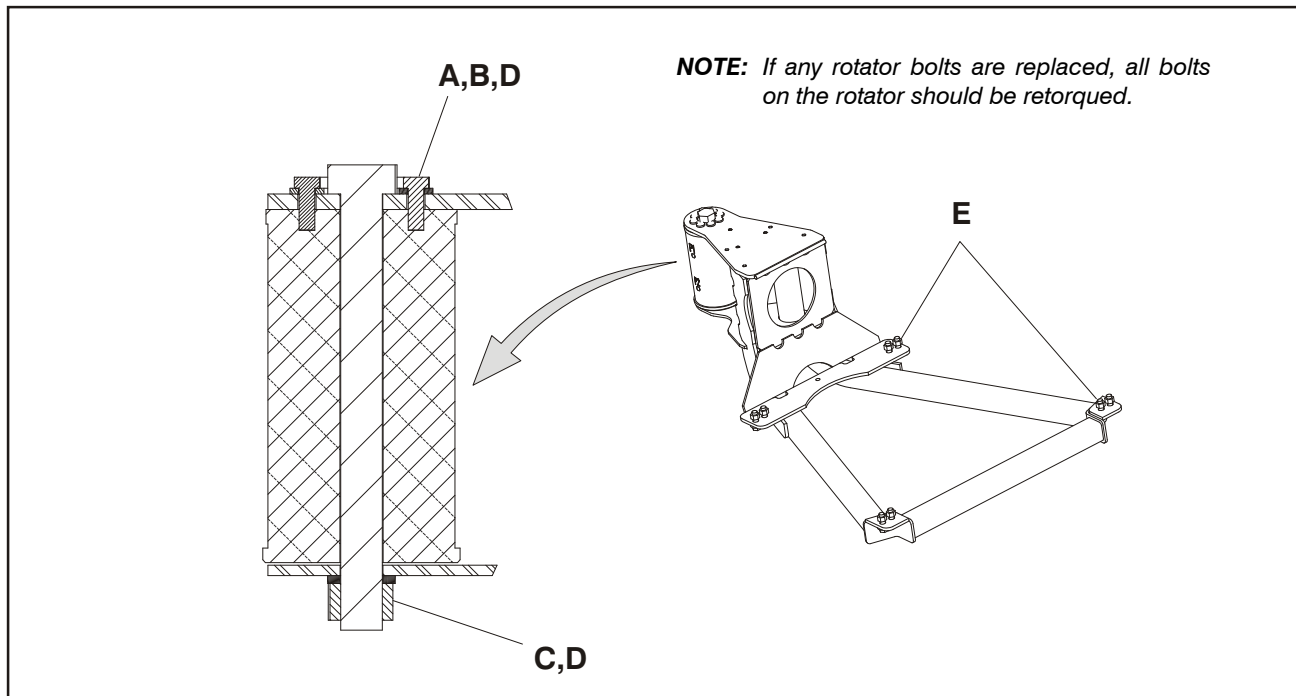


Figure 4-5. Transport Limit Switch (CE Only)

4.2 LOAD CELL CALIBRATION PROCEDURE

1. Place the machine in the stowed position.
2. Activate both emergency stop switches and turn the key switch to the platform position.
3. Remove all loads from the basket including the operator.
4. Turn P1 clockwise (in) until the potentiometer begins to click.
5. Plug the analyzer into the port in the platform.
6. Enter the password 33271.
7. Select Machine Set-Up/Load Cell/ 1=Warn Only.
8. Select Diagnostics/System/Load Cell on the Analyzer.
9. Adjust P2 until the load = 0%.
10. Place 455 lbs. in the center of the basket.
11. Adjust P1 until the load = 100%.
12. Verify that the overload lamp lights continuously and the alarm sounds continuously during an overload condition.
13. Remove the weight from the basket.
14. Adjust P2 until the load = 0%.
15. Place 500 lbs. (230kg) in the center of the basket.
16. Adjust P1 until the load = 95%.
17. Add 55lbs. (25kg) in center of the basket.
18. Verify that the overload lamp lights continuously and the alarm sounds continuously during an overload condition.
19. Remove weight from the basket.
20. Seal Potentiometers with fingernail polish.
21. When an overload condition is reached, the machine will give an indication by activating the tilt alarm, lighting the overload light, put all platform functions into creep, cutout lift up and telescope out at platform and ground.
The horn will be activated when MTB ground control switch is selected to ground and overload condition is reached.



- | | |
|---|---|
| A | Torque to 50 ft.lbs. (68 Nm) |
| B | Loctite #242 |
| C | Torque to 480 ft. lbs. (650 Nm) |
| D | Check torque every 150 hours of operation |
| E | Torque to 85 ft. lbs. (115 Nm) |

Figure 4-6. Platform Support Torque Values

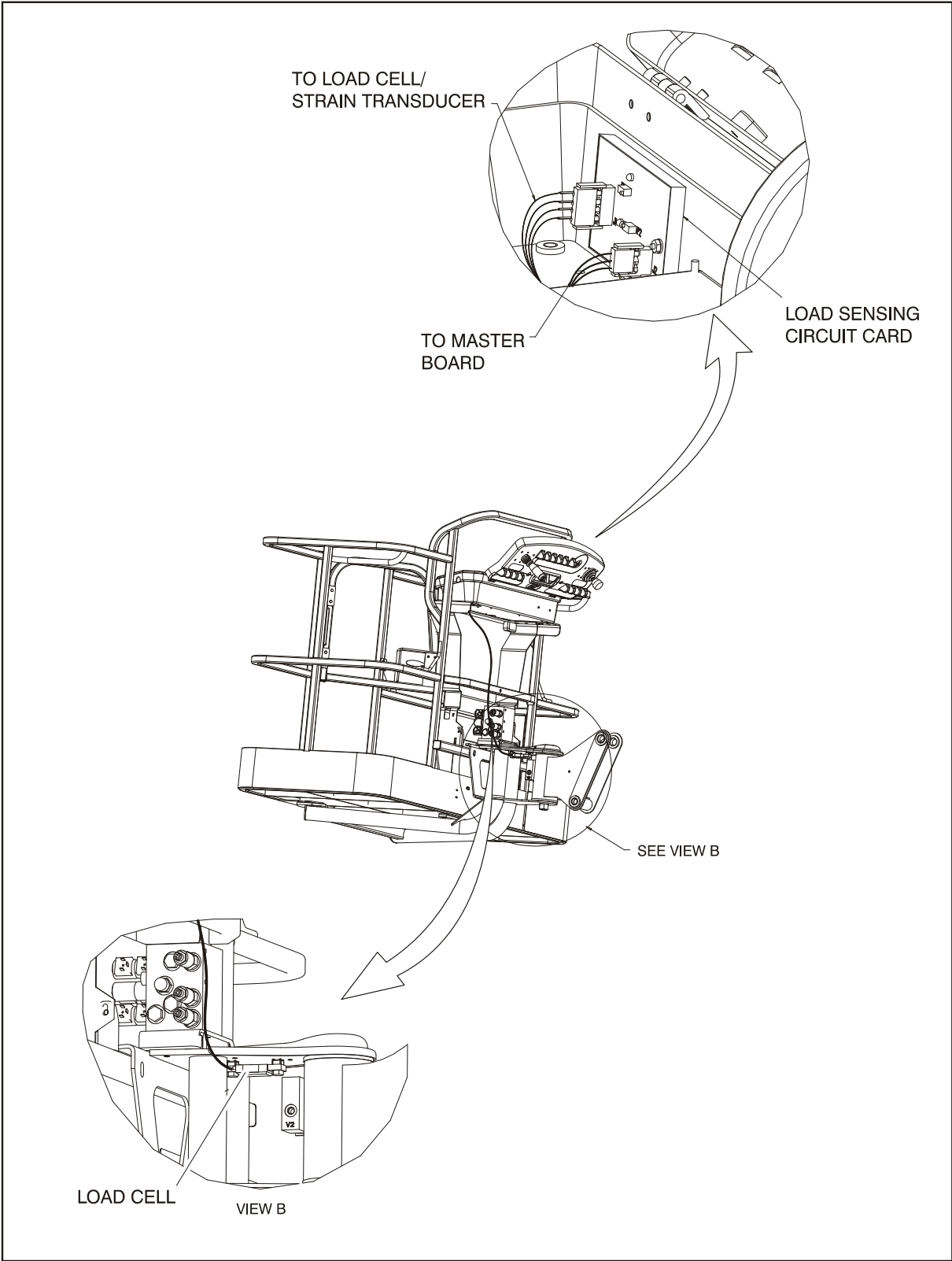


Figure 4-7. Load Sensor

4.3 PLATFORM ROTATOR (PRIOR TO S/N 0300130810)

Theory of Operation

See Figure 4-9., Platform Rotator Assembly - Cutaway

Fluid entering Port P2 under pressure will bear on the piston (4) and force the piston sleeve (3) upwards. The left-handed spline of the piston sleeve (3) will combine with the right-handed spline of the shaft (2A) and cause rapid counter-clockwise rotation of the shaft and flange (2B) (looking down). Fluid entering Port P1 will reverse this rotation.

Displacement and torque are identical for clockwise and counterclockwise rotation.

The shaft (2A) is integral with the shaft flange (2B) and bearing tube (2C). The shaft is supported radially by the large upper radial bearing (19) and the lower radial bearing (18). Axially, the shaft is separated from the housing by the upper and lower thrust rings (20). The end cap (5) is adjusted for axial clearance and locked in position by cap screws (7).

Disassembly and Inspection

Place on a clean workbench with room to place the internal parts as they are removed. Remove all hydraulic fittings. Loosen cap screws (7) and unscrew locknut (6) and end cap (5). The shaft is now free to move up and out of engagement with the piston sleeve (3). Note the orientation between the spline teeth (see Figure 11), as this will greatly simplify actuator timing upon reassembly.

After removing the shaft, the piston sleeve and the piston assembly can now be moved down and out of the housing. Remove all seals and bearings from their grooves, except static piston seals (9) and (11). These seals generally do not require replacement. Clean all parts thoroughly and inspect for wear. A small amount of wear in the spline teeth will have little effect on the actuator strength. New spline sets are manufactured with a backlash of about 0.005" (0.127 mm) per mating set. After long service, a backlash of about 0.015" (0.381 mm) per set may still be acceptable in most cases, depending on the required accuracy of the application.

Item (1) is the integral housing and ring gear. Check the ring gear for wear and weld damage to the pins. Inspect the cylinder bore for wear and scratches. The surface finish should be 32 RMS or better; re-hone if necessary. The radial bearings (18) and (19) and the piston bearings (17) should have a maximum radial clearance of 0.006" (0.152 mm). A clearance in excess of 0.008" (0.203 mm) requires replacement of the bearings. Rough and grooved shaft journals require shaft replacement.

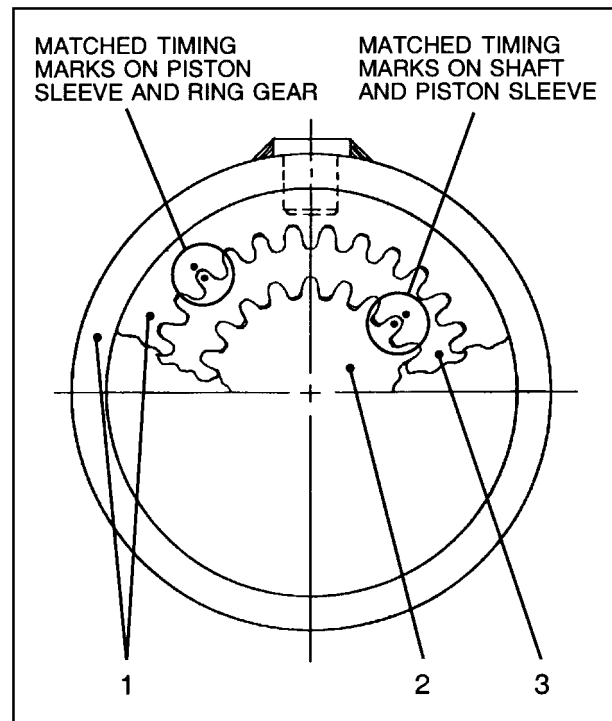
Assembly and Testing

Wash all parts thoroughly in cleaning solvent and blow dry. Coat all sealing and working surfaces with a good grade hydraulic oil. Install seals and bearings in the piston sleeve, piston, shaft, and end cap. The lips of the exclusion seals (16) face outward, and the lips of the high pressure seals face inward.

Place the actuator in a vertical position, install the piston sleeve (3) in timed relation to the housing, applying firm pressure as the new seals and bearings enter the housing and become compressed by the housing chamber.

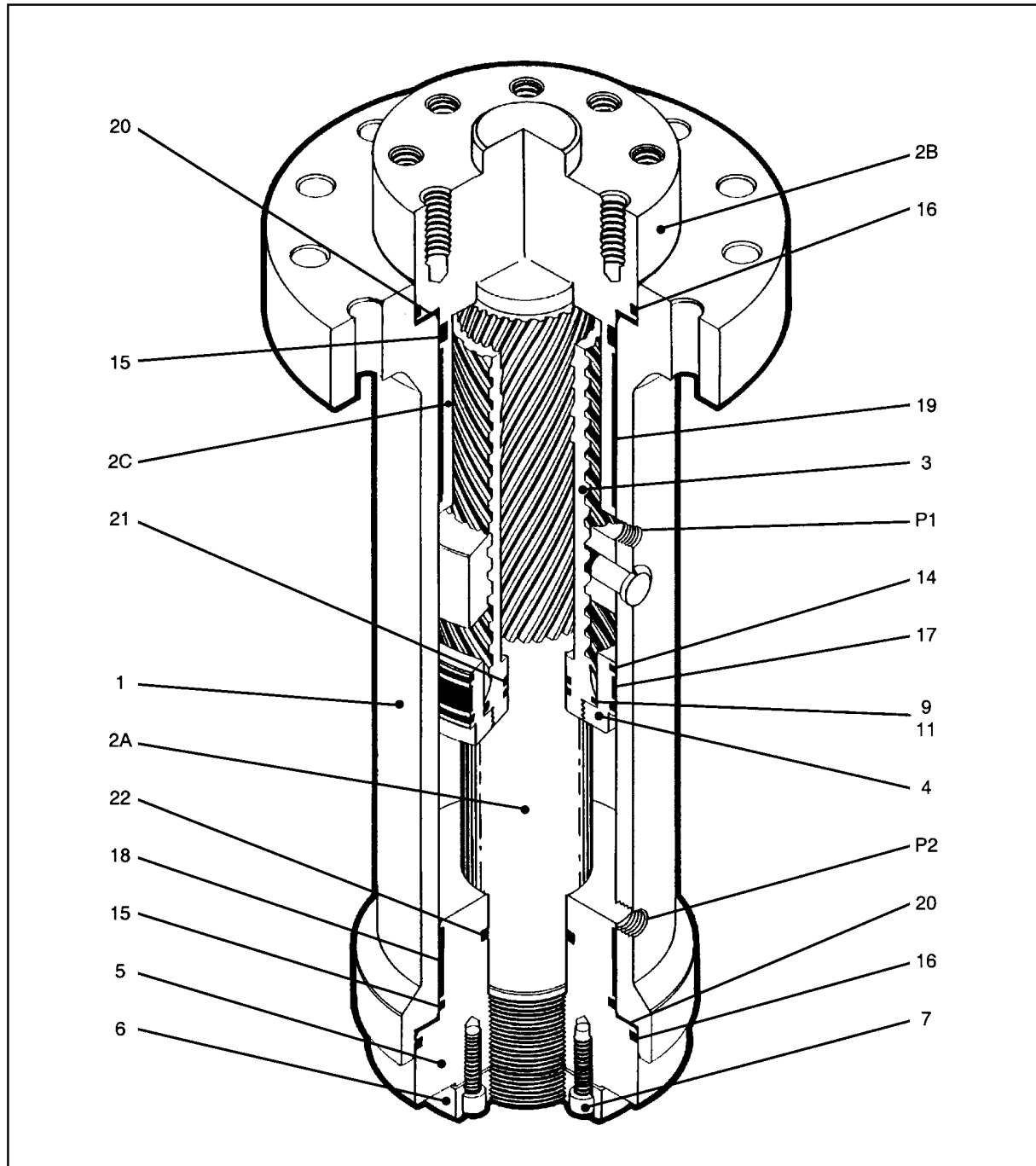
CAUTION

DO NOT MISALIGN THE SLEEVE TOO MUCH ANY ONE WAY, AS IT WILL MAR THE CYLINDER BORE. THE TIMING MARKS (THE SMALL PUNCH MARKS ON THE FACE OF EACH GEAR), MUST BE ALIGNED FOR PROPER SHAFT ORIENTATION. REFER TO FIGURE 4-8., TIMING MARKS.



1. Integral Housing & Ring Gear
2. Shaft
3. Piston Sleeve

Figure 4-8. Timing Marks



- | | | | |
|------------------------|-----------------|---------------------|------------------|
| 1. Housing & Ring Gear | 5. End Cap | 15. O-ring | 21. O-ring |
| 2A. Shaft | 6. Locknut | 16. Exclusion Seals | 22. O-ring |
| 2B. Flange | 7. Capscrew | 17. Piston Bearing | P1 Pressure Port |
| 2C. Bearing Tube | 9. Piston Seal | 18. Radial Bearing | P2 Pressure Port |
| 3. Piston Sleeve | 11. Piston Seal | 19. Radial Bearing | |
| 4. Piston | 14. O-ring | 20. Thrust Bearing | |

Figure 4-9. Platform Rotator Assembly - Cutaway

If the actuator is not equipped with grease fittings, the thrust bearings (20) are coated with good grease before sliding on the shaft and end cap. The shaft is installed by again aligning the proper punched timing marks. Temporarily taping the threaded portion of the shaft will help installation past the shaft seals (masking tape works well).

Apply anti-seize to threaded and surrounding areas of the end caps. Also, depending on the size of the actuator (60K and larger), the end cap may need to be installed with the actuator in a vertical position.

The end cap (5) is torqued to 60-400 ft-lb (84-560 Nm) depending on the actuator size, such that the actuator begins rotation at approximately 100 psi (6.9 bar) pressure. The shaft flange cannot be rotated by hand; the combined backdrive efficiency and friction prevent manual rotation. If the end cap is torqued too high, the actuator may require as much as 300 psi (20.7 bar) to rotate. If the end cap is not torqued high enough, shaft axial motion and radial backlash will result. The end cap must be secured against the shaft by tightening cap screws (7), or by installing axial setscrews, depending on the model. Apply hydraulic pressure and check for breakaway pressure and shaft axial motion.

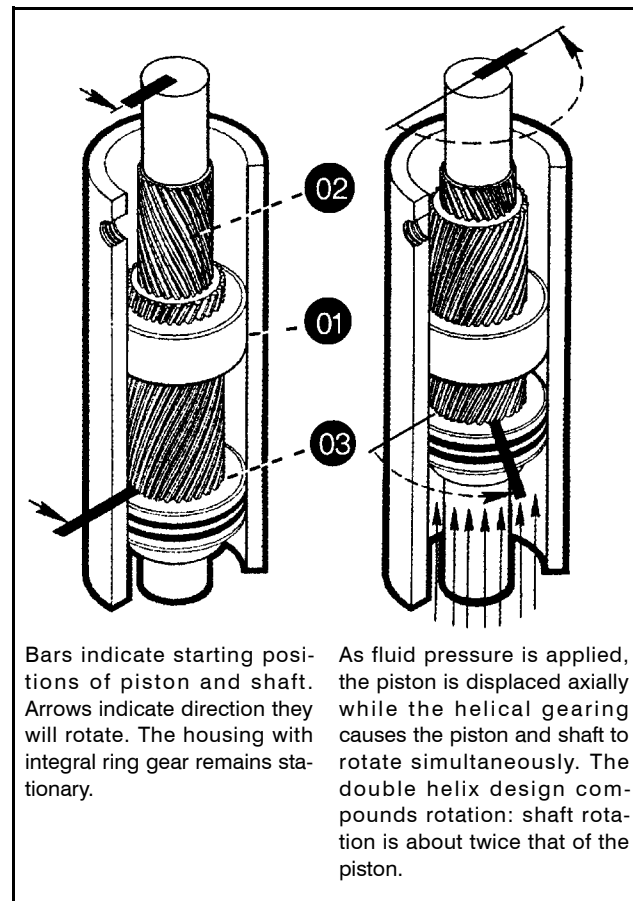
To test for leakage, pressurize Port P2 to 3000 psi (206.8 bar). No oil should seep from Port P1 or from around end cap (5). Repeat test by pressurizing Port P1 and check for leakage out of Port P2, around shaft flange (2B), and from ring gear pin welds.

4.4 PLATFORM ROTATOR (S/N 0300130810 TO PRESENT)

Theory of Operation

The L20 Series rotary actuator is a simple mechanism that uses the sliding spline operating concept to convert linear piston motion into powerful shaft rotation. Each actuator is composed of a housing with integrated gear teeth (01) and only two moving parts: the central shaft with integrated bearing tube and mounting flange (02), and the annular piston sleeve (03). Helical spline teeth machined on the shaft engage matching splines on the inside diameter of the piston. The outside diameter of the piston carries a second set of splines, of opposite hand, which engage with matching splines in the housing. As hydraulic pressure is applied, the piston is displaced axially within the housing - similar to the operation of a hydraulic cylinder - while the splines cause the shaft to rotate. When the control valve is closed, oil is trapped inside the actuator,

preventing piston movement and locking the shaft in position.



The shaft is supported radially by the large upper radial bearing and the lower radial bearing. Axially, the shaft is separated from the housing by the upper and lower thrust washers. The end cap is adjusted for axial clearance and locked in position by set screws or pins.

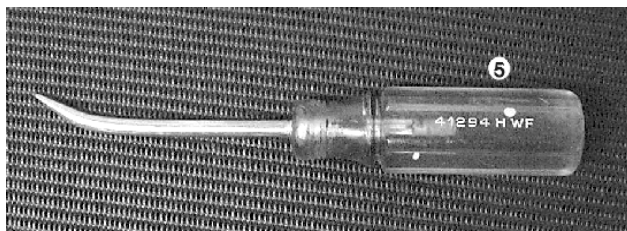
Required Tools

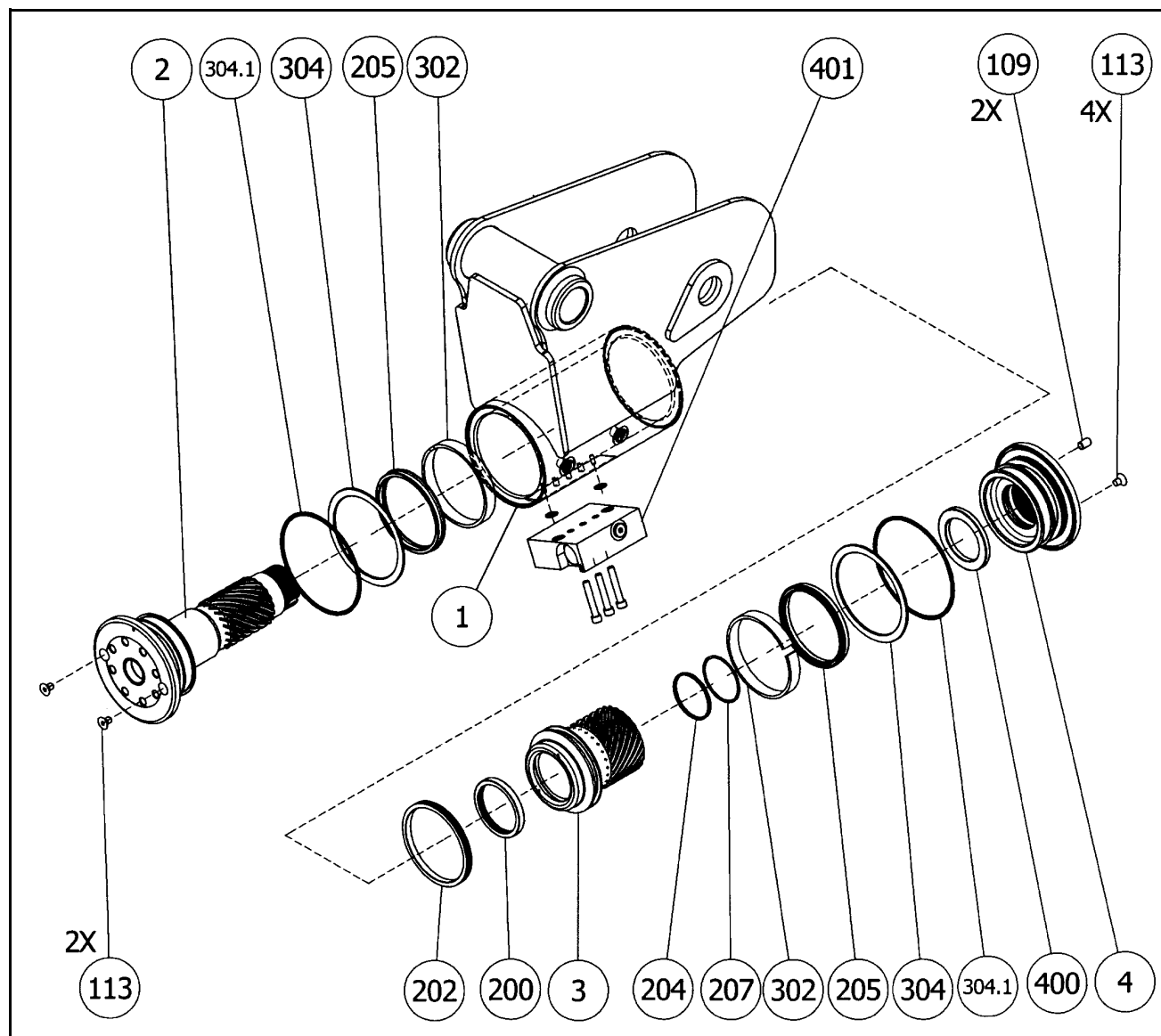
Upon assembly and disassembly of the actuator there are basic tools required. The tools and their intended functions are as follows:



1. Flashlight - helps examine timing marks, component failure and overall condition.
2. Felt Marker - match mark the timing marks and outline troubled areas.
3. Allen wrench - removal of port plugs and set screws.
4. Box knife - removal of seals.
5. Seal tool - assembly and disassembly of seals and wear guides.
6. Pry bar - removal of end cap and manual rotation of shaft.
7. Rubber mallet- removal and installation of shaft and piston sleeve assembly.
8. Nylon drift - installation of piston sleeve
9. End cap dowel pins - removal and installation of end cap (sold with Helac seal kit).

The seal tool is merely a customized standard flat head screwdriver. To make this tool you will need to heat the flat end with a torch. Secure the heated end of the screwdriver in a vice and physically bend the heated end to a slight radius. Once the radius is achieved round off all sharp edges of the heated end by using a grinder. There may be some slight modifications for your own personal preference.





PARTS

- 1. Housing
- 2. Shaft
- 3. Piston Sleeve
- 4. End Cap

HARDWARE

- 103.1. Screw
- 103.2. Washer
- 106.1. Port Plug
- 106.2. Port Plug
- 109. Lock Pin
- 113. Capscrew

SEALS

- 200. T-Seal
- 202. T-Seal
- 204. O-ring
- 205. Cup Seal
- 207. Backup Ring
- 304.1. Wiper Seal

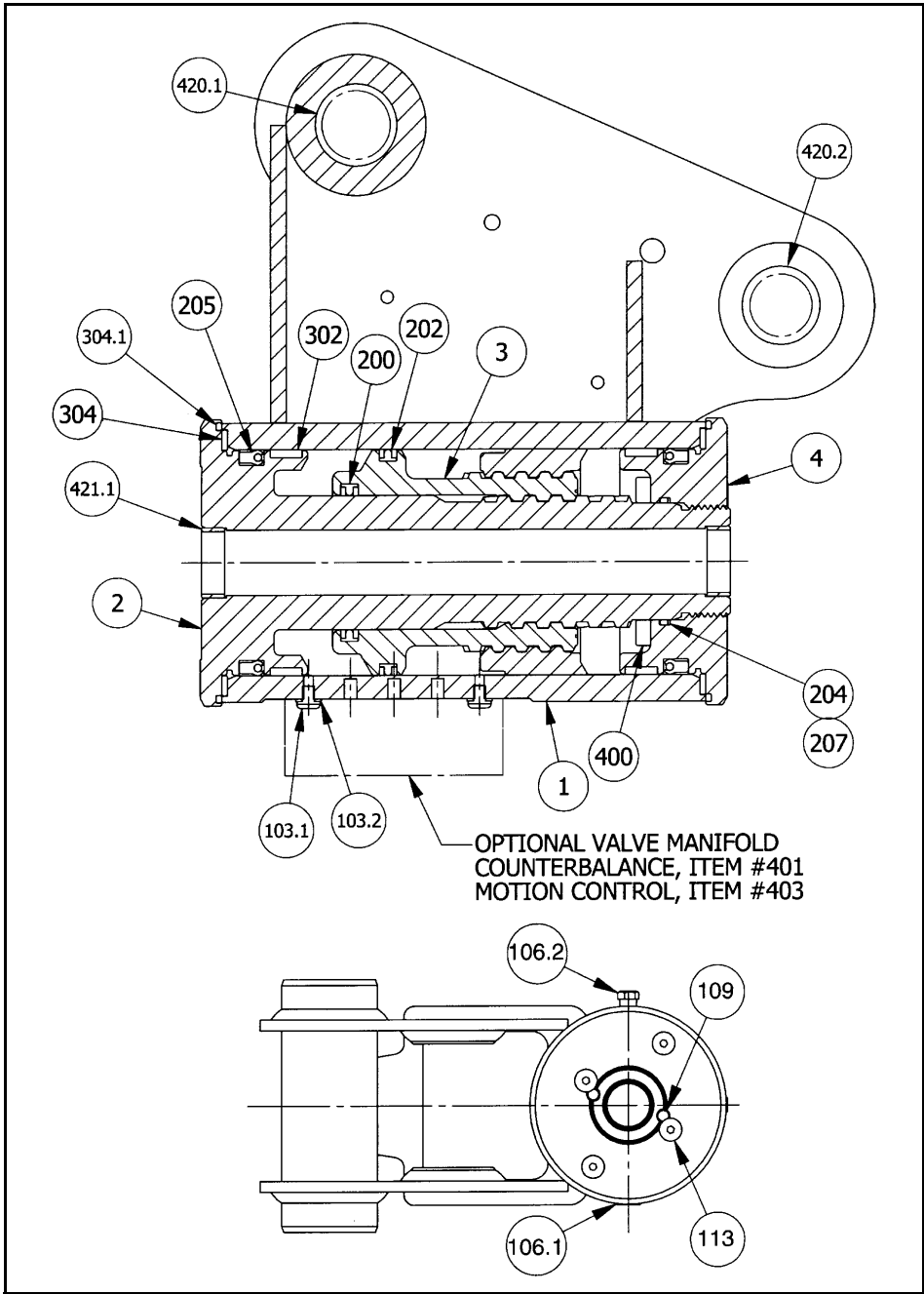
BEARINGS

- 302. Wear Guide
- 304. Thrust Washer

ACCESSORIES

- 400. Stop Tube
- 420.1 Bushing
- 420.2 Bushing
- 421.1 Bushing

Figure 4-10. Rotary Actuator - Exploded View



PARTS	HARDWARE	SEALS	BEARINGS	ACCESSORIES
1. Housing	103.1. Screw	200. T-Seal	302. Wear Guide	400. Stop Tube
2. Shaft	103.2. Washer	202. T-Seal	304. Thrust Washer	420.1 Bushing
3. Piston Sleeve	106.1. Port Plug	204. O-ring		420.2 Bushing
4. End Cap	106.2. Port Plug	205. Cup Seal		421.1 Bushing
	109. Lock Pin	207. Backup Ring		
	113. Capscrew	304.1. Wiper Seal		

Figure 4-11. Rotary Actuator - Assembly Drawing

Disassembly

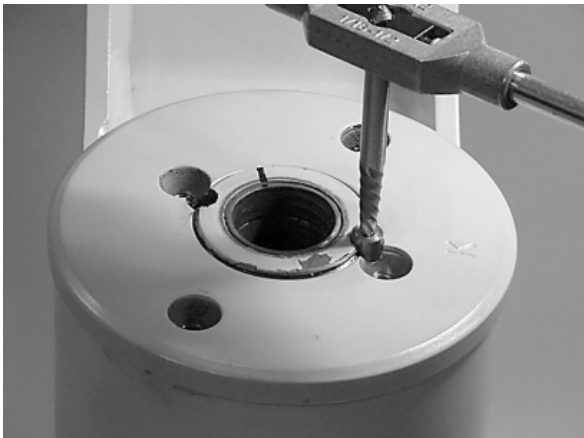
1. Remove the capscrews (113) over end cap lock pins (109).



2. Using a 1/8" (3.18mm) drill bit, drill a hole in the center of each lock pin to a depth of approximately 3/16" (4.76mm).



3. Remove the lock pins using an "Easy Out" (a size #2 is shown).



If the pin will not come out with the "Easy Out", use

5/16" drill bit to a depth of 1/2" (12.7mm) to drill out the entire pin.

4. Install the end cap (4) removal tools provided with the Helac seal kit.



5. Using a metal bar, or something similar, unscrew the end cap (4) by turning it counter clockwise.



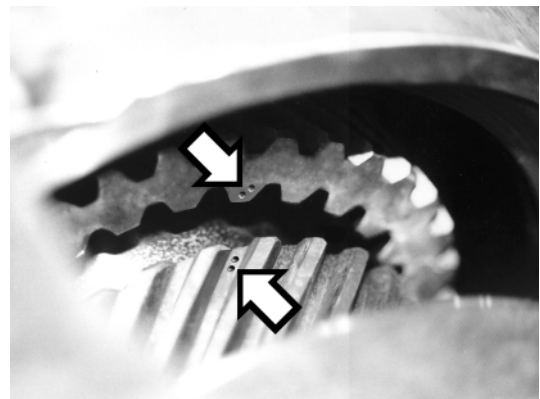
6. Remove the end cap (4) and set aside for later inspection.



7. Remove the stop tube if included. The stop tube is an available option to limit the rotation of the actuator.



8. Every actuator has timing marks for proper engagement.

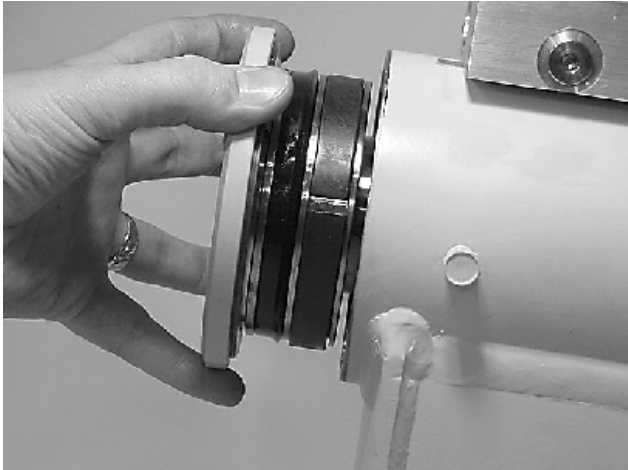


9. Prior to removing the shaft, (2), use a felt marker to clearly indicate the timing marks between shaft and piston. This will greatly simplify timing during assembly.



SECTION 4 - BOOM & PLATFORM

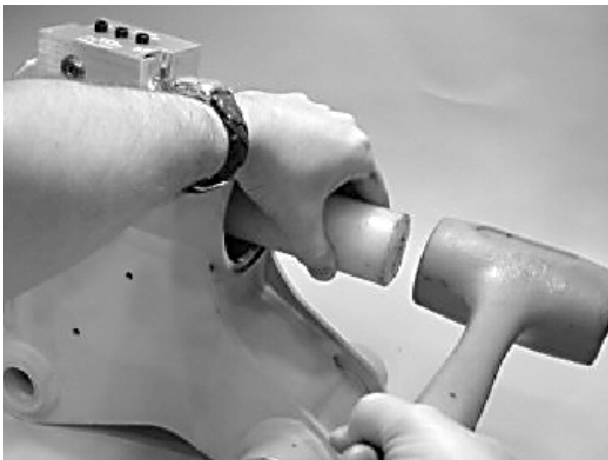
10. Remove the shaft (2). It may be necessary to strike the threaded end of the shaft with a rubber mallet.



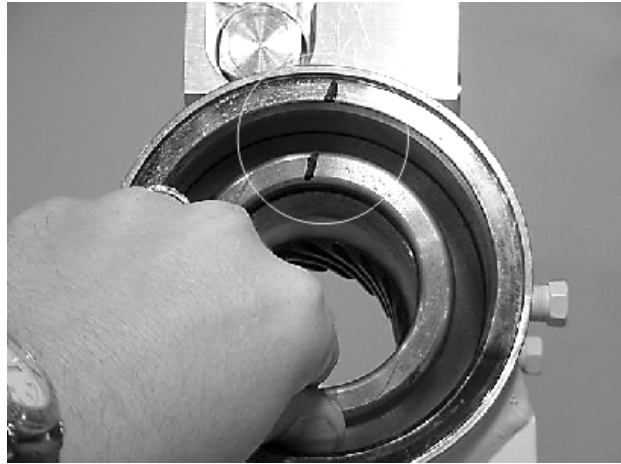
11. Before removing the piston (3), mark the housing (1) ring gear in relation to the piston O.D. gear. There should now be timing marks on the housing (1) ring gear, the piston (3) and the shaft (2).



12. To remove the piston (3) use a rubber mallet and a plastic mandrel so the piston is not damaged.



13. At the point when the piston gear teeth come out of engagement with the housing gear teeth, mark the piston and housing with a marker as shown.



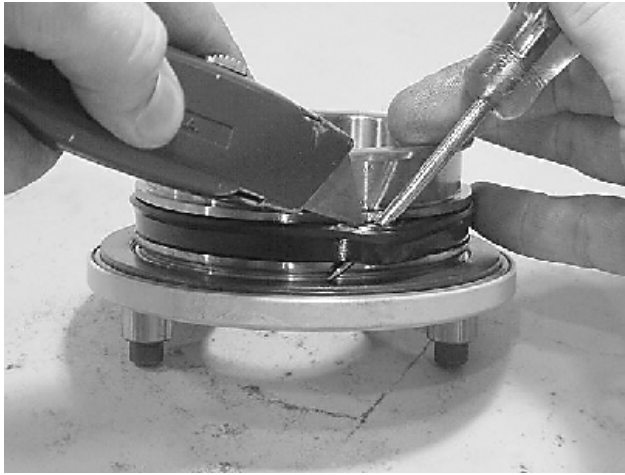
14. Remove the o-ring (204) and backup ring (207) from end cap (4) and set aside for inspection.



15. Remove the wear guides (302) from the end cap (4) and shaft (2).



- 16.** To remove the main pressure seals (205), it is easiest to cut them using a sharp razor blade being careful not to damage the seal groove.



- 19.** Remove the piston O.D. seal (202).



- 20.** Remove the piston I.D. seal (200). You may now proceed to the inspection process.

- 17.** Remove the thrust washers (304), from the end cap (4) and shaft (2).



- 18.** Remove the wiper seal (304.1) from its groove in the end cap (4) and shaft (2).

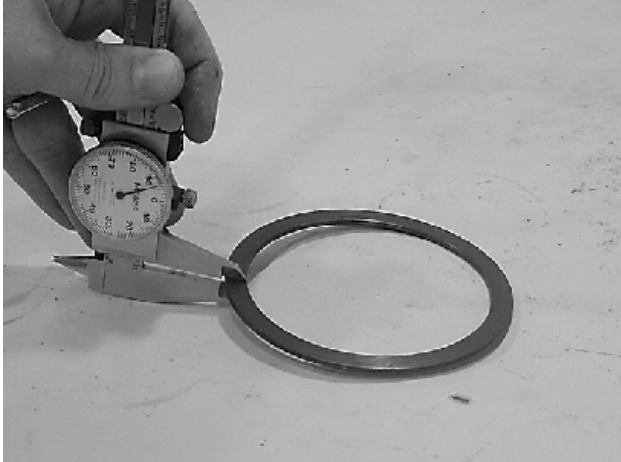


Inspection

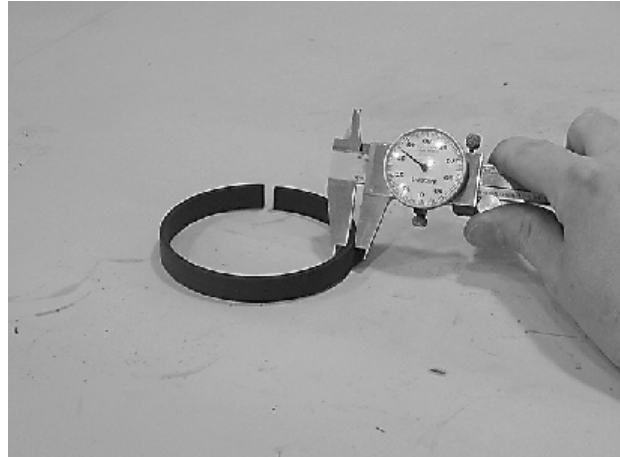
1. Clean all parts in a solvent tank and dry with compressed air prior to inspecting. Carefully inspect all critical areas for any surface finish abnormalities: Seal grooves, bearing grooves, thrust surfaces, rod surface, housing bore and gear teeth.



2. Inspect the thrust washers (304) for rough or worn edges and surfaces. Measure its thickness to make sure it is within specifications (Not less than 0.092" or 2.34 mm).

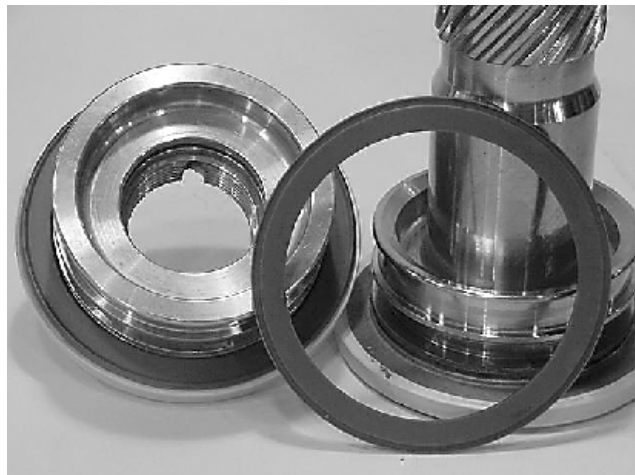


3. Inspect the wear guide condition and measure thickness (not less than 0.123" or 3.12 mm).



Assembly

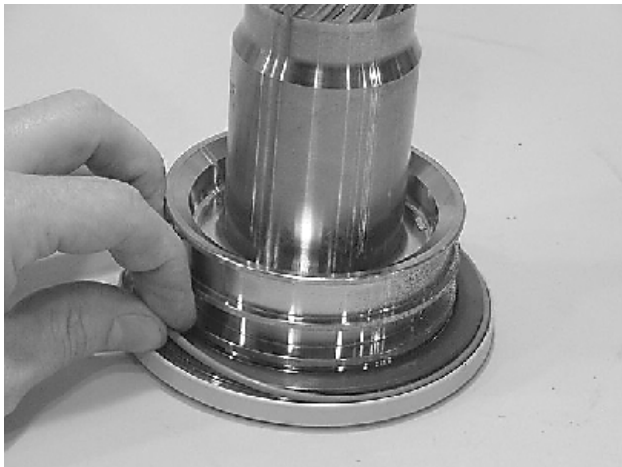
1. Gather all the components and tools into one location prior to re-assembly. Use the cut away drawing to reference the seal orientations.



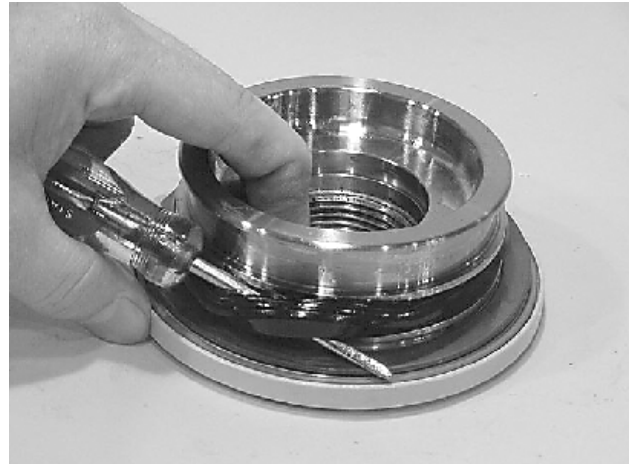
2. Install the thrust washer (304) onto shaft (2) and end cap (4).



3. Install the wiper seal (304.1/green O-ring) into its groove on the shaft (2) and end cap (4) around the outside edge of the thrust washer (304).



4. Using a seal tool install the main pressure seal (205) onto shaft (2) and end cap (4). Use the seal tool in a circular motion.



5. Install the wear guide (302) on the end cap (4) and shaft (2).



6. Install the inner T-seal (200) into the piston (3) using a circular motion.

Install the outer T-seal (202) by stretching it around the groove in a circular motion.

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Each T-seal has 2 back-up rings (see drawing for orientation).

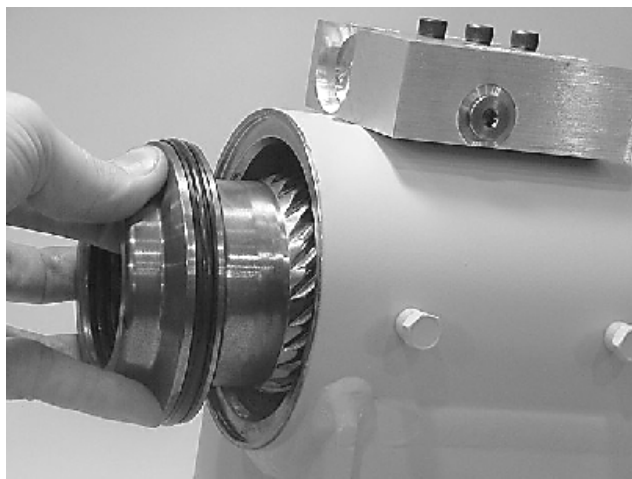


Beginning with the inner seal (200) insert one end of b/u ring in the lower groove and feed the rest in using a circular motion. Make sure the wedged ends overlap correctly.

Repeat this step for the outer seal (202).



7. Insert the piston (3) into the housing (1) as shown, until the outer piston seal (202) is touching inside the housing bore.



8. Looking from the angle shown, rotate the piston (3) until the marks you put on the piston and the housing (1) during disassembly line up as shown. Using a rubber mallet, tap the piston into the housing up to the point where the gear teeth meet.



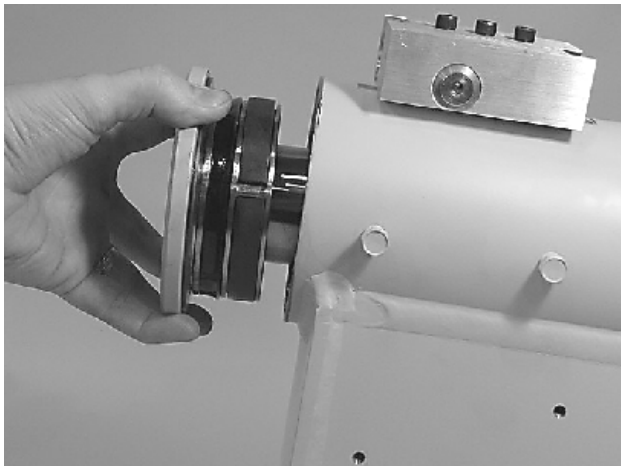
9. Looking from the opposite end of the housing (1) you can see if your timing marks are lining up. When they do, tap the piston (3) in until the gear teeth mesh together. Tap the piston into the housing the rest of the way until it bottoms out.



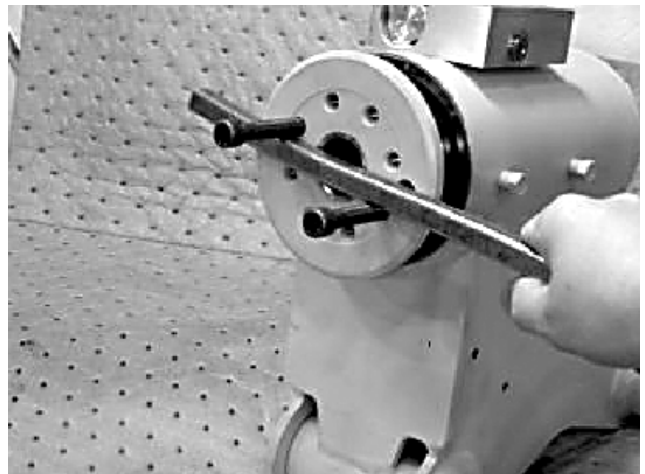
11. Looking from the view shown, use the existing timing marks to line up the gear teeth on the shaft (2) with the gear teeth on the inside of the piston (3). Now tap the flange end of the shaft with a rubber mallet until the gear teeth engage.



10. Install the shaft (2) into the piston (3). Be careful not to damage the seals. Do not engage the piston gear teeth yet.



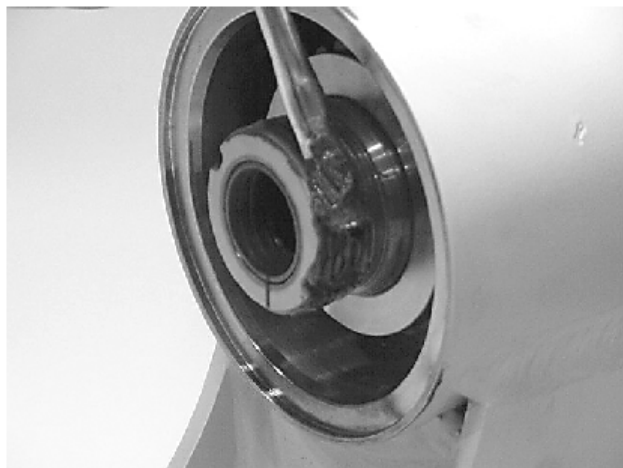
12. Install 2 bolts in the threaded holes in the flange. Using a bar, rotate the shaft in a clockwise direction until the wear guides are seated inside the housing bore.



13. Install the stop tube onto the shaft end. Stop tube is an available option to limit the rotation of an actuator.

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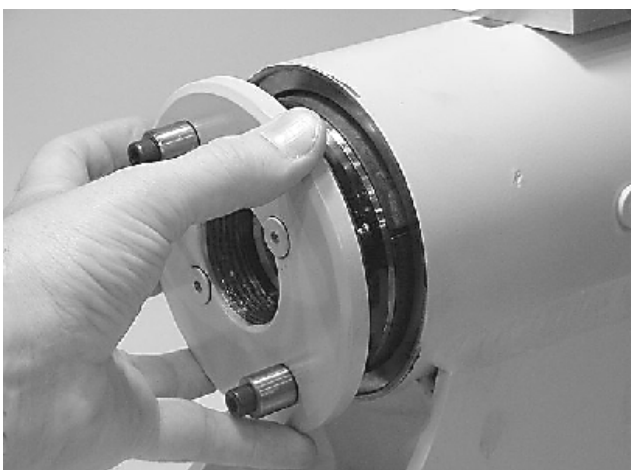
14. Coat the threads on the end of the shaft with anti-seize grease to prevent galling.



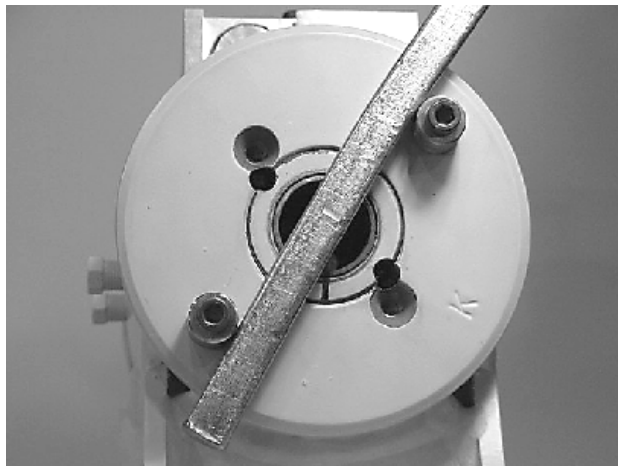
15. Install the O-ring (204) and back-up ring (207) into the inner seal groove on the end cap (4).



16. Thread the end cap (4) onto the shaft (2) end. Make sure the wear guide stays in place on the end cap as it is threaded into the housing (1).



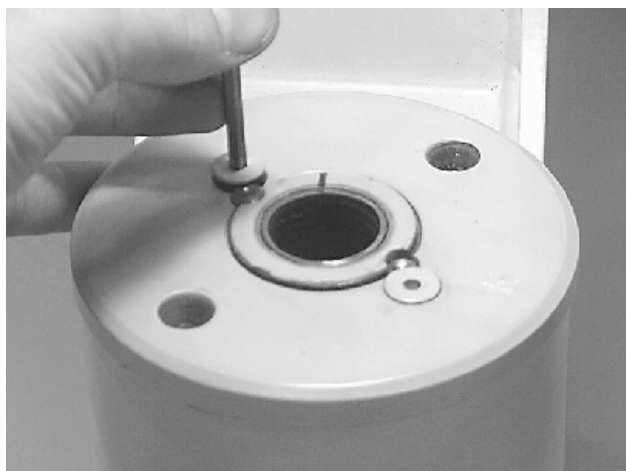
17. Tighten the end cap (4). In most cases the original holes for the lock pins will line up.



18. Place the lock pins (109) provided in the Helac seal kit in the holes with the dimple side up. Then, using a punch, tap the lock pins to the bottom of the hole.



19. Insert the set screws (113) over the lock pins. Tighten them to 25 in. lbs. (2.825 Nm).



4.5 JIB ROTATOR

Operating Principle

Helac's helical hydraulic rotary actuators use our sliding spline technology which converts linear piston motion into powerful shaft rotation. The actuators are composed of a housing and only two moving parts, the central shaft and the annular piston. Helical spline teeth machined on the shaft engage matching splines on the inside diameter of the piston. The outside diameter of the piston carries a second set of splines, of opposite hand, which engage matching splines in the housing's ring gear. As hydraulic pressure powers the piston back and forth within the housing – similar to the operation of a hydraulic cylinder – the splines cause the shaft to rotate.

Disassembly

1. Remove all hydraulic fittings. Drain the oil from both sides of the piston through the pressure ports.
2. Place the actuator horizontally on a clean work bench with ample room to place the internal parts as they are removed.
3. Unthread the socket head cap screws (102) from the lockwasher(05). Remove the lock washer from the shaft (02).
4. Secure the actuator firmly to the work surface to prevent movement. A pipe vise works well. Insert two long screws (1/4-20) into the end cap (04) and, using a pry bar, unthread the end cap from shaft by

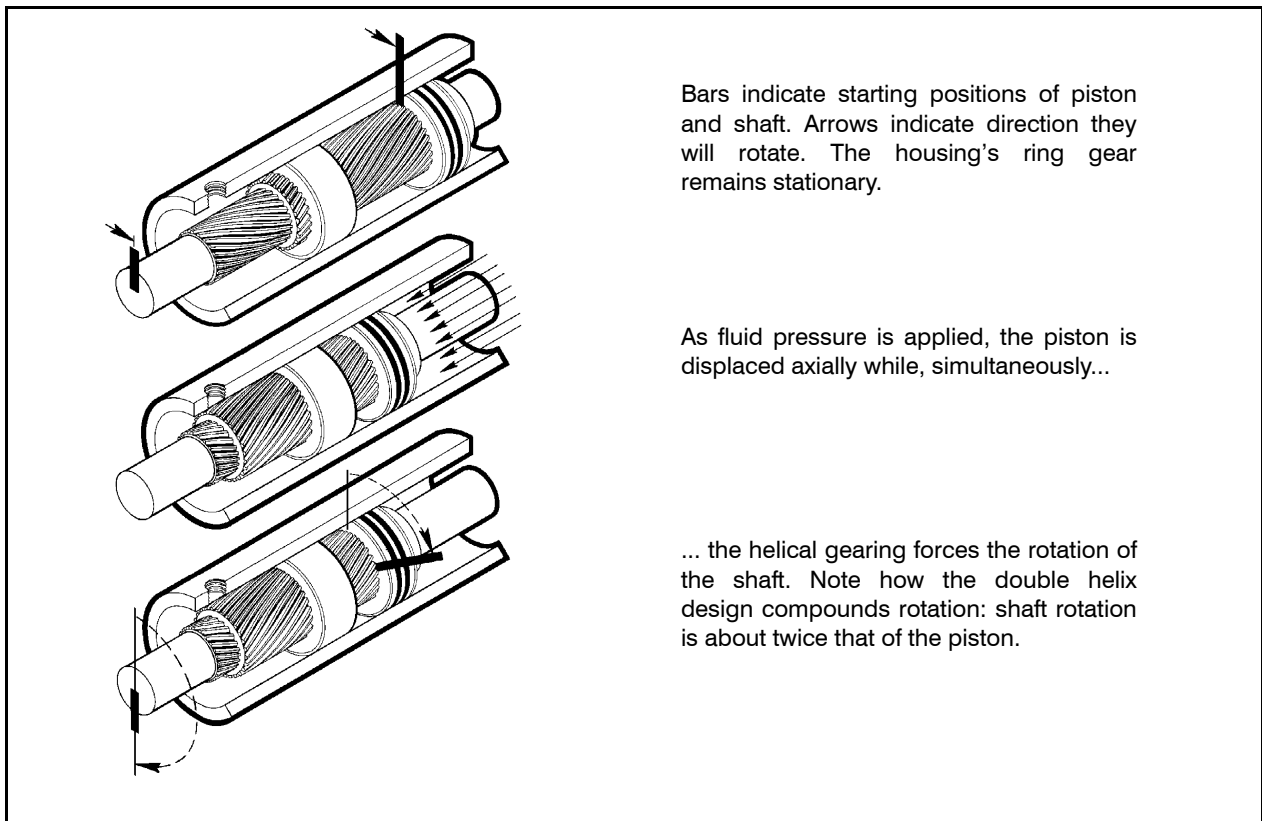
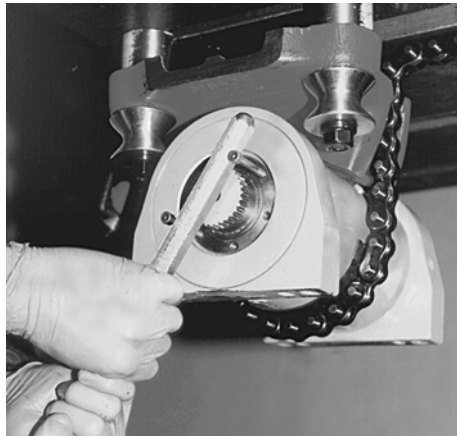


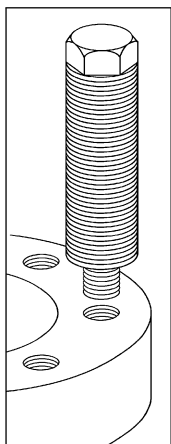
Figure 4-12. Operating Principle - Jib Rotator

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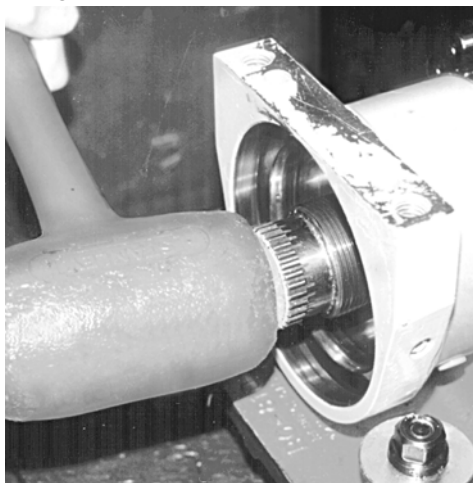
turning in a counterclockwise direction as shown below.



A considerable amount of torque may be required to loosen the end cap. Completely filling the length of the screws with a stack of washers or a bushing as seen in the illustration to the right will permit more force to be applied to the screws and prevent them from bending – be sure to thread the screws completely into the endcap. If the end cap is difficult to break loose, special tooling may be fabricated according to the drawing below.

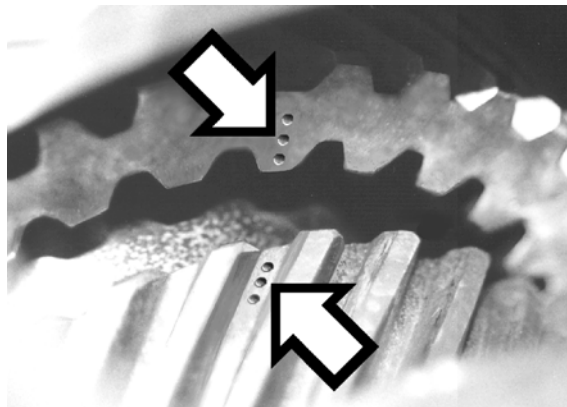


5. Remove the shaft from the housing assembly by driving it out with a plastic hammer as seen below.

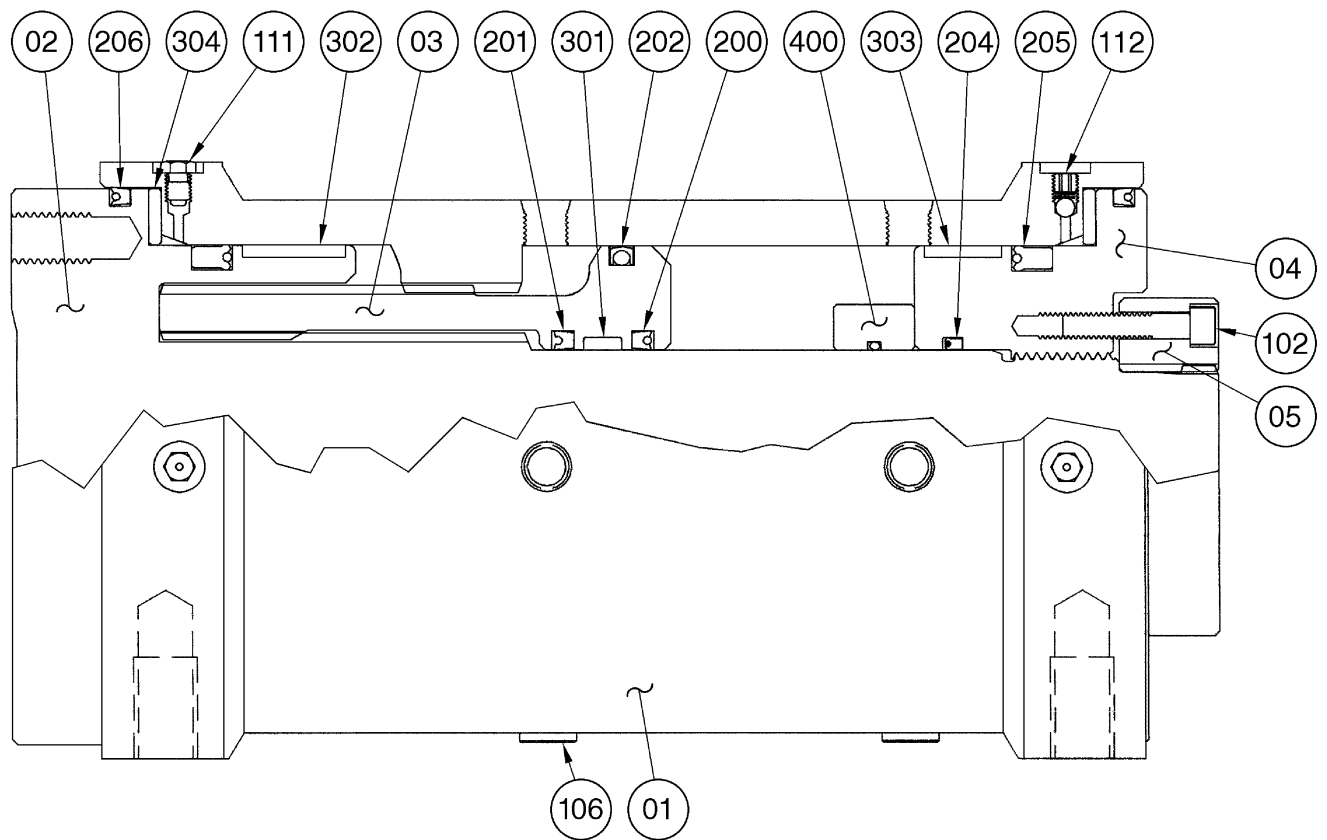


Before the shaft and piston gearing are completely disengaged, note the orientation between the spline teeth: small punch marks on the face of the piston

and the root of a spline tooth on the shaft gearing indicate timing as seen below.



Marking the teeth at this time with a permanent felt tip marker will make the marks easier to see and greatly simplify actuator timing during reassembly. For 120° rotation actuators, remove the stop tube from the shaft before removing the shaft from the housing. Do not remove the O-ring from the stop-tube. It performs no sealing functions and should be reused when the actuator is reassembled.



- | | | |
|---------------------------|--------------------------|---------------------|
| 1. Housing | 111. Grease Fitting | 205. Bearing Seal |
| 2. Shaft | 112. Grease Relief Valve | 206. Exclusion Seal |
| 3. Piston Sleeve | 400. Stop Tube | 301. Piston Bearing |
| 4. End Cap | 200. Rod Seal | 302. Shaft Bearing |
| 5. Lockring | 201. Rod Seal | 303. Shaft Bearing |
| 102. Socket Head Capscrew | 202. Piston Seal | 304. Thrust Washer |
| 106. Port Plug | 204. Cap Seal | |

Figure 4-12. Jib Rotator Assembly

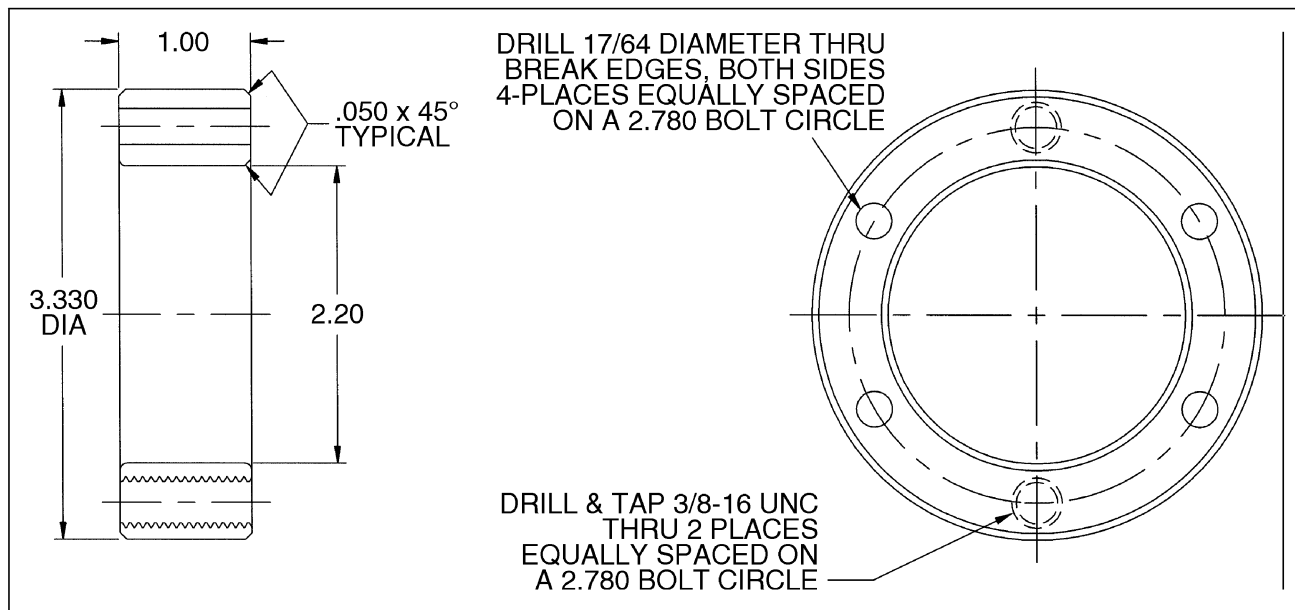
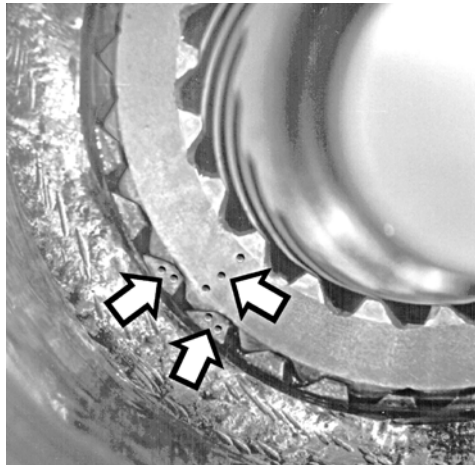


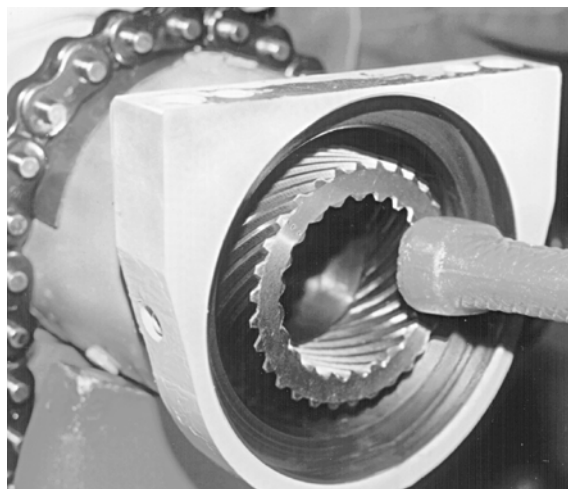
Figure 4-13. Tool for Removing End Cap

6. With the shaft removed, note the orientation of the timing marks on the piston sleeve and ring gear in the housing as below.



The adjacent weld can make the ring gear timing marks difficult to locate; using a light can help. Again, mark the teeth with a felt tip marker to make the marks easier to see and to simplify timing during reassembly. Drive the piston sleeve out of the hous-

ing using the handle of a rubber mallet as shown below.



Support the piston sleeve as it is removed from the housing. Great care should be taken to insure that the gear teeth are not damaged and the piston sleeve does not damage the housing bore as it is removed.

7. Remove all seals and bearings from their grooves. Note the orientation of the sealing lips prior to removal.
8. Clean all components thoroughly with solvent or in a parts washer. Be sure to flush all grease and contaminants from the grease fittings and grease relief passages.

Inspection

Inspect all parts for wear, damage, cracks, etc.

HOUSING

Inspect the cylinder bore for wear and scratches. The surface finish should be 32 RMS or better. Rehone if necessary. Minor scratches and damage can be repaired by local polishing. Inspect all bearing contact surfaces for damage and/or contamination and repair and clean as necessary. Inspect the exterior of the housing for damage, cracks, integrity of welds, etc.

SHAFT

Check the sealing surface of the shaft for scratches and damage. Polish if necessary.

GEAR COMPONENTS

Check gearing for excessive wear. Nominal movement between gear components in excess of 1.5 degrees can result in sloppy response.

BEARINGS

All radial bearings are of a reinforced nylon material. If the thickness measures less than 0.123 in. (3.125 mm), the bearings should be replaced.

THRUST WASHERS

Manufactured from an orkot material. If the thickness measures less than 0.113 in. (2.870 mm), or if contaminants are noticed imbedded in the material, the thrust washers should be replaced.

Reassembly

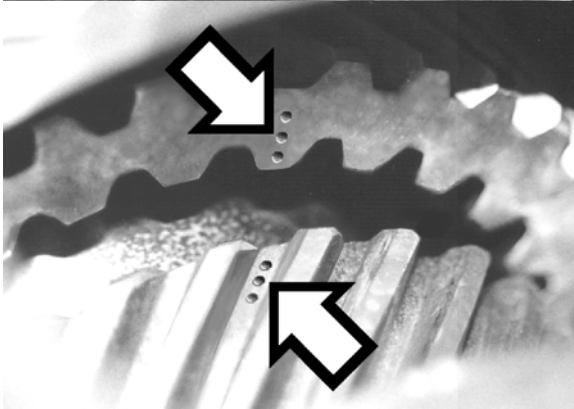
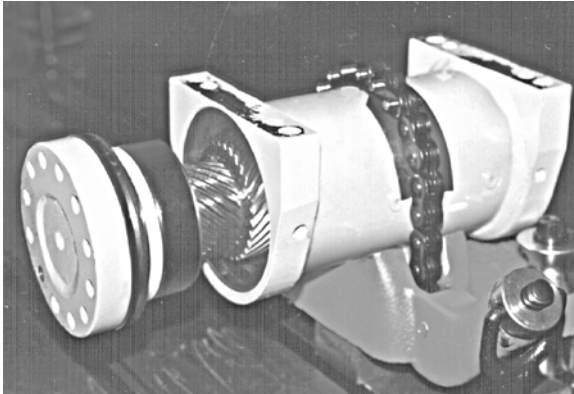
It is recommended that you first practice assembling the actuator with the bearings and thrust washers installed but without the seals. The seals are easily damaged and their increased friction makes assembly more difficult. Be sure that the timing marks on the gear components are engaged in the correct orientation. Mark the timing marks with a felt tip marker for better visibility to make assembly easier.

1. Wash all parts thoroughly in cleaning solvent and blow dry.
2. Pump a high quality NLGI-2 lithium based grease into the grease fittings (111) to flush any contaminants out of the fittings and passages and to insure the fittings are functioning properly. Replace any non functioning fittings. Wipe off all excess grease. The set screws of the relief valves (112) must be flush with the countersunk bore to ensure proper tension on the spring as seen in Photo F. If the set screws are threaded in too far, the seals will be extruded during greasing and damaged. Secure the set screws with Loctite# 242.

3. Lightly coat the thrust washers (304) with grease and install them on the shaft (02) and end cap (04) prior to seal installation.
4. Lightly coat all sealing and working surfaces with a good grade of hydraulic oil.
5. Install all seals in their respective grooves. Refer to the Assembly Drawing on page 2 to ensure the correct orientation of all seals. Note that the O-ring energizer should be removed from seal (201) on the inside diameter of the piston nearest the piston splines. This prevents pressure from being trapped between seals (200) and (201).
6. With the housing positioned horizontally and firmly secured to prevent movement, insert the piston sleeve into the housing bore until the piston seal contacts the housing chamfer. Look through the opposite side (shaft flange side) of the housing bore and rotate the piston sleeve as necessary to align the timing marks on the housing ring gear and piston sleeve. While holding the piston sleeve steady to prevent damage to the cylinder bore, drive the piston sleeve into the housing with a rubber mallet until the gear teeth engage. This assembly step is difficult and might require several attempts to successfully engage the gear teeth. Double check the timing marks and the engagement of the gear teeth to insure correct alignment, then drive the piston sleeve as far as possible into the housing until it comes to a stop against the ring gear.
7. Install the shaft as seen below in timed relation to the piston sleeve by aligning the punched timing marks as shown below. Temporarily taping the threaded portion of the shaft with masking tape will make it easier to clear the rod seals and prevent their damage. Once the gear teeth are engaged, rotate the shaft clockwise until it is bottomed out against the piston sleeve. Using a rubber mallet, drive the shaft into the housing until the thrust

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washer comes to a stop against the housing thrust surface.



8. Remove the masking tape and apply anti-seize to the shaft threads.
9. Install the stop tube if applicable.
10. Apply a thin film of grease to the seals, then thread the end cap onto the shaft to a net fit where the end cap just begins to damp against the thrust washer. Tighten the end cap to approximately 120 FT-LB (163 N.m).
11. Apply a generous amount of anti-seize to the splines at the end of the shaft. Locate the correct position of the locknut to align its bolt circle with that of the end cap. If the bolt circles do not align, unthread the end cap no more than a half a pitch of the shaft splines. Insert the cap screws and torque to 108 IN-LB (147 N.m).
12. Grease the thrust washers. Pump a high quality NLGI-2 lithium based grease into the grease fittings at both ends of the housing until it begins to ooze from the grease reliefs. If possible, rotate the shaft during greasing to ensure even distribution on the thrust surfaces.

Installing Counterbalance Valve

Refer to Figure 4-14., Rotator Counterbalance Valve.

1. Make sure the surface of the actuator is clean, free of any contamination and foreign debris including old Loctite.
2. Make sure the new valve has the O-rings in the counterbores of the valve to seal it to the actuator housing.
3. The bolts that come with the valve are grade 8 bolts. New bolts should be installed with a new valve. Loctite #242 should be applied to the shank of the three bolts at the time of installation.
4. Torque the 1/4-inch bolts 110 to 120 inch pounds (12.4 to 13.5 Nm). Do not torque over 125 inch pounds (14.1 Nm). Torque the 5/16-inch bolts 140 inch pounds (15.8 Nm). Do not torque over 145 inch pounds (16.3 Nm).

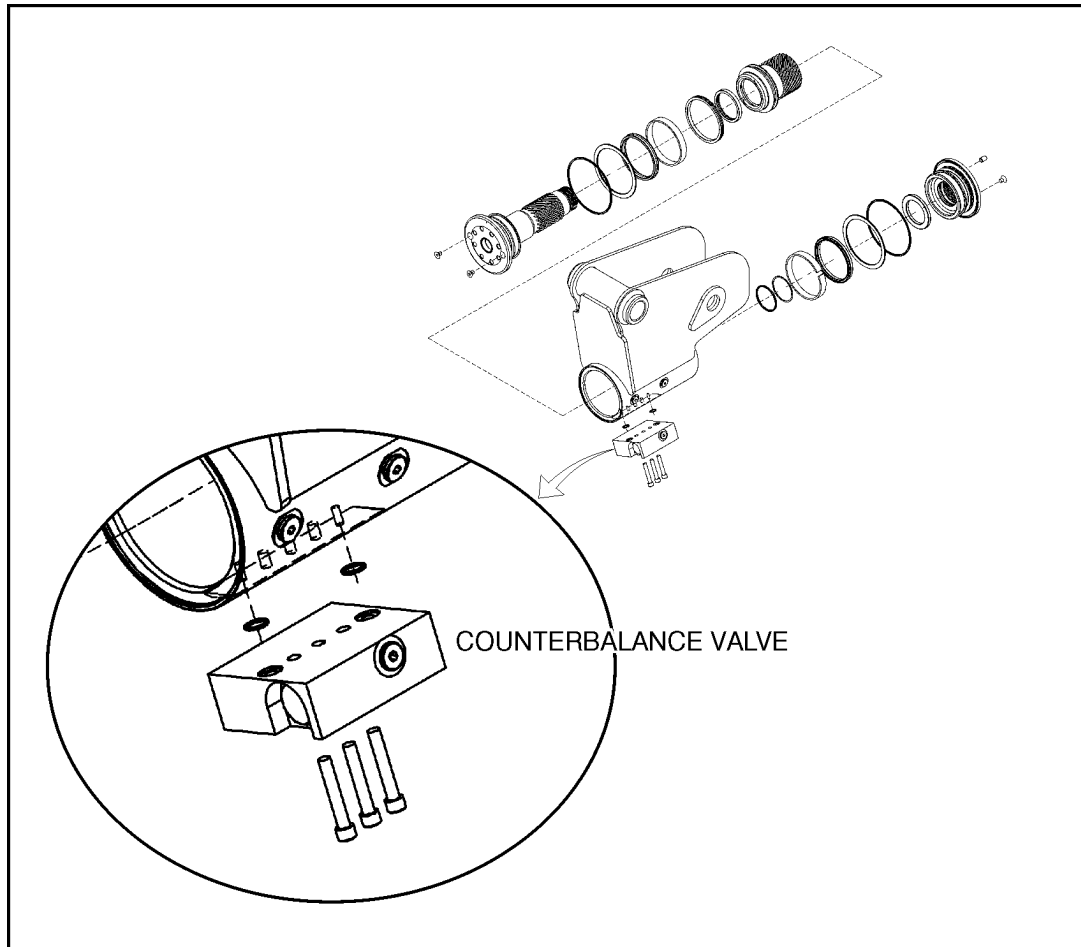


Figure 4-14. Rotator Counterbalance Valve

Testing the Actuator

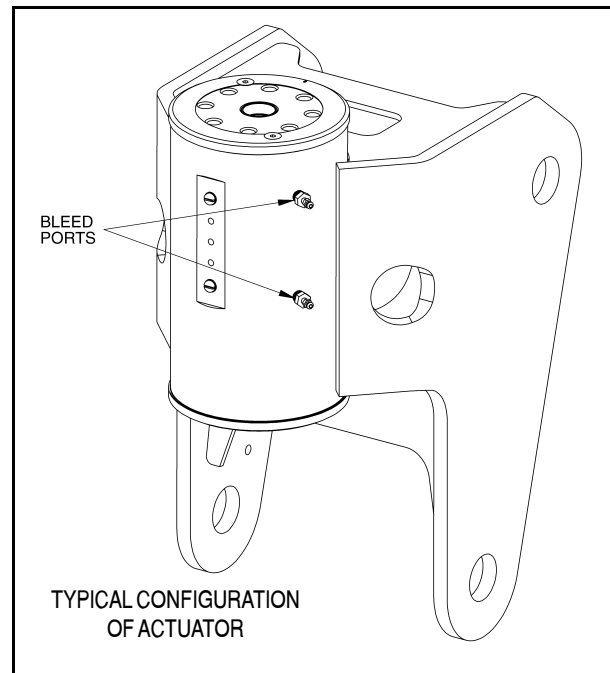
If the equipment is available, the actuator should be tested on a hydraulic test bench. The breakaway pressure — the pressure at which the shaft begins to rotate — should be approximately 400 psi (28 bar). Cycle the actuator at least 25 times at 3000 psi (210 bar) pressure. After the 25 rotations, increase the pressure to 4500 psi (315 bar) to check for leaks and cracks. Perform the test again at the end of the rotation in the opposite direction.

TESTING THE ACTUATOR FOR INTERNAL LEAKAGE

If the actuator is equipped with a counterbalance valve, plug the valve ports. Connect the hydraulic lines to the housing ports. Bleed all air from the actuator (see Installation and Bleeding). Rotate the shaft to the end of rotation at 3000 psi (210 bar) and maintain pressure. Remove the hydraulic line from the non-pressurized side.

Continuous oil flow from the open housing port indicates internal leakage across the piston. Replace the line and rotate the shaft to the end of rotation in the opposite direction. Repeat the test procedure outlined above for the other port. If there is an internal leak, disassemble, inspect and repair.

collect the purged oil. The oil can be returned to the reservoir after this procedure is completed.



Installation and Bleeding

After installation of the actuator on the equipment, it is important that all safety devices such as tie rods or safety cables are properly reattached.

To purge air from the hydraulic lines, connect them together to create a closed loop and pump hydraulic fluid through them. Review the hydraulic schematic to determine which hydraulic lines to connect. The linear feet and inside diameter of the hydraulic supply lines together with pump capacity will determine the amount of pumping time required to fully purge the hydraulic system.

Bleeding may be necessary if excessive backlash is exhibited after the actuator is connected to the hydraulic system. The following steps are recommended when a minimum of two gallons (8 liters) is purged.

1. Connect a 3/16" inside diameter x 5/16" outside diameter x 5 foot clear, vinyl drain tube to each of the two bleed nipples. Secure them with hose clamps. Place the vinyl tubes in a clean 5-gallon container to

2. With an operator in the platform, open both bleed nipples 1/4 turn. Hydraulically rotate the platform to the end of rotation (either clockwise or counterclockwise), and maintain hydraulic pressure. Oil with small air bubbles will be seen flowing through the tubes. Allow a 1/2 gallon of fluid to be purged from the actuator.
3. Keep the fittings open and rotate the platform in the opposite direction to the end position. Maintain hydraulic pressure until an additional 1/4 gallon of fluid is pumped into the container.
4. Repeat steps 2 & 3. After the last 1/2 gallon is purged, close both bleed nipples before rotating away from the end position.

Troubleshooting

Table 4-1. Troubleshooting

Problem	Cause	Solution
1. Shaft rotates slowly or not at all	a. Insufficient torque output b. Low rate of fluid flow c. Control or counterbalance valve has internal leak d. Piston and/or shaft seal leak e. Corrosion build-up on the thrust surfaces f. Swollen seals and composite bearings caused by incompatible hydraulic fluid	a. Verify correct operating pressure. Do not exceed OEM's pressure specifications. Load may be above maximum capacity of the actuator. b. Inspect ports for obstructions and hydraulic lines for restrictions and leaks. c. Disconnect hydraulic lines and bypass valve. Leave valve ports open and operate the actuator through housing ports (do not exceed OEM's operating pressure). The valve must be replaced if a steady flow of fluid is seen coming from the valve ports. d. Remove the plug and the housing's valve ports. Operate the actuator through the housing ports. Conduct the internal leakage test as described in the Testing section on page 24 of this manual. e. Re-build the actuator. Remove all rust then polish. Replacement parts may be needed. f. Re-build the actuator. Use fluid that is compatible with seals and bearings.
2. Operation is erratic or not responsive	a. Air in actuator	a. Purge air from actuator. See bleeding procedures.
3. Shaft will not fully rotate	a. Twisted or chipped gear teeth b. Port fittings are obstructing the piston	a. Check for gear binding. Actuator may not be able to be re-built and may need to be replaced. Damage could be a result of overload or shock. b. Check thread length of port fittings. Fittings should during stroke not reach inside the housing bore.
4. Selected position cannot be maintained	a. Control or counterbalance valve has internal leak b. Piston and/or shaft seal leak c. Air in actuator	a. Disconnect hydraulic lines and bypass valve. Leave valve ports open and operate the actuator through housing ports (do not exceed OEM's operating pressure). The valve must be replaced if a steady flow of fluid is seen coming from the valve ports. b. Remove the plug and the housing's valve ports. Operate the actuator through the housing ports. Conduct the internal leakage test as described in the Testing section on page 24 of this manual. c. Purge air from actuator. See bleeding procedures

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

SECTION 5. HYDRAULICS

5.1 LUBRICATING O-RINGS IN THE HYDRAULIC SYSTEM

When assembling connectors in the hydraulic that use o-ring fittings, it is necessary to lubricate all fittings with hydraulic oil prior to assembly. To lubricate the fittings, use one of the following procedures.

NOTE: All O-ring fittings must be pre-lubricated with hydraulic oil prior to assembly.

Cup and Brush

The following is needed to correctly oil the o-ring in this manner:

- A small container for hydraulic oil
- Small paint brush



1. Hold the fitting in one hand while using the brush with the other hand to dip into the container. Remove excess hydraulic oil from the brush so an even film of oil is applied on the o-ring.



2. Holding the fitting over the hydraulic oil container, brush an even film of oil around the entire o-ring in the fitting, making sure the entire o-ring is completely saturated.



3. Turn the o-ring on the other side of the fitting and repeat the previous step, ensuring the entire o-ring is coated with hydraulic oil.



Dip Method

NOTE: This method works best with Face Seal o-rings, but will work for all o-ring fitting types.

The following is needed to correctly oil the o-ring in this manner:

- A small leak proof container
 - Sponge cut to fit inside the container
 - A small amount of hydraulic oil to saturate the sponge.
1. Place the sponge inside the container and add hydraulic oil to the sponge until it is fully saturated.
 2. Dip the fitting into the sponge using firm pressure. Upon lifting the fitting, a small droplet will form and drip from the bottom of the fitting. This should signify an even coating of oil on the fitting.



3. O-ring Boss type fittings will require more pressure in able to immerse more of the fitting into the saturated sponge. This will also cause more oil to be dispersed from the sponge.



Spray Method

This method requires a pump or trigger spray bottle.

1. Fill the spray bottle with hydraulic oil.
2. Hold the fitting over a suitable catch can.
3. Spray the entire o-ring surface with a medium coat of oil.



Brush-on Method

This method requires a sealed bottle brush.

1. Fill the bottle with hydraulic oil.
2. Using slight pressure to the body of the spray bottle, invert the bottle so the brush end is in the downward position.
3. Brush hydraulic oil on the entire o-ring, applying an even coat of oil.



5.2 CYLINDERS - THEORY OF OPERATION

Lift, Telescope, Slave, Master, Oscillation (if equipped), Jib (if equipped), and Steer

A double acting cylinder is one that requires oil flow to operate the cylinder rod in both directions. Directing oil (by actuating the corresponding control valve to the piston side of the cylinder) forces the piston to travel toward the rod end of the barrel, extending the cylinder rod (piston attached to rod). When the oil flow is stopped, movement of the rod will stop. By directing oil to the rod side of the cylinder, the piston will be forced in the opposite direction and the cylinder rod will retract.

Holding valves are used in the Lift circuits to prevent retraction of the cylinder rod should a hydraulic line rupture or leak develop between the cylinder and its related control valve.

5.3 CYLINDER CHECKING PROCEDURES

NOTE: *Cylinder checks must be performed any time a cylinder component is replaced or when improper system operation is suspected.*

Cylinder Without Counterbalance Valves

Steer Cylinder and Master Cylinder

1. Using all applicable safety precautions, activate hydraulic system and fully extend cylinder to be checked. Shut down hydraulic system.
2. Carefully disconnect hydraulic hose from retract port of cylinder. There will be initial weeping of hydraulic fluid which can be caught in a suitable container. After initial discharge, there should be no further leakage from the retract port.
3. Activate hydraulic system, and activate cylinder extend function.
4. If cylinder retract port leakage is less than 6-8 drops per minute, carefully reconnect hose to retract port and retract cylinder. If leakage continues at a rate of 6-8 drops per minute or more, cylinder repairs must be made.
5. With cylinder fully retracted, shut down motor and carefully disconnect hydraulic hose from cylinder extend port.
6. Activate hydraulic system and activate cylinder retract function. Check extend port for leakage.
7. If extend port leakage is less than 6-8 drops per minute, carefully reconnect hose to extend port, then activate cylinder through one complete cycle and check for leaks. If leakage continues at a rate of 6-8

drops per minute or more, cylinder repairs must be made.

Cylinders With Single Counterbalance Valve

Lift Cylinder and Oscillation Cylinder

NOTICE

OPERATE ALL FUNCTIONS FROM GROUND CONTROL STATION ONLY.

1. Using all applicable safety precautions, activate hydraulic system.

⚠ WARNING

WHEN WORKING ON THE UPPER BOOM LIFT CYLINDER RAISE THE UPPER BOOM TO HORIZONTAL AND PLACE A BOOM PROP APPROXIMATELY 1 INCH (2.54 CM) BELOW THE MAIN BOOM. IF WORKING ON LOWER BOOM LIFT CYLINDER, RAISE LOWER BOOM HALFWAY, FULLY ELEVATE UPPER BOOM AND ATTACH OVERHEAD CRANE TO THE UPRIGHT FOR SUPPORT, LEAVING APPROXIMATELY 1 INCH (2.54 CM) OF SLACK IN CHAIN OR SLING FOR TEST PURPOSES.

2. After completing the above, shut down hydraulic system and allow machine to sit for 10-15 minutes. This is done to relieve pressure in the hydraulic lines. Carefully remove hydraulic hoses from appropriate cylinder port block.
3. There will be initial weeping of hydraulic fluid, which can be caught in a suitable container. After the initial discharge, there should not be any further leakage from the ports. If leakage continues at a rate of 6-8 drops per minute or more, the following cylinder repairs must be made. If the retract port is leaking, the piston is leaking, the piston seals are defective and must be replaced. If the extend port is leaking, the counterbalance is defective and must be replaced.
4. If no repairs are necessary or when repairs have been made, carefully reconnect hydraulic hoses to the appropriate ports.
5. Remove boom prop/overhead crane, activate hydraulic system and run cylinder through complete cycle to check for leaks and operation.

Cylinders With Dual Counterbalance Valve

Telescope and Slave Cylinders

NOTICE

OPERATE ALL FUNCTIONS FROM GROUND CONTROL STATION ONLY.

1. Using all applicable safety precautions, activate hydraulic system.
2. When working on the platform slave cylinder, stroke platform slave level cylinder forward until platform sits at a 45 degree angle.
3. After completing the above, shut down hydraulic system and allow machine to sit for 10-15 minutes. This is done to relieve pressure in the hydraulic lines. Carefully remove hydraulic hoses from appropriate cylinder port block.
4. There will be initial weeping of hydraulic fluid, which can be caught in a suitable container. After the initial discharge, there should not be any further leakage from the ports. If leakage continues at a rate of 6-8 drops per minute or more, the following cylinder repairs must be made. If the retract port is leaking, the piston is leaking, the piston seals are defective and must be replaced. If the extend port is leaking, the counterbalance is defective and must be replaced.
5. To check piston seals, carefully remove the counterbalance valve from the retract port. After initial discharge there should not be any further leakage from the ports. If leakage occurs at a rate of 6-8 drops per minute or more, the piston seals are defective and must be replaced.
6. If no repairs are necessary or when repairs have been made, carefully reconnect hydraulic hoses to the appropriate ports.
7. Remove boom prop/overhead crane, activate hydraulic system and run cylinder through complete cycle to check for leaks and operation.

5.4 CYLINDER REPAIR

NOTE: The following are general procedures that apply to all of the cylinders on this machine. Procedures that apply to a specific cylinder will be so noted.

Disassembly

NOTICE

DISASSEMBLY OF THE CYLINDER SHOULD BE PERFORMED ON A CLEAN WORK SURFACE IN A DIRT FREE WORK AREA.

1. Connect a suitable auxiliary hydraulic power source to the cylinder port block fitting.

⚠ WARNING

DO NOT FULLY EXTEND CYLINDER TO THE END OF STROKE. RETRACT CYLINDER SLIGHTLY TO AVOID TRAPPING PRESSURE.

2. Operate the hydraulic power source and extend the cylinder. Shut down and disconnect the power source. Adequately support the cylinder rod, if applicable.
3. If applicable, remove the cartridge-type holding valve and fittings from the cylinder port block. Discard o-rings.
4. Place the cylinder barrel into a suitable holding fixture.

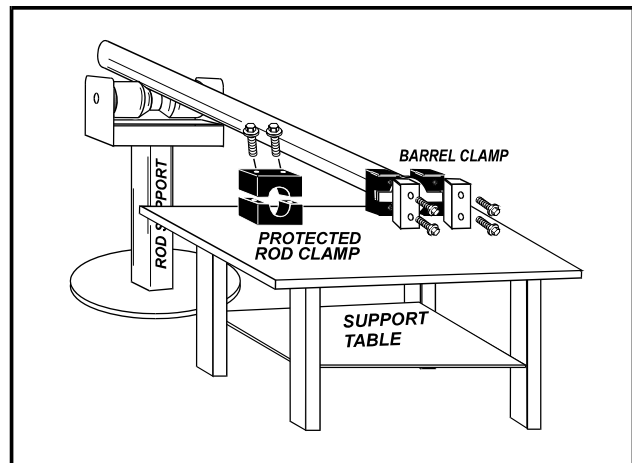


Figure 5-1. Cylinder Barrel Support

5. Mark cylinder head and barrel with a center punch for easy realignment. Using an allen wrench, loosen the cylinder head retainer cap screws, and remove cap screws from cylinder barrel.

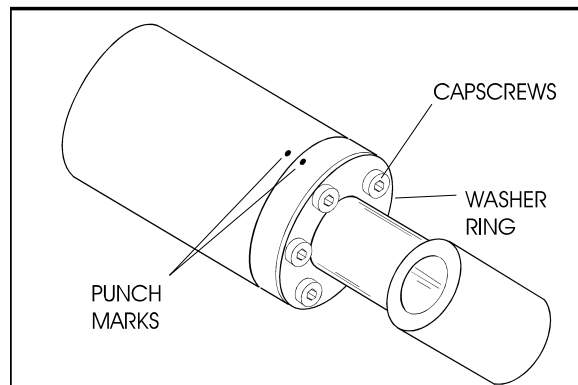
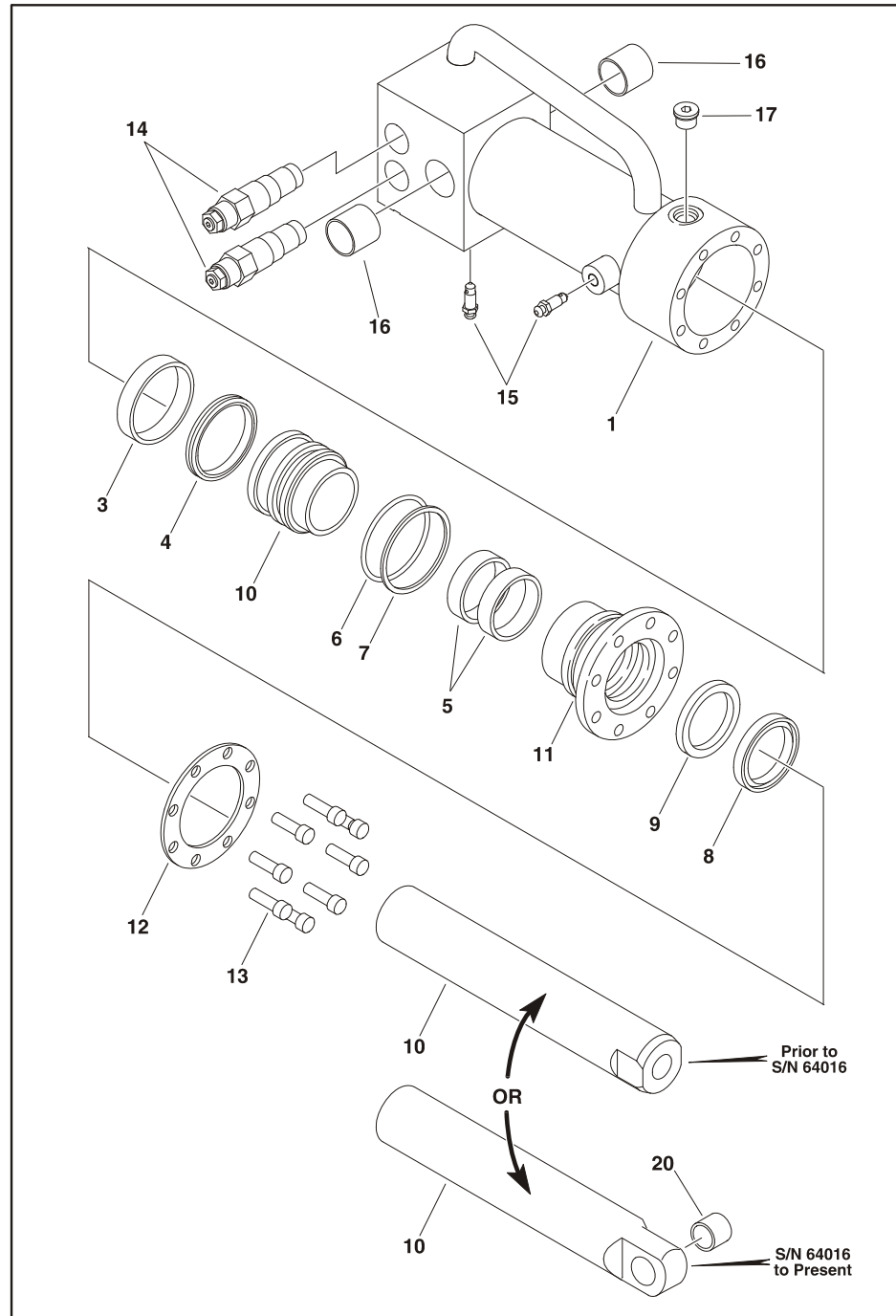
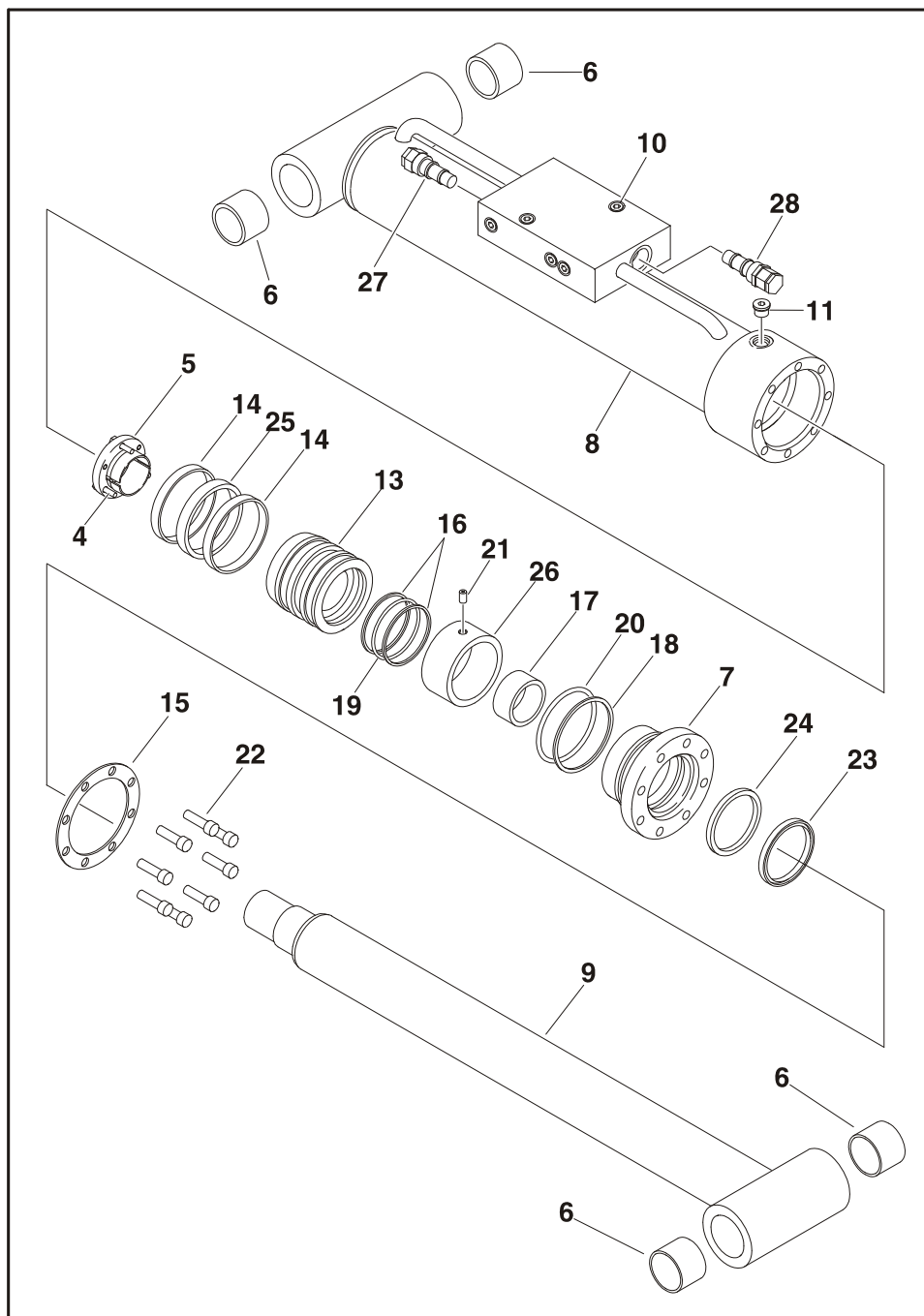


Figure 5-2. Capscrew Removal



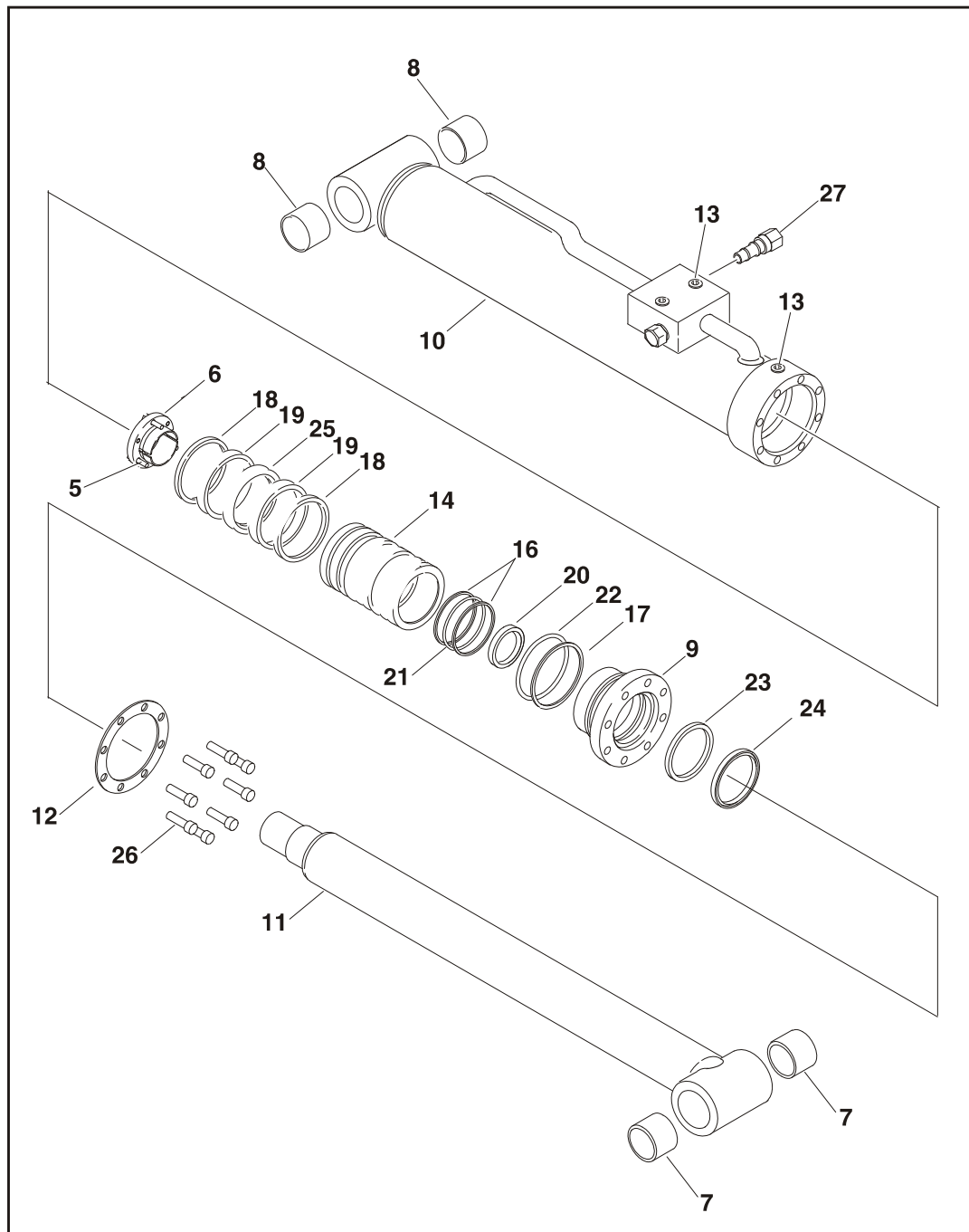
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|--------------|----------------|--------------------------|--------------------------------|
| 1. Barrel | 6. O-ring | 11. Cap | 16. Bushing |
| 2. Not Used | 7. Backup Ring | 12. Washer Ring | 17. O-ring Plug |
| 3. Wear Ring | 8. Wiper Ring | 13. Bolt | 18. Loctite #242 |
| 4. T-Seal | 9. Seal | 14. Counterbalance Valve | 19. Locking Primer (Not Shown) |
| 5. Wear Ring | 10. Rod | 15. Bleeder Valve | 20. Bushing |

Figure 5-3. Axle Lockout Cylinder



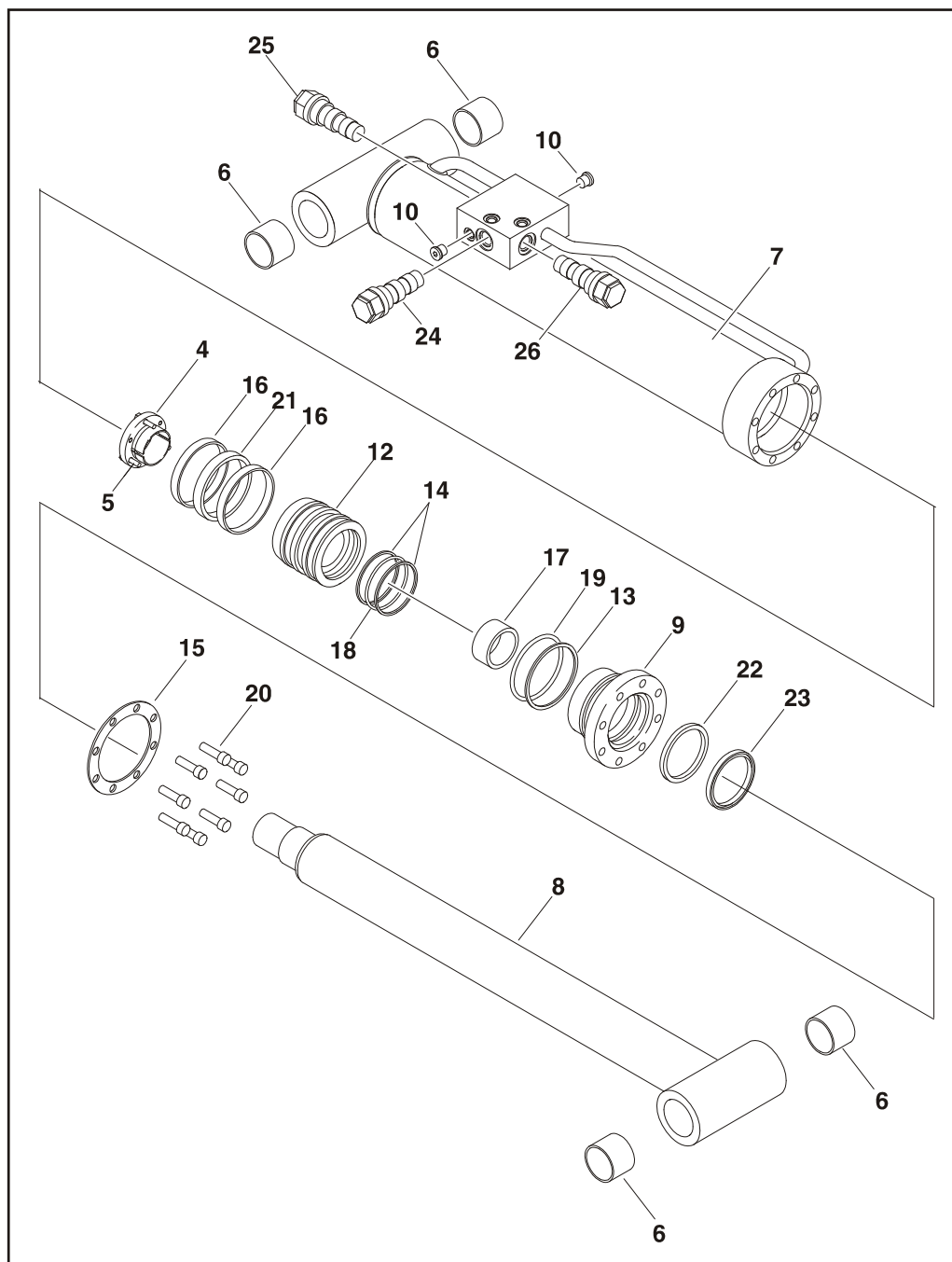
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|-------------------------------|-----------------|-----------------|--------------|--------------------------|
| 1. Loctite #242 (Not Shown) | 7. Head | 13. Piston | 19. O-ring | 25. T-Seal |
| 2. Locking Primer | 8. Rod | 14. Wear Ring | 20. O-ring | 26. Spacer |
| 3. Loctite #RC609 (Not Shown) | 9. Barrel | 15. Washer Ring | 21. Setscrew | 27. Counterbalance Valve |
| 4. Bolt | 10. O-ring Plug | 16. Backup Ring | 22. Bolt | 28. Counterbalance Valve |
| 5. Tapered Bushing | 11. O-ring Plug | 17. Wear Ring | 23. Wiper | |
| 6. Bushing | 12. Not Used | 18. Backup Ring | 24. Seal | |

Figure 5-4. Level Cylinder



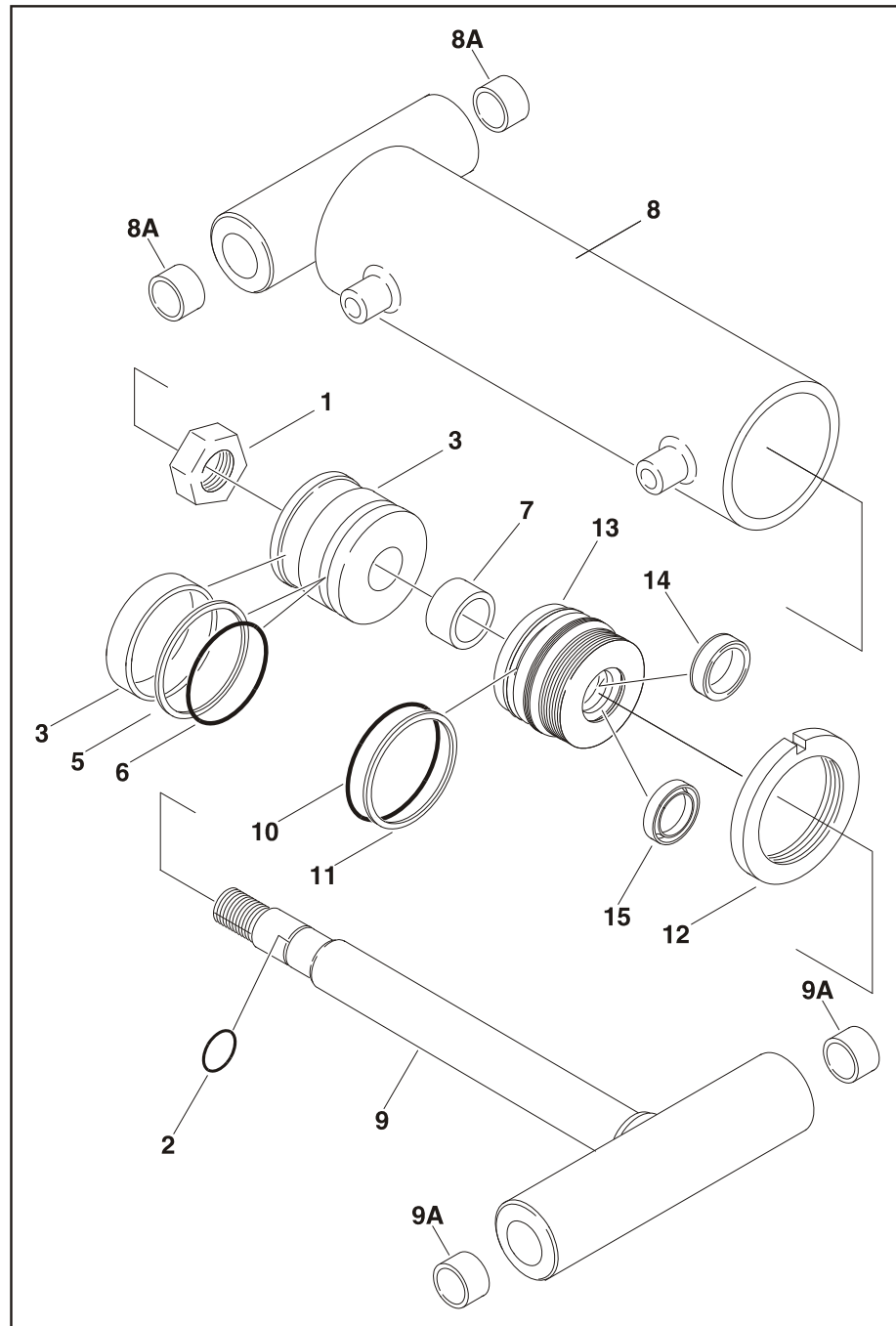
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|-------------------------------|-----------------|-----------------|---------------|--------------------------|
| 1. Loctite #242 (Not Shown) | 7. Bushing | 13. O-ring Plug | 18. Seal | 23. Seal |
| 2. Not Used | 8. Bushing | 14. Piston | 19. Wear Ring | 24. Wiper |
| 3. Locking Primer (Not Shown) | 9. Head | 15. Not Used | 20. Wear Ring | 25. T-Seal |
| 4. Loctite #RC609 (Not Shown) | 10. Barrel | 16. Backup Ring | 21. O-ring | 26. Bolt |
| 5. Bolt | 11. Rod | 17. Backup Ring | 22. O-ring | 27. Counterbalance Valve |
| 6. Tapered Bushing | 12. Washer Ring | | | |

Figure 5-5. Jib Lift Cylinder



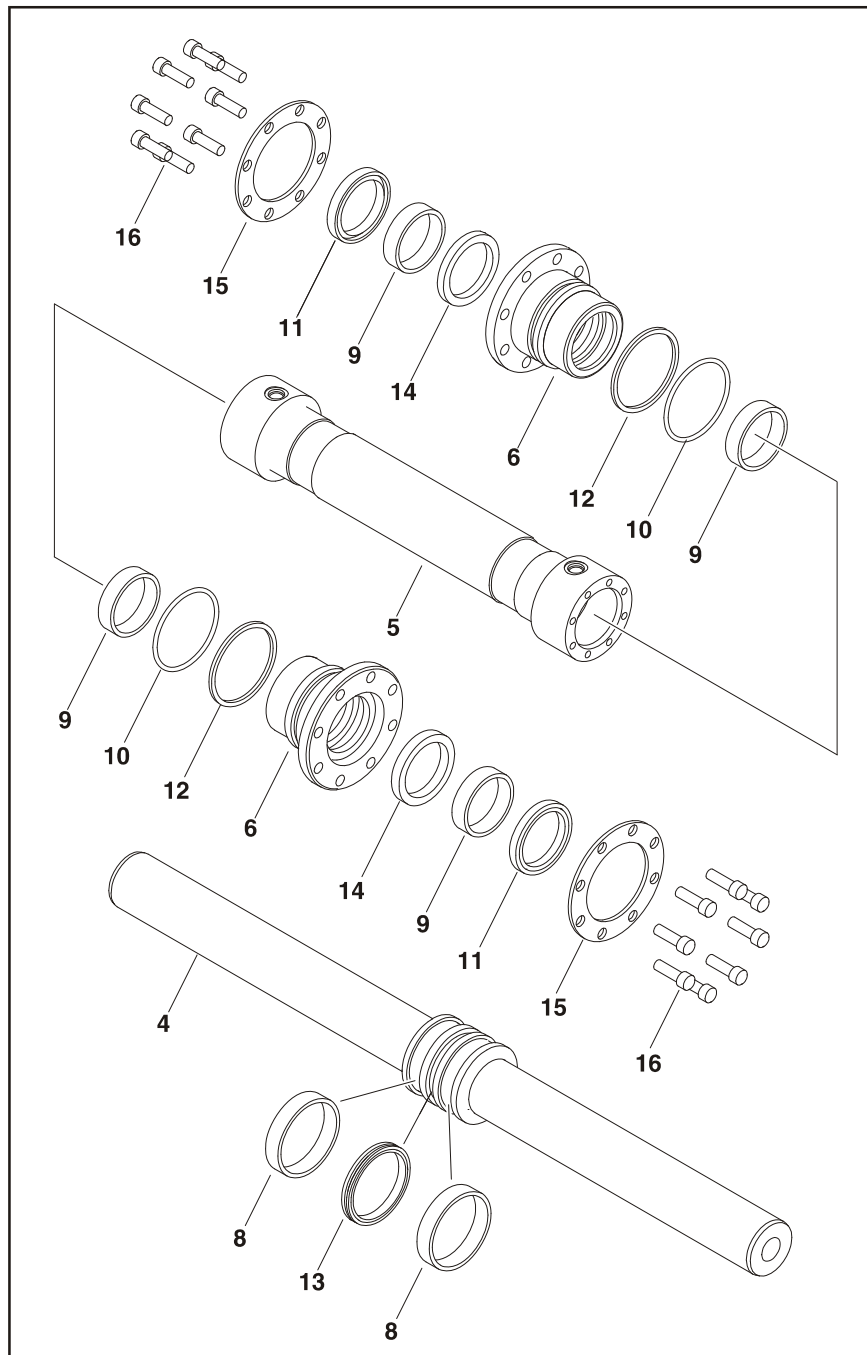
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|-------------------------------|-----------------|-----------------|---------------|--------------------------|
| 1. Loctite #242 (Not Shown) | 7. Barrel | 12. Piston | 17. Wear Ring | 22. Rod Seal |
| 2. Locking Primer (Not Shown) | 8. Rod | 13. Backup Ring | 18. O-ring | 23. Wiper |
| 3. Loctite (Not Shown) | 9. Head | 14. Backup Ring | 19. O-ring | 24. Check Valve |
| 4. Bolt | 10. O-ring Plug | 15. Washer Ring | 20. Capscrew | 25. Counterbalance Valve |
| 5. Tapered Bushing | 11. Not Used | 16. Wear Ring | 21. Seal | 26. Check Valve |
| 6. Bushing | | | | |

Figure 5-6. Lift Cylinder



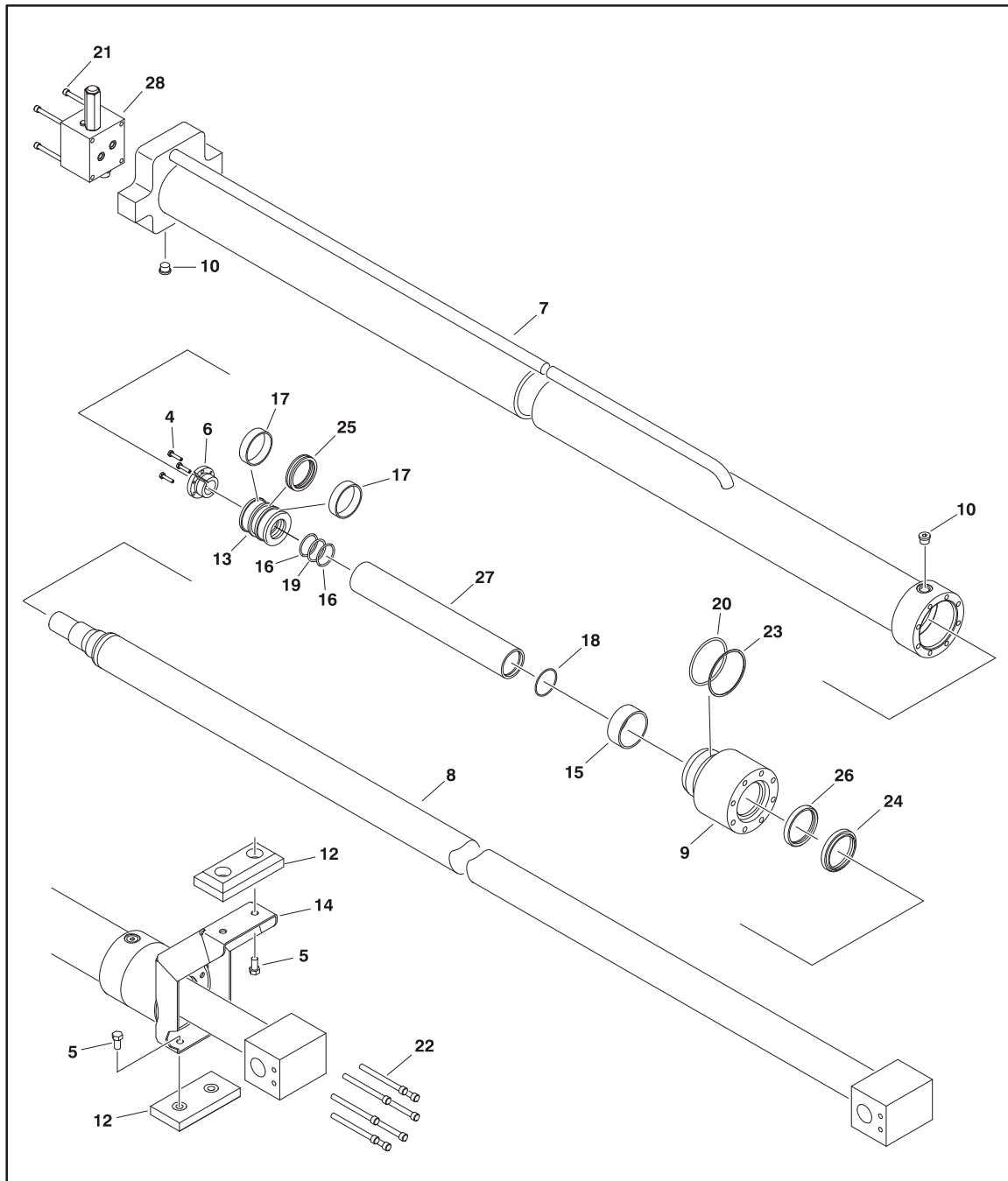
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|----------------|-------------|-----------------|
| 1. Locknut | 7. Spacer | 11. Backup Ring |
| 2. O-ring | 8. Barrel | 12. Setscrew |
| 3. Wear Ring | 8A. Bushing | 13. Guide |
| 4. Piston | 9. Rod | 14. Seal |
| 5. Piston Seal | 9A. Bushing | 15. Wiper |
| 6. O-ring | 10. O-ring | |

Figure 5-7. Master Cylinder



- | | | | |
|-------------------------------|--------------|-----------------|-----------------|
| 1. Loctite #242 (Not Shown) | 5. Barrel | 9. Wear Ring | 13. T-Seal |
| 2. Locking Primer (Not Shown) | 6. Head | 10. O-ring | 14. Seal |
| 3. Loctite (Not Shown) | 7. Not Used | 11. Wiper | 15. Washer Ring |
| 4. Rod | 8. Wear Ring | 12. Backup Ring | 16. Bolt |

Figure 5-8. Steer Cylinder



- | | | | | |
|-------------------------------|-----------------|-------------------|-----------------|--------------|
| 1. Loctite #242 (Not Shown) | 7. Barrel | 13. Piston | 19. O-ring | 24. Wiper |
| 2. Locking Primer (Not Shown) | 8. Rod | 14. Support Plate | 20. O-ring | 25. Seal |
| 3. Loctite (Not Shown) | 9. Head | 15. Wear Ring | 21. Bolt | 26. Rod Seal |
| 4. Bolt | 10. O-ring Plug | 16. Backup Ring | 22. Bolt | 27. Spacer |
| 5. Bolt | 11. Not Used | 17. Wear Ring | 23. Backup Ring | 28. Valve |
| 6. Tapered Bushing | 12. Support Pad | 18. O-ring | | |

Figure 5-9. Telescope Cylinder

NOTE: Steps 6 applies only to the telescope cylinders.

6. Using a spanner wrench, loosen the end cap or head retainer, and remove from cylinder barrel.
7. Attach a suitable pulling device to the cylinder rod port block end or cylinder rod end, as applicable.

NOTICE

EXTREME CARE SHOULD BE TAKEN WHEN REMOVING THE CYLINDER ROD, HEAD, AND PISTON. AVOID PULLING THE ROD OFF-CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.

8. With the barrel clamped securely, apply pressure to the rod pulling device and carefully withdraw the complete rod assembly from the cylinder barrel.

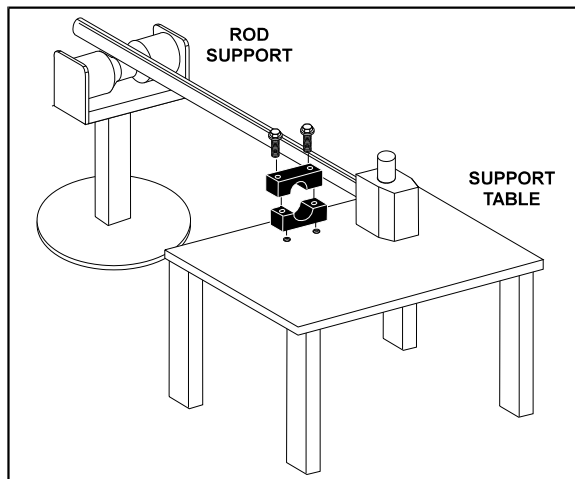


Figure 5-10. Cylinder Rod Support

9. Using suitable protection, clamp the cylinder rod in a vise or similar holding fixture as close to the piston as possible.
10. Loosen and remove the cap screw(s), if applicable, which attach the tapered bushing to the piston.
11. Insert the cap screw(s) in the threaded holes in the outer piece of the tapered bushing. Progressively tighten the cap screw(s) until the bushing is loose on the piston.

12. Remove the bushing from the piston.

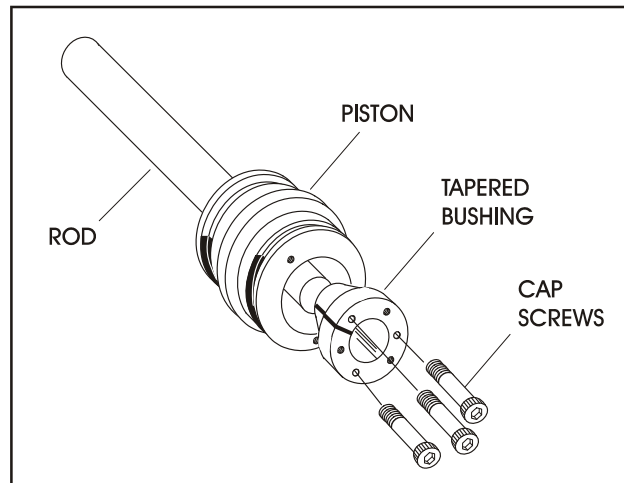


Figure 5-11. Tapered Bushing

13. Screw the piston CCW, by hand, and remove the piston from cylinder rod.
14. Remove and discard the piston o-rings, seal rings, and backup rings.
15. Remove piston spacer, if applicable, from the rod.
16. Remove the rod from the holding fixture. Remove the cylinder head gland and retainer plate, if applicable. Discard the o-rings, back-up rings, rod seals, and wiper seals.

Cleaning and Inspection

1. Clean all parts thoroughly in an approved cleaning solvent.
2. Inspect the cylinder rod for scoring, tapering, ovality, or other damage. If necessary, dress rod with Scotch Brite or equivalent. Replace rod if necessary.
3. Inspect threaded portion of rod for excessive damage. Dress threads as necessary.
4. Inspect inner surface of cylinder barrel tube for scoring or other damage. Check inside diameter for tapering or ovality. Replace if necessary.
5. Inspect threaded portion of barrel for damage. Dress threads as necessary.
6. Inspect piston surface for damage and scoring and for distortion. Dress piston surface or replace piston as necessary.
7. Inspect threaded portion of piston for damage. Dress threads as necessary.
8. Inspect seal and o-ring grooves in piston for burrs and sharp edges. Dress applicable surfaces as necessary.

9. Inspect cylinder head inside diameter for scoring or other damage and for ovality and tapering. Replace as necessary.
10. Inspect threaded portion of head for damage. Dress threads as necessary.
11. Inspect seal and o-ring grooves in head for burrs and sharp edges. Dress applicable surfaces as necessary.
12. Inspect cylinder head outside diameter for scoring or other damage and ovality and tapering. Replace as necessary.
13. If applicable, inspect rod and barrel bearings for signs of correct excessive wear or damage. Replace as necessary.
 - a. Thoroughly clean hole, (steel bushing) of burrs, dirt etc. to facilitate bearing installation.
 - b. Inspect steel bushing for wear or other damage. If steel bushing is worn or damaged, rod/barrel must be replaced.
 - c. Lubricate inside of the steel bushing with WD40 prior to bearing installation.
 - d. Using an arbor of the correct size, carefully press the bearing into steel bushing.

NOTE: Install pin into the Gar-Max bearing dry. Lubrication is not required with nickel plated pins and bearings.

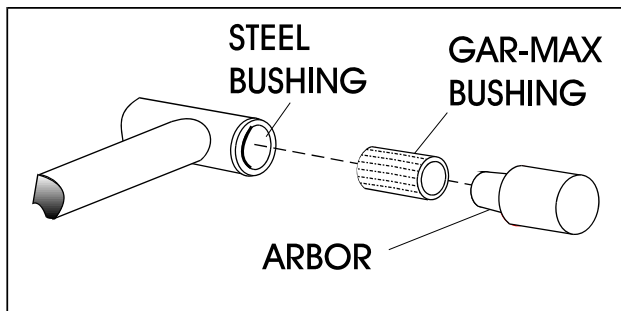


Figure 5-12. Gar-Max Bearing

14. Inspect travel limiting collar or spacer for burrs and sharp edges. If necessary, dress inside diameter surface with Scotch Brite or equivalent.
15. If applicable, inspect port block fittings and holding valve. Replace as necessary.
16. Inspect the oil ports for blockage or the presence of dirt or other foreign material. Repair as necessary.
17. If applicable, inspect piston rings for cracks or other damage. Replace as necessary.

Assembly

NOTE: Prior to cylinder assembly, ensure that the proper cylinder seal kit is used. See your JLG Parts Manual.

Apply a light film of hydraulic oil to all components prior to assembly.

1. A special tool is used to install a new rod seal into the applicable cylinder head gland groove.

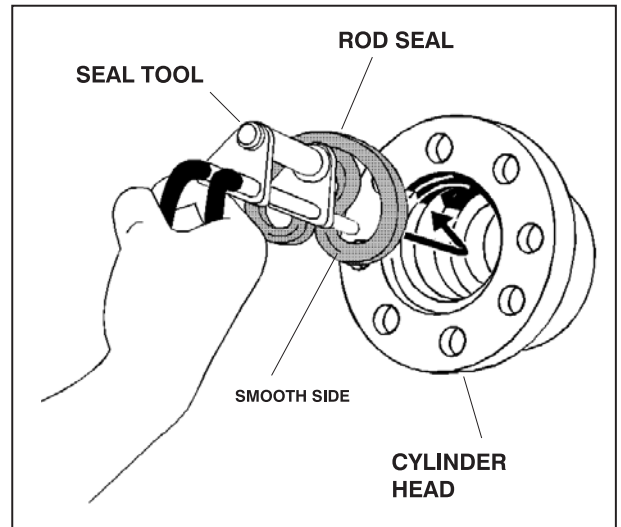


Figure 5-13. Rod Seal Installation

NOTICE

WHEN INSTALLING "POLY-PAK" PISTON SEALS, ENSURE SEALS ARE INSTALLED PROPERLY. REFER TO WIPER SEAL INSTALLATION FOR CORRECT SEAL ORIENTATION. IMPROPER SEAL INSTALLATION COULD RESULT IN CYLINDER LEAKAGE AND IMPROPER CYLINDER OPERATION.

2. Use a soft mallet to tap a new wiper seal into the applicable cylinder head gland groove. Install a new wear ring into the applicable cylinder head gland groove.

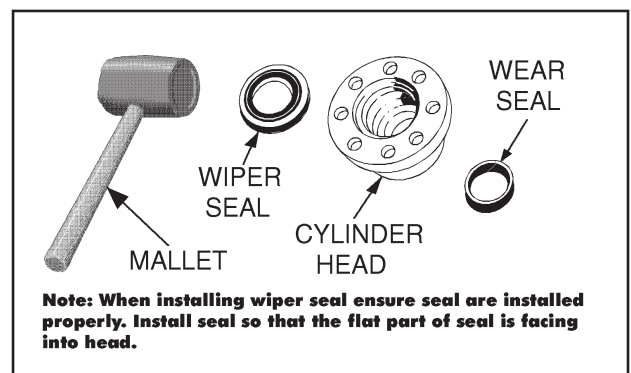


Figure 5-14. Wiper Seal Installation

SECTION 5 - HYDRAULICS

- Place a new o-ring and back-up seal in the applicable outside diameter groove of the cylinder head.

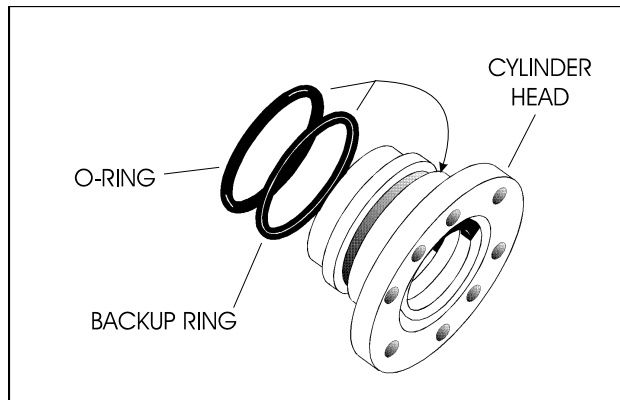


Figure 5-15. Installation of Head Seal Kit

- Install washer ring onto rod, carefully install the head gland on the rod, ensuring that the wiper and rod seals are not damaged or dislodged. Push the head along the rod to the rod end, as applicable.
- Carefully slide the piston spacer on the rod.
- If applicable, correctly place new o-ring in the inner piston diameter groove. (The backup ring side facing the O-ring is grooved.)
- If applicable, correctly place new seals and guide lock rings in the outer piston diameter groove. (A tube, with I.D. slightly larger than the O.D. of the piston is recommended to install the solid seal.)

NOTE: The backup rings for the solid seal have a radius on one side. This side faces the solid seal. (See magnified insert in Figure 5-16.) The split of seals and

backup rings are to be positioned so as not to be in alignment with each other.

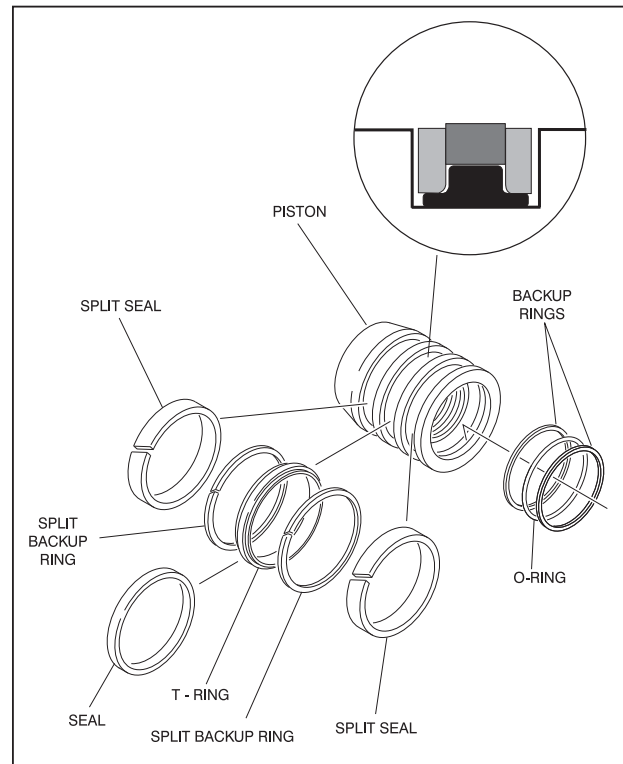


Figure 5-16. Piston Seal Kit Installation

- Using suitable protection, clamp the cylinder rod in a vise or similar holding fixture as close to piston as possible.
- Carefully thread the piston on the cylinder rod hand tight, ensuring that the o-ring and back-up rings are not damaged or dislodged.
- Thread piston onto rod until it abuts the spacer end and install the tapered bushing.

NOTE: When installing the tapered bushing, piston and mating end of rod must be free of oil.

⚠ WARNING

WHEN REBUILDING THE STEER, LOWER LIFT, LEVEL CYLINDER, OR UPPER LIFT CYLINDER, APPLY LOCTITE #242 TO TAPERED BUSHING BOLTS, THEN TIGHTEN SECURELY.

- Assemble the tapered bushing loosely into the piston and insert JLG capscrews (not vendor cap-

screws) through the drilled holes in the bushing and into the tapped holes in the piston.

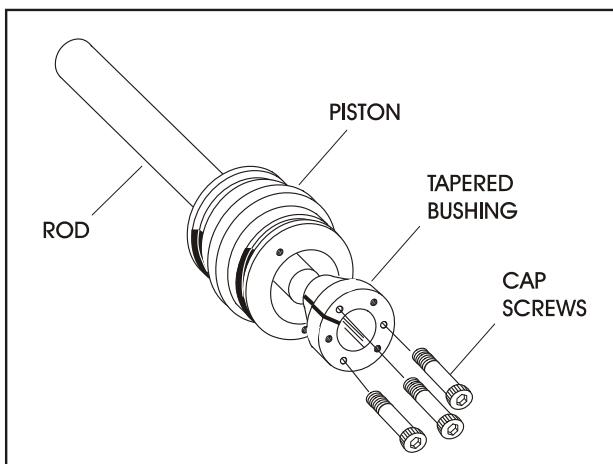


Figure 5-17. Tapered Bushing Installation

12. Tighten the capscrews evenly and progressively in rotation to the specified torque value. (See Table 5-1, Cylinder Head and Tapered Bushing Torque Specifications.)
13. After the screws have been torqued, tap the tapered bushing with a hammer (16 to 24 oz.) and brass shaft (approximately 3/4" in diameter) as follows;
 - a. Place the shaft against the cylinder rod and in contact with the bushing in the spaces between the capscrews.

- b. Tap each space once; this means the tapered bushing is tapped 3 times as there are 3 spaces between the capscrews.

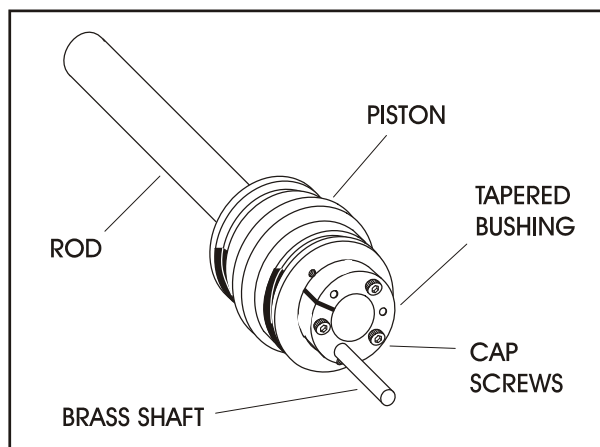


Figure 5-18. Seating the Tapered Bearing

14. Retorque the capscrews evenly and progressively in rotation to the specified torque value. (See Table 5-1, Cylinder Head and Tapered Bushing Torque Specifications.)
15. Remove the cylinder rod from the holding fixture.
16. Place new guide locks and seals in the applicable outside diameter grooves of the cylinder piston. (See Figure 5-19., Poly-Pak Piston Seal Installation)

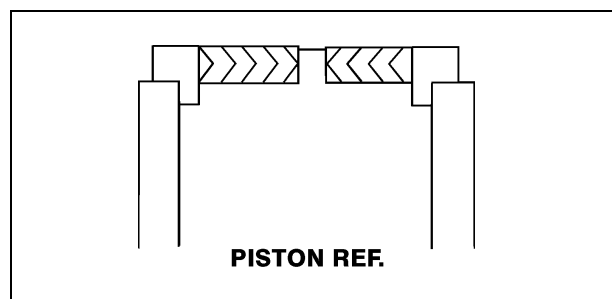


Figure 5-19. Poly-Pak Piston Seal Installation

SECTION 5 - HYDRAULICS

17. Position the cylinder barrel in a suitable holding fixture.

NOTICE

EXTREME CARE SHOULD BE TAKEN WHEN INSTALLING THE CYLINDER ROD, HEAD, AND PISTON. AVOID PULLING THE ROD OFF-CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.

18. With barrel clamped securely, and while adequately supporting the rod, insert the piston end into the barrel cylinder. Ensure that the piston loading o-ring and seal ring are not damaged or dislodged.
19. Continue pushing the rod into the barrel until the cylinder head gland can be inserted into the barrel cylinder.
20. Secure the cylinder head gland using the washer ring and socket head bolts.

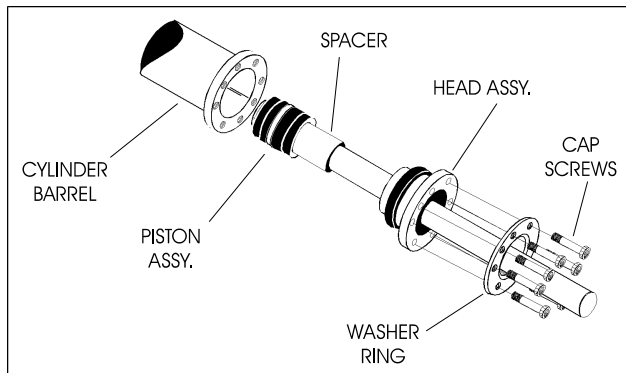


Figure 5-20. Rod Assembly Installation

21. After the cylinder has been reassembled, the rod should be pushed all the way in (fully retracted) prior to the reinstallation of any holding valve or valves.
22. If applicable, install the cartridge-type holding valve and fittings in the rod port block, using new o-rings as applicable. (See Table 5-2, Holding Valve Torque Specifications).

CAUTION

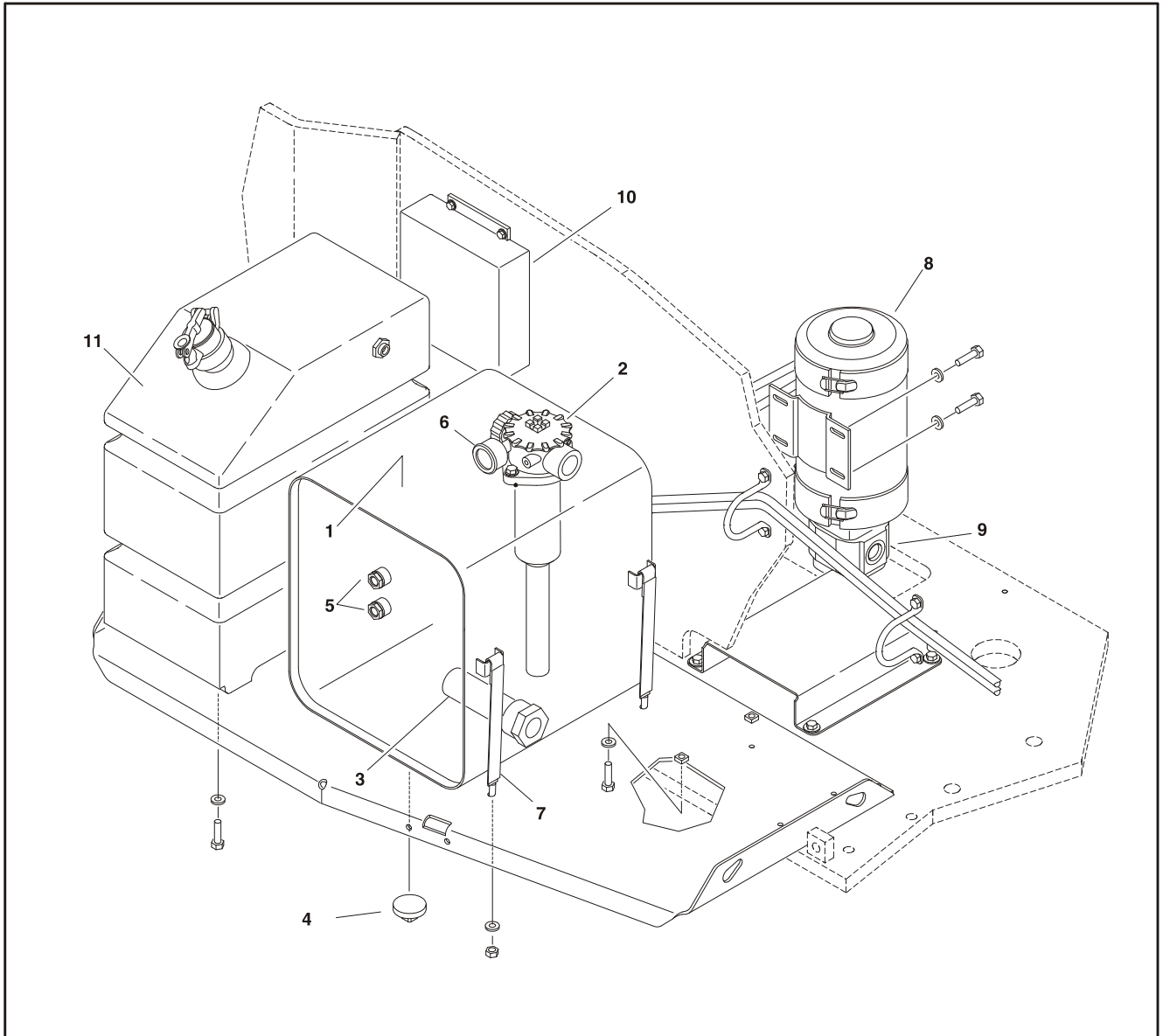
IF THE CYLINDER IS TO BE TESTED PRIOR TO INSTALLATION ON THE MACHINE, EXTREME CARE SHOULD BE USED TO INSURE THAT THE OUTER END OF THE ROD IS SUPPORTED. USE EITHER A TRAVELING OVERHEAD HOIST, FORK-LIFT, OR OTHER MEANS TO SUPPORT THE OVERHANGING WEIGHT OF THE EXTENDING ROD.

Table 5-1. Cylinder Head and Tapered Bushing Torque Specifications

Description	Head Torque Value (Wet)	Tapered Bushing Torque Value (Wet)
Lift Cylinder	190 ft. lbs. (260 Nm)	35 ft. lbs. (47 Nm)
Slave Cylinder	30 ft. lbs. (41 Nm)	5 ft. lbs. (7 Nm)
Telescope Cylinder	N/A	9 ft. lbs. (12 Nm)

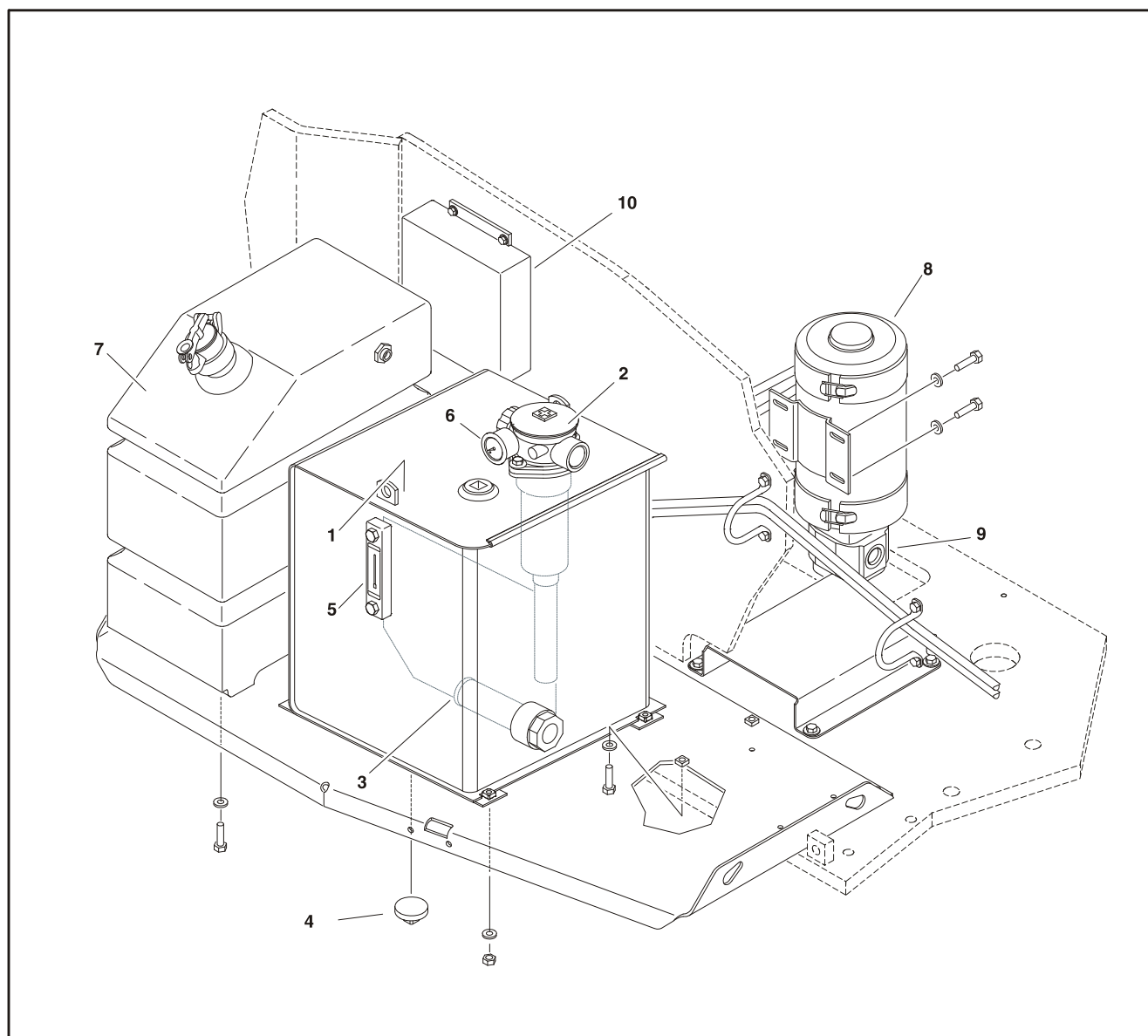
Table 5-2. Holding Valve Torque Specifications

Description	Torque Value
SUN - 7/8 HEX M20 X 1.5 THDS.	30-35 ft. lbs. (41-48 Nm)
SUN - 1 1/8 HEX 1 - 14 UNS THDS.	45-50 ft. lbs. (61-68 Nm)
SUN - 1 1/4 HEX M36 X 2 THDS.	150-160 ft. lbs. (204-217 Nm)
RACINE - 1 1/8 HEX 1 1/16 - 12 THDS.	50-55 ft. lbs. (68-75 Nm)
RACINE - 1 3/8 HEX 1 3/16 - 12 THDS.	75-80 ft. lbs. (102-109 Nm)
RACINE - 1 7/8 HEX 1 5/8 - 12 THDS.	100-110 ft. lbs. (136-149 Nm)



- | | |
|-----------------------------|-------------------------------|
| 1. Hydraulic Tank | 7. Tank Strap |
| 2. Filter & Pressure Switch | 8. Electric Motor |
| 3. Suction Strainer | 9. Hydraulic Pump |
| 4. Magnetic Plug | 10. Contactor Module |
| 5. Sight Gauge | 11. Fuel Tank (M Models Only) |
| 6. Filter Indicator | |

Figure 5-21. Hydraulic Tank and Pump (Prior to S/N 51941)



- | | |
|-----------------------------|-------------------------------|
| 1. Hydraulic Tank | 7. Tank Strap |
| 2. Filter & Pressure Switch | 8. Electric Motor |
| 3. Suction Strainer | 9. Hydraulic Pump |
| 4. Magnetic Plug | 10. Contactor Module |
| 5. Sight Gauge | 11. Fuel Tank (M Models Only) |
| 6. Filter Indicator | |

Figure 5-22. Hydraulic Tank and Pump (S/N 51941 to Present)

5.5 PRESSURE SETTINGS

Proportional Main Relief - 3200 psi (220 Bar)

Bang Bang Main Relief - 3000 psi (207 Bar)

Lift Down - 1100 psi (76 Bar)

Lift Up - 2500 (172 Bar)

Swing - 2500 psi (172 Bar)

Flow Control - 3000 psi (207 Bar)

Steer - 1800 (124 Bar)

Platform Level Up - 2500 psi (172 Bar)

Platform Level Down - 1500 psi (103 Bar)

Jib Up - 2300 psi (158.5 Bar)

Jib Down - 2300 psi (158.5 Bar)

NOTE: All functions must be activated from the platform control station when adjusting pressures at the Platform Control and Main Valve Blocks.

Proportional Main Relief

1. Connect the pressure gauge at the MP port on the main valve and disconnect the lift up coil on the main valve block.
2. Activate the lift up switch from the platform. Adjust pressure to 3200 psi (220 Bar).

Lift Down

1. Connect the pressure gauge at the MP port on the main valve.
2. Activate and bottom out lift down. Adjust pressure to 1100 psi (76 Bar).

Lift Up

1. Connect the pressure gauge at the MP port on the main valve.
2. Activate lift up until end of lift cylinder stroke. Adjust pressure to 2600 psi (179 Bar). If ceiling height will not allow elevation, disconnect lift up hose (port #8 on valve bank) and cap the port to make the setting.

Swing

1. Connect the pressure gauge at the MP port on the main valve.
2. Activate the swing function with the turntable lock pin engaged. Adjust pressure to 2500 psi (172 Bar).

Flow Control / Bang Bang Main Relief

1. Connect the pressure gauge at the MP port on the main valve.
2. Activate and bottom out telescope in. Adjust pressure to 3000 psi (207 Bar).

Steer

1. Connect the pressure gauge at the MP port on the main valve.
2. Activate and bottom out steer right or left. Adjust pressure to 1800 psi (124 Bar).

Platform Level Down

1. Connect a pressure gauge to the M1 port on the platform control valve bank.
2. Activate and bottom out Platform Level Down. Adjust to 1500 psi (103 Bar).

Platform Level Up Relief

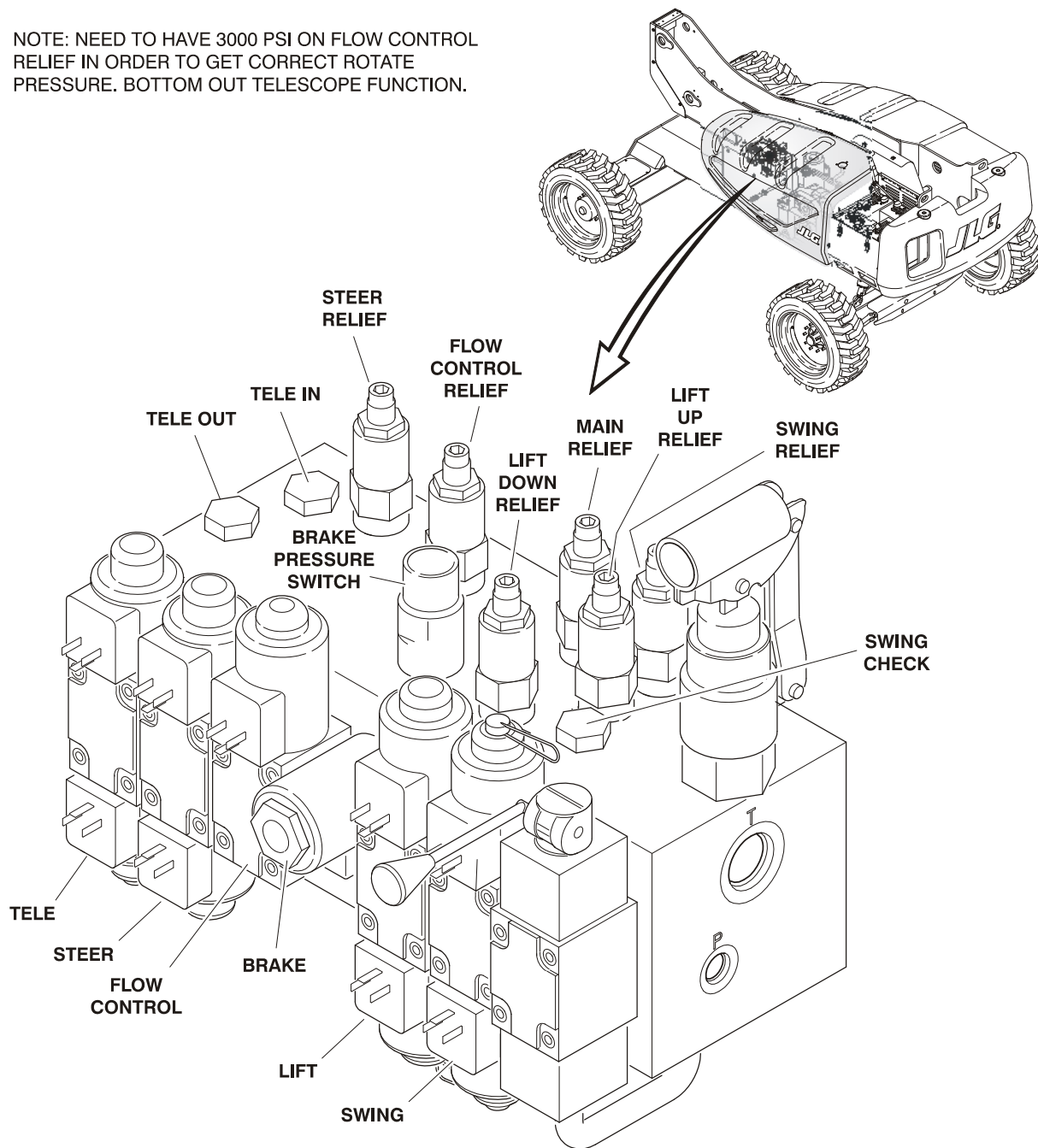
1. Connect a pressure gauge to the M1 port on the platform control valve bank.
2. Activate and bottom out Platform Level Up. Adjust to 2500 psi (172 Bar).

Jib Relief

1. Connect a pressure gauge at the M1 port on the platform control valve bank.
2. Activate and bottom out either Jib Up or Down. Adjust the relief to 2300 psi (158.5 Bar).

NOTE: WHEN CHECKING MAIN RELIEF PRESSURE UNPLUG LIFT UP COIL.

NOTE: NEED TO HAVE 3000 PSI ON FLOW CONTROL RELIEF IN ORDER TO GET CORRECT ROTATE PRESSURE. BOTTOM OUT TELESCOPE FUNCTION.



NOTE: Torque all cartridges to 20 ft. lbs.(28 Nm)

Figure 5-23. Hydraulic Control Valve - Main Valve

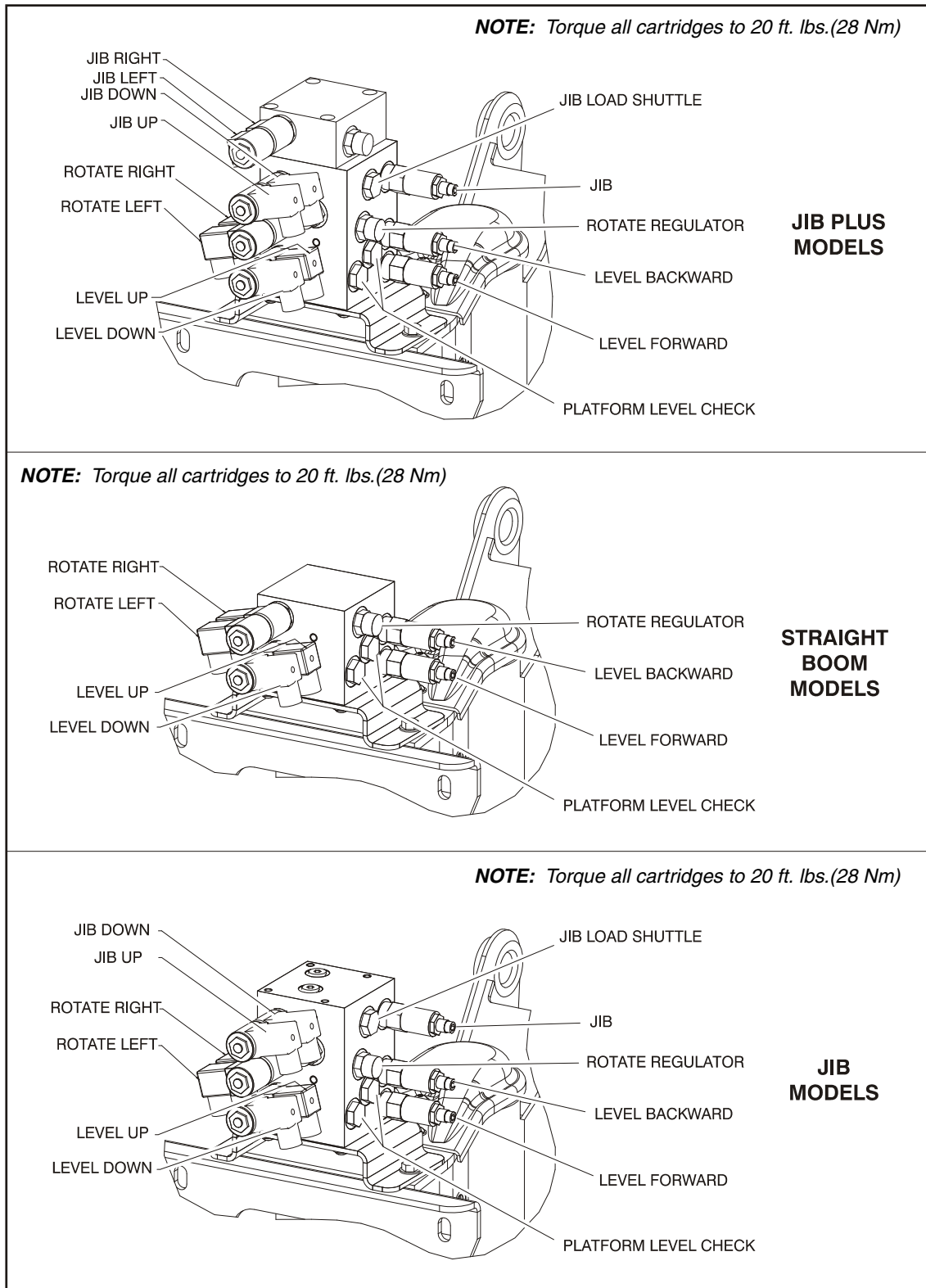


Figure 5-24. Hydraulic Control Valve - Platform Valve

[illegible]

SECTION 6. JLG CONTROL SYSTEM

6.1 INTRODUCTION

NOTICE

WHEN INSTALLING A NEW POWER MODULE CONTROLLER ON THE MACHINE, IT WILL BE NECESSARY TO PROGRAM THE CONTROLLER FOR THE PROPER MACHINE CONFIGURATION, INCLUDING OPTIONS.

NOTICE

IT IS A GOOD PRACTICE TO AVOID PRESSURE-WASHING ELECTRICAL/ELECTRONIC COMPONENTS. SHOULD PRESSURE-WASHING BE UTILIZED TO WASH AREAS CONTAINING ELECTRICAL/ELECTRONIC COMPONENTS, JLG INDUSTRIES, INC. RECOMMENDS A MAXIMUM PRESSURE OF 750 PSI (52 BAR) AT A MINIMUM DISTANCE OF 12 INCHES (30.5 CM) AWAY FROM THESE COMPONENTS. IF ELECTRICAL/ELECTRONIC COMPONENTS ARE SPRAYED, SPRAYING MUST NOT BE DIRECT AND BE FOR BRIEF TIME PERIODS TO AVOID HEAVY SATURATION.

The JLG designed Control System is a 48 volt based motor control unit installed on the boom lift.

The JLG Control System has reduced the need for exposed terminal strips, diodes and trimpots and provides simplicity in viewing and adjusting the various personality settings for smooth control of: acceleration, deceleration,

creep and max.-speed for all boom, drive, and steering functions.

The motor controller will control current output, as programmed for smooth operation and maximum cycle time. Ground control speeds for all boom functions can also be programmed into the motor controller. The motor controller also features an adjustable time limit for positive traction.

The JLG Control System controller has a built in LED to indicate any faults. The system stores recent faults which may be accessed for troubleshooting. Optional equipment includes an hour meter, beacon light, function cut-out, and ground alarm. These options may be added later but must be programmed into the motor controller when installed.

The Control System may be accessed utilizing a custom designed, hand held analyzer (Analyzer Kit, JLG part no. 2901443) which will display two lines of information at a time, by scrolling through the program.

NOTE: Each module has a label with the JLG part number and a serial number which contains a date code.

The following instructions are for using the hand held analyzer.

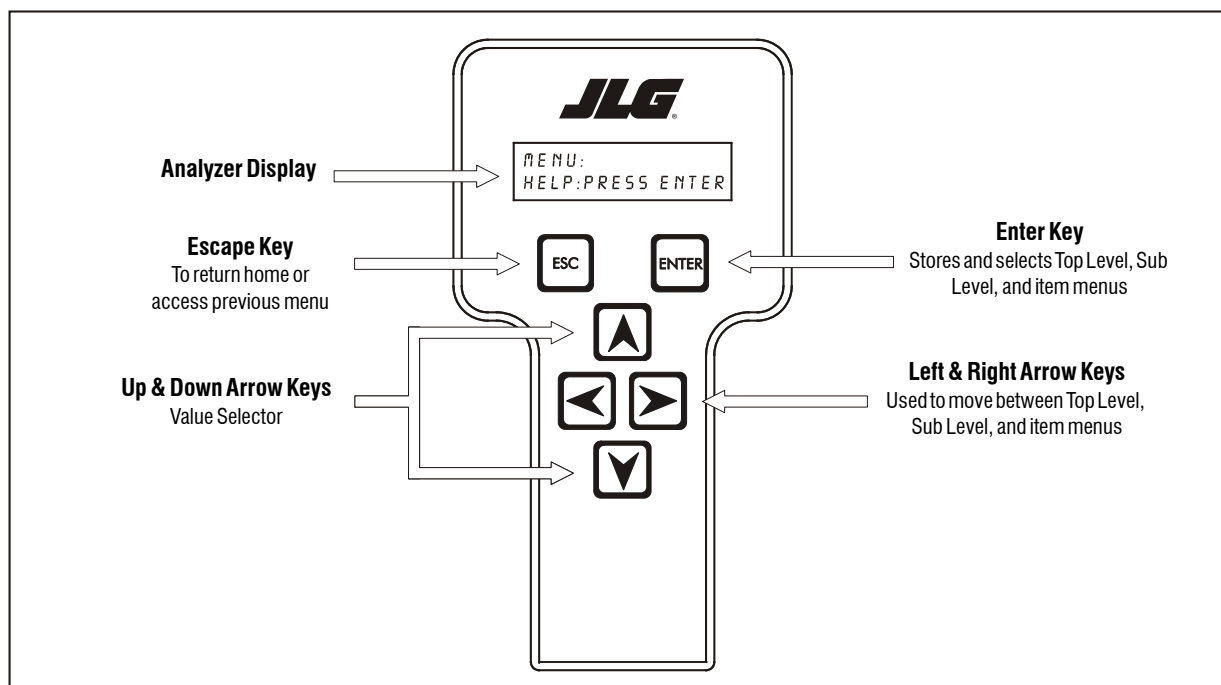


Figure 6-1. Hand Held Analyzer

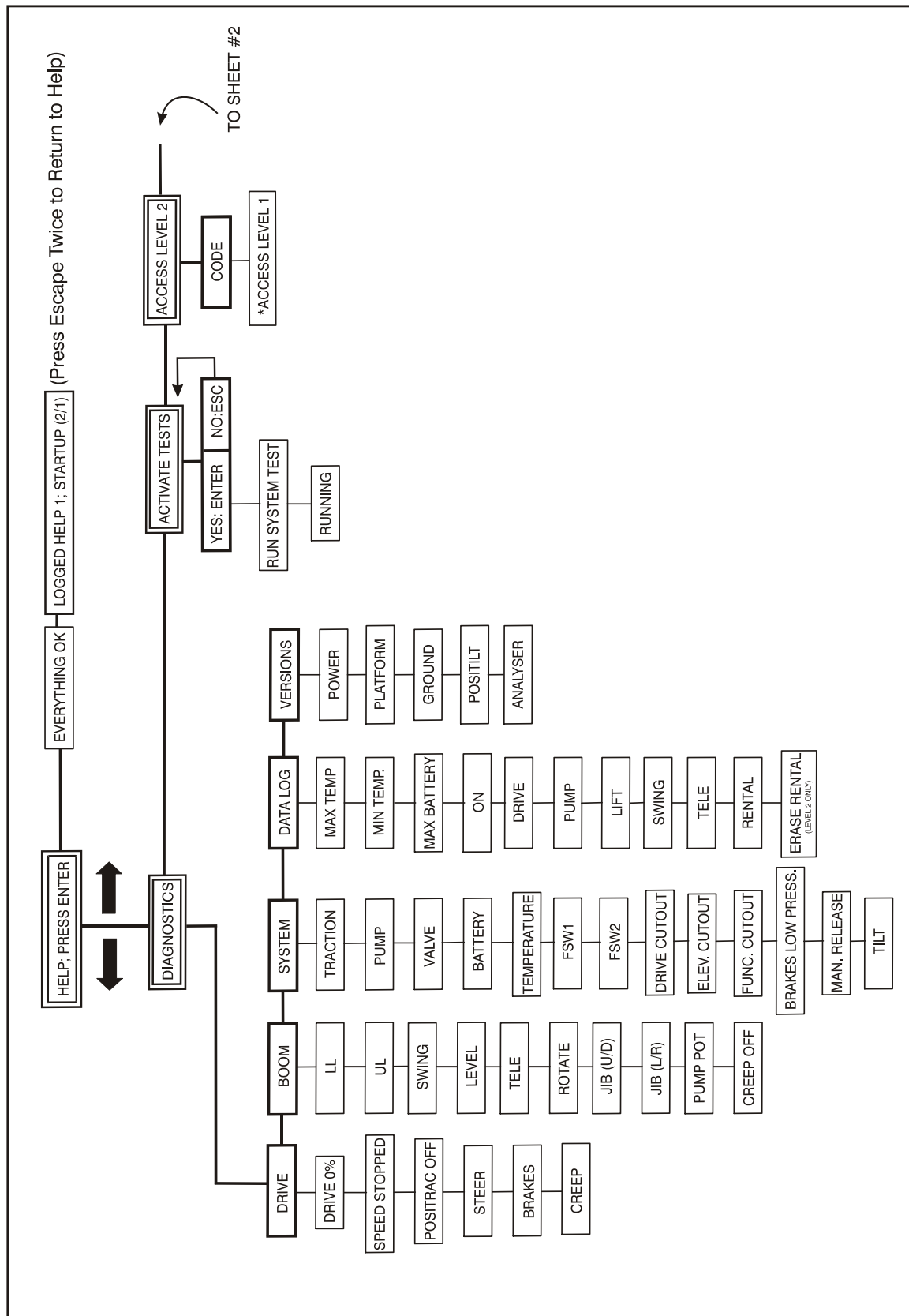


Figure 6-2. Analyzer Flow Chart - Sheet 1 of 2

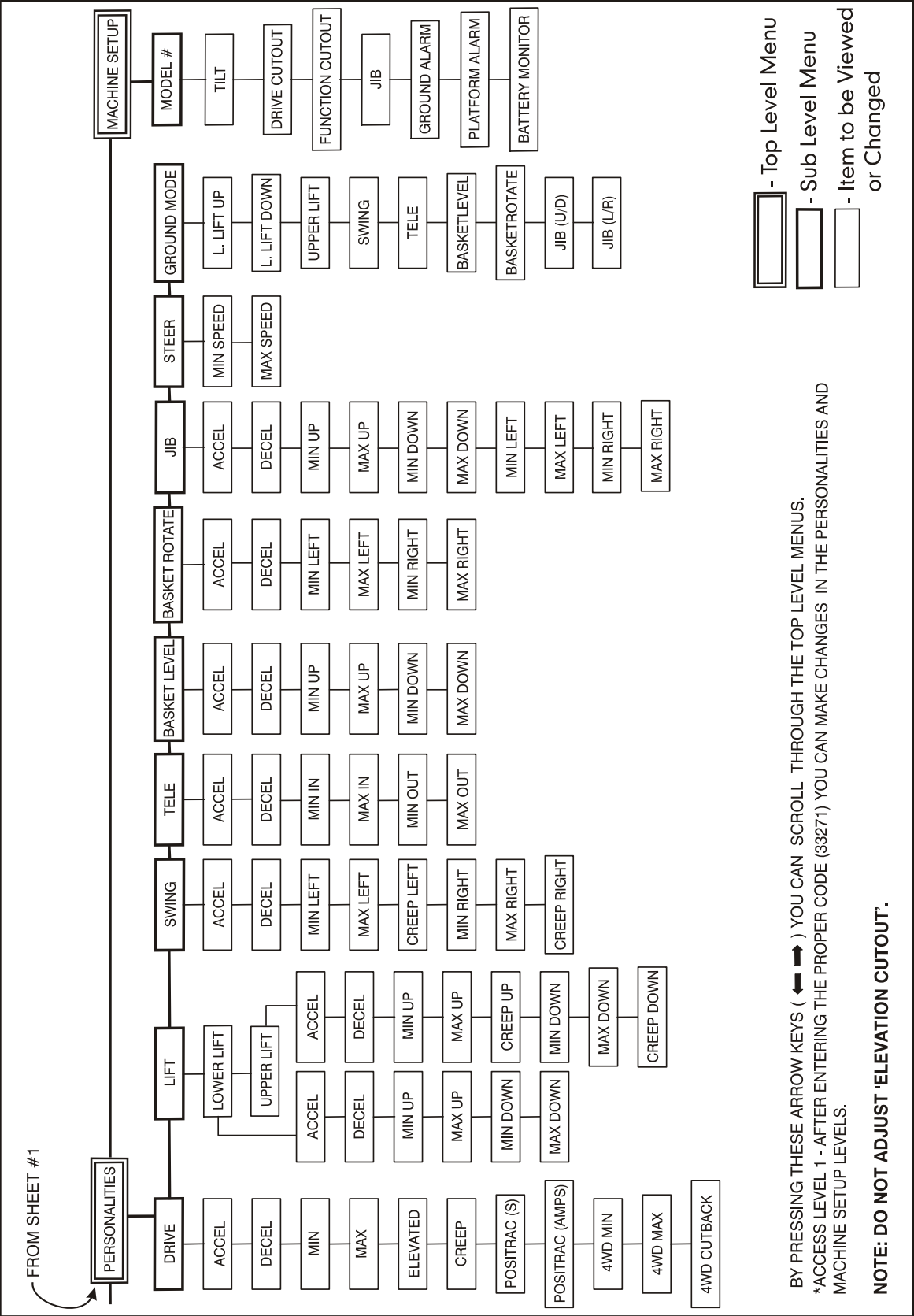


Figure 6-3. Analyzer Flow Chart - Sheet 2 of 2

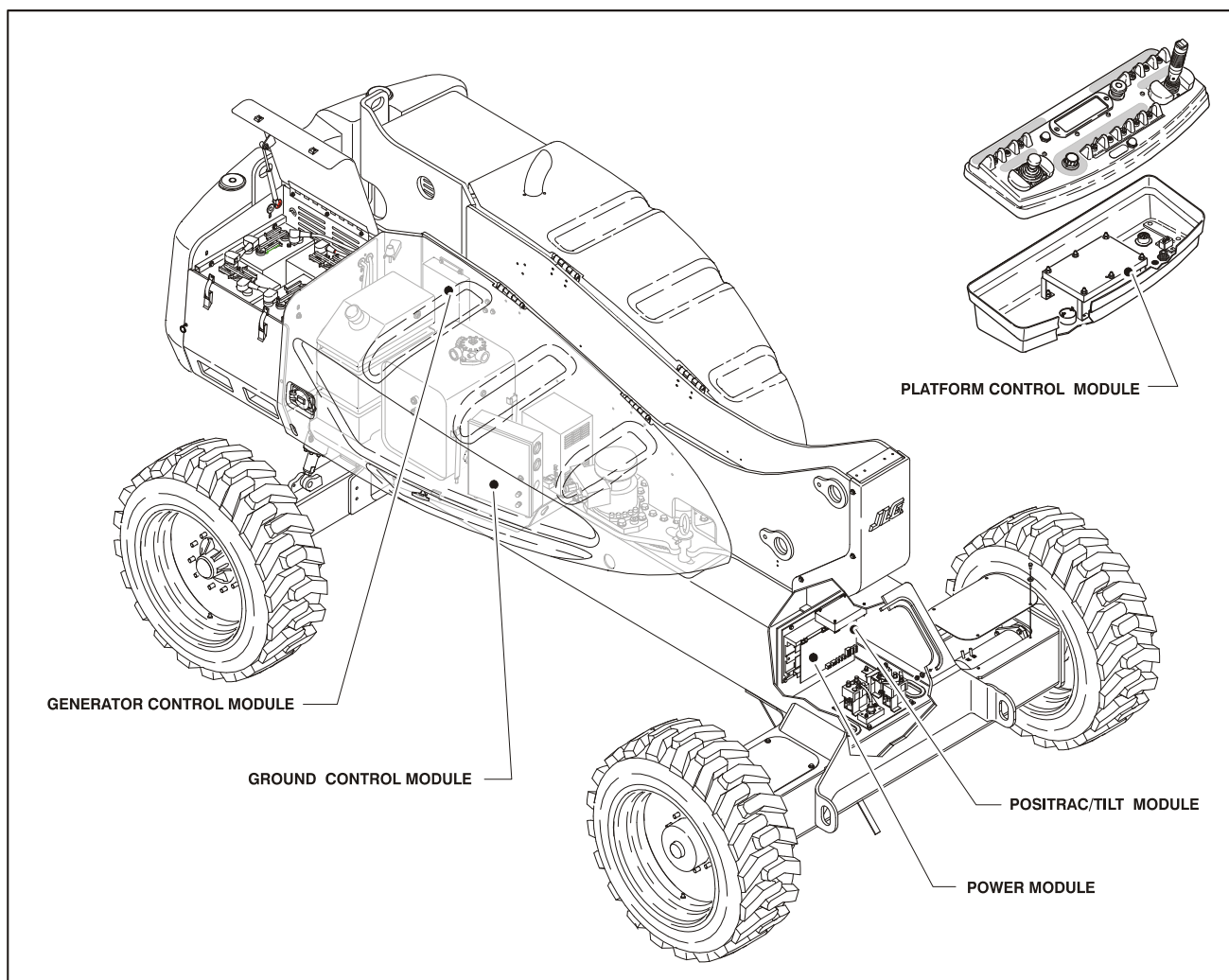


Figure 6-4. Control Module Location

6.2 TO CONNECT THE JLG CONTROL SYSTEM ANALYZER

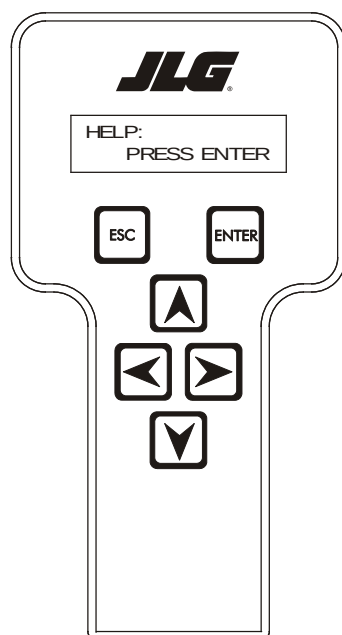
1. Connect the four pin end of the cable supplied with the analyzer, to the motor controller module located in the platform box or at the power module and connect the remaining end of the cable to the analyzer.

NOTE: The cable has a four pin connector at each end of the cable; the cable cannot be connected backwards.

2. Power up the Control System by turning the lower key to the platform or ground position and pulling both emergency stop buttons on.

6.3 USING THE ANALYZER

With the machine power on and the analyzer connected properly, the analyzer will display the following:



**HELP:
PRESS ENTER**

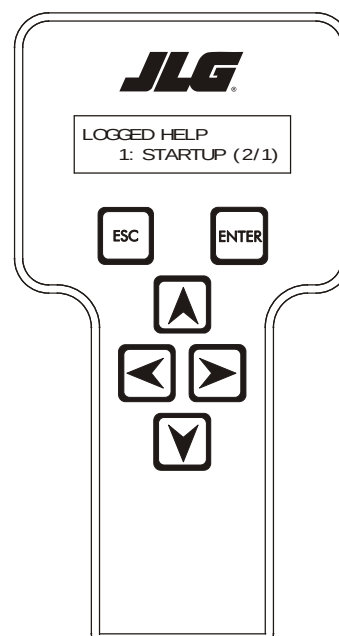
At this point, using the **RIGHT** and **LEFT** arrow keys, you can move between the top level menu items. To select a displayed menu item, press **ENTER**. To cancel a selected menu item, press **ESC**.; then you will be able to scroll using the right and left arrow keys to select a different menu item.

The top level menus are as follows:

HELP
DIAGNOSTICS
ACTIVATE TEST
ACCESS LEVEL
PERSONALITIES
MACHINE SETUP
LEVEL VEHICLE (level 1 only)
CALIBRATIONS (view only)

If you press **ENTER**, at the **HELP: PRESS ENTER** display, and a fault is present, the analyzer display will scroll the fault across the screen. If there was no fault detected, the display will read: **HELP: EVERYTHING OK**. If powered up at the ground station, the display will read: **GROUND OK**.

If **ENTER** is pressed again, the display moves to the following display:



**LOGGED HELP
1: STARTUP (2/1)**

At this point, the analyzer will display the last fault the system has seen, if any are present. You may scroll through the fault logs to view what the last 25 faults were. Use the right and left arrow keys to scroll through the fault logs. To return to the beginning, press **ESC**. two times. **STARTUP (2/1)** indicates a power up.

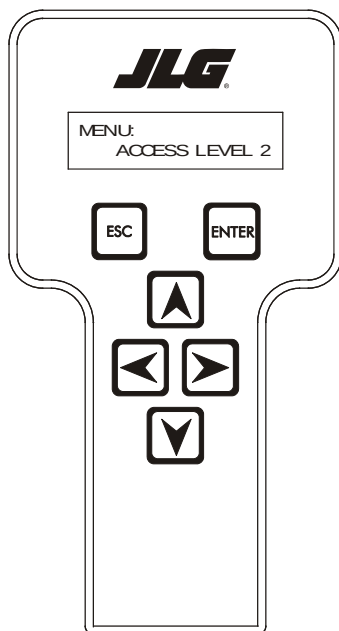
When a top level menu is selected, a new set of menu items may be offered: for example:

DRIVE
BOOM
SYSTEM
DATALOG
VERSIONS

Pressing **ENTER** with any of the above displayed menus, will display additional sub-menus within the selected menu. In some cases, such as **DRIVE**, the next level is the parameter or information to be changed. Refer to the flow chart for what menus are available within the top level menus. You may only view the personality settings for selected menus while in access level 2. Remember, you may always cancel a selected menu item by pressing the **ESC**. key.

6.4 CHANGING THE ACCESS LEVEL OF THE HAND HELD ANALYZER

When the analyzer is first connected, you will be in access level 2 which enables you to only view most settings which cannot be changed until you enter a password to advance to a lower level. This ensures that a setting cannot be accidentally altered. To change the access level, the correct password must be entered. To enter the password, scroll to the **ACCESS LEVEL** menu. For example:



**MENU:
ACCESS LEVEL 2**

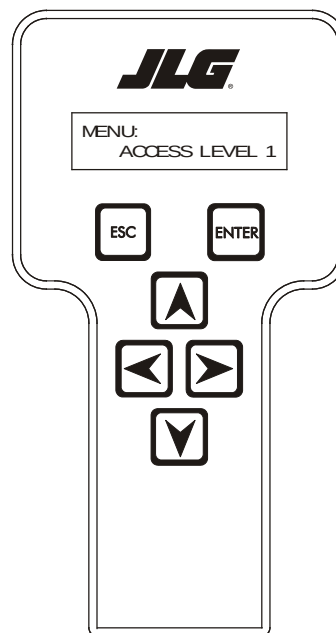
Press **ENTER** to select the **ACCESS LEVEL** menu.

Using the **UP** or **DOWN** arrow keys, enter the first digit of the password, 3.

Then using the **RIGHT** arrow key, position the cursor to the right one space to enter the second digit of the password.

Use the **UP** or **DOWN** arrow key to enter the second digit of the password which is 33271.

Once the correct password is displayed, press **ENTER**. The access level should display the following, if the password was entered correctly:

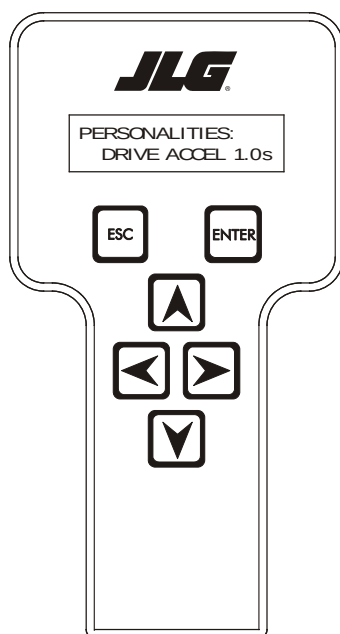


**MENU:
ACCESS LEVEL 1**

Repeat the above steps if the correct access level is not displayed or you can not adjust the personality settings.

6.5 ADJUSTING PARAMETERS USING THE HAND HELD ANALYZER

Once you have gained access to level 1, and a personality item is selected, press the UP or DOWN arrow keys to adjust its value, for example:

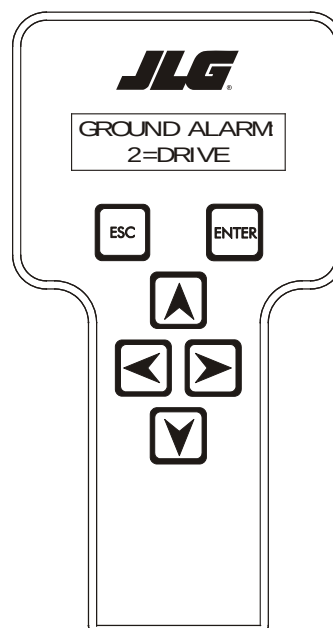


**PERSONALITIES:
DRIVE ACCEL 1.0s**

There will be a minimum and maximum for the value to ensure efficient operation. The Value will not increase if the **UP** arrow is pressed when at the maximum value nor will the value decrease if the **DOWN** arrow is pressed and the value is at the minimum value for any particular personality. If the value does not change when pressing the up and down arrows, check the access level to ensure you are at access level 1.

6.6 MACHINE SETUP

When a machine digit item is selected, press the UP or DOWN arrow keys to adjust its value, for example:



**GROUND ALARM:
2 = DRIVE**

The effect of the machine digit value is displayed along with its value. The above display would be selected if the machine was equipped with a ground alarm and you wanted it to sound when driving. There are certain settings allowed to install optional features or select the machine model.

When selecting the machine model to match the size of the machine, the personality settings will all default to the factory recommended setting.

NOTE: Refer to Table 6-2, Personality Ranges/Defaults, and Table 6-1, Machine Setup Descriptions in this Service Manual for the recommended factory settings.

NOTE: Password 33271 will give you access to level 1, which will permit you to change all machine personality settings.

SECTION 6 - JLG CONTROL SYSTEM

There is a setting that JLG strongly recommends that you do not change. This setting is so noted below:

ELEVATION CUTBACK

WARNING

CHANGING THIS SETTING MAY ADVERSELY AFFECT THE PERFORMANCE OF YOUR MACHINE.

NOTICE

ITS IS A GOOD PRACTICE TO AVOID PRESSURE-WASHING ELECTRICAL/ELECTRONIC COMPONENTS. SHOULD PRESSURE-WASHING BE UTILIZED TO WASH AREAS CONTAINING ELECTRICAL/ELECTRONIC COMPONENTS, JLG INDUSTRIES INC. RECOMMENDS A MAXIMUM PRESSURE OF 750 PSI (52 BAR) AT A MINIMUM DISTANCE OF 12 INCHES (30.5CM) AWAY FROM THESE COMPONENTS. IF ELECTRICAL/ELECTRONIC COMPONENTS ARE SPRAYED, SPRAYING MUST NOT BE DIRECT AND BE FOR BRIEF TIME PERIODS TO AVOID HEAVY SATURATION.

Table 6-1. Machine Setup Descriptions

MODEL NUMBER...	Displays/adjusts machine model NOTE: all personalities reset to default when model number is altered
TILT...	Displays/adjusts tilt sensor function
DRIVE CUTOUT...	Displays/adjusts drive cutout switch presence/ function
FUNCTION CUTOUT...	Displays/adjusts function cutout switch presence/function
JIB. . .	Displays/adjusts jib presence
GROUND ALARM...	Displays/adjusts ground alarm presence/ function
PLATFORM ALARM...	Displays/adjusts platform alarm presence/ function
4WD ASSIST...	Displays/adjusts 4WD assist presence
SOFT TOUCH	Displays/adjusts soft-touch system presence

6.7 MACHINE PERSONALITY SETTINGS

NOTE: Personality settings can be adjusted within the adjustment range in order to achieve optimum machine performance.

Table 6-2. Personality Ranges/Defaults

FUNCTION	PERSONALITY	RANGE	DEFAULTS
DRIVE	ACCEleration	0.5s to 5.0s	1.0
	DECEleration	0.1s to 2.0s	0.5
	MINimum speed	0 to 25%	3
	MAXimum speed	0 to 100%	72
	ELEVATED MAXimum speed	0 to 25%	12
	CREEP MAXimum speed	0 to 45%	30
	POSITRAC time	0 to 60s	10
	POSITRAC current	50-400 A	300A
	4WD MINimum	0 to 50%	20
	4WD MAXimum	0 to 100%	50
	4WD Cutback	0 to 50%	30
LIFT	ACCEleration	0.5 to 5.0	0.7
	DECEleration	0.1 to 3.0	1.0
	MINimum UP speed	0 to 20%	8
	MAXimum UP speed	0 to 100	85
	CREEP Maximum UP speed	0 to 50	25
	MINimum DOWN speed	0 to 10	1
	MAXimum DOWN speed	0 to 100	53
	CREEP maximum DOWN speed	0 to 30	15
SWING	ACCEleration	0.5 to 5.0s	0.7
	DECEleration	0.1 to 3.0s	1.5
	MINimum LEFT speed	0 to 10%	1
	MAXimum LEFT speed	0 to 60%	6
	CREEP maximum LEFT speed	0 to 35%	4
	MINimum RIGHT speed	0 to 10%	1
	MAXimum RIGHT speed	0 to 60%	6
	CREEP maximum RIGHT speed	0 to 35%	4

SECTION 6 - JLG CONTROL SYSTEM

Table 6-2. Personality Ranges/Defaults

FUNCTION	PERSONALITY	RANGE	DEFAULTS
TELEscope	ACCEleration	0.5 to 5.0	0.7
	DECEleration	0.1 to 3.0	0.5
	MINimum IN speed	0 to 20	20
	MAXimum IN speed	0 to 100	50
	MINimum OUT speed	0 to 20	20
	MAXimum OUT speed	0 to 100	55
BASKET LEVEL	ACCEleration	0.5 to 5.0	1.5
	DECEleration	0.1 to 3.0	1.3
	MINimum UP speed	0 to 20	3
	MAXimum UP speed	0 to 50	22
	MINimum DOWN speed	0 to 20	2
	MAXimum DOWN speed	0 to 60	12
BASKET ROTATE	ACCEleration	0.5 to 5.0	2
	DECEleration	0.1 to 3.0	1.5
	MINimum LEFT speed	0 to 15	6
	MAXimum LEFT speed	0 to 100	10
	MINimum RIGHT speed	0 to 15	6
	MAXimum RIGHT speed	0 to 100	10
JIB	Lift ACCEleration	0.5 to 5.0	1.5
	Lift DECEleration	0.1 to 3.0	0.5
	MINimum UP speed	0 to 50	4
	MAXimum UP speed	0 to 100	23
	MINimum DOWN speed	0 to 25	3
	MAXimum DOWN speed	0 to 100	15
	MINimum LEFT speed	0 to 50	17
	MAXimum LEFT speed	0 to 100	30
	MINimum RIGHT speed	0 to 50	17
	MAXimum RIGHT speed	0 to 100	30
STEER	MINimum speed	0 to 100	20
	MAXimum speed	0 to 100	30

Table 6-2. Personality Ranges/Defaults

FUNCTION	PERSONALITY	RANGE	DEFAULTS
GROUND MODE	LIFT UP speed	0 to 100	85
	LIFT DOWN speed	0 to 100	63
	SWING speed	0 to 100	4
	TELEscope speed	0 to 100	60
	BASKET ROTATE speed	0 to 100	10
	BASKET LEVEL speed	0 to 100	8
	JIB LIFT speed	0 to 100	15
	JIB SWING speed	0 to 100	20

4150341-B

6.8 MACHINE CONFIGURATION PROGRAMMING INFORMATION

Table 6-3. Machine Configuration Programming Information

Configuration Digit	Number	Description	Default Number
1 MODEL #	1	E600	1
	2	M600	
2 TILT SENSOR	1	When tilted the tilt light is lit (continuously) and drive speed is reduced to the creep speed setting 5 degree - reduces the maximum speed of all platform functions to creep when tilted and above elevation. Reduces drive speed to creep when tilted. (Domestic/Japan)	1
	2	4 degree - reduces the maximum speed of all platform functions to creep when tilted and above elevation. Reduces drive speed to creep when tilted. (European/Australian)	
	3	4 degree - cuts out drive and reduces boom functions to creep speed when tilted and above elevation. Reduces drive speed to creep when tilted only. (Option)	
	4	3 degree - reduces the maximum speed of all boom functions to creep when tilted and above elevation. Reduces drive speed to creep when tilted. (CE and Australian E600JP, M600JP)	
		NOTE: Any of the selections above will light the tilt lamp when a tilted condition occurs and will sound the platform alarm when the machine is tilted and above elevation.	
3 DRIVE CUTOUT	0	Battery Charger Cutout - cuts out drive when the battery charger is plugged in	0
	1	Battery Charger Cutout and Simultaneous Drive and Boom functions disabled above elevation (European/Australian)	
	2	Battery Charger Cutout and Drive Cutout above elevation (Option)	
4 FUNCTION CUTOFF LIMIT SWITCH	0	0 = No Function Cutout	0
	1	1 = Cuts out all boom functions when switch opens (Option)	
	2	2 = Cuts out all functions when the switch opens (Option)	
5 JIB	0	No jib installed	0
	1	Jib installed which has up and down movements only (Option)	
	2	Jib installed which has up and down movements and side to side movements (Option)	
6 GROUND ALARM	0	No ground alarm installed	0
	1	Travel Alarm - Sounds when the drive function is active (Option)	
	2	Descent Alarm - Sounds when either lift down is active (Option)	
	3	Motion Alarm - Sounds when any function is active (Option)	

Table 6-3. Machine Configuration Programming Information

Configuration Digit	Number	Description	Default Number
7 PLATFORM ALARM	0	Sounds continuously when above elevation and tilted only.	0
	1	Sounds continuously when above elevation and tilted, and in conjunction with fault code flashes (Option)	
8 SOFT TOUCH	0	0= No Soft Touch system installed	0
	1	1 = Soft Touch system installed (Option)	
9 LOAD CELL	0	No Load Cell Installed	0
	1	Warn Only	
	2	Warn & Cutout	
NOTE: The following information is to be used when working with the MACHINE SETUP menu. When configuring the machine, the machine configuration must be completed before any personality settings can be changed. Changing the personality settings first and then changing the model number of the machine configuration will cause the personality settings to return to default values.			
Default settings will be shown in bold type.			

4150342-3

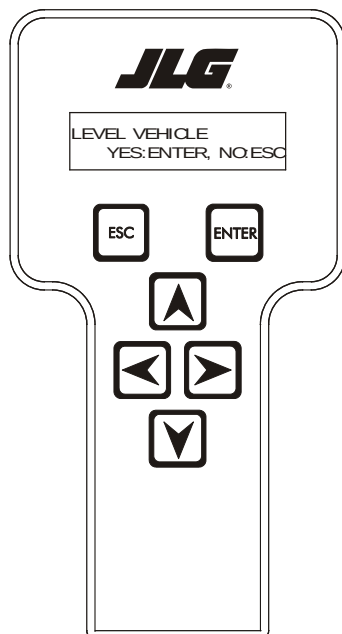
6.9 LEVEL VEHICLE DESCRIPTION

NOTICE

A NEW TILT MODULE WILL ACT AS IF IT IS TILTED ALL OF THE TIME UNTIL THE FOLLOWING PROCEDURE IS PERFORMED.

WARNING

DO NOT LEVEL VEHICLE EXCEPT ON A LEVEL SURFACE.



LEVEL VEHICLE
YES:ENTER, NO:ESC

Not available at password level 2 ENTER confirms that vehicle is currently level, and zeroes the tilt sensor measurements

Help Descriptions and Fault Flash Codes

Table 6-4. JLG Control System Flash Codes

Code	Description
2-1	Faulty Footswitch/EMS
2-2	Drive/Steer inputs/Footswitch Interlocks
2-3	Boom function inputs/Lift-Swing Joystick
2-5	Function Cutout/Drive Cutout
3-1	Contactors miswired/Motors miswired
3-2	Line contactor welded
3-3	Contactor short circuit or valve short circuit
3-5	Brake pressure input
4-2	Controller Overtemperature
4-4	Battery voltage out of range
5-5	Speed Sensor input
6-6	CANbus inputs
7-7	Traction /Pump motor wiring or motor faulty
9-9	Power Module Failure

Table 6-5. Help Descriptions and Fault Flash Codes

Flash Code	Description
No flash code is indicated for the following help messages; they are intended to hint at a possible problem if the vehicle is not behaving as expected.	
	EVERYTHING OK The "normal" help message in platform mode
	GROUND MODE OK The "normal" help message in ground mode
	BATTERY LOW Battery voltage is below 40V. This is a warning – the controller does not shut down (the low battery lamp will light below 45V and flash below 40V.
	BRAKES RELEASED Indicates manual brake release in ground mode
	DRIVING AT CREEP - TILTED Drive speed is limited to creep because the vehicle is tilted.
	FSW OPEN A drive or boom function has been selected but footswitch is open.
	PUMP MOTOR AT CURRENT LIMIT Pump current has reached controller current limit or safe operating area limit.
	RUNNING AT CREEP - CREEP SWITCH OPEN All function speeds are limited to creep because the creep switch is open.
	RUNNING AT CREEP - TILTED & ABOVE ELEVATION All function speeds are limited to creep because the vehicle is tilted and above elevation.
	RUNNING AT CUTBACK - ABOVE ELEVATION Drive speed is limited to cutback because the vehicle is above elevation.
	TESTS ACTIVE - RECYCLE EMS TO END The system tests have been activated; normal vehicle operation is not allowed.
	TILT MODULE FAILURE: BAD TILT SENSOR There is a problem with the tilt sensor in the positilt module; the controller defaults to massively tilted and does not try to prevent vehicle roll on the grade.
	TRACTION MOTOR AT CURRENT LIMIT Traction current has reached controller current limit or safe operating area limit.
2/1	Flash code 2/1 indicates problems with footswitch.
	FSW FAULTY The two footswitch signals do not agree. EMS recycle required.
	STARTUP Neither EMS input is active - the system is just switching on or is discharging the capacitor bank. A welded line contactor might also cause this.

SECTION 6 - JLG CONTROL SYSTEM

Table 6-5. Help Descriptions and Fault Flash Codes

2/2	Flash code 2/2 indicates problems with drive & steer selection.
	DRIVE JOYSTICK FAULTY The drive joystick center tap is out of valid range, or the wiper is wire-off.
	DRIVE LOCKED - JOYSTICK MOVED BEFORE EMS/FSW Drive was selected before and during footswitch closure or at EMS switch-on.
	FSW INTERLOCK TRIPPED Footswitch was closed for seven seconds with no function selected.
	STEER LOCKED - SELECTED BEFORE EMS/FSW Steer was selected before and during footswitch closure or at EMS switch-on.
	STEER SWITCHES FAULTY Both steer switches are active together.
	WAITING FOR FSW TO BE OPEN Footswitch was closed when platform mode was selected.
	4WD ASSIST DISABLED-NOT AVAILABLE WITH BOOM 4WD Assist has been selected and is not available due to a boom function being operated at the same time.
	JOYSTICK FAULTS - CHECK PLATFORM BOX WIRING There are drive, lift, or swing joystick faults but the exact cause cannot be determined (a short-circuit of any one joystick or the pump pot could cause this).
2/3	Flash code 2/3 indicates problems with boom function selection.
	LIFT/SWING JOYSTICK FAULTY The lift or swing joystick center tap is out of valid range, or the wiper is wire-off.
	LIFT/SWING LOCKED - JOYSTICK MOVED BEFORE EMS/FSW Platform upper lift or swing was selected before and during footswitch closure.
	PUMP POT FAULTY The pump pot is open-circuit; all platform boom functions except upper lift & swing will run at creep.
	PUMP SWITCHES FAULTY - CHECK DIAGNOSTICS/BOOM A boom function (telescope, basket level, basket rotate, jib) has both directions selected together.
	PUMP SWITCHES LOCKED - SELECTED BEFORE EMS/FSW A boom function (telescope, basket level, basket rotate, jib) was selected before keyswitch or footswitch closure.
	PUMP SWITCHED LOCKED - SELECTED BEFORE EMS A ground boom function (telescope, basket level, basket rotate, jib) was selected before keyswitch.
	SWING/LIFT JOYSTICK FAULTY The swing joystick center tap is out of valid range, or the wiper is wire-off.

Table 6-5. Help Descriptions and Fault Flash Codes

2/5	Flash code 2/5 indicates that a function is prevented due to a cutout.
	BOOM PREVENTED - DRIVE SELECTED A boom function is selected while a drive function is selected and drive cutout is configured to prevent simultaneous drive & boom operation.
	BOOM PREVENTED - FUNCTION CUTOUT ACTIVE A boom function is selected while function cutout is active and configured to cutout boom functions.
	DRIVE & BOOM PREVENTED - FUNCTION CUTOUT ACTIVE Drive or a boom function is selected while function cutout is active and configured to cutout all functions.
	DRIVE PREVENTED - ABOVE ELEVATION Drive is selected while above elevation and drive cutout is configured to prevent drive.
	DRIVE PREVENTED - BOOM MOVEMENT SELECTED Drive is selected while a boom function is selected and drive cutout is configured to prevent simultaneous drive & boom operation.
	DRIVE PREVENTED - CHARGER CONNECTED Drive is selected while the charger is on (indicated by drive cutout being active) and drive cutout is configured to prevent drive.
	DRIVE PREVENTED - TILTED & ABOVE ELEVATION Drive is selected while tilted and above elevation and tilt is configured to cutout drive.
3/1	Flash code 3/1 indicates that a contactor did not close when energized.
	LINE & DIRECTION CONTACTORS MISWIRED When the line contactor was closed traction point A went high (and the capacitor bank charge did not increase to battery supply) - this occurs if the line contactor coil wiring is swapped with that for a direction contactor coil.
	OPEN-CIRCUIT FORWARD CONTACTOR OR TRACTION MOTOR Traction point A did not go high when forward contactor was energized (this could be due to traction motor open-circuit or a power wiring error).
	OPEN-CIRCUIT LINE CONTACTOR The capacitor bank charge did not increase to battery supply when line contactor was energized (this could be due to a power wiring error).
	OPEN-CIRCUIT REVERSE CONTACTOR OR TRACTION MOTOR Traction point A did not go high when reverse contactor was energized (this could be due to traction motor open-circuit or a power wiring error).
3/2	Flash code 3/2 indicates that a contactor did not open when deenergized.
	WELDED LINE CONTACTOR The capacitor bank charge did not decrease from battery supply when line contactor was deenergized (this could be due to a power wiring error). WARNING: If the line contactor is welded, the controller will not switch off when EMS or keyswitch is turned off.

Table 6-5. Help Descriptions and Fault Flash Codes

3/3	Flash code 3/3 indicates that a contactor coil is short-circuit.
	OVERLOADED VALVE SUPPLY-CHECK WIRING There is a high current draw from the valve supply when no valve is energized; this is probably due to a wiring error at the ground module.
	SHORT-CIRCUIT FORWARD CONTACTOR COIL The forward contactor was not energized when required, due to coil overcurrent protection.
	SHORT-CIRCUIT LINE CONTACTOR COIL The line contactor was not energized when required, due to coil overcurrent protection.
	SHORT-CIRCUIT REVERSE CONTACTOR COIL The reverse contactor was not energized when required, due to coil overcurrent protection.
3/5	Flash code 3/5 indicates that there is a brake pressure problem.
	BRAKES DID NOT LOCK Brake pressure did not clear when the brake valve was deenergized.
	BRAKES DID NOT RELEASE No brake pressure was detected when running the pump motor and energizing the brake valve and steer speed valve.
4/2	Flash code 4/2 indicates that the controller is overtemperature.
	SYSTEM TOO HOT - PLEASE WAIT The controller heatsink temperature reached 75 degrees. The controller is shut down until it cools to below 70 degrees.
4/4	Flash code 4/4 indicates problems with the battery supply.
	BATTERY LOW Battery voltage is below 40V. This is a warning - the controller does not shut down.
	BATTERY TOO HIGH - SYSTEM SHUT DOWN Battery voltage is above 62V. EMS recycle required.
	BATTERY TOO LOW - SYSTEM SHUT DOWN Battery voltage is below 33V. EMS recycle required.

Table 6-5. Help Descriptions and Fault Flash Codes

5/5	Flash code 5/5 indicates problems with vehicle speed or the encoder.
	NO VEHICLE MOVEMENT DETECTED AT MAXIMUM POWER No speed was measured with traction motor full on. This could be due to a traction motor fault, a power wiring error, a speed encoder fault, the brakes not releasing (although brake pressure is OK) or the vehicle being overloaded so that the motor cannot turn the wheels.
	DRIVE PREVENTED - BOTH SPEED ENCODERS FAULTY Both speed encoder input voltages are out of range.
	LEFT SPEED ENCODER FAULTY The speed encoder on the left wheel (connected to the positilt module) has a short-circuit or open-circuit fault; drive is still possible at creep speed (automatic positrac is disabled).
	RIGHT SPEED ENCODER FAULTY The speed encoder on the right wheel (connected to the power module) has a short-circuit or open-circuit fault; drive is still possible at creep speed (automatic positrac is disabled).
	SPEED ENCODERS READING INVALID SPEED One or both speed encoders is indicating an impossible number of pulses. This is probably due to a faulty speed encoder.
	TILT MODULE FAILURE: NOT COMMUNICATING No information is being received from the positilt module (it may be miswired); the system will drive at creep speed using the speed encoder connected to the power module; the controller defaults to massively tilted and does not try to prevent vehicle roll on the grade.
	VEHICLE RUNAWAY - CHECK SPEED ENCODERS Speed in the wrong direction was measured with traction motor full on. This is probably due to the speed encoder being fitted incorrectly; it could also be due to a speed encoder fault or faults as for "NO VEHICLE MOVEMENT DETECTED" with the vehicle on a grade.
6/6	Flash code 6/6 indicates problems with the CANbus.
	48V PROTECTION TRIPPED - CHECK INTER-MODULE WIRING The power module is not receiving acknowledgements from the platform, ground modules, or positilt modules to transmitted data, and the protection circuit which supplies the platform, ground, and positilt modules has tripped. This is probably due to wiring problems at the platform, ground, or positilt module.
	CANbus FAILURE: GROUND MODULE The power module is receiving from the platform module but not the ground module. This should not be possible!
	CANbus FAILURE: PLATFORM MODULE The power module is receiving from the ground module but not the platform module. This is probably due to wiring problems between the platform and ground modules.
	CANbus FAILURE: POWER MODULE The power module is not receiving acknowledgments from the platform, ground, or positilt modules to transmitted data. This is probably due to wiring problems between the power and positilt modules.
	GROUND MODULE FAILURE: OBSOLETE ON THIS VEHICLE The ground module is an old design which is incompatible with the E600 vehicle; it must be replaced (it can be used on E300/M45/E45 vehicles).

Table 6-5. Help Descriptions and Fault Flash Codes

7/7	Flash code 7/7 indicates problems with a motor.
	CAPACITOR BANK FAULT - CHECK POWER/MOTOR WIRING The capacitor bank is not charging. This is probably due to a motor or power wiring error causing illegal current drain; it could also be due to a very low battery supply.
	OPEN-CIRCUIT PUMP MOTOR Pump point A is collapsing when the pump MOSFETs are pulsed. This is probably due to an open circuit pump motor or a power wiring error. WARNING: If the power wiring between the power module & contactor panel is wrong, this fault can occur – any attempt to operate the vehicle could damage the power module.
	OPEN-CIRCUIT DIRECTION CONTACTOR OR TRACTION MOTOR Traction point A is collapsing when the traction MOSFETs are pulsed. This is probably due to an open circuit traction motor or directional contactor or wiring error. NOTE: This fault is unlikely to be seen due to interaction with speed control ...
	PUMP POINT A LOW - CHECK POWER / MOTOR WIRING Pump point A is near 0V when the pump MOSFETs are off. This is probably due to a motor or power wiring error.
	STALLED TRACTION MOTOR The power module traction MOSFET protection circuit is active. This is due to massive current drain and could be a stalled traction motor or a power wiring error.
7/7	Flash code 7/7 indicates problems with a motor (continued).
	STALLED PUMP MOTOR The power module pump MOSFET protection circuit is active. This is due to massive current drain and could be a stalled pump motor or a power wiring error.
	TRACTION MOTOR OVERLOADED The traction motor is drawing Excessive current for an extended period of time; the system shuts down to prevent destruction of the motor or power module.
	PUMP MOTOR OVERLOADED The pump motor has been operating in current limit at a low percentage on for a period of time greater than 10 seconds
	TRACTION CURRENT AT ZERO - CHECK SHUNT WIRING Traction current measurement is at zero. This is probably due to an open-circuit between the current measurement shunt and the power module.
	TRACTION POINT A HIGH - CHECK POWER / MOTOR WIRING Traction point A is near battery supply when neither direction contactor is energized and the traction MOSFETs are off. This could be due to a welded direction contactor or a power wiring error.
	TRACTION POINT A LOW - CHECK POWER / MOTOR WIRING Traction point A is near 0V when neither direction contactor is energized and the traction MOSFETs are off. This could be due to a power wiring error.

Table 6-5. Help Descriptions and Fault Flash Codes

9/9	Flash code 9/9 indicates problems with the controller.
	POWER MODULE FAILURE: CONTACTOR DRIVE CODE 1 A contactor remained energized when turned off.
	POWER MODULE FAILURE: HWFS CODE 2 The hardware fail-safe tests did not complete because traction point A is not safe, or the hardware fail-safe is permanently tripped.
	POWER MODULE FAILURE: HWFS CODE 3 The hardware fail-safe tests did not complete because a contactor was energized when all should be turned off.
	POWER MODULE FAILURE: HWFS CODE 4 The hardware fail-safe tests did not complete because the hardware fail-safe tripped immediately when the traction MOSFETs were turned on.
	POWER MODULE FAILURE: HWFS CODE 10 The hardware fail-safe tests failed because the hardware fail-safe did not trip within the allowed test time.
	POWER MODULE FAILURE: HWFS CODE 11 The hardware fail-safe tests failed because the hardware fail-safe tripped too slowly.
	POWER MODULE FAILURE: HWFS CODE 12 The hardware fail-safe tests failed because the hardware fail-safe tripped too quickly.
9/9	Flash code 9/9 indicates problems with the controller. (continued)
	POWER MODULE FAILURE: HWFS CODE 13 The hardware fail-safe tests failed because the hardware fail-safe remained tripped when the traction MOSFETs were turned off.
	POWER MODULE FAILURE: HWFS CODE 14 The hardware fail-safe tests failed because the line contactor could still be energized when the hardware fail-safe was tripped.
	POWER MODULE FAILURE: HWFS CODE 15 The hardware fail-safe tests failed because the contactor drive fail-safe did not trip within the allowed test time.
	POWER MODULE FAILURE: HWFS CODE 16 The hardware fail-safe tests failed because the contactor drive fail-safe tripped too slowly.
	POWER MODULE FAILURE: HWFS CODE 17 The hardware fail-safe tests failed because the contactor drive fail-safe tripped too quickly.
	POWER MODULE FAILURE: HWFS TEST STALLED The hardware fail-safe tests did not complete, but no reason can be determined.
	POWER MODULE FAILURE: BAD TEMPERATURE SENSOR The temperature sensor measurement is invalid; this is probably due to a disconnected wire within the power module. The possibility of other disconnected wires (which could cause dangerous system function) means that the controller is shut down.
	POWER MODULE FAILURE: S/C LINE CONTACTOR DRIVER The line contactor energized when the footswitch was closed, before it was turned on; this is probably due to a failed driver within the power module, although it could be due to bad power module wiring.

6.10 ANALYZER DIAGNOSTICS MENU STRUCTURE

In the following structure descriptions, an intended item is selected by pressing ENTER; pressing ESC steps back to

the next outer level. The LEFT/RIGHT arrow keys move between items in the same level. The UP/DOWN arrow keys alter a value if allowed

Table 6-6. ADJUSTMENTS - Personality Descriptions

DRIVE	
ACCEL ...	Displays/adjusts drive acceleration
DECEL ...	Displays/adjusts drive deceleration
MIN ...	Displays/adjusts minimum drive speed
MAX ...	Displays/adjusts maximum drive speed
ELEVATED MAX ...	Displays/adjusts maximum drive speed NOTE: used when elevation cutout switches are limiting maximum speed
CREEP MAX ...	Displays/adjusts maximum drive speed NOTE: used when creep switch on pump pot is active
TRACTION ...	Displays/adjusts the amount of time traction control is enabled after each input activation
POSITRAC ...	Displays/adjusts the maximum traction motor current at which positrac will activate
4WD MIN ...	Displays/adjusts the minimum 4WD assist speed
4WD MAX ...	Displays/adjusts the maximum 4WD assist speed
4WD CUTBACK ...	Displays/adjusts the maximum 4WD assist speed NOTE: used when elevation cutout switches are limiting maximum speed
LIFT	
ACCEL ...	Displays/adjusts upper lift acceleration
DECEL ...	Displays/adjusts upper lift deceleration
MIN UP ...	Displays/adjusts minimum upper lift up speed
MAX UP ...	Displays/adjusts maximum upper lift up speed
CREEP UP ...	Displays/adjusts maximum upper lift up speed NOTE: used when creep switch on pump pot is active
MIN DOWN ...	Displays/adjusts minimum upper lift down speed
MAX DOWN ...	Displays/adjusts maximum upper lift down speed
CREEP DOWN ...	Displays/adjusts maximum upper lift down speed NOTE: used when creep switch on pump pot is active
SWING	
ACCEL ...	Displays/adjusts swing acceleration
DECEL ...	Displays/adjusts swing deceleration
MIN LEFT ...	Displays/adjusts minimum swing left speed
MAX LEFT ...	Displays/adjusts maximum swing left speed

Table 6-6. ADJUSTMENTS - Personality Descriptions

CREEP LEFT ...	Displays/adjusts maximum swing left speed NOTE: used when creep switch on pump pot is active
MIN RIGHT ...	Displays/adjusts minimum swing right speed
MAX RIGHT ...	Displays/adjusts maximum swing right speed
CREEP RIGHT ...	Displays/adjusts maximum swing right speed NOTE: used when creep switch on pump pot is active
TELE	
ACCEL ...	Displays/adjusts telescope acceleration
DECEL ...	Displays/adjusts telescope deceleration
MIN IN ...	Displays/adjusts minimum telescope in speed
MAX IN ...	Displays/adjusts maximum telescope in speed
MIN OUT ...	Displays/adjusts minimum telescope out speed
MAX OUT ...	Displays/adjusts maximum telescope out speed
BASKET LEVEL	
ACCEL ...	Displays/adjusts basket level acceleration
DECEL ...	Displays/adjusts basket level deceleration
MIN UP ...	Displays/adjusts minimum basket level up speed
MAX UP ...	Displays/adjusts maximum basket level up speed
MIN DOWN ...	Displays/adjusts minimum basket level down speed
MAX DOWN ...	Displays/adjusts maximum basket level down speed
BASKET ROTATE	
ACCEL ...	Displays/adjusts basket rotate acceleration
DECEL ...	Displays/adjusts basket rotate deceleration
MIN LEFT ...	Displays/adjusts minimum basket rotate left speed
MAX LEFT ...	Displays/adjusts maximum basket rotate left speed
MIN RIGHT ...	Displays/adjusts minimum basket rotate right speed
MAX RIGHT ...	Displays/adjusts maximum basket rotate right speed
JIB	Not displayed if JIB = NO
ACCEL ...	Displays/adjusts jib acceleration
DECEL ...	Displays/adjusts jib deceleration
MIN UP ...	Displays/adjusts minimum jib up speed
MAX UP ...	Displays/adjusts maximum jib up speed
MIN DOWN ...	Displays/adjusts minimum jib down speed

Table 6-6. ADJUSTMENTS - Personality Descriptions

MAX DOWN ...	Displays/adjusts maximum jib down speed
MIN LEFT ...	Displays/adjusts minimum jib left speed
MAX LEFT ...	Displays/adjusts maximum jib left speed
MIN RIGHT ...	Displays/adjusts minimum jib right speed
MAX RIGHT ...	Displays/adjusts maximum jib right speed
STEER	
MIN SPEED ...	Displays/adjusts minimum steer speed, which applies when vehicle speed is at maximum
MAX SPEED ...	Displays/adjusts maximum steer speed, which applies when vehicle speed is at minimum
GROUND MODE	
LIFT UP ...	Displays/adjusts fixed lift up speed
LIFT DOWN ...	Displays/adjusts fixed lift down speed
SWING ...	Displays/adjusts fixed swing speed
TELE ...	Displays/adjusts fixed telescope speed
BASKETLEVEL ...	Displays/adjusts fixed basket level speed
BASKETROTATE ...	Displays/adjusts fixed basket rotate speed
JIB (U/D) ...	Displays/adjusts jib lift speed Not displayed if JIB = NO
JIB (L/R)...	Displays/adjusts jib swing speed Not displayed if JIB = NO

Table 6-7. Diagnostic Menu Descriptions

DRIVE	
DRIVE ...	Displays drive joystick direction & demand
SPEED ...	Displays vehicle direction & speed
4WD ...	Displays 4WD status NOTE: Not Displayed when 4WD ASSIST = NO
POSITRAC ...	Displays positrac status
STEER ...	Displays steer switch direction & demand NOTE: steer demand is inversely proportional to vehicle speed
BRAKES ...	Displays brake control system status
CREEP ...	Displays pump pot creep switch status
BOOM	
LIFT ...	Displays lift joystick direction & demand
SWING ...	Displays swing joystick direction & demand
LEVEL ...	Displays basket level switch direction & demand NOTE: demand is controlled by the pump pot
TELE ...	Displays telescope switch direction & demand NOTE: demand is controlled by the pump pot
ROTATE ...	Displays basket rotate switch direction & demand NOTE: demand is controlled by the pump pot
JIB (U/D) ...	Displays jib lift switch direction & demand NOTE: demand is controlled by the pump pot Not displayed if JIB = NO
JIB (L/R) ...	Displays jib swing switch direction & demand NOTE: demand is controlled by the pump pot Not displayed if JIB = NO
PUMP POT ...	Displays pump pot demand
CREEP ...	Displays pump pot creep switch status
SYSTEM	
TRACTION ...	Displays measured traction motor current
PUMP ...	Displays measured pump motor current
VALVE ...	Displays measured valve (12V supply) current NOTE: this includes current for the ground alarm & hourmeter, but not for any lamps
BATTERY ...	Displays measured battery voltage
TEMPERATURE ...	Displays measured heatsink temperature

Table 6-7. Diagnostic Menu Descriptions

FSW1 ...	Displays footswitch status NOTE: FSW1 is wired to the power module
FSW2 ...	Displays footswitch status NOTE: FSW2 is wired to the platform module
DRIVE CUTOUT ...	Displays drive cutout switch status
ELEV. CUTOUT ...	Displays elevation cutout switch status
FUNC. CUTOUT ...	Displays function cutout switch status
BRAKES ...	Displays brake pressure switch status
MAN.RELEASE ...	Displays manual brake release switch status
TILT ...	Displays measured vehicle tilt The first value indicates tilt in the forward/ reverse direction (pitch) The second value indicates tilt in the left/ right direction (roll)
DATALOG	
MAX.TEMP ...	Displays maximum measured heatsink temp.
MIN.TEMP ...	Displays minimum measured heatsink temp.
MAX.BATTERY ...	Displays maximum measured battery voltage
ON ...	Displays total controller on (EMS) time
DRIVE ...	Displays total controller drive operation time
PUMP ...	Displays total controller pump running time NOTE: includes all boom functions, steer and brake release
LIFT ...	Displays total controller lift operation time
SWING ...	Displays total controller swing operation time
TELE ...	Displays total controller tele operation time
RENTAL ...	Displays total controller operation time NOTE: can be reset
ERASE RENTAL	Not available at password level 2
YES:ENTER, NO:ESC	ENTER resets rental datalog time to zero
VERSIONS	
POWER ...	Displays power module software version
PLATFORM	Displays platform module software version
GROUND	Displays ground module software version
POSITILT	Displays positrac/tilt module software version
ANALYSER ...	Displays Analyzer software version

Table 6-8. Calibration Descriptions

CALIBRATIONS	Not available at password level 2; can be viewed but not changed at level 1
CONTROLLER CALS	
TEMPERATURE ...	Displays/adjusts heatsink temperature calibration The setting should not be altered from that set during manufacture
TRACTION I ...	Displays/adjusts traction motor current calibration The setting should not be altered from that set during manufacture
PUMP I ...	Displays/adjusts pump motor current calibration The setting should not be altered from that set during manufacture
TILTdelayIN ...	Displays/adjusts how long the tilt sensor must indicate a tilted condition before it is registered The setting should be adjusted to optimize controller response to a sudden tilt, while minimizing spurious tilt indications during acceleration & deceleration
TILTdelayOUT ...	Displays/adjusts how long the tilt sensor must indicate a not-tilted condition before it is registered The setting should be adjusted to optimize controller response to a sudden tilt, while minimizing spurious tilt indications during acceleration & deceleration
MACHINE CALS	
BRAKE	Displays/adjusts brake release speed The setting should be adjusted to release the brakes in the desired time, with minimal effect on other boom functions
PUMP@0%	Displays/adjusts minimum pump%on The setting should be adjusted to minimize speed variations when functions are used individually and in combinations
PUMP@100%	Displays/adjusts maximum pump%on The setting should be adjusted to minimize speed variations when functions are used individually and in combinations
Vflow@0%	Displays/adjusts minimum flow control proportional valve%on
Vflow@100%	Displays/adjusts maximum flow control proportional valve%on
Vlift@0%	Displays/adjusts minimum lift proportional valve%on
Vlift@100%	Displays/adjusts maximum lift proportional valve%on
Vswing@0%	Displays/adjusts minimum swing proportional valve%on
Vswing@100%	Displays/adjusts maximum swing proportional valve%on
SPEEDprop1 ...	Displays/adjusts speed control PID algorithm proportional term in traction mode The setting should be adjusted to optimize speed control
SPEEDprop2 ...	Displays/adjusts speed control PID algorithm proportional term in plugging mode The setting should be adjusted to optimize speed control
SPEEDint ...	Displays/adjusts speed control PID algorithm integral term in traction & plugging mode The setting should be adjusted to optimize speed control
PLUGmax ...	Displays/adjusts maximum plugging current The setting should be adjusted to ensure that the vehicle can be safely stopped when being driven down maximum grade

Table 6-9. Calibration Ranges/Defaults

Calibration	Range	Defaults	
		E600	M600
BRAKE	0 to 100	25	
PUMP@0%	0 to 50	6	
PUMP@100%	50 to 100	100	
FLOW VALVE@0%	0 to 50	44	
FLOW VALVE@100%	50 to 100	60	
LIFT VALVE@0%	0 to 100	40	
LIFT VALVE@100%	0 to 100	70	
SWING VALVE@0%	0 to 100	45	
SWING VALVE@100%	0 to 100	52	
TEMPERATURE	0 to 100	50	
TRACTION I	0.50 to 2.00	1.00	
PUMP I	0.50 to 2.00	1.00	
SPEEDprop1	0 to 30	8	
SPEEDprop2	0 to 30	16	
SPEEDint	0.0 to 2.5	0.3	
PLUGmax	30 to 100	75	
TILTdelayIN*	0.0 to 5.0	1.0	
TILTdelayOUT*	0.0 to 5.0	0.1	

*NOTE: TiltDelayIN and TILTdelayOUT are adjusted in internal units, not in 0.1 s increments.

6.11 SYSTEM SELF TEST

The system self test is utilized to locate typical problems. See Table 6-10, System Test Descriptions and Table 6-11, System Test Messages for information concerning the tests performed and available messages in this mode.

1. When the keyswitch is in the platform position and the self test enabled, the self test function will test all valves, contactors, platform inputs, indicator lamps, and system alarms for various fault conditions.

When the keyswitch is in the ground position, the self test function will test all valves, the line contactor, ground control inputs, and the ground alarm output for various fault conditions.

2. In order to test the inputs on the machine, the controller will ask the service technician to perform various tasks at the appropriate operator control station. An example of this is "Close LLU Switch". The controller expects the operator to close the lower lift up switch. When the controller sees that the lower lift up

switch has been closed, it will move on to the next input, lower lift down LLD. If the switch is faulty or the wiring is faulty, the controller will not move on to the next input. The controller will continue to wait for the closure of the input. If the operator knows the switch is faulty and wants to continue the tests he must simply press the enter key on the analyzer to continue.

3. After the controller has conducted the tests from the chosen operator station, it will display "TESTS COMPLETE". This indicates that the controller has checked all inputs and outputs for that station.

NOTICE

IN ORDER FOR THE MACHINE TO FUNCTION AFTER THE SELF TEST IS COMPLETE, POWER MUST BE RECYCLED USING THE EMS OR THE KEYSWITCH.

Table 6-10. System Test Descriptions

ACTIVATE TESTS	Not available once tests are activated
YES:ENTER, NO:ESC	ENTER activates system tests NOTE: cannot be done while controller is in use (footswitch closed) and for a short time afterwards
RUN SYSTEM TEST	ENTER starts system test Not available until tests are activated
...	Displays messages while system test runs Some messages are prompts, requiring user intervention. ENTER can be pressed if a fault is found, to confirm that the fault has been noted and to continue the system test. NOTE: a flashing message is critical, and prevents the system test running

Table 6-11. System Test Messages

RUNNING	Initial display when system test is run; certain “critical” checks are made. Problems which can be reported include: ONLY 1 ANALYZER! Do not connect two Analyzers while running the system test. BAD POWER WIRING The capacitor bank is not charged or pump point A is low or traction point A is high or low. Check all power wiring. LINE CONT WELDED The capacitor bank is at battery voltage. Check line contactor. Check all power wiring. BATTERY TOO LOW The system test cannot run with battery voltage below minimum. BATTERY TOO HIGH The system test cannot run with battery voltage above maximum. CHECK CAN WIRING The system test can’t run in platform mode unless data is being received from the platform, ground & positrac/tilt modules. The system test cannot run in ground mode unless data is being received from the ground and positrac/tilt modules. CHECK LEFT SPD. There is an open- or short- circuit in the left speed encoder wiring. Check left speed encoder. CHECK RIGHT SPD. There is an open- or short- circuit in the right speed encoder wiring. Check right speed encoder. CHECK SHUNT The traction current measurement is open-circuit. Check wiring between power module and contactor panel. BAD PUMP WIRING Pump point A is not high, probably caused by an open-circuit pump motor or wiring. Check all power wiring. Check pump motor. BAD POWER MODULE An internal problem was detected in the power module. BAD POWER WIRING Traction point A is high, probably caused by incorrect traction motor wiring. Check all power wiring. Check traction motor. HIGH TILT ANGLE The vehicle is very tilted, or the tilt sensor has been damaged. Check tilt sensor. HOT POWER MODULE The heatsink temperature exceeds 75°C; this is only a warning. BAD I/O PORTS The controller detected a problem with its internal circuits at switchon. If other problems are also detected, the controller may need replacing. SUSPECT EEPROM The controller detected a problem with its EEPROM stored personality settings at switch on. Check and, if necessary correct, all personality settings. WAIT:CAPBANK HI This message can be displayed if the system test is run shortly after the vehicle was used; after a short wait, it should clear. OPEN FSW In platform mode, the footswitch must be open at the start of the test. CLOSE FSW In platform mode, the footswitch must be closed when this message is displayed; the footswitch MUST BE KEPT CLOSED during the valve & contactor tests. BAD FSW The two footswitch signals are not changing together, probably because one is open-circuit. One footswitch signal (“FSW1”) is routed to the power module, the other (“FSW2”) is routed to the platform module. Check footswitch & wiring.
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Table 6-11. System Test Messages

TESTING VALVES	Indicates that the valve test is beginning. Each valve is alternately energized and de-energized; checks are made for open- and short- circuit valve coils. NOTE: in platform mode, the footswitch must be closed. NOTE: jib valves are not tested if JIB = NO NOTE: left/right jib valves are not tested unless JIB = SIDESWING. Problems which can be reported include: CANT TEST VALVES There is a wiring problem which prevents the valve test from functioning correctly. Check valve wiring. Check ground alarm & hourmeter wiring. valvename S/C The named valve is drawing too much current so is presumed to be short-circuit. Check valve wiring. valvename O/C The named valve is drawing too little current so is presumed to be open-circuit. Check valve wiring.
VALVE TEST DONE	Indicates that the valve test is complete (with or without faults).
TESTING CONTS	Indicates that the contactor test is beginning. In platform mode, the forward & reverse direction contactors are energized and de-energized; checks are made that they close & open correctly and for short-circuit coils. In platform and ground mode, the line contactor is energized and de-energized; checks are made that it closed & opened correctly and for a short-circuit coil. In platform mode, the positrac contactors are energized and de-energized; checks are made for short-circuit and open-circuit coils. Problems which can be reported include: CANT TEST CONTS There is a wiring problem which prevents the contactor test from functioning correctly. Check power wiring. Check contactor wiring. BAD CONT WIRING There is a wiring problem which caused the capacitor bank to be charged when a direction contactor was energized; probably the wiring to the contactor coils is incorrect. Check contactor wiring. Check power wiring. contname WELDED The named contactor appears to have not opened. Check named contactor. Check power wiring. contname COIL O/C The named contactor coil did not load its driver circuit so is presumed to be open-circuit. Check contactor wiring. contname COIL S/C The named contactor coil overloaded its driver circuit so is presumed to be short-circuit. Check contactor wiring. contname DIDNT CLOSE The named contactor appears to have not closed. Check contactor wiring. Check power wiring.
CONT TEST DONE	Indicates that the contactor test is complete (with or without faults).

Table 6-11. System Test Messages

CHECKING INPUTS	Indicates that the inputs test is beginning. Every input is checked to ensure that it is in its “normal” position; function switches should be open, cutout switches should be closed, joysticks should be in neutral. In platform mode any non-neutral platform switch or joystick is reported; any active cutouts are reported. In ground mode any non-neutral ground switches is reported; any active cutouts are reported. NOTE: switches which are not in use (due to the settings of machine digits) are not checked. NOTE: the pump pot is checked only for a wire-off condition; it can be at any demand from creep to maximum. Problems which can be reported include: CHECK switchname The named switch is not in its “normal” position. Check switch & wiring. CHECK switchname JOY. The named joystick appears to be faulty. Check joystick.
INPUTS DONE	Indicates that the inputs test is complete (with or without faults).
TESTING LAMPS	Indicates that the lamps test is beginning. Each lamp is energized in turn; a prompt asks for confirmation that the lamp is lit - ENTER must be pressed to continue the test. NOTE: lamps which are not in use (due to the settings of machine digits) are not checked. NOTE: lamps are only tested in platform mode. Problems which can be reported include: lampname S/C A short-circuit condition appeared while the named lamp was being tested, presumably because it is short-circuit.
LAMP TEST DONE	Indicates that the lamps test is complete.
TESTING ALARMS	Indicates that the alarms test is beginning. Each alarm is energized in turn; a prompt asks for confirmation that the alarm is sounding - ENTER must be pressed to continue the test. NOTE: the platform alarm is only tested in platform mode. NOTE: the ground alarm is not tested if GROUND ALARM = NO. Problems which can be reported include: alarmname S/C A short-circuit condition appeared while the named alarm was being tested, presumably because it is short-circuit.
ALARM TEST DONE	Indicates that the alarms test is complete.

Table 6-11. System Test Messages

TEST ALL INPUTS?	Prompts whether to check every operator input. If ESC is pressed, the system test ends. If ENTER is pressed, each operator input is prompted for in turn. In platform mode every platform switch and joystick is tested. In ground mode every ground switch is tested. NOTE: the jib switches are not tested if JIB = NO. NOTE: left/right jib switches are not tested unless JIB = SIDESWING. Prompts displayed during the operator input test include: CLOSE switchname The named switch should be closed. OPEN switchname The named switch should be opened. joystickname direction TO MAX The named joystick should be pushed to its full extent in the named direction. joystickname direction TO MIN The named joystick should be returned to neutral from the named direction. PUMP POT TO MAX The pump pot should be turned to maximum. PUMP POT TO MIN The pump pot should be turned to minimum. MULTIPLE CLOSURE More than one operator input is closed; if only one has been operated, there could be a short between two inputs.
TESTS COMPLETE	Indicates that the system test is complete. Any problems reported should have been noted and should now be rectified. Press ESC to return to the RUN SYSTEM TEST Analyzer menu.

[illegible]

SECTION 7. BASIC ELECTRICAL INFORMATION & SCHEMATICS

7.1 GENERAL

This section contains basic electrical information and schematics to be used for locating and correcting most of the operating problems which may develop. If a problem should develop which is not presented in this section or which is not corrected by listed corrective actions, technically qualified guidance should be obtained before proceeding with any maintenance.

7.2 MULTIMETER BASICS

A wide variety of multimeters or Volt Ohm Meters (VOM) can be used for troubleshooting your equipment. This section shows diagrams of a common, digital VOM configured for several different circuit measurements. Instructions for your VOM may vary. Please consult the meter operator's manual for more information.

Grounding

"Grounding the meter" means to take the black lead (which is connected to the COM (common) or negative port) and touch it to a good path to the negative side of the Voltage source.

Backprobing

To "backprobe" means to take the measurement by accessing a connector's contact on the same side as the wires, the back of the connector. Readings can be done while maintaining circuit continuity this way. If the connector is the sealed type, great care must be taken to avoid damaging the seal around the wire. It is best to use probes or probe tips specifically designed for this technique, especially on sealed connectors. Whenever possible insert probes into the side of the connector such that the test also checks both terminals of the connection. It is possible to inspect a connection within a closed connector by backprobing both sides of a connector terminal and measuring resistance. Do this after giving each wire a gentle pull to ensure the wires are still attached to the contact and contacts are seated in the connector.

Min/Max

Use of the "Min/Max" recording feature of some meters can help when taking measurements of intermittent conditions while alone. For example, you can read the Voltage applied to a solenoid when it is only operational while a switch, far from the solenoid and meter, is held down.

Polarity

Getting a negative Voltage or current reading when expecting a positive reading frequently means the leads are reversed. Check what reading is expected, the loca-

tion of the signal and that the leads are connected to the device under test correctly. Also check that the lead on the "COM" port goes to the Ground or negative side of the signal and the lead on the other port goes to the positive side of the signal.

Scale

M = Mega = 1,000,000 * (Displayed Number)

k = kilo = 1,000 * (Displayed Number)

m = milli = (Displayed Number) / 1,000

μ = micro = (Displayed Number) / 1,000,000

Example: 1.2 k Ω = 1200 Ω

Example: 50 mA = 0.05 A

Voltage Measurement

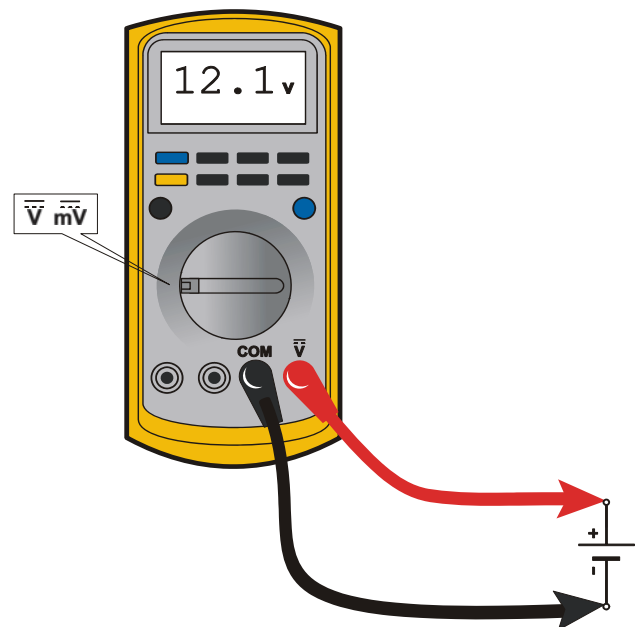


Figure 7-1. Voltage Measurement (DC)

- If meter is not auto ranging, set it to the correct range (See multimeter's operation manual)
- Use firm contact with meter leads

Resistance Measurement

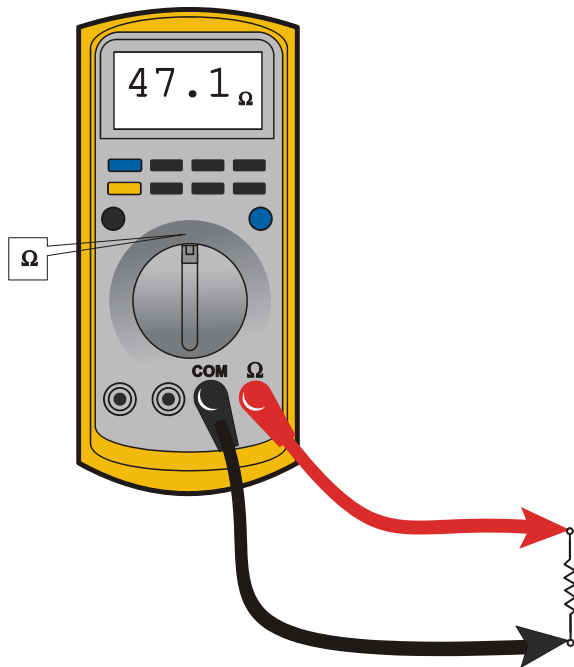


Figure 7-2. Resistance Measurement

- First test meter and leads by touching leads together. Resistance should read a short circuit (very low resistance)
- Circuit power must be turned OFF before testing resistance
- Disconnect component from circuit before testing
- If meter is not auto ranging, set it to the correct range (See multimeter's operation manual)
- Use firm contact with meter leads

Continuity Measurement

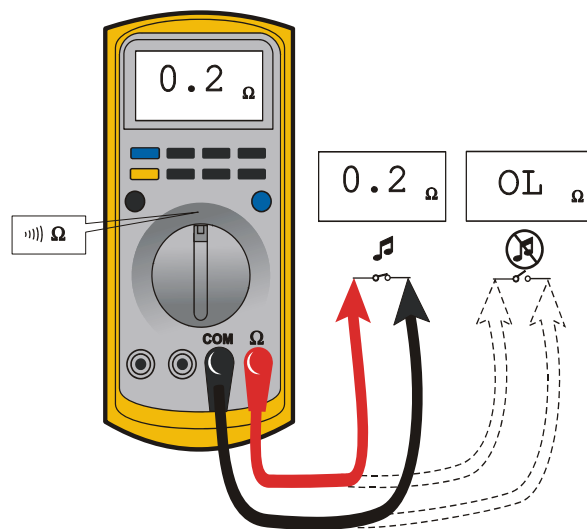


Figure 7-3. Continuity Measurement

- Some meters require a separate button press to enable audible continuity testing
- Circuit power must be turned OFF before testing continuity
- Disconnect component from circuit before testing
- Use firm contact with meter leads
- First test meter and leads by touching leads together. Meter should produce an audible alarm, indicating continuity

Current Measurement

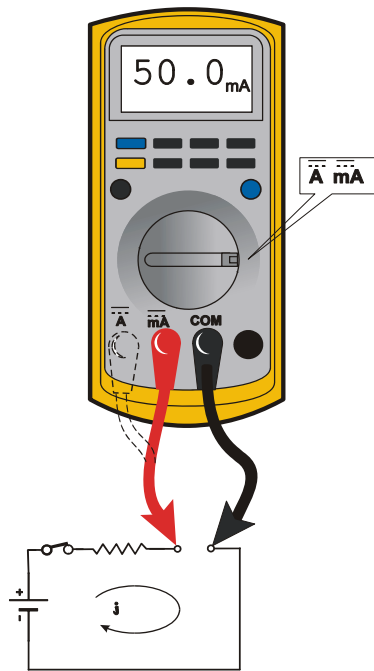


Figure 7-4. Current Measurement (DC)

- Set up the meter for the expected current range
- Be sure to connect the meter leads to the correct jacks for the current range you have selected
- If meter is not auto ranging, set it to the correct range (See multi meter's operation manual)
- Use firm contact with meter leads

7.3 CHECKING SWITCHES

Basic Check

The following check determines if the switch is functioning properly, not the circuit in which the switch is placed. A switch is functioning properly when there is continuity between the correct terminals or contacts only when selected.

1. De-energize the circuit.
2. Isolate the switch from the rest of the circuit if possible. If not possible, keep in mind it may affect readings.
3. Access the terminals to the switch.
4. If the switch has two terminals:
 - a. Measure resistance across the terminals.
 - b. Change the switch position.

- c. Measure resistance again with the leads in the same positions. If the meter was reading short, it should read an open. If the meter was reading open it should read short.
5. If the switch has more than two terminals, consult the schematic or switch diagram to determine what terminals will be connected. The test is similar to testing a switch with two terminals.
 - a. Place one meter lead on the common contact and the other on a different contact in the same circuit.
 - b. Cycle through all positions of the switch. The meter should read short only when the switch connects the two terminals and open otherwise.
 - c. If the switch has more than one common contact repeat the process for that circuit.

Limit Switches

Limit switches are used to control movement or indicate position. Mechanical limit switches are just like manually operated switches except that the moving object operates the switch. These switches can be tested the same way as a standard switch by manually operating the sensing arm.

Another type of limit switch used by JLG is the inductive proximity switch, also referred to as a "prox switch". Inductive proximity switches are actuated only by ferrous metal (metal that contains Iron, such as steel) near the switch. They do not require contact, and must be energized to actuate. These types of switches can be used to detect boom or platform position, for example. These switches have a sensing face where the switch can detect ferrous metal close to it. To find the sensing face, take note how the switch is mounted and how the mechanisms meet the switch. Test this type of switch as follows:

1. Remove prox switch from its mount.
2. Reconnect harness if it was disconnected for step a, and turn on machine.
3. Hold switch away from metal and observe switch state in the control system diagnostics using the Analyzer. See vehicle or control system documentation on how to do this.
4. Place sensing face of switch on the object to be sensed by the switch. If that is not available, use a piece of ferrous metal physically similar to it. The switch state in the control system diagnostics should change.
5. When reinstalling or replacing switch be sure to follow mounting instructions and properly set the gap between the switch and object sensed.

Automatic Switches

If the switch is actuated automatically, by temperature or pressure for example, find a way to manually actuate the switch to test it. Do this either by applying heat or pressure, for example, to the switch. These switches may need to be energized to actuate.

1. Connect instrumentation to monitor and/or control the parameter the switch is measuring.
2. Observe switch state in control system with the Analyzer. See vehicle or control system documentation on how to do this.
3. Operate system such that the switch actuates. This could be going over a certain pressure or temperature, for example. The state indicated in the control system should change.

Switch Wiring - Low Side, High Side

When controlling a load, a switch can be wired between the positive side of the power source and the load. This switch is called a "high side" switch. The switch supplies the power to the load. When a switch is wired between the negative side of the power source and the load, it is a "low side" switch. The switch provides the ground to the load.

A low side switch will allow voltage to be present on the load. No power is applied because the switch is stopping current flow. This voltage can be seen if the measurement is taken with one test lead on the load and the other on the battery negative side or grounded to the vehicle. What is actually being measured is the voltage drop across the switch. This could mislead a technician into thinking the load is receiving power but not operating. To produce an accurate picture of power or voltage applied to the load, measure voltage across the load's power terminals. Also, the technician can measure the voltage at both power terminals with respect to battery ground. The difference between those two measurements is the voltage applied to the load.

7.4 APPLYING SILICONE DIELECTRIC COMPOUND TO ELECTRICAL CONNECTIONS

Silicone Dielectric Compound must be used on all electrical connections for the following reasons:

- To prevent oxidation at the mechanical joint between male and female pins.
- To prevent electrical malfunction caused by low level conductivity between pins when wet.

Use the following procedure to apply Silicone Dielectric Compound to the electrical connectors. This procedure applies to all plug connections not enclosed in a box. Silicone grease should not be applied to connectors with external seals.

1. To prevent oxidation, silicone grease must be packed completely around male and female pins on the inside of the connector prior to assembly. This is most easily achieved by using a syringe.

NOTE: *Over a period of time, oxidation increases electrical resistance at the connection, eventually causing circuit failure.*

2. To prevent shorting, silicone grease must be packed around each wire where they enter the outside of the connector housing. Also, silicone grease must be applied at the joint where the male and female connectors come together. Any other joints (around strain reliefs, etc.) where water could enter the connector should also be sealed.

NOTE: *This condition is especially common when machines are pressure washed since the washing solution is much more conductive than water.*

3. Anderson connectors for the battery boxes and battery chargers should have silicone grease applied to the contacts only.

NOTE: *Curing-type sealants might also be used to prevent shorting and would be less messy, but would make future pin removal more difficult.*

7.5 AMP CONNECTOR

Applying Silicone Dielectric Compound to AMP Connectors

Silicone Dielectric Compound must be used on the AMP connections for the following reasons:

- To prevent oxidation at the mechanical joint between male and female pins.
- To prevent electrical malfunction caused by low level conductivity between pins when wet.

Use the following procedure to apply Silicone Dielectric Compound to the electrical connectors.

1. To prevent oxidation and low level conductivity, silicone dielectric grease must be packed completely around male and female pins on the inside of the connector after the mating of the housing to the header. This is easily achieved by using a syringe to fill the header with silicone dielectric compound, to a point just above the top of the male pins inside the header. When assembling the housing to the header, it is possible that the housing will become air locked, thus preventing the housing latch from engaging.
2. Pierce one of the unused wire seals to allow the trapped air inside the housing to escape.
3. Install a hole plug into this and/or any unused wire seal that has silicone dielectric compound escaping from it.

Assembly

Check to be sure the wedge lock is in the open, or as-shipped, position (See Figure 7-5.). Proceed as follows:

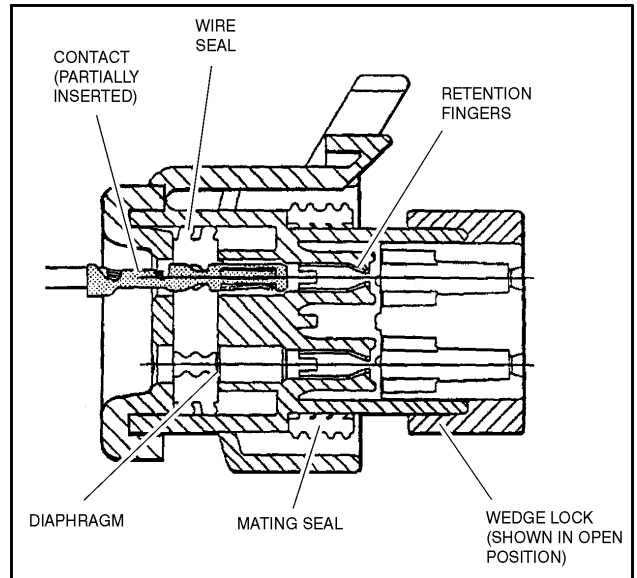


Figure 7-5. Connector Assembly Figure 1

1. To insert a contact, push it straight into the appropriate circuit cavity as far as it will go (See Figure 7-7.).
2. Pull back on the contact wire with a force of 1 or 2 lbs. to be sure the retention fingers are holding the contact (See Figure 7-7.).

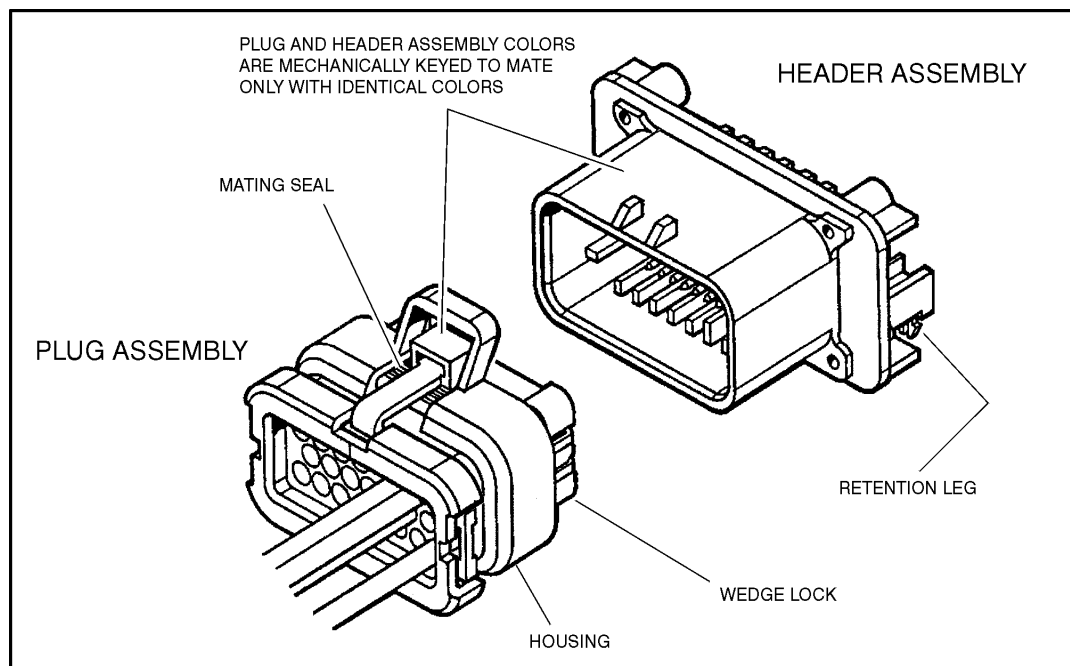


Figure 7-6. AMP Connector

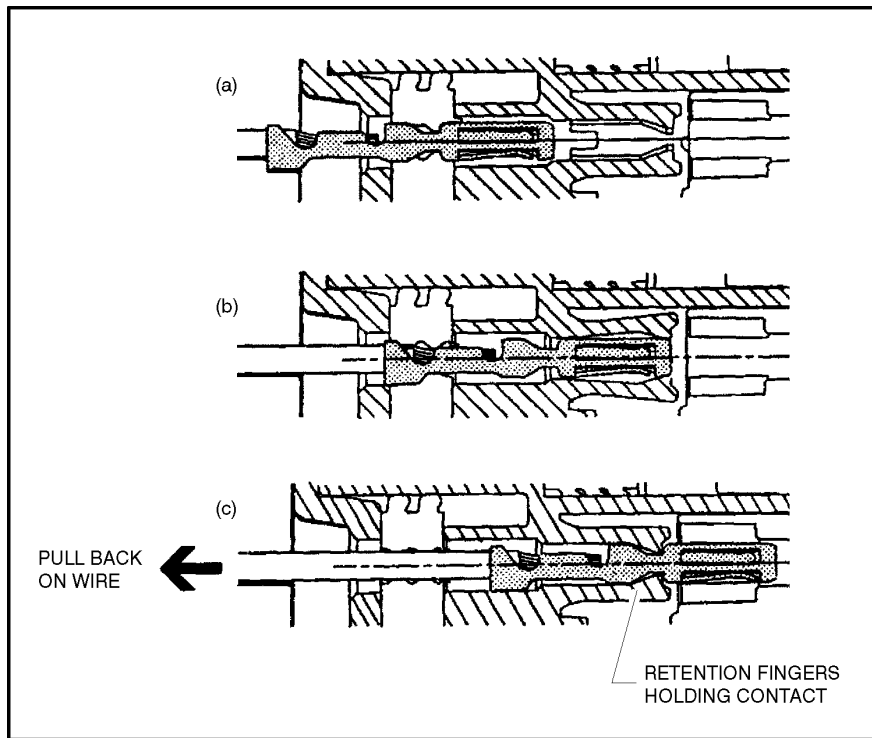


Figure 7-7. Connector Assembly Figure 2

3. After all required contacts have been inserted, the wedge lock must be closed to its locked position. Release the locking latches by squeezing them inward (See Figure 7-8.).

4. Slide the wedge lock into the housing until it is flush with the housing (See Figure 7-9.).

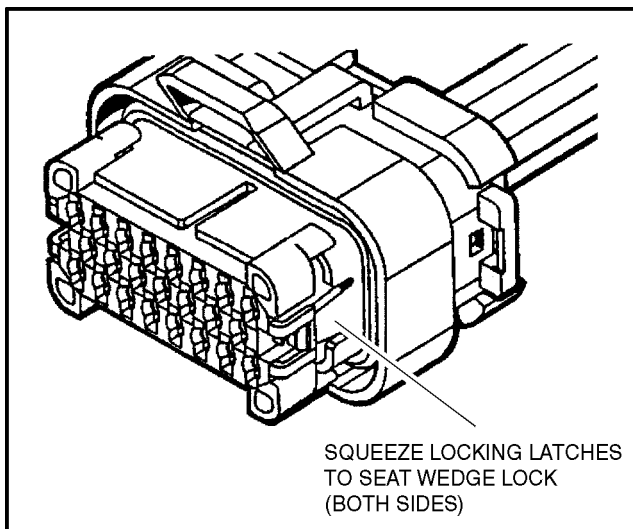


Figure 7-8. Connector Assembly Figure 3

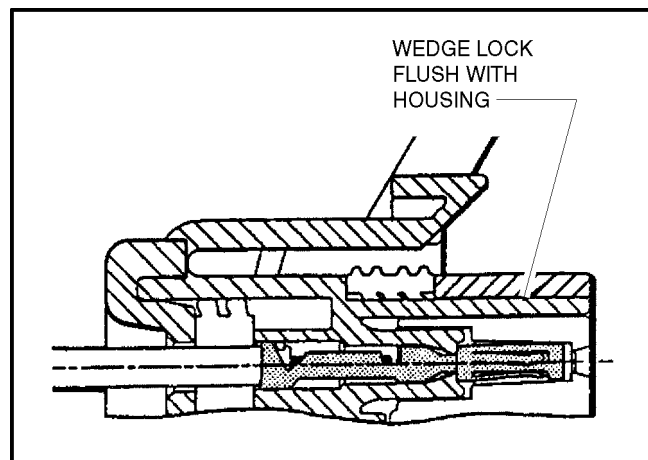


Figure 7-9. Connector Assembly Figure 4

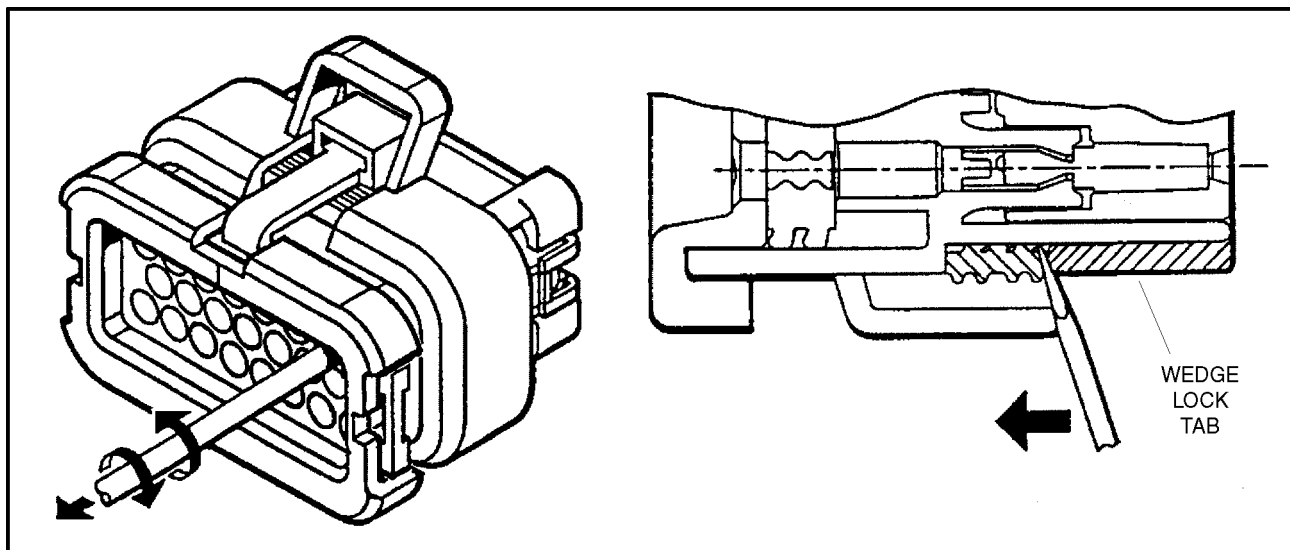


Figure 7-10. Connector Disassembly

Disassembly

1. Insert a 4.8 mm (3/16") wide screwdriver blade between the mating seal and one of the red wedge lock tabs.
2. Pry open the wedge lock to the open position.
3. While rotating the wire back and forth over a half turn (1/4 turn in each direction), gently pull the wire until the contact is removed.

NOTE: The wedge lock should never be removed from the housing for insertion or removal of the contacts.

Wedge Lock

The wedge lock has slotted openings in the forward, or mating end. These slots accommodate circuit testing in the field, by using a flat probe such as a pocket knife. DO NOT use a sharp point such as an ice pick.

Service - Voltage Reading

⚠ CAUTION

DO NOT PIERCE WIRE INSULATION TO TAKE VOLTAGE READINGS.

It has been common practice in electrical troubleshooting to probe wires by piercing the insulation with a sharp point. This practice should be discouraged when dealing with the AMPSEAL plug assembly, or any other sealed connector system. The resulting pinholes in the insulation will allow moisture to invade the system by traveling along the wire strands. This nullifies the effectiveness of the connector seals and could result in system failure.

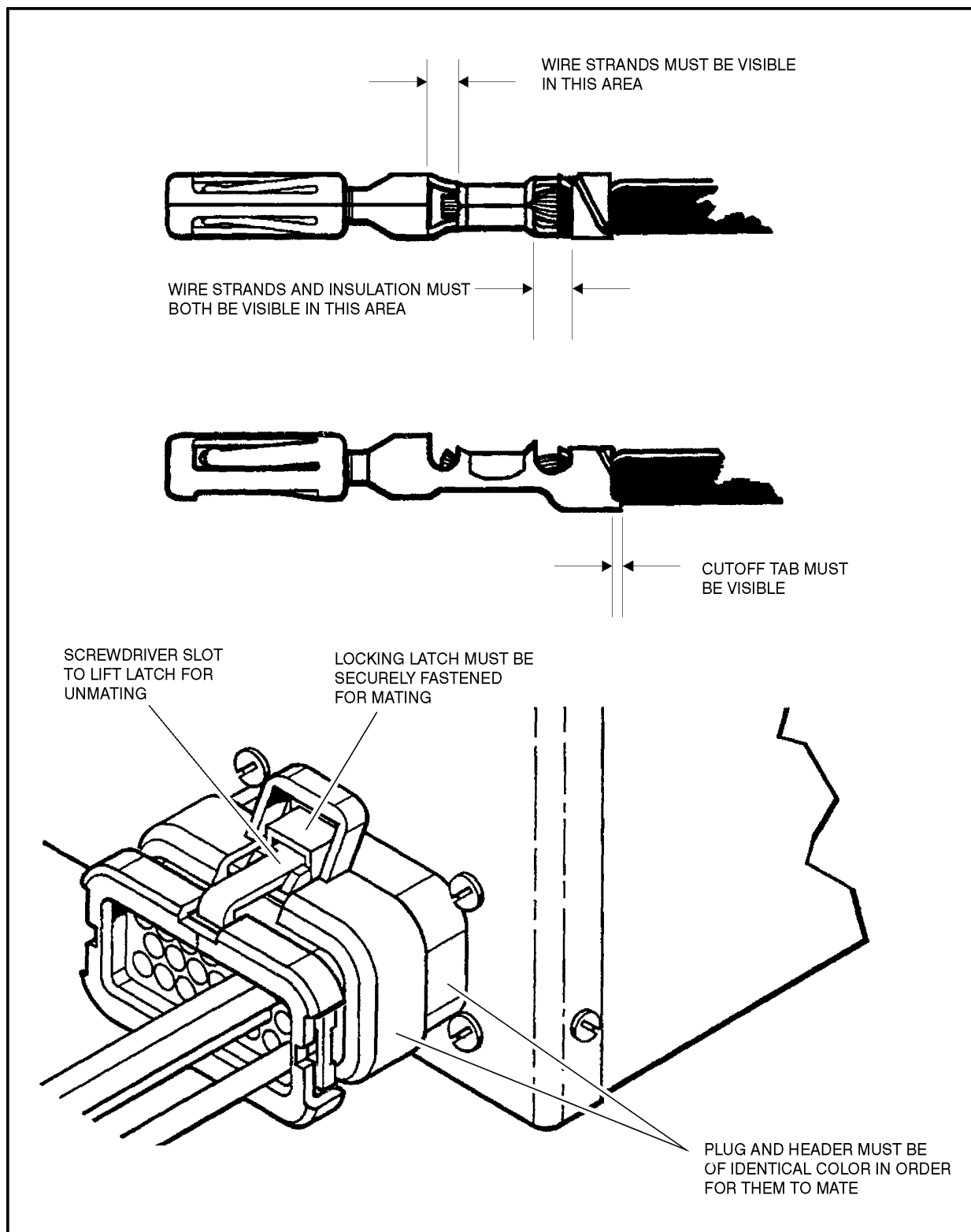


Figure 7-11. Connector Installation

7.6 DEUTSCH CONNECTORS

DT/DTP Series Assembly

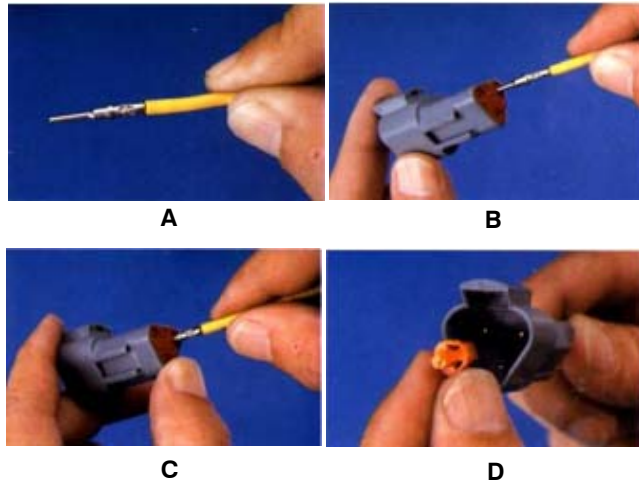


Figure 7-12. DT/DTP Contact Installation

1. Grasp crimped contact about 25mm behind the contact barrel.
2. Hold connector with rear grommet facing you.
3. Push contact straight into connector grommet until a click is felt. A slight tug will confirm that it is properly locked in place.
4. Once all contacts are in place, insert wedgelock with arrow pointing toward exterior locking mechanism. The wedgelock will snap into place. Rectangular wedges are not oriented. They may go in either way.

NOTE: The receptacle is shown - use the same procedure for plug.

DT/DTP Series Disassembly

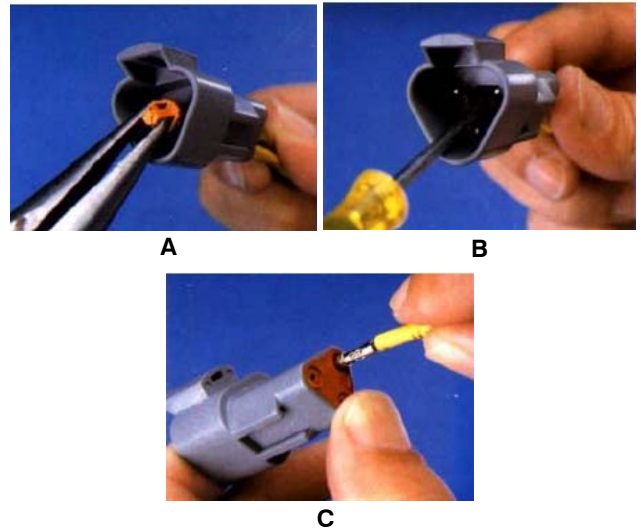


Figure 7-13. DT/DTP Contact Removal

1. Remove wedgelock using needlenose pliers or a hook shaped wire to pull wedge straight out.
2. To remove the contacts, gently pull wire backwards, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.
3. Hold the rear seal in place, as removing the contact may displace the seal.

HD30/HDP20 Series Assembly

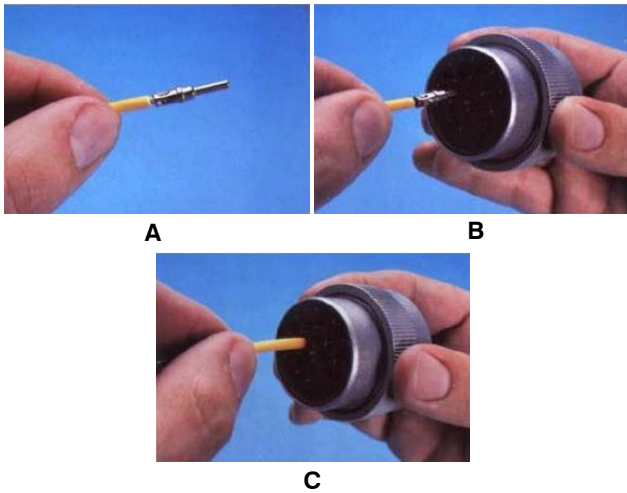


Figure 7-14. HD/HDP Contact Installation

1. Grasp contact about 25mm behind the contact crimp barrel.
2. Hold connector with rear grommet facing you.
3. Push contact straight into connector grommet until a positive stop is felt. A slight tug will confirm that it is properly locked in place.

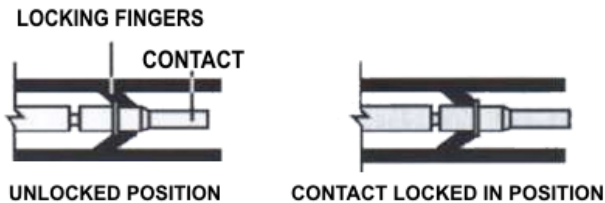


Figure 7-15. HD/HDP Locking Contacts Into Position

NOTE: For unused wire cavities, insert sealing plugs for full environmental sealing

HD30/HDP20 Series Disassembly

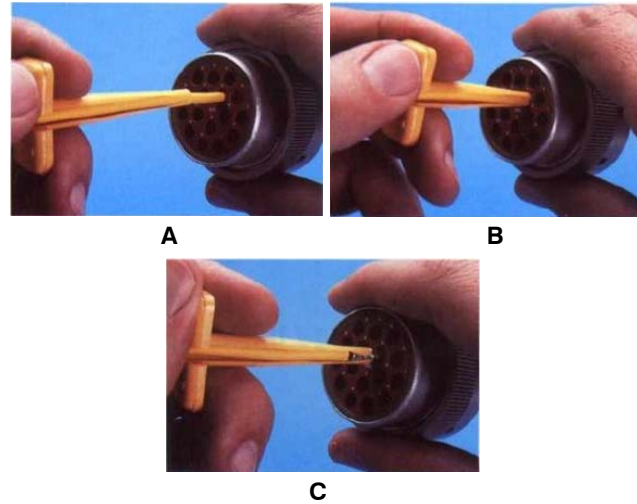


Figure 7-16. HD/HDP Contact Removal

1. With rear insert toward you, snap appropriate size extractor tool over the wire of contact to be removed.
2. Slide tool along into the insert cavity until it engages contact and resistance is felt.
3. Pull contact-wire assembly out of connector.

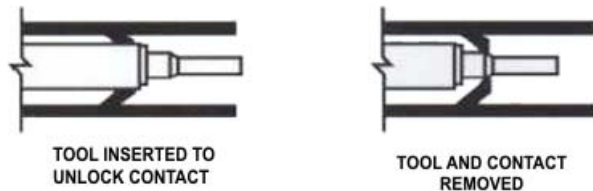


Figure 7-17. HD/HDP Unlocking Contacts

NOTE: Do Not twist or insert tool at an angle.

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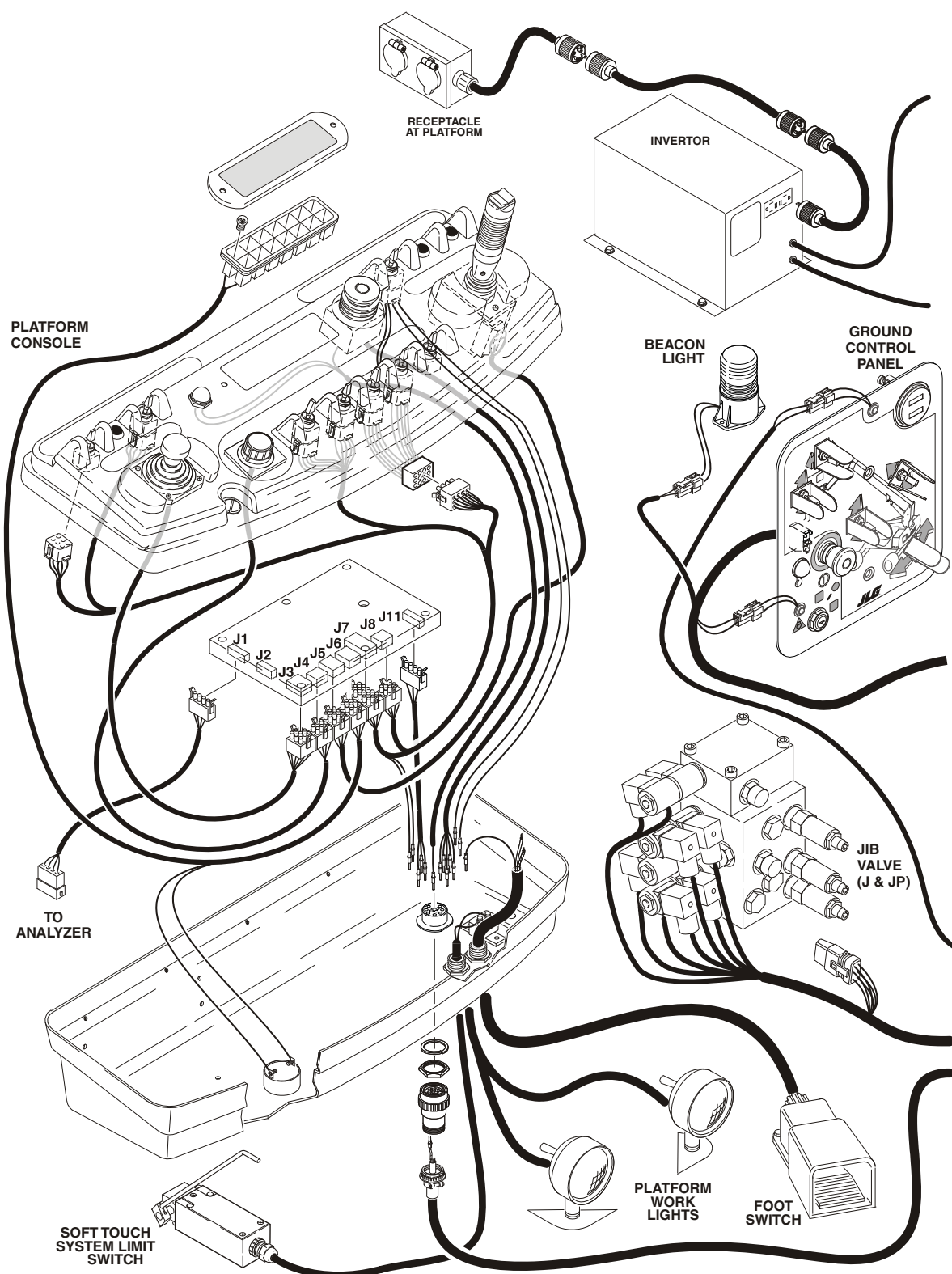


Figure 7-18. Electrical Components Installation - Sheet 1

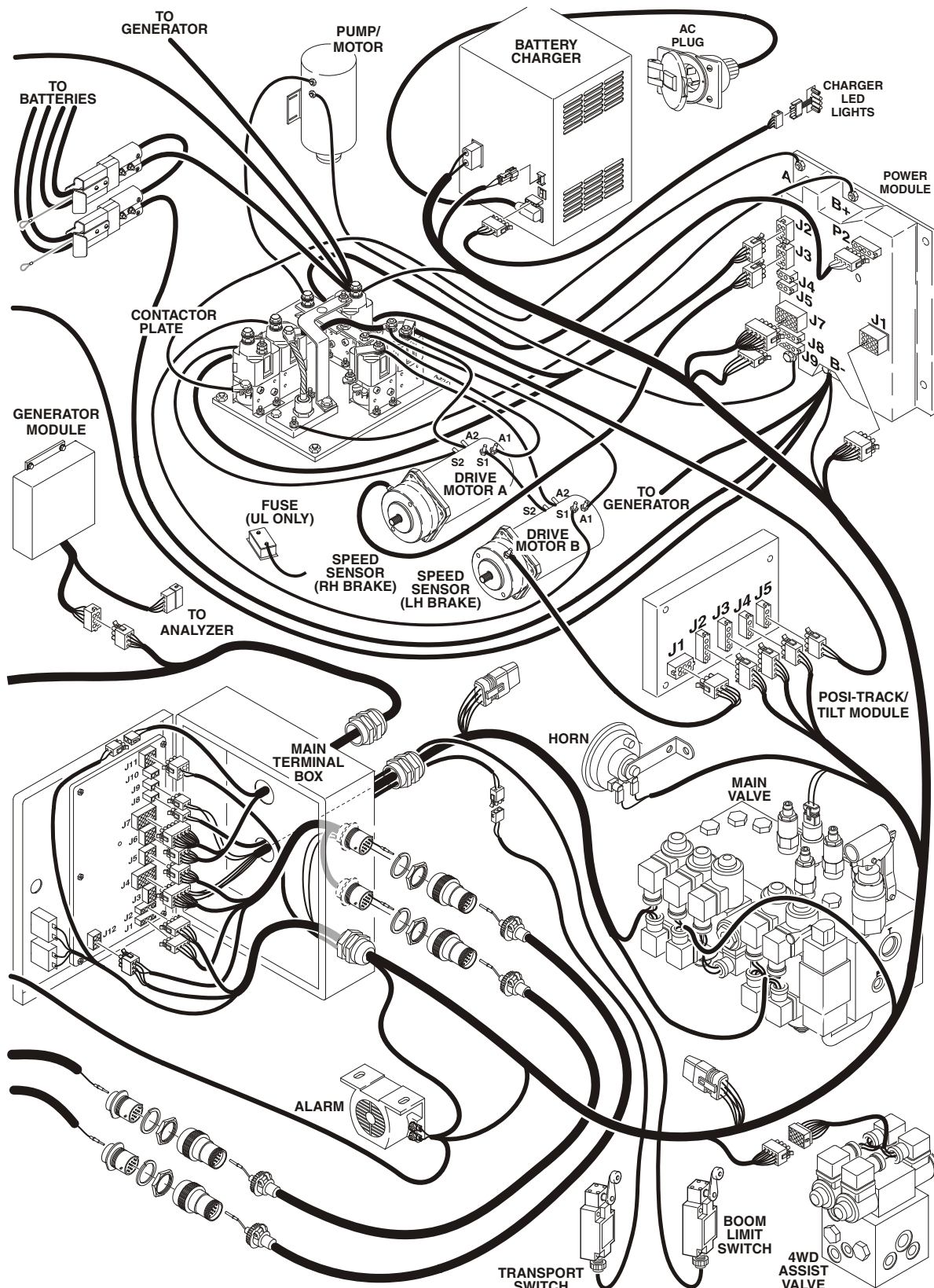


Figure 7-19. Electrical Components Installation - Sheet 2

SECTION 7 - BASIC ELECTRICAL INFORMATION & SCHEMATICS

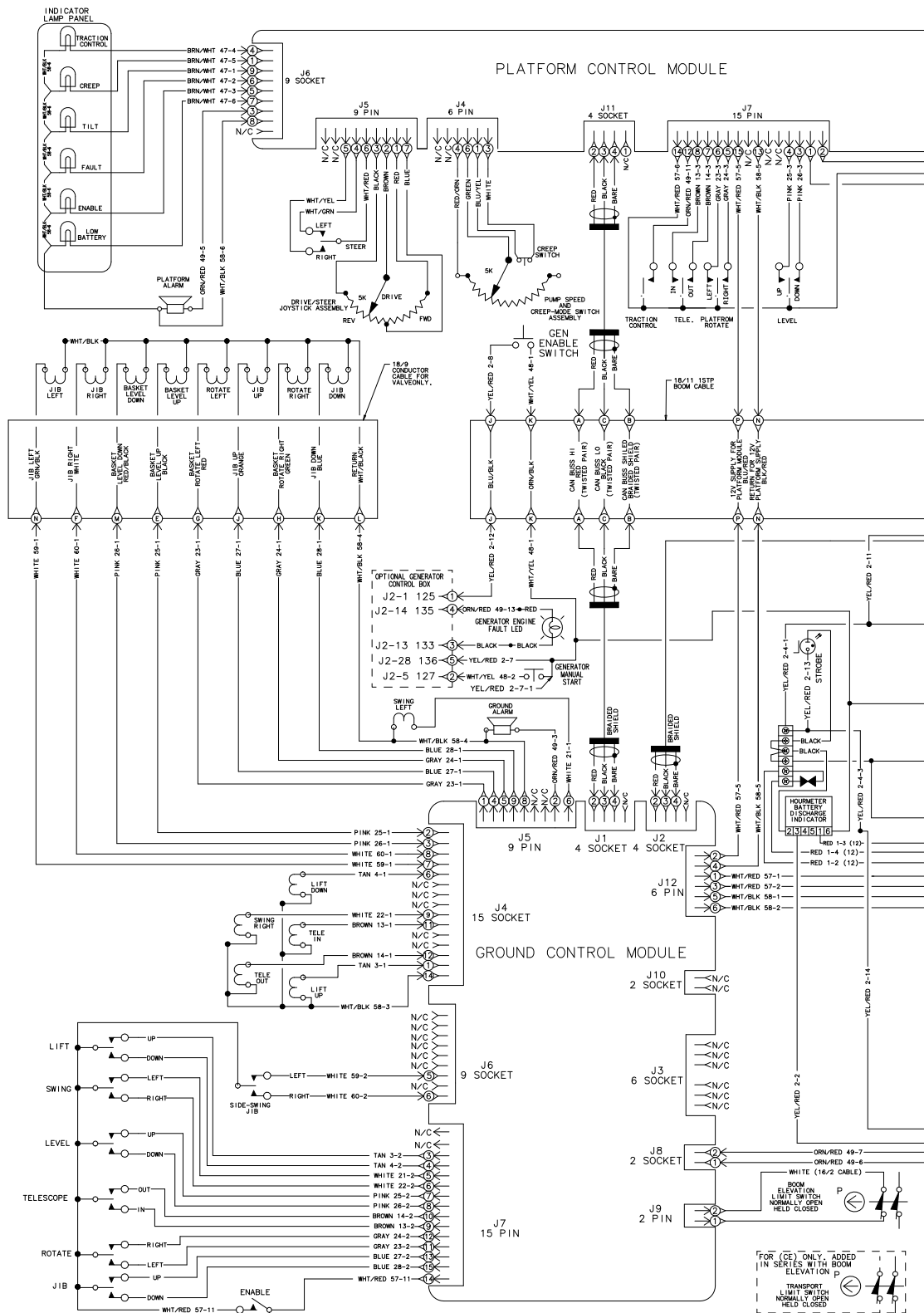
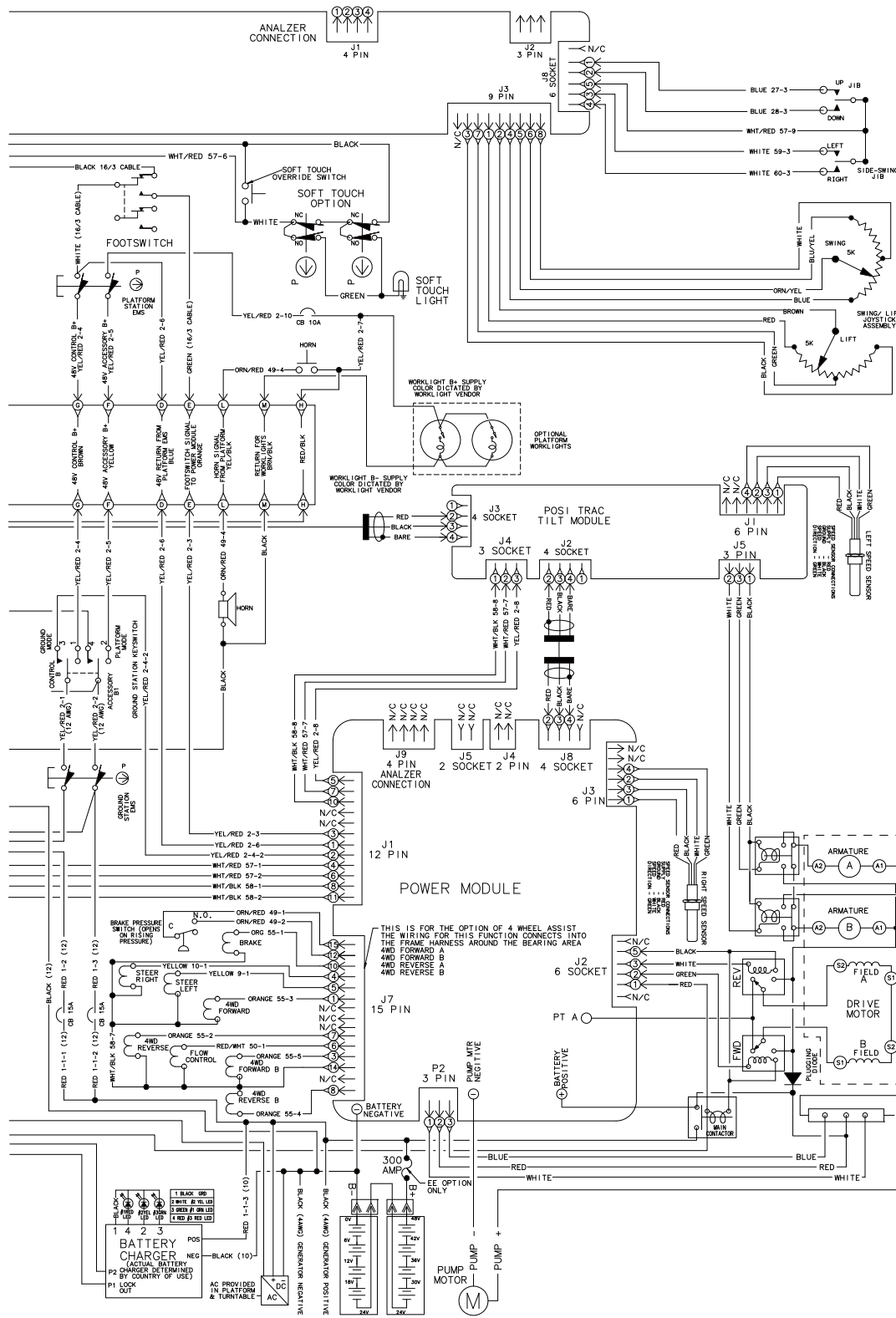


Figure 7-20. Electrical Schematic - Sheet 1 of 4



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Figure 7-21. Electrical Schematic - Sheet 2 of 4

SECTION 7 - BASIC ELECTRICAL INFORMATION & SCHEMATICS

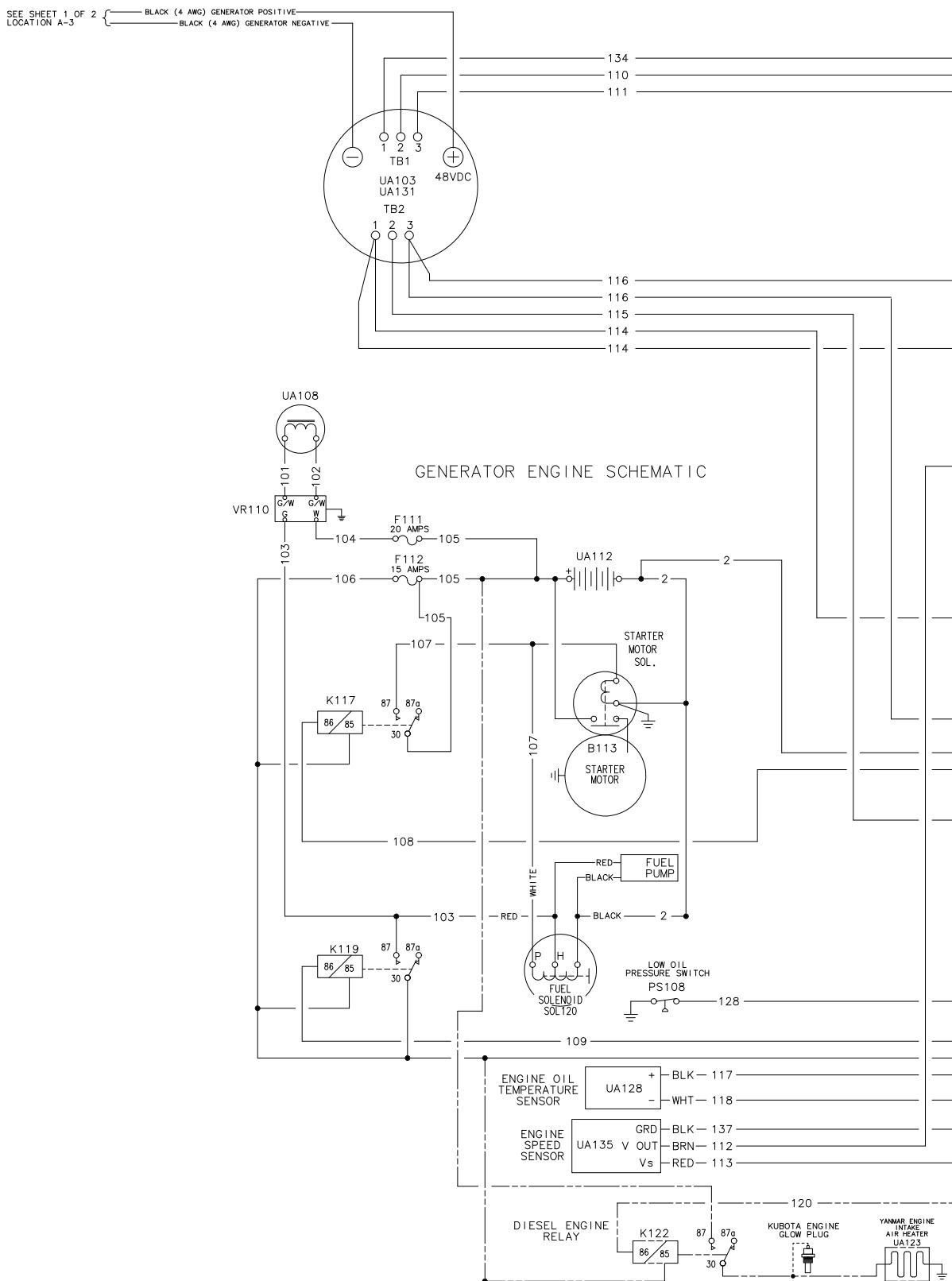
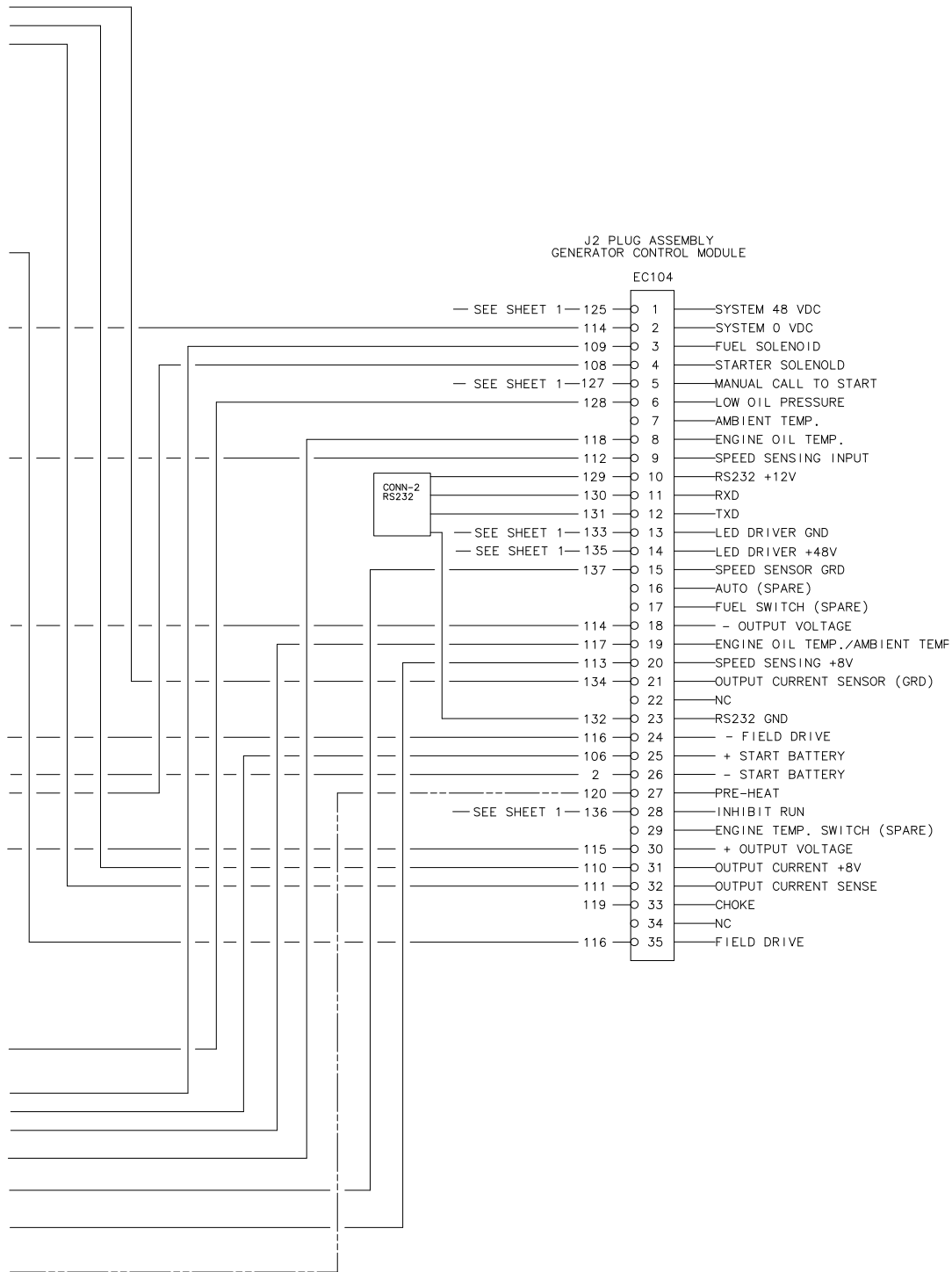


Figure 7-22. Electrical Schematic - Sheet 3 of 4



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Figure 7-23. Electrical Schematic - Sheet 4 of 4

SECTION 7 - BASIC ELECTRICAL INFORMATION & SCHEMATICS

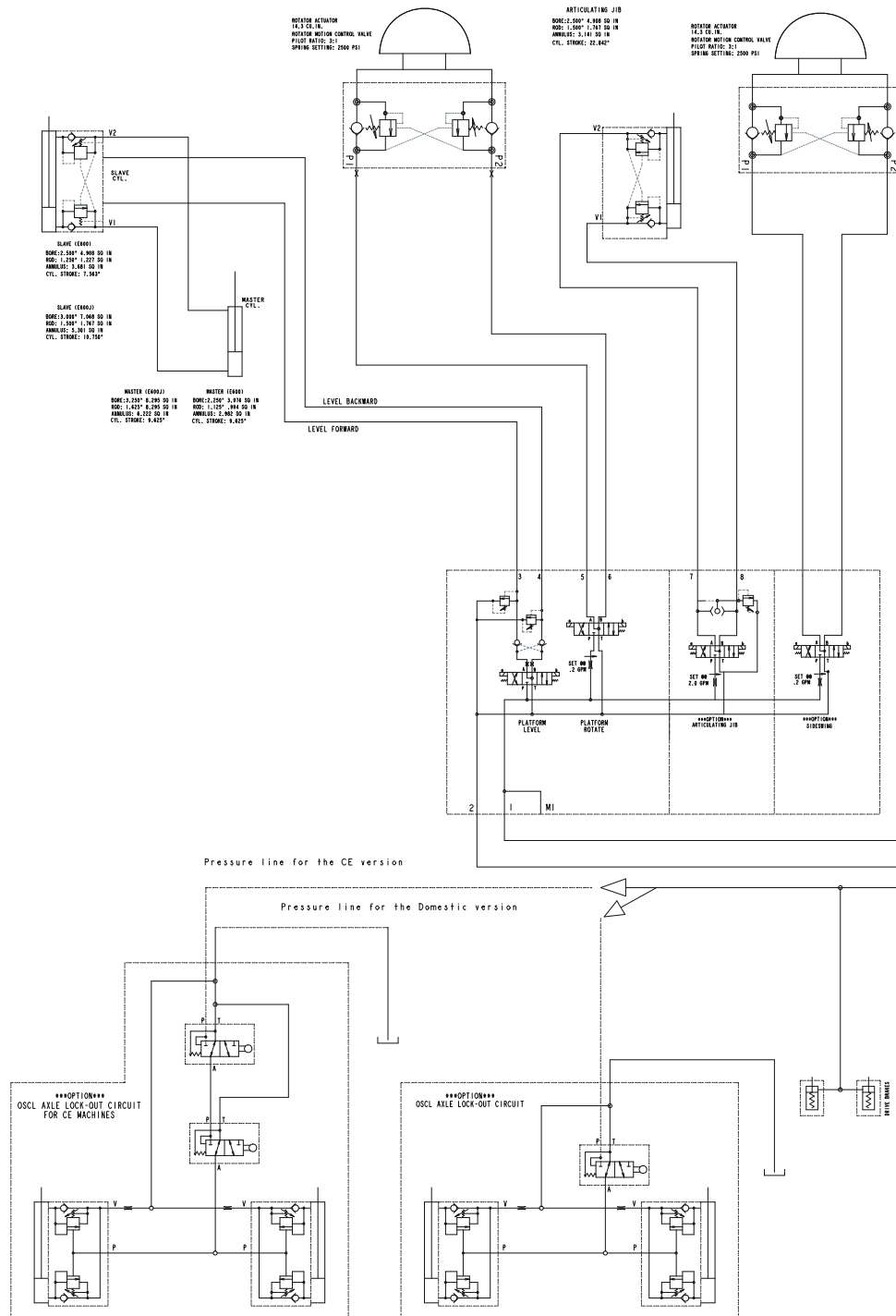
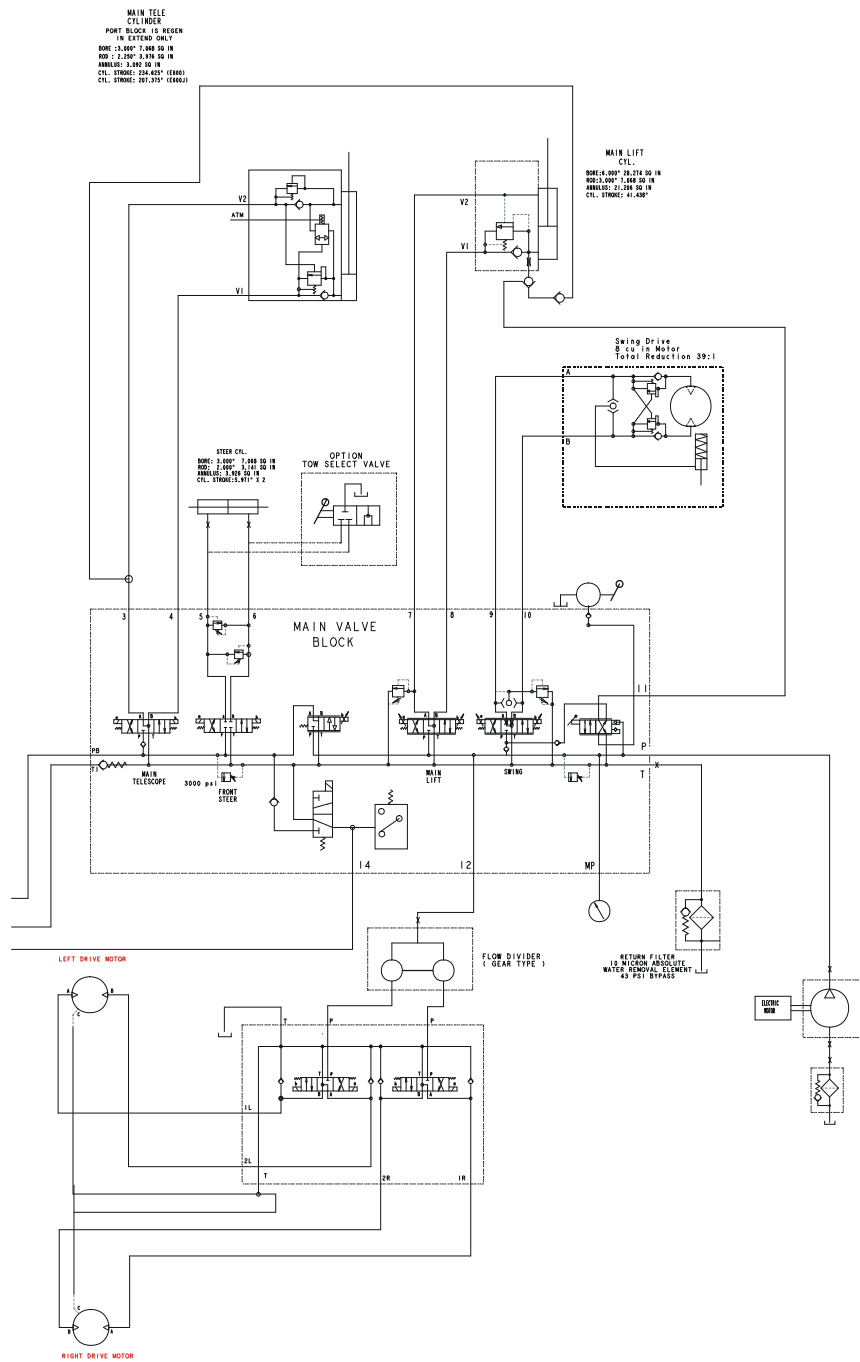


Figure 7-24. Hydraulic Schematic - Sheet 1 of 2



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Figure 7-25. Hydraulic Schematic - Sheet 2 of 2

[illegible]

PROPOSITION 65 WARNING

- **Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.**
- **Batteries also contain other chemicals known to the State of California to cause cancer.**
- **Wash hands after handling.**



WARNING:



The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

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